ENCYCLOPEDIA
OF
US AIR FORCE AIRCRAFT AND MISSILE SYSTEMS

Volume 1

by
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FOREWORD

This publication is the first of a multi-volume *Encyclopedia of U.S. Air Force Aircraft and Missile Systems*. Volume I deals with the development, deployment, and operations of fighter aircraft between 1945 and 1973, commencing with the F–80 *Shooting Star* and ending with the development of the F–15 *Eagle.* Many of these aircraft were employed during the Korean War, the war in Southeast Asia, and during cold war crises throughout the world. Additional volumes to be published in this series will cover Air Force bombers, transports, trainers, other military aircraft, and missile systems.

JOHN W. HUSTON
Major General, USAF
Chief, Office of Air Force History

PREFACE

This volume contains basic information on all Air Force fighters developed between World War II and 1973, including all configurations. It is based primarily on US Air Force sources. The origin of each aircraft is noted as well as its most troublesome development, production, and operational problems. Also covered are significant modifications, most of which can be attributed to ever-changing aeronautical technology. Production totals, delivery rates, unit costs, phaseout dates, and other important milestones are provided, as well as a brief description of each version's new features.

The book begins with the first postwar American jet fighter—the F–80 Shooting Star. It ends with Northrop's F–5 Freedom Fighter. Complete consistency of data on each fighter was not always available, but each section describes the aircraft's basic development, production decision dates, program changes, test results, procurement methods, and the like. Technical data and operational characteristics also are provided.

Many people contributed to this work, in particular members of the Historical Office, Aeronautical Systems Division, of the Air Force Systems Command (AFSC), and the Historical Office, Air Force Logistics Command (AFLC), both located at Wright-Patterson AFB, Ohio. The author also owes a special debt to Colonel Monte D. Montgomery, a former staff officer in the Allocations Division, Deputy Chief of Staff, Programs and Resources, Headquarters USAF; and to Dr. Thomas G. Belden, former Chief Historian of the Air Force, who strongly encouraged publication of such an encyclopedia. Finally, she is indebted to her office colleagues, Max Rosenberg, Deputy Chief Historian, Office of Air Force History; Carl Berger, Chief, Histories Division; Bernard C. Nalty, Clyde R. Littlefield; and several other colleagues; members of the Editorial Branch, particularly Eugene P. Sagstetter; and Eleanor C. Patterson, who typed the entire manuscript without faltering.

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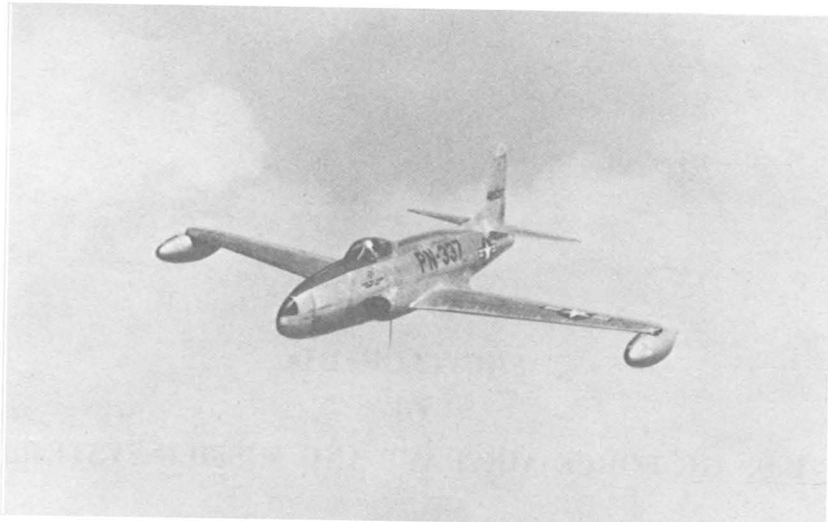

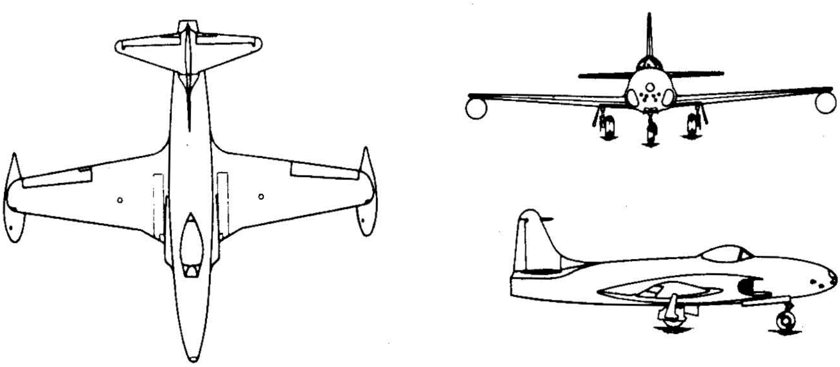

LOCKHEED F–80 SHOOTING STAR—First True American Jet Fighter

F–80B: featured underwing rocket launchers that were added to the F–80A.
TF–80C: had extended fuselage (38.5 inches more) to fit extra seat under lengthened canopy. Became T–33, commonly known as the T-Bird.

LOCKHEED F-80 SHOOTING STAR

Manufacturer's Model 80

Basic Development **May 1943**

The Army Air Forces (AAF) requested Lockheed Aircraft Company to design a jet-propelled airplane using the British DeHavilland-built Halford engine. This followed the Advanced Development Objectives (ADO) of July 1941, soon after the British had flown their first jet—a Gloster plane powered by a Whittle jet-propelled engine of an entirely new design. Germany's first jet, the Messerschmitt 262, had been flight-tested by the Luftwaffe early in 1941, a few months ahead of the British aircraft. Lockheed's 1943 design yielded an experimental plane that gave way to the F-80. Known as the P-80 until mid-1948,[1] the F-80 was the first true American jet fighter—even though Bell's P-59A Airacomet preceded it by 2 years.[2]

General Operational Requirements (GOR) **17 June 1943**

This GOR called for development of a jet-propelled plane of superior performance.

Go-Ahead Decision **June 1943**

During a conference (16–19 June) at Wright Field, Ohio, Lockheed proposed to build one airplane around the Halford engine in just 180 days. Backing its proposal with solid performance data, Lockheed secured immediate approval.

Development Contract **1943**

A letter contract (LC) on 24 June (6 days after the Wright Field conference) let Lockheed begin work without delay. The formal contract, signed on 16 October, provided for one XP-80, to be delivered within 180 days of the LC date. Total cost of $515,000

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[1] The United States Air Force, established 26 July 1947 (when the National Security Act of 1947 became law) as a separate service, coequal with Army and Navy, came into being on 18 September 1947. In the ensuing months the Air Force revised its duty prefix letter, in the designation given to fighter aircraft, from "P" for Pursuit to "F" for Fighter. The actual date for the revision of designation letters was 11 June 1948.

[2] The XP-59A Airacomet (ordered in September 1941 to take advantage of early British work on gas turbine engines) flew on 1 October 1942. It was powered by 2 General Electric I-A turbojets, developed from the Whittle jet. Bell's experimental Airacomet and 13 subsequent prototypes were followed by 20 productions (designated P-59A) that were equipped with better but still underpowered J-31-GE-3 turbojets. The P-59As were single-seaters. They carried nose armament of one 37-mm cannon, three .50-cal machineguns, and bomb racks under the outer wings, but were utilized to train jet pilots. Entering service a year before the war ended, they were all in use in the summer of 1945. Their performance, however, was disappointing—top speed (359.5 knots per hour) at 30,000 feet was slower than that of the conventional P-47 and P-51.

included a 4 percent fixed fee of $19,800. Two other experimental planes (XP–80As) were ordered under similar provisions in February 1944. In March, the AAF also ordered 13 prototypes (YP-80As)—more than usual, to speedup testing.

Mockup Inspection **20-22 July 1943**

Except for the engine (not yet available), the XP–80 mockup was complete. The sleek low-wing-airframe was so simple it elicited few immediate changes.

First Flight (XP-80) **8 January 1944**

Even though delayed by engine problems, the flight was on schedule. Lockheed actually produced the first XP–80 in 145 days. However, the Halford H–1 engine, held up abroad for 2 months, still did not work. A second imported engine arrived in December 1943—only a few weeks ahead of the first flight.[3] During flight tests in the spring of 1944, the XP–80 became the first AAF airplane to exceed 500 mph in level flight. Nevertheless, the XP–80 was discarded in favor of an airframe having the more powerful General Electric I–40 engine (later designated the J33–11). After brief pilot transition with the Fourth Air Force, the XP–80 in November 1946 went to the Museum Storage Depot of Orchard Park, Illinois.

First Flights (XP-80A) **1944**

The two XP–80As, ordered early in 1944, were first flight tested on 1 June and 1 August. The AAF continued testing the first XP-80A's flight characteristics[4] until the plane crashed on 20 March 1945 and was completely destroyed. The second XP–80A differed from the first by featuring an additional seat, behind the pilot's. This XP–80A was primarily flown to test the new J33–11 engine performance.[5]

First Flight (YP-80A) **13 September 1944**

The AAF accepted the first of the 13 P–80 prototypes on 18

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[3] Production of the British Halford engine was assumed by the Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin. The Navy monitored production of the new engines, plagued by endless maintenance difficulties. The AAF received only 3 Allis-Chalmers H–1 engines, and turned them over to the Navy in January 1947.

[4] The XP–80A was heavier and had a slightly bigger wing than the XP–80. Testing showed that its stability, maneuverability, and the like excelled that of the best fighters then in use.

[5] The General Electric Company, Schenectady, New York, was the original manufacturer of the I–40 (J33–11) engine, adopted for the P–80 over the troublesome Allis-Chalmers H–1 (J36) engine. However, production slippage at the Schenectady plant prompted the opening of a second engine source. Hence, the Allison Division of the General Motors Corporation, Indianapolis, Ind., entered the engine program in the spring of 1944.

September (5 days after its first flight). The plane was given more instruments and transferred to the National Advisory Committee for Aeronautics (NACA) for high-speed experiments. The second YP–80A was completed as the XF–14, a reconnaissance version of the basic prototype (later to become the RF–80). Despite late engine deliveries, all YP–80As (including the XF–14) had left the Lockheed plant by the end of February 1945 to engage in usual prototype operations. An exception was four prototypes allocated to tactical duty under "Extraversion," a European/Mediterranean Theater project that ended in May 1945. Two of the four Extraversion planes (one, re-equipped with a Rolls Royce B–41 engine) were lost. The others returned to a remote control research program in the United States.

F–80A

Production Decision **1944**

The AAF definitively endorsed the P–80 on 4 April (2 months ahead of the XP–80A's first flight) with a LC that introduced the first production contract. This contract, as approved in December, called for two lots of P–80s (500 in each). Delivery of the first 500 was to be completed by the end of 1945; the rest, by February 1946.[6] Each of the first 500 P–80s would cost $75,913; the later ones, $20,000 less per aircraft. A second production contract in June 1945 raised the P–80 procurement above 3,500—most of them subsequently cancelled.[7]

First Acceptance (Production Aircraft) **February 1945**

Despite major problems, the AAF received its first P–80A on schedule. The P–80 actually attained quantity production in March (only 21 months from its design), even though precision tools were lacking and the engines were either in short supply or unacceptable.

Testing **October–November 1945**

Accelerated service tests showed that with proper maintenance the P–80A was safe for flight. Many mechanical "bugs" were found, however. An engineering inspection of the 126th P–80A in mid-November (delayed for months because the first planes were practically handmade and hardly typical of later ones) also disclosed a number of deficiencies.

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[6] Germany's growing use of jet fighters (and the North American P–51's inability to measure up) underlined the P–80's urgency. In January 1945, the P–80 production got the same high priority as the B–29. This came after concluding that a slowdown of P–38 production would not solve the manpower, space, and part shortages preventing Lockheed from speeding up the P–80 production.

[7] An additional 1,000 P–80s were to be built by North American and labeled P–80Ns to distinguish them from the Lockheed productions. They too were cancelled.

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Program Changes **1945-1949**

The close of WW II brought a sharp curtailment of the P–80 procurement. The second production contract (June 1945) was completely cancelled on 5 September; the first went through several changes before settling for a total of 917 airplanes, against the 1,000 originally contracted for. Moreover, the P–80's cost climbed some $19,000 per unit, due to reduced procurement, readjusted delivery schedules, and more particularly, required configuration changes. Nevertheless, postwar procurement through fiscal year 1950 raised the entire program to 1,731 P–80s (by then redesignated F–80s) of one model or another.[8]

Enters Operational Service **1946**

Months after many of the P–80s had been accepted, the aircraft were assigned to the 412th Fighter Group.[9] In the spring of 1946 the AAF had 301 P–80s, hardly any of them overseas. The main reason was the same shortage of parts and engines that had kept the P–80 out of WW II. All P–80As using J33–9 engines had been grounded in 1945, while a General Motors strike the following year further complicated the engine situation. Furthermore, the P–80 had the highest accident rate in the AAF[10]—36 crashes alone between March and September 1946. Here, low pilot experience played a part.

Production Modifications **1946**

Beginning with the 346th production, Lockheed put the Allison J33–17 engine in the P–80A. The GE J33–11 and Allison J33–9 engines, used interchangeably by earlier P–80As, would be reconfigured along the lines of the new J33–17.[11]

Modernization **1947-1948**

The AAF paid Lockheed $8.5 million to give the P–80As some features of the next model (P–80B). This took roughly 1 year. By March 1948, all P–80As in service had received under-wing rocket

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[8] This Air Force Logistics Command (AFLC) figure included all experimental and prototype planes, some 60 P–80s bought for the Air National Guard (ANG), and 128 F–80Cs converted to TF–80Cs (also referred to as T–33s). Lockheed reported F–80 production to be below 1,700. Headquarters AAF/USAF showed 1,552 F–80s bought for the active forces. All three sets of figures were correct, being based on different accounting methods.

[9] After testing the aircraft, this unit had reported in mid-1945 that the P–80 "was the only fighter airplane with sufficient speed to escort proposed jet-propelled bombers." The 412th also thought the P–80 well-suited for other tactical roles—counter air and ground support.

[10] More than twice that of any other fighter, excluding the P–59 which was seldom flown.

[11] There was no money for Allison to do the work. It would be handled over several years during regular depot engine overhauls.

launchers, and all but a few got an engine water-alcohol injection system to ease takeoff. To cure canopy problems at high speed, Lockheed installed newly-developed canopy remover kits on many of the P–80As as part of the $8.5 million modernization deal. Oversea units did their own canopy work. The same fund shortages that kept Allison from improving the engines of the early P–80As slowed other postproduction modifications. Faulty aileron boost pumps (the cause of several accidents) and hydraulic pressure losses still existed. These, like upgrading the original engines, would eventually be corrected during regular depot overhauls.

End of Production **December 1946**

Production terminated with delivery of 12 last aircraft.

Total P-80As Accepted

525

Acceptance Rates

The AAF accepted 33 P–80As in FY 45, 311 in FY 46, and 181 in FY 47.

Flyaway Cost Per Production Aircraft

Approximately $95,000[12]

Subsequent Model Series

P–80B

Other Configurations—RF-80A

FP–80A. A P–80A, with a longer and deeper nose to house cameras in place of the six M–2 guns, initially on the basic aircraft. The FP–80A's prototype (the XF–14) was flown in the fall of 1944. It was followed by the XFP–80A, a reconnaissance version of the production P–80A. The AAF earmarked 152 of the 917 P–80s procured under the first production contract for conversion to photographic models. These FP–80As were all accepted in FY 47 (between July 1946 and April 1947) at a flyaway cost per production aircraft of $107,796—airframe, $75,967; engine (installed), $21,584; electronics, $4,195; ordnance, $2,335; other (including armament), $3,715.[13] The Air Force in 1951 converted 70 of the redesignated F–80As to the reconnaissance type. To better fit these RF–80As for Korean operations, they were given improved photographic equipment.[14] In 1953, 98 RF–80As exchanged their J33–A–11 engines for the more powerful J33–A–35s of yet another F–80 version (the famed

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[12] Average cost of the various P–80s ordered under the first production contract of December 1944. If included, research and development costs boosted the aircraft's average price to over $110,000.

[13] Average aircraft costs in Air Force Technical Order (T.O.) 00–25–30 did not reflect engineering change and modification costs after basic contract approval.

[14] Redesignated 94th Fighter-Interceptor Squadron (FIS) on 16 April 1950.

and most produced T–33). This upped performance and prolonged aircraft service life. The Air Force flew a few RF–80s until late 1957.

Oversea Deployments **1948–1949**

In July 1948, 16 F–80s of the 56th Fighter Group, Strategic Air Command (SAC), departed Selfridge AFB, Mich., on a pioneer journey. The planes left Bangor AFB, Maine, on the 20th and made refueling stops in Labrador, Greenland, and Iceland. They landed in Scotland 9 hours and 20 minutes after leaving the United States. This first west-east transatlantic jet flight, on the heels of the Soviet land blockade of Berlin, was followed by a similar F–80 crossing in the summer of 1949. After that, use of the North Atlantic route became routine—saving time, money, and bolstering European security.

War Commitments **1950**

F–80As never directly took part in the Korean conflict. In 1950 they were used in the United States for training. Production of jet fighter pilots was too important to be curtailed—even temporarily. This fact rather than the aircraft's obsolescence was the reason they were kept at home.[15]

Phaseout **1951**

The F–80A began leaving the Air Force in October 1951.

Milestones **19 June 1947**

The AAF as early as 1945 wanted to achieve a world speed record with the P–80A. When minor modifications failed, the AAF spent $35,000 to devise a speedier, slimmed down version (the P–80R).[16] Piloted by Colonel Albert Boyd, Chief of the Wright Field's Flight Test division, the P–80R on 19 June 1947 set an official record of 623.73 mph over a 3-kilometer course at Muroc, Calif. This broke the British Gloster twin-jet Meteor IV's 616 mph record of 7 September 1946. Colonel Boyd's record speed was an average—on one of the four runs, the tiny plane streaked across the course at 632.5 mph.

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[15] The Air Force filled most early F–80 requisitions from the Far East Air Force (FEAF) with the only planes immediately available in large numbers. These were older F–51s, retrieved from the Air National Guard or withdrawn from storage. FEAF fighter pilots knew the F–51 and needed no transitional training—a crucial factor at the time.

[16] The P–80R had a J33–A–23 engine, with water-alcohol injection, clipped wings, a smaller cockpit canopy, and a high-speed sleek finish.

F-80B

Previous Model Series

F-80A

New Features

Thinner wings with thicker skin; stronger nose bulkheads to support greater fire power (six M-3 .50-in machine guns); stainless steel armored compartment containing the new Allison J33-21 engine, with water-alcohol injection and fitted for jet-assisted take-off (JATO).[17] The F-80B also featured underwing rocket launchers (added to the F-80A), cockpit cooling and canopy anti-frosting systems, and a jettisonable pilot seat (designed, manufactured, and installed by Lockheed).

Basic Development **1945**

The P-80B got its start in early 1945, when Lockheed presented plans for the P-80Z—an advanced P-80 type. The Lockheed's sophisticated P-80Z plans were unrealistic. To follow them would amount to building a whole new aircraft. Instead, the AAF settled for a much simpler model. This aircraft also bore the P-80Z designation until the spring of 1947. A March engineering inspection found that after 65 changes the P-80Z still differed little from the P-80A. The P-80Z accordingly became the P-80B 1 month later.

Procurement **1946**

A December 1946 letter contract ordered 60 P-80Bs (still known as P-80Zs); an amendment on 31 January 1947 raised the order to 140. This included 60 for the ANG, reduced to 54 in March due to a shortage of funds. In the end a grand total of 240 P-80Bs was purchased under the several-time altered production contract of 1944.

First Acceptance (Production Aircraft) **7 March 1947**

It was accepted after 3 days of engineering inspection and 1 month before the aircraft became the P-80B.

End of Production **March 1948**

Production terminated with delivery of the 765th P-80 (525 P-80As, then 240 P-80Bs).

Total P-80Bs Accepted

240

Flyaway Cost Per Production Aircraft

The AAF in May 1947 set the P-80B's unit cost below $75,000. In

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[17] Those F-80As with the 4,000-lb-thrust J33-17 engine (600 pounds weaker than the J33-21) were given water-alcohol injection systems. All F-80As were fitted for jet-assisted takeoff. This minor modification was directed in March 1947.

the long run, the F–80A and the similar F–80B were priced under a single tag—around $95,000 per plane.

Subsequent Model Series

P–80C (F–80C on 11 June 1948).

Other Configurations

None

Phaseout **1951**

In practice F–80Bs and F–80As were usually considered the same aircraft. Both models began USAF phaseout in late 1951.

F-80C

Previous Model Series

F–80B

New Features

A more powerful engine and better armament.[18]

Contractual Arrangements **1948-1949**

The AAF used fiscal year 1947 funds to order the first P–80Cs, but the definitive contract was not signed until 2 February 1948. Procurement of the last increment (F–80Cs) was authorized in fiscal year 1950.

Enters Operational Service **1948**

Still little more than an improved P–80, the F–80C's early days achieved scant recognition. Yet, it was this aircraft that introduced the jet fighter into the Korean conflict.

Oversea Deployments **1949-1950**

Most FEAF fighter wings had F–80Cs months before the Korean war. In May 1950, 365 of the 553 aircraft in FEAF operational units were F–80Cs.

War Commitments **1950-1953**

Because of FEAF's defensive mission, F–80Cs on 25 June 1950 (when the war broke out) had only .50-caliber machineguns. As counter air interceptors, they were equipped with mid-wing rocket posts for carrying up to 16 5-inch high-velocity rockets. Designed as fighters, none of them were fitted with pylon bomb racks. The F–80C used the least fuel at 15,000 feet, but its range at that altitude was still quite short. Yet, before they knew it, the F–80Cs were tapped for all types of jobs—from escorting B–29s to flying

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[18] Early F–80Cs had the J33–A–23 engine of the P–80R; later productions, the J33–A–35 (5,400-pound-thrust with water injection). All F–80Cs were armed with the F–80B's M–3 guns. The improvement lay in an increase of the gun's rate of fire.

interdiction and close air support.[19] As fighter-bombers, they stood down on 1 May 1953, but a few remained committed to the interceptor role until the truce on 27 July.

Special Modifications **1950**

The F–80C's radius of action was around 100 miles. With two Lockheed external 165-gallon tanks (and a full rocket load) it was only 225 miles. Lieutenants Edward R. Johnston and Robert Eckman of the 49th Fighter-Bomber Wing at Misawa Air Base in Japan came up with one answer. Two center sections of a standard disposable tank were inserted in the middle of each of the two external tanks. These modified "Misawa" tanks each held 265 gallons—enough fuel for 1 extra hour of flight and a 350-mile radius of action, depending on the type of combat mission. Every FEAF F–80C would get a pair of Misawa tanks, even though they might overstress the wing tips.[20]

Appraisal

As early as March 1951, pilots realized the F–80C's shortcomings as escort. The MIGs were able to fly through bomber formations before the F–80Cs (100-mph-slower at 25,000 feet) could engage them.[21] The F–80Cs proved excellent fighter-bombers and stood up well under rough field conditions. The strain of combat flying, however, caused them to deteriorate faster than they could be repaired. In 1952, they already required more routine maintenance for each hour flown than any other fighter, including the F–51 of WW II note.[22] In air-to-air combat, the F–80C's success was short lived.[23] Soon, these aircraft relied on F–86 support to keep them out of MIG–15 gunsights. In the long run, enemy aircraft downed only 14 F–80Cs. Still, operational losses were high—277, 113 of them due to ground fire. The 277 represented almost one-half of the entire F–80C production.

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[19] Pre-1950 economy programs prevented the building of longer and stronger runways at temporary air installations in Japan, where conventional aircraft were being replaced by jets. This postponed deployment of the F–84E (specifically adapted for air-ground operations) and severely pared FEAF flight training. Too, fund shortages back home added to the problems of the new F–84 and F–86 jets.

[20] The F–80C's radius of action reverted to 100 miles, when bombs replaced the external fuel tanks.

[21] F–80C production was barely ended when the Korean war started, but the aircraft were already behind the times, as more advanced jets came onto the scene.

[22] In the spring of 1952, an average of 7,500 manhours per aircraft would be needed to recondition some of the 49th Wing's F–80Cs after only 4 months of flying.

[23] Nevertheless, an F–80C on 8 November 1950 destroyed a MIG–15 in what was believed to be the first conclusive air combat between jet fighters.

Total F-80Cs Accepted

The Air Force accepted 670, against 798 ordered. The last 128 were completed as TF-80Cs (redesignated T-33As on 5 May 1949). By 30 June 1950, all but a few of the 798 F/TF-80Cs had been accepted.

Flyaway Cost Per Production Aircraft (F/TF-80C)

$93,456.00—airframe, $62,050; engine (installed), $21,192; electronics, $5,536; armament, $4,678.

Subsequent Model Series

None

TF-80C

Other Configurations

A P-80C fuselage, taken off the production line in August 1947, was extended by 38.5 inches to fit an extra seat under the lengthened canopy. This prototype trainer was first flown on 22 March 1948. Redesignated TF-80C in June, it became the T-33A within a year. The TF-80C first had the J33-A-23 engine, then the more powerful -25. The trainer also retained 2 of the F-80C's .50-caliber machineguns that were optional in the T-33A. Commonly called the T-Bird, the T-33 was produced in larger quantities than any other F-80. Eventually, given a still better engine (the J33-A-35), the T-33 served as the Air Force's standard jet trainer for almost two decades.

Phaseout **1954-1955**

Discontinuance of the last USAF tactical F-80C squadron—some 8 months after the Korean war—foretold the F-80C phaseout from the regular forces. Yet, several F-80Cs lingered in the active inventory until October 1955.[24] The Air National Guard still flew a mix of F-80 day fighters in 1956, shelving the last ones in mid-1958.

Other Countries

Around 100 F-80Cs went to allied nations under the Military Assistance Program (MAP).

Other Uses

A number of F-80s ended up as drones. Designated QF-80s, they collected fallout samples from radioactive clouds. They served in addition as missile targets. The Air Force Missile Development Center at Holloman AFB, N. Mex., was still using them in late 1963.

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[24] The Air Force Reserve (AFR) also got F-80Cs—a few in mid-1953 and 175 by mid-1955. After switching some F-80Cs for more modern fighters, the AFR in November 1957 dropped all its fighters and became a troop carrier force.

PROGRAM RECAP

The Air Force accepted a grand total of 1,731 F–80s—counting all prototypes and P–80 deliveries actually received by the AAF. The program consisted of 1 XF–80, 2 XF–80As, 13 YF–80As, 525 F–80As, 240 F–80Bs, 670 F–80Cs, 152 RF–80As,[25] and 128 TF–80Cs (redesignated T–33As in 1949).

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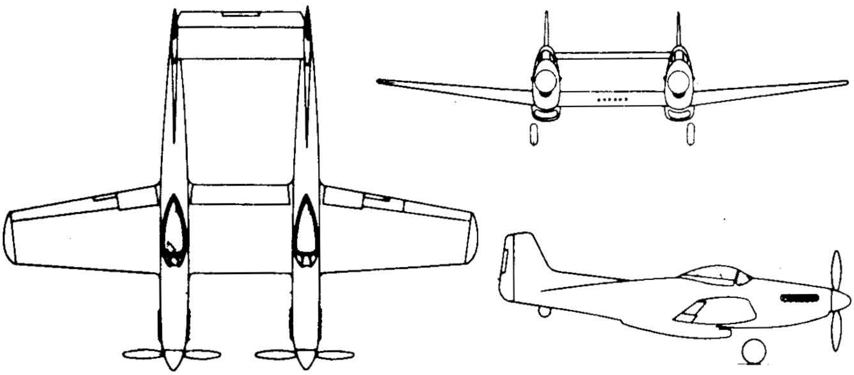
[25] All other RF–80As in the inventory were converted F–80As.

TECHNICAL DATA

F–80A/B, F–80C, and T–33A

Manufacturer	(Airframe)	Lockheed Aircraft Corporation, Burbank, Calif.
	(Engine)	Allison Division of General Motors Corporation, Kansas City, Mo.
Nomenclature		F–80, fighter; T–33, subsonic jet trainer.
Popular Name		Shooting Star/T-Bird

Characteristics	*F–80A/B*	*F–80C*	*T–33A*
Engine, Number & Designation	1 J33–A–11 or 1 J33–A–17; F–80B, 1 J33–A–21	1 J33–A–23 or 1 J33–A–35	1 J33–A–23 or 1 J33–A–25 or 1 J33–A–35
Length/Span	34.6 ft/39.11 ft	34.6 ft/39.11 ft	37.9 ft/38.11 ft
Weight (empty)	7,920 lb	8,240 lb	8,084 lb
Max. Gross Weight	14,500 lb	16,856 lb	11,965 lb
Max. Speed	484.5 kn (sea level)	503.6 kn (7,000 ft)	471.5 kn (25,000 ft)
Cruise Speed	356.0 kn	381.2 kn	
Rate of Climb (sea level)	4,580 fpm	6,870 fpm	6.5 min. to 25,000 ft
Service Ceiling	45,000 ft	42,750 ft	47,500 ft
Range	360 nm	920 nm	3.12 hours
Armament	6.50-in machine guns	6.50-in machine guns	None (2.50-in machine guns in TF–80C)
Ordnance	up to 2,000 lb	up to 2,000 lb	
Rockets	8 5-in HV	16 5-in HV	
Crew	1	1	2



NORTH AMERICAN F–82 TWIN MUSTANG—All F–82s Were Much the Same.

F–82E: long-range escort fighter; first truly operational model (F–82As and Bs went to testing).

F–82F/G/H: featured a nacelle beneath the center-wing to house radar equipment. They were used as all-weather fighter interceptors.

NORTH AMERICAN F-82 TWIN MUSTANG

Manufacturer's Model NA-123

Basic Development **January 1944**

As a double-fuselaged P–51 Mustang, the post-World War II P–82 in reality reached back to October 1940, when the P–51 prototype first flew.[1] Since North American used some Curtiss P–40 technical data to quickly develop the YP–51, the P–82's ancestry may even be traced to 1937, when the experimental P–40 Warhawk was ordered.[2]

Advanced Development Objective **20 February 1942**

A special escort plane was needed. The ADO of 1942 responded to the AAF's 1941 air war plans that "urged development of special escort planes [even though] bombers for the moment could rely on current interceptor-type models for support, especially the P–47." Since Republic's incoming P–47s also served as fighter-bombers, these plans suggested employment of a modified bomber type for the escort role.[3]

General Operational Requirements **January 1944**

With even longer range than the latest P–51 then in production,[4]

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[1] The North American P–51 Mustang was developed in record time to satisfy British WW II requirements for a fighter that would take into account the early lessons of aerial combat over Europe. Among the aircraft's most notable features were a laminar-flow wing section, aft-mounted ventral radiator for minimum drag, and simple lines to ease the production that began in late 1941. A year later, the Army Air Forces adopted the P–51 for its own use. It ordered some 2,000 P–51Bs, a ground attack version of the Royal Air Force P–51 single-seat fighter.

[2] During May 1939, in competition with other pursuit prototypes, the Curtiss Warhawk was evaluated at Wright Field. This plane was immediately selected for procurement under a first contract of nearly $13 million—largest at the time for a US fighter. The first P–40s (of 12,302 produced) were delivered in May 1940.

[3] The 1941 air war plans sounded a discordant note at a time of overwhelming faith in the bomber's supremacy. Moreover through the late summer of 1942, WW II experience tended to confirm that escorts were only necessary to support bombers past enemy fighters along the coasts of France and Belgium. Once the "fighter belt" was crossed, little if any German opposition would be met.

[4] This P–51D, like the later P–51H and P–51K, closely resembled the P–51B and P–51C, both of which could carry 184 gallons of fuel internally, 150 gallons in external tanks, and remain in the air 4 hours and 45 minutes. In November 1943 (1 month before the first P–51Bs entered service with the British-based Eighth Air Force), the AAF chose the P–51B and P–51C for escort duty over the battle-tested P–47 and Lockheed's slightly older P–38. This step was meant to stop the soaring bomber losses due to escorts being too short-ranged even with extra fuel tanks. (The use of extra fuel tanks for longer range dated back to WW I, when it first proved a definite fire hazard. It was also long resisted on the grounds that interceptor-type fighters weighted with fuel would be more vulnerable to enemy aircraft.)

the new plane was to penetrate deep into enemy territory.[5] Its immediate role would be to escort the B–29 bombers used in the Pacific against Japan.

Initial Procurement **February 1944**

On 7 January North American presented a bold design based on the successful P–51.[6] This design promised range, reliability, and less pilot fatigue (the two pilots could spell one another). The AAF endorsed it at once. In fact, a February letter contract to construct and test three experimental P–82s gave way in the same month to an order for 500 productions.

First Flight (XP-82) **6 July 1945**

The AAF accepted this XP–82 in August and a second one in September. Both were equipped with Packard Merlin V–1650–23 and –25 engines.[7] The third experimental plane, designated XP–82A, had two Allison V–1710–119 engines. It was accepted in October.

F-82B

Program Changes **1945-1950**

Germany's surrender on 7 May 1945 and Japan's on 1 September caused the cancellation or the drastic cutback of many military contracts. Conversely, the AAF had to confront new requirements and problems.[8] In the process, the P–82 program fared pretty well. Against the 500 P–82Bs initially planned, overall procurement was finalized on 7 December 1945 at 270 P–82s. Included were 20 P–82Zs (P–82Bs, actually), already on firm order and later allocated to testing. The rest would be long-range P–82E escorts (P–82Bs, equipped with new Allison engines). The definitive contract (W33–038 ac–13950), signed on 10 October 1946, spelled out delivery dates for the 250 P–82Es. But this schedule was never met. Moreover, by

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[5] A requirement learned the hard way. Two 1943 missions (17 August and 14 October) over Schweinfurt, Germany, had resulted in the loss of 120 B–17s (more than 25 percent of those engaged) and death or capture of 1,200 airmen. In the P–51's case, this had prompted the AAF to rush modification of the plane's fuselage to insert an extra tank that would extend range to more than 800 miles.

[6] North American's idea of joining two standard, well-proven, P–51 fuselages (complete with engine) was not unique. It was reminiscent of the Heinkel–111Z transport and glider tug, a "Siamese Twin" arrangement of two Heinkel–111 bombers, built by the Germans earlier in the war. In any case, North American's plane proved to be the sole American example.

[7] British Rolls Royce-type engines built in the United States.

[8] The need existed to perfect an American liquid-cooled engine and to make use of government-owned war surplus engine parts. Then too, so-called "Z" airplanes had to be procured in lots of 20 to keep some major aircraft companies going until new production requirements were firmed up.

January 1950, some 90 change orders and supplemental agreements had pared the 250 F–82Es[9] to 100; the remaining 150 becoming night fighters to cope with rising air defense demands.

First Acceptance (Production Aircraft) **January 1946**

With delivery of 2 P–82Bs—formerly known as P–82Zs. All P–82B productions were used for testing, as initially planned.

Total P-82Bs Accepted

The Air Force accepted 19—against 20 ordered.

End of Production **March 1946**

With the AAF acceptance of 13 last P–82Bs.

Acceptance Rates

The AAF accepted all P–82Bs in fiscal year 1947—2 in January 1946, 4 in February, and 13 in March.

Flyaway Cost Per Production Aircraft

$140,513

Other Configurations

P–82C. A P–82B, modified in late 1946, for testing as a night interceptor. The P–82C featured a new nacelle (under the center wing section) housing an SCR–720 radar.

P–82D. This modified P–82B was a P–82C with a different radar—the APS–4. The two modified planes (P–82C and P–82D) had radar operators in lieu of copilots.

Subsequent Model Series

P–82E

Phaseout **1949**

By December, no P–82Bs (by then redesignated F–82Bs) remained in the Air Force inventory.

F-82E

Previous Model Series

F–82D, technically. But in effect, the F–82E followed the F–82B, which it so closely resembled.

New Features

Two Allison liquid-cooled engines, V–1710–143 and V–1710–145.[10] Otherwise, the twin-fuselage (joined by a center-wing panel and

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[9] The newly-formed United States Air Force had renamed all pursuit aircraft as fighters on 11 June 1948.

[10] Each of these 12-cylinder engines developed 1,600 horsepower at takeoff; each of the F–82B's Packard-built V–1650 engines, only 1,380.

tailplane) low-wing, long-range, F–82E escort was similar to the F–82B.[11]

Contractual Arrangements **1946**

The $35 million procurement contract of October 1946 covered 250 F–82Es plus tools and spare parts. $17 million was for the first 100 planes, $14.5 million for the remaining 150, and $3.5 million for special tools and ground-handling equipment. Delivery of the first F–82Es was scheduled for November 1946, and the contract would be reviewed after completion of 100 airplanes. However, these plans fell through. Overall procurement of F–82s remained intact, but total costs rose to more than $50 million, and the number of E models was quickly reduced by more than one-half.

Program Slippage

Malfunctions of government-furnished, Allison-built engines plagued the shrunken F–82E program from the start.[12] While waiting for acceptable engines, North American had to bear the expense of storing unequipped F–82 airframes.[13] The situation grew so bad that the contractor requested and was granted in December 1947 greater partial payments, even though only four planes had been delivered.

First Flight (Production Aircraft) **April 1947**

Although the engine had passed its 150-hour teststand test in

[11] The wing had a NACA low-drag, laminar flow air foil section and could haul external fuel tanks, bombs, or rockets. Both the F–82B and E could be provided with jettisonable canopies, hydraulic boost controls for all movable surfaces, thermal anti-icing, anti-G suits, adequate cabin heating and ventilation, low-pressure oxygen system, and armorplating to protect the two pilots.

[12] The government had always wanted to give its Twin Mustang F–82 a purely American and stronger engine than the foreign-born P–51's V–1650 (built at Packard plants, dismantled after the war). It therefore negotiated in August 1945 with the Allison Division of the General Motors Corporation for a new version of the V–1710. Various models of this engine had equipped the P–38, P–39, and P–40 of WW II fame, and Allison promptly agreed to buy surplus government V–1710 parts for the new project. Even so, the F–82 program's new V–1710 engines proved costly in the long run—reaching $18.5 million after many amendments. The airplane-engine combination was never satisfactory. Yet, no damages could be assessed against Allison, because the engines has passed the 150-hour qualification tests and met procurement specifications. Nonetheless, the contract was cut back in early 1948, and the Air Force made Allison store special engine tools for 2 years at no cost to the government.

[13] The planes were kept at the Consolidated Vultee Aircraft Corporation, Downey, Calif. Assembly lines were set up at Downey to install the engines and deliver the F–82s, rather than taking them back to the North American plant in Inglewood, Calif. Storage costs, paid by North American, included rent, plant protection, maintenance and insurance. Many F–82s stayed at Downey for nearly 2 years, exposing their electrical and radar equipment to damage from moisture. Special precautions had to be taken to prevent corrosion. The Air Force figured this alone raised costs by more than $2 million.

October 1946, troubles appeared on the first flight. Hence, this F–82E and three later ones underwent special engine tests at once. By year's end, the Air Force had accepted and restricted to testing these four F–82Es, redesignating them F–82As.[14]

Engine Problems **1947-1948**

Spark plug fouling, auxiliary stage super-charger failure, oil loss by spewing, backfiring at high and low power, plus engine oil leakage, roughness, and surging were but a few of the V–1710–143 and V–1710–145 deficiencies. Spark plug fouling was an early and most difficult problem. Oil accumulation required a new set of plugs for nearly every flight. By December 1947, North American was about ready to give up flight-testing the F–82. But the combined efforts of Allison, North American, and the Air Force were beginning to pay off. Nonetheless, extensive engine flight-tests continued through June 1948—months after the first F–82Es entered service.[15]

Enters Operational Service **May 1948**[16]

Three months after the Strategic Air Command had received the first B–50 bomber[17] the aircraft entered operational service. By 31 December, SAC counted 81 F–82E long-range escorts among its tactical aircraft.

Total F-82Es Accepted

96 (excluding the 4 that were booked as F–82As).

End of Production **December 1948**

With delivery of the last F–82E.

Acceptance Rates

The Air Force accepted 72 F–82Es in fiscal year 1948 (between January and June 1948), and 24 in fiscal year 1949 (22 in July 1948, 1 in October, and 1 in December).

Flyaway Cost Per Production Aircraft

The cost amounted to $215,154. Except for the F–82B, every F–82 carried the same price tag.

Other Configurations

None

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[14] One was accepted in September 1947, one in November, and two in December.

[15] The first 200 engines could only be operated at lower than the specified power rating. They were accepted to avoid further F–82 slippage, after Allison promised to later align them to specification.

[16] The F–82 program (as twice revised after the war) slipped about 1 year, but the North American storage problem lasted almost 2.

[17] The Boeing B–50 was basically an improved B–29 Superfortress—the Twin Mustang had been programmed to escort the B–29, back in 1944.

Subsequent Model Series

F-82F

Phaseout **1950-1951**

F-82Es (last piston-engined fighters to enter Air Force service) quickly disappeared from the SAC inventory. The first sizeable lot was declared surplus in March 1950.

F-82F, F-82G, F-82H

Previous Model Series

F-82E

New Features

A nacelle beneath the center-wing that housed radar equipment (F-82F's AN/APG-28 and F-82G's SCR-720C[18]); automatic pilot; and a radar operator replacing the second pilot. When winterization was added to the F or G, it became an F-82H.[19]

Go-Ahead Decision **1946-1947**

The LC of February 1946 covered 250 P-82Es, but the October contract gave the AAF the option to adjust requirements after completion of 100 planes. Moreover, the P-82 in November 1945 was already linked to an all-weather role, "assuming that yet-to-be held tests would show it to be adequate for that purpose." Testing soon showed that the P-82 was hard to maneuver, decelerated slowly, and had poor pilot visibility. Still, the night fighter survived in early 1947, because there was little choice. If the year-old Air Defense Command (ADC) did not get the P-82, it would have nothing better than the P-61 while awaiting the P-87 and the P-89.

Program Slippage

Slippage of F-82F and G deliveries was slight, since interceptor production was not due to start until the 100 F-82Es were completed. When the engine impasse was broken in early 1948, F-82s of all types started flowing in.[20]

Enters Operational Service **September 1948**

By the end of the month, ADC had 29 F-82Fs. Five squadrons of the 52d and 325th All-Weather Wings flew F-82s in late 1949, but

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[18] The SCR-720 radar was not new, having been used by the Northrop P-61 Black Widow in WW II.

[19] In late 1946, modification of two P-82Bs to C and D night interceptors had confirmed that all P-82s were much the same. All it took to convert the long-range escort into a single-place interceptor was to remove the controls and canopy from the right-hand cockpit. Adding interceptor components virtually completed the transformation.

[20] All 250 F-82s were shop-completed by 30 April 1948, exactly 1 year after F-82s (minus engines) started piling up in storage.

the combat capability of ADC (under the newly formed Continental Air Command (CONAC) since December 1948) was not much improved.[21]

End of Production **April 1948**

Total F–82s Accepted

150[22]—91 F–82Fs, 45 F–82Gs, and 14 F–82Hs.

Acceptance Rates

One F–82G was accepted in fiscal year 1948 (February 1948), all other F–82s (F, G, and H models) in fiscal year 1949. The last F–82G and 6 winterized F–82Hs were received in March 1949.

Flyaway Cost Per Production Aircraft

Same as the F–82E—$215,154.

Other Configurations

None

Subsequent Model Series

None

Oversea Deployments **December 1948**

The Caribbean Air Command was the first to receive F–82s—15 by year's end. Fifth Air Force was next, with one squadron (the 68th) soon flying F–82s out of Itazuke Air Base in Japan. Another squadron (the 4th) was in place at Kadena Air Base, Okinawa, before the Korean war. It was part of the Twentieth Air Force, which once had directed the worldwide operations of all B–29 Superfortresses.

War Commitments **1950–1952**

Few of the 40 F–82s available to the Far East Air Forces in mid-1950 were combat-ready. In July, Fifth Air Force[23] spared three F–82s of the 68th Fighter All-Weather Squadron for operations over Korea, but the planes proved of little value except against known and fixed targets. In addition, FEAF's F–82 operations (like ADC's)[24] were hampered by parts shortages and maintenance troubles. If Fifth Air Force continued to use F–82s over Korea,

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[21] In mid-December 1949, the Air Force began classifying its airplanes into first and second-line categories. The stipulated first-line life was 3 years from the time of delivery. Hence, the F–82E (available since the spring of 1948) would reach second-line status in 1951. This criterion was not applied to other F–82s. Based on Air Proving Ground's suitability tests, all F–82 interceptors were immediately relegated to second-line category.

[22] This was in addition to the 100 F–82 escorts.

[23] The Fifth was the largest air force under FEAF.

[24] ADC resumed major air command status in January 1951.

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only 60 days of extra supply support could be expected.[25] Hence, although a few of SAC-surplus F–82Es went to FEAF, all F–82s were withdrawn from combat in February 1952. Despite limited use, the F–82s managed to leave a pretty good war record. They destroyed 20 enemy planes (4 in air fights, 16 on the ground). They scored the first aerial victory in Korea on 27 June 1950, downing a Soviet-built Yakovlev–11.

Phaseout **1950–1953**

In mid-1950 Air Defense units began trading F–82s for F–94s,[26] and in early 1951 the few Twin-Mustangs remaining in ADC were towing targets. The F–82s coming out of Korean combat in February 1952 lingered a bit longer in the inventory. After June 1953, no F–82s appeared on Air Force, Air National Guard, or Air Reserve Forces rolls.

PROGRAM RECAP

The Air Force accepted a grand total of 272 F–82s (including 22 prototype, test, and early productions received by the AAF). Specifically, the F–82 program consisted of 2 XF–82s, 1 XF–82A, 19 F–82Bs (known for a while as P–82Zs and all allocated to testing), 4 F–82As, 96 F–82Es, 91 F–82Fs, 45 F–82Gs, and 14 F–82Hs.

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[25] When F–82 production ceased in 1948, no provision had been made for an adequate supply of spare parts. Further, the Air Force did not have many F–82s to begin with. It could ill afford to weaken the F–82 units committed to the Pacific Northwest's defense or to draw from the 14 F–82Hs in Alaska.

[26] The F–94 was the first USAF jet interceptor.

TECHNICAL DATA

F–82E, F–82F, and F–82G

Manufacturer	(Airframe)	North American Aviation, Inc., Inglewood, Calif.
	(Engine)	Allison Division of General Motors Corporation, Indianapolis, Ind.
Nomenclature	(F–82E)	Long-Range Escort Fighter
	(F–82F/G)	All-Weather Fighter Interceptor
Popular Name		Twin-Mustang

Characteristics (Basic Mission)	*F–82E*	*F–82F*	*F–82G*
Engine, Number & Designation	1 V–1710–143 (left) & 1 V–1710–145 (right)	same	Same
Length/Span	39.11 ft/51.2 ft	42.2 ft/51.6 ft	42.2 ft/51.6 ft
Max. Takeoff Weight	24,864 lb	26,208 lb	25,891 lb
Weight (empty)	14,914 lb	16,309 lb	15,997 lb
Takeoff Ground Run (sea level)	1,865 ft	2,135 ft	2,060 ft
Average Cruise Speed	261 kn	250 kn	250 kn
Combat Speed (max. power)	400 kn	396 kn	396 kn
Combat Range	2,174 nm	1,920 nm	1,945 nm
Service Ceiling	29,800 ft	27,700 ft	28,300 ft
Combat Ceiling (max. power)	38,400 ft	36,800 ft	37,200 ft
Rate of Climb (max.)	4,020 fpm	3,690 fpm	3,770 fpm
Combat Radius (sea level)	976 nm	870 nm	882 nm
Crew	2	2	2
Ordnance Max.[27]	4,000 lb	4,000 lb	4,000 lb
Guns (Internal)[28]	6	6	6

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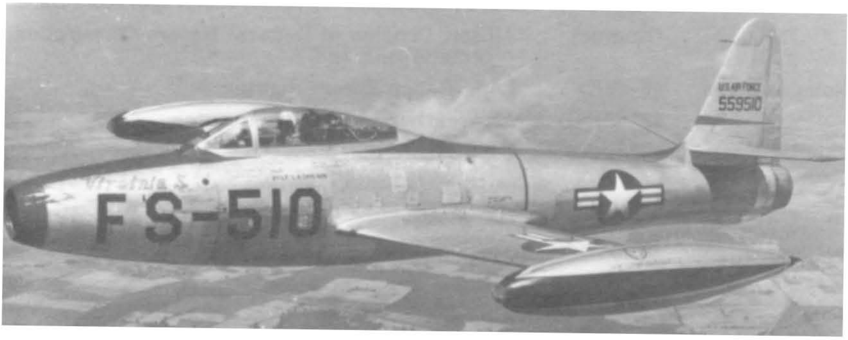
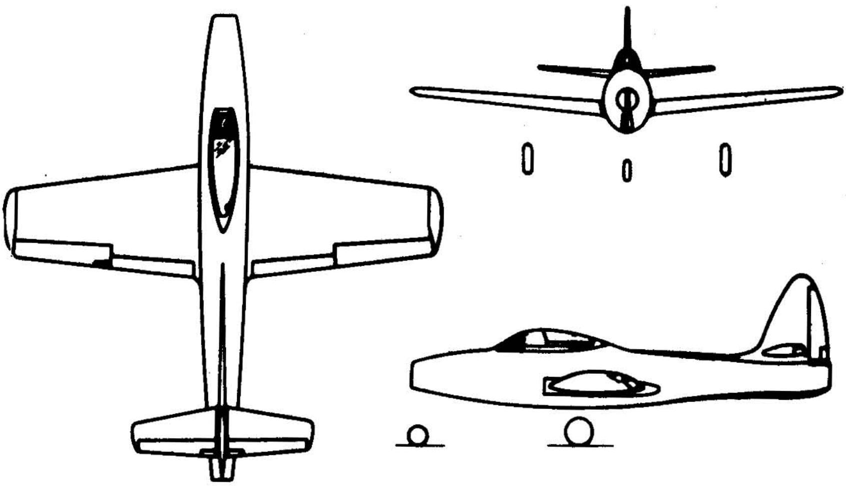
[27] Four 1,000-lb bombs, or two 2,000-lb bombs, or twenty-five 5-inch rockets.
[28] Six 0.5-inch Browning MG 53–2 machineguns in center wing section.





REPUBLIC F–84 THUNDERJET

F–84Bs/Cs/Ds:	Almost alike.
F–84Es:	Slightly longer fuselage; fuel tanks carried on bomb-schackles, located beneath the wings and inboard of the landing gear.
F–84G:	First fighter built with the capability of refueling in flight. The F–84G was also the first single-seat fighter-bomber with atomic capability.
F–84F:	Republic development of its straight wing Thunderjet into a swept-wing, single-seat fighter-bomber. Originally labeled F–96, the "Thunderstreak" was redesignated F–84F in September 1950. Yet, it was largely a new aircraft.
RF–84F Thunderflash:	Elongated and enclosed nose, containing 15 cameras; engine air intake ducts located in the wing roots (rather than in the nose section).
RF–84K:	A recon F–84F, modified for use with the B–36. It featured a reconfigured tail and a retractable hook in the nose section. The RF–84K could be stored half-way within the bomb-bay of the B–36.

REPUBLIC F-84 THUNDERJET

Manufacturer's Model AP-23F (F-84C)

Basic Development **1944**

Republic F–84, like the subsequent F–105 Thunderchief, was a descendant of the first bearer of the "Thunder" name, the company's P–47 Thunderbolt, famed "jug" of World War II.[1] Conceived as a jet successor to the Thunderbolt and first designated the P–84, the F–84 was designed around the General Electric TG–180 (J–35) turbojet and was of straightforward design and construction.

General Operational Requirements **11 September 1944**

This GOR called for development of a mid-wing day fighter having top speed of 600 miles per hour (521 kn), combat radius of action of 850 miles (738 nm), and an armament installation of eight .50-caliber machineguns or six .60-caliber guns. It was soon recognized, however, that military requirements were penalizing the plane too severely. In the final version of the basic airplane, armament was reduced to six .50-caliber guns, or an alternate installation of four .60-caliber machineguns, and radius of action was decreased to 705 miles (612 nm). The object of these deviations was to reduce weight, which, together with low thrust, constituted the aircraft's most serious problem.

Other Requirements **11 September 1944**

The purpose of procuring the new aircraft was also to secure a suitable airframe for the GE TG–180 axial flow gas turbine engine, that the Air Technical Service Command of the Army Air Forces was committed to develop—production of this engine was later taken over by the Allison Division of General Motors.

Contractor Proposal **November 1944**

This was a revised proposal for three fighter airplanes, static test article, mockup, models, and engineering data. It included AAF Engineering Division comments on an informal proposal submitted 2 months before.

Go-Ahead Decision **11 November 1944**

The decision was made and a letter contract was issued without resorting to the commonly used competitive-bid contract method. Two factors accounted for this unusual procedure. The proposed

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[1] The Thunderbolt first took shape in a sketch made by Alexander Karveli, Republic vice-president and renowned designer, on the back of an envelope. That was at an Army fighter-plane requirements meeting in 1940. Kartveli, who was born in Russia and educated in Czarist military schools and leading French engineering institutions, joined Republic's predecessor company, Seversky Aviation Corporation, in 1931 after serving with several other outstanding aviation enterprises in Europe and the United States.

airplane promised higher maximum speed and greater combat radius than were provided by the P–80, and the Republic Aviation Corporation had had experience in single-place fighter design and development.

Initial Letter Contract **4 January 1945**

The AAF order covered 100 service test and production P–84 airplanes—25 of the former and 75 of the latter. This was subsequently decreased to 15 service test articles, which were redesignated YP–84As. The production articles were correspondingly increased from 75 to 85 and redesignated P–84Bs.

Mockup Inspection **5-11 February 1945**

The inspection, conducted at the contractor's plant, revealed a satisfactory mockup. However, certain design changes would have to be made to improve the safety and tactical suitability of the aircraft.

First Definitive Contract **12 March 1945**

This was a formal cost-plus-a-fixed-fee (CPFF) contract (W33–038 ac–11052) for three XP–84 airplanes, static test model, small models, spare parts, and data at estimated cost of $2.5 million, plus a 4 percent fixed fee of some $99,000.00. This contract was first amended on 17 May 1945 to include a blanket bailment agreement providing for governmental loan to Republic of aircraft, aircraft engines, and aircraft equipment or materiel for use in experimental research, testing, or development work. With Republic's concurrence, it was further amended on 25 June 1945 to comprise the January LC, which was nullified. In the process, the amount of expenditure originally authorized by the nullified LC was raised from $17.5 million to almost $24 million.

Development Problems **May-July 1945**

Development tests at the Langley Field Laboratory of the National Advisory Committee for Aeronautics were disappointing. Bulging of the stabilizer skin became evident and undesirable longitudinal stability characteristics showed up in high-speed tunnel tests of the semispan horizontal model. The armament installation, even then, posed a major problem. Weight was increasing at such an alarming rate that in July a revised version of the P–84 was agreed upon. Design gross weight was set at 13,400 pounds. Necessary changes would be incorporated in the third experimental plane, which was designated XP–84A.

Testing Slippages **December 1945**

The lack of satisfactory engines delayed flight testing of the No. 1 and No. 2 XP–84 airplanes at Muroc Flight Test Base. Republic wanted to know when additional engines would be available.

First Flight (XP-84) **28 February 1946**

The first test flight from Muroc was successful and performance of the experimental planes soon proved spectacular. The second XP-84 flew in August 1946 and, a month later, established a US national speed record of 611 mph (530 kn). Both these aircraft had a 3,750 lb. s.t. J35–GE–7 turbojet. The 4,000 lb. s.t. Allison-built J35–A–15 engine was fitted in the XP–84A, in the 15 YP–84A prototypes reserved for special evaluation, and in all the initial P–84B productions.

New Procurement **1946**

In that year, Republic was awarded two letter contracts for 141 and 271 aircraft, respectively. A definitive contract for the lot of 141 airplanes was to have followed the first of the two new LCs by 1 August 1946, but the many problems encountered at that time and during the later part of the year postponed its approval until June 1947. This delay, in turn, partly accounted for the deeper problems that overtook Republic late in 1946, when advance payments on the XP–84 contract had to be made in order to preserve production.[2] The second batch of new aircraft was also ratified by contract in June 1947 (after Republic's financial status had improved sensibly), but was reduced from 271 to 191 airplanes to allow immediate reinstatement of Lockheed's P–80s. With the new fiscal year, another contract for 154 additional P–84s was issued and approved in October 1947.

Other Problems **1946-1947**

Problems of sizeable proportions began to manifest themselves. Republic expressed its concern that production quantities of P–84 aircraft were in "final stages of completion with little knowledge of certain stability and control characteristics." This situation arose partly from the lack of Government-furnished TG–180 engines during the Muroc test program. Also, because attempts to make an official world speed record had prevented comprehensive flight testing of the No. 2 XP–84 airplane. Nevertheless, a major contributing factor was the contractor's slow delivery of the third XP–84 (XP–84A) and static test article in 1946. Important design changes that were being made on the XP–84A would go into later production planes. The AAF had warned Republic that if untried designs were put in production models (as had happened in the B–29 and

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[2] Republic's financial status was investigated and approved in 1945. Nevertheless, in October 1946 the corporation was so hard pressed for funds that it had only enough cash to carry it for 3 weeks. By May 1947, tax refunds in the amount of approximately $6,000,000.00 had alleviated the crisis, but the AAF was awaiting further evidence of Republic's financial improvement before considering additional P–84 procurement.

P–80 programs), the costly modifications that would inevitably follow might "eliminate" the P–84 program.

Prototype Acceptances **1947**

The AAF took delivery of its 15 YP–84As in February. Aside from a more powerful engine, the prototype aircraft also differed from the first two experimental planes by having provisions for wing-tip fuel tanks, and by mounting six .50-inch M2 machineguns—four in the upper front fuselage and two in the wings.

F-84B

First Production Deliveries **1947**

The P–84Bs began reaching the AAF in the summer of 1947. The first P–84B productions were virtually the same as the YP–84A prototypes, but M3 machineguns were used instead of M2s.

Enters Operational Service **December 1947**

With the 14th Fighter Group at Dow Field in Bangor, Maine. The initial operational capability (IOC) of December 1947 was accompanied by stringent flying restrictions, pending correction of new deficiencies discovered 3 months before. Speed was limited to a Mach number of .80 because of a slight reversal of trim. Wrinkling of the fuselage skin restricted the first P–84Bs to a maximum acceleration of 5.5 "G's."[3]

Operational Problems **December 1947**

Operational deficiencies were immediately compounded by critical shortages of parts and by innumerable maintenance difficulties that were to earn for several of the aircraft model series the nickname "Mechanic's Nightmare." The maintenance problems were particularly acute at first, because Republic's early delivery slippages had delayed training of jet maintenance personnel deployed to Muroc for this very purpose.

Production Modifications **December 1947**

Beginning with the 86th production late in 1947, the P–84B's armament was supplemented by eight retractable rocket launchers beneath the wing.

Grounding **24 May 1948**

Because of structural failure and almost concurrent with the end of its production, the entire P–84B fleet was grounded for inspection. The inspected aircraft returned to flying status were limited to specific maximum speeds until necessary fairing modifications could be accomplished by Republic.

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[3] One G is the measure or value of the gravitational pull of the earth or of a force required to accelerate or decelerate at the rate of 32.16 feet per second per second any free moving body.

New Designation **11 June 1948**

The newly formed US Air Force stopped using US Army's aircraft terminology. The AAF pursuit aircraft, formerly identified by the letter P, acquired the F prefix for fighter, their new classification. In the process, the P–84 Thunderjet officially became the F–84. The name "Thunderjet," suggested by Republic, had been approved late in 1946.

Subsequent Model Series

F–84C

Other Configurations

None

End of Production **June 1948**

With delivery of one last aircraft.

Total F-84Bs Accepted

The Air Force accepted 226. This was less than half of the total ordered. The other F–84Bs under contract underwent production changes sufficiently important to warrant new designations.

Acceptance Rates

Three F–84Bs were accepted in FY 47, all the others in FY 48—14 in July 1947, 3 in August, 11 in September, 25 in October, 17 in November, 18 in December, 13 in January 1948, 50 in February, 35 in March, 30 in April, 6 in May, and one in June 1948, when production was ended.

Flyaway Cost Per Production Aircraft

The cost of the first 100 P–84s (15 prototypes and 85 F–84Bs), authorized for procurement in FY 45, was set at $286,407.00 per aircraft. The next 141 aircraft, authorized for procurement in FY 46, also came off the production line as F–84Bs. Their unit cost was lower and decreased to $163,994.00. Neither of the two figures reflected subsequent modification costs.

Postproduction Modifications **1949-1950**

The F–84Bs were covered by the $8 million modification program approved in May 1949—a few months after the entire F–84 program was nearly disolved. This "mandatory" program included reinforcement of the aircraft's wings and over 100 other structural and engineering modifications.

Phaseout **1952**

Although the directed modifications substantially improved the F–84B's operational capability, the aircraft left the Air Force inventory before the end of 1952.

F-84C

Previous Model Series

F-84B

New Features

There was an engine change from the J-35-A-15 to the A-13 engine in the F-84C, and a new electrical system. Otherwise, few features distinguished the new model from its predecessor.

First Acceptance **May 1948**

Eleven aircraft were delivered.

Enters Operational Service **1948**

The 20th Fighter Group, Shaw AFB, Sumter, S.C., was first to receive the F-84B. The second unit to be equipped with the aircraft was the 33rd Fighter Group, relocated in 1949 from Roswell, N. Mex., to Otis AFB, Mass. Both the F-84B and C aircraft became operational equipment for the 31st Fighter Group at Albany, Ga., and the 78th Fighter Group, Hamilton AFB, Calif.

Total F-84Cs Accepted

191

Acceptance Rates

All the aircraft were delivered over a 6-month period. The last 23 joined the Air Force inventory in November 1948.

Operational Problems

Being almost similar, the Cs shared most of the F-84B problems. The F-84Cs also had trouble with their new engine.

Modifications

While in production, the F-84C underwent numerous engineering changes in its prototype engine installation and other equipment.[4] Like the Bs, the F-84Cs later received the extensive structural modifications, approved in the spring of 1949.

Subsequent Model Series

F-84D

Other Configurations

None

Flyaway Cost Per Production Aircraft

Unit cost of $147,699.00 was set for the 191 aircraft authorized for procurement in FY 47—a $16,000.00 decrease from the previous

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[4] The only jet craft in service when the F-84 production began was the Lockheed F-80, powered by a totally different J-33 turbojet engine from the one installed in the F-84C. In addition, the F-84's jet tailpipe with a cooling shroud was a Republic innovation and a radical departure from the F-80.

lot's unit cost. As in the F–84B, these figures did not reflect subsequent modification costs.

Attrition **1950**

The F–84B and C inventories registered heavy losses. Shortly before the start of the Korean conflict, overall fighter accident rates reached new post-WW II high levels. Although materiel failures accounted for many of the accidents, pilot errors were a major factor.

Revised Training **1950**

To curb the accident trend, Headquarters USAF directed that more thorough indoctrination be given pilots in planes new to them, and that better training be given to new pilot trainees in jet aircraft. In addition, in collaboration with factory representatives, presentations were made on the flight characteristics and limitations of the F–84 Thunderjets. The success of these presentations was so great with the several groups to which they were given that they were distributed in printed form to all F–84 units. Similar presentations were given to various summer encampments of the Air National Guard.

Phaseout **1952**

Like the F–84Bs, the Cs disappeared from USAF inventory within a few years. The last F–84C was phased out in 1952.

F-84D

Previous Model Series

F–84C

New Features

As a development of the F–84B, the F–84D introduced a number of new features. These included a thicker skin gauge on wings and ailerons, winterized fuel system suitable for JP4, and mechanical linkages instead of hydraulic in the landing gear to shorten the shock strut during retraction. The F–84D was fitted with the J–35–A–13 engine, first used on the F–84C.

Procurement **October 1947**

This contract was negotiated as a supplement to the $19 million fixed-price contract of 30 June 1947, which covered the 191 F–84Cs. The $16 million October supplement called for delivery of 154 additional aircraft—F–84Ds.

First Acceptance **November 1948**

The Air Force accepted one aircraft in November, and 36 others in December. The first 4 months of 1949 saw the delivery of 117 additional F–84Ds.

Production Modifications

Since the early F–84s were less than satisfactory maintenance-wise, development changes, geared toward some kind of improvement, accompanied each production group of F–84D airplanes.

Program Appraisal **September 1948**

Two months before taking delivery of the first F–84D and 2 months after procurement of the aircraft's subsequent model series had been tentatively approved, the Air Force undertook a complete review of the entire F–84 program. Results of the study that ensued were baffling. The F–84 of the B and C series did not satisfactorily meet "any phase of the missions of the major commands," and only a major retrofit program could make the aircraft operational. Although 571 F–84s of the B, C, and D series had been purchased on four previous procurement programs, amounting to a total of some $80 million, production was a year behind schedule. Theorically, cancellation of the F–84D production would save the government close to $20 million, but in actuality, production of the D had progressed to the point that if cancelled, "more than half the cost of the 154 F–84D aircraft would be spent without anything in return." Too, the resultant adverse effect upon Republic's financial status might jeopardize the F–84E production, should it be finally approved.

Special Testing **2 February-6 March 1949**

To solve its dilemma, the Air Force directed special tests. Specific purposes were to determine if discrepancies in the F–84 prototypes had been corrected on the D type, and which of the F–84 or F–80 aircraft was the more suitable for fighter operation. Results of the tests conducted early in 1949 at both Wright-Patterson AFB, Ohio, and Eglin AFB in Florida, were encouraging. They indicated that many of the deficiencies of previous types of F–84 aircraft had been eliminated in the D model. The Air Proving Ground (APG) tests also concluded that "the F–84 range, acceleration, versatility, load carrying ability, high altitude climb, and level flight speed exceeded that of the F–80. Not all comments were favorable, however. The F–84 was inferior to the F–80 in shortness of takeoff roll, low altitude climb, and maneuverability. Furthermore, it was the opinion of maintenance personnel at both air bases that the maintenance improvements made in the F–84D airplanes were partially offset by the additional time required to change accessories on the front end of the engine.

Program Re-endorsement **1949**

Despite other minor discrepancies uncovered during the APG tests, the Air Force reached a final decision in favor of the F–84 program. Specifically, the F–84Ds would be accepted for standard use, but no further procurement beyond the current contract would be made. Additional funds in the amount of $3.3 million would be secured for design improvements of the programmed F-84E, and $8 million would be spent to modernize the 382 F-84B and C aircraft remaining in the operational inventory. In May 1949, implementation of the $8 million modernization program received Presidential approval.

Enters Operational Service **1949**

The F-84D was the first version of the Thunderjet to arrive in Korea (December 1950).

Total F-84Ds Accepted

154

Acceptance Rates

One F-84D was accepted in November 1948, 36 in December of the same year. Thirty were delivered during each of the first 3 months of 1949, and the last 27 aircraft were delivered to the Air Force in April.

Subsequent Model Series

F-84E

Other Configurations

None

Flyaway Cost Per Production Aircraft

$212,241.00—airframe, $139,863; engine (installed), $41,654; electronics, $7,165; armament, $23,559.

Postproduction Modifications

Republic, at a cost of about $2.9 million, modified the leading edge of all F-84D wings and made other engineering changes. Attempts also were made to correct some of the additional discrepancies uncovered during the APG tests. Efforts centered on improvement of the A-1B gunsight, and reduction of the tailpipe's excessive temperature caused by the aircraft's high thrust J-35-A-13 engine.

Oversea Deployments **1951-1952**

The F-84B and C aircraft were not assigned to oversea units because early versions of the J-35 engine allowed only 40 hours of operation between overhauls. Although also not earmarked for oversea use, modified F-84Ds were deployed to the Korean war theater where they began serving with the 27th Fighter Escort Wing. In the spring of 1952, as the Fifth Air Force's fighter-bomber strength had been seriously depleted by logistical causes and excessive losses during the railway interdiction campaign, additional F-84Ds were sent overseas. Headquarters USAF decided that the Fifth Air Force would for 5 months receive a total of 102 F-84Ds as attrition replacements. Most of these aircraft were assigned to the 136th Wing, a former Air National Guard organization whose period of authorized service was running out.

Phaseout **1952-1957**

Receipt of new F-84 models during August and September 1952 accelerated phaseout of the F-84Ds, which had created many combat logistical and operational problems. In mid-1957 the Guard[5] likewise phased out the last of its Ds.

F-84E

Previous Model Series

F-84D

New Features

Allison J-35A-17 engine, rated at 5,000 lb. s.t. Strengthened wing structure to increase permissible G loads, and a longer fuselage to give more room in the cockpit. The F-84E had a radar gunsight and improved wing-tip tanks for combat use. Also, a modified fuel system allowing use of two 230-US gallon tanks to increase combat radius from 850 to over 1,000 miles (739 to 869.5 nm).[6] These tanks were carried on bomb-shackles, located beneath the wings and inboard of the landing gear.

Basic Development **1948**

Republic proposed a new version of the existing F-84 type—then referred to as P-84—early in 1948, a few months before the entire F-84B fleet was grounded. Notwithstanding the fact that the new version did not "compare favorably with the [North American] P-86 airplane," procurement was tentatively approved in July 1948. Several factors contributed to the Air Force decision. It would cost little more to buy the new F-84 version than to improve existing models. Republic was overcoming earlier production difficulties and future delivery schedules appeared realistic. Finally, it seemed advisable to maintain two sources of fighter production—North American and Republic.

Procurement **29 December 1948**

The Air Force approved the first contract for the "E" model and then re-endorsed the entire F-84 program. This first "E" contract provided for the production of 409 aircraft at a cost of $44 million.

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[5] While on active duty, the 116th Fighter Group had flown F-84Ds as early as 1950.

[6] Up to the early 1950's, aircraft speed and range were generally defined in statute miles. Later, the Air Force calculated speed in knots and range in nautical miles, even though speed records remained in miles per hour and kilometers showed distances. A knot (nautical mile per hour) is 1.1516 times faster than a statute mile per hour; a nautical mile equals about 6,080 feet, i.e., 800 feet longer than the statute mile.

In mid-1949, following completion of the APG tests connected with the entire F–84 program's reappraisal, $3.3 million were added to the $44 million procurement contract to ensure further preproduction improvements of the new model. The Air Force subsequently issued three other F–84E production contracts, including one for 100 articles earmarked for the Mutual Defense Assistance Program (MDAP).[7]

First Flight (Production Aircraft) **18 May 1949**

First Acceptance **26 May 1949**

Two aircraft were delivered.

Testing **August 1949**

Accelerated service tests at Wright-Patterson AFB demonstrated that the F–84E met serviceability standards and was "comparatively easy to maintain." General flight handling characteristics also were satisfactory, but the complex A–1B sighting system was still unreliable. Despite renewed efforts, modified sights (A–1Cs) did not become available until the beginning of 1950. Pending their availability the F–84E deliveries were suspended.

Enters Operational Service **1949**

They went to Korea 1 year later (December 1950) with SAC's 27th Fighter-Escort Wing.

Total F–84Es Accepted

843—743 for the Air Force and 100 for MDAP

Acceptance Rates

Two F–84Es were accepted in FY 49, 348 in FY 50, and 393 in FY 51. The MDAP deliveries were made toward the end of production—97 in FY 51 and three during the first month of FY 52.

End of Production **July 1951**

Production ended with delivery of the last three MDAP F–84Es.

Subsequent Model Series

F–84G. The normally intervening F–84F—largely a different aircraft—was preceded by F–84G productions by almost 2 years.

Other Configurations

None. As an answer to USAF need for an interceptor, Republic early in 1949 offered to produce still another F–84 version at a unit cost of $190,000.00. The contractor also offered to substitute future productions of its new proposal for the F–84E fighter-bombers already under contract. The Air Force turned down both offers.

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[7] The Mutual Defense Assistance Program was created by the Mutual Defense Assistance Act of 6 October 1949—6 months after the North Atlantic Treaty was signed. The MDAP became the Military Assistance Program 5 years later. The new program reflected changes in the basic legislation of the MDA Act, effective 26 August 1954. (The MDAP designation lingered a while longer).

Flyaway Cost Per Production Aircraft

$212,241.00—airframe, $139.863; engine (installed), $41,654; electronics, $7,165; armament, $23,559.

Operational Problems **1950-1951**

More than 50 percent of the F-84s in USAF operational inventory were out of commission in April 1950. One year later, despite determined efforts in the intervening months, in-commission rates were still below par and only 549 of the Air Force's 829 F-84B, C, D, and E aircraft were operational. The main problem was the critical shortages of spare parts and supporting equipment, especially in the engine field. In the F-84E's case, the J-35-A-17 engines had been procured on the assumption that units would operate each plane for 25 hours per month and for 100 hours between overhauls. But the worldwide dispersal of F-84Es and the required low number of hours between overhauls made it doubtful in April 1951 that enough engines could be produced in a short period to meet the flying time planned for this plane even if the manufacturer were allocated funds. By May, the engine shortage endangered future oversea deployments of F-84Es. Although US commanders in Korea were asking for the accelerated conversion of all fighter-bomber squadrons to F-84E aircraft, Fifth Air Force received no immediate relief. The US Air Force allocated $26 million to expand GM's Allison Division J-35 productions, but the scheduled augmentation of North Atlantic Treaty Organization (NATO) air forces retained its higher priority and prevented any accelerated buildup of F-84E aircraft in the Far East.

Combat Appraisal **1951-1953**

Only 27 of the first 60 F-84Es deployed to the Far East in December 1950 were operationally ready, but this situation was quickly improved. Nevertheless, the aircraft were much too slow to cope on even terms with the swept-wing MIG-15s. They, therefore, never did perform outstandingly as escort for the B-29 bombers. On the other hand, the F-84E by the end of 1951 had acquired the reputation of being "the best ground-support jet in the theater."

Phaseout **1951**

The inventory of war-committed F-84D and F-84E aircraft shrank through attrition, especially during the winter of 1952-1953. Other significant losses occurred because of materiel failures and pilot errors, continuing problems that led the Tactical Air Command (TAC) to use a number of F-84Es for training until 1956, when these aircraft finally ended their active service. Other F-84Es had begun to reach the ANG in 1951, totaling 115 in 1957. The Guard phased out their last two F-84Es in mid-1959—2 years after the Air Force Reserve (first assigned a few F-84Es in mid-1954) gave up all its fighters.

Special Achievements **22 September 1950**

Two F–84Es (redesignated EF–84Es), fitted with probe equipment and using air refueling, made an experimental nonstop flight across the North Atlantic. Both aircraft left England on 22 September, piloted by Col. David C. Schilling and Lt. Col. William Ritchie, respectively. Schilling touched down in the United States 10 hours and 2 minutes later, after three inflight refuelings.[8] Ritchie had to bail out over Newfoundland. The flights explored the feasibility of rapidly moving large numbers of jet fighters across the Atlantic. They also tested new air-to-air refueling techniques, using the British-developed "probe and drogue" refueling system. TAC later adopted this system as standard on its fighters and converted B–29 and B–50 tankers.[9]

Other Uses **1951**

Korean experience pointed up the urgent need of a powerful air-launched projectile that could penetrate armor and knock out enemy tanks. Four F–84Es were modified to carry 24 Oerlikon[10] 8-cm. aerial rockets. The aircraft sent to the Far East for evaluation incurred minimum performance degradation as a result of their new armament. The high velocity of the Swiss rocket also resulted in much greater accuracy of fire. This armament project, however, never went beyond testing.[11]

Other Countries **1951-1952**

Before 1950, the foreign aid program had been primarily in the planning stage. By contrast, the regular FY 51 congressional appropriation for the MDAP amounted to more than $1.2 billion, with an Air Force allocation for materiel aid of some $181 million. This included 307 new F–84Es to be distributed to France, Belgium, the Netherlands, and Turkey. Soon afterward, a supplemental appropriation gave the Air Force another $800 million to hasten the supply of USAF weapons to NATO nations. The Air Force subsequently reduced to 100 the MDAP quota of F–84Es and made-up the difference with newer F–84G and F aircraft.

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[8] This first nonstop jet flight across the Atlantic was not Colonel Schilling's first brush with fame. The 30-year-old pilot had in World War II shot down 24 German planes and destroyed another 10 on the ground. Schilling died in an auto accident 6 years later, and Smokey Hill AFB, Kansas, was renamed in his memory.

[9] Use of an in-flight refueling system to stretch aircraft range had long been held feasible. In 1923, two US Army Air Service Lieutenants (Ritcher and Smith) flew a bomber (DH–4B–Liberty 400) nonstop between Canadian and Mexican borders, by means of two in-flight refuelings.

[10] Oerlikon Machine Tool Works, Hispano-Suiza Company, Switzerland.

[11] A later USAF test program of a costly Oerlikon surface-to-air missile was cancelled before completion.

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F-84G

Previous Model Series

F-84E

New Features

Incorporating in-flight refueling equipment with wing receptacle in port wing for use with the Boeing-developed and SAC-endorsed "flying boom" system, the F-84G was the first fighter built with the capability of refueling in-flight and at a single point. Allison J-35-A-29 engine, autopilot, A-4 gunsight, new instrument landing system, and a revised armament, with up to 4,000 lb. of external stores—the F-84G was also the first single-seat fighter-bomber with atomic capability.

Production Modifications **1951**

The F-84G was progressively developed from the F-84E. Production variances, therefore, occurred. The new A-4 gunsight first appeared on the 86th article, the new instrument landing system on the 301st. Similarly, an atomic capability was only introduced in the F-84Gs late in 1951, after a number of the new aircraft had already left the production line.

First Delivery **July 1951**

Eighty aircraft were accepted. This was a delivery slippage of several months, caused by difficulties with the new J-35-A-29 engine.

Enters Operational Service **1951**

The 31st Fighter-Escort Wing at Turner AFB, Ga., was the first SAC wing to receive the new aircraft, beginning in August 1951. By the end of the year, the 31st, like the 27th Fighter-Escort Wing at Bergstrom AFB, Tex., possessed about half of their complement of F-84Gs—35 and 36, respectively. However, F-84G aircraft, equipped to refuel with the flying boom system, did not enter the SAC inventory until 1952.

Total F-84Gs Accepted

3,025—789 for the USAF and 2,236 for the MDAP.

Acceptance Rates

The Air Force accepted 447 F-84Gs in FY 52, 342 in FY 53. The Air Force also took delivery of the aircraft earmarked for the MDAP during the same period—710 in FY 52, 1,505 in FY 53, and 21 during the first month of FY 54.

End of Production **July 1953**

It ended with delivery of the last 21 F-84Gs purchased for the MDAP.

Subsequent Model Series

F-84F. Although this F-84 aircraft carried the F suffix, it was preceded in the USAF operational inventory by more than 700 F–84Gs.

Other Configurations

None

Flyaway Cost Per Production Aircraft

$237,247.00—airframe, $150,846; engine (installed), $41,488; electronics, $4,761; ordnance, $2,719; armament, $37,433.

Oversea Deployments **1952–1953**

F–84Gs began reaching the Far East in the summer of 1952. Even though some of the new planes arrived without various items of needed supporting equipment, the F–84Gs were available in sufficient numbers by September 1952 to permit Fifth Air Force to bring its war depleted Thunderjet wings up to unit-equipment strength for the first time in more than a year. In December, Fifth Air Force moved the 49th Wing's 9th Fighter-Bomber Squadron of F–84Gs from Korea to Japan to train its aircrews in the delivery of tactical atomic weapons. In mid-1953, concurrent with development of the low-altitude bombing system (LABS) to allow safe delivery of nuclear bombs from low altitudes, the 49th Air Division, based in the continental United States (CONUS), converted to a nuclear force and with the F–84G-equipped 81st Fighter Bomber Wing deployed to Bentwaters in the United Kingdom (U.K.). The following month, on 20 August 1953, 17 USAF F–84Gs, refueling from KC–97s, flew nonstop 4,485 miles from Albany, Ga., to Lakenheath, also in the U.K. This was the longest nonstop mass movement of fighter-bomber aircraft in history and the greatest distance ever flown nonstop by single-engine jet fighters.

Special Achievements **1952**

The success of the in-flight refueling capabilities developed by SAC was first confirmed in mid-1952 with the staged deployment of the 31st Fighter-Escort Wing from Turner to Misawa Air Base in Japan. Dubbed Operation Fox Peter I, this July oversea deployment counted 58 F–84Gs, configured to refuel with the flying boom system.

1953

In March 1953, a few months before the end of hostilities on 27 July, F–84Gs of the Fifth Air Force completed the longest mission to that date in the Korean war. These fighter-bombers made an 800-mile round trip to strike at the industrial center of Chonjin on the east coast of North Korea, approximately 40 miles south of the Manchurian border.

War Attrition **December 1950–July 1953**

A total of 335 F–84D, E, and G aircraft were lost in Korea, where the F–84s earned such appellations as "workhorse" and "champ of all low-level bombers." More than 50 percent of these losses were due to ground fire.

Other Uses **1953**

The Air Force Air Demonstration Squadron, Thunderbirds, was organized in May 1953 to promote a better understanding and appreciation of air power. One of the most important decisions of the newly-formed Thunderbirds was the selection of their first aircraft. Primarily, the aircraft had to be stable for maneuvers in formation; reliable to meet show schedules; rugged for demonstration aerobatics; and combat proven. The choice was the F-84G Thunderjet. In 1955, the Thunderbirds transitioned into the faster and more maneuverable F-84F Thunderstreak. The team was re-equipped with the supersonic F-100C Super Sabre in mid-1956.

1954

F-84G aircraft were being employed in conjunction with Project ZELMAL (Zero Length Launch and Mat Landing), one of the Air Force's several projects in the area of reducing required takeoff and landing distances. The ZELMAL program was conducted by The Glen L. Martin Company to study rocket boost takeoff and arrested landing on a pneumatic landing mat. The first pneumatic mat landing with a ZELMAL-modified F-84G airplane was attempted on 2 June 1954.

Phaseout **1955-1960**

The F-84G had been retired from SAC by August 1955, but the aircraft continued to serve TAC for a few more years and did not completely disappear from USAF inventory until mid-1960.

F-84F Thunderstreak

Previous Model Series

The F-84G, not the F-84E—from which that aircraft was progressively developed—was produced before the F-84F. Actually, the swept-wing, single-seat F-84F was largely a new aircraft.

New Features

Wings and tail with sweepback of 40° at 25 percent of the chord; use of many press forgings in wing structure instead of built-up components; wings fitted with leading-edge auto slats; Wright J65-W-3 turbojet engine, rated at 7,220 lb. s.t.; irreversible power-boost control system; upward-hinged canopy; perforated air-brakes hinged to the fuselage sides aft of the wing trailing edge; F-84G's in-flight refueling equipment, with inlet nozzle relocated in the upper surface of the port wing; F-84G's standard armament, but capable of carrying heavier loads of offensive stores, including atomic weapons; and two adaptable 450-gal (US) external tanks for long-range escort fighter missions.

General Operational Requirements **December 1948**

The Air Force issued a revision of the GOR published by the AAF in September 1944. The revision called for significant increases of the operational performances required by the original document.

Basic Development **November 1949**

The F–84F aircraft was officially conceived in November 1949 in a letter proposal through which Republic offered to satisfy the USAF-revised GOR by changing its straight wing F–84 to a model incorporating a swept back wing and swept back tail. In a further proposal, the contractor offered to build an increased ordnance capability into the aircraft. Although its drawings were labeled F–96, Republic also stated that the proposed low-cost aircraft would be a modification of the F–84E that was entering USAF inventory and that 55 percent of the F–84E tooling would be utilized for the new production. The Air Force tentatively endorsed Republic proposal in December 1949. During the same month, Republic was allocated one F–84E to build a prototype of its swept-wing aircraft. At the insistence of the Air Force, the paper F–96 was redesignated, officially becoming the F–84F on 8 September 1950. The aircraft's "Thunderstreak" nickname, result of a "new name" contest among Republic employees, was retained.

Prototype Testing **June-November 1950**

Republic delivered the YF–84F prototype at Edwards AFB, Calif., in May 1950. Phase I tests were started in June and completed in approximately 1 month by a Republic test pilot. Air Force pilots conducted Phase II tests, which ended in November, after 64 flights totaling 70 hours of flying time. The tests demonstrated conclusively that the 5,300 pounds of engine thrust generated by the YF–84F's Allison J–35–A–25 engine was not sufficient for the proper performance of the mission assigned the aircraft under the revised GOR of December 1948.

Initial Shortcomings **1950**

Almost as soon as the YF–84F flight tests had begun, both Republic and the Air Force realized the extent of the J–35–A–25 engine deficiencies and both agreed to rework an F–84E fuselage to fit the more powerful Sapphire jet engine, selected in mid-1950 as the best possible replacement. The Sapphire was a hand-tooled production of the British firm Armstrong-Siddeley for which the Curtiss-Wright Corporation at Wood-Ridge, New Jersey, had acquired a manufacturing license. However, production of the Wright YJ–65 (as the Sapphire engine was redesignated) was not expected to begin before September 1951. This forecast was the first indication that, if produced, the F–84F would be off Republic initial production schedule by at least 3 months. In any case, while the Air Force in December 1949 had practically bought the

Republic-proposed F-84F, the engine deficiencies of the first F-84F prototype created a new situation and procurement, which had been expected to be finalized in August 1950, was postponed. In November of the same year, the Air Materiel Command (AMC) recommended that two additional prototypes be built to evaluate the F-84F and Sapphire combination before to entertain further production consideration.

Production Decision **December 1950**

Before the additional prototypes could be obtained and prior to the testing of the Republic prototype with the Sapphire engine, Headquarters USAF ordered full production of the new combination. Because of the urgent need for improved fighter-bombers since the outbreak of the Korean war, the Air Force also directed the opening of second sources of production for both the airframe and engine. The Buick, Oldsmobile, Pontiac Assembly Division of the General Motors Corporation at Kansas City, Kans., was selected as the second producer of the F-84F airframe in January 1951, 1 month after the production decision. The Buick Division of the General Motors Corporation was also selected as the second source for the Sapphire engine.

First Flight (Revised Prototype) **February 1951**

The new F-84F prototype, powered by an "imported" Sapphire engine, was first flown from the Air Force Flight Center at Edwards AFB on 14 February 1951. While the performances were impressive, the airplane proved unsafe and flying was restricted to Edwards AFB.

First Definitive Contract **9 April 1951**

This contract, AF 33(038)-1438, covered production of 274 F-84Fs at a unit target cost of $215,035.27—about one-third of the aircraft's eventual unit price, all modification costs excluded. This first contract was amended in less than a year by nine supplementary agreements, which raised the F-84F procurement to the FY 51 approved total of 719 aircraft and endorsed substantial price increases. Two other definitive contracts, AF 33(600)-6704 and AF 33(600)-22316, were issued in FY 52 and FY 53, respectively, but the number of aircraft they covered was drastically reduced in later years. Believing the F-84F to be a production modification of the F-84E, no development contract preceded any of these contracts. However, notwithstanding nonavailability of the Wright YJ-65 engines until at least September 1951, Republic had optimistically signed on 22 March an Air Force fighter-bomber configuration contract, calling for delivery of the first F-84F productions in December 1951.

Unexpected Setback **1951-1952**

Despite Republic's belief at the outset that 55 percent of the tooling used in the production of the F-84E would be adapted to the manufacture of the F-84F, experience proved that only 15 percent could be reusable. This problem was quickly compounded by a shortage of aluminum alloy and the fact that once available, the aluminum alloy could not be processed. Only three presses in the United States could produce the aluminum wing spar and rib forgings for the F-84F, and these presses were almost fully occupied with satisfying concurrent forging requirements for the B-47, which enjoyed the Brickbat[12] Scheme's priority precedence. Unexpected difficulties also were encountered during the Americanization of the Sapphire engine. Again, contrary to the contractor's expectations, the scarcity of machine tools (diverted to higher priority programs) was a major problem until April 1952, when the Wright engine and the F-84F airframe finally were also assigned to the Brickbat Scheme. Other engine problems remained, however. Foremost in these problems was the engine's weight increase, which degraded its performance. By January 1952, the YJ-65-W-1 engine was considered obsolescent and further modifications had to be made to keep it in operation.

First Flight (Production Aircraft) **November 1952**

First Production Deliveries **November 1952**

On 3 December, the Air Force officially accepted the first two F-84F productions that had been delivered in November 1952. The delivery date was an 11-month slippage from the contractor's schedule. Moreover, the Air Force approved a revised schedule authorizing further slippage at both the Republic and General Motors plants.

Propulsion Problems **1952-1954**

The YJ-65 engine was not interchangeable in successive models. Hence, an airplane built for the YJ-65-W-1 was bound to use the engine. Yet, while Wright replaced the obsolescent YJ-65-W-1 with the improved YJ-64-W-1A and developed their successor, the more powerful J-65 engine. Republic had begun producing F-84F airframes at the rate of three per day and merely put them into storage pending delivery of a satisfactory engine. In mid-1953, while investigating the possibility of equipping the F-84F with a General Electric engine, the Air Force of necessity decided that the first 275 F-84Fs would retain the YJ-65-W-1 engine. But for some 100 other F-84Fs that were fitted with the YJ-65-W-1A, all F-84Fs were eventually equipped with the J-65-W-3 engine.

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[12] A high priority list of critical items designated for specific Air Force procurement programs.

Other Major Difficulties **1952-1954**

Major difficulties were also encountered because of design deficiencies in the F-84F airframe and airframe components. Development of the F-84F's subsystems also proved more difficult than first anticipated. In mid-1953, after more than a year of corrective effort, the tail of the F-84F was still considered unacceptable for any kind of tactical operations; both the aircraft's longitudinal and lateral controls remained inadequate at high speeds; a redesign of the landing gear up-lock was necessary; the basic hydraulic system was still over-sensitive; the extremely sensitive electrical emergency system still caused concern; the aircraft's dive brakes were susceptible to damage from ejected spent cartridges; and none of the aircraft's weight problems had been solved.

Production Modifications **1952-1954**

By mid-1954, correction of most of the F-84F design deficiencies was assured, but unavoidable delays occurred that created further difficulties. Incorporation of a stabilator in production F-84F aircraft, although approved in 1953, had to be postponed because of the long lead time required for the manufacture of the stabilator. In the meantime, in order to continue production, an interim measure was taken. A number of F-84Fs were equipped with the two-piece "poor man's flying tail," which consisted of an interconnected horizontal stabilizer and elevator. Although successfully flight tested by Republic, this expedient did not work. In December 1953 the Air Force directed that the installation be stopped and that the "poor man's flying tail" be removed from the aircraft already so equipped. By the end of 1954, numerous other expensive or time consuming modifications had been made or were scheduled for the near future. More than 785 F-84Fs had been modified through the installation of aileron spoilers at a cost of $4.7 million; 506 by receiving true air speed indicators for a $1.3 million outlay; and 258 F-84F airplanes were to be modified by installing the F-5 auto-pilot at an estimated cost of $3 million.

Enters Operational Service **January 1954**

SAC's 506th Strategic Fighter Wing,[13] at Dow AFB, Maine, received the first F-84Fs. However, these aircraft, 14 of which were in the hands of SAC by mid-January, were of limited use because of their unsatisfactory engines and other deficiencies. They required special inspections and maintenance and were part of some 400 early F-84F productions, conditionally accepted by the Air Force. By May 1954, SAC had received 125 of the 400 F-84Fs having obsolescent YJ-65-W-1 engines, still deficient YJ-65-W-

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[13] SAC's fighter-escort wings were redesignated strategic fighter wings on 20 January 1953.

1As or other shortcomings. Twelve similar aircraft were undergoing additional testing, 20 had been delivered to the Air Training Command (ATC) at Luke AFB, Ariz., and the remainder would be modified and also released to training.

Operational Capability **May 1954**

Initial operational capability with J–65-equipped F–84Fs did not come until 12 May 1954, when a few of them finally reached TAC's 405th Fighter Bomber Wing at Langley AFB, Va. Although first on the priority list, the 405th had less than half its quota of new aircraft—36 against 75—by the end of June. On 18 June, SAC's first J–65-equipped F–84Fs had joined the 27th Strategic Fighter Wing at Bergstrom AFB. This was another 6-month slippage of the latest delivery date which SAC had anticipated.

Program Reappraisal **July-December 1954**

Deficiencies found in the J–65-equipped F–84Fs, accepted since May 1954, compelled the Air Force to ground several of the aircraft and to suspend Republic deliveries. Other stringent measures ensued. In August the contractor was directed to reduce its daily output from five to three aircraft—two F–84Fs and one RF-84F—and in September a hold order was placed on 400 of the last 500 articles scheduled for production. The Air Force concurrently initiated a series of new operational suitability tests. Referred to as Project Run In, these tests upon completion in November 1954 "proved the F–84F a satisfactory figher-bomber, capable of the mission role for which it had been planned" as well as a "considerably better aircraft than the [F–84]G." The results of Project Run In, together with Republic reorganization of its quality control group and increases in plant personnel, induced the Air Force to approve an accelerated delivery schedule that would make up for some of the time lost. This year-end schedule called for all Republic-stored aircraft to be readied for delivery late in March 1955.

New Operational Problems **1955**

Early in 1955 TAC F–84F units experienced difficulties in the aircraft's braking system. Meanwhile, the new J–65-equipped F-84Fs continued to present problems.

Fleet Grounding **1955**

Engine failures in late 1954 led to the grounding of all F–84Fs in early 1955. Because of the latest grounding, the Air Force once again stopped accepting F–84F deliveries. Although a number of engines had to be overhauled, most grounded aircraft returned to flying status after inspection. The production hold-order of September 1954 was rescinded in February 1955, after which F–84F deliveries were resumed. The idea of making F–84Js out of some F/

RF–84Fs—by exchanging the J–65 engine for the General Electric J–73[14]—was reconsidered but rejected for the last time in March. Soon afterward, however, SAC and TAC F–84Fs again experienced a number of engine flame outs when flying in heavy precipitation. Several accidents occurred in severe weather because of engine failures that were attributed to faulty compressor shrouds. Pending correction, flying restrictions were imposed.

Final Slippage **1956**

F–84F production slipped another 6 months in 1956. This time the slippage stemmed from a 4-month labor strike at Republic early in the year.

End of Production **August 1957**

With Republic delivery of the last MAP F–84F. Republic production of USAF F–84Fs ended in February 1957, that of General Motors in February 1955.

Total F–84Fs Accepted

2,348—852 for MAP and 1,496 for the Air Force. Air Force's total represented a reduction of 756 articles from the contingent originally funded. The Air Force also accepted three YF–84Fs from Republic.

Acceptance Rates

Forty-eight F–84Fs were accepted in FY 53 from the Republic plant in Farmingdale, N.Y., 510 in FY 54, 597 in FY 55, 103 in FY 56, and one in FY 57. One F–84F, built in Kansas City by the General Motors Corporation, was accepted in FY 53, 56 in FY 54, and 180 in FY 55. The F–84Fs earmarked for MAP were accepted by the Air Force between FY 55 and FY 58—77 in FY 55, 326 in FY 56, 400 in FY 57, and 49 in FY 58. All MAP F–84Fs were manufactured at the Republic plant.

Flyaway Cost Per Production Aircraft

$769,330.00—airframe, $562,715; engine (installed), $146,027; electronics, $9,623; ordnance, $9,252; armament, $41,713.

Average Cost Per Flying Hour

$390.00

Average Maintenance Cost Per Flying Hour

$185.00

Subsequent Model Series

None—the F–84G, progressively developed from the F–84E, entered USAF inventory ahead of the F–84F.

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[14] The J–73, used by North American F–86H, was in short supply. Furthermore, it also had more than its share of problems.

Other Configurations **1953–1954**

RF–84F. Reconnaissance version of the Thunderstreak and only other F–84F configuration that went into full production.

XF–84H. First aircraft powered solely by a supersonic propeller driven by a gas turbine. The XF–84H, first flown in 1953, was designed for possible tactical use after completing its research role. Two F–84F airframes were modified for this purpose.

YF–84J. An F–84F airframe, modified by Republic to incorporate a General Electric J–73 engine with 2,000 pounds more thrust than the J–65–W–3 Sapphire. This prototype, delivered to Edwards AFB on 24 April 1954, on 7 May reached a speed of Mach 1.09 during a 52-minute flight that encountered no major difficulties. Nevertheless, the Air Force rejected a new engine as the solution to the F–84F's problem because it would cost more than $70 million just to retrofit the 295 aircraft under consideration. Republic's second YF–84J was cancelled on 16 June 1954; the entire conversion program on 31 August. The F–84J project, first conceived in mid-1953, was re-entertained in early 1955, but again did not materialize.

Initial Phaseout **1954–1958**

Soon after the F–84Fs arrived in SAC and TAC, they were turned over to the ANG. SAC transferred its first lot in August 1954. The remainder were cleared from the regular combat inventory by 10 January 1958, when TAC released its last aircraft. TAC received some F–84Fs in July 1958, when it assumed former ATC responsibilities at Luke and at Nellis AFB, Nev., but these aircraft were used only for training.

Reactivation **October 1961**

The Berlin crisis of 1961–1962 brought four ANG wings of F–84Fs to active duty. A number of these units were deployed to Europe, the other trained under TAC for possible contingency deployment. In late 1961 the Air Force decided to retain the ANG F–84Fs after the wings returned to state control. These F–84Fs would equip USAF tactical fighter units to be activated. Then, as the new units received later-model aircraft, the F–84Fs would be returned to the Guard. The Air Force would loan the F–84Fs to the ANG until required by the newly activated units. This would avoid downgrading ANG capability until absolutely necessary.

Reactivation Problems **1962**

Despite all efforts, operationally ready F–84Fs decreased early in the year. Recall of the ANG units made spare parts more critical. Age of the F–84F imposed heavier maintenance requirements. In March, all F–84Fs were grounded for replacement of corroded control rods. Modifications were also necessary to increase the aircraft's conventional ordnance capability. In effect, some 1,800 manhours were expended on each of the 222 F–84Fs that temporarily equipped TAC's new 12th and 15th Tactical Fighter Wings and the new 366th TFW of the United States Air Forces in Europe (USAFE).

Final Phaseout **1963–1964**

USAF. As more modern fighters became available, F–84Fs were returned to the ANG. In June 1964, 13 years of MAP F–84B/C/F training at Luke AFB, ended in favor of the F–104G program. In July 1964 TAC returned the last USAF F–84Fs to the ANG.

1971–1972

ANG. The Guard still had 56 F–84Fs in November 1971 when a serious accident occurred due to structural corrosion. The 183rd Tactical Fighter Group, Springfield, Ill., the only ANG unit still equipped with F–84Fs, was programmed for F–4C aircraft, and over 90 percent of the grounded F–84Fs showed signs of stress corrosion. Hence no repairs were made. In February 1972, however, the Air Force used two ANG F–84Fs in developing repair procedures that would be offered to the many allied nations using the elderly aircraft.

Other Countries

The F–84F aircraft saw long service with some of the United States's most sophisticated allies. Beginning in 1955, the French Air Force flew F–84Fs for over 10 years. In 1972 the aircraft was still flown by air forces in such countries as Denmark, Italy, Belgium, the Netherlands, Greece, and Turkey.

RF-84F Thunderflash

Previous Model Series

F–84F, which shared the same basic characteristics as the RF-84F.

New Features

Engine air intake ducts were located in the wing roots of the RF–84F rather than in the nose section. The elongated and enclosed nose contained 15 cameras: six standard forward-facing, one Tri-Metrogen horizon-to-horizon, and eight in oblique and vertical positions for target closeups. The RF–84F featured many firsts: the Tri-Metrogen camera, a computerized control system based on light, speed, and altitude, it adjusted camera settings to produce pictures with greater delineation and a vertical view finder with a periscopic presentation on the cockpit panel to enhance visual reconnaissance. Talking into a wire recorder, the pilot could describe ground movements that might not appear in still pictures.

Production Decision **1951**

Production of the RF–84F was linked to that of the F–84F. In both cases, the Korean War prompted the decision.[15] Nonetheless, the first RF–84F order was not formalized until 12 June 1951—2 weeks after satisfactory inspection of the mockup and 6 months past official endorsement of the F–84F full-scale production. The initial RF–84F contract only called for two prototypes (later reduced to one), but the Air Force was already convinced the new aircraft would be the best in terms of endurance, speed, and sensors. The RF–84F would also be able to fly night missions by using magnesium flares carried under its wings in flash-ejector cartridges. Hence, the first 130 RF–84Fs were ordered before the new fiscal year (July 1951).

First Flight (YFR-84F) **February 1952**

Before this flight, an F–84F prototype had already tested the RF–84F's new air intake configuration. The test disclosed no serious impairment of overall aircraft performance.

First Production Delivery **August 1953**

Almost 1 year after delivery of the first F–84F. The Air Force accepted a second RF–84F in September.

First Flight (Production Aircraft) **9 September 1953**

The flight lasted 40 minutes.

Production Slippages **1953-1955**

Being almost identical to the F–84F, the RF–84F did not escape some of its predecessor's problems. Republic's shortage of forgings prevented further deliveries of the RF–84Fs until January 1954. In April, after only 24 of the reconnaissance aircraft (counting the 2 released in 1953) had been accepted, engine troubles brought another delay. Eighteen months passed before RF–84F deliveries finally resumed in November 1955.

Enters Operational Service **March 1954**

First with TAC, but in December 1955, SAC began equipping a Strategic Reconnaissance Wing, Fighter, with a mix of RF–84Fs and RF–84Ks. (The latter were specially configured RF–84Fs, developed during the Fighter Conveyor (FICON) B–36 project.)

Production Modifications **1953-1957**

The RF–84F underwent most of the F–84F's production modifications. Likewise, while the first RF–84F lot was equipped with the 7,200-lb static thrust Wright J–65–W–3 engine, later ones received the –W–7 (a 7,800-lb static thrust version of the same Wright engine).

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[15] The Tactical Air Command had to withdraw tactical aircraft from storage and modify active F–80s to meet the war's reconnaissance requirements. The RF–80 actually became the Air Force's recon workhorse in Korea, but this plane could not fly at low altitude long enough to perform suitable visual reconnaissance.

End of Production **December 1957**

With delivery of 28 RF-84Fs—the last of 327 RF-84Fs ordered into production for the Military Assistance Program.

Total RF-84Fs Accepted

There were 715 accepted—327 for MAP and 388 for the Air Force. Included in USAF total were 25 reconfigured RF-84Fs, subsequently identified as RF-84Ks.

Acceptance Rates

The Air Force accepted 24 RF-84Fs for its own use in FY 54, 163 (counting 6 future RF-84Ks) in FY 55, 137 (19 RF-84Ks included) in FY 56, and 64 in FY 57. All MAP RF-84Fs were accepted within 3 years—47 in FY 55, 174 in FY 56, and 106 in FY 57.

Flyaway Cost Per Production Aircraft

$667,608.00—airframe, $482,821; engine (installed), $95,320; electronics, $21,576; ordnance, $4,529; armament, $63,632.

Average Maintenance Cost Per Flying Hour

$185.00

Postproduction Modifications **1957**

Originally fitted for the boom type of aerial refueling, the RF-84F was later modified for the probe and drogue method.

Subsequent Model Series

None

Other Configurations

RF-84K. This was a modified RF-84F, developed for the Fighter-Conveyor B-36 program of 1953. The FICON program would stretch the RF-84F's effective operating radius, which was relatively short (700 nautical miles at high altitude, but only half this distance when flying low). It would also extend the usefulness of the B-36 (growing vulnerable as more modern jet fighters were being produced by the Soviet Union to protect its vital installations). The Air Force decided to go ahead with the program after successful tests of an ordinary F-84F prototype during April-July 1953. In the fall of 1955, Republic delivered 25 RF-84Fs, modified for use with the B-36. Soon known as the RF-84K, the modified plane featured a reconfigured tail and retractable hook in the nose section. Meanwhile, Convair had attached a trapeze-yoke system to the B-36's underside. This let the B-36 hook and store the RF-84K (half-way within the bomb bay), fly close to the target, and release the K to perform reconnaissance. After retrieving and storing the RF-84K, the bomber returned to a friendly base.

Initial Phaseout **1957**

SAC's 71st Strategic Reconnaissance Wing flew the last RF-84F/K mission on 22 May 1957. Within the next 12 months, TAC turned over the remainder of its RF-84Fs to the ANG.

Reactivation **1961**

The Berlin crisis brought the recall of the ANG's 117th Tactical Reconnaissance Wing, equipped with about 60 RF-84Fs. The 117th returned to state control after the crisis.

Final Phaseout **1972**

The drain of TAC units to Southeast Asia in the late 1960's rendered TAC dependent upon ANG units for support of other contingency plans. Hence, by 1967 six of seven RF-84F ANG squadrons had attained either C-1 or C-2 readiness status.[16] USAF plans called for the ANG to keep at least three RF-84F squadrons through fiscal year 1976. However, more advanced aircraft became available, and the ANG disposed of its RF-84Fs more rapidly. On 26 January 1972, the last RF-84Fs were flown to a storage depot. They had belonged to the 155th Tactical Reconnaissance Group, which traded them for RF-4Cs.

Other Countries

RF-84Fs were flown by the Chinese Nationalist Air Force as well as by air forces of eight other countries: Germany, France, Greece, Turkey, Italy, Belgium, Denmark, and Norway. In the late 1950's the Italian Air Force put into practice President Eisenhower's "Open Skies" aerial inspection proposal for enforcing arms limitation agreements. While crisscrossing Italy at 550 mph (477.5 kn), RF-84Fs were able to photograph small vehicles and people as well.

PROGRAM RECAP

Counting 3,515 aircraft accepted by the Air Force for MDAP, the program attained a grand total of 7,524 F-84s of all sorts. The 4,009 tagged for the Air Force embraced 2 XP-84s (accepted by the AAF in 1946), 15 YF-84As, 226 F-84Bs, 191 F-84Cs, 154 F-84Ds, 743 F-84Es, 789 F-84Gs, 3 YF-84Fs, 1,496 F-84Fs, 1 YF-84J, 1 YRF-84F, 25 RF-84s (FICON), and 363 RF-84Fs. MDAP acceptances consisted of 100 F-84Es, 2,236 F-84Gs, 852 F-84Fs, and 327 RF-84Fs.

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[16] The same rating system still applied in mid-1973. The Air Force gave C-1 ratings to units that were fully combat ready and C-2 ratings to those substantially combat ready. Units marginally combat ready received a C-3 rating; the ones not combat ready, a C-4—the lowest rating.

TECHNICAL DATA

F–84B, F–84C/D, F–84E, and F–84G

Manufacturer	(Airframe)	Republic Aviation Corporation, Farmingdale, N. Y.
	(Engine)	Allison Division of General Motors Corporation, Kansas City, Mo.
Nomenclature		Fighter, Fighter-bomber.
Popular Name		Thunderjet

Characteristics	*F–84B*	*F–84C/D*	*F–84E*	*F–84G*
Engine, Number & Designation	1 J–35–A–15	1 J–35–A–13	1 J–35–A–17	1 J–35–A–29
Length/Span	37.5 ft/36.5 ft	37.5 ft/36.5 ft	38 ft/36 ft	38.1 ft/36.5 ft
Weight (empty)	9,538 lb		11,000 lb	11,095 lb
Max. Gross Weight	19,689 lb		18,000 lb	23,525 lb
Max. Speed	509.7 nm		521 nm	540 nm
Cruise Speed	378.6 nm			418.4 nm
Service Ceiling	40,750 ft		45,000 ft	40,500 ft
Range	1,114.7 nm			1,739 nm
Combat Radius			739 nm (869.5 nm w/4 external fuel tanks)	
Armament	4 .50-cal machine guns	6 .50-cal machine guns	6 .50-cal machine guns	6 .50-cal machine guns
Ordnance Max.			up to 4,500 lb	6,000 lb
Crew	1	1	1	1

TECHNICAL DATA

F-84F and RF-84F

Manufacturer	(Airframe)	Republic Aviation Corporation, Farmingdale, N. Y.
	(Engine)	General Motors Corporation, Kansas City, Mo.
Nomenclature	(F-84F)	Fighter, Fighter-bomber.
	(RF-84F)	Reconnaissance.
Popular Name	(F-84-F)	Thunderstreak
	(RF-84F)	Thunderflash

Characteristics	*F-84F*	*RF-84F*
Engine, Number & Designation	1 7,200 lb s.t. J-65-W-3	1 7,200 lb s.t. J-65-W-3 or 1 7,800 lb s.t. J-65-W-7.
Length/Span	43 ft/33 ft	47 ft/33 ft
Max. Takeoff Weight	24,200 lb	25,400 lb
Takeoff Ground Run	4,500 ft	5,000 ft
Cruise Speed	.82 Mach	480 kn
Max. Speed	600 kn (35,000 ft)	536 kn
Service Ceiling	44,300 ft	45,600 ft
Rate of Climb (sea level)	6,300 fpm	
Radius	375 nm	
Ferry Range		1,570 nm
Endurance		3.4 hr
Armament	6 0.5-in Colt-Browning M-3 machine guns	4 0.5-in Colt-Browning M-3 machine guns
Crew	1	1
Ordnance—Max. Tons	.81	NA

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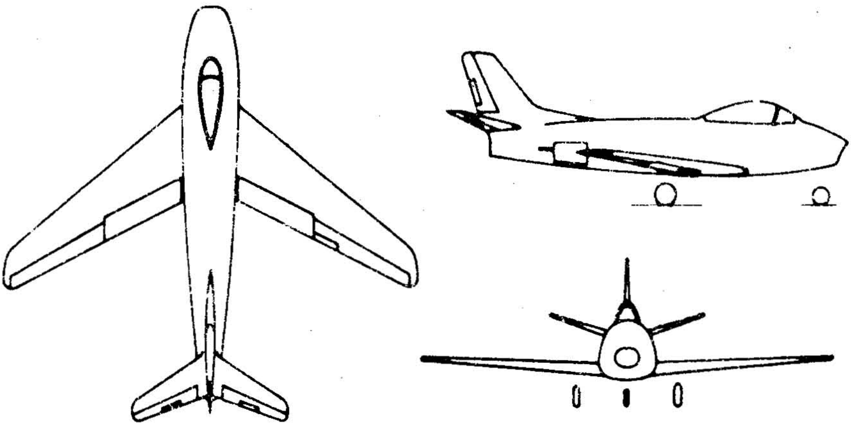

NORTH AMERICAN F–86 SABRE

F–86A: The Air Force's first swept-wing fighter. Rushed to Korea, the F–86As quickly captured the air superiority gained at the onset of the Korean conflict by the inferior F–51s, and a few F–80 jets, skillfully piloted against a not-too-determined enemy.

F–86E: Flying a Canadian-built F–86E at Edwards AFB on 18 May 1953, Jacqueline Cochran became the first woman to fly faster than sound.

F–86F: With its new engine and built-in improvements, the F–86F eventually supplanted the F–86E in Korea. Nonetheless the overall F–86 combat performance was remarkable. The final boxscore showed 14 MIGs downed for every F–86 lost.

F–86D: The F–86D fighter interceptor was virtually a new machine, retaining only the wing common to other F–86s. It was also the first single-seat fighter in which the classic gun armament gave way to missiles.

F–86K: Developed from the F–86D for supply to the NATO forces. The F–86K featured an extended fuselage, cannon ports in the walls of the nose intake, and simplified electronic equipment.

F–86L: A converted F–86D, with slightly longer wings, and data-link components for operation in the semi-automatic ground environment system, deployed in the late fifties.

NORTH AMERICAN F-86 SABRE

Manufacturer's Model NA-151

Basic Development **1944-1945**

The F–86 grew out of North American's several straight-wing configurations of the XFJ–1 Fury (a projected Navy jet fighter) and engineering (including wind-tunnel data) on swept-wings obtained in Germany after V-E Day. The Army Air Forces accepted a variant of the straight-wing XFJ–1 design in May 1945, ordered two prototypes, and applied the designation XP–86. Soon afterward, North American engineers found that adapting the Messerschmitt 262 swept-wing design would give the XP–86 about 70 mph (60.7 knots) greater speed.

General Operational Requirements **May 1945**

The GOR called for a day fighter of medium range that could work as an escort fighter and dive bomber. Speed was one of the primary military characteristics on which the AAF was most insistent. The straight-wing XP–86 under letter contract, with an estimated top speed of 582 mph, fell short of the minimum 600 mph required.

Design Change **1 November 1945**

The AAF endorsed North American proposal to scrap the straight-wing design in favor of the swept-wing, even though this would probably mean a year's delay in delivery.

Definitive Contract **20 June 1946**

The LC of May 1945 was superseded by a definitive research and development (R&D) contract that raised to three the number of prototypes ordered.

Production Go-Ahead **20 December 1946**

Although the prototypes were still under construction, a production order was released. Unit cost of the first 33 P–86s authorized for procurement was set at $438,999.00—more than twice the aircraft's eventual price.

First Flight (Prototype) **1 October 1947**

The aircraft, powered by a Chevrolet-built General Electric J35–C–3 turbo-jet, delivering 3,750 lb. s.t., was later re-equipped with the more powerful J47–GE–3 engine. A re-engined prototype (YP–86A) first exceeded Mach 1 on 25 April 1948.

Flight Testing **1947-1949**

Category II flight tests were started in December 1947; Category III, in January 1949—1 month before the first F–86As entered operational service.

Additional Procurement **28 December 1947**

North American received a second production order for 188 P–86s, but these aircraft, as ordered at the time never materialized. They actually came off the production lines as early F–86As, after also receiving a 5,200 lb. s.t. J–47–GE–3 engine. Subsequent F–86A productions were successively fitted with the J47–GE–7, –9, and –13.

First Flight (Production Aircraft) **20 May 1948**

The Air Force accepted two other initial productions of its first swept-wing fighter on 28 May and changed their P–86A designation to F–86A the following month. In June also an order for another 333 F–86As was awarded.

Enters Operational Service **February 1949**

The 94th Fighter Squadron[1] of the 1st Fighter Group received the first F–86As at March Field, Calif. The Group was completely equipped by the end of May.

Oversea Deployments **1 December 1950**

The 4th FI Group of the 4th Fighter Interceptor Wing (urgently deployed to Japan in November 1950) was the first F–86 unit to reach the Korean war theater.

War Commitments **16 December 1950**

Despite a shortage of aircraft (only 15 of the 19 F–86As initially deployed to Korea were combat ready), the 4th FI Group began combat operations in support of the Far East Air Force on 16 December. The following day, the first recorded combat between swept-wing fighters ended in favor of the F–86A. Four other Russian-built MIG–15s were claimed during the week without any F–86 losses. The retreat of United Nations (UN) ground forces in the last days of 1950 forced redeployment of the F–86As to Japan. Despite the availability of the long-range F–84Es, B–29 raids over North Korea could not be resumed until late in February 1951, when the F–86As returned to Korea.

Combat Achievements **1951**

Following their first successes, the F–86As quickly captured the air superiority gained at the onset of the Korean conflict by the inferior F–51s, F–82 Twin Mustangs, and a few F–80 jets, skillfully piloted against indecisive opposition. Chinese Communist MIG–15s later threatened this supremacy. F–86As of the 4th FI Group, although designed to escort the B–29s and fighter-bombers of the Fifth Air Force operating deep in North Korea, at first were used primarily as an air superiority force. They were pitted against

[1] Redesignated 94th Fighter-Interceptor Squadron (FIS) on 16 April 1950.

large numbers of MIG–15s that could take refuge on the Manchurian side of the Yalu River where they enjoyed the immunity of UN aircraft. Of the Group's 4,885 sorties between 16 December 1950 and 28 June 1951, only 336 resulted in combat. Yet, the Group destroyed 40 MIG–15s, probably destroyed 6, and damaged 71. In contrast, it lost 7 F–86As—one due to operational accident.

Overall Appraisal

The F–86A's initial performances balanced those of its Russian counterpart. In light of later model improvements, the Air Force eventually judged the two aircraft roughly equal. Meanwhile, the F–86A success over the MIG–15 rested chiefly in the ability and aggressiveness of its pilots. Paradoxically, the F–86's lopsided victory score in 6 months of operation also pinpointed a serious deficiency. Inadequate armament (the M–3 .50-caliber machinegun in particular) explained the high number of MIGs "damaged and probably destroyed" against those positively "destroyed" (77 to 44). Despite all efforts, this armament problem persisted in the F–86E that followed the F–86A into production and combat. The F–86A's gross weight was also criticized—16,000 lbs against the MIG's 12,000. Some of this excess derived from such "gadgets" as emergency fuel pumps, self-sealing fuel tanks (that did not hold against the MIG–15's 23- and 37-mm cannons), and an unreliable, electronic gunsight that was hard to maintain.[2] Fuel pump and fuel tank improvements in subsequent F–86 models, and another gunsight introduced in the last F–86A off the production line took care of difficulties in an otherwise sound aircraft.

Modifications **1951**

In the last 24 F–86As produced, the Mk 18 gunsight was supplanted by the A–1CM sight, which was coupled with an AN/APC–30 radar installed in the upper lip of the aircraft's nose intake. Earlier F–86As were retrofitted with the A–1CM sight, which was linked either to an AN/APG–5C radar or, more commonly, to the AN/APG–30.

[2] The Air Force concurrent concern over the increasing complexity and size of fighter aircraft was acknowledged in a December 1951 GOR that called for a compact, lightweight supersonic day fighter. In the following months, as no American aircraft company appeared capable of satisfying these requirements in their entirety, the Air Force investigated the British "Annihilation," a proposed lightweight fighter, capable of being "zero-launched and landed on unprepared surfaces." While awaiting the results of a Navy lightweight fighter design competition, the Air Force also studied two Lockheed proposals for construction of two development aircraft in the lightweight fighter class. Late in 1952 a Republic design, the future F–105 with certain modifications and much lighter than the eventual production configuration, finally set the stage for satisfying the day fighter weapon system requirement, although one of the Lockheed projects, the subsequent F–104, for a while seemed to be a surer contender.

Subsequent Model Series

F–86E. The production of several intervening models in the series either did not materialize or was delayed.

Other Configurations

F–86B. An F–86A with deeper fuselage and larger tires. The 188 aircraft on order were cancelled in favor of an equivalent number of additional F–86As.

F–86C (YF–93A). This variant had a completely redesigned fuselage with flush side air-intakes (replacing one intake in the nose). They were to lead to a Pratt and Whitney J48–P–6 engine which, fitted with an afterburner, would have delivered 8,750 lb thrust. Because of such extensive changes, the F–86C designation was changed to F–93. Although the first of two prototypes (YF–93A, powered by a J48–P–3 engine) flew on 25 January 1950, production of the 118 aircraft on order since 9 June 1948 was cancelled.

F–86D (YF–95A). This major F–86 variant should have followed the F–86A, but it was preceded in production by the F–86E.

RF–86A. Some F–86As, mostly from the early lot of aircraft powered by the J47–GE–3 engine, were fitted with reconnaissance equipment. The modification, referred to as Project Ashtray, followed combat experience in Korea where, in areas dominated by MIG interceptors, the speed-limited RF–80s were virtually useless. The photographic capability of the faster RF–86A, although below RF–80 standard, was still superior to that of the RF–51. Moreover, the small number of cameras installed in the modified F–86A allowed retention of the aircraft armament. As in the RF–51 and in contrast to that of the RF–80, this gave reconnaissance pilots a means of defense. Although considered at the time as a temporary expedient, the few RF–86As available in mid-1952 in effect weathered the Korean conflict without the help of the production-delayed RF–84, which had been chosen as the RF–80's successor.

End of Production **December 1950**

The last two F–86As manufactured were accepted by the Air Force in February 1951.

Total F-86As Accepted

554—the Air Force also accepted three YF–86As, first ordered as experimental aircraft.

Acceptance Rates

Three F–86As were accepted in FY 48, 148 in FY 49, 304 in FY 50, and 99 in FY 51. The three YF–86As were accepted in FY 49—the first two in December 1948, the third in March 1949.

Flyaway Cost Per Production Aircraft

$178,408.00—airframe, $101,528; engine (installed), $52,971; electronics, $7,576; armament, $16,333.

Total RDT&E Costs

$4,707,802.00—this amount (not included in the compilation of the F–86A's unit cost) also covered the cost of carrying the three experimental aircraft (YF–86As) through their Category II flight tests.

Phaseout **1954**

The F–86A, which comprised the bulk of the F–86 day fighters in early combat, was almost completely replaced by the F–86E and F models by the fall of 1952. Withdrawal from Korea did not spell the end of the F–86A service and the aircraft remained in the regular Air Force several more years. The first ANG units to receive F–86As early in 1952 were the 123d FIS (giving up its WW II F–51s) and the 126th (formerly equipped with F–80 jets), but these units had been recalled to active duty early in 1951 and, when released from federal service late in 1952, their aircraft were retained by the Air Defense Command. In effect, the F–86A only began reaching the Guard in 1954. There it remained active until the late fifties, when it was replaced by the F–86D.

Milestones **15 September 1948**

The Air Force established a new world's speed record of 670.981 mph over a measured course at Muroc, with a standard F–86A complete with armament and normal combat equipment.

F-86E

Previous Model Series

F–86A—the normally intervening F–86D was actually preceded in production by the E.

New Features

As a progressive development of the F–86A, the F–86E featured a new tail with both tailplane and elevators controllable and linked for coordinated movement. All controls were power-operated. The F–86E retained the F–86A's M–3 guns and the J47–GE–13 engine of the latest F–86As.

First Flight (Production Aircraft) **23 September 1950**

The Air Force accepted its first two F–86Es in February 1951—just a few months after the aircraft's first flight.

Enters Operational Service **May 1951**

The first aircraft were assigned to ADC's 33d Fighter Interceptor Wing.

Oversea Deployments **July 1951**

The Air Force furnished FEAF whatever F–86s it could spare from air defense. Almost as soon as operational, F–86Es joined the F–86As in the Korean war.

Logistical Problems **1951-1952**

Initial provisioning for the F–86 was based on peacetime consumption rates. Hence, the 51st Wing's unprogrammed conversion to F–86Es severely strained logistical support. By January 1952, 45 percent of the war-committed F–86A and E fighters were out of commission for want of parts or maintenance. Theater supplies of external fuel tanks, without which the range-limited F–86s were badly handicapped, also were nearly exhausted. "Peter Rabbit," a crash project for buying a 1-year supply of all urgently needed items, solved most of these problems, but it took several months.

Other Difficulties **1951-1952**

The F–86As, first deployed to the Far East, were flown by highly qualified, regular and reservist, career pilots. Most of these men were being rotated as 100-mission veterans by mid-1951, when the F–86Es arrived, and supplying qualified replacement pilots for service in Korea became a challenge. During the winter of 1951–1952 the 4th FI Wing (still flying a mixture of F–86As and Es) and the F–86E-equipped 51st received pilots whose previous experience had been attained in multi-engine transports and bombers. This problem persisted until March 1952, when large numbers of jet fighter pilots began to arrive from replacement training centers in the United States.

Combat Achievements **1952**

Largely outnumbered by an enemy favored by the odds of combat,[3] F–86Es of the 51st FI Wing destroyed 25 MIGs during January 1952. Most of the kills were achieved by patrols that entered the combat area at 45,000 feet and made astern attacks on the elusive enemy aircraft, sighted at lower altitudes. Held to reduced flying rates because of logistical deficiencies, the 4th and 51st Wings could only claim the destruction of 17 MIGs during February, but impressive victories were recorded soon afterward. Although some MIG pilots continued to avoid action, enemy tactics changed and MIG formations were met at lower altitudes in March and April. In these months, at the cost of only 6 F–86s, 83 MIGs were destroyed.

Modifications **1952-1953**

The operational suitability tests that ended in July 1952, after the F–86E had already acquired some 12 months of combat experi-

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[3] As already noted, the MIGs were provided with an inviolable sanctuary where they could take refuge when damaged or unwilling to fight. By contrast the combat area was at the outer range of the F–86E's combat radius and over enemy territory at all times. While visual acuity was a problem that affected both sides equally at high altitudes, the MIG pilots had the advantage of GCI direction. In essence, the F–86E, a relatively general purpose aircraft, faced the specialized MIG–15 under conditions which favored the specialized type.

ence, called for improvement of the aircraft's overall performance. This was particularly urgent because of the enemy's increasing capability. Yet, none of the several courses of action available to the Air Force appeared too promising. The F–86E could be retrofitted with the more powerful J–47–GE–27 engine, for this possibility had been taken into consideration before production, but this engine was in short supply. As recommended by North American, the thrust of the F–86E's J–47–GE–13 engine could be boosted. This would alleviate the aircraft's most serious shortcoming by increasing its rate of climb.[4] However, neither General Electric nor the Air Force favored this second solution. The former, because it would severely reduce the engine life; the latter, because it would pose a difficult, "if not impossible," supply and maintenance problem. After combat testing proved its effectiveness, a kind of expedient was adopted that later became a standard feature of subsequent F–86 models. Referred to as the "6–3 wing," the modification, credited with speed increases of several knots, gave the F–86E wing a slightly increased sweepback. This was achieved by extending the wing inboard and outboard edges by 6 and 3 inches, respectively, and by eliminating the slats of the wing's original leading edges. The "6–3 wing" modification kits were inexpensive, $4,000 each, but only 50 had been sent to Korea by the end of 1952, and they were not plentiful until mid-1953.

End of Production **April 1952**

The Air Force took delivery of its last six F–86Es in October.

Total F-86Es Accepted

456—396 for the Air Force[5] and 60 for the Mutual Defense Assistance Program. Because of the Korean War demands on American production, 60 of the Air Force's 396 F–86Es were built by Canadair, a Canadian aircraft company. Like other F–86Es, they were powered by the J47–GE–13 engine. The 60 MDAP F–86Es were also produced by Canadair, but they were fitted with the Avro Canada Orenda engine and the designation F–86J was applicable to this version.

Acceptance Rates

Eighty F–86Es were accepted in FY 51, 218 in FY 52, and 98 in FY 53. Fifty-five of the 60 USAF F–86Es bought from Canadair were received in FY 52, the remaining five in FY 53. The 60 MDAP F–86Es were accepted in 1953, 26 each in June and July, and 8 in August.

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[4] The F–89A Scorpion, with afterburner, could outclimb the unmodified F–86E.

[5] Of the 396, 225 were ordered as F–86Fs but completed as F–86Es, owing to a shortage of the F's powerful J47–GE–27 engine.

Flyaway Cost Per Production Aircraft

$219,457.00—airframe, $145,326; engine (installed), $39,990; electronics, $6,358; ordnance, $4,138; armament, $23,645.

Other Configurations

F–86G. Similar to F–86E but fitted with J47–GE–29 engine which required a longer fuselage by about 6 inches. The prototype on order was cancelled.

F–86J. Canadair-built F–86E, fitted with the Avro Canada Orenda engine and delivered to the Air Force for the MDAP.

Phaseout **April 1954**

Like the F–86As, the F–86Es began leaving the Air Force operational inventory soon after the end of the Korean war. The ANG owned 140 F–86Es by mid-1956 and still flew a few of them in 1960. Also, several foreign countries received badly needed F–86Es through the Military Assistance Program—using them until the end of 1958.

Milestones **17 August 1951**

The Air Force set world record of 635.685 mph for a 100-kilometer closed course at Romulus, Mich.

18 May 1953

Flying a Canadian-built F–86E at Edwards AFB, Jacqueline Cochran became the first woman to fly faster than sound. She broke the international speed record for a 100-kilometer closed course by averaging 652.337 mph, also breaking the women's jet speed record.

Other Countries

The Canadian government decided to manufacture the F–86 under license in 1949 and in August of that year placed an order for 100 of them with Canadian Limited. Initially, it was planned to manufacture the F–86A but only one example, designated Sabre Mk.1, was completed, subsequent productions being built to F–86E standards as Sabre Mk.2s. A number of modifications, introduced by Canadair after the 353rd Mk.2 production, changed the aircraft's designation to Mk.4, of which 438 examples were built. The United Kingdom and West Germany, with the assistance of MDAP funds, acquired many Mk.2 and Mk.4 aircraft that were flown by the Royal Air Force (RAF) until mid-1956, when they were transferred to the Italian Air Force. A further 120 ex-RAF Sabre Mk.4s were also transferred to the Yugoslav Air Force. Former Royal Canadian Air Force Mk.2 and Mk.4 aircraft, after being retrofitted with extended-wing leading edges, were redesignated F–86E (M)s and allocated to the Royal Hellenic and Turkish air forces.

F-86F

Previous Model Series

F-86E, although a few F-86Ds came off the assembly line ahead of the F-86F.

New Features

The F-86F incorporated the J-47-GE-27 turbojet engine, which had a military rating of 5,910-lb thrust (a 700-lb thrust increase over the -13 engine of the F-86E), and 200-gallon, droppable fuel tanks (replacing the 120-gallon tanks of the F-86A and E models). The F-86F also featured the so-called "6-3" solid-wing leading-edge (later modified to reintroduce deleted slats), with small boundary layer fences fitted for the first time.

Production Decision **1951**

The Korean War precipitated a kind of blanket decision. The F-86A and E day fighters (called for by the May 1945 GOR) could double as escort fighters or dive bombers, but the Air Force now wanted mainly a fighter-bomber. Overriding efforts were then underway to enhance the performance of all F-86s—war-committed or earmarked for combat in Korea. Hence, it was mid-1952 before final configuration changes were established, after production of the urgently needed aircraft had already begun. Nonetheless, the F-86F eventually satisfied the USAF fighter-bomber requirements. Equipped with four underwing pylons, it could carry bombs and external stores at the same time. Other configuration changes added 5″ High Velocity Aircraft Rockets (HVARs) and various tactical nuclear stores.

First Flight (Production Aircraft) **19 March 1952**

This F-86F and 77 other first productions barely differed from the F-86E. They were equipped with the J-47-GE-27 engine which, if available, would also have powered the F-86E.

First Acceptance (Production Aircraft) **27 March 1952**

With the delivery of 6 aircraft. Under the impetus of the war, North American opened a second F-86 plant in Columbus, Ohio, where the F-86F was the first model built. Beginning in April 1952, after completion of the 396th and last F-86E, F-86F were also manufactured in Los Angeles.

Oversea Deployments **Mid-1952**

The new F-86F began serving with the 51st Fighter Interceptor Wing in Korea within 3 months of being first accepted by the Air Force.

Production Modifications **1952-1953**

A second production batch of F-86Fs featured for the first time larger fuel tanks that increased combat radius to 402.6 nautical miles—115.6 nautical miles farther than the F–86A and E fighters. The F–86F's external fuel tanks could also be dropped. Extra care helped eliminate tank hangups that too often had kept F–86s from air-to-air combat. In effect, each F–86F variance included additional improvements, the nature of which had been determined through combat experience in Korea. Replacement of the A–1 gunsight by the simpler A–4 was followed by a revised cockpit arrangement, a modified radio system, and better armor protection for the tail-plane control system. Another group of F–86Fs introduced dual-store provision and even more fuel tanks that stretched combat radius another 100 miles (87 nm). The last F–86Fs produced for the Air Force carried a LABS computer, a 1,200-lb tactical nuclear store, more conventional bombs, and two 750-lb Napalm tanks (or eight 5″ HVARs). After combat-testing the 20-mm cannon, the F–86Fs again retained the deficient M–3 machine-guns of early F–86s.[6]

Other Modifications **1952–1955**

More than half of the Air Force F–86Fs were retrofitted with the extended, solid-wing leading edges, first tested on the F–86E. Other F–86Fs were produced under this new configuration. In both cases, the results were gratifying. Operating altitude jumped to 52,000 feet (a 4,000-ft gain); maximum Mach went to 1.05; climb exceeded earlier rates by almost 300 fpm; and tighter turns could be made at high altitudes. These reduced the advantages of the highly maneuverable MIG–15—still, the Air Force sought improvement. After extensive tests, it found it in a reversion to slats, plus a leading edge and wing tip extension. This raised the F–86F's combat capability over the two original configurations—the first slat-equipped, short-wing leading-edge F–86Fs (subsequently retrofitted), and the extended wing leading-edge F–86F productions in which all slats had been eliminated. The combination slat-extension improved the aircraft handling at low speeds, extended combat radius, increased maneuverability at high altitudes, and reduced landing and take-off speeds. The slats also added 200 pounds to the 17,000-lb F–86F, but it was well worth it.[7] In March 1955 the Air Force directed retrofit of all F–86Fs with the new, slated leading edge.

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[6] The 20-mm cannon, tested in Korea during the spring of 1953 as part of Project "Gun Val," showed promise, but was not yet combat-ready.

[7] Reduction of the F–86's weight and the performance improvements to be gained from such a reduction received particular attention in 1952, during the F–86E modification. North American several proposals came to no avail, however, for the Air Force could not chance decreasing the aircraft capability by stripping it from any of its components.

Combat Appraisal **1952–1953**

Despite the higher thrust of the F–86F's new engine, early F–86Fs demonstrated no marked combat superiority over modified F–86Es. Yet, they outperformed their predecessors in acceleration and rate of climb below 30,000 feet. Ensuing F–86F variances with their built-in improvements increased the gap and, by March 1953, F–86Es were being withdrawn from combat in favor of the new model. In the fighter-bomber role, F–86Fs also proved their effectiveness quickly. In mid-1953, after but a few months in combat, the Fifth Air Force described the aircraft as "the most suitable fighter-bomber employed in Korea." The F–86F "displayed a superior ability to survive, was a stable gun and bomb platform, had no airfield or operating problems not peculiar to other jets, and possessed satisfactory stability when carrying external ordnance at high altitudes."

Combat Achievements **27 July 1973**

By the end of the war, the F–86s—and the F–86Fs in particular—had achieved and held air superiority in Korea. The final boxscore showed 14 MIGs downed for every F–86 lost (818 versus 58).

End of Production **October 1955**

Fifteen months after delivery of the Air Force's last 40 F–86Fs. All productions accepted by the Air Force after June 1954 were allocated to MAP, the last such lot of 13 aircraft being delivered in December 1956.

Total F–86Fs Accepted

1,959—700 from Columbus, the remainder from Inglewood, Calif. The Air Force accepted also from Inglewood an additional 280 F–86Fs, earmarked for the MAP.

Acceptance Rates

The Air Force accepted for its own use 111 F–86Fs in FY 52, 971 in FY 53, and 877 in FY 54. The MAP F–86Fs were accepted after a 2-year lapse—142 in FY 56 and 138 in FY 57.

Flyaway Cost Per Production Aircraft

$211,111.00—airframe, $140,082; engine (installed), $44,664; electronics, $5,649; ordnance, $3,047; armament, $17,669.

Average Maintenance Cost Per Flying Hour

$135.00

Subsequent Model Series

F–86H

Other Configurations

RF–86F. As in the F–86A's case, a few F–86Fs were fitted with reconnaissance equipment. The RF–86Fs served in Korea with the 67th Tactical Reconnaissance Wing.

TF-86F. Two-place version of the basic F-86F, requested by TAC as a replacement for the T-33 trainer. The first TF-86F flew for the first time on 14 December 1953 and was destroyed in an accident soon after. A second TF-86F was completed and flown in the summer of 1954, but the Air Force cancelled the program a few months later.

Phaseout **1954-1956**

The F-86F, like the F-86E, left the Air Force inventory after the Korean war. By early 1955, the Air Defense Command had no F-86F interceptors. By the end of the year, the remaining 53 F-86F fighter-bombers of TAC's 323d Fighter Bomber Wing and 83d Fighter Day Wing were being replaced by F-86Hs (the F-86F's subsequent model). The Guard inventory, which counted four F-86Fs in mid-1957, reached a peak of 25 F-86Fs 2 years later, but these ANG aircraft were also quickly supplanted by F-86Hs. Export of surplus F-86Fs to MAP recipient nations began in 1954. Within 4 years, the F-86Fs had become the Free World's most widely-used jet combat aircraft. TAC used some F-86Fs for training of allied foreign pilots through the early sixties.

Other Uses **1954**

F-86Fs of TAC's 612th Fighter Bomber Squadron participated in Night Owl, an Air Proving Ground Command project to determine the feasibility of using fighter bombers at night. The F-86Fs convinced the Night Owl observers of their effectiveness. Moreover, necessary modifications would not affect the aircraft daytime capabilities. Pilot training, if closely monitored, also should present no problem. TAC considered the positive results of Night Owl the greatest single development in night operations since the end of WW II. The F-86F was also used in 1954 to test future computer equipment (the M-1 toss-bomber computer was under development and the "A Box" computer, due in mid-1957). Four F-86Fs were therefore equipped with the basic BT-9 computer—Swedish made, production-limited, and not yet installed in any other aircraft. The tests uncovered technical malfunctions which could also impair the improved M-1 toss-bomber computer.

Other Countries **1954**

One of the first recipients of F-86Fs (either surplus or specifically purchased for the Mutual Defense Assistance Program) was Nationalist China, who also received several RF-86Fs equipped with one K-17 and two K-22 cameras. Most of these aircraft, totaling eventually more than 325 aircraft, were still in operation at the end of 1964. The Spanish Air Force also received a significant number of F-86Fs (some 250). The Republic of Korea gained no fewer than 112 F-86Fs and 10 RF-86Fs; Pakistan received 120 F-86Fs; Norway, 90; Portugal, 50; Thailand and the Philippines, 40 each. Twenty-eight F–86Fs were allocated to Argentina, 22 to Venezuela, and 10 to Peru. A joint production agreement between North American and Japanese Mitsubishi manufacturers provided Japan with numerous F–86Fs—180 completed aircraft were delivered by North American and Mitsubishi assembled a total of 300 F–86Fs from imported components. Before North American deliveries of the F–86F to Japan began, the Japanese Air Self-Defense Force received 28 MAP F–86Fs for training operations, the first of these arriving in December 1955.

F-86H

Manufacturer's Models NA-187 and -203

Previous Model Series

F–86F

New Features

General Electric J73 turbojet (substantially more powerful than the F–86F's J47–GE–27 engine), deeper fuselage, larger intake duct, greater fuel capacity, larger tail-plane without dihedral, electrically-operated flaps, hydraulically-operated speed brakes and controls, heavier landing gear, improved suspension and release mechanism for carrying droppable wing tanks in conjunction with bombs and rockets. Clamshell-type canopy (similar to that of the F–86D), superior armament (four 20–mm. M–39 cannons, beginning with the 116th production) and improved ejection seat.

Go-Ahead Decision **16 March 1951**

The Air Force ordered the F–86H fighter-bomber at about the same time the F–86F entered production. Installation of the new J73 engine in the future F–86H was slated from the outset. Since this would entail a departure from previous F–86 airframes, two prototypes were included in the production contract, officially approved in May 1951.

New Requirements **1952**

Late in 1952 the Air Force reclassified the F–86H as a primary day fighter—coincident with finalization of the fighter-bomber configuration for the F–86F and the emergence of development problems on the urgently needed F–100 day fighter. The F–86H mission change did not affect the production order issued 18 months earlier or the aircraft's planned configuration. No appreciable performance increase was expected from the deletions to be made as a result of this reclassification, since the F–86H would still retain a secondary fighter-bomber capability.

First Flight (Prototype) **9 May 1953**

The Air Force had taken delivery of the first YF–86H in January

1953, and of the second one 2 months later. Early flight tests did not uncover any problems serious enough to warrant a major redesign of the new aircraft. However, completion of the Phase II tests in December of the same year confirmed that "numerous deficiencies" existed in both the airframe and power plant. The latter had yet to complete the usual 150-hour qualification test and this alone was a sure indication that F-86H allocations to the tactical forces would be delayed.

First Flight (Production Aircraft) — 4 September 1953

The F-86H production at the North American Columbus plant began in September 1953 at a very slow rate and, as a result of the YF-86H's aerodynamic and propulsion problems, the Air Force earmarked for testing all 20 aircraft produced through January 1954. Notwithstanding, additional testing time would probably still be needed to test the bombing equipment required by the F-86H day fighter's secondary mission.

Reclassification — 14 May 1954

The F-86H's high-wing loading and power deficiencies at high altitudes demoted its role. The J-73 engine generated almost 50 percent more thrust (with only 18 percent more gross weight) but gained little in top speed due to the airframe's Mach limitations.[8] Hence, the F-86H, ordered in 1951 as a fighter bomber, reclassified in 1952 as a primary day fighter, ended up in 1954 as a tactical support fighter-bomber. This did not mark the F-86H—last of the F-86 series—as a complete failure. It eventually became a better air-to-ground gunnery platform than the F-86F, with faster climb and acceleration rates. Meanwhile, problems of all kinds plagued the aircraft.

[8] The "Loose Shoe" concept (the practice of providing for a certain growth potential in a given aircraft by designing the airframe so as to permit installation of newly developed engines) was not new. The F-86H could not exactly qualify as a case in point, however. It might look like previous F-86s, but its fuselage had been split longitudinally and an additional 6-in. portion spliced in to increase its depth. Nonetheless, despite the extra 3,000-lb thrust of the J-73 engine, early F-86Hs performed little better than the J47-GE-13-equipped F-86A. This matter received particular attention in late 1953, as a result of a Northrop proposal which significantly differed from the older theory of growth potential. In its second design of the "Fang" (a light-weight day fighter in competition with the North American design of the "Rapier"), Northrop suggested an airframe that could accommodate future engines and allow use of present power plants. While the suggestion appeared cost-effective, the Air Force did not endorse either Northrop's "Fang" or its long-term growth concept. Mainly, it doubted anyone could technically anticipate the kind of airframe needed 10 years hence. The Air Force also detected two basic fallacies in the Northrop's new "Loose Shoe" concept. In the first place, the immediate maximum performance of the aircraft would be below par because the airframe would not be the best for the interim engine. Secondly, the long-term performance of the plane would be poor for the airframe would be obsolete when the engines of the rather distant future arrived.

Delivery Slippages **Mid-1954**

A series of engineering problems delayed the F–86H deliveries. In September a production pool of 58 F–86Hs awaited modifications of one kind or another because of defective gun blast panels, repeated gun jamming, misalignment of the wing spar attaching bolts, defective fire detectors, and a number of other deficiencies of lesser importance.

Enters Operational Service **Fall of 1954**

With the delivery of 68 aircraft to TAC's 312th Fighter Bomber Wing at Clovis AFB, N. Mex.

Engine Shortages **1954–1955**

The new J–73 engines were in short supply and this problem was soon compounded by a lack of spare parts. Logistical support of the J–73 became even more difficult following modification of all J–73s to the –3A configuration and the subsequent upgrading of all –3As to the –3D final version. In May 1955 General Electric was 224 production engines behind schedule, the Air Force was unable to satisfy projected engine changes, and logistical support of the engines in use remained critical. In the meantime, to make matters worse, F–86H airframes had to be modified before any of the earlier J–73 engines could be replaced by the new J–73D.

Operational Problems **1955–1956**

The January discovery that firing the guns dented and cracked various parts of the F–86H structure called for tight flying restrictions that remained in effect through most of the first half of 1955. Engine failures, due to faulty second stage compressor discs made of titanium with an abnormally high hydrogen content, were next. This problem accounted for the loss of two aircraft and the grounding of all F–86Hs equipped with J–73 engines incorporating the faulty titanium items. The F–86Hs were also temporarily grounded on several other occasions either because of their disconcerting ability to shed nose landing gear doors in flight, or because of deficient ejection seats. Nonetheless, although still slated for modification, the F–86H in mid-1956 already encountered fewer operational problems than the F–84F.

Modifications **1955–1956**

Except for the last 10 F–86Hs that were modified before leaving the production lines, all F–86Hs were retrofitted with slat-equipped, extended-wing leading edges, similar to those of the F–86F. The F–86H's tail pipe also was modified, but the resulting improvement was considered modest for its cost ($13,000 per aircraft). Hence, although there might be future promise in an improved version of tail augmentation, the Air Force cancelled the requirement for further consideration of augmentation—for the F–86H at least. In any case, the F–86H with wing slats and a

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longer tail pipe proved to have a considerably better performance than the F–86F. The tail pipe augmentation, alone, gave the F-86H as much as 10 percent more thrust at sea level.

End of Production **August 1955**

The Air Force took delivery of its last seven F–86Hs in October 1955.

Total F-86Hs Accepted

473

Acceptance Rates

The Air Force accepted 18 F–86Hs in FY 54, 378 in FY 55, and 77 in FY 56 (from July through October 1955). The two YF–86Hs were accepted in early 1953.

Flyaway Cost Per Production Aircraft

$582,493.00—airframe, $316,360; engine (installed), $214,612; electronics, $6,831; ordnance, $17,117; armament, $27,573. The cost of the two YF–86Hs totaled $3 million.

Average Cost Per Flying Hour

$451.00

Subsequent Model Series

None

Other Configurations

None

Initial Phaseout **1956-1958**

The Air Force quickly disposed of its F–86Hs in favor of the F-100C—TAC's first level flight, supersonic day fighter. In late 1957 the only F–86Hs still possessed by TAC were assigned to a fighter-day unit at Seymour Johnson AFB, N.C., and their transfer to the Air National Guard was completed in June 1958.[9]

Reactivation **October 1961**

The Berlin crisis of 1961–62 brought one ANG wing of F–86Hs to temporary active duty. The F–86Hs, deployed to Europe shortly after the 102d Tactical Fighter Wing was recalled, were armed with conventional weapons. They featured four 20-mm. M–39 guns, six .50 caliber M3s, and four MA–3 launchers. They could carry two M–117 general purpose bombs and two M–116 Napalm bombs.

Final Phaseout **1970**

The Guard operational inventory reached a peak of 168 F–86Hs in 1961 and that aircraft remained an ANG asset for more than a decade. Conversion of the 174th Tactical Fighter Group to the A–

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[9] Some F–86Hs briefly served with the Air Force Reserve in 1957, then went to the Guard.

37B-type aircraft marked the end of the last F–86Hs in the fall of 1970. The ANG had first received early F–86 models in 1954.

F-86D Interceptor

Weapon System 206A

Previous Model Series

F–86A— the F–86B and C were cancelled. In terms of time, a few F–86Ds came out of production between the F–86Es and F–86Fs. In actuality, the F–86D was virtually a new machine, retaining only the wing common to other F–86s. Its concept was unprecedented—an all-weather interceptor in which the second crew member (standard in all aircraft of this category) was supplanted by highly sophisticated electronic systems. The F–86D was also the first single-seat fighter in which the classic gun armament gave way to missiles.

New Features

Air intake repositioned under nose, which enclosed radar scanner; stronger wing (the wing slats of earlier F–86s were retained) and enlarged vertical tail surfaces to compensate for the additional fuselage area. Vortex generators (small tabs) fitted around the fuselage and tail-plane to ruffle the air flow around these areas and prevent air on the airframe surface from separating and causing drag. Hughes Aircraft Company's interception radar and associated fire-control system.[10] These electronic devices could compute an air target's position, guide the fighter on to a beam-attack converting to a collision course, lower a retractable tray of 24 rockets (2.75-inch Mighty Mouse,[11] each with the power of a 75-mm shell) and within 500 yards of the targets fire these automatically in salvos. More than half of the F–86Ds were powered by either the J47–GE–17 turbojet or by the –17B. Later productions received the higher-thrust J47–GE–33. All had afterburners. Engine control was an added feature of every F–86D. An electronic device to control fuel flow, it relieved the lone pilot of another responsibility.

Basic Development **1949**

Slippage of the F–89 program which prompted the decision to procure the F–94 also led to conversion of the F–86 to interceptor configuration.[12] Other proposals were considered, but selection of

[10] This equipment was not confined to the North American F–86D; Lockheed had dispensed with machineguns in their two-seater F–94C.

[11] Test-firing of the Navy's Mighty Mouse, the first successful air-to-air rocket, was announced by the Department of Defense on 6 February 1950.

[12] An intelligence warning of 1948—when the F–102 program began to take shape as the so-called "1954 Interceptor"—underlined the urgent need to bridge the gap between the F–89 and F–102 interceptors.

the F-86 as the basic airframe for elaboration was almost automatic. It was the best of the current jet fighters. Moreover, it would require little structural modification to accommodate the necessary nose radar and afterburner. Doubts of a single-seat interceptor's feasibility caused a slight delay, but production availability and tooling clinched the January selection. The F-95, as the one-man interceptor was then designated, went on the drawing boards in March 1949—at about the same time the F-86A entered operational service. In May North American began to modify two F-86A aircraft in line with the tentative interceptor specifications drawn during the intervening months.

Go-Ahead Decision **19 July 1949**

The Secretary of the Air Force formally endorsed the Board of Senior Officers' recommendations 3 weeks after the Hughes Aircraft Company had been issued a contract for developing the new interceptor's fire-control system. The Secretary's approval was accompanied by the authorization to spend $7 million for conversion of the F-86 to the interceptor configuration.

First Flight (XF-95) **September 1949**

An engineering inspection of the experimental aircraft in August 1949 and the ensuing flight of September favorably impressed the Air Force. In the latter month, $79 million were made available for the purchase of 124 aircraft. The new interceptor, designated as the F-95 during the early stage of development, reverted to the F-86D designation soon afterwards.

Initial Procurement **7 October 1949**

This order covered two prototypes and 122 production articles. Two months later, concurrent with the December decision that Soviet possession of the atomic bomb dictated prompt creation of a modern interceptor force, the F-86D was chosen to be the backbone of that force until the advanced "1954 Interceptor" became available. Another procurement order for 31 F-86Ds was issued in June 1950.

First Flight (Prototype) **22 December 1949**

The YF-86D was powered by a J47-GE-17 turbojet. Its afterburner boosted its 5,000-lb static thrust to 6,650 pounds. The second prototype, fitted with a similar engine, was completed in March 1950.

Development Problems **1950-1951**

North American used the second YF-86D to test a prototype of the Hughes 50-kw E-3 fire-control system (developed in advance of the more sophisticated 250-kw E-4). In October 1950, after numerous engineering changes, the E-3-equipped YF-86D moved to Hughes for further testing. The number and extent of the changes that ensued delayed until July 1951 delivery of the E–3 productions that eventually equipped some 35 F–86Ds. Meanwhile, fabrication of the E–4 prototype proceeded. When completed in November 1950, however, no F–86Ds were available to flight test it and a B–25 had to be used. E–4 production systems reached North American in December 1951, after a 3-month delay. Still, the new E–4s did not properly perform. In addition, deficiencies in components shared by both the E–3 and E–4 fire-control systems continued uncorrected.

First Production Deliveries **March 1951**

The Air Force earmarked for testing the first F–86D deliveries because the F–86D had been committed to production before receipt (or even development) of its fire-control system and of the first electronic engine fuel control.[13] Too, the Air Force could expect a number of problems simply due to the aircraft's overall complexity.[14] Nonetheless, there was still hope in mid-1951 that the F–86D would reach the operational units by the spring of 1952.

Additional Procurement **1951–1953**

In March 1951, 341 F–86Ds were on order. Two months later this total jumped to 979 aircraft. The growth to 2,500 planes by January 1953 underlined the F–86D program's urgency and scope. Yet, by that time, the Air Force had accepted less than 90 F–86Ds.

Program Slippages **1951–1953**

Delay of the F–86D program stemmed from two principal problems. First, the E–4 fire-control system had deficiencies not detected until service tests were run, and the development period was unusually long (in 1952 alone, Hughes had to make 150 changes to the system). Second, the General Electric J47–GE–17 turbojet engine—chiefly its electronic fuel control system—was far from ready. By early 1952, GE had fallen 18 months behind in engine deliveries and the J47–GE–17 did not pass its 150-hour qualification test until the latter part of 1952. Meanwhile, after an initial production slippage, airframes had begun piling up around the North American plant for lack of engines.

Other Initial Deliveries **March 1952**

The Air Force received more F–86Ds in March 1952. Although no

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[13] Several years later, the Air Materiel Command still stressed that it took much more time to design, develop, and produce new equipment such as guns, engines, and fire-control systems than it did to produce new fighter airframes.

[14] A chief source of the F–86D's complexity stemmed from placing the intercept responsibility with a pilot-radar operator. Yet it had offsetting advantages. It saved the weight of the radar operator and his gear (350 pounds); his training costs; and the cost of designing/fabricating his share of the aircraft. It also lowered the entire operation's overhead costs. The pilot had only to stretch his training slightly to understand radar equipment.

longer considered test aircraft, they (and a few more delivered during the summer) did not fully satisfy the Air Force requirements. They lacked the Lear F–5 autopilot and the E–4 fire-control system. The former had failed its qualifying environment tests and the latter was not reliable enough for inclusion in production aircraft until August 1952. The Air Force allocated these early F–86Ds to the Air Training Command.

Enters Operational Service **April 1953**

Nearly 2 years behind schedule and 6 months past the revised date of November 1952. However, several ADC squadrons were quickly equipped and later buildup was rapid. The Air Defense Command had 600 F–86Ds by the end of 1953. In June 1955, 1,026 (or 73 percent) of the command's 1,405 tactical aircraft were F–86Ds—the remainder were F–94Cs and F–89Ds.

Operational Problems **1953-1954**

Engine malfunctions dogged the F–86Ds almost as soon as they became operational. When engine fires and explosions destroyed 13 aircraft, the entire F–86D fleet was grounded in December 1953. Most of the aircraft were back flying by the end of February 1954, after hastily formed teams of North American and General Electric technicians corrected the faulty fuel system. This was merely a stop-gap measure, however. Soon afterward, 19 more accidents occurred in 1 month, this time because of poor maintenance of the complex weapon system (a situation which had been predicted in early service tests of the F–86D' single-man concept). Meanwhile, despite other deficiencies, production rates increased significantly.

Program Appraisal **1953-1954**

The Air Force knew the F–86D needed improvement. Back in January 1953, 40 mandatory engineering fixes had been identified along with required changes to bring the aircraft to peak capability. Nevertheless, the F–86D was still a better interceptor than the other two in service and its immediate availability was crucial. The Air Force deemed the F–86D "almost as important as the B–47" and the rash of operational troubles in 1953 only hastened the aircraft improvement. Project Pullout would embody in all F–86Ds the fixes accumulated piecemeal thus far, as well as the more important modifications previously intended for the future.

Oversea Deployments **1953-1959**

Cold War pressure forced the Air Force to ship 52 F–86Ds to the Far East Air Force in the fall of 1953. These aircraft were known to be deficient. Of those sent to Korea (where only short landing strips were available), few ever flew. The contingent soon returned to the United States and went through the Pullout modifications as part of FEAF's retrofit program. FEAF received in exchange modified or new F–86D productions. In 1959, 6 years after the first F–86D oversea deployment, two squadrons of F–86D interceptors (the 431st and 437th FIS), recently placed under the Strategic Air Command's control, stood on alert at Torrejon and Zaragoza Air Bases in Spain.

Modifications **1954–1955**

The Pullout modifications, started in March 1954, were completed at a cost of some $100 million after a purposeful year-and-a-half schedule. It was important that the 1,128 aircraft involved (plus 53 spare aft fuselages) be modified as rapidly as possible. Still the Air Force could not chance endangering the nation's air defenses by pulling too many F–86Ds out of service at once. Each aircraft underwent close to 300 modifications, some involving major changes. These included: correction of the autopilot and fire-control systems (accomplished by Lear and Hughes, respectively); installation of a radar tape system to record radar-scope data during flight; modification of the stabilizer control system; installation of a 16-foot, ring-slot type drag chute in the aircraft tail (expected to reduce landing roll as much as 40 percent); and replacement of the J47–GE–17 engine by the much improved –17B (predecessor of the J47–GE–33 which powered the last 987 F–86D productions). The Sacramento Air Materiel Area (SMAMA) at McClellan AFB, Calif., was charged with the entire Pullout program. A large part of the work, however, was done under contract by the North American plants at Inglewood and at Fresno, Calif. Upon completion, the Air Force had a modern, all-weather interceptor, but problems still loomed ahead.

Special Tests **1954–1955**

An F–86D squadron operational suitability test (OST), Project Lock-On, was conducted at George AFB, Calif., during February 1954—1 month before the beginning of Pullout. As anticipated Lock-On concluded that an ADC F–86D squadron could not perform its assigned mission until elimination of the aircraft malfunctions by the forthcoming Pullout modifications. The Lock-On findings also confirmed ineffectiveness of the F–86D squadron's air-ground control team and known requirements for additional ground-support equipment, better maintenance personnel, and increased pilot training. Other tests disclosed that the F–86D's 2.75-inch folding-fin aerial rockets were marginal in accuracy and effectiveness. Use of the Falcon missile (given up in 1952) was reconsidered, but again discarded because it would require refitting the aircraft with the E–9 fire-control system. In early 1955 the Air Force also decided not to arm the F–86D with Ding Dong rockets, since the Air Defense Command's two-missile load requirement would drastically reduce the aircraft's radius of action.

Continued Engine Problems **1955-1956**

The new J47–GE–33 fitted in the last 987 F–86Ds was much more powerful than the –17 engine of the earlier productions. The –33's static thrust with afterburner reached 7,650 pounds, a 1,000-lb increase over the –17, under similar conditions. The –33 had better cooling and afterburner ignition. It also featured several detail changes which eliminated the flaws that had led to replacement of the original –17 by the improved –17B. Yet, 65 of 209 accidents in the 15 months preceding mid-1956 were attributed to the aircraft's –17B or –33 engine. Of these 65 accidents, 22 were caused by engine fuel control malfunctions, 17 by defective engine parts, and the remaining 26 (most occurring in early 1955) by turbine wheel failures in the –17B power plants.[15] In mid-1955 the Air Force thought of retrofitting all –17B engines (as well as the –17 which still powered several F–86Ds) with a redesigned "locking-strip" model. This project's $20 million price tag shaped the ultimate decision of installing the redesigned turbine wheels only upon attrition. Insistence on accurate records of turbine wheel use would assure adequate protection.

Other Operational Deficiencies **1956-1957**

In addition to engine problems and despite the remarkable overall achievement of Pullout, the F–86D needed further improvement. Its E–4 fire-control system remained unreliable and difficult to maintain. Various engineering changes could still be made to increase reliability, ease maintenance and, perhaps, raise the F–86D's kill capability. However, the gain would not justify the cost. The Air Force, therefore, reconsidered providing the aircraft with additional armament. Two F–86Ds were prototyped, one with GAR–1B Falcons, the other with infrared homing Sidewinder missiles. Budgetary limitations, nevertheless, ended the two projects in September 1957. The Air Force concurrently altered several plans. It decided to phaseout the F–86D as soon as possible and its converted version, the F–86L, tentatively by mid-1960.[16]

End of Production **September 1953**

With delivery of the last 26 F–86Ds.

Total F-86Ds Accepted

The Air Force accepted 2,504, in addition to two F–86D prototypes.

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[15] This problem immediately concerned only the F–86D. However, B–47s powered with J47–GE–23 and –25 engines had the same type turbine wheel. The cost of replacing these would be $100,000,000.

[16] Two former ADC squadrons of F–86Ds received a temporary lease of service life. They were transferred to SAC and sent overseas.

Acceptance Rates

The Air Force accepted 3 F–86Ds in FY 51, 26 in FY 52, 448 in FY 53, 1,014 in FY 54, 860 in FY 55, and 153 in FY 56 (from July through September 1955). The two YF–86Ds were accepted in FY 52.

Flyaway Cost Per Production Aircraft

$343,839.00—airframe, $191,313; engine (installed), $75,036; electronics, $7,085; ordnance, $419; armament, $69,986.

Subsequent Model Series

F–86K

Other Configurations

F–86G. As an F–86E prototype with a different engine, the F–86G never materialized. The designation was also provisionally applied to an F–86D development with the new J–47–GE–33 engine and a few other changes. However, the 406 aircraft ordered under the latter configuration as well as other –33-equipped productions were completed as F–86Ds.
F–86L. A converted F–86D with slightly longer wings and data-link components for operation in the semi-automatic ground environment (SAGE) system which was deployed in the late fifties.

Phaseout **1958–1961**

The F–86D was phased out of the Air Defense Command in April 1958. By mid-1959 two ANG squadrons (the 122 and 182 FIS) were fully equipped. However, the Guard's F–86Ds were also quickly supplanted by F–86Ls (converted F–86Ds). By June 1961 the F–86D no longer appeared on either the USAF or ANG rolls. Yet, the interceptor's operational life was not over. Of 300 F–86Ds reaching MAP countries, Japan received 106.

Milestones **19 November 1952**

The Air Force set world speed record of 699.92 mph over a 3-kilometer course at Salton Sea, Calif. This record was to stand unbeaten until raised by another F–86D.

16 July 1953

New world speed record of 715.74 mph established with F–86D over the Salton Sea 3-kilometer course.

2 September 1953

The Air Force set world speed record of 690.185 mph over 100-kilometer closed course at Vandalia, Ohio. On the same day, with another F–86D, the Air Force also set speed record of 707.876 mph over the Vandalia 15-kilometer straight course.

F-86K

Previous Model Series

F-86D

New Features

Extended fuselage (8 inches longer than that of the F-86D) and cannon ports in the walls of the nose intake. Reduced electronic equipment and modified armament.

Go-Ahead Decision **18 December 1952**

The Air Force decided that the F-86K, a future development of the F-86D, would be the all-weather interceptor for supply to NATO forces under the MDAP. The Air Force reached its decision in December 1952, when less than 90 F-86Ds had been accepted, because it was already convinced of the aircraft' superiority. Moreover, a great deal of the F-86D's initial problems stemmed from the E-4 fire-control system, which would be excluded from the F-86K.

Basic Development **14 May 1953**

The Air Force provided North American with two F-86Ds. These aircraft were modified as F-86K prototypes.

Initial Procurement **1 June 1953**

The Air Force called for North American production of 120 F-86Ks. An additional lot of 221 aircraft, produced by North American, was assembled in Italy under a special agreement reached with the Fiat Company on 18 May 1953.

First Flight (Prototype) **15 July 1954**

This prototype and the second YF-86K were powered by the J47-GE-17B engine and this engine could be installed in all the F-86K airframes subsequently built. The F-86Ks could also be equipped without significant modifications with either one of the F-86D's successive engines (J47-GE-17, -17B, or -33). However, to simplify logistical support the Air Force decided in mid-1954 that all F-86K productions would receive the same type of engine. The latest and more powerful -33 was chosen.

Testing **1954-1955**

Major operational suitability tests were conducted to devise tactics for the NATO-committed F-86Ks. Qualification tests (10,000-round firing) of the North American-developed MG-4 fire-control system, earmarked to replace the E-4 which equipped the F-86D, were completed and the new aircraft's modified armament was selected. Instead of the F-86D's retractable tray of folding fin rockets, the Air Force decided to arm the F-86K with four 20-mm M-24A-cannons and two AIM-9B Sidewinders. The F-86K retained the AN/APG-37 radar of the F-86D.

First Flight (Production Aircraft) **23 May 1955**

This was the first of the 221 Fiat-assembled F–86Ks. This flight followed by 1 month the Air Force acceptance of the first five F–86Ks completed by the North American's Inglewood plant.

Enters Operational Service **Mid-1955**

First to fly the F–86K was the Italian Air Force's 1st Aerobrigata. Other initial F–86K recipients were the French Armée de l'Air and the Federal German Luftwaffe.

Total F–86Ks Accepted

The Air Force accepted 120 F–86Ks assembled by North American for MAP (MDAP until mid-1954).

Acceptance Rates

21 F–86Ks were accepted in FY 55 and 99 in FY 56—all during 1955, from April through December.

Flyaway Cost Per Production Aircraft

$441,357.00—airframe, $334,633; engine (installed), $71,474; electronics, $10,354; ordnance, $4,761; armament, $20,135.

Subsequent Model Series

None—the F–86L was a converted F–86D.

Other Configurations

None

Phaseout **1964**

The Italian Air Force started to replace its F–86Ks by more modern F–104Gs during 1964. Still, the aircraft's service life was far from concluded. Overhauled F–86Ks, formerly flown by the Royal Netherland Air Force, just began reaching the Turkish Air Force in 1964.

Other Uses **1959**

The Air Force flew an F–86K to test the so-called Thunderstick fire-control system. It also planned to use the aircraft for testing of a blind-dive toss bombing system, still under development in the fall of 1959.

F–86L

Previous Model Series

F–86D, from which the F–86L was converted.

New Features

Electronic equipment (AN/ARR–39 Data Link receiver, AN/ARC–34 command radio, AN/APX–25 identification radar, and new glide slope receiver) that permitted the aircraft to operate in conjunction with the SAGE ground environment and with the GPA–37, electronic heart of an advanced system of ground control interception which immediately preceded SAGE. Also, slat-equipped, extended-wing leading edges (similar to those of the F–86F and F–86H), which brought the aircraft's empty weight to 13,822 pounds (a 1,352-lb increase), but improved maneuverability at high altitudes.

Preconversion Problems **1955**

Conversion of the F–86D to the F–86L was more a matter of modification than development, but delays arose. In January 1955 deficiencies were noted in the control surface tie-in (CSTI) equipment, the signal data recorder (NADAR) slipped, a coupler for the data link (AN/ARR–39) was needed, and modification of the E–4 fire-control system to accept inputs from the coupler remained to be done. Despite such uncertainties, the Air Force hoped to have a completed electronic prototype by December 1955.

Mockup Inspection **16 May 1955**

The Air Force conducted a development engineering inspection of the F–86D cockpit mockup readied for the new electronic configuration. The inspection, held at the North American Fresno plant on 16 May 1955, was a success. The Air Force found the new cockpit satisfactory and only minor changes were forecast. The ensuing lack of installation data, lack of flight test data, and nonavailability of the equipment to be installed, torpedoed North American's optimism that the electronic modification program might well start earlier than planned.

Program Change **1955–1957**

In the fall of 1955 when the modification program was officially announced, the Air Force intended to modify 1,240 ADC F–86D aircraft, but the number actually converted amounted to about half that number.

Modifications **May 1956**

Conversion of the F–86D to the L configuration was accomplished by the Sacramento Air Materiel Area and North American's Inglewood and Fresno plants. Known as Project Follow-On, the modification program did not begin until May 1956. Once started, however, the Follow-On outputs accelerated rapidly.

Enters Operational Service **October 1956**

The first to receive the new aircraft was the 49th Fighter Interceptor Squadron at Hanscom Field, Mass. By the end of 1957, only 18 months after the beginning of Follow-On, ADC had received 576 F–86L aircraft.

Flyaway Cost Per Production Aircraft

The F–86L, being a converted F–86D, carried that aircraft's price tag of $343,839.00. This amount did not reflect the significant cost of the Follow-On modifications.

Average Maintenance Cost Per Flying Hour

$187.00

Phaseout **1960–1965**

With the advent of more modern interceptors of the F–101B and F–106 types, the need for the F–86L declined. Two ANG squadrons (the 111th and 159th) already had flown the F–86L by mid-1959, and by the end of that year the ADC inventory of F–86Ls was down to 133. The last F–86L left the Air Defense Command in June 1960, but the interceptor remained a valuable Guard asset until mid-1965.

Other Countries

A small number of F–86Ls went to the Royal Thai Air Force.

PROGRAM RECAP

The Air Force accepted 6,353 F–86s (all models included), 5,893 of them for its own use and 460 ordered into production for MDAP. A breakdown of the USAF F–86 total showed 3 experimental and prototype F–86As, 554 F–86As, 393 F–86Es, 1,959 F–86Fs, 2 YF–86Hs, 473 F–86Hs, 2 YF–86Ds, and 2,504 F–86Ds (all F–86Ls being converted F–86Ds). The MDAP count was 60 F–86Es, 280 F–86Fs, and 120 F–86Ks.

TECHNICAL DATA

F-86, F-86F, and F-86H

Manufacturer	(Airframe)	North American Aviation Inc., Inglewood, Calif. and Columbus, Ohio.
	(Engine)	Aircraft Gas Turbine Division, General Electric Company, Cincinnati, Ohio.
Nomenclature		Fighter, Fighter-bomber.
Popular Name		Sabre

Characteristics	*F-86A*	*F-86F*	*F-86H*
Engine, Number & Designation	1 5,200 lb s.t. J47-GE-13	1 5,910 lb s.t. J47-GE-27	1 8,920 lb s.t. J73-GE-3D
Length/Span	36.6 ft/37.1 ft	36.6 ft/39 ft	38.8 ft/39.1 ft
Weight (empty)	10,495 lb	10,950 lb	13,836 lb
Max. Gross Weight (Takeoff)	16,357 lb	20,650 lb	21,800 lb
Takeoff Ground Run		4,100 ft	4,500 ft
Cruise Speed		.83 Mach	.84 Mach
Max. Speed (35,000 ft)		600 kn	650 kn
Service Ceiling		45,000 ft	47,200 ft
Rate of Climb (sea level)		6,000 fpm	6,300 fpm
Radius		250 nm	365 nm
Crew	1	1	1
Armament	6 0.5-in Colt-Browning M-3 machine guns	6 0.5-in Colt-Browning M-3 machine guns	4 20-mm M-39 cannons
Ordnance Max.		2,000 lb*	1.36 ton (8/5" HVAR)

*2 M-64 or M-65 or M-117 or Napalm Bomb, or 4 GAR-8

TECHNICAL DATA

F-86D—F-86L

Manufacturer	(Airframe)	North American Aviation Inc., Inglewood, Calif.
	(Engine)	Aircraft Gas Turbine Division, General Electric Company, Cincinnati, Ohio.
Nomenclature		Fighter Interceptor.
Popular Name		Sabre

Characteristics	*F-86D*	*F-86L (Point)*[17]	*F-86L (Area)*[18]
Engine, Number & Designation	1 5,550 lb s.t. J47-GE-33	1 5,550 lb s.t. J47-GE-33	1 5,550 lb s.t. J47-GE-33
Length/Span	40.3 ft/37.1 ft	40.3 ft/39 ft	40.3 ft/39 ft
Weight (empty)	13,498 lb		
Max. Gross Weight (Takeoff)	18,160 lb (Point) 19,952 lb (Area)	18,480 lb	20,275 lb
Takeoff Ground Run		2,450 ft	3,000 ft
Max. speed (sea level)	601.7 kn (0.9 Mach) 534.9 kn (at 40,000 ft)	464.5 kn (at 35,000 ft)	464.5 kn (at 35,000 ft)
Service Ceiling	49,600 ft	49,600 ft	48,250 ft
Rate of Climb (sea level)		11,100 fpm	10,600 fpm
Radius/Loiter Time	234.7 nm (combat radius) at 477.6 kn		227 nm/15.3 min
Crew	1	1	1
Armament/Ordnance	24 2.75-in FFAR	24 2.75-in FFAR	24 2.75-in FFAR

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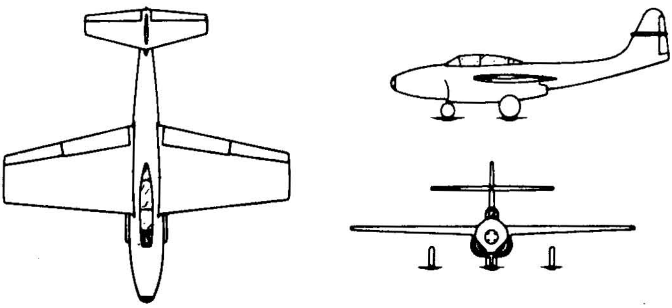
[17] Point Defense—defense of specified geographical areas, cities, and vital installations.

[18] Area Defense—locating defense units to intercept enemy attacks remote from and without reference to individual vital installations, industrial complexes, or population centers.



NORTHROP F–89 SCORPION

Northrop engineers chose to place the horizontal stabilizer well above the turbulent exhaust from the two jet engines. This gave the F–89 the appearance of an angry Scorpion—its tail raised to strike.

F–89A/B/C: Almost alike.

F–89D: The 20mm. nose-mounted cannons of earlier F–89s were replaced by 104 2.75 in. folding-fin aerial rockets, carried in permanently mounted wing-tip pods.

F–89H: Redesigned wing-tip pods each carrying three of the new Falcon air-to-air missiles.

F–89J: An F–89D modified to carry two Douglas-built, unguided, air-to-air Genie rockets. The F–89J was the Air Force's first nuclear-armed interceptor.

NORTHROP F-89 SCORPION

Manufacturer's Model N-35

Basic Development **1945**

The basic development started with the Northrop design of an all-weather ground attack fighter incorporating General Electric TG-180 axial-flow gas-turbine engines and many of the desired features of penetration and interceptor fighters. Engineers chose to place the horizontal stabilizer well above the turbulent exhaust from the two jet engines. This gave the proposed aircraft the appearance of an angry scorpion, its tail raised to strike. It influenced the selection of a nickname.

Military Characteristics **1945**

The Army Air Forces set general requirements—known in later years as Advanced Development Objective—in the spring of 1945 and on 28 August asked aircraft manufacturers to submit design proposals conforming to the tentative military characteristics listed in these general requirements. The specifications confronting the competitors called for a conventional (propeller-driven) aircraft that could fly at 525 mph (455.8 kn) at 35,000 feet, 550 mph (477.6 kn) at sea level, climb to 35,000 feet in 12 minutes, and have a 600-mile (521.7 nm) combat radius. A capability for launching air-to-air rockets would also be included.

Competitors and Selection **March 1946**

Six aircraft manufacturers entered the competition (Bell, Consolidated, Curtiss, Douglas, Goodyear, and Northrop), and most submitted designs for a jet-propelled model instead of the propeller-driven type originally sought by the AAF. Although Curtiss had already been given a contract to develop its entry (a jet-propelled development of the A-43, subsequently known as the XP-87), one of the four designs actually submitted by Northrop was selected.[1] This design also called for the use of jet-propelled engines.

[1] Included in the three Northrop proposals that were rejected was the design of a radical tailless "flying wing" jet, first conceived in the fall of 1942. Northrop, manufacturer of the P-61 Black Widows, had been so busy with standard types of aircraft during World War II that development of the P-79, as the "flying wing" jet was called, had been turned over to a small subcontractor that proved unable to do what Northrop wanted done. The project had been resumed in Northrop's own shops in 1944 and the only P-79 ever built was completed in 1945. Aside from its distinctive appearance, the P-79 was also unique in that the pilot was placed in a prone position. It was powered by a single Westinghouse jet engine and was designed to reach a speed of 630 miles an hour and an altitude of 45,000 feet. The P-79—which, Northrop believed, could easily be adapted to all-weather use—crashed and was destroyed during its first flight on 12 September 1945.

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Initial Procurement **13 June 1946**

Northrop received a $4 million letter contract for two experimental, two-place, twin-engine, turbojet propelled P–89 fighters. After several change orders requesting modifications of the aircraft's basic design, the LC of June 1946 was superseded. Procurement negotiations for the two XP–89s finally ended on 21 May 1947, with the execution of the first definitive contract. This $5.6 million contract—an increase of $1.6 million from the LC's amount—called for delivery of the first XP–89 within the next 14 months, i.e., not later than mid-1948.

Mockup Inspections **1946**

The Air Materiel Command was not favorably impressed with the mockup presented by Northrop in September 1946. The AMC inspection team wanted the radar operator moved closer to the pilot, the canopy redesigned, aluminum substituted for magnesium in the wings and something done about unsatisfactory fuel and oil systems. After another mockup session in December, Northrop was authorized to proceed with construction of the first XP–89 on the basis that certain other changes would also be made in order to improve the safety of the aircraft.

Development Problems **1948**

Despite the contractor's efforts, following the mockup inspections of 1946, an engineering acceptance inspection in June 1948 revealed that many discrepancies remained in the first XP–89.[2] Foremost was the aircraft's instability (caused by tail flutter) and buffeting, the latter generally attributed to the airframe's basic design. Structural integrity also was still questioned. Further modifications and development changes would have to be incorporated in the second XF–89 in order to produce a satisfactory aircraft.

First Flight (XF-89) **16 August 1948**

The flight took place 9 months later than planned, but the ensuing flight tests conducted by the contractor's pilots at Edwards AFB divulged no special problems. The first XF–89 finally appeared airworthy and functionally dependable.

Go-Ahead Decision **14 October 1948**

Comparisons with three possible all-weather interceptors—the Curtiss XF–87, the Lockheed XF–90, and the Navy's Douglas F3D—showed none to be really satisfactory, with the F–89 perhaps the least unsatisfactory. The successful flight of the Northrop experimental aircraft clinched the Air Force decision. In November 1948, concurrent with Secretary of Defense James Forrestal's

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[2] Like other pursuit aircraft of the former AAF, the experimental P–89 in mid-1948 became the XF–89 fighter.

endorsement of the Air Force decision, Curtiss' 4-month old contract for 88 F-87 Blackhawks was cancelled.

F-89A

First Production Order **1949**

Funds released by President Harry S. Truman in January 1949 enabled the Air Force to execute, during May of that year, a cost-plus-a-fixed-fee contract amounting to some $48 million, excluding a fixed-fee of almost $3 million. The estimated costs stipulated in the contract covered modification of the second XF-89 (YF-89) and fabrication of the first 48 production aircraft (F-89As). Spare parts, ground-handling equipment, special tools, and one static test article were included. Northrop received an additional order for 27 F-89As on 19 September 1949.[3]

First Acceptance (XF-89) **July 1949**

Although damaged on 27 June 1949, because of the failure of its main landing gear, the experimental aircraft was repaired in time for Air Force acceptance in July 1949—1 year behind schedule. This aircraft, involved in a new series of trials since February, had been re-equipped with "decelerons," a split surface operating in one piece as a conventional aileron but which could be opened out to serve as dive brake and auxiliary landing flap. The decelerons, developed by Northrop, eventually became a standard feature of all F-89 productions.

Unexpected Setback **1950**

On 22 February, during the second Phase II flight test of its ability to meet all-weather interceptor requirements, the XF-89 crashed and was damaged beyond repair. By that time, the second experimental F-89 (YF-89) was already in flight test, having been first flown on 15 November 1949 and accepted by the Air Force in January 1950.

Program Reappraisal **1950**

Review of the XF-89's last flight test report aroused great concern. Despite substitution of the J-35-A-9 for the TG-180[4] (J35-GE-3) engine (initially proposed by Northrop), the aircraft still lacked power; it also had poor takeoff characteristics and a slow rate of climb. In addition, the tests confirmed the existence of suspected deficiencies and disclosed that known failings had not been corrected. Shortly before the February crash, the aircraft had demonstrated little endurance, disappointing altitude per-

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[3] The number of F-89As on order became meaningless because production-line modifications resulted in many being delivered as new model series.

[4] First tested by Republic during the F-84 development, and also subsequently replaced by increasingly more powerful engines.

formance, signs of instability, and questionable structural integrity. Moreover, although major changes had already been introduced in the second experimental aircraft (YF–89), the latter undoubtedly still carried many of the deficiencies recently identified in the lost aircraft.

Prototype Modification **1950**

Loss of the XF–89 prompted the modification of the YF–89 and addition of an "A" suffix. Among the changes made to improve performance was the substitution of even more powerful engines—J–35–A–21s with afterburners in place of the J–35–A–9s that had powered the first experimental aircraft. The YF–89A also had a more pointed nose which lengthened its fuselage to 53 feet (3 feet longer than that of the F–89). The newly designated YF–89A first flew on 27 June 1950.

First Acceptance (Production Aircraft) **28 September 1950**

As pointed out by Northrop in mid-1950—immediately following the YF–89A's successful June flight—the F–89 was probably as good as "the state of the art at the moment would permit" and most likely surpassed any other aircraft currently in production. Although skeptical, the Air Force decided to reserve judgement until further testing of the Northrop second F–89 configuration could be made. For this purpose, one of the F–89As already manufactured was accepted on 28 September 1950, and two more before the end of the year. Meanwhile, production, which had been halted after the February crash, remained suspended.

Program Re-endorsement **November 1950**

With the understanding that unless solutions were forthcoming, other interceptor sources would be investigated, the Air Force re-endorsed the F–89 program. The decision was accompanied by stringent conditions. Testing of the new YF–89A would be accelerated; early F–89A productions (particularly, the three aircraft already accepted) would be subjected to a series of special tests to determine if recently introduced modifications had eliminated earlier flutter problems; no other unproven F–89As would be accepted, and production would not resume until January 1951—Northrop's deadline for correcting all known deficiencies.

Additional Procurement **1951**

Satisfied with Northrop's progress, the Air Force finalized long-pending negotiations for the purchase of additional F–89As. Procurement of the F–89As ordered in September 1949 was re-approved and a July 1950 letter contract was reactivated. Overall, though, the number of additional aircraft purchased was decreased because of the extra costs generated by recent configuration changes. In fact, the aircraft finally bought in 1951 differed sufficiently from early F-89As to acquire new model designations. They entered the Air Force inventory either as F-89Bs or F-89Cs and carried higher price tags than first anticipated.

Total F-89As Accepted

Eleven were accepted—37 less than ordered under the first production contract of May 1949.

Acceptance Rates

All F-89As were accepted in FY 51—between September 1950 and March 1951.

Enters Operational Service **1952**

Because of their limited number, the F-89As contributed little to the Air Force operational capability. Most of them were used for extensive operational suitability tests that did not end until mid-1952. Nonetheless, some F-89As joined subsequent model series in the operational inventory of the Air Defense Command.

Subsequent Model Series

F-89B

Other Configurations

None

Phaseout **1954**

F-89B

Previous Model Series

F-89A

New Features

Internal changes and additional equipment, including Lear F-5 autopilot, a Zero-Reader,[5] and an instrument landing system (ILS).

First Acceptance (Production Aircraft) **February 1951**

The F-89B was first accepted more than 5 years from the date Northrop had been authorized to proceed with development of the F-89.

Enters Operational Service **June 1951**

ADC's 84th Fighter Interceptor Squadron, at Hamilton AFB, was the first to acquire the new aircraft.

Initial Problems

Engine failures marred the beginning of the operational life of both the F-89A and F-89B aircraft and seriously affected the Air Proving Ground concurrent operational suitability tests of the two

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[5] Trade name of a gyroscopic instrument that combined the functions of gyro horizon, direction gyro, magnetic compass, sensitive altimeter, and cross-pointer indicator.

model series. This problem led to the use of modified engines (J–35–A–21A) that eventually replaced the J–35–A–21s, originally installed in the first 48 F–89s to emerge from the assembly line.

Modifications

All F–89As and Bs had externally mass-balanced elevators, adopted to overcome a severe high-frequency, low-amplitude flutter induced by the jet exhaust, but elevators with internal mass balance were fitted to earlier models after being developed for the F–89C, which followed the B series from the production line. Most of the first 48 F–89s were included in the F–89C's postproduction modification program.

End of Production **September 1951**

Production terminated with the delivery of the final four aircraft.

Total F-89Bs Accepted

37—remainder of the first production order of May 1949.

Acceptance Rates

Nineteen F–89Bs were accepted in FY 51, and 18 during the first 3 months of FY 52.

Flyaway Cost Per Production Aircraft

$1,085,882.00—airframe, $950,298; engines (installed), $90,364; electronics, $4,870; armament, $40,350.

Phaseout **1954**

Like the As, the F–89Bs left the Air Defense Command early in 1954. They first equipped the ANG's 176th FIS, replacing the squadron's elderly F–51s.

F-89C

Previous Model Series

F–89B

New Features

As a progressive development of the F–89B, the C presented few new features. However, elevators with internal mass balances replaced external mass-balanced elevators of previous model series.

First Acceptance (Operational Aircraft) **September 1951**

The aircraft was first accepted with the delivery of four aircraft.

Enters Operational Service **January 1952**

ADC's 74th FIS at Presque Isle AFB, Maine, had received only 19 F–89Cs by March, when the Air Force stopped further allocations because of the aircraft's lack of structural reliability.

Engine Problems **1952**

The F–89's J–35 engine continued to cause a great deal of difficulty. In addition, the low-slung engine of the F–89 earned a reputation as the "world's largest vacuum cleaner" by picking up litter from the runway. A vagrant piece of metal, on several occasions, was sucked into engine inlets, causing disintegration of the compressor blades. Pieces of the compressor then destroyed the remainder of the engine. Inlet screens were an answer of sorts, although it was discovered that at extremely high altitudes the inlet screen could become completely clogged with ice. Grounding orders, engine changes, inlet screen modifications, and similar actions seemed to have partially resolved the problem by mid-year.

Other Operational Problems **1952**

While the F–89's propulsion problems were being tended, a far more serious crisis developed. Starting with a crash on 25 February, a whole series of almost identical accidents occurred. Despite increasingly severe speed restrictions, six F–89s—mostly F–89Cs—had disintegrated in mid-air by 15 September. Accident investigations and study of the F–89 structure made it appear that the failures resulted from the stresses imposed by maneuvers, poor stability, and possible structural fatigue.

Grounding **1952**

On 22 September, except for 13 aircraft that would be flight tested to identify needed structural and stability corrections, all F–89 aircraft—including five new model series already accepted by the Air Force—were grounded. At year-end, the grounding was still in effect.

Modifications **1953**

The structural failures of the early F–89 productions were finally attributed to a faulty design of the wing structure—a mistake, however, that most "aerodynamicists and structures designers" would not have recognized at the time it was made. All that could be done at that point was to redesign the F–89s already produced (at a cost of approximately $17 million) and apply the new knowledge to aircraft to be produced. Modification of the F–89C received the highest priority, but by the middle of 1953 ADC still had only 31 of the modified F–89Cs available. Moreover, the modified aircraft could be used at only 80 percent of performance potential. This was true of the 194 early F–89s reworked by January 1954, when the modification program ended.

End of Production **November 1952**

Production ended with the delivery of six aircraft. The design improvements directed in late 1952 did not find their way into the Northrop production line until April 1953 and all F–89Cs were modified after production.

Total F-89Cs Accepted

163

Acceptance Rates

Except for 48 aircraft delivered during the last 4 months of 1951, all F-89Cs were accepted during 1952—128 in FY 52 and 35 in FY 53.

Flyaway Cost Per Production Aircraft

$797,202.00—airframe, $612,533; engines (installed), $95,110; electronics, $10,557; ordnance, $4,519; armament, $74,483.

Subsequent Model Series

F-89D

Other Configurations **1954**

YF-89E—an F-89C re-equipped with two Allison YJ71-A-3 engines. This experimental project, under contract since 5 November 1951, reached a cost of $5.7 million but never went past the prototype stage. The YF-89E, accepted by the Air Force on 27 August 1954, was used as an engine test bed until 1955.

Phaseout **1954**

The F-89C, in development for so many years, almost reached obsolescence before to become operational to a significant degree. Like the F-89As and Bs, the aircraft left the active inventory in 1954. The three model series were still being flown by the ANG in early 1960.

F-89D

Previous Model Series

F-89C

New Features

Different Allison J-35 engines and high-altitude afterburners; additional 262-gallon nose fuel tank; and improved fire control and armament—the 20-mm nose-mounted cannons of earlier F-89 model series were replaced by 104 2.75 in. folding-fin aerial rockets, carried in permanently mounted wing-tip pods.

Military Characteristics **1945**

The tentative military characteristics of early 1945, as revised in November of that year, were nearly satisfied in 1954 (after almost 10 years), when the F-89D became operational.

First Acceptance (Production Aircraft) **1952**

Northrop met its latest target date of June 1952 by delivering two of the interceptor aircraft, but the Air Force grounded the entire

F–89 force 2 months later. Full production of the F–89D was not resumed until November 1953 and that aircraft did not reach the Air Defense Command until 1954—a new setback of more than a year.

Production Modifications **1953**

The initial F–89Ds were almost of the same configuration as the earlier, structurally deficient F–89 aircraft. Major changes, therefore, were phased into production in order to correct the faulty wing design that had been principally responsible for the series of F–89C mid-air disintegrations.

Necessary Retrofit **1953-1954**

Only five F–89Ds had been accepted by the Air Force by November 1952, when the structural failings of the basic F–89 were finally ascertained, but another 120 F–89Ds had already left the production lines. Moreover, although Northrop daily programmed output of 17 aircraft came practically to a halt, several other F–89Ds were manufactured before the appropriate modifications could be merged into production. Hence, approximately 170 F–89Ds required some postproduction modifications similar to those made on the 194 earlier model series.

Enters Operational Service **7 January 1954**

ADC's 18th Fighter Interceptor Squadron at Minneapolis, St. Paul, Minn., was the first to receive F–89Ds. At year-end, 118 F–89Ds were in the command's inventory, but these urgently needed aircraft lacked the E–6 fire control system and E–11 autopilot of subsequent D productions.

Subsystem Integration **1953-1954**

The F–89D, the most produced of the F–89 model series, actually epitomized the transition from WW II gun-armed interceptors to ADC's guided missile carriers of the late fifties. The transitional nature of the F–89 meant that engineering problems were all but certain to arise. The crash on 20 October 1953 of a structurally modified F–89B, that had been adapted to the D configuration and specially fitted for the testing of rocket firing equipment, offered an example of the complexity of the pioneering problems encountered. Examination of the YF–89D wreckage, while uncovering no evidence of structural failure, failed to reveal what part had been played by the rocket malfunctions, reported by the pilot prior to the accident. Ensuing testing of the E–6, Hughes' new fire control system, was further hampered by its scarcity—the E–6 was also being tested with North American F–86D and Lockheed F–94C—and by the manufacturer's deficient spare part support. Similarly, the integration of new autopilot systems proved to be more difficult than anticipated. Beginning in July 1954, F–89Ds in production were equipped with E–11 autopilots (replacing the F–5 retrofitted in the F–89D and C aircraft and long considered a candidate for the first 193 F–89Ds, which like earlier F–89 productions had been delivered without autopilots), but use of the E–11 at speed in excess of Mach .75 had to be temporarily prohibited.

Structural Limitations **1954**

The F–89D also continued to suffer from the fact that the Northrop designers of the ground-attack F–89, in fashioning the aircraft as the high-altitude interceptor that the Air Force needed, had seemingly sacrificed the necessary structural features that would have enabled the plane to withstand low-level, high-speed flight maneuvers. Hence, despite the successive structural changes made between 1948 and 1953, all F–89Ds early in 1954 were still restricted from exceeding a speed of 425 knots at altitude of less than 20,000 feet—a restriction which essentially limited the F–89D's effectiveness to B–29 type targets. Subsequent improvements to the rudder and automatic pilot improved the maneuver capability of the aircraft but only to a degree.

New Propulsion Problems **1954–1955**

Although the modified J–35–A–21A engines of the F–89B and C model series had already been replaced in the F–89D by the more powerful J–35–A–33s, engine troubles continued to plague the F–89. More specifically, "power droop" under certain conditions, particularly at altitudes in excess of 30,000 feet, induced a significant loss of thrust in both the –21A and –33. Substitution of yet another model in the J–35 series did not cure the problem immediately for "power droop" also began to affect the operation of the new −35 engine. Because of the basic difficulty in finding the precise cause of the improper engine operation, the problem was not resolved until early 1955. Shielding of the temperature-sensing element of the J–35–A–35 engine power control proved to be the answer. Yet, the use of another engine was considered for a time.

Other Difficulties **1954**

One of the new features of the F–89D aircraft was the addition of permanently mounted wing-tip pods. This configuration, first flown in 1951 (on the modified F–89B, lost in October 1953), still proved troublesome 3 years later. The pods became excessively corroded after a few rocket firing missions and operational squadrons were sometimes required to dissemble and rebuild them. Moreover, corrosion and the damage it caused accounted on several occasions for minor explosions which collapsed the rocket tubes. The problem seemed to solve itself, however, with the introduction of new "thick wall" rocket launcher pods, successfully tested by mid-1954.

Program Change and Final Procurement **1954**

The fate of the F–89 as prospective carrier of the Falcon[6] was still uncertain early in 1954—2 years after the F–86D and F–94 had been dropped as potential Falcon carriers in favor of the Northrop interceptor. Adaptation of the early F–89 productions to the Falcon-carrying mission was no longer considered, and although provisions for the E–9 fire control system and Falcon missiles were included in all F–89Ds (605 of which were in the production program by 1954), the original 1 January 1954 IOC for the F–89-Falcon combination had already slipped. In March 1954, after a 6-month review of the entire F–89 program, the Air Force decided to dispense entirely with plans for fitting the E–9 system and Falcon pods into the F–89Ds. The decision was accompanied by a new and final procurement order for 233 additional F–89s. The first 77 aircraft in this group would be identical to the F–89Ds then being produced, but the other 156 future productions would incorporate the E–9 fire control system and pods for 42 standard folding-fin rockets and six Falcon missiles. The combination was officially dubbed F–89H in April 1954, to distinguish it from the earlier F–89D, which had provisions for the installation of this equipment but lacked the equipment itself.

Total F–89Ds Accepted

Of 682 accepted, 350 were identified as F–89Js after delivery, leaving a remainder of 332 F–89Ds.

Acceptance Rates

Two F–89Ds were accepted in FY 52, 10 in FY 53, 191 in FY 54, 300 in FY 55, and 179 during the first 9 months of FY 56. Delivery rates were almost constant between February 1954 and December 1955, with a monthly average of 25 aircraft.

Flyaway Cost Per Production Aircraft

$801,602.00—airframe, $598,439; engines (installed), $101,954; electronics, $11,392; ordnance, $1,857; armament, $87,960.

End of Production **March 1956**

Production ended with delivery of the last seven aircraft.

Subsequent Model Series

F–89H

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[6] Originally known as the XF–98, redesignated GAR–1, and first in the family of Falcon homing missiles developed by Hughes in the early fifties. The XF–98 Falcons were supersonic, fighter-launched, air-to-air missiles, propelled by solid-fuel rocket engines and equipped with semi-active radar-seekers to guide them on a collision course to their targets. They had a maximum range of 4.5 nautical miles, a maximum speed of Mach 3, and were to be used against subsonic targets operating at altitudes between 5,000 and 40,000 feet.

Other Configurations **1952-1954**

F–89F—this aircraft, which would have featured the armament of the F–89D and the Allison YJ71–A–3 engines of the YF–89E, never flew. The Air Force inspected the F–89F mockup at the Northrop plant in Hawthorne, Calif., on 26 May 1952, but cancelled the project 3 months later.

F–89G—patterned on the F–89F and programmed to include revised armament and a new fire control system, the expensive F–89G also did not materialize.

F–89J—a reconfigured F–89D, modified after production, but which acquired the status of a new model series.

F–89X—an F–89D that had traded its Allison J–35 engines for the Wright J–65 Sapphires, utilized by Republic F–84F. The new combination raised the combat ceiling of the aircraft and improved its rate of climb. Maximum speed, however, was barely affected. Mach .85 was reached, but this was essentially the top speed of the J–35-equipped F–89D. In July 1954 Northrop reported a new technique to reduce induced drag by setting the wing flaps and speed brakes at specific and unconventional angles. This would further increase the F–89X's ceiling to 57,000 feet or more, thereby enabling the proposed aircraft to compete better with modern high-speed, high-altitude bombers. Although ensuing tests substantiated Northrop's estimates, the Air Force toward the end of November notified the contractor that it had no further interest in the F–89X proposal for it would eventually result in development of an entirely new aircraft.

Phaseout **1958**

ADC used the two-place F–89D until late 1958, then began to equip the ANG's 178th FIS.

Milestones **21 October 1953**

Actually, the F–89D was the initial carrier of Hughes' Falcon air-to-air missiles. The first firing (October 1953) was not entirely successful for the missile pod collapsed after firing. Necessary redesign postponed the operational date of Falcon-equipped F–89s (F–89Hs) from January 1954 to late 1955.

27 January 1955

An armed Falcon, also fired from a modified F–89D, downed a QB–17 drone—the first GAR–1 armed with a warhead to strike an airborne aircraft. This time the operation was a complete success.

F-89H

Previous Model Series

F–89D

New Features

E–9[7] fire control system; redesigned wing tip pods each carrying three Falcons (Hughes GAR–1, –2, –3 or –4 air-to-air missiles) and 21 folding fin aerial rockets (FFAR); up to six more FFARs carried under the wings.

Production Problems **1954–1956**

Technical difficulties slowed Northrop development of F–89H wing tip pods that preceded integration of the Falcon missile. By mid-1955 these pods—the third F–89 pod model, but the first specifically designed to house GAR–1 Falcons—had been successfully tested, but corrosion of the missile cavities again occurred. The need to modify the E–9 fire control system for improved missile performance also delayed deliveries of the F–89H. Because these changes would apply to similar fire control systems, the Air Force in June 1956 postponed acceptance of the last 25 F–89Hs until completion and testing of the E–9-required modifications.

First Acceptance (Production Aircraft) **September 1955**

One aircraft was delivered.

Enters Operational Service **March 1956**

The first recipient was ADC's 445th FIS at Wurtsmith AFB, Mich. This was more than 2 years after the date originally set for operational employment of the Falcon-equipped F–89.

Subsequent Model Series

None, for the F–89J was a modified F–89D. The F–89H was the final production version of the Scorpion.

Other Configurations

None

End of Production **August 1956**

The Air Force took delivery of Northrop's last seven F–89Hs 2 months later.

Total F–89Hs Accepted

156

Acceptance Rates

Except for one aircraft delivery in September 1955, and another 2 months later, all F–89Hs were accepted during 1956—109 in FY 56 and 47 during the first 4 months of FY 57.

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[7] The E–9 fire control system differed from the E–6 (used in early F–89s) by the inclusion of a universal computer. Essentially, this computer made it possible for the pilot to select either a lead collision or a lead pursuit course for rocketry, with the option of a lead collision course for missile launching.

Flyaway Cost Per Production Aircraft

$988,884.00—airframe, $536,748; engines (installed), $105,697; electronics, $10,094; ordnance, $998; armament, $335,347.

Phaseout **1959**

The delay in converting the F–89 to missile armament doomed the F–89H to short operational life, because the F–102A, which also mounted Falcon missiles and offered performance superior to that of the F–89H, was nearly ready by the time the F–89H became available. The F–89Hs began reaching the ANG in November 1957–first replacing F–89Ds of the Guard's 123d FIS at Portland, Oreg. Only 21 F–89Hs remained in the ADC inventory by the middle of 1959 and these had disappeared by the following September.

F-89J

Weapon System 205G

Previous Model Series

None—the F–89J was a modified F–89D. The modification, accomplished after production at Northrop's Palmdale plant in California, gave the aircraft a new armament—a change sufficiently important in this case to warrant a new designation.

New Features

Hughes MG–12 fire control system;[8] two Douglas-built, unguided, air-to-air MB–1 Genie rockets—subsequently redesignated AIR–2As. The F–89J was the first nuclear-armed interceptor.

First Acceptance (Modified Aircraft) **November 1956**

Initial deliveries of Genie-equipped F–89Ds began in November and December 1956. The aircraft were identified as F–89Js soon afterward.

Enters Operational Service **January 1957**

With ADC's 84th FIS at Hamilton AFB, thereby meeting the deadline established in March of 1955.

End of Modification **21 February 1958**

While the F–89Js were accounted for as F–89Ds, the production of which ended at the contractor's Hawthorne plant in March 1956, their modification did not end until 2 years later. This was still 2 weeks ahead of schedule.

Modification Costs

The new armament, and airframe modification for its installation, raised the price of the aircraft, but Northrop completed the

[8] A modified E–9, including the "snap-up" attack mode—a somewhat misleading description of a technique involving rocket launch while the interceptor was in a nose-high, climbing altitude. Its purpose was to permit the fighter to "kill" a bomber which was cruising at a higher altitude.

modification with a cost underrun. The first modified F–89Ds cost $1,008,884.00 apiece, or $207,282.00 more than each original F–89D. Despite unchanged armament costs, the overall unit price of the modified F–89Ds was later cut by $20,000.00. The reduction lowered the aircraft unit price to that of the F–89H.

Total F-89Ds Modified

350

Flyaway Cost Per Modified Aircraft (F-89J)

$988,884.00—airframe, $536,748; engines (installed), $105,697; electronics, $10,094; ordnance, $998; armament, $335,347.

Average Maintenance Cost Per Flying Hour

$223.00

Phaseout **1960**

Although several ANG units began to convert to the F–89J in July 1959, the aircraft remained much in evidence at the end of the year. Two hundred and seven of a peak ADC inventory of 286 (30 June 1958) were on hand at that time. However, the increasing availability of F–101Bs and F–106As (ADC's subsequent atomic carriers) in 1960 marked the end of the F–89J as a most important member of the regular forces. But the aircraft's operational life was not over. Eight ANG squadrons flew F–89J aircraft that were to be equipped with nuclear Genies in mid-1961. In 1962, a ninth ANG squadron, the 124th at Des Moines, Iowa, received F–89Js. This squadron, together with the 132d, located at Dow AFB, still flew nuclear armed F–89Js in 1968.

Milestones **19 July 1957**

Firing of the first air-to-air rocket (modified MB–1 Genie) with nuclear warhead. The rocket, launched from an ADC F–89J, was detonated at a point in space more than 15,000 feet above the northern portion of Yucca Flat, Nev. The warhead was of a weapon design by Los Alamos Scientific Laboratory.

1964

148th Fighter Group of the Minnesota Air National Guard became the first ANG unit to win the US Air Force Missile Safety Award. Equipped with F–89Js, armed with AIR–2A Genies, the 148th based at Williamson-Johnson Municipal Airport in Duluth, Minn., flew active air defense missions on a 24-hour-a-day alert basis with the Air Defense Command.

PROGRAM RECAP

The Air Force ordered and accepted for its own use a grand total of 1,052 F–89s—2 XP–89s, 11 F–89As, 37 F–89Bs, 163 F–89Cs, 682 F–89Ds (350 of them, redesignated F–89Js after modification), and 156 F–89Hs.

TECHNICAL DATA

F-89J

Manufacturer	Northrop Aircraft Incorporated, Hawthorne, Calif.
Nomenclature	Subsonic Fighter Interceptor (all-weather, day/night)
Popular Name	Scorpion

Characteristics	*Point Intcp*	*Area Intcp*
Takeoff Weight	45,575 lb	45,575 lb
Length Fuselage/Wing	53′.7″/59′.8″	53′.7″/59′.8″
Max. Speed at 35,000 ft	450 kn	450 kn
Radius		435 nm
Engine, Number & Designation	2J35-A-35	2J35-A-35
Takeoff Ground Run	3,950 ft	3,950 ft
Rate of Climb (sea level)	5,160 fpm	5,160 fpm
Combat Ceiling	42,100 ft	43,500 ft
Crew	2	2
Ordnance	2 AIR-2A	2 AIR-2A

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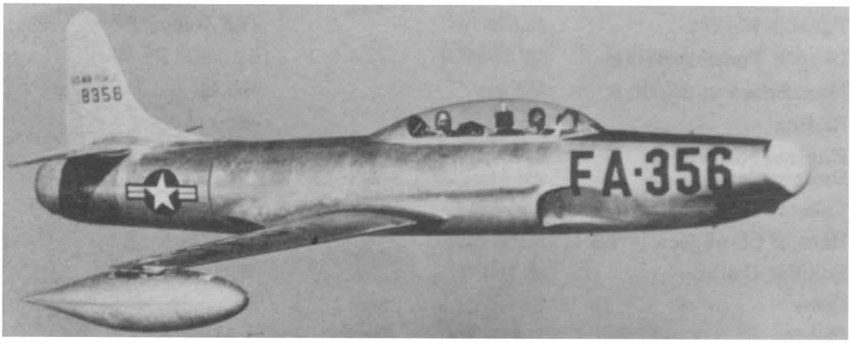

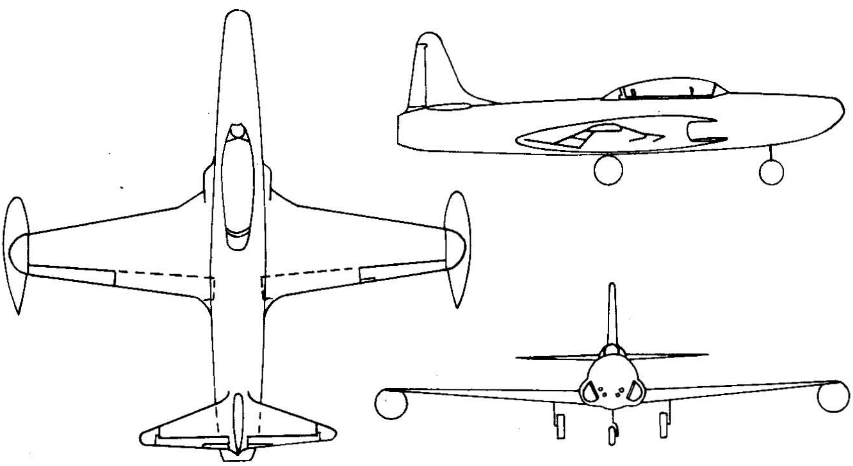

LOCKHEED F–94 STARFIRE

First jet-powered all-weather fighter to enter service with the U.S. Air Force and first to feature a speed-boosting afterburner.

F–94A and B: Both closely resembled Lockheed's two-seater TF–80C, first of the famous T–33 trainers.

F–94B: Differed from the F–94A by using larger, better-shaped, drop fuel tanks, and improved electronics and hydraulic systems.

F–94C: Initially known as the F–97A, the redesignated F–94C was the third, biggest, and last of the Starfires as well as the final upshot of the basic Shooting Star design. It was also the first rocket-bearing interceptor.

Pilots generally like the F–94C, commenting that the J48–P–5 engine "wheezed, coughed, spurted, and blurped at altitude; but it never quit running."

LOCKHEED F-94 STARFIRE

Manufacturer's Model 780-76-08 (F-94B)

Basic Development **June 1943**

The roots of development for the F-94 lay in the WW II P-80 Shooting Star, USAF's first truly operational jet fighter. Specifically, however, the F-94 interceptor stemmed from Lockheed's successful conversion of the basic P-80 into a two-seat trainer. This TF-80C, first flown in March 1948, became the T-33 in mid-1949. The F-94 was born the same year.

General Operational Requirements **8 October 1948**

The GOR called for the extra punch of an all-weather jet interceptor. Early availability took precedence over its capability to counter any threat beyond that of the TU-4 (Russian equivalent to the B-29).

Go-Ahead Decision **14 October 1948**

One week after re-endorsing continued development of the Northrop F-89,[1] the Air Force directed production of the two-place, radar-equipped F-80 (christened F-94 in 1949). Two major factors prompted the decision. The North American F-82 (the only "all-weather interceptor" available) was highly unsatisfactory.[2] Moreover, operational integration of its replacement would probably be delayed, since the F-89 was an entirely new design.

Initial Procurement **January 1949**

Secretary of Defense Forrestal's approval of the future interim F-94 in November 1948, followed by President Truman's release of funds, led to a January letter contract with Lockheed. This LC was replaced a few months later by a definitive contract (AF-1849) covering 150 F-94 productions (later reduced to 109).

First Flight (XTF-80C) **16 April 1949**

By a radar-equipped TF-80C.

F-94A

First Flight (YF-94) **1 July 1949**

By one of two T-33A trainers (improved, redesignated TF-80Cs),

[1] The Air Force considered the F-89 "the best of a poor lot." It reluctantly voted to uphold the project on 8 October 1948. General operational requirements for an interim interceptor were issued on the same date.

[2] North American never built any interceptor-type F-82s. But the two-engine, twin-fuselage, low-wing, long-range escort fighter could be converted into a single-place interceptor by removing the controls and canopy from the right-hand cockpit. The F-82Fs, -Gs, and -Hs, officially classified as fighter-interceptors, were two-seaters with a radar operator in place of the copilot. These F-82s actually could not cope with bad weather. Even as night fighters, their performance was becoming obsolete.

modified for the interceptor role by adding radar noses and rear-fuselage afterburners. Lockheed used the converted T-33s as F-94 prototypes to speed development, but both were little more than TF-80Cs. In effect, production aircraft flight-tested before the end of 1949 comprised 75 percent standard F-80C parts.[3] Like the F-80/T-33 Shooting Stars, the Starfire's first model (F-94A) had wing tip drop tanks.

Program Changes **1949**

The F-94 program changed twice in less than a year. Despite reduction of the Air Force's size, procurement quickly rose to 288—almost double the quantity sought in January 1949. The August detonation of an atom bomb in Russia forced another evaluation of Air Force planning. The F-94 procurement was raised again in December (to 368 aircraft) because "foreign possession of the atomic bomb necessitates acceleration of the USAF program to modernize its interceptor and all-weather force at the earliest possible time." Growing F-94 importance brought renewed, concerted efforts to improve the aircraft's overall performance. Lockheed proposed and the Air Force bought the F-97A, a drastically redesigned F-94. When technical hindrances immediately arose, the Air Force had to endorse still another, but far less ambitious, F-94 configuration. This became the F-94B, while the F-97A ended up as the F-94C.

Enters Operational Service **May 1950**

F-94As began reaching air defense units about 6 months behind schedule. These makeshift interceptors were received at McChord and Moses Lake, Wash., by the 325th Fighter Wing of the Continental Air Command.[4]

Initial Operational Capability **August 1950**

By the end of the year, CONAC's operational inventory counted 60 of the new F-94A.

Operational Problems

The F-94A's Allison J-33 engine, slated for the F-94B, did not work well. Despite improvement, it still suffered from turbine blade failures 2 years after the first F-94A had become opera-

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[3] Advertising the Starfire's last model (F-94C) in later years, Lockheed praised it as "an engineering achievement of creating a more advanced model out of an existing airplane." By then, however, the Air Force generally believed this was the aircraft's foremost shortcoming.

[4] CONAC, formed on 1 December 1948, included the Air Defense Command, the Tactical Air Command, and nine fighter squadrons formerly assigned to the Strategic Air Command. The rationale for CONAC (under economy programs of the pre-Korean years) was to train all fighter units for both tactical and air defense action. This would make many more aircraft available for all missions.

tional. Also, the F–94's fuel system was far from perfect; the aircraft was unstable and hard to maneuver at high altitude. Moreover, the cockpits were too small. The pilot and radar operator found it impossible to get in and out quickly during alerts and scrambles. They had to fly in a cramped position. Even more vital, the clearance for seat ejection was slight.

Postproduction Modifications **Mid-1952**

The Air Force got Lockheed to correct the ejection seats and cockpits of 330 F–94 (A and B) aircraft for some $4.5 million. Minor improvements, already scheduled by the Air Force, would be done concurrently with the Lockheed modification.

Total F-94As Accepted

109

Acceptance Rates

All F–94As were accepted by the Air Force between December 1949 and December 1950—14 in FY 50, and 95 in FY 51.

Flyaway Cost Per Production Aircraft [5]

$258,123.00—airframe, $193,721; engine (installed), $45,227; electronic, $4,014; armament, $15,161.

Subsequent Model Series

F–94B

Other Configurations

None

Phaseout **1954**

A few ANG squadrons, federalized during the Korean War, flew F–94s in late 1951. Upon reverting to inactive status, their planes stayed with active Air Defense Command units.[6] Nonetheless, no F–94As remained in the USAF inventory in mid-1954.

F-94B

Previous Model Series

F–94A[7]

New Features

Gyroscopic instrument (Sperry Zero Reader) for more accurate landings in bad weather; high pressure oxygen system; improved

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[5] Excluding the cost of ordnance and government-furnished aeronautical equipment (GFAE).

[6] ADC was established on 21 March 1946. It lost its major air command status and became an operational command under CONAC in December 1948, but reemerged as a major air command on 1 January 1951.

[7] The F–97A (redesignated F–94C) was ordered right after the F–94A. The third model followed the F–94A in production and became the F–94B.

hydraulic system; and larger, better-shaped, external fuel tanks. These were mounted along the airplane's center line instead of being suspended from the wings, as on the F–94A.

First Flight (YF-94B) **December 1950**

A converted F–94A, the 19th production, flew the maiden flight. F–94Bs began reaching the operational forces a few months later.

Enters Operational Service **April 1951**

With ADC's 61st Fighter Interceptor Squadron at Selfridge AFB.

Operational Problems

Despite its new features, the F–94B closely resembled the F–94A. The two had similar engines and cockpits, the same configuration weaknesses, and deficient fuel systems. Thus, they shared identical operational problems and required like postproduction modifications. Lacking adequate anti-icing equipment, neither the F–94A nor F–94B could qualify as an all-weather interceptor.[8] Pending something better, ADC welcomed the B.

War Commitments **January 1952**

A handful of F–94Bs soon joined the 15 F–94As allocated to the Far East Air Forces in March 1951. The aircraft were so few, however, that they could not be easily spared. Hence, they did not enter the Korean war until late December 1951, when the 68th FIS posted two F–94s on strip alert at Suwon Air Base.[9] Even then the aircraft's involvement was limited to local air defense scrambles under positive ground-radar control. The new F–94s were fitted with the latest fire-control system.[10] The Air Force, therefore, did not want them to fly over enemy territory where this secret electronic equipment could be compromised. The restriction was not lifted until nearly a year later—after continued B–29 losses were tied to the ineffectiveness of fighter-escorts equipped with the older airborne-intercept radars. The 319th FIS

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[8] The B's windshield—but not the A's—did have some kind of anti-icing system.

[9] The Air Force hurried the conversion of FEAF's old F–82s to more modern F–94Bs. In addition, it deployed the 319th FIS to Korea. This unit's F–94Bs went into operation at Suwon on 22 March 1952.

[10] Produced by the Hughes Aircraft Company, the E–1 was the first in the E series of sophisticated fire-control systems that were to equip more modern planes. The Air Force ordered the system in June 1948, when it asked that the AN/APG–3 radar (being developed for the tail defense of the B–36) be adapted to the Northrop F–89. A November amendment of the June contract extended the requirement to the F–94. The modified AN/APG–3 radar was redesignated AN/APG–33 and the entire system, including its A–1C gunsight, became the E–1 in late 1949. It was installed in early F–89s as well as F–94As and –Bs. Low-powered, the E–1 was fairly primitive alongside the E–5 of the rocket-firing F-94C. The system was nevertheless a pioneer achievement.

in November 1952 began using some of its F–94Bs as a screen between the Yalu and Chongehon rivers. Soon after, F–94s also flew within a 30-mile radius of the B–29 targets. Enemy planes usually retreated rather than come up against F–94 barrier patrols.

Appraisal

Although not too successful against low-flying aircraft, few planes proved as reliable as the F–94 against the enemy in the Korean war, even in nasty weather and darkness. Besides B–29 escort duties and enemy fighter interception missions, F–94s protected B–26 light bombers and could fly deep into North Korea when most other aircraft were grounded due to bad weather. Korean veterans as a rule praised the F–94. It was rugged and could fly many hours without maintenance.

Attrition

The Air Force lost 28 F–94s between January 1952 and 27 July 1953—the day the war ended. Only one of the 28 losses was due to direct enemy action.[11] During the same period, F–94 pilots claimed four enemy planes destroyed.

Total F-94Bs Accepted

356, plus 1 prototype—a converted F–94A.[12]

Acceptance Rates

The Air Force accepted 176 F–94Bs in FY 51 and 180 in FY 52—the last four in January 1952.

Flyaway Cost Per Production Aircraft

$196,248.00—airframe, $123,422; engine (installed), $31,336; electronics, $7,635; ordnance, $2,947; armament, $30,908.

Subsequent Model Series

F–94C

Other Configurations

None

Phaseout

The F–94B, like the F–94A, left the active force by mid-1954. The Guard still flew the two models in late 1957.

Milestones **30 January 1953**

Using the E–1 fire-control system, the F–94 made its first Korean kill at night, destroying a conventional, but speedy LA–9. The

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[11] Air Force-wide there were 51 USAF/ANG F–94 major accidents in fiscal year 1953, 34 of then attributable to pilot errors.

[12] 150 F–94Bs were ordered under AF Contract 9844 and 206 under AF Contract 14804. The YF–94B was booked against the initial F–94 contract (AF–1849).

Starfire pilot (Capt. Ben L. Fithian) and observer (Lt. Sam R. Lyons) never saw the enemy plane until it burst into flames. F–94s shot down three other elusive enemy jets before the armistice.

F-94C

Manufacturer's Model 880–75–13

Previous Model Series

F–94B

New Features

Pratt & Whitney J48–P–5 or –5A engine (8,300-lb thrust with afterburner; 6,250-lb, without); thinner wings, with increased dihedral; sweptback horizontal stabilizer; aft dive flaps, drag chute; and longer nose with radome in retractable shield. All-rocket armament accommodated 48 2.75-inch folding-fin aerial rockets—24 in a ring of firing tubes around the nose and 24 in two cylindrical pods. One pod was located on each of the two wings, midway between root and tip. Also featured were wing and horizontal stabilizer thermal de-icing, single-point refueling, greater fuel capacity, as well as the Hughes E–5 fire-control system and Westinghouse W–3A autopilot (for instrument approach).

First Flight (Prototype) **18 January 1950**

The prototype flight took place 11 months before the YF–94B's first official flight. Converted F–94As were used in each case.[13]

Production Decision **February 1950**

The USAF decision for a redesigned F–94 (referred to as the F–97A) followed reappraisal of the F–94 program and January 1950 plans calling for haste in supplying the air defense forces with better and more of the Lockheed interim interceptors.[14]

Redesignation **12 September 1950**

The F–97A, endorsed by the Air Force in February 1950, formally became the F–94C—third, biggest, and last of the F–94 model series as well as the final upshot of the basic Shooting Star design.

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[13] The entire F–94 program finally totaled 852 productions—109 F–94As (against a first order for 150), 356 F–94Bs, and 387 F–94Cs (originally known as F–97As). Air Force records, however, showed only 2 prototypes (1 YF–94B and 1 YF–94C) officially accepted—others were accounted for as production aircraft, or charged to another program (as were the F–94A prototypes, developed from F–80C and T–33 productions).

[14] The Air Force realized a drastically improved F–94A was not there for the asking. It then settled for a third, but "in-between type," that preceded the so-called F–97A—the F–94B, which still fell short of the Air Force's early 1950 expectations.

Development Problems **1950–1951**

The F–94C ran immediately into trouble. To begin with, the first production deliveries were scheduled for 1951—far too early. Both the Pratt & Whitney J–48 engine and laminar wings specifically earmarked for the F–94C, were not likely to be fully developed when needed. Other improvements or new components (many also intended for the F–94B) were slipping. The automatic approach system was not ready; testing of the 250-kilowatt-radar, rocket-nose, and collision-course sight was not due until 1951; development of an advanced fuel purging system showed scant progress, and the only autopilot available was too big even for the larger F–94C.

First Flight (Production Aircraft) **October 1951**

Although this plane was not accepted by the Air Force until May 1952, it did not go directly to the operational forces.

Testing **1951-1952**

The Air Force allocated to the testing program the F–94C prototype (first flown as the YF–97A in January 1950 and accepted in October), together with 9 other aircraft received by the end of June 1952. None of these "test productions" performed well. ADC concluded that low speed (some 40 knots less than the F–89) and poor maneuverability downgraded the F–94C. Nevertheless, it would be acceptable if these deficiencies were corrected.[15]

Engine Problems **1952**

On its first trial in August 1951, the F–94C's J48–P–5 engine had passed its 150-hour qualification test, but its afterburner had warped and cracked. After much testing and redesign, the engine finally passed new qualification tests in May 1952 with afterburner intact. Fuel burner nozzle failures occurred soon afterward. Since it was impossible to find defective nozzles by visual inspection, the F–94Cs were grounded.[16] Despite fairly good engine performance after some modifications, the Air Force in mid-1952 still sought to enhance the rate of climb and high-altitude reliability of the P–5. It considered switching to the higher thrust J48–P–8, but installation difficulties wiped out the project.

Required Improvements **August 1952**

A joint study (Headquarters USAF, Air Proving Ground Command (APGC), ARDC, and ADC) called for variable position dive

[15] Some of them—the unsatisfactory fuel system in particular—were reported by test pilots of the Air Research and Development Center (ARDC) as resulting from poor design and substandard quality control during production. Others reflected a variety of causes that combined to erode the plane's efficiency.

[16] Fitting all engines with improved nozzles solved the problem before the end of 1952.

brakes, aileron spoilers, a better drag chute, and further improvement of the engine reliability. The study also recommended speedy installation of the aircraft's new rocket armament (early F–94Cs still carried machineguns) and additional rockets.

Immediate Modifications **1952**

By mid-October 1952, the F–94C's flight characteristics and controls were improved. More than $3.5 million had been allotted to modify the cockpits of early F–94Cs,[17] and work was underway to correct the aircraft's inadequate de-icing boots and faulty stall warnings. Lockheed had also arranged for field installation of the variable position dive brakes and aileron spoilers. Drag chute improvements were progressing and ways to upgrade the engine's reliability were under review. Armament difficulties, however, remained unsolved.

Armament Problems **Mid-1952**

The success of the F–94C's all-rocket armament hinged on rocket accuracy and interceptor performance reliability. The F–94C and its rockets had neither.[18] Worse, the P–5 engine flamed out when the full-nose load of 24 rockets was salvoed above 25,000 feet. If only 12 rockets were fired, a near flameout still occurred that slowed the interceptor speed. The Air force wanted the problems cured and the rocket load doubled. Both could be done. In fact, the mounting of additional rockets in wing pods had been considered since 1951. Nonetheless, it was unlikely the F–94C would get its extra rockets before the 163d production.

Program Reduction **1952**

Improvements notwithstanding, two of the four production contracts (the first, definitized on 27 July 1950, dealt with the F–97A) were cancelled late in the year, cutting F–94C procurement from 617 to 387.[19]

Production Modifications **1953**

In the spring (beginning with the 100th production—not the 163d), F–94Cs came off the assembly line with wing pod "sidearms." Each pod packed 12 of the Aeromite-developed FFARs. The long cylinder pods measured 9 feet 6 inches and their fiberglass nose covers protruded about 6 feet from the wing leading edge. Before the rockets left the pods, the fiberglass covers

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[17] Some 260 F–94Cs would probably feature the F–94A and F–94B small cockpits and the Air Force did not expect $3.5 million to fill the bill.

[18] The F–94C's all-rocket armament had been a key selling point. Admittedly, a salvo of rockets would cause more damage than a burst of machinegun fire.

[19] The Air Force considered cancelling the entire program in July. It held off because of anything better and the need (in the midst of the Korean War) to keep Lockheed in production.

disintegrated due to rocket-generated gas pressure. The production-improved F–94Cs also came with new ejection seats that would lift both the pilot and radar observer well above the cockpit sill.

Enters Operational Service **7 March 1953**

With ADC's 437th FIS at Otis AFB. As the first rocket-bearing interceptor, the F–94C generated less enthusiasm than expected.[20] Nearly 2 years behind schedule, it showed limited performance. And, clearly, its basic design could not be stretched further to meet future needs.[21]

Initial Operational Capability **1953**

The 437th FIS attained initial operational capability in June.

Operational Deficiencies **1954**

In mid-1954, squadron operational suitability tests confirmed the F–94C's poor weather-proofing[22] and disclosed leaky fuel tanks. They also revealed the need to improve the E–5 fire-control system.

Postproduction Modifications **September 1954**

Known as Hop–Up, these modifications resolved the F–94C's recently confirmed shortcomings. Early F–94Cs also exchanged their ejection seats for the safer ones featured by later productions. The Hop–Up modification of the E–5 eventually added an optical sight to the system.

End of Production **May 1954**

With delivery of the last two aircraft.

Total F-94Cs Accepted

387—plus 1 prototype

Acceptance Rates

The Air Force took delivery of 9 F–94Cs in FY 52, 153 in FY 53, and 225 in FY 54. The YF–94C had been accepted in October 1951.

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[20] Maintenace crews praised the F-94C, because they could get to its electronics equipment easily. Pilots generally liked the aircraft, commenting that the J48–P–5 engine "wheezed, coughed, spurted, and blurped at altitude; but it never quit running."

[21] Intended as a "quick-fix" all-weather interceptor to fill the air defense gap until the F–89 was ready, 1949 planning had envisioned an operational F–94C in 1951. Moreover, the F–94C (like the F–94A and B) could not destroy any bomber superior to the Russian TU–4 that compared with the B–29.

[22] During continuing rain in late 1953, 80 percent of the alert aircraft at one base went out of commission. Moisture in the cockpit had short-circuited the electrical and fire-control systems.

Flyaway Cost Per Production Aircraft

$534,073.00—airframe, $380,755; engine (installed), $90,147; electronics, $7,058; ordnance, $518; armament, $55,595.

Subsequent Model Series

None

Other Configurations

F-94D. A single-seat fighter-bomber for long-range ground support. The D would have a high-thrust centrifugal flow turbojet engine with afterburner, plus autopilot and airborne equipment to allow automatic approach and tactical control from the ground. Authorized for procurement in mid-1951 (when the Korean War started), one F-94D prototype was developed (through conversion of an early F-94 production), but the 112 F-94Ds on order were all cancelled.

Phaseout **February 1959**

Despite mediocre performance, the F-94C lasted a long time as a first-line interceptor. The Air Force wanted to get rid of the aircraft,[23] but could ill afford it. The F-94C in mid-1954 (when ADC counted a peak 265) was still regarded as the best two-man interceptor at low altitudes.[24] The F-94C finally disappeared from USAF rolls in early 1959; from the ANG's in mid-1960.

PROGRAM RECAP

USAF records revealed a grand total of 854 F-94s—2 prototypes, 109 F-94As, 356 F-94Bs, and 387 F-94Cs. All aircraft were ordered into production for the Air Force's own use.

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[23] At one time during 1955, 48 percent of the Air Force's remaining F-94Cs were grounded for lack of parts.

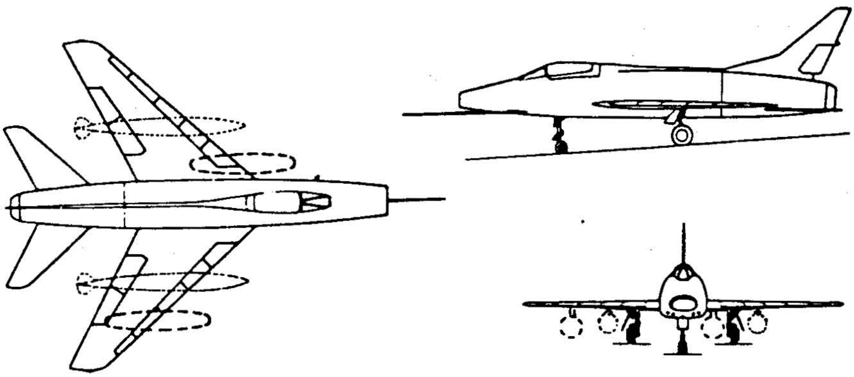
[24] Despite many structural modifications, the F-89 operated poorly, particularly at low level; and the Convair F-102 (originally due to enter service in mid-1953) was several years away. As for the development of a low-altitude surface-to-air missile (investigated under Project LASAM), this was out of the question insofar as the Air Force was concerned. It planned instead to test low-altitude seekers that ADC could possibly use on its future Bomarcs.

TECHNICAL DATA

F-94A, F-94B, and F-94C

Manufacturer	(Airframe)	Lockheed Aircraft Corporation, Burbank, Calif.
	(Engine)	Allison Division of General Motors Corporation, Indianapolis, Ind. (F-94A/B). Pratt & Whitney, East Hartford, Conn. (F-94C).
Nomenclature		Fighter Interceptor.
Popular Name		Starfire

Characteristics	*F-94A*	*F-94B*	*F-94C*
Engine, Number & Designation	1 J33-A-33	1 J33-A-33	1 J48-P-5
Length/Span	40.1 ft/38.9 ft	40.1 ft/37.5 ft	44.5 ft/37.3 ft
Weight (empty)	9,557 lb	10,064 lb	12,708 lb
Max. Gross Takeoff Weight	15,710 lb	16,000 lb	24,200 lb
Max. Speed (sea level)	526 kn	511 kn	556 kn
Combat Speed (Basic Mission)	474 kn	426 kn	454 kn
Rate of Climb (sea level)	4,250 fpm	6,850 fpm	7,980 fpm
Service Ceiling	46,000 ft	48,000 ft	51,400 ft
Combat Range (Basic Mission)	937 nm		12,000 st. miles
Armament	4 .50-in machine guns	4 .50-in machine guns	24 2.75-in FFARs + 12 ea in 2 wing pods
Max. Bomb Load	2,000 lb	2,000 lb	2,000 lb
Crew	2	2	2



NORTH AMERICAN F–100 SUPER SABRE

Evolved from the F–86 Sabre. The North American F–100 was the forefather of the Air Force's Century Series of fighters.

F–100A: This day fighter was the world's first supersonic airplane ever produced.

F–100C: Differed from the F–100A by carrying extra fuel drop tanks and additional stores (bombs and rockets), as called for by the aircraft's secondary fighter-bomber role.

F–100D: In contrast to the F–100C, the F–100D served primarily as a fighter-bomber. It became the major production type of the Super Sabre series.

F–100F: Tandem two-seat cockpit with dual controls. Only two of the F–100D's four built-in 20 mm. M–39 guns were retained.

Both the F–100D and F–100F proved their worth in SEA.

In 1966, modified F–100Fs began attacking the North Vietnamese Fan Song fire control radars.

NORTH AMERICAN F-100 SUPER SABRE

Manufacturer's Model NA-192

Basic Development **1949**

Evolved from the F-86 Sabre. North American designated its undertaking Sabre 45 because of the aircraft's 45 degrees of wing sweepback.

Advanced Development Objective **September 1950**

Unsolicited Proposal **January 1951**

North American submitted Sabre 45 design for consideration as supersonic day fighter.

General Operational Requirements **27 August 1951**

Called for an air superiority weapon to be operational preferably in 1955 and not later than 1957.

Go-Ahead Decision **October 1951**

The Air Force Council pressed for the development of revised Sabre 45. This decision ran counter to the belief of key development personnel that the aircraft would not meet the simplicity and cost requirements, basic to a day fighter. To obtain quickly a new fighter that would substantially surpass the F-86, the Air Force Council also agreed with the Aircraft and Weapons Board's recommendations to buy it in quantity prior to flight-testing, even though this ran the risk of extensive modifications in the future.

Mockup Inspection (Sabre 45) **7 November 1951**

The Mockup Board received more than 100 airplane configuration change requests. The Board also identified several armament deficiencies and requested a number of modifications to increase the "kill" potential of the aircraft.

Official Designation **30 November 1951**

The revised Sabre 45 was standardized as the F-100.

Initial Contract Date **3 January 1952**

The Air Force issued a letter contract for two F-100A prototypes.

First Contract for Production **11 February 1952**

The Air Force rushed through a second letter contract to procure 23 F-100As with fiscal year 1952 funds.

Mockup Inspection (F-100A) **21 March 1952**

Concentration on F-84 and F-86 improvement and faster production during the Korean War slowed down design of the F-100. However, the revised mockup featured most of the changes requested by the Air Force in late 1951.

Second Production Contract **August 1952**

Having found the revised mockup basically satisfactory, the Air Force directed procurement of 250 additional F-100As.

First Flight (Prototype) **25 May 1953**

The prototype flight was accomplished 7 months ahead of date set by contractor. In a subsequent flight, the first YF-100A reached a speed of Mach 1.05 while equipped with a derated prototype engine (one Pratt & Whitney XJ-57-P-7 turbojet not tuned up to its full power). However, by the time initial flight testing of the prototype was completed on 25 September, three major deficiencies were confirmed, all of which required correction before the F-100A could be considered an acceptable combat weapon system. The second prototype flew on 14 October, later than expected but still ahead of the original schedule.

First Flight (Production Aircraft) **29 October 1953**

Two weeks after the first flight of the second prototype.

Flight Testing **November 1953-December 1955**

The first F-100A was subjected to considerable testing in order to develop "fixes" for the deficiencies disclosed during the prototype's flight tests, but a general strike by the North American labor force during the last 3 months of 1953 impeded progress by delaying delivery of early production aircraft earmarked for the USAF flight test program. During the same period, a North American pilot demonstrated the aircraft's high-speed guarantees by reaching Mach 1.34 during level flight at 35,000 feet. In late 1955, despite the many improvements made during the 2 intervening years, the F-100A was evaluated by the Air Proving Ground Command as superior in performance to other fighters in the USAF inventory, but of limited tactical capability because of functional deficiencies. The month-long operational suitability tests conducted under Project Hot Rod—a project initiated because of the difficulties encountered with the Convair F-102 interceptor—once more confirmed the F-100A's shortcomings and the inadequacies of the tactical air control system. APGC also concluded that a fighter-day squadron equipped with F-100A aircraft could operate substantially as well as an F-86 squadron, but did require an augmentation of support facilities and personnel.

Program Change **December 1953**

In spite of its serious flight control and stability deficiencies, the F-100A was still urgently needed by the Tactical Air Command. Greatly concerned by concurrent slippages in the F-84F program, TAC also recommended production of a day fighter with a secondary fighter-bomber capability to satisfy forthcoming Air Force requirements as well as those of the foreign countries covered by the Mutual Development Assistance Program. In consideration of such factors, the Air Council directed the deletion of 70 F–100As and production of an equivalent number of a tactical-bomber version of the aircraft.

Early Modifications **December 1953**

Black boxes were incorporated in the yaw and pitch control axis of the F–100A to eliminate stability and control problems at certain speeds. Glass was added to the side panels of the forward cockpit to increase visibility, but further improvement of this third major deficiency was also under study. Two other major modifications were approved. The first, suggested by North American, involved the installation of integral fuel wings on future F–100A productions to provide the aircraft with a radius equivalent, on internal fuel, to that obtained with two 275 gallon tanks. The other, as proposed by TAC in mid-1953, would give forthcoming F–100As both a conventional and nuclear bombing capability.

First Acceptance (Production Aircraft for Operational Inventory) **September 1954**

This F–100A and 69 others differed from the prototype aircraft in having a shorter fin and rudder of increased chord. In an attempt to overcome continuing control difficulties in the roll, the shape of the vertical tail surfaces of the other 133 F–100As built was again changed. The Air Force began to take delivery of the latter aircraft in the spring of 1954, but the initial productions were allocated to the testing program. Unmodified F–100As were the first to be released for operational use. They began reaching TAC on 18 September.

Second Program Change **September 1954**

Because of improvements in Soviet fighters, the Air Force decided to accelerate the F–100 production and to procure a third model series of the aircraft. North American was directed to open a second production source at Columbus.

Enters Operational Service **27 September 1954**

With TAC's 479th Fighter Day Wing, at George AFB, as an interim aircraft pending replacement by modified F–100A versions and subsequent model series. The wing did not acquire an initial operational capability until September 1955, but the operational F–100As gave TAC's pilots valuable experience in supersonic flight.

Significant Operational Problems **10 November 1954**

All F–100A aircraft were grounded following six major accidents caused by still unsatisfactory yaw characteristics, structural failures induced by aerodynamic forces exceeding the airframe's

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limits, and malfunctions of the flight control system's hydraulic pump. Concurrently, the aircraft coming off the production line were kept in storage to await corrective modification. Production, which had been expanded 2 months before, was limited to 24 aircraft per month. Although the Air Force partially lifted the imposed flying and production restrictions in February 1955 and aircraft deliveries were resumed in April, the IOC of most of the F–100A squadrons was set back about 6 months.

Subsequent Model Series

F–100C

Other Configurations **December 1954**

YF–107A (F–100B). The model series between the F–100A and the F–100C, the F–100B, as called for on 16 December 1954 by GOR 68, was conceived as a tactical fighter-bomber as well as an air superiority day and night fighter. Three prototypes were built, but they were so extensively redesigned that their intended designation was changed to YF–107A before the first example flew on 10 September 1956. A unique feature of the YF–107A (powered by a J–75–P–11 axial flow gas turbine engine with afterburner) was the engine inlet duct, located on the upper fuselage behind the cockpit canopy, which incorporated a wedge and a two-position ramp to ensure optimum propulsion during high speeds. Another unusual feature of the YF–107A configuration was a logistics pod, proposed by North American to increase the aircraft's ground force support capability. According to North American, the YF–107A airframe's pod cavity could also be used to carry a power plant to start transient aircraft. In mid-1956 the Air Force considered the YF–107A as a possible substitute for the troublesome F–105 being developed by the Republic Aviation Corporation and testing of the three prototypes was accelerated. In February 1957, however, the F–107 program was discontinued because, despite recurring slippages, the Republic F–105 was still significantly ahead of the North American plane from a production standpoint. GOR 68 was cancelled on 22 March 1957 and the three YF–107As were transferred to the National Aeronautics and Space Administration (NASA) for further research in high supersonic speed ranges.[1]

Mid-1954

F–100BI. An interceptor version of the F–100B also was considered before that aircraft matured as the prototype F–107A. In July a mockup of the future F–100BI, as it was referred to, was completed as a potential backup for the F–102 interceptor being produced by Convair. Development of the aircraft did not material-

[1] One YF–107A is now on display at the Air Force Museum.

ize when it became evident that the known deficiencies of the F–100A, regardless of the improvements expected from the subsequent model series, would prevent the F–100BI from satisfying the Air Defense Command's operational requirements more fully than the F–102 interceptor already under contract.

1961

RF–100A. Another configuration of the F–100A came into being when four of the aircraft were fitted with reconnaissance equipment. The new RF–100As were delivered to Nationalist China in late 1961 under the auspices of the Military Assistant Program.

End of Production **April 1955**

The Air Force took delivery of the last 23 F–100As in July 1955.

Total F-100As Accepted

203

Acceptance Rates

Fifteen F–100As were accepted in FY 54, 165 in FY 55, and 23 during the first month of FY 56.

Flyaway Cost Per Production Aircraft

$1,014,910.00—airframe, $748,259; engine (installed), $217,390; electronics, $8,549; ordnance, $20,807; armament, $19,905.

Average Maintenance Cost Per Flying Hour

$215.00

Total RDT&E Cost

$23.2 million. When the F–100 program ended, prorating this cumulative R&D cost boosted every F–100 model's unit price by $10,134.00.

Phaseout **1958-1961**

F–100As began leaving the Air Force tactical inventory in 1958 when 47 aircraft were transferred to the ANG. In mid-1959, the military assistance program allocated 15 F–100As to Nationalist China and TAC prepared to store most of the remaining aircraft at Nellis AFB. In 1960, 65 additional F–100As were given to the Chinese Nationalist Air Force. The ANG inventory reached its full quota of 70 F–100As during the same year. By the end of 1961, 47 major flying accidents and the modification or cannibalizing of a few of the other aircraft accounted for the active fleet's entire phaseout.

Reactivation **1961-1962**

F–100As rejoined the Air Force's operational inventory, as ANG and AFR units were recalled to active duty because of the Berlin crisis. In early 1962, despite the aircraft's operational deficiencies, the Air Force decided to extend the F–100's service life. Many of the ANG aircraft which came under the operational control of TAC, after the release of the ANG personnel, were retained in the command's inventory.

Final Disposition **1962-1970**

Thirty-eight of the aircraft repossessed from the ANG were subsequently transferred to Nationalist China, bringing to 118 the total of F-100As furnished to that country by the Military Assistant Program. Most of the other F-100As retained by the Air Force were used for aircrew training. The Air Force gave up its last F-100A in early 1970, 3 years after the ANG had lost its remaining few through attrition.

Record Flight **29 October 1953**

The first of the two YF-100A prototypes set a world speed record of 755.149 mph in the last such record established at low altitude.

Other Milestones

The F-100A Super Sabre was also first as the Air Force's Century-series fighter, and as an operational fighter capable of level supersonic performance.

F-100C

Manufacturer's Models NA-214, -217, and -222

Previous Model Series

F-100A

New Features

Fuel tanks inside the wings. Pylons to hold extra fuel drop tanks and additional stores (bombs and rockets), as called for by the aircraft's secondary fighter-bomber role. The first F-100Cs, like the F-100As, were equipped with the Pratt & Whitney J-57-P-7 engines. Others, before the 101st production, were powered by the J-57-P-39s. The later version of the F-100C incorporated the increased thrust of the J-57-P-21. The F-100C also differed from the F-100A by being fitted for the probe and drogue type of in-flight refueling.

Definitive Contract for Production **February 1954**

The Air Force eventually bought 476 F-100Cs, using FY 53 funds for the first 70, FY 54 funds for the next 381, and FY 55 funds for the last 25.

First Flight (Prototype) **March 1954**

First Flight (Production Aircraft with P-7 Engine) **17 January 1955**

The aircraft was accepted by the Air Force in April 1955. Production of the first F-100Cs, totaling 100 aircraft equipped with J-57-

P–7 or –P–39 engines, was completed in September of the same year.

Enters Operational Service **14 July 1955**

With the 450th Day Fighter Wing (later the 322d Fighter Day Group) at Foster AFB, Tex.

First Flight (Production Aircraft with P-21 Engine) **September 1955**

Two months after the –P–7 engine-equipped F–100C entered operational service and 2 months before being accepted by the Air Force.

Flight Testing **1955**

Functional development testing (Phase VI) of the F–100C started in February with the first production (J–57–P–7 engine-equipped) aircraft. The tests confirmed that the F–100C, with many of the features of the F–100A day fighter from which it was developed, could be expected to fill the bomber role only until a more suitable fighter-bomber could be added to the Air Force inventory. Operational suitability testing of the later F–100C productions was conducted toward the end of the year. The tests disclosed that the aircraft's chief advantage over the earlier F–100A and F–100C configurations derived from the increased thrust delivery of the J–57–P–21 engine. The tests also indicated that earlier configuration deficiencies were still present, not the least of which was the susceptibility of the Pratt & Whitney J–57 engine to compressor stall. On the other hand, the OST reports pointed out, the F–100C was an excellent vehicle for the low-altitude bombing system (LABS) because its maximum ground speed of 1,050 feet per second was considerably higher than the delivery speed of contemporary operational fighters. Another worthy feature of the F–100C, shared by all other F–100 configurations, was the aircraft's nose-wheel steering system which permitted safe taxiing even in cross winds up to 30 knots per hour.

Modifications **1955**

Like the F–100A, when used in its primary day fighter role, the F–100C at high speeds had the tendency to yaw and then go into an uncontrollable roll. Beginning with the 146th F–100C production, significant improvement was obtained with the installation of an hydraulically activated and electrically controlled yaw damper. Assisted by North American teams, the Air Force retrofitted the first 145 F–100Cs with the device. Similarly, damping of longitudinal oscillations was increased by the addition of a pitch damper in the horizontal stabilizer control system. Factory incorporation of the pitch damper started with the 301st F–100C at a cost of almost $10,000.00 per aircraft. Another modification to reduce the F–100C's landing speed, an increasingly critical jet aircraft problem, was given up. The modification, North American revealed, would require replacement of the aircraft's wings. The Air Force concluded that the cost involved would be out of proportion to the benefit received.

Operational Problems **December 1955**

An asset of the F–100C over the F–100A was the aircraft's capability to carry extra fuel. Fuel tanks were located in the fuselage as well as in the wings and external fuel was carried in two 275-gal tanks which could be supplemented by two 200-gal tanks. The additional 200-gal tanks permitted greater range but resulted in a loss of directional stability which was most critical at speeds in excess of Mach .8 when these tanks were used on the inboard stations in conjunction with the 275-gal tanks. Remedial action through enlargement of the aircraft's stabilizer—a feature of subsequent F–100 model series—was disapproved because of the excessive cost and time involved. Instead, after testing showed that larger external tanks did not affect the F–100C's longitudinal stability, the Air Force prohibited the use of the 200-gal tanks and directed replacement of the 275 and 200-gal tank combination by 450-gal external tanks. During the same period, Pratt & Whitney improvised a partial remedy for compressor stalls in the F–100's J-57 engine by installing a pressure bleed off which served to release the accumulated gases and prevent internal explosions.

End of Production **April 1956**

Production ended after the 476th aircraft—451 built by the North American's Inglewood plant in California, and 25 by the contractor's second plant at Columbus, Ohio.

Subsequent Model Series

F–100D

Other Configurations

None

Acceptance Rates

Sixteen F–100Cs were accepted in FY 55, 459 in FY 56, and one in the first month of FY 57.

Last Acceptance **July 1956**

Total F-100Cs Accepted

476

Flyaway Cost Per Production Aircraft

$663,181.00—airframe, $439,323; engine (installed), $178,554; electronics, $12,050; armament, $21,125; ordnance, $12,125.

Average Maintenance Cost Per Flying Hour

$249.00

Special Utilization **1956**

The Air Force began to re-equip its Air Demonstration "Thunderbirds" Squadron with supersonic F–100Cs. The team retained the C-model Super Sabre until 1964.

Oversea Deployments **December 1956**

More than 150 F–100Cs had reached the USAFE inventory, 55 at Bitburg, 6 at Furstenfelbruck, 30 at Landstuhl, and 26 at Hahn, all air bases located in West Germany. Thirteen USAFE F–100Cs were at Sidi Slimane AB, in Morocco, and 26 at Camp New Amsterdam in the Netherlands.

Other Transfers **Mid-1959**

Four F–100Cs reached the ANG in FY 60, 89 more the following year. The aircraft with their units were returned to TAC's operational control during the Berlin crisis. Soon afterwards, in contrast with USAF retention of some of the recalled F–100As, F–100C transfers to the ANG were resumed. The Guard's F–100C inventory began climbing steadily from 122 aircraft in mid-1963 to its authorized peak of 210 in mid-1966. The USS Pueblo incident in January 1968 brought another recall of the Air National Guard, including the temporary mobilization of eight F–100C groups for a total of 200 aircraft. However, as called for by USAF planning, the ANG inventory in late 1970 again totaled 210 F–100Cs. Seventeen of these aircraft were used for training. More than 90 percent of the others were combat ready.

Problems and Additional Modifications **1961-1966**

The F–100's initial deficiencies, the extended retention of the aircraft, the shortages and requirements created by the war in Vietnam, all were to cause numerous modifications of the weapon system. In 1961 the lack of J–59–39 engine spares made it necessary to replace the engine of numerous F–100Cs. In 1962 the aircraft's capability to carry two MA–3 launchers was increased to six and another modification was accomplished to exchange the F–100C's AB/APG–30A radar for the more modern AN/ASC–17. Meanwhile, the F–100 fuel tank problem, identified in 1955, persisted. The Air Force directed as an initial solution the use of 450-gallon tanks, but these proved expensive and scarce. A TAC recommendation to replace 450-gallon tanks with 335-gallon ones was later approved, but still posed many technical difficulties. In addition to the known deficiencies calling for further improvement, other problems were either defined or took on added importance in the following years. Foremost in the mid-sixties, was the F–100C's inability to deliver all of the primary non-nuclear weapons in the Air Force arsenal. Late in 1965, only 125 ANG F–100Cs could use the CBU bombs and AIM–9B Sidewinder missiles. Despite TAC efforts to improve the armament systems of the aircraft allocated to the Guard, the modifications scheduled for 1966 were postponed for over a year because of a shortage of adapters and Aero 3B launchers. During the same period, the operational capability of the ANG's F–100Cs also was limited by the scarcity of MJ–1 bomb lifts and MHU–12H trailers.

Phaseout **June 1970**

In spite of the 1962 decision to extend the F–100 service life, the F–100Cs were quickly supplanted by the F–100Ds. Eighty-five major flying accidents, the cannibalizing of 18 aircraft, re-equipping of the Thunderbirds, and priority modernization of the ANG tactical fighter units, almost entirely depleted the inventory of the regular forces. The Air Force used most of its few available F–100Cs for training until March 1970, when the last three flew their final missions. Two of the three F–100Cs remaining in the training program had accumulated a combined total of 4,929 flying hours since the fall of 1958. Transfer of these aircraft and of 12 other F–100Cs to the Air National Guard completed the fleet's phaseout from the Air Force inventory.

Record Flight **20 August 1955**

An F–100C established a world speed record—the first above Mach 1—at 822.135 mph.

Other Milestones **4 September 1955**

F–100C won the Bendix Trophy transcontinental race, 2,325 miles at average speed of 610.726 mph.

13 May 1957

Three USAF F–100C Super Sabres set a distance record for single-engine jet aircraft, flying 6,710 miles from London, England to Los Angeles, Calif., in 14 hours and 4 minutes, using in-flight refueling.

F-100D

Manufacturer's Model NA-223, -224, -235, -245.

Previous Model Series

F–100C

New Features

Increased wing and vertical tail area, additional electronic equipment, autopilot, provision for "Buddy" tanker refueling equipment, two 450 gallon air-refuelable external tanks, and inboard landing flaps.

Basic Development **May 1954**

TAC's request for a more sophisticated fighter-bomber led to an Air Force study of a third configuration in the 100-series—the F–100D. In contrast to the F–100A and F–100C, the F–100D would serve primarily as a fighter-bomber and only secondarily as a day fighter.

Initial Contract for Production **October 1954**

Additional procurement was directed in March and December 1955. On the latter date, however, total procurement dropped from scheduled peak of 1,604 F–100Ds. The decrease resulted from the Air Force's decision to purchase a two-seat trainer version of the aircraft.

Special Armament Tests **December 1955**

Six F–100Cs were modified to test the possibility of arming the F–100D with infrared missiles. Some of the prototyped F–100Cs were equipped with the Hughes GAR–1B infrared seeker models of the air-launched Falcon missiles; others, with the GAR–8 (later redesignated AIM–9B) Sidewinders being developed by Philco and General Electric. Testing of the two combinations resulted in the September 1956 selection of the Sidewinder to increase the F–100D's potency in the intercept role. Provisions for installation of the air-to-air Sidewinders started with the 184th F–100D production, when provisions for center line special stores also began.

First Acceptance **November 1955**

The delivery of all F–100Ds earmarked for testing was completed in the spring of 1956.

First Flight (Production Aircraft) **24 January 1956**

The aircraft had been built by the Inglewood plant. The first F–100D completed by the North American's second production line at Columbus first flew on 12 June 1956.

First Acceptance (Production Aircraft) **April 1956**

Deliveries to TAC units at Langley AFB began in September. By the end of the year 79 F–100Ds were in TAC's operational inventory.

Initial Problems and Directed Modifications **27 June 1956**

The Air Force identified for North American several major deficiencies of the F–100D. Included were the failings of the Sundstrand Constant Speed Drive (designed to provide the aircraft's electrical system with constant frequency electricity), the incomplete tie-in between the autopilot and low-altitude bombing systems, the inaccuracy of the MA–3 fire control and, depending on its load, the gravitational pull ("G" force) sustained by the F–100D when flying at subsonic speed above 32,000 feet. Despite TAC's concern, a large number of F–100Ds entered the operational inventory before these and other F–100D shortcomings could be rectified.

Improvement Slippages **July 1956**

In spite of considerable efforts, improvement of the F–100D's autopilot was delayed. Installation of the improved autopilot, scheduled to begin with the first production-provisions for Sidewinder missiles and center line special stores, slipped from the 184th F–100D production to the 384th. In-service F–100Ds were subsequently retrofitted.

Enters Operational Service **29 September 1956**

With TAC's 405th Fighter-Bomber Wing at Langley AFB.

Oversea Deployments **December 1956**

TAC's recommendation that F–100D oversea deployments be postponed was overruled. USAFE acknowledged the aircraft's deficiencies and needed modifications, but pointed out that the F–100D, as it was, still represented an improvement of its forces. Too, in anticipation of the command's conversion to F–100Ds, modification of the USAFE F–84F and F–86F fighter-bombers had already been stopped. The Far East Air Forces took side with USAFE, and by the end of December 136 F–100Ds had reached the oversea theaters—the 46 FEAF F–100Ds were at Itazuke AB; the 70 USAFE F–100D aircraft were at Etain and Chaumont, France, and at Boulhaut and Sidi Slimane Air Bases in Morocco.

Other Modifications **1957-1959**

High-altitude maneuver problems were solved in early 1957. Necessary adjustments were first included in the aircraft's 225th production and earlier F–100Ds were retrofitted. Various engineering changes to improve the F–100D's Constant Speed Drive (CSD) were not so successful. To minimize the danger of in-flight case rupture, the Air Force in June 1957 directed that the CSD be placed on a separate oil system. Modification of the aircraft already released from the factories was completed in February 1958. Sixty-five F–100Ds were modified to increase their striking power by using the GAM–83 Bullpup air-to-surface missiles. This additional modification was completed in late 1959 as programmed, but the Bullpup deliveries fell behind schedule. The first GAM–83-equipped F–100D squadron became operational in December 1960 and three more by June 1961.

Other Special Features

Boosted by a 150,000-lb Astrodyne rocket, the F–100 first demonstrated zero-length launching on 7 June 1957 at Edwards AFB. Final F–100D productions incorporated equipment for the zero-length launches from atomic shelters.

End of Production **1957-1959**

Production of the F–100D, scheduled to end in early 1958, was stretched out to keep North American's labor force in being. In April 1957 production began to drop gradually from a monthly average of 45 aircraft to about five in October 1958. This low rate of production remained in effect until August 1959, when the Air Force took possession of the last five F–100Ds built by the Inglewood factory. The Air Force stretch-out directive did not cover the North American's second production line. As initially programmed, F–100D productions at Columbus ended in December 1957.

Subsequent Model Series

F–100F

Other Configurations

None. A number of other single-seat versions of the Super Sabre were proposed but failed to materialize, including the all-weather F–100J offered to Japan through the Foreign Military Sales Program, the F–100L with a J–57–P–55 engine in place of the –21A, and the F–100N, a simplified D-model with reduced electronic equipment.

Acceptance Rates

One hundred and thirteen F–100Ds were accepted from the Inglewood factory in FY 56, 576 in FY 57, 166 in FY 58, 75 in FY 59, and 10 in FY 60. Two F–100Ds, built in Columbus, were accepted in FY 56, 212 in FY 57, and 120 in FY 58.

Last Acceptances

From Columbus, December 1957; from Inglewood, August 1959.

Total F–100Ds Accepted

1,274—940 from Inglewood and 334 from Columbus.

Flyaway Cost Per Production Aircraft[2]

$697,029.00—airframe, $448,216; engine (installed), $162,995; electronics, $10,904; ordnance, $8,684; armament, $66,230.

Average Cost Per Flying Hour

$583.00

Average Maintenance Cost Per Flying Hour

$249.00

Postproduction Problems **1959–1962**

Parts shortages and some of the J–57 malfunctions were alleviated but problems with the engine bearings and the aircraft's afterburner fuel system remained unsolved. Moreover, deficiencies persisted in the pylon assembly. Testing disclosed that correction of these deficiencies would not stop inadvertent bomb releases due to improper bomb-loading procedures. Procurement of additional pylons for war reserve was therefore postponed. Air refueling of the

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[2] Excluding $10,134 of prorated RDT&E cost and cumulative modification costs specifically spent on certain F–100 models, i.e., $224,048 on each F–100C; $110,599 on each F–100D; and $105,604 on each F–100F.

F–100D also did not work as well as first expected. Recurring losses of probes during high speed and high "G" force maneuvers caused the removal of refueling probes from all F–100Ds, except for air refueling missions, pending reinforcement of the aircraft's underwing structures. In late 1962, a shortage of 450-gallon tanks and the depletion of TAC's 335-gallon tank reserves compounded the difficulty of standardizing the F–100 fleet.

Postproduction Improvements 1962–1965

Like previous F–100 model series, the D's combat life was extended in 1962, and the aircraft's capability to deliver non-nuclear weapons was increased. Necessary modifications, applied also to the F–100Fs, were completed in April of the same year. Another much more extensive modification program, referred to as High Wire, ensued. The main purpose of the High Wire work, accomplished by both the Air Force and North American, was to standardize a weapon system which had been modified on so many occasions that individual aircraft differed from each other. The High Wire modifications, requiring about 60 workdays per aircraft, were applied to some 700 F–100s and completed in mid-1965. Overall cost reached $150 million, but the results were gratifying.

Unrelenting and New Difficulties 1965

Regardless of the remarkable High Wire achievements, the F–100Ds, as well as all other F–100s, continued to present operational problems. Malfunctions of the aircraft's landing gear and the unreliability of its drag chutes accounted for a number of accidents. In addition, while compressor stalls in the J–57–21 engine still occurred, of new concern was the engine itself, which had gone beyond its reliable service life and for which no replacement was available. Complete overhaul of the engines, as subsequently directed, took care of this new problem, but not without trials. Some of the Aerodex-overhauled J–57 engines proved to be unsatisfactory, and a continuing shortage of spares further slowed down the F–100 inspection and repair as necessary (IRAN) cycle.

Combat Deployments 1965

Several F–100 aircraft, belonging to the Thirteenth Air Force in the Phillipines, were initially deployed in Thailand in May 1962 to restrain Communist forces overrunning most of Northwest Laos. However, F–100 operations over North Vietnam did not start until 1965. The Air Force used F–100 jets in South Vietnam in February of the same year, also for the first time. F–100 deployments to Southeast Asia (SEA)[3] were accelerated soon afterwards, and by 30 June 1967 only five F–100 squadrons remained in the United States.

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[3] Republic of Vietnam, Thailand, Laos, and Cambodia.

Structural Modifications **1966-1969**

A second decision in 1966 to keep the F–100s in the USAF inventory longer than ever anticipated prompted the Air Force to investigate the extent and cost of the structural modifications needed to stretch the F–100-designed service life of 3,000 flying hours to a ceiling of 5,500 hours. This was later increased to 7,000 hours to permit retention of the D and F model series through 1971. Because of the F–100's high rate of weapon deliveries in SEA, the Air Force, assisted by North American, also began in early 1967 to examine the structural condition of the aircraft's wings. They also examined the possibility of redesigning the wing lower skin should this be needed due to the aircraft's extensive combat use. In mid-1967, the urgent need for safety improvements was confirmed when one aircraft crashed because of wing failure. The accident led the Air Force to ground a number of F–100s, pending reinforcement of their wings with external straps. In the final months of 1967, the Air Force came up with a complete F–100 structural modification program. By 1969, modification of the wing center section was completed on 682 of the program's 882 aircraft. Modification of the F–100's lowest wing outer panel—considered mandatory by the Air Force before the aircraft reached a total of 4,000 flying hours—also went well.

Special SEA Modifications **1967-1968**

As operational requirements rose, various modifications were undertaken to raise the combat capability of the F–100 aircraft, some of which reached almost 14 years of age. The aircraft's weapon release and firing system were improved; new guns and a more accurate target-marking system were provided. Combat Skyspot, a modification program first implemented in April 1966 and covering most of the USAF SEA aircraft, was completed. The modification, which included the equipping of each aircraft with Motorola's new SST–181X band radar transmitter, gave a ground-directed bombing capability to all F–100s operating at night or in bad weather.

Attrition **July 1956-June 1970**

The Air Force lost over 500 F–100Ds, with many of the accidents occurring during the first 2 years of the aircraft's operational service. In the following years, numerous modifications and an intensive training program to curtail pilot errors reduced accident rates. This trend was reversed in the late sixties as F–100D combat operations increased. In 1 year, more than 50 F–100Ds were lost in the war.

Phaseout **Mid-1972**

The ANG received its first F–100Ds in 1969 but by mid-1970 had only 20. USAF plans called for keeping most of its 364 operational F–100Ds through 1971. However, phaseout of F–100D/F fighters in South Vietnam was stepped up.[4] Hence, by mid-1972 only 12 F–100Ds remained on USAF rolls while the Guard boasted 335.

Other Countries

The Air Force lost 203 of its 1,274 F–100Ds to the Military Assistant Program. The aircraft, used to modernize NATO forces, were all equipped—at a cost of $17,755. per aircraft—with the ARN–21 UHF navigation equipment, commonly adopted by the Air Force and the allied air forces. Another modification, one that would allow use of the early GAR–8 Sidewinder missiles, was only approved for 150 of the aircraft. It was completed in 1960 at a total cost of some $2 million. France, the first recipient country, was given 68 F–100Ds; Denmark followed, with the allocation of 48 aircraft. The F–100D Military Assistance Program was also extended to Turkey which received the highest number—87 aircraft.

Other Uses

The F–100Ds played an important role in the Air Force critical training of SEA replacement crews. In mid-1970, 44 F–100Ds remained assigned to the training programs conducted at Luke and at Cannon AFB, N. Mex.

Special Assignment

The Air Force Thunderbirds squadron began replacing its F–100Cs with F–105 Thunderchiefs in early 1964, but a major F–105 flying accident in May prompted the Air Force to re-equip its precision flying team with eight F–100Ds, modified for demonstration purposes. The team received its new Super Sabres in July and resumed its demonstrations 30 days later. The Thunderbirds flew F–100Ds until November 1968 when they started to transition into the faster, higher-flying F–4E Phantoms.

Milestones **26 December 1956**

Buddy refueling was first achieved between two F–100D aircraft.

F-100F

Manufacturer's Model NA-243.

Previous Model Series

F–100D

New Features

Tandem two-seat cockpit with dual controls. Only two of the F–100D's four built-in 20-mm M–39 guns.

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[4] F–100D/F fighters from the 35th Tactical Fighter Wing redeployed from Phan Rang AB, to the United States in July 1971.

Basic Development **8 September 1955**

North American Aviation proposal to modify an F–100C to a trainer fighter version at no cost to the Air Force.

Production Decision **November 1955**

The Air Force Council decision stemmed from the alarming rate of F–100 flying accidents which indicated the urgent need of a two-place supersonic trainer to replace the Air Force's standard jet trainer—the 7-year-old T–33, a variant of the Lockheed P–80 "Shooting Star," first developed in the latter part of World War II. The decision vindicated, at least temporarily, those who had advocated a two-seat trainer version for each fighter aircraft.

Initial Contract for Production **December 1955**

For 259 two-place aircraft. The contract was accompanied by a reduction in F–100D procurement.

Mockup Inspection **January 1956**

The inspection covered only the aircraft's cockpit.

First Flight (TF–100C) **6 August 1956**

This was the conversion trainer proposed by North American. Designated TF–100C, the aircraft, which lacked all operational equipment, served as the prototype for the F–100F.

First Flight (Production Aircraft) **7 March 1957**

This was the F–100F, derived from the single-seat F–100D tactical fighter bomber and designed to combine this role with that of combat proficiency trainer.

First Acceptance **January 1958**

This was the first F–100F, its delivery having been preceded, beginning in May 1957, by that of a number of F–100 trainers which were subsequently brought up to the F–100F's dual configuration. The aircraft entered TAC's operational inventory almost immediately, and by December 1958 the new F–100Fs had reached most of the oversea commands' F–100D units.

Flight Testing **1958-1959**

Because of its similarity to the F–100D, testing of the F–100F, like its operational use, could be speeded. Only limited performance and qualitative (stability and control) tests were conducted, and those were completed in May 1958. The Category II performance tests, also curtailed, were completed 1 year later.

End of Production **1959**

As with the F–100D and for the same reasons, the Air Force slowed down production of the F–100Fs. Delivery of the last one in September represented a slippage of several months from previous production schedules.

Total F-100Fs Accepted

The Air Force accepted 339—a total finalized in October 1958, after numerous program changes. Included in this number were 45 aircraft, specifically purchased for the Military Assistance Program.

Acceptance Rates

Fourteen two-seaters were accepted for the Air Force in FY 57, 227 in FY 58, and 53 in FY 59. Fourteen F-100Fs were accepted for the MAP in FY 58, 16 in FY 59, and 15 in FY 60.

Flyaway Cost Per Production Aircraft

$804,444.00—airframe, $577,023; engine (installed), $143,527; electronics, $13,677; ordnance, $3,885; armament, $66,332.

Average Cost Per Flying Hour

$583.00

Average Maintenance Cost Per Flying Hour

$249.00

Subsequent Model Series

None

Other Configurations

None. In 1964 North American attempted to establish a production line in France for some 200 two-seat Super Sabres designated F-100S by the manufacturer. The proposed F-100S utilized the basic F-100F airframe and a Rolls-Royce RB 168-25R Spey turbofan in place of the J-57-P-21 or -21A to improve performance. As in the case of the proposed F-100J, L, and N versions, the project did not materialize.

Postproduction Problems and Improvements 1959-1965

Engine malfunctions, spare and part shortages, and F-100D component deficiencies were experienced by the aircraft's two-seat model. Consequently, F-100D modification programs encompassed the F-100Fs. In 1959 fifteen of the aircraft were modified to increase their striking power through use of the GAM-83 Bullpups. In 1962 all F-100Fs were modified to increase their nonnuclear combat capability.

Structural Modifications

The F-100 service life's several extension decisions and resulting structural modifications of necessity were applied to the F-100F, because this last model in the series was of the D vintage, with the same airframe and wings.

Special SEA Modifications

Seven F-100F aircraft—designated "Wild Weasel I"—were modified to carry special equipment. This included the APR-25 vector radar homing and warning (RHAW) receiver to detect S-band signals (emitted by SA–2 fire control radar and early warning/ground controlled intercept radar), and C-band signals (from improved SA–2) and the X-band airborne intercept radar. They also were equipped with the APR–25 (WR–300) L-band warning receiver to indicate missile guidance emissions, and the IR–133 panoramic receiver that could detect S-band signals at a greater range than the APR–25. The KA–60 panoramic camera and a dual-track tape recorder also were installed in the Wild Weasel I aircraft.

Wild Weasel Deployments **1965-1966**

Four aircraft were deployed from Eglin to Korat, Thailand on 21 November 1965 and assigned to the operational control of the 388th Tactical Fighter Wing. They began to fly war missions on 3 December. Three additional Wild Weasel I aircraft were deployed to the SEA theater on 27 February 1966, also to participate in the "Iron Hand" anti-SAM air campaign.

Other Combat Modifications **1966**

F–100Fs were equipped with the AGM–45 Shrike missile. In April the Wild Weasel planes themselves began attacking the North Vietnamese Fan Song fire control radars.

Attrition **July 1958-June 1970**

F–100F accident rates followed the F–100D's pattern, with 31 losses registered during the first 2 years of the aircraft's service life. Accident rates decreased subsequently, but the losses began again to rise in the mid-sixties. By June 1970 a total of 74 aircraft, one fourth of the Air Force's 294 F–100Fs, had been lost in major accidents.

Phaseout **Mid-1972**

Like the F–100D, the F–100F was practically out of USAF inventory by mid-1972. The ANG had received an initial increment of six F–100Fs in 1958, but little more until the late sixties. In June 1972, however, the Guard had 550 F–100s, 100 of then F–100Fs. Five ANG squadrons had already completed the installation of F–102-type afterburner on their assigned F–100s. This modification—service-tested by the Air force—helped solve the F–100's chronic compressor stall problem and reduced engine bay temperatures. Although available F–102 afterburners were being overhauled, $8 million worth of new flap-type afterburners had to be ordered. Yet, the Air Force believed the latest F–100 modification would pay for itself in 2 years.

Other Countries

A number of F–100Fs were flown by the Danish, French, and Turkish air forces.

332–464 O - 80 - 10 : QL 3

 7 August 1959
Two USAF F–100Fs made first flight by jet fighter aircraft over North Pole.

PROGRAM RECAP

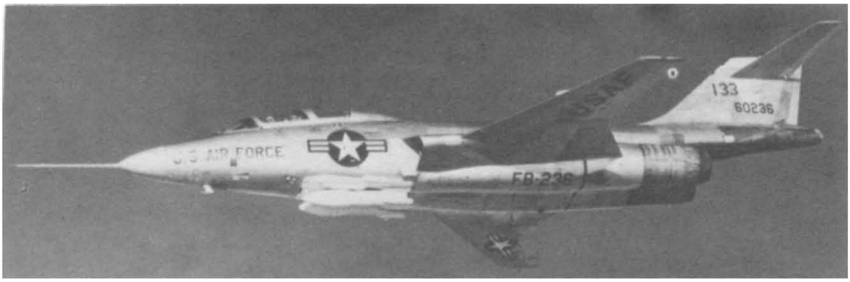
The Air Force accepted a grand total of 2,294 F–100s—45 F–100Fs for the Military Assistance Program; the rest, for its own use. Among the USAF 2,249 F–100s were 2 F–100A prototypes, 203 F–100As, 476 F–100Cs, 1,274 F–100Ds, and 294 F–100Fs.

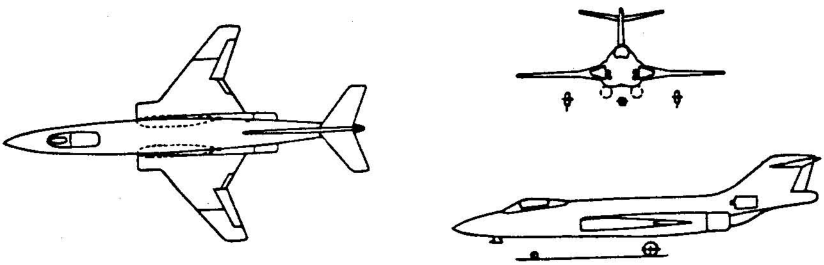
F–100A/C/D and F–100F

Manufacturer	North American Aviation Inc., Inglewood, Calif. and Columbus, Ohio (F–100C and D).
Nomenclature	Supersonic Tactical Fighter (F–100A/C). Supersonic Tactical Fighter-Bomber (F–100D). Supersonic Tactical Fighter-Bomber and Combat Trainer (F–100F).
Popular Name	Super Sabre

Characteristics	*F–100A*	*F–100C*	*F–100D*	*F–100F*
Length/Wing	48 ft/39 ft	47 ft/39 ft	49 ft/39 ft	52.5 ft/39 ft
Takeoff Weight	32,500 lb	37,000 lb	39,750 lb	40,100 lb
Takeoff Ground Run	6,150 ft	4,590 ft	5,030 ft	5,210 ft
Max. Speed at 35,000 ft	710 kn	803 kn	790 kn	790 kn
Radius	510 nm	500 nm	460 nm	450 nm
Engine, Number & Designation	1 J–57–P–7	1 J–57–P–21	1 J–57–P–21A	1 J–57–P–21
Crew	1	1	1	2
Combat Ceiling	49,000 ft	49,000 ft	47,700 ft	47,300 ft
Rate of Climb (sea level)	4,200 fpm	4,600 fpm	4,100 fpm	4,000 fpm
Guns	4 20-mm M–39s	4 20-mm M–39s	4 20-mm M–39s	2 20-mm M–39s
Rockets	14 2.75″ FFARs	42 2.75″ FFARs or 2 AIM–9B/E/J	38 2.75″[5] FFARs or 4 AIM–9B/E/J	38 2.75″[5] FFARs or 4 AIM–9B/E/J
Max. Bomb Load	5,000 lb	5,000 lb	7,040 lb	5,000 lb
Special Stores	1 MK–7 (Wg Station)	1 MK–7 (Wg Station)	1 MK–28 or MK–43/57/61 (C/L Pylon)	1 MK–7 or 1 MK–28/43/57/61 (C/L Pylon)

[5] In LAU–3/A launchers.





McDONNELL F-101 VOODOO

F–101A: The supersonic, single-seat F–101A Voodoo was developed from the experimental F–88.

F–101C: Looked like the A, but its structure had been strengthened.

RF–101: The most distinctive feature of the RF–101A was its nose, which had been lengthened for the installation of photographic equipment.

RF–101C: Retained the F–101C's capability of delivering nuclear weapons. The single-place, supersonic RF–101C soon established itself as the Air Force's reconnaissance workhorse.

F–101B: The interceptor version of the Voodoo had an elongated cockpit, permitting sitting of observer behind pilot. Moreover, it carried missiles and rockets. One out of every four F–101Bs (TF–101Bs), were fitted with dual-control kits for pilot training. Late F–101B productions featured a number of modifications and were identified as F–101Fs in 1961.

McDONNELL F-101 VOODOO

Manufacturer's Model 36W
Weapon System 105A

Basic Development **June 1946**

McDonnell's detail design of a strategic penetration fighter intended to escort bombers of the recently established—21 March 1946—Strategic Air Command. The Air Force ordered two prototypes of McDonnell's original Voodoo under the designation XF-88. The first XF-88 flew on 20 October 1948, some 6 months after the contracted delivery date. This initial slippage, the contractor claimed, was the result of changes in the prototype's structural design. The change from straight wing to a 35-degree wing-swept back, along with the danger of compressor stalls at high speed, caused McDonnell engineers to alter the shape of the ducts through which air entered the turbine engines. The second XF-88, with short afterburners boosting the thrust of its J-43-WE-22 engines, did not fly until 2 years later.

Program Cancellation **August 1950**

The Air Force cancelled the XF-88 contract a few months after the second prototype's first flight. The decision was due primarily to the shortage of funds that had been forewarned by President Truman in mid-1948 and to the United States endorsement of defense plans brought back from Europe by Secretary of Defense James V. Forrestal in the fall of the same year. These plans, urging greater use of the atomic bomb, meant that more atomic power had to be packed into SAC's forces. Hence, most of the Air Force money was spent on the B-36, one of the bombers that the F-88 had been designed to escort. Although the F-88 had failed to perform satisfactorily in its intended roles of escort fighter and ground support plane, many desirable qualities were attributed to its prototypes. Nevertheless, there were other reasons for cancelling production. A significant number of Republic's F-84Es, under contract since late 1948, had already entered USAF inventory and could satisfy immediate requirements for a penetration fighter. Moreover, a new model series of the proven North American Sabre, the F-86D—flown in December 1949—was expected to meet the urgent requirements for a better interceptor.

Program Reactivation **January 1951**

The Air Force, pending development of a new fighter, planned to replace the F-84E with the F-84F, the production of which had been decided. SAC, however, did not support these plans and wanted a long range fighter capable of escorting the transoceanic B-36s. On 12 January SAC outlined the minimum characteristics of the interim aircraft needed for the period 1952–1953. Headquarters USAF agreed to evaluate several contractor offers which might more nearly satisfy SAC.

General Operational Requirements **6 February 1951**

This GOR, published as Skeleton GOR 101, was subsequently expanded as GOR 101–2 to cover the aircraft's next model series. Both GORs were cancelled in November 1958, when the Air Force decided to terminate the F–101 production—the F–101B interceptor, excepted. New requirements, if any, would be met by modifying existing F–101s.

Competitors and Selection **May 1951**

Included in the contractor's offers in response to GOR 101 were Lockheed's F–90 and F–94, an improved configuration of the McDonnell F–88, North American's F–93, Northrop's improved F–89, and three Republic submissions—the F–91, the already purchased F–84F, and another version of the F–84F that would be equipped with a turboprop engine. McDonnell's new F–88 was chosen, but the Air Force did not commit itself to go to production until several months later.

Production Go-Ahead **October 1951**

The October production decision was the result of Korean War experiences. Existing fighters had proved unsatisfactory as escorts for B–29s. Between June 1950 and September 1951, American pilots flew a mix of fighters and downed 13 Russian-built MIGs for every plane lost, a ratio reflecting superior flying skill rather than better equipment.[1] The Air Force thus found itself facing two problems: development of a satisfactory escort fighter and replacement of the F–84s and F–86s used in Korea. In October 1951, it released fiscal year 1952 funds, previously allocated to the F–84F and F–86F aircraft, to get McDonnell's new F–88 into production without further delay. Moreover, instead of procuring the Voodoo solely as an interim fighter while an "ultimate" long range fighter was being developed, the Air Force decided that the latter would be obtained by improving early Voodoo productions. The first production aircraft would have the same airframe as the "ultimate" series, but the first aircraft would only incorporate "available" production-type equipment, systems components, and engines. Then, as more advanced equipment became available, the airframes would be modified to receive them.

Production Policy **26 November 1951**

The Cook-Craigie production policy, outlined for the Convair F–102, was extended to the new Voodoo. This meant that the initial production run of the basic aircraft would be kept to the minimum

[1] The F–86's final boxscore was 14 to 1.

needed for comprehensive testing. While these aircraft were being assembled, preparations would be made for full scale production of a version that would incorporate the changes judged necessary because of the test program. The test airplanes already produced would then be reworked on the production line into the approved configuration. The leading objectives were to eliminate the faults in a basic design before many aircraft had been built and to get operationally effective weapon systems into tactical use as quickly as possible.

Official Designation **30 November 1951**

The improved Voodoo bore the designation F–101. The Air Force Council directed the new designation because of the significant differences between the F–88 and the new configuration proposed by McDonnell in May 1951.

F101A

Contractual Arrangements **1952**

McDonnell accepted on 15 January the initial F–101A letter contract offered by the Air Force on condition that the final contract would be of the fixed price, incentive type. The Air Force accepted McDonnell's terms and signed such a contract on 11 June 1952. Cost increases, judged excessive by the Air Force, led to a renegotiation of the contract. It was finally concluded in November 1956 as a modified fixed price-incentive contract, in which the cost ran about 5 percent more than the target cost. McDonnell made neither the 10 percent maximum profit, nor the 8 percent target profit permitted by the original F–101 contract. The contractor's profit reached 6.85 percent of the total cost, or about as much as a cost-plus-fixed fee contract would have allowed. Other F–101 contracts followed almost the same buying pattern. As with the original model, the manufacturer began production under a temporary letter contract which was later replaced by a more formal, negotiated agreement. The Air Force endorsed the LC procedure only to make sure that the contractor's work would not be delayed by time consuming negotiations.

Contractor's Production Proposal **March 1952**

McDonnell proposed building and testing the first 33 F–101As as 6.33 g[2] airplanes; then making necessary modifications on the next 30 airplanes to bring them up to the 7.33 g strength requirements specified by GOR 101. The Air Force agreed in principle, but negotiations over design details for making the Voodoo a strategic fighter—one that could not only escort bombers but also could act

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[2] One g is the measure or value of the gravitational pull of the earth or of a force required to accelerate or decelerate at the rate of 32.16 feet per second per second any free moving body.

as an atomic bomber and at all times be able to engage in air-to-air combat—were to consume almost another 2 years.

Mockup Inspection **21 July 1952**

The Air Force Board approved close to 90 requests for alteration, half of which concerned items required by contract and, therefore, mandatory on the first airplane. This first inspection was supplemented in the following 12 months by several others, including that of an atomic weapons mockup held on 17 and 18 March 1953.

Production Hold Order **May 1954**

The Air Force decided that release of FY 54 funds allocated to the F–101 would be held in abeyance until the end of the Category II flight tests, then expected to be sometime in March 1955. This suspension of funds resulted in a postponement of mass production. The armistice in Korea enabled the Air Force to move more deliberately in committing itself to a particular design. This less frenzied approach was dubbed the "fly-before-you-buy policy," a catchphrase that accurately reflected the shift of emphasis from a crash production to a peacetime, more economical research and development program.

First Delivery **August 1954**

The aircraft was delivered as programmed in early 1952.

First Flight **29 September 1954**

The aircraft was flown at Edwards AFB through the programmed flight test profile with encouraging results and attained Mach 1.07 in dive. Three other F–101As were accepted by the Air Force before the end of the year. They immediately began to undergo Category I flight tests.

Production Resumption **28 October 1954**

The Air Force lifted its production hold order and gave McDonnell an early 1957 operational deadline.

Flight Testing **1954–1956**

Category II flight tests, started in January 1955, confirmed deficiencies first identified during the Category I flight tests of late 1954. Foremost in the problems encountered, and which proved to be much more difficult to overcome than anticipated, were the compressor stalls of the two Pratt & Whitney J57–P–13 turbojet engines (that had replaced the less powerful J–43–WE–22 engines of the F–88 prototypes) and the aircraft's tendency to "pitch up." Despite ensuing corrective efforts, by mid-1956 the continued testing of 29 F–101As thus far accepted by the Air Force showed a number of still unsolved structural, propulsion, aerodynamic, and armament problems.

New Production Stoppage **May 1956**

McDonnell's failure to fix the aircraft's malfunctions led the Air

Force once again to halt production. The hold order was of short duration, but the F–101A production and that of the aircraft's reconnaissance version remained limited to a total of eight airplanes per month through the end of October 1956.

Early Structural Problems **June 1956**

In September 1955 McDonnell had informed the Air Force that F–101A production had proceeded much faster than the test program so that the two were out of phase. Contrary to past expectations, it would be impossible to get a 7.33-g F–101 from the production line prior to production of the 116th airframe. The 115 6.33-g airframes built, including those of the aircraft already accepted by the Air Force, could still be brought up to the 7.33-g load specification of GOR 101, but they would have to be torn down and practically rebuilt. Furthermore, so much redesign work would be necessary that most of the 7.33-g airplane parts would not be interchangeable with the parts of the former 6.33-g aircraft. After investigating every possible modification, including cost and time required, the Air Force decided in June 1956 that it would accept the 6.33-g aircraft. When accepted, this type of aircraft would not be able to engage in aerial maneuvers at a gross weight in excess of 37,000 pounds. The immediate concern, however, was to get an aircraft that would meet even these reduced operational requirements.

Special Identification **September 1956**

Three months after the June decision to accept the 6.33-g aircraft, Headquarters USAF approved designation of the 7.33-g F–101 as the C model series. Except for one aircraft used in development of the F–101's interceptor version, all 6.33-g aircraft received the A suffix assigned to the initial F–101s and to their reconnaissance counterparts.

Modification Progress **September 1956**

Since the end of May 1956 McDonnell had been running a modification rather than a production line, incorporating more than 300 Air Force-approved design changes and some 2,000 engineering improvements of its own in the aircraft that were in production. Although the first of these modified aircraft would not be ready for delivery before the end of November, it looked as if the contractor was finally getting a fix for pitch-up, the most serious deficiency of the aircraft and the one that took longest to correct.

Hold-Order Release **26 November 1956**

Satisfied with the active inhibitor (pitch-up device) installed by McDonnell, the Air Force decided that production for the combat inventory could proceed and completely rescinded the May production restrictions. The decision marked the conclusion of a 3-month review of the entire F–101 program, including funding, schedules, requirements for the aircraft, and any alternatives available to the Air Force.

Program Changes **December 1956**

The Air Force final endorsement of the F–101 was accompanied by several changes. The peak production rate projected for the Voodoo interceptor and the F–101A program was reduced, with the last 96 F–101As scheduled to be converted to the reconnaissance configuration. This conversion was associated with an accompanying decision to delete the RF–104 and RF–105 from the Air Force budget. Reduction of the F–101A program also reflected the impact of SAC's 1954 cancellation of its original requirements, the forthcoming reassignment of the aircraft, the 7.33-g F–101Cs included, to the Tactical Air Command, and TAC's mild enthusiasm toward its new acquisitions. Initially developed as a strategic penetration fighter, intended to escort SAC bombers and therefore designed to operate from permanent installations, the F–101A, as well as the F–101C, would be difficult to adapt to TAC's doctrine of dispersal because their weights and takeoff/landing needs would not permit them to deploy to or from temporary or hastily prepared runways. Too, the F–101A and F–101C were only nuclear fighter-bombers, incapable of delivering conventional bombs.

First Acceptance (Production Aircraft) **2 May 1957**

This was the 41st F–101A built, but the first one accepted for the operational inventory.

Enters Operational Service **2 May 1957**

The aircraft became operational at Bergstrom with the 27th Fighter-Bomber Wing, a SAC unit which, like the aircraft, was to be transferred to TAC on 1 July 1957. The whole complement of F–101As were used ultimately to equip three squadrons of TAC's 81st Tactical Fighter Wing.

Subsequent Model Series

F–101B

Other Configurations

RF–101A, F–101C, RF–101C, RF–101G, and RF–101H.

End of Production **October 1957**

With the delivery of the last seven aircraft.

Total F-101As Accepted

Of 77 accepted, only 50 reached the combat forces. The others, referred to as "preproductions," were allocated to the experimental and test inventory.

Acceptance Rates

Fifteen F–101As were accepted in FY 55, 14 in FY 56, 13 in FY 57, and 35 in the first 4 months of FY 58.

Flyaway Cost Per Production Aircraft

$2,906,373.00—airframe, $2,364,143; engines (installed), $429,016; electronics, $25,249; ordnance, $15,300; armament, $72,665.

Average Maintenance Cost Per Flying Hour

$362.00

Phaseout **1966–1970**

The F–101A began leaving the USAF inventory in 1966, when 27 of the aircraft were transferred to the Air National Guard. By mid-1970, several major flying accidents, the cannibalization of a dozen aircraft, and a number of conversions accounted for the rest of the F–101As.

F-101C

Manufacturer's Model 36W
Weapon System 105

Previous Model Series

F–101A. Although bearing an earlier suffix letter, the F–101B interceptor was predated by the F–101C.

New Features

The only major difference between the A and C models was the strengthening of the internal structure of the F–101C to the 7.33 g specified by GOR 101.

Contractual Arrangements **March 1956**

Production of the F–101C, so designated in September 1956, was in fact initiated by a March 1956 letter contract, calling for an additional number of F–101As. In December of the same year, however, the combined F–101A and C program was reduced to a total of 124 aircraft.

First Acceptance (Production Aircraft) **August 1957**

This was the first of the aircraft accepted for the combat forces.

Enters Operational Service **September 1957**

The 523d Tactical Fighter Squadron (TFS) of the 27th Fighter Bomber Wing received the first aircraft.

Subsequent Model Series

None, except for the F–101B model.

Other Configurations

RF–101C, RF–101G, and RF–101H.

End of Production **May 1958**

With delivery of the last aircraft.

Total F–101Cs Accepted

47

Acceptance Rates

All 47 F–101Cs were accepted by the Air Force during fiscal year 1958.

Flyaway Cost Per Production Aircraft

$1,276,145.00—airframe, $803,022; engines (installed), $287,764; electronics, $61,079; ordnance, $441; armament, $123,839.

Average Maintenance Cost Per Flying Hour

$362.00

Oversea Deployments **1958**

By the end of the year, 17 F–101Cs had been deployed to Europe. The USAFE Voodoos were stationed in England with the Royal Air Force at Bentwaters.

Phaseout **1966**

For all practical purposes, the F–101C left USAF inventory in mid-1966, when 31 of the 47 7.33 g aircraft were assigned to the ANG. Several major flying accidents and a number of conversions during the preceding years accounted for most of the original fleet.

First Record Flight **12 December 1957**

An F–101C established an FAI[3] world speed record at 1,207 mph, at Edwards AFB. Moreover, McDonnell's Voodoo remained the fastest tactical fighter in operational service until the advent of the F–104. At the time of its introduction into service it was also the heaviest single-seat fighter ever accepted by the Air Force.

Other Milestones **1958**

In addition to speed, a striking feature of the F–101 was its 1,000-mile unrefueled range. The aircraft could also be refueled in-flight by the flying boom or the probe and drogue methods. On 28 May 1958 two F–101Cs from Bergstrom AFB, Tex., made a nonstop, round trip flight of 5,600 miles. On 28 June, four F–101Cs flew nonstop from Andrews AFB, Md., to Liege, Belgium, at an average speed of 640 mph. In August of the same year, a flight of seven Voodoos completed a 6,100-mile nonstop deployment from Bergstrom to Bentwaters, England.

RF–101A

Manufacturer's Model 36X
Weapon System 105L

Previous Model Series

F–101A

General Operational Requirements **6 February 1951**

The reconnaissance version of the future F–101A was included in

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[3] Fédération Aéronautique Internationale (FAI). An international organization founded in October 1905 in Paris for the purpose of authenticating aeronautical flights, both civilian and military, and promoting good will and understanding among world aviation interests.

the initial GOR of February 1951. Soon thereafter, McDonnell expressed doubts about the basic aircraft's capability of satisfying the reconnaissance configuration requirements.

Letter Contract **January 1953**

Procurement of the RF–101A was initiated by a letter contract covering the production of two prototypes. A formal contract was not negotiated until the following year.

Mockup Inspection **12-13 January 1954**

The RF–101A mockup inspection took place about 18 months after the first mockup inspection of the basic F–101.

First Flight (YRF-101A) **May 1954**

The Air Force accepted delivery of the second prototype the following month.

Configuration Changes **May 1956**

The December 1955 reassignment of the future RF–101As from SAC to TAC generated a number of configuration changes in order to satisfy TAC's request for additional electronic devices.

First Flight (Production Aircraft) **June 1956**

This aircraft, identified as the RF–101A–20, and two other productions had the 1,773-Imperial gallon fuselage fuel tank capacity of the F–101A.

Production Modifications **April 1957**

The fourth production aircraft—the RF–101A–25, first delivered in April 1957–and all subsequent RF–101A productions were built to the same specifications and grouped under the same block number. Their fuselage fuel tank capacity was supplemented by two 75-Imperial gallon tanks—one in each wing. Otherwise, being the reconnaissance version of the F–101A, there was little dissimilarity between the two. The RF was lighter, however, and had retained the bombing capability of the F–101A.

New Features **April 1957**

The most distinctive feature of the RF–101A was its nose, which had been slightly lengthened for the installation of photographic equipment. This equipment—initially unavailable or scarce—normally comprised a long focal length Fairchild KA–1 framing camera, one vertical and two side oblique Fairchild KA–2 framing cameras, and one CAI KA–18 strip camera.

Enters Operational Service **6 May 1957**

The aircraft was assigned to the 363d Tactical Reconnaissance Wing (TRW) at Shaw AFB as a replacement for the RF–84F, which was being transferred out of the Tactical Air Command. Although harboring distinct advantages over the subsonic RF–84Fs, the new, high-performance RF–101As were delivered without certain equipment vital to the accomplishment of the reconnaissance mission and their picture-taking capability would be limited until photographic production items became available. Even then it was doubtful whether the RF-101A could compensate for the RB-57, which was also being phased out of the reconnaissance inventory. The RF-101A, at best, was considered as a sort of consolation prize for the RF-104 and RF-105, both of which had been scratched from the Air Force's future reconnaissance forces.

Subsequent Model Series

RF-101C.

Other Configurations

RF-101G—an F-101A modified for reconnaissance. The F-101 airframe of the RF-101G, so designated in 1966, was extensively modified to accommodate photographic and electronic components far superior to those of the original RF-101As. Although it also involved significant airframe modifications, several of the 35 RF-101A productions were brought up to the G standard.

End of Production **1957**

The last two RF-101As were accepted by the Air Force in October.

Total RF-101As Accepted

35

Acceptance Rates

Twenty RF-101As were accepted in FY 57, and 15 during the first 4 months of FY 58.

Flyaway Cost Per Production Aircraft

$1,604,963.00—airframe, $1,150,903; engines (installed), $288,466; electronics, $32,566; ordnance, $591; armament, $132,457.

Flyaway Cost Per Modified Aircraft (RF-101G)

$2,979,745.00—airframe, $2,387,899; engines (installed), $429,016; electronics, $106,630; armament, $56,200; ordnance, none.

Average Cost Per Flying Hour (RF-101A)

$853.00

Average Maintenance Cost Per Flying Hour (RF-101A)

$322.00

Phaseout **1971**

Like the F-101As from which they derived, the few RF-101As produced had a limited impact on the Air Force's operational capability. Between 1960 and 1970, eight of them were supplied to Nationalist China through the Military Assistance Program. Several flying accidents, the cannibalization of a few others, and transfer of one RF-101A to the Air National Guard in 1966 further depleted the 35-aircraft fleet. In June 1970 six of the 14 RF-101As remaining in the regular reconnaissance forces were used for training, but all RF-101s were phased out of USAF inventory during the following year. The RF-101Gs, including the two or three RF-101As converted to the G configuration, were allocated to the Guard almost as soon as they became operational, and nine of them were transferred in mid-1966. Toward the end of 1970 the ANG inventory still counted 26 RF-101Gs.

Item of Special Interest — **January 1968**

The *Pueblo* crisis led the President to activate three RF-101 squadrons from the Air National Guard. Each of the squadrons served a rotational tour in Japan and compiled impressive records. Combined, they flew 19,715 tactical flying hours in 11,561 sorties and processed 841,601 feet of aerial film and 318,856 prints.

RF-101C

Manufacturer's Model 36X
Weapon System WS-105L

New Features

The single-place, supersonic RF-101C differed from the RF-101A in two respects. It had the strengthened internal structure of the F-101C, and had retained that aircraft's capability for delivering nuclear weapons. In terms of operational service, the RF-101C also followed the F-101C's pattern. Both quickly outclassed their A counterparts, with the RF-101C soon establishing itself as the Air Force's reconnaissance workhorse.

Production Contract — **March 1956**

The contract called for procurement of 70 RF-101Cs.

Additional Procurement — **December 1956**

The Air Force decided to reduce production of the F-101 and to convert to the reconnaissance configuration the last 96 aircraft under contract. Being late F-101 productions built to the 7.33-g specification of GOR 101 and singled out by the C suffix since September 1956, the converted aircraft entered the inventory as RC-101Cs.

First Flight — **12 July 1957**

First Acceptance (Production Aircraft) — **September 1957**

Enters Operational Service — **1957**

The aircraft became operational at Shaw AFB, with the 20th and 29th Photo Jet squadrons of the 432d TRW.

Subsequent Model Series

None

Other Configurations **1966**

RF-101H—an F-101C, converted to the reconnaissance configuration. Like the RF-101Gs, the RF-101Hs were transferred to the ANG as soon as operational, the first transfer of 10 aircraft occurring in late 1966. In June 1970, 30 RF-101Hs were in the Guard's inventory.

End of Production **1959**

The last six RF-101Cs were accepted by the Air Force in March.

Total RF-101Cs Accepted

166

Acceptance Rates

Eighty RF-101Cs were accepted in FY 58, and 86 in FY 59.

Flyaway Cost Per Production Aircraft[4]

$1,276,145.00—airframe, $803,022; engines (installed), $287,764; electronics, $61,079; ordnance, $441; armament, $123,839.

Flyaway Cost Per Modified Aircraft (RF-101H)[5]

$2,979,745.00—airframe, $2,387,899; engines (installed), $429,016; electronics, $106,630; armament, $56,200; ordnance, none.

Average Cost Per Flying Hour

$853.00

Average Maintenance Cost Per Flying Hour

$322.00

Oversea Deployments **1958**

The new aircraft reached the oversea commands almost as soon as operational. By the end of 1958, 30 RF-101Cs had already joined the USAFE. They were stationed at Nouasseur AB, Morocco, and Laon and Phalsbourg Air Bases in France. In May 1959, following TAC inactivation of the 17th and 18th Photo Reconnaissance Squadrons, another contingent of 36 RF-101s came under USAFE's control. Deployment of the RF-101C to the Pacific Air Forces (PACAF) also took place in early 1958, but it was preceded by that of a few RF-101As. In December PACAF's 40 RF-101A/C aircraft, four more than first authorized, were located at Kadena AB, Okinawa and Misawa AB, Japan.

Initial Operational Problems **1958-1959**

Both the RF-101A and RF-101C were beset with excessive maintenance difficulties and poor supply support. Premature failure of components, due to design deficiencies, aggravated the initial operational problems. In January 1959 all RF-101s were grounded for 1 week because of the collapse of main landing gears. In

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[4] Excluding $277,658 in Class V modification costs for each RF-101C.

[5] Also omitting Class V modification costs of $416,718 per RF-101H.

August of the same year, the aircraft were again temporarily grounded because of deficient hydraulic systems. The hydraulic problems, first experienced by the USAFE and PACAF aircraft, were not limited to the F/RF-101A and C model series; early F-101B productions were also grounded for the same reasons. Urgent modifications, accomplished by McDonnell teams and Air Force depot personnel, while helpful did not immediately eliminate the landing gears and hydraulic system malfunctions. In the latter case, some 500 manhours per aircraft—depending upon date of manufacture—were needed to solve the problem completely.

Other Significant Problems **1960**

The Air Force quickly improved maintenance and supply support of the Voodoos. By 1960 the squadrons so equipped were highly operational. Yet, no easy solution had been found for the skin crack and corrosion problems that plagued all model series of the F-101 since their service introduction. Cracks in fairing doors, wheel wells, ailerons, trailing edges and speed brakes were discovered during each periodic inspection, and contractor teams had to be hired to assist Air Force sheet metal specialists in the repair of affected areas. A main wing carry through spar also had to be perfected to correct suspected cases of wing fatigue. The corrosion problems, which later equally affected the USAFE F-101Cs of Bentwaters, first reached alarming proportions in PACAF. Although some repairs were made at the operating bases by depot field teams, many of the PACAF RF-101s had to be returned to the United States for reskinning of the wings, shingle, and fuselage at a cost of 8,400 manhours per aircraft. To alleviate the problem, the Air Force in June 1963 awarded a $1.5 million contract for the construction of a corrosion control facility at Kadena AB in Okinawa.

Modernization **1962**

The Air Force continuously strove to improve the RF-101's reconnaissance capability and gave the aircraft better photographic and electronic components as soon as they became available. However, the first major modernization program did not take place until 1962. New high resolution cameras were then installed in most RF-101s. A special modification allowed the aircraft to fly at lower altitudes and the installation of flash cartridge pods gave them a limited night capability. McDonnell's Voodoos were air refuelable. A simple modification, accomplished also in 1962, gave all RF-101 aircraft the added capability of air refueling one another. The modification consisted essentially of installing a buddy refueling tank in place of the external tank of the aircraft's left wing.

Special Assignment **23 October 1962**

Following confirmation on 14 October of the presence of missile

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sites in Cuba, USAF RF–101Cs were directed to fly at low level over the island. The occasion accented the RF–101C's shortcomings and the aircraft's continued lack of a satisfactory reconnaissance system.

New Improvements **1962–1967**

The Air Force decided that the Hycon KS–72A framing camera being developed for the RF–4C—another McDonnell production, under contract since May 1962—also would be installed on the RF–101s. The decision in effect endorsed a whole new modernization program, first suggested by TAC in early 1960. Numerous modifications were grouped under Modification 1181, as the modernization was known, and estimated costs were high. They ran over $180,000.00 per aircraft, in addition to some $3 million of basic expenditures. Modification 1181 involved the installation of several new components, and anticipated technical difficulties were soon confirmed. Initial flight tests in July 1963 revealed major deficiencies in the KS–72A prototype. Testing of the camera's low-altitude reliability in late 1964 also was disappointing. Modification 1181, including the night capability expected of it, ran into further difficulties as testing was delayed because of the limitations of the RF–101 navigation system. Finally started in the fall of 1964 and first applied to the PACAF and USAFE aircraft, the new modernization program did not end until 1967. However, when completed, Modification 1181 and the KS–72A camera gave the RF–101C an improved low-altitude photographic capability that permitted taking full advantage of the aircraft's speed performance. Other accrued advantages were a high-altitude true vertical photographic capability, and an increase in sensor reliability through the use of automatic exposure control and an improved camera control system.

Interim and Other Modifications **1963–1965**

Pending availability of the KS–72 cameras to supplement the KA–2s, faster KA–45 cameras were installed in some RF–101Cs during 1963. In the following 2 years, the Air Force also improved the flight safety and maintainability of the aircraft. New main landing gear struts were installed. The RF–101C's fire warning system was modified, and the main fuel lines, fuel filters, and air ducts of the aircraft were overhauled.

SEA Deployments **1961–1970**

The RF–101s, the only Voodoos in the Vietnam War, performed reconnaissance and strike evaluations from 1961 through 1970. RF–101s were pathfinders for F–100s in the first USAF strike against North Vietnam on 8 February 1965. Operating originally out of South Vietnam, the RF–101s later flew most of their missions over North Vietnam from Thailand.

Attrition **1958–1970**

More than 30 RF–101Cs were lost during the early years of the aircraft's service life, often because of pilot inexperience. The first RF–101C combat loss occurred in late 1964. Highly sophisticated enemy defenses in North Vietnam accounted for most of the later losses.

Revised Training **October 1966**

The RF–101 pilots in Southeast Asia were still accident prone and not proficient in aerial refueling. Hence, despite acute shortages in aircraft and instructors, the Air Force extended RF–101 flying training to 94 hours.

Program Changes **1967–1969**

The RF–101s were earmarked to equip the Air National Guard. The RF–101Cs were to be supplemented beginning in 1965, and soon thereafter entirely replaced by the new RF–4C Phantoms. Continued increases both in war toll and reconnaissance requirements altered USAF plans. The older aircraft did not possess the speed and radar-homing and warning devices of the RF–4C, but its cameras could obtain broad and detailed coverage of the kind of targets encountered in the war and in 1967 all but one of TAC's RF–101C squadrons were dispatched to SEA. In October of the same year, following the arrival of an additional squadron of RF–4Cs, one squadron of RF–101s at Udorn AB, Thailand, was inactivated, but this was as far as earlier RF–101 planning could be carried. The RF–101s rendered surplus were distributed to depleted SEA units instead of being transferred to the ANG. At year end, and also contrary to plans, the Air Force decided to convert to reconnaissance configuration 29 F–101B interceptors in late 1968 and nine more in early 1969.

Other Reversals **1969**

With the RF–101 weapon system in SEA, the Air Force in late 1965 decided to accelerate the installation of long-range navigation (LORAN) D avionics in the aircraft. Delivery postponements and funding difficulties were to cause another change of plans. The project was cancelled in early 1969.

Phaseout **1969–1971**

A first contingent of five RF–101Cs was transferred to the Air National Guard in early 1969. Concurrently, in consonance with Vietnamization and force modernization programs, the RF–101Cs departed SEA, and the sole RF–101C squadron remaining in Europe converted to the RF–4C. The Air Force transferred its last RF–101Cs to the Guard during 1971. In October, upon completion of the final transaction and including earlier RF–101A and RF–101G and H allocations, the ANG inventory counted 131 RF–101s, 116 of which were fully operational.

Milestones **15 April 1959**

A new world speed record of 816.279 mph was set by an RF–101C Voodoo on a 500-kilometer closed circuit course without payload at Edwards AFB.

F-101B

Manufacturer's Model 36 AT
Weapon System 217A

Previous Model Series

F–101A and C

New Features

Elongated cockpit, permitting sitting of observer behind pilot; different armament (missiles and rockets carried by and launched from a hydraulically actuated rotary armament door); and a fire control system providing automatic search and track. The engines of the F–101B interceptor—two J–57–P–55 turbojets—also differed from those of both the F–101A and F–101C tactical fighter bombers by being fitted with longer afterburners.

Program Development

Development of the F–101B program was generated by a combination of factors. First, by Convair's failure to satisfy quickly the Air Force's "ultimate" interceptor requirements. Secondly, by the difficulties encountered with the same contractor's interim F–102, yet to be delivered in August 1953, when Russia exploded a thermonuclear bomb—less than a year after the United States first successfully demonstrated one. Finally, by ADC's insistence for the greater security that two new interceptors would provide pending availability of Convair's "ultimate" F–106.

Initial Requirements **October 1952**

Impressed by McDonnell's revised version of the F–88 Voodoo (rechristened F–101 in November 1951), ADC in October 1952 suggested the possibility of modifying the aircraft to serve as an interceptor. Headquarters USAF, mainly because of the Voodoo's high cost, rejected the plan and decided to attempt solving the interceptor problem by increasing the numbers of F–86Ds and "putting the heat" on the F–102. The suggestion was revived, however, with ADC's proposal in April 1953 to use the long range F–101 as an interceptor on the perimeter of the United States and in areas where ground radar was inadequate. The Air Force Council late in 1953 directed that the aircraft industry be invited to compete in determining the characteristics required by an interceptor other than the F–102—that would help fill the gap between the F–89 and F–106.

Competition's Results **June 1954**

ADC announced that of the three aircraft proposals that might meet its requirements—an advanced F–89, offered by Northrop, and interceptor versions of North American F–100 and McDonnell F–101—the F–101 was the best. Soon afterwards, the Air Force decided that the aircraft (titled F–101B in mid-1955), if produced, would include the MG–13 fire control system of the F–102 and would carry Falcon missiles.

Go-Ahead Decision **25 February 1955**

Almost 6 months elapsed between the F–101's first flight and the Air Force official endorsement of the F–101 interceptor program. Interim predictions that the interceptor, equipped with the advanced J–67 engine, would be ready to fly by the middle of 1956, that production could begin in 1957, and that the aircraft could be made available to active interceptor squadrons in early 1958 proved wrong or too optimistic. Nevertheless, later events wholly vindicated the production decision.

Contractual Arrangements **March 1955**

Just as with other F–101s, procurement was initiated by letter contracts, the first of which, issued in March 1955, covered 28 aircraft. Four months later, a formal contract, released on 12 July, increased the fiscal year 1956 program to a total of 96 interceptors. However, in December 1956 the Air Force curtailed the peak monthly production rate originally projected for the aircraft and significantly reduced future procurement.

Official Designation **August 1955**

The Air Force officially designated the interceptor version of the F–101 as the F–101B.

Mockup Inspection **14–15 September 1955**

Two of the alterations requested were of particular import. The first involved the aircraft's armament rack. The second dealt with the replacement of the F–101B's initial engines—two advanced but unproven J–67 turbojets developed by Pratt and Whitney.

Production Hold Order **May 1956**

The production restrictions imposed on the F–101A were extended to the F–101B. In the latter case, however, the Air Force restrictions were more drastic. The hold order remained totally in force through the end of 1956, at which time the projected armada of 651 F–101Bs was reduced by almost one quarter.

First Flight **27 March 1957**

The flight took place at Lambert Municipal Airport at St. Louis, Mo., nearly a year later than predicted in early 1955.

Flight Testing **1957-1959**

The Air Force spent close to 2 years of extensive testing and accepted 50 F–101Bs before allowing the Voodoo interceptors to enter operational service. Category I flight tests, conducted at

Edwards AFB, started immediately upon delivery of the first F-101B—March 1957. Category II and Category III flight tests, conducted at Eglin and at Otis AFB, respectively, were completed on 15 March 1959.

Unsolved Problems **1958**

Despite modifications that resulted from the experience with the basic F-101A, two serious flaws surfaced during flight tests of the B model. Both were unique to the interceptor version. The radar observer's cockpit had been badly designed and little could be done except to make minor changes. Too, the MG-13 fire control system developed by the Hughes Aircraft Company was not as advanced as the airframe in which it was placed. The MG-13 was merely a refinement of the E-6 fire control system of the F-89D and could not control the weapons of an interceptor as fast as the F-101B. Headquarters USAF denied replacement of the MG-13 with the MA-1 system of the F-106 because of the cost involved. This left only one course of action: to improve the Central Air Data Computer that was the heart of the MG-13 system.

Enters Operational Service **5 January 1959**

This was a 6-month delay from latest estimates, 18 months later than first expected and almost 2 years after USAF acceptance of the first F-101B. On the other hand, the F-101B received by the 60th Fighter Interceptor Squadron at Otis AFB, the first ADC unit to be so equipped, was a thoroughly tested aircraft, capable of advanced performance.

Operational Readiness **1959-1960**

Although support of the F-101B had been initially handicapped by shortages of parts, it improved during the later part of 1959, and by mid-1960 supply and maintenance problems were well under control. Other difficulties remained, however, including all Voodoos' susceptibility to corrosion and the skin cracks discovered in the rudder area of the F-101B model series. All the same, in December 1960 nine of ADC's 17 squadrons of F-101Bs were rated C-1—the highest degree of combat readiness—and seven were C-2. Only one squadron was considered deficient, and this was due to a temporary shortage of qualified personnel. On the average, 70 percent of the 371 F-101Bs, then assigned to the combat forces, were operationally ready.

Additional Testing **1960**

Despite the extensive flight tests of the 1957-1959 period, two separate testing programs were conducted at the Air Force Missile Development Center at Holloman AFB. One of the test programs further investigated the F-101B compatibility with both Falcon-guided missiles and MB-1 nuclear Genies. The other was an overall review of the entire weapon system. Representatives of

McDonnell and Hughes as well as Douglas, the producer of the MB-1 unguided nuclear rockets, participated in the latter.

Subsequent Model Series

None

Other Configurations **1959-1961**

TF-101Bs—F-101Bs with dual controls for pilot training. Contrary to plans, and because McDonnell took longer than promised to install the dual control kits, only one out of every four F-101Bs produced was so equipped. When fitted out as a trainer, the F-101B retained its original operational capability. The trainer versions entered ADC service in 1959. In April 1960 several of them were allocated to TAC for the training of tactical reconnaissance aircrews. *F-101Fs*—these were late F-101B productions that included modifications accomplished on the production line. Technically referred to as block 115-120 configurations,[6] these aircraft were first identified as F-101Fs in 1961 as arrangements were made to transfer 66 of them to the Royal Canadian Air Force (RCAF), where they acquired still another designation and became CF-101Bs. The trainer version of the block 115-120 F-101B configuration, the TF-101F, was known in RCAF service as the CF-101F. Ten TF-101Fs were included in the 66 Voodoo interceptors transferred to Canada in exchange for that country's operation and maintenance of 14 radar sites.

End of Production **March 1961**

It ended with delivery of the last three aircraft.

Total F-101B/F Accepted

480

Acceptance Rates

One Voodoo interceptor was accepted in FY 57, 15 in FY 58, 133 in FY 59, 241 in FY 60, and 90 in FY 61.

Flyaway Cost Per Production Aircraft[7] (F/TF-101B/F/TF-101F)

$1,754,066.00—airframe, $1,105,034; engines (installed), $332,376; electronics, $52,770; ordnance, $1,001; armament, $262,885.

[6] Because of the increasing complexity of aircraft being developed, modifications no longer necessarily entailed a change of the letter suffix in the aircraft model series designation. Since 1941, the aircraft being built with the same specifications were grouped into blocks as they were assembled on the production lines. The blocks were numbered beginning with 1, 5, and subsequently with sequential multiples of five. The intermediate figures were reserved for the identification of aircraft modified after production at a modification center or in the field. In general, block numbers were only allocated to combat aircraft and transports. Exceptions occurred, however. F-4s and C-123s left their assembling plants with consecutive block numbers. On the other hand, T-33 and T-38 trainers received block numbers.

[7] Did not include $13,333 of RDT&E costs and $52,922 in Class V modifications, spent on every F-101 interceptor.

Average Cost Per Flying Hour

$1,004.00

Average Maintenance Cost Per Flying Hour

$501.00

Postproduction Modifications **1961**

As a result of the additional tests conducted at the Air Force Missile Development Center during 1960, the Air Force decided to equip the F–101B/F with the MB–1 Genies produced by Douglas. Necessary modifications were authorized in July 1961.

Subsequent Improvements **1963–1966**

Because of the threat from airbreathing aircraft and missiles, the Air Force began planning modernization of its aging interceptor systems. The Interceptor Improvement Program increased the ability of the F–101B/F to thwart electronic countermeasures and to employ radar to search for and track low-flying aircraft. The two-phase program initiated in early 1963 was completed in mid-1966.

Other Modifications **1964–1968**

The unreliability of the F–101 engine starter (unimproved despite all efforts until the end of 1964) caused a number of incidents and personnel injuries. The problem was finally solved by installing a separate pneumatic cartridge starter for each of the two engines.

The Pitch Control System (PCS) of the MB–5 Automatic Flight Control System (AFCS) in the F–101B/F interceptors also had been a source of difficulties for many years. In April 1968 Headquarters USAF approved the installation of a modifying kit which had been thoroughly tested by Honeywell, builder of the AFCS. The new kit completely eliminated use of the poorly designed PCS.

Attrition

The Air Force lost about one fifth of its Voodoo interceptors in some 10 years of operation. Accounting for most of these losses—the majority of which occurred during the early years of the aircraft's operational use—was the F–101's addiction to spins, a definite hazard to inexperienced pilots.

Phaseout **1968–1971**

The Voodoo interceptors began leaving USAF operational inventory sooner than expected because of the economy-induced accelerated inactivation of seven ADC F–101 squadrons in 1968. This action produced a surplus of 163 aircraft, 30 of which were converted to the reconnaissance configuration and transferred to the Tactical Air Command. Another 66 of these Voodoos were allocated to Canada to replace the older F–101Bs, previously furnished to the northern partner in the North American Air Defense Command (NORAD). Such allocations left a residue of 67 aircraft for storage at Davis-Monthan AFB, Ariz. Because of continued budgetary restrictions, three of the last six F–101 squadrons in the regular interceptor force were inactivated in mid-1969. Phaseout of the entire F–101B/F fleet was concluded in the spring of 1971.

Other Uses **December 1969**

Aside from five TF–101B aircraft allocated in 1966 for training, the Voodoo interceptors did not reach the Air National Guard until December 1969. Once underway, however, the conversion of ANG F–102 fighter groups to more modern F–101Bs proceeded smoothly. The three units involved—the 101st, 119th, and 141st Fighter Groups—resumed their alert posture actually ahead of schedule. The Guard proved itself further in 1970 by taking first place in the William Tell F–101 competition. Three other ANG fighter groups (the 142d, 148th, and 107th) began converting to the F–101B/F aircraft in March and April 1971, also without trouble. The 147th Fighter Group (Training) received some F–101Fs in June 1971 but retained its F–102s to train crews for both the F-101B and the F–102—a task turned over to the Guard by ADC.

PROGRAM RECAP

The Air Force bought a grand total of 807 F–101s—2 experimental models (first known as XF–88s), 77 F–101As, 47 F–101Cs, 35 RF–101As, 166 RF–101Cs, and 480 F–101B and F–101F interceptors.

TECHNICAL DATA
F-101A/C and RF-101A/C

Manufacturer	McDonnell Aircraft Corporation, St. Louis, Mo.
Nomenclature	Supersonic Tactical Fighter-Bomber (F-101A/C). Reconnaissance Aircraft (RF-101A/C).
Popular Name	Voodoo

Characteristics	*F-101A*	*F-101C*	*RF-101A/C*
Length/Wing	67 ft/40 ft	67 ft/40 ft	69 ft/40 ft
Take Off Weight	48,000 lb	49,000 lb	48,100 lb
Takeoff Ground Run	4,600 ft	4,800 ft	3,380 ft
Cruise Speed	0.87 kn	0.87 kn	
Max. Speed at 35,000 ft	870 kn	870 kn	
Cruise/Max. Speed			480 kn/ 875 kn
Cruise Range/Endurance			NA/3.9 hr
Ferry Range			1,864 nm
Radius	690 nm	525 nm	
Engine, Number & Designation[8]	Two J57-F-13	Two J57-F-13	Two J57-P-13
Crew	1	1	1
Rate of Climb (sea level)	8,300 fpm	8,300 fpm	
Service Ceiling	50,300 ft	50,300 ft	45,200 ft
Ordnance[9]	4 M-39 20-mm guns	4 M-39 20-mm guns	NA

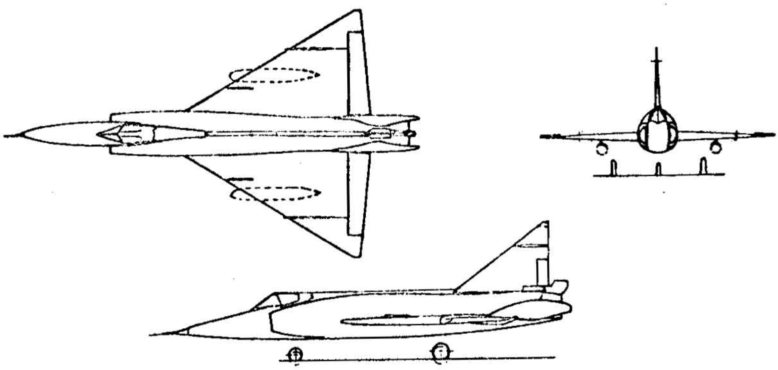
[8] Pratt & Whitney
[9] Bombs—One Mark 7, one Mark 28, and one Mark 43

TECHNICAL DATA

F-101B/F and TF-101B/F

Manufacturer	McDonnell Aircraft Corporation, St. Louis, Mo.
Nomenclature	Fighter Interceptor. Fighter Interceptor/Trainer.
Popular Name	Voodoo

Characteristics	*Point Interceptor*	*Area-Interceptor*
Length/Wing	71 ft/39 ft	71 ft/39 ft
Takeoff Weight	45,461 lb	51,724 lb (w/two 450 gallon drop tanks)
Takeoff Ground Run	2,600 ft	6,280 ft w/o afterburner
Max. Speed at 35,000 ft	950 kn	950 kn (drops external tanks)
Rate of Climb (sea level)	36,000 fpm	7,610 fpm (Mil. Pwr. climb to best cruise alt)
Combat Ceiling	51,000 ft	50,700 ft
Radius	NA	603 nm
Engine, Number & Designation	2 Pratt & Whitney J57–P–55	2 Pratt & Whitney J57–P–55
Crew	2	2
Armament	2 AIR–2A rockets 2 AIM–4C missiles	2 AIR–2A rockets 2 AIM–4C missiles



CONVAIR F-102 DELTA DAGGER

F-102A: Supersonic, all-weather, fighter-interceptor, and the Air Force's first operational delta-wing aircraft.

TF-102A: A two-seat combat proficiency trainer, identical to the single-seat F-102A from the wing leading-edge back.

CONVAIR F-102 DELTA DAGGER

Manufacturer's Model 8-10
Weapon System 201A

Basic Development

Convair F-102, like the subsequent F-106, grew out of the company's experimental XF-92A—the world's first delta wing airplane, originally known only as Model 7002, was successfully flown in September 1948.[1]

Advanced Development Objective **13 January 1949**

Called for an advanced, specially designed interceptor (dubbed the "1954 Interceptor"— for the year it was expected to become operational) that could surpass the estimated speed and altitude of Soviet intercontinental jet bombers. Recent intelligence warning and growth limits of the F-86, F-89, and F-94 interceptors spurred development of the Air Force ADO.

Concept Formulation **1948-1949**

The ADO of January 1949 also departed radically from past procedures. The Air Force recognized that the increasing complexity of weapons no longer permitted the isolated and compartmented development of equipment and components which, when put together in a structural shell, formed an aircraft or missile. It concluded that the new interceptor should be developed in conformity with the Weapon System Concept. This concept (yet to be tried) integrated the design of the entire weapon system, making each component compatible with the others.

Request for Proposals (RFPs) **18 June 1950**

As one of the coordinated steps toward development of the new interceptor (Project MX-1554), the Air Force requested an airframe structurally capable of withstanding a speed of more than Mach 1, at an altitude of 50,000+ ft. The 1954 operational date was included in the bidding announcement. In October 1950, 3 months before the MX-1554 bidding ended, the Hughes Aircraft Company was awarded a contract for Project MX-1179, the Electronic Control System (ECS), "around" which the MX-1554 airframe would be built. Hughes had been working on new radars, fire-control systems (beginning with the E-1, developed for the gunfir-

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[1] Like many other aerodynamic innovations, the delta wing had its inception in the wind tunnels of wartime Germany, although low-aspect-ratio wing forms were also studied by the US National Advisory Committee for Aeronautics. Dr. Alexander M. Lippisch (leader of the German program) helped develop the spectacular Me-163 rocket-propelled interceptor for the Messerschmitt combine. Early design studies by NACA, captured reports of the Lippisch program, and later conferences with Lippisch himself convinced engineers of the Consolidated Vultee Aircraft Corporation (Convair) that the delta wing might be the answer to many of the problems of supersonic flight.

ing F–94A and F–86A aircraft) and related components since 1946. Production of the MX–1179 ECS was programmed for 1953.

Competitors and Selection **1951**

When the MX–1554 bidding closed in January 1951, six contractors had submitted nine proposals. Republic submitted three bids, North American two. Single proposals were made by Lockheed, Chance-Vought, Douglas and Convair. The Air Force on 2 July named three winners: Convair, Republic, and Lockheed, who were all to proceed with development through the mockup stage. At that time the firm providing the most promising design would be awarded a production contract. The MX–1554 three-pronged development was short-lived, however. The Air Force soon decided it was unwise to finance three concurrent Phase I development programs. It cancelled the Lockheed project in its entirety.

Letter Contract **11 September 1951**

The LC awarded Convair authorized use of the Westinghouse J–40 power plant for the MX–1554, pending availability of the much more powerful Wright J–67. Performance requirements for the MX–1554/J–40 prototype were set at Mach 1.88 with a 56,500-ft altitude. The J–67-equipped MX–1554 combination, officially designated by the Air Force as the F–102 and also referred to as the 1954 or Ultimate Interceptor, would include the Hughes MX–1179 ECS and was expected to reach Mach 1.93 at 62,000 feet. Production, if approved, was programmed for 1953 or early 1954 at the latest. Although development of one of the Republic proposals (the Air Force-designated XF–103) was still authorized, the LC of September 1951, in effect, declared Convair the undisputed winner of the design competition for the 1954 Interceptor.[2]

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[2] The XF–103, one of the winning entries of the MX–1554 competition, was developed by the Republic Aviation Corporation from its AP–44A, a 1948 design for an all-weather, high-altitude defensive fighter. Like the AP–44A, the XF–103 (AP 57) presented numerous innovations, including all-titanium construction, dual-cycle propulsion, periscope for forward vision, and downward ejecting capsule for escape. The F–103 concept of a high-altitude (80,000 feet) Mach 3 interceptor was also far ahead of the state of the art. After a full-scale mockup inspection in March 1953, the Air Force decided to defer the XF–103 Phase II work and to extend for some 18 months the Republic Phase I development contract of September 1951. Republic finally received a contract for three experimental aircraft in June 1954 and the XF–103 (Weapon System 204A) Phase II program began 3 months later. In the following years, however, significant set-backs slowed the development pace of the new XF–103. Low titanium priority, difficulties encountered in the titanium alloy fabrication process, difficulties in engine development, funding problems—all had a hand in program slippage. After being reduced from three to one aircraft, the XF–103 program, still hampered by budgetary restrictions, was cancelled in September 1957—about 1 year before the aircraft's programmed first flight.

Production Decision **24 November 1951**

The Air Force decided to expedite the 1954 Interceptor program.[3] It confirmed that production of the new aircraft would follow the Cook-Craigie Plan for early tooling, limited production at first, elimination of faults by test flights, and accelerated production thereafter.[4] To permit full-scale testing prior to full-scale production, initial production would use the existing Westinghouse J–40 engine (previously earmarked for the MX–1554 F–102 prototype). As also called for by the LC of September 1951, Convair would equip the MX–1554 F–102 with the more powerful J–67, as soon as feasible.

Program Change **December 1951**

The November production go-ahead, while reflecting the Air Force's urgent need of the 1954 Interceptor, did not ignore the fact that the J–67 engine and the MX–1179 ECS were yet to be produced. In December 1951, convinced that the J–67 would not be ready on schedule, the MX–1179 ECS might also be late, and the so-called 1954 Interceptor would never meet its operational deadline, the Air Force changed plans. After surveying once again all existing fighter aircraft and future programmed designs that could be modified to an interceptor configuration, the Air Force gave Convair a new letter contract calling for the June 1953 production of an interim version of the MX–1554 interceptor. It decided to omit industrial competition, considering it time-consuming as well as useless so soon after the MX–1554 competition. Moreover (and of primary concern to the Air Force) use of the Convair MX–1554 airframe for the interim interceptor would allow a thorough, rational, carefully phased development of both the interim and ultimate interceptors. One would lead into the other—an arrangement very similar to that originally devised under the new weapon system concept and the Cook-Craigie production plan.

Operational Requirements **December 1951**

The Air Force in December 1951 drew no specific operational requirements for the interim interceptor. The only stipulation (and the basis for the Air Force decision to buy the Convair aircraft)

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[3] The decision to accelerate Convair interceptor program halted further development of the Republic XF-91A, originally slated as an interim interceptor. Work stopped in October 1951, following the mockup inspection. The two experimental F–91s, already available, were modified to serve as high-speed armament test vehicles by augmenting their jet engines with rocket motors.

[4] The Cook-Craigie production plan was actually a mere concept, developed in the late forties by USAF Generals Laurence C. Craigie, DCS/Development, and Orval R. Cook, DCS/Materiel. This concept (closely related to the "fly-before-you-buy" concept of the late sixties) could be expensive. The generals both thought "it was only applicable where you had a high degree of confidence that you were going to go into production."

was that the interim interceptor be sufficiently advanced over North American forthcoming F-86D to warrant its procurement. Similarly, the single guideline for selection of components specified that the engine, armament, and, if need be, the electronic control system (while being as technically progressive as possible) would be available to meet the production of the MX-1554 airframe. In any case, the Air Force in late 1951 did not contemplate any large-scale production of the interim interceptor.

F-102A

Official Designation **1952**

The Air Force designated Convair interim interceptor the F-102A. The production-delayed, ultimate MX-1554, while retaining its original designation, would acquire a subsequent model letter series and become the F-102B. In 1956, after numerous engineering changes had further widened the two interceptors' dissimilarities, the Air Force redesignated the F-102B as the F-106.

Mockup Inspection **18 November 1952**

A number of design changes were requested. The Air Force decided the F-102A should be capable of carrying external stores (fuel tanks, armament, and the like). Also, cockpit components of the MX-1179 ECS (simultaneously inspected with the F-102A) had to be rearranged.

Second Program Change **1952-1953**

The Air Force, Convair, and Hughes agreed to equip the F-102A with an interim fire-control system, since it had become certain service-test quantities of the MX-1179 ECS would not be available prior to October 1955. Huges E-9, a modified E-4, was selected. The MX-1179 ECS and the MX-1554 airframe had been specifically designed to complement each other, and the MX-1179's temporary deletion from the F-102A proved to be an important decision. In effect, it marked the defeat of the weapon system concept's first application, for the MX-1179 never reached the F-102A. The E-9 (renamed MG-3 after a number of technical changes had substantially increased its overall capability) was eventually replaced by the MG-10. This system (itself a former MG-3 incorporating the AN/ARR-44 data link, the MG-1 automatic flight control system, and the AN/ARC-34 miniaturized communication set) became a permanent feature of the F-102A. Meanwhile, by almost imperceptible steps, the interim F-102A took on greater importance, and the quantities discussed grew larger. More emphasis on the F-102A meant less on the ultimate interceptor, leading to an insidious program change. The realities of the development situation, however, dictated this undesirable trend.

Development Problems **1952–1953**

The F–102A's development problems first centered on its weight, which was increasing continuously. The Westinghouse J–40 (the most powerful US turbojet engine qualifed for production in early 1951) lacked the thrust to give the F–102A the minimum requisite speed and altitude. Its replacement, the Pratt and Whitney J–57–P–11, officially rated as being in the 10,000-lb class and due to enter production in February 1953, was heavier. The post-mockup inspection requirements for additional armament also generated extra weight, as did the aircraft's new fire-control system, heavier than the future MX–1179. Meanwhile, a much more serious problem loomed.

Other Initial Problems **1953**

NACA wind tunnel tests in early 1953 showed that the maximum altitude of 57,000 feet and combat radius of 350 miles (304.3 nm) predicted for the F–102A were too optimistic. The designers of the original Convair proposal (MX–1554) had failed to make proper allowance for a delta-wing aircraft's aero-dynamic drag.[5] Convair drag estimates of the F–102A in its bulky amidship configuration did not coincide with the data upon which they were based. The solution was to indent the fuselage to a "coke-bottle" or "wasp waist" configuration, but first the contractor had to be convinced that its original design was in error. However, it was not until mid-1953 that Convair accepted the implications of the "NACA ideal body theory" and joined in the recommendations that the F–102A's design conform to this theory's requirements.

Definitive Contract for Production **12 June 1953**

The LCs, previously awarded to Convair, were superseded by a definitive contract. This contract, still based on the Cook-Craigie production plan, did not affect the number of aircraft initially ordered. Out of the 42 aircraft under procurement, several were earmarked for testing and two (F–102A prototypes) were scheduled for flight in October and December 1953, respectively. Production dates were significantly changed, however. Limited production would not begin until April 1954—10 months later than programmed in December 1951. Accelerated production of a combat-ready, fully tested weapon system was planned for December 1955—almost 2 years later than first anticipated.

First Flight (Prototype) **24 October 1953**

The first YF–102A, flown from Edwards AFB in October 1953,

[5] The area-rule concept of aircraft design (that interference drag at transonic speed depends almost entirely on the distribution of the aircraft's total cross-sectional area along the direction of flight) was verified during December 1952 by Richard T. Whitcomb in NACA's new transonic wind tunnels.

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crashed on 2 November, but not before the aircraft's anticipated poor performance was fully demonstrated. The flight tests, resumed several months later with the second YF–102A (first flown on 11 January 1954), could only confirm that the F–102A in its present configuration was drag-limited to Mach .98 with a 48,000-ft ceiling—considerably below the required performance.[6]

Design Changes **1954**

While the MX–1179 deletion from the F–102A defeated the weapon system concept's first application, the aircraft's unavoidable redesign made havoc of the Cook-Craigie plan for early tooling. Of the 30,000 tools already purchased by Convair in October 1953 (when testing established unequivocally that important changes had to be made in the plane's design), 20,000 had to be discarded and new ones bought—a sizeable increase in production costs. Meanwhile, the April 1954 wind-tunnel and scale-model tests of a remodeled F–102A (that included cambered leading edges, reflex wing tips, rearward relocation of wing, relocation of vertical fin, 7-ft fuselage extension, and redesign of fuselage to incorporate the principles of the area-rule "coke-bottle" configuration) reflected continuing deficiency in performance. Moreover, airframe and component changes had added 3,500 pounds to the aircraft's weight.

Further Redesign **1954**

In May 1954 the Air Force approved further redesign of the first "coke-bottle" configuration. The new drag-reducing changes extended the fuselage another four feet and added: a new canopy (lighter and providing better visibility), new engine-intake ducts, an aft fuselage fairing, and wing-camber modifications. The J–57–P–23 engine (generating 16,000 pounds of thrust, or approximately 1,200 pounds more thrust than the -11) was to replace the -11 and the interim -41 (an -11 engine modified for new air bleed probes to eliminate cabin fumes). A major weight-reduction, likewise, was initiated.

New Procurement **1954**

Redesign of the F–102A, once agreed upon, was accompanied by new production decisions. The Air Force in March 1954 gave Convair a second production contract calling for delivery of 37 additional F–102As between February and July 1955. A third and larger order, placed in June 1954, scheduled the delivery of another 108 aircraft between August and December 1956.

General Operational Requirements **4 November 1954**

Convair's new production contracts were soon followed by definite

[6] The F–86D, that the F–102A was supposed to supplant, had a service ceiling of 49,600 feet and a maximum speed of 601.7 kn(Mach .9). It was fully operational in mid-1953, the initial production date originally set for the F–102A.

qualifications. In November 1954 the Air Force issued a set of general operational requirements that called for altitude performances up to 54,000 feet, a combat radius of 326 nautical miles, and speeds up to Mach 1.23 at 35,000 feet. The Air Force also placed an informal (but nevertheless meaningful) hold order on the FY 1955 funds for the 108 F–102As, recently ordered. This hold order would prevail until forthcoming flight tests of the new F–102A proved to be satisfactory.

First Flight (Revised Prototype) **19 December 1954**

A "synthetically modified" production F–102A made its initial flight and demonstrated substantial performance improvement over the original configuration, reaching Mach 1.22 and an altitude of 53,000 feet. This demonstration "coke-bottle" prototype (nick-named the Hot Rod to distinguish it from the two earlier YF–102As and the few initial straight-fuselage productions allocated to the testing program) was fitted with fillets designed to the latest, light-weight configuration that had been approved by the Air Force in May 1954. It was powered by an advanced production of the improved J–57–P–23 turbojet, due for delivery in June 1955.

Testing **1955**

Evaluation of the Hot Rod prototype's preliminary flight tests led the Air Force to rescind in early 1955 its administrative hold order of the previous year. Ensuing flight tests by Air Force pilots, while demonstrating that the aircraft's stability needed improving, were also satisfactory. They ended in June 1955, after the aircraft's initial high speed had been equaled and its original altitude performance actually exceeded. Ten months of structural integrity testing were initiated in July, when the Air Force concluded (after numerous airborne firing tests) that the F–102A would be able to launch the Falcon missile, as well as 2.75- and 2-inch rockets. A high point in the series of armament tests was reached on 8 July, when the YF–102A fired 6 Falcons and 24 rockets in less than 10 seconds.

First Flight (Production Aircraft) **24 June 1955**

This was the first production F–102A built to the Hot Rod, lightweight, "coke-bottle" configuration. The aircraft was accepted by the Air Force on 29 June, 5 days after its first flight.

Enters Operational Service **April 1956**

The F–102A first entered service with the Air Defense Command's 327th FIS at George AFB. It became the Air Force's first delta-wing aircraft—almost 3 years past the June 1953 production date in the LC of December 1951, some 7 months beyond the revised delivery schedule of 1954, and nearly 10 years after the experimental, delta-wing F–92's first flight.

Production Modifications **1956**

One month before the F–102A entered operational service, the Air Force and Convair decided to give the F–102A a larger fin. This new design change, endorsed after a period of extensive testing, would alleviate the aircraft's instability, a remaining problem particularly acute at high speeds. The change became effective with the 26th F–102A, after Convair production schedule had been adjusted for this purpose. Enlarged fins were retrofitted on the 25 aircraft already off the production lines.

Armament Changes **1956**

As once planned and in order to simplify logistical support of the F–102A, the Air Force decided in mid-1956 that (beginning with all post-December productions) only the 2.75-inch Folding Fin Aerial Rocket would be used as backup to the Falcon (GAR–1 and infrared -1B) guided missiles—the aircraft's primary armament. Operational F–102As and those released from production before the decision could be implemented, would exchange their T–214 2-inch FFARs for the standard 2.75-inch rockets. Necessary modifications were subsequently made in the field by teams from the Air Force San Antonio Air Materiel Area, Tex. Some 170 F–102s were modified. In the meantime, after the first air-firing of an MB–1 rocket was accomplished from a YF–102 in May 1956, the Air Force again considered equipping the F–102A with Genie rockets, even though this would entail another production delay. This project, however, was given up in early 1957.

Additional Procurement **September 1956**

The Air Force gave Convair a fifth and final contract for 140 F–102As in September 1956, 10 months after the fourth and largest (562 aircraft) F–102A production contract had been placed.

Operational Problems **1957**

One year after becoming operational, the F–102A still harbored a number of deficiencies, but most defects were being corrected. By November, all F–102As had been retrofitted with serviceable struts and the incorporation of a new oleo strut metering pin and revision of the side brace boss bearing of the landing gear in all future F–102A productions gave assurance that the long-standing problem of landing gear failure (susceptible of affecting also the more advanced F–106 interceptor) was finally solved. Convair in addition had devised a fix for speed brake failures in flight, another critical problem which had dictated the reinspection of speed brake in each F–102A.

Other Production Modifications **1957**

While the F–102A's operational problems were being corrected, efforts to further improve the aircraft's performance did not slacken. After a successful prototype flight in May 1957, F–102As acquired a new wing. Referred to as the Case XX wing and phased into production after October 1957 (beginning approximately with the 550th F–102A), this final major structural change raised combat ceiling to 55,000 feet (a 5,000-ft increase), boosted maximum speed at 50,000 feet to Mach 1 (a Mach 0.06 gain), and substantially improved maneuverability. The F–102A's stability at low speeds, still marginal despite the previous in-production incorporation of a larger fin, also improved vastly.

Modernization **1957–1963**

Modernization of the F–102A, undertaken almost concurrently with the aircraft's final production change, lasted several years.[7] First involved were the addition of data link[8] and replacement of the MG–3 fire-control system by the improved MG–10. There followed the substitution of more sophisticated and less troublesome GAR missiles (as they became available) and the addition of the nuclear Falcon Model Y52A. This atomic missile, first known as the GAR–11 and subsequently redesignated the AIM–26A, had been designed by Hughes specifically for the F–102A. In 1963, after more than 450 aircraft had been modified and provided the necessary kits (one kit per aircraft, at an initial cost of $10,000 per kit), half of the F–102 interceptors (trainers included) could carry the AIM–26A. Ensuing modifications eventually provided interchangeable utilization of AIM–26 and AIM–4 (GAR–1 through 4 series of Falcons in post-1962 nomenclature) missiles in the center missile bay of a number of F–102As. Under project Big Eight (and still as part of the F–102A modernization), incorporation of an Infrared Search and Track System into the F–102 fleet also began in 1963.

Oversea Deployments **1958**

The F–102As were first deployed oversea in June 1958, when ADC's 327th FIS—the Air Force's first F–102A unit—moved to Thule, Greenland. The F–102As reached Europe and Alaska early in 1960, after some of the aircraft (due for deployment to oversea bases which only had tactical air navigation ground stations) were engineered to provide for the installation of AN/ARN–21 airborne TACAN equipment. The F–102As also joined the Pacific Air Forces early in 1960. They were to remain in both the European and Pacific theaters for nearly 10 years.

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[7] The F–102A was still being modernized long after some of the aircraft had already begun to leave the regular forces. This took care of the air defense needs, increasingly provided by the Air National Guard, and of important oversea requirements.

[8] Data link furnished the pilot information electronically rather than by voice.

War Commitments **1962-1969**

Four F-102s were sent from Clark AB, P. I., to South Vietnam in March 1962, after radars had detected low-flying, unidentified aircraft along the Cambodian border. This started a series of rotations every 6 weeks by Navy EA-1F all-weather fighters and USAF F-102s to Tan Son Nhut. The rotation ended in May 1963 due to base overcrowding. Nonetheless, from the summer of 1963 to mid-1964, Thirteenth Air Force conducted no-notice deployments of F-102s to South Vietnam and brief training flights to Tan Son Nhut and Da Nang. The small number of aircraft committed to SEA air defense before 1965 tripled by the end of 1966. At that time 12 F-102s stood alert in South Vietnam (6 at Bien Hoa and 6 at Da Nang) and another 10 in Thailand (6 at Udorn[9] and 4 at Don Muang). Little change occurred in 1967 and 1968, the Air Force keeping a minimum of 14 F-102s on 5-minute alert with the remainder of the force on 1-hour call. F-102 operations in SEA ended in December 1969[10] with a remarkable safety record. In almost 10 years of flying air defense and a few combat air patrols for SAC B-52s, just 15 F-102s were lost.

Attrition **1956-1971**

The F-102A's overall safety record (including all SEA losses) was also impressive. In more than 14 years of operation, only 16 percent of the F-102A total force, or less than 140 aircraft were lost in flying accidents.[11]

Subsequent Model Series

None—the TF-102 (trainer variant of the F-102A) entered production almost concurrently with the Hot Rod, light-weight, F-102A.

Other Configurations

None, besides the TF-102A. The F-102C, an F-102A that would use an advanced engine (the J-57-P-47 with titanium compressor), never came into being. The Convair F-102C proposal of 1956, then referred to as the F-102X, also included a tail cone extension of 7 inches and an armament load of one MB-1 Genie rocket and four Falcon missiles. The contractor expected that these changes (estimated to result in a speed increase to Mach 1.33 and a 3,000-ft altitude gain over existing F-102As) would qualify the new model to fill a possible gap between the end of the service life of the F-102A and the introduction of the F-106. The Air Force in April

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[9] More than a dozen F-104s based at Udorn also had air defense duties as a secondary mission.

[10] The last F-102 squadron at Clark was inactivated. However, a few F-102s remained at the Royal Thai Air Base of Don Muang until the summer of 1970.

[11] A minimal number of ground accidents occurred, bringing total F-102A operational losses to 141 as of 30 June 1971.

1957 decided to refuse the Convair proposal and to rely rather on the F–106 being ready for tactical inventory starting in mid-1958. Throughout the years the Air Force used a number of F–102As for special tests. As required by the testing programs in which they were used, these aircraft were sometimes stripped of their original components or fitted with additional equipment. They appeared on Air Force rolls on and off as JF–102As, but this was only a temporary designation. The Air Force used the J prefix to identify every tactical aircraft diverted to special test programs and later returned to their original or standard operational configuration.

End of Production **September 1958**

With delivery of five last aircraft.

Total F-102As Accepted

Of 889 accepted, 875 were assigned to the operational inventory and 14 were set aside for the testing program (2 YF–102As, 8 other early straight-fuselage aircraft, and 4 F–102As, built to the first major redesign configuration without intention of modification to a tactical configuration).

Acceptance Rates

One F–102A was accepted for the operational forces in FY 55, 45 in FY 56, 372 in FY 57, 427 in FY 58, and 30 in the first 3 months of FY 59. The highest production delivery was made in June 1956, when the Air Force accepted 51 aircraft. The Air Force accepted five straight-fuselage F–102As (including two prototypes) in FY 54 and five more in FY 55. The four redesigned, nontactical F–102As were accepted in FY 55.

Total RDT&E Costs

$101.92 million—prorated, it came to $101,921 and was included in every F–102's unit cost.

Flyaway Cost Per Production Aircraft[12]

$1.2 million—airframe, $744,258; engine (installed), $210,308; electronics, $9,208; armament, $219,876; ordnance, $525.

Average Cost Per Flying Hour

$611.00

Phaseout **1961-1973**

The F–102A replaced the F–86D as the most numerous interceptor and by the end of 1958 they numbered 627, or about half the total number of interceptors controlled by ADC. The F–102A began to leave the air defense system with the receipt of the F–101B and F–106A, but in mid-1961 there were still 221 of these aircraft

[12] Excluding $137,947 in prorated Class V modification costs and $11,612 spent on each F–102A for specific modifications.

available within ADC. Toward the end of 1969, when except for one squadron maintained in Iceland, all F-102s of the Air Defense Command had been transferred to the Air National Guard, the Air Force still retained a few oversea F-102 squadrons. Two were in the Pacific theater, three in Germany and one in the Netherlands. However, the F-102 squadrons stationed in Europe were being re-equipped with newer, more versatile F-4s and the F-102A's Pacific commitments were coming to an end. In mid-1972, only 17 F-102s (15 F-102As and 2 TF-102As) remained in the operational inventory of the Air Force and 69 F-102s were surplus. By 30 June 1973 the number of active USAF F-102s had been reduced to 10. Meanwhile, the F-102A had become an important asset of the Air National Guard. After receiving in 1960 an initial contingent of seven F-102As, the ANG's operational inventory of F-102As grew quickly. It jumped to 130 F-102s in 1961 and in mid-1966 reached 339 (311 F-102As and 28 TF-102As), a total that remained fairly constant in the ensuing years. In mid-1972, the ANG operational inventory of F-102s was down to 206 (181 F-102As and 25 TF-102As), but a USAF allocation of surplus F-102s had boosted this total to 224 by 30 June 1973.

Other Uses

The Air Force decided to convert aging F-102s into target drones. They would be used in Pave Deuce, an Eglin AFB program calling for low-cost, full-size, supersonic targets, representative of enemy aircraft (MIG-21s) in aerial combat. The Sperry Rand Corporation was selected for the conversion over Lear Siegler, Northrop, Celesco Industries, Lockheed Aircraft and Hughes Aircraft teamed with Honeywell. The $5.5 million Air Force contract awarded in April 1973 called for the modification of six F-102s into two different drone configurations. Two aircraft would be converted into QF-102A versions, retaining pilot controls for use in contractor-operated flights. The remaining four would be turned into "de-man-rated" afterburning targets, designated PQM-102As. The Pave Deuce PQM-102As would only be flown as drones, using less costly "de-man-rated" parts and checkout procedures. Sperry Flight Systems Divisions, Phoenix, Ariz., would handle the conversion, to be completed within 16 months. Ultimately, as many as 200 surplus F-102s might be modified.

TF-102A

Manufacturer's Model 8-12
Weapon System 201L

Previous Model Series

None. This was the trainer variant of the F-102A.

New Features

Wider forward fuselage providing side-by-side cockpit seating for student and instructor.

General Operational Requirements **April 1952**

For a dual-controlled trainer version of the F–102A interceptor to transition jet pilots to the intricately different delta-wing airplane. Neither ADC nor the Air Training Command believed that this training could be provided with conventional type jet trainers.[13]

Go-Ahead Decision **16 September 1953**

The Air Force authorized production of the TF–102A. However, because of the problems encountered with the basic F–102A design, initial procurement was delayed and further production postponed until the fate of the tactical program was determined.

Contractual Arrangements **July 1954**

A firm order for 20 TF–102As was placed on contract, with first delivery due in July 1955. This initial procurement followed approval by the TF–102A Mockup Board of the side-by-side trainer nose configuration, presented by the Convair Fort Worth plant in January 1954. It was endorsed (in preference to the conventional tandem configuration) to simplify training, realizing that the extra weight of the new forward fuselage would probably hinder trainer performance.

Mockup Inspection **September 1954**

The two-place TF–102A was identical to the F–102A aft of the cockpit section. It would also retain the F–102A's weapon capability.

Additional Procurement **1955**

In early 1955, following the December 1954 successful flight of the revised YF–102A, 28 additional trainers were ordered. The Air Force gave Convair a letter contract for 150 other TF–102As in December—1 month after the trainer's first flight. These planes were to be delivered between March and December 1957.

First Flight (Production Aircraft) **8 November 1955**

The Air Force accepted the first TF–102A during the month it first flew and took delivery of a second production in December 1955—several months past the original deadline.

Initial Problems **1955-1956**

Extensive operational testing soon revealed that the TF–102A's large cockpit and canopy created a serious buffeting problem at high speed. A new cockpit configuration with a cut-down canopy and revised windshield, flight-tested in April 1956, did not prove to

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[13] Shortcomings of the then available T–33 and radar-equipped B–25 trainers had been confirmed by the F–86D and F–94 transition training programs.

be the answer. Buffeting was somewhat reduced but at the expense of landing visibility, which had become less than marginal. The simplest solution was to revert to the trainer's original cockpit. The buffeting problems would be eliminated by adding vortex generators and an increased area vertical stabilizer to the aircraft fuselage. These structural modifications, successfully tested with the third TF–102A accepted by the Air Force in June 1956, were introduced in all subsequent productions.

Production Hold Order **January/June 1956**

The TF–102A's initial buffeting problem caused the Air Force to stop Convair production. The Air Force released its hold order late in June 1956, after successful testing of the third TF–102A—a modified article, representative of subsequent productions. During the same period the Air Force also decided to reduce its TF–102A procurement and cut Convair's last order almost by half. Despite the reduction, Convair did not make up for the time lost. Final deliveries to the Air Force still lagged 6 months behind the original schedule.

End of Production **July 1958**

With delivery of the last five TF–102As.

Total TF–102As Accepted

111 (68 less than once programmed), bringing total F/TF–102A procurement to 1,000 aircraft.

Acceptance Rates

Three TF–102As were accepted in FY 56, 27 in FY 57, 76 in FY 58, and 5 in FY 59.

Flyaway Cost Per Production Aircraft[14]

$1.5 million—airframe, $1,135,018; engine (installed), $144,474; electronics, $11,365; armament, $173,777; ordnance, $1,192.

Average Cost Per Flying Hour

$611.00

Phaseout

The TF–102A's phase out and operational life followed the F-102A's pattern. As a rule, two TF–102As accompanied each F-102A squadron.

PROGRAM RECAP

The Air Force accepted a grand total of 1,000 F–102s. Of these, 889 were listed as F–102As, even though they included 2 prototypes, 8 early straight-fuselage, and 4 F–102A test aircraft. The remaining 111 were TF–102As.

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[14] Excluding $137,947 in prorated Class V modification costs and $11,182 spent on each TF-102A for specific modifications.

TECHNICAL DATA

F/TF-102A

Manufacturer	Convair Division of General Dynamics Corporation, San Diego, Calif.	
Nomenclature	Supersonic, all-weather, fighter-interceptor.	
Popular Name	Delta Dagger	
Characteristics	*Point Interceptor*	*Area Interceptor*
Takeoff Weight	28,150 lb	31,276 lbs (w/two 215 gallon extra tanks)
Length Fuselage/Wing	68."3′/38."1′	68."3′/38."1′
Max. Speed at 35,000 ft	677 kn	677 kn
Radius		566 nm (w/two 215 gallon extra tanks)
Engine, Number & Designation	1J57-P-23A	1J57-P-23A
Takeoff Ground Run	2,290 ft	2,800 ft
Rate of Climb (sea level)	17,400 fpm	4,500 fpm (Mil. power climb)
Combat Ceiling	51,800 ft	51,400 ft
Crew[15]	1	1
Armament[16]	12 2.75″ FFAR rockets	12 2.75″ FFAR rockets
Ordnance	2 AIM-26/26A or 1 AIM-26/26A + 2 AIM-4A or 1 AIM-26/26A + 2 AIM-4C/D or 6 AIM-4A or 6 AIM-4C/D	2 AIM-26/26A or 1 AIM-26/26A + 2 AIM-4A or 1 AIM-26/26A + 2 AIM-4C/D 6 AIM-4A or 6 AIM-4C/D

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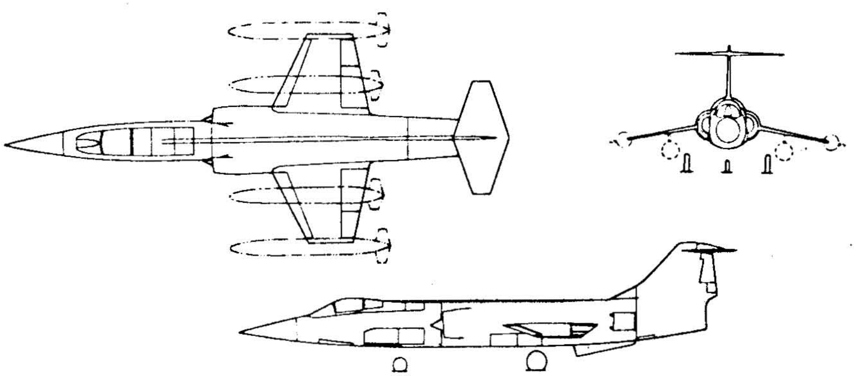
[15] TF-102A, when used as trainer, provided accommodation for a two-man crew (student and instructor).

[16] FFAR rockets capability removed from aircraft modified to provide interchangeable utilization of Falcon AIM-26 and Falcon AIM-4 missiles in the center missile bay.



LOCKHEED F–104 STARFIGHTER

F–104A: One of the Air Force's smallest and lightest planes. The tiny F–104A, with its long-nosed fuselage and razor-thin trapezoid wings, had never been intended as an interceptor, but the Air Defense Command liked its performance.

F–104B: Second cockpit aft of the F–104A's single seat—in the space otherwise designed for the M–61 Vulcan gun. The F–104B trainer retained the Sidewinder air-to-air missiles of the F–104A.

F–104C: The slightly heavier F–104C served as a tactical fighter with the Tactical Air Command. It featured a more powerful engine, a probe-drogue air refueling system, and could carry nuclear stores. Several F–104Cs were used in Southeast Asia.

F–104D: The two-seater training version of the F–104C was eventually fitted with 2.75 inch rockets for air-ground support.

F–104G: This all-weather fighter-bomber had a stronger structure. It was produced under patent by Europe and Canada in various configurations. Japanese-made F–104s were interceptors, designated F–104Js.

LOCKHEED F-104 STARFIGHTER

Manufacturer's Model 183-93-02
Weapon System 303A

Basic Development **1949-1952**

Lockheed developed the F-104 from its F-90—flight tested in 1949 but never produced. The F-104 also benefited from Douglas work on the X-3—an experiment flown in October 1952 that did not meet expectations because of the lack of an adequate engine.[1]

Unsolicited Proposal **November 1952**

Lockheed knew[2] the Air Force (based on its Korean experience) needed a new air superiority fighter, capable of operating from forward air fields, accelerating rapidly from the ground, and fighting at high altitudes. Lockheed proposed a light-weight, straight-wing design, when the Air Force had in mind a relatively heavy delta-wing aircraft. Yet Lockheed's small, "Gee Whizzer" day-fighter (later dubbed Starfighter) was tempting for it would be cheaper.[3]

General Operational Requirements **12 December 1952**

Called for development of a light-weight air superiority day fighter to replace TAC's F-100s in 1956. The formal USAF requirement of December 1952 (finalized 1 month after Lockheed's unsolicited proposal) soon entered competitive bidding.

Contractor Selection **January 1953**

After considering entries from Republic and North American Aviation, the Air Force endorsed Lockheed's official bid. Circumstances had favored Lockheed from the outset. The relative merits

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[1] To recoup its losses on the X-3 program, the Air Force insisted that Douglas deliver the aircraft plans to Lockheed.

[2] In fact, Lockheed had rejected in May 1952 a letter contract covering the construction of flying prototypes because of a clause forfeiting all patent features to, and permitting, the government to assign the new airplane's production to others. Similar provisions, initially included in the North American F-100, Convair F-102, and McDonnell F-101 production contracts, were also turned down by the contractors. In all these cases, the government eventually gave in.

[3] Moreover, in late 1952 all criteria in the world of aviation were subordinated to flight performance. The weight controversy born of the Korean air battles was unsettled. Despite its kill superiority over the MIG, the heavier F-86 (with its sometimes superfluous gadgets) was criticized for complexity and extra weight. Notwithstanding, Clarence L. (Kelly) Johnson, Lockheed's chief engineer, said in 1954: "This [the XF-104] is still a highly complex airplane. You simply don't fly around at 40,000 feet at those kinds of speeds just by throwing a saddle over the thing and riding it. But what we have done is bring an end to the trend toward constantly bigger, constantly more complicated, constantly more expensive airplanes."

of each proposal were of primary importance. Nevertheless, the Air Force wanted to prevent Republic and North American from monopolizing the development and production of new fighters.[4]

Letter Contract **11 March 1953**

Selection of the Lockheed proposal was not a blanket endorsement of the F-104 design. The Air Force moved cautiously. Lockheed was awarded a development LC for two XF-104s and 1 year of flight testing. An early 1954 first flight was scheduled.

Mockup Inspection **30 April 1953**

This initial inspection led to replacement of two 30-mm guns with one 20-mm GE Gatling gun-type M-61 Vulcan cannon (under development and then known as the T-171 gun) for a net weight decrease of 80 pounds. The F-104 cockpit's final inspection did not take place until 29 January 1955—almost 2 years later. Still, the F-104's early development stages were unusually rapid.[5]

First Flight (XF-104) **28 February 1954**

The aircraft featured a Buick-built J-65 engine,[6] far less powerful than the General Electric J-79,[7] intended for any F-104 productions. Lockheed flew its second XF-104 on 5 October, after fitting the J-65 engine with an afterburner. This raised the aircraft performance significantly.

F-104A

Go-Ahead Decision **July 1954**

Still cautious, the Air Force programmed only 17 aircraft under "fly-before-you-buy." This meant more development tests before any large-scale production.

Initial Procurement **October 1954**

One month after the first XF-104 successfully completed Phase I

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[4] Republic was already committed to the XF-105, the XF-103, and the F-84 program; North American, to the F-86 and F-100.

[5] Less than a year separated the development LC of March 1953 and the XF-104's first flight. Nevertheless, Lockheed had turned down 1 year before a contract calling for similar prototypes. In effect, the same 1951 design competition which resulted in the so-called 1954 Ultimate Interceptor (F-102 and F-106) also, in a sense, spawned the F-104. The Air Force removed Lockheed from consideration as regards the Ultimate Interceptor in September 1951, but soon went back for development of a very advanced day fighter. Nonetheless, the F-104 was unique—experiencing few serious problems during development, perhaps due to its derivation from earlier (F-90 and X-3) developments.

[6] An adaptation of the British Sapphire, the J-65 was first built by Curtiss-Wright for the F-84F.

[7] The static thrust of the GE-J-79 engine (developed for the B-58 bomber and first tested in June 1954), with afterburner, exceeded 14,000 pounds. The XF-104's J-65 had only an 11,500-lb thrust, counting the 3,500 pounds added by its afterburner.

testing. Yet as programmed, Lockheed's first production contract covered only 17 F–104s[8] (closely resembling their experimental predecessors). The Air Force planned to refurbish these aircraft for normal employment, after completion of scheduled suitability tests.

Initial Testing (XF-104) 1954–1956

Scheduled XF–104 flight tests ended in August 1956, marred by the April 1955 crash of one of the two aircraft.[9] In March 1955 an XF–104, still powered by the interim J–65 had attained Mach 1.7 and an altitude of 60,000 feet. Lockheed designers had predicted a speed around Mach 2 and a combat ceiling of 53,000 feet for the aircraft.

First Flight (Production Aircraft) 17 February 1956

The flight was conducted at the Air Force Flight Test Center, Edwards AFB, Calif. A second aircraft, accepted in March, entered flight testing on 15 June.[10]

Other Flight Tests 1956–1958

The F–104 evaluation and suitability test program uncovered all sorts of unexpected problems. This stretched testing to 52 F–104s—35 more than the 17 test productions originally forecasted.

Engine Problems 1955–1958

Fearing the General Electric J–79 turbojet might not be ready in time, the Air Force (until 1955) thought of using the J–65 for initial F–104s. J–65's new malfunctions took care of this temporary planning, however. Since no F–104 airframes were available in 1955 the Air Force then flight-tested the experimental J–79 in a borrowed Navy XF–4D. This worked. The December 1955 testing of the XJ–79–GE–3 and production of the J–79–GE–3A enabled the F–104 2 years later to approach Mach 2. Notwithstanding, flameouts, ignition failures, and oil depletions caused several crashes and in-flight emergencies during testing and after the aircraft had become operational. General Electric came up with a better engine (the J–79–GE–3B), but not before the F–104s were repeatedly grounded. Retrofit of the –3B in early F–104s began in April 1958.

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[8] The Air Force ordered 209 additional F–104s the following year and 480 more (including 106 earmarked for training) in late 1956. By 1957, 722 F–104s of one kind or another were programmed for production. This number was drastically reduced in December 1958—the entire USAF F–104 program never went past 294.

[9] Testing of the armament and fire-control system in this aircraft was then switched to a Lockheed F–94C, because none of the 17 aircraft ordered in October 1954 were yet available.

[10] First of the F–104s ordered in October 1954. Primarily earmarked for testing, these aircraft were immediately accounted for as production models.

Structural Deficiencies **1956-1957**

Lockheed reduced the F-104's pitchup to an acceptable USAF level in December 1956 and continued improvement. It corrected an aerodynamic weakness in 1957 by redesigning the tail section.

Other Problems **1956-1957**

The 20-mm, M-61 Vulcan cannon was selected for the F-104 in 1953. However, repeated flight-testing of the gun led the Air Force in November 1957 to consider it too unreliable for the early aircraft. (It was retrofitted in 1964.) The F-104's high speed rendered its downward ejection seat unsatisfactory despite safety improvements. Lockheed was perfecting a replacement upward ejection system, but progress was slow. Even so, retrofitting of all F-104s with the new seat got under way in the early 60's.

Enters Operational Service **26 January 1958**

The F-104A entered service 2 years late and not with TAC (as originally planned), but with ADC's 83d Fighter Interceptor Squadron at Hamilton AFB. This April 1956[11] shift rested on two factors: slippage of the F-104 operational due-date (causing TAC to make other arrangements) and ADC's urgent need of a fighter to fill the gap between the F-102 and F-106. The tiny F-104,[12] with its longnosed fuselage and razor-thin trapezoid wings, had never been intended as an interceptor. But ADC believed it could use it, due to its impressive performance.

Oversea Deployments **October 1958**

Twelve F-104As from the 83d FIS were disassembled and flown by C-124s to beef up Taiwan's air defense during the Quemoy crisis of 1958. This took place less than a year after the F-104 became operational.

Total F-104As Accepted

170 (excluding the two XF-104 s ordered in March 1953)—against the 610 programmed in 1957. Fund shortages accounted for most of the cut; TAC revised requirements, the remainder.

Acceptance Rates

The Air Force accepted 7 F-104As in FY 56, 28 in FY 57, 94 in FY 58, and 41 in FY 59.[13]

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[11] The Air Force also decided at this time to give the aircraft Philco air-to-air, heat-seeking Sidewinder missiles—developed by the US Navy in 1947 and first carried by TAC's F-100Ds. The timing of the two decisions was coincidental. All F-104s were equipped with Sidewinders and a final decision on each model's allocation (F-104As and Bs to ADC, and F-104Cs and Ds to TAC) was not reached until January 1958.

[12] One of the Air Force's smallest, with a 21.9-ft wing span; lightest too, with maximum takeoff weight below 28,000 pounds for most models.

[13] Extensive F-104 testing and the problems uncovered resulted in only one or two F-104As being accepted each month until May 1957. Thereafter, monthly acceptance rates increased several fold.

End of Production **December 1958**

In that month, the last eight F–104As were received and the entire F–104 program was slashed.

Flyaway Cost Per Production Aircraft

$1.7 million—airframe, $1,026,859; engine (installed), $624,727; electronics, $3,419; ordnance, $29,517; armament, $19,706.

Average Cost Per Flying Hour

$655.00

Average Maintenance Cost Per Flying Hour

$395.00

Subsequent Model Series

F–104B

Other Configurations

None. In 1956 the Air Force approved a November 1954 TAC proposal of a preliminary design for a reconnaissance version of the F–104. The Air Force, however, cancelled all RF–104 work in January 1957, believing that forthcoming RF–101s (RF–101Cs in particular) would satisfy TAC requirements.[14]

Initial Phaseout **1960**

Longer-range all-weather F–101 and F–106 interceptors,[15] operational malfunctions and shortages of spare parts prompted ADC to quickly get rid of its four F–104 squadrons (B trainers included). Too small to carry the data link equipment called for by ADC's new SAGE control-system, the F–104 would be a windfall for the Air National Guard and the Military Assistance Program.

Reactivation **1961–1963**

The Berlin Crisis of 1961 embarked the F–104 on a new tour of active service. In October three federalized ANG squadrons of F–104s went to Europe and stayed until the summer of 1962. Then, one squadron converted to C–97 transports to support active military airlift requirements. The other two wound up their federalized duty with ADC. The Cuban Missile Crisis of October 1962 rekindled USAF interest in the F–104. This quick-reacting aircraft could challenge most hostile aircraft that might attack the United States from Cuba. So, upon return to state control, the two ANG F–104 squadrons surrendered their aircraft[16] to ADC's 331st

[14] TAC considered the earlier RF–101A (operational in May 1957) as a sort of consolation prize for the RF–104 and RF–105, both deleted from future reconnaissance forces for lack of money. TAC at one point had envisioned four RF–104 squadrons.

[15] Both the F–101B and F–106 entered operational service in 1959—the F–101B in January; the F–106, in May.

[16] Receiving F–102A interceptors in return.

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FIS at Webb AFB, Tex., and to the 319th FIS at Homestead AFB, Fla.[17] Reactivated F–104s were retrofitted with M–61 Vulcans.

Final Phaseout **1967-1969**

A general reduction in active ADC fighter-interceptor squadrons brought the F–104A's final phaseout—the 331st was inactivated in February 1967; the Homestead-based 319th, in December 1969.

Other Countries

A number of F–104As relinquished by the Air Force in 1960 were transferred to the Chinese Nationalist Air Force and to the Pakistan Air Force.

Other Uses **1960-1963**

The Air Force converted 24 F–104As into target drones[18] soon after ADC first declared the aircraft surplus. In October 1963 one F–104A was delivered to Edwards AFB's Flight Test Center to test a liquid-fueled rocket that would add 6,640 pounds to the engine thrust. This test aircraft (NF–104A) set on 6 December 1963 an unofficial world altitude record by reaching 120,000 feet.

Milestones **1958**

The F–104 was the first USAF combat aircraft to sustain a speed faster than Mach 2. In May 1958 an F–104A at Edwards AFB set a world speed record of 1,404.19 miles per hour and a 91,249–foot altitude record for ground-launched planes. The following December, F–104A aircraft at Pt. Mugu, Calif., set three time-to-climb records: 3,000 meters in 41.35 seconds, 15,000 meters in 131.1 seconds; and 25,000 meters in 266.03 seconds.

F-104B

Manufacturer's Model Series 283-93-03

Previous Model Series

F–104A

New Features

Second cockpit aft of the F–104A's single seat—in the space otherwise designed for the M–61 Vulcan gun.[19]

Basic Development

Lockheed developed the F–104B purely as a two-seat training version (TF–104) of the F–104A. The Air Force's December 1955

[17] The 319th was purposefully relocated to Homestead during the Cuban Crisis.

[18] Flyaway cost per drone (QF–104) reached $1.7 million—airframe, $1,010,830; engine (installed), $628,551; electronics, $3,419; ordnance, $29,517; armament, $19,706.

[19] In contrast to the F–104A (retrofitted with the M–61 in 1964), the F–104B's armament never exceeded two AIM–9B (originally designated GAR–8) Sidewinders.

decision to equip operational F–104A squadrons with the two-seater brought about its redesignation (all possible F–104A armament was retained—usual in such cases). The Air Force earlier in the year also thought of using the F–104 trainer for suitability, high-altitude, and physiological research tests.

Initial Procurement **April 1956**

Procurement started slowly, as it had for the F–104A. The Air Force first ordered six F–104Bs; 106 more in 1957.

First Flight (Production Aircraft) **16 January 1957**

The flight took place less than a year after the two-seater's first mockup inspection—an uneventful flight over California, from the Lockheed Palmdale plant to the nearby USAF Flight Test Center. The Air Force took official delivery of the aircraft in the same month.

Flight Testing **1957**

The first 30 days of flight tests showed F–104A and F–104B performance to be similar. This was expected. The Air Force did not plan to accept any more F–104Bs until the fall of 1957, when extensive F–104A flight tests would be completed. Meanwhile, it needed the first F–104B to test the downward ejection seat that first equipped most F–104s. The Air Force took official delivery of a second F–104B in September—1 month ahead of schedule.

Enters Operational Service **1958**

With the 83d FIS (the first F–104A recipient) at Hamilton AFB. ADC's three other F–104A squadrons shared later F–104Bs.

Total F-104Bs Accepted

26—against 112 ordered in 1957.

Acceptance Rates

The Air Force accepted one F–104B in FY 57, 14 in FY 58, and 11 in FY 59.

End of Production **November 1958**

With delivery of the last 4 F–104Bs.

Subsequent Model Series

F–104C

Other Configurations

None

Flyaway Cost Per Production Aircraft

$2.4 million—airframe, $1,756,388; engine (installed), $336,015; electronics, $13,258; ordnance, $59,473; armament, $231,996.

Average Maintenance Cost Per Flying Hour

$544.00

Phaseout **1960–1969**

Transferred to the ANG in 1960, the F–104B returned to ADC's active inventory in 1962–1963. It phased out again in 1967–1969, along with and in the same manner as the F–104A.

F-104C

Manufacturer's Model 583-04-05

Previous Model Series

F–104B

New Features

J–79–GE–7A engine (15,000–lb static thrust with afterburner) having 1,000 pounds more thrust than the J–GE–3B (with afterburner) in F–104Bs, late F–104As, and retrofitted in early F–104As. The F-104C also featured an improved fire-control system (AN/ASG–14T–2, replacing the F–104A's–1) for day and clear-night operations; a probe-drogue air refueling system; and external nuclear stores.[20]

First Flight Production Aircraft **July 1958**

First Acceptance **September 1958**

The Air Force accepted four F–104Cs, then seven or more each month, beginning in October.

Enters Operational Service **September 1958**[21]

The 476th Tactical Fighter Squadron at George AFB, along with three other squadrons of the 479th Tactical Fighter Wing, became TAC's only F–104 combat units. All four squadrons at George converted from F–100s, the last in 1959.

Total F-104Cs Accepted

77

Acceptance Rates

All F–104Cs were accepted in FY 59—seven to nine each month from October 1958 through June 1959.

End of Production **June 1959**

It ended with delivery of the last seven F–104Cs.

Subsequent Model Series

F–104D

Other Configurations

None

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[20] Previous F–104s carried only conventional ordnance and extended their range with external fuel tanks (suspended from a centerline fuselage rack, in place of additional Sidewinders).

[21] TAC officially accepted the F–104C in mid-October during the USAF annual fighter weapons meet at Nellis AFB.

Flyaway Cost Per Production Aircraft[22]

$1.5 million—airframe, $863,235; engine (installed), $473,729; electronics, $5,219; ordnance, $44,684; armament, $91,535.

Average Maintenance Cost Per Flying Hour

$395.00

Operational Problems **1959–1964**

Shortages of engines, components, and supplies plagued TAC's F–104Cs and their few accompanying trainers (F–104Ds). Even worse was the unreliability of components—the new J–79–GE–7A engine a major culprit. In less than 5 years, 40 major accidents occurred claiming nine lives and destroying 24 aircraft. This paved the way for Project Seven Up, a General Electric modification that started in May 1963 and ended in June 1964.

Modernization **1961–1963**

In October 1961,[23] the Air Force had launched Project Grindstone by which Lockheed modernized the F–104 air superiority fighter. Completed by early 1963, Grindstone gave the F–104C four Sidewinders (all other F–104s carried only two), plus a variety of airground weapons—2.75–inch rockets, napalm and gravity bombs.

Special Deployments **1962–1964**

The Cuban Missile Crisis of 1962 saw the unexpected deployment of F–104Cs to Key West, Fla. As a result of the same crisis, F–104Cs in 1964 were also called upon to fulfill some F–104As air defense commitments. They moved to Homestead AFB, while F–104A interceptors were retrofitted with M–61 Vulcans.

Oversea Deployments **1965–1967**

F–104Cs went first to Southeast Asia on a temporary basis. In 1965 one squadron stood alert at Kung Kuan, Taiwan, and Da Nang, South Vietnam. From Da Nang, the aircraft soon struck targets in both South and North Vietnam—enemy ground fire taking its toll. A new contingent of F–104Cs returned to SEA in mid–1966, this time permanently. F–104Cs of TAC's 479th Tactical Fighter Wing were then assigned to the 435th TFS at Udorn, resuming their attacks until they were replaced by more efficient F–4Ds in July 1967.

Phaseout **1966–1967**

The F–4D program slippage and the war's impact on USAF resources postponed the aircraft phaseout. In 1962 one of TAC's four squadrons of F–104 tactical fighters equipped a combat crew training squadron, the other three did not begin converting to F–

[22] Plus cumulative R&D and Class V modification costs of $189,473 and $198,348 per aircraft.

[23] Almost 2 years before implementing the upcoming Seven Up modification.

4Ds until 1966. For all practical purposes, phaseout wound up in 1967—almost 5 years later than planned—with redeployment of the last F–104s left in Thailand. The aircraft joined the ANG in time for the 198th Tactical Fighter Squadron in Puerto Rico to convert in August from the elderly F–86H.[24]

Milestones **14 December 1959**

An F–104C reached 103,389 feet, breaking the world altitude records set by the Soviets and the US Navy (who had broken records set by an F–104A in May 1958).

F-104D

Manufacturer's Model 583-04-06

Previous Model Series

F–104C

New Features

A rear cockpit, basic to most trainers. (To make room, the M–61 Vulcan had to be removed.)

First Flight **October 1958**

Enters Operational Service **November 1958**

First, the 476th Tactical Fighter Squadron at George AFB, and later TAC's three other F–104C squadrons were equipped with the F–104D.

Total F-104Ds Accepted

21

Acceptance Rates

The Air Force accepted 16 in FY 59 and 5 in FY 60 (2 monthly from November 1958 through August 1959).

End of Production **September 1959**

With the delivery of the last F–104D.

Flyaway Cost Per Production Aircraft[25]

$1.5 million—airframe, $873,952; engine (installed), $271,148; electronics, $16,210; ordnance, $70,067; armament, $269,014.

Average Maintenance Cost Per Flying Hour

$395.00

Modernization **1961**

Under Project Grindstone's F–104C modernization, Lockheed fitted the F–104D with 2.75–inch rockets for air-ground support.

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[24] By mid–1972, the Air Force had only 18 F–104s (6 F–104Cs and 12 F–104Ds) in active service; the Guard, 6 (2 F–104Cs and 4 F–104Ds).

[25] Excluding cumulative R&D and Class V modification costs of $189,473 and $196,396 for each F–104D.

Subsequent Model Series

F-104G—mostly foreign-made.

Other Configurations

F-104F. Built in the United States for MAP, the F-104F was accepted by the Air Force (20 in FY 60 and 10 in FY 61) for West German pilot training in Europe. The F-104F closely resembled the F-104D but featured upward ejection seats. Until retrofitted, most USAF F-104s (D models included) had the troublesome downward ejection seat.

Phaseout **1966-1967**

F-104Ds phased out of TAC's active inventory along with and in the same manner as the F-104Cs. In 1967, the D model, as well as the C, equipped the ANG 198th Tactical Fighter Squadron in Puerto Rico.

F-104G

Manufacturer's Model 863-10-19

New Features

Stronger structure (through extensive internal redesign) for performing many roles in any weather.[26] Had four Sidewinders for interceptor duty. Carried air-to-surface missiles,[27] rockets, and gravity bombs for attack. Featured the J-79-GE-11A engine—with the -7's thrust, but more reliable—and F-15AM-11 fire-control system.

Production Decision **December 1960**

The Office of the Secretary of Defense, based the decision on West Germany interest in 1958 and the growing obsolescence of allied forces' F-84s and F-86s.[28]

Production Policy **December 1960**

US agreements with West Germany, Belgium, the Netherlands, and Italy authorized these countries to produce F-104s. The United States subsequently signed similar agreements with Canada and Japan. In keeping with political restraints on offensive

[26] The F-104G retained the 20-mm M-61 Vulcan of other F-104s and, in addition, the nuclear-conventional ordnance of the F-104C.

[27] Two nuclear warhead AGM-12Bs, an improved version of the Martin air-to-surface Bullpup missile developed in 1954 by the US Navy. Then known as the GAM-83B, the AGM-12B first equipped TAC's F-100s in November 1960.

[28] F-84/F-86 shortcomings had long been known. USAF as early as 1953 needed a lightweight, high-performance fighter to satisfy the requirements of the North Atlantic Treaty Organization standing group. The Lockheed F-104 was then the leading American contender; the British pushed their Folland Knat (FO-141) small jet fighter. As a ground-support fighter, the French SNCASE (*Société Nationale de Constructions Aéronautiques du Sud-Est*) SE-5000 Baroudeur transonic jet was highly favored by the Western European powers.

operations, Japanese production was limited to an interceptor version of the F–104.

First Production Order **February 1961**

The order was placed by the United States with the Lockheed California plant (with MAP funds) for TAC training of allied pilots.

Other US Procurement

F–104G components, paid for by MAP, would also be manufactured in the United States to support allied F–104 production. Moreover, MAP-funded F–104Gs would be fabricated by Canadair (a Lockheed subsidiary in Ontario, Canada) and handed out to Denmark, Norway, Greece, and Turkey.

First Acceptance **July 1962**

The Air Force accepted the first American-made MAP F–104G earmarked for TAC. The Air Force then accepted the first Canadair-built F–104G in September 1963.

Enters Operational Service **10 October 1962**

With a TAC combat crew training unit at George AFB. MAP F–104 training began at George and Luke AFB, Arizona. It was later consolidated at Luke, where West German pilots had been the first students.

Total MAP F–104Gs Accepted

Of 192 accepted, 52 came from California (for TAC allied training) and 140 from Canadair (for designated allies).

Acceptance Rates

From California, 23 in FY 63 and 29 in FY 64; from Canadair, 40 in FY 64, 74 in FY 65, 25 in FY 66, and 1 in FY 67.

End of Production **June 1964**

Production first ended in California. Canadair F–104G production extended to September 1966.

Subsequent Model Series

None

Other Configurations

RF–104G. A MAP, California-produced, F–104G was equipped with three KS–67A cameras to demonstrate its reconnaissance potential. The Air Force accepted 24 RF–104Gs between March and September 1963 (14 in FY 63 and 10 in FY 64), but quickly returned 5 to their basic F–104G configuration.

TF–104G. A two-cockpit F–104G built in California for MAP and Military Assistance Sales (MAS). The Air Force accepted 29 MAP TF–104Gs—28 for TAC allied training (the first in September 1962, the last in December 1964) and 1 for Spain in October 1965. The Air Force also accepted 87 MAS TF–104Gs between October 1962 and February 1965 (40 in FY 63, 35 in FY 64, and 12 in FY 65). West Germany bought 72; Italy, 12; and Belgium, 3.

F-104J. Produced by Mitsubishi Heavy Industries, under license from Lockheed. Japan also manufactured a two-cockpit F-104J interceptor—the TF-104J trainer.

CF-104. Produced by Canadair for air support of Canadian ground troops. For better ground-attack performance it sacrificed versatility—an F-104G strong point. A two-crew CF-104D accompanied the Canadian CF-104.

Flyaway Cost Per Production Aircraft[29]

F-104G. $1.42 million—airframe (including electronics, ordnance, and armament), $1,251,000; engine (installed), $169,000.
TF-104G. $1.26 million.

Items of Special Interest

More than 1,400 F-104Gs of one configuration or another were produced during the 1960's by Europe, Japan, Canada, or the United States. This bore out Lockheed's financial foresight in retaining all F-104 patent rights.

PROGRAM RECAP

The Air Force accepted a grand total of 663 F-104s—296 for its own use, the rest for MAP and MAS. The USAF lot counted 2 XF-104s, 170 F-104As, 26 F-104Bs, 77 F-104Cs, and 21 F-104Ds. The 280 MAP F-104s consisted of 30 F-104Fs, 197 F-104Gs (some of them accepted as RF-104Gs but quickly stripped of recon equipment and returned to F-104G configuration), 24 RF-104Gs, and 29 TF-104Gs. All 87 MAS F-104s were TF-104Gs.

[29] Applied to both the California and Canadair-built F-104Gs and TF-104Gs, accepted by the Air Force for MAP.

TECHNICAL DATA

F–104A and F–104B

Manufacturer		Lockheed Aircraft Corporation, Burbank, Calif.
Nomenclature	XF–104	Air Superiority Jet Fighter.
	F–104A	Lightweight Fighter (served as a day-night interceptor).
	F–104B	Lightweight Fighter/Trainer (served as a day-night interceptor and trainer).
Popular Name		Starfighter

Characteristics	*F–104A*	*F–104B*
Length/Span	54.8/21.9 ft	54.8/21.9 ft
Engine, Number & Designation	1J79–GE–3	1J79–GE–3
Max. Takeoff Weight	24,804 lb	24,294 lb
Takeoff Ground Run	6,190 ft	5,870 ft
Average Cruise Speed	520 kn	515 kn
Max. Speed	2 Mach	2 Mach
Ferry Range	1,376 nm	1,210 nm
Combat Ceiling	55,200 ft	48,600 ft
Rate of Climb (max.)	36,000 fpm	37,000 fpm
Combat Radius	350 nm	188 nm
Crew	1	2
Ordnance Max. lb[30]	930 lb	420 lb
Guns (internal)	1 M–61[31]	None

[30] Ordnance included combinations of Sidewinder (AIM–9B) air-to-air missiles, 2.75-inch (FFAR) rockets, and gravity bombs (MK–117, MK–84, MK–83, MK–28 and MK–43) and ammunition for the M–61 gun.
[31] Five years after its production, the F–104A received the M–61 Vulcan cannon.

F–104C, F–104D, and F–104G

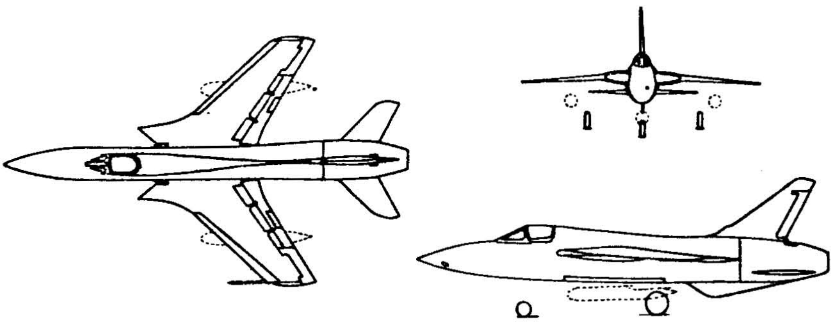
Nomenclature	F–104C	Lightweight Fighter (served as a tactical fighter).
	F–104D	Lightweight Fighter/Trainer (served as a tactical fighter and trainer).
	F–104G	All Weather Fighter Bomber.[32]

Characteristics	*F–104C*	*F–104D*	*F–104G*
Length/Span	54.8/21.9 ft	54.8/21.9 ft	54.8/21.9 ft
Engine, Number & Designation	1J79–GE–7	1J79–GE–7	1J79–GE–11A
Max. Takeoff Weight	27,853 lb	23,725 lb	29,038 lb
Takeoff Ground Run	5,880 ft	5,400 ft	6,000 ft
Average Cruise Speed	507 kn	500 kn	509 kn
Max. Speed	2 Mach plus	2 Mach plus	2 Mach plus
Ferry Range	1,500 nm	1,195 nm	1,628 nm
Combat Ceiling	58,000 ft	53,000 ft	46,500 ft
Rate of Climb (max.)	45,000 fpm	45,000 fpm	41,000 fpm
Combat Radius	306	157	538
Crew	1	2	1
Ordnance Max. lb[33]	930 lb	420 lb	2,510 lb[34]
Guns (internal)	1 M–61	none	1 M–61

[32] The F–104G version used by Japan (the F–104J) was fabricated as in interceptor.

[33] Ordnance included combinations of Sidewinder (AIM–9B) air-to-air missiles, 2.75-inch (FFAR) rockets, and gravity bombs (MK–117, MK–84, MK–83, MK–28 and MK–43) and ammunition for the M–61 gun.

[34] On a LO-LO-LO bombing mission, maximum ordnance 4,000 lb.



REPUBLIC F-105 THUNDERCHIEF

F-105D: Supersonic, long-range, thin mid-wing F-105D fighter-bomber. Most produced of the F-105 model series.

F-105F: A higher tail fin and a longer fuselage, to accommodate second cockpit, set the F-105F apart from the F-105D.

REPUBLIC F-105 THUNDERCHIEF

Manufacturer's Model AP 63-31

Weapon System 306A

Basic Development **1951**

Developing this aircraft on its own, Republic envisioned it as the Mach 1.5 successor to the F–84F Thunderstreak (before the latter entered the USAF tactical inventory in 1954). Republic studied many configurations (all labeled AP–63) before settling on a single-seat, single-engine aircraft, meant for a nuclear role but also having an air-to-air capability.

Contractor's Proposal **April 1952**

Republic's proposed Model AP–63 contained most of the features which the Air Force would have liked to have added to the F–84F had it been technically possible.

Go-Ahead Decision **May 1952**

As recommended by the Aircraft and Weapon Board, the Air Staff endorsed the F–105's development in lieu of creating an improved F–84F. No general operational requirements were issued at that time.

Letter Contract **September 1952**

This contract covered preproduced engineering, tooling design and fabrication, and fabrication and material procurement as called for by the Air Force's original planning which envisaged the acquisition of 199 aircraft, the first of which to be operationally ready by 1955. In March 1953 a change of plan reduced the program to 37 F–105s and nine RF–105s.

Mockup Inspection **October 1953**

No sweeping changes were recommended. Interim use of the Pratt & Whitney J–57 engine was discussed upon confirmation that the J–71 engine, earmarked for installation into the F–105, might not meet thrust requirements. Delivery of the first aircraft was still scheduled for the spring of 1955.

Development Slippages **December 1953**

The Air Force suspended procurement of the F–105, marking the beginning of a period of uncertainty because of excessive delays at Republic. Procurement was reinstated in February 1954 but reduced to 15 aircraft. At the same time, decision was made to equip the test aircraft with the proven, 16,000–lb thrust, J–75 engine and to incorporate the J–75 engine into the production aircraft. Further development slippages led the Air Force in September 1954 to reduce the program to three aircraft. An October revision of the month-old stop order restored the number of aircraft to six.

General Operational Requirements **1 December 1954**

Based on the Fighter Bomber Weapon System's Military Characteristics of January 1951, as revised in January 1952 but published some 18 months after development of the F–84F successor had been approved. GOR 49, three times amended between December 1954 and April 1955, called for an inflight refueling capability, a more complex fire-control system, and improved performance. The GOR also dictated the installation of the higher-thrust J–75 engine to qualify the fighter-bomber for first-line service from 1958 through 1960.

F-105A

New Procurement **February 1955**

The Air Force again authorized acquisition of the 15 test aircraft funded in February 1954—2 As, 10 Bs, and 3 RFs.

First Flight (YF-105A Prototype) **22 October 1955**

After 22 hours of flight time, the first YF–105 was returned to the factory because of major damage sustained in flight and on landing. The second YF–105A, still powered with the J–57 engine, flew for the first time on 28 January 1956. These were the only F–105As built. The other test aircraft were designated YF–105Bs (except for three, finally accounted for as TF–105Bs) and equipped with the production type J–75 engine. All 15 test F–105s had been built by April 1958.

F-105B

First Flight (YF-105B) **26 May 1956**

The aircraft flew for 1 hour but was damaged on landing. Necessary repairs delayed the flight test program.

Significant Problems **1955-1957**

Further development slippages and excessive costs plagued the F–105 program, in turn generating numerous changes in Air Force procurement planning. In March 1956 the Air Force released $10 million of FY 57 funds for the acquisition of 65 F–105Bs and 17 RF–105s. In June five F–105Cs were added to the program. This was the first of several two-seat versions of the F–105 considered at one time or the other. In July 1956 procurement of the RF–105 was cancelled as was that of the F–105C in 1957.

Preproduction Modification **22 January 1957**

A major preproduction modification of the F–105 was directed. The modification called for incorporating the APN–105 all-weather navigation system into the new tactical aircraft.

Revised General Operational Requirements — **22 November 1957**

A complete revision of GOR 49 was published, consolidating all F-105 requirements in one document. Installation of an inertial navigation system was deleted in favor of the projected AN/APN 105 system. Several requirements were added. Namely, a new cockpit instrument display, a tow target subsystem, and a TX-43 nuclear weapon capability were required.

Production Slippages — **1958**

The Air Force plans of May 1958 called for a 4-year production of 472 F-105D and E aircraft, but the added requirements of November 1957 and the complexities of the F-105 subsystems compounded the contractor's difficulties. Republic again requested new production schedules. In March 1959 the Air Force cancelled production of the F-105E, a second two-seat version of the F-105.

First Acceptance (Production Aircraft) — **27 May 1958**

The Air Force accepted the first production model of the F-105 at the Republic's Farmingdale plant in Long Island, N. Y. This F-105B was the first aircraft specifically designed as a fighter-bomber and developed under the integrated or weapon system concept.

Enters Operational Service — **August 1958**

It was delivered 3 years later than originally planned, to the 335th Tactical Fighter Squadron of the Tactical Air Command's 4th Fighter Wing, first at Eglin and subsequently at Seymour-Johnson AFB, the squadron's permanent station. Production slippages still occurred, however, and TAC did not have a complete squadron of F-105Bs until mid-1959.

Flight Testing — **1957-1960**

Category I, II, and III flight tests either were delayed or interrupted because of the difficulties encountered with the pioneer F-105. Special tests of the new weapon system's unproven components were conducted. Their results, often calling for engineering changes or the incorporation of "fixes" in the aircraft, contributed to the delays. Category II testing, a joint contractor-USAF effort started on 8 January 1957, was extended beyond the 30 November 1959 deadline, officially ending 30 March 1960. Four additional tests, properly part of Category II, were conducted subsequently under an amended test directive. To speed transition of the new F-105B jet from test to squadron use, operational testing at Eglin AFB was accomplished by the 335th TFS. Category III testing, postponed until modification of the aircraft's fire-control system was completed, started in late July 1960. It was conducted by both the 334th and 335th TFS at Williams AFB, Ariz., and Nellis AFB, respectively. The Category III tests were completed on 15 August, after being handicapped by a severe shortage of parts. During the tests, the poor reliability of the MA–8 fire control system placed doubt on the success of the modification recently accomplished.

Modifications **1959**

The first F–105B productions, designated F–105B–10s and F–105B–15s, were essentially similar and were equipped with the J–75–P–5 engine. A third F–105B version, the F–105B–20, featuring changes in electronic equipment and powered by a J–75–P–19 engine, was flown successfully in June 1959. The gas turbine J–75–P–19 engine, providing an additional 1,000–lb thrust, substantially improved the aircraft's performance, and replacement of the J–75–P–5 engines in the earlier F–105Bs was directed. The Air Force also approved a new antiskid brake system developed by Goodyear, directed installation of the system on all future F–105s, and retrofitting of the aircraft already manufactured. Other modifications were directed toward the end of 1959 as Category II tests brought to light deficiencies of the MA–8 fire control system, central air data computer (CADC), and autopilot of the F–105B. The modifications, referred to as Project Optimize, eventually involved 26 engineering changes requiring on occasions that components be returned to the factories for rework. Scheduled for completion in April 1960, Project Optimize also slipped several months because of the lack of spares and repair money. In any case, there was still no guarantee that the modifications would eliminate most of the problems.

Operational Readiness **1960**

During the first 3 months of the year, none of the 56 aircraft possessed by TAC were operationally ready. The unreliability of the MA–8 system, CADC, and autopilot remained the principal deterrents. However, the average number of aircraft out of commission for lack of parts and repairs also was abnormally high.

Significant Operational Problems **1961**

The difficulties inherent to the increased complexity of the F–105 weapon system did not subside. The aircraft in-commission rates remained low. It required 150 maintenance manhours for each hour of flying. Moreover, problems stemming from a shortage of spare parts and maintenance skills were not solved. Temporary groundings were frequent.

Subsequent Model Series

F–105D

Other Configurations

None

End of Production **1959**

With the December delivery of six aircraft.

Total F-105Bs Accepted

Seventy-five, 13 of which were former test aircraft—the other test aircraft, 2 YF-105s and 3 TF-105Bs—were accepted by the Air Force in FY 56 and FY 58, respectively. The 3 TF-105Bs were used for development of the proposed RF-105 aircraft.

Acceptance Rates

Three F-105Bs were accepted in FY 57, 6 in FY 58, 28 in FY 59, and 38 in FY 60.

Flyaway Cost Per Production Aircraft[1]

$5,649,543.00—airframe, $4,914,016; engine (installed), $328,797; electronics, $141,796; ordnance, $32,021; armament, $232,913.

Average Maintenance Cost Per Flying Hour

$718.00

Item of Special Interest **May 1963**

Modernization of the F-100C-equipped "Thunderbirds," the Air Force Aerial Demonstration Team, was decided. Flight-testing of the first of the nine F-105Bs, to be modified for team use, ensued a few months later. The last modified aircraft was delivered to the "Thunderbirds" on 16 April 1964, 10 days before the first scheduled performance with the new plane. A serious accident in May of the same year, as well as the modifications directed as a result of this accident, prevented the "Thunderbirds" from using the aircraft. Because of its heavy schedule, the team was re-equipped with eight F-100Ds, urgently modified for demonstration purposes. The exchange, considered temporary at the time, was extended until 1969, when the "Thunderbirds" began flying F-4Es.

Phaseout **1964-1967**

TAC's two squadrons of F-105Bs were re-equipped with F-105Ds and most B model series were phased out of the active inventory during 1964. The first excess F-105Bs reached the ANG's 108th Wing on 16 April 1964. The F-105Bs, including those modified for the "Thunderbirds," were so different from the D and F model series that their training value was limited. Nonetheless, the Air Force utilized a few of them for training at McConnell AFB, Kans., until late 1969—2 years after disposing of all other F-105Bs.

Record Flight **11 December 1959**

An F-105B, without payload, set world speed record of 1,216.48 mph over a 100-kilometer closed course at Edwards AFB. Previous record was set in June 1959 at 1,100.42 mph by a French Nord-Griffon II aircraft.

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[1] Excluding $2,716 of prorated RDT&E cost. Cumulative modification costs (differing according to model) were also excluded. By 30 June 1973, $261,793 had been spent on each F-105B; $282,687 on each F-105D; $701,645 on each F-105F, and an additional $1,803 on the F-105G—a reconfigured F-105F.

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F-105D

Manufacturer's Model AP-63-31
Weapon System 306A

Previous Model Series

F–105B

New Features

Higher thrust J–75–P–19W engine with water injection, cockpit with vertical instrument panel, bad-weather navigation system, attack equipment, and integrated instruments. The last Ds off the line could refuel from either the flying boom or hose-drogue type tanker.

Configuration Planning — **Mid-1957**

Configuration of the D cockpit was finalized by a Mockup Board on 11 December.

Preproduction Slippages — **1958**

Republic requested new production schedules. The contractor claimed that the F–105D, although similar in appearance to the F–105B would be different enough to make it difficult to use the B production line, even with many modifications. The higher gross weight of the new model series would require stronger main gear, wheels, and brakes. The F–105D's improved engine would necessitate changes in the fuselage and intake ducts. Fabrication time, Republic stated, would be raised from 144 to 214 workdays.

General Operational Requirements 49-1 — **16 May 1958**

GOR 49, as revised 22 November 1957, was amended. The amendment required that the F–105 be capable of delivering at least two of the air-to-surface missiles specified in GOR 166 of October 1957.

Program Change — **18 March 1959**

Production of an increased number of F–105Ds was programmed at the expense of the two-place F–105E. The Air Force hoped that cancellation of the high cost F–105E and replacement by the cheaper F–105D, on a one-for-one basis, also would enable Republic to speed production.

First Flight — **9 June 1959**

From Farmingdale. Republic reported that the vertical instrument panel and nose wheel steering of the aircraft worked well.

First Acceptance — **28 September 1960**

TAC formally accepted the first F–105D at Nellis AFB.

Modifications — **1960-1961**

Despite the efforts expanded on the aircraft and its components, the F–105B was still not fully proven when the first F–105D was accepted by the Air Force. The engineering changes made on the

F–105B under Project Optimize and the subsequent Prove Out testing of the MA–8 fire control system were but one example of the difficulties experienced with the new components and their integration into the weapon system. Other modifications were either established or proposed for both the production-completed F–105Bs and the incoming F–105Ds. To avoid a variety of aircraft configurations, the Air Force decided to process these modifications as a single package. The first production black box aircraft, received at Eglin AFB on 27 October 1960, upon evaluation proved to be adequate and the F–105D's operational capability in all visual and blind bombing was recognized. The black box modification of all F–105 aircraft was confirmed in November. Republic's lack of experience in delivering aircraft with the modification affected production schedules and delayed various phases of the F–105D flight testing program.

Flight Testing **1959–1962**

During tests, the F–105D encountered problems similar to those that had plagued the F–105B. Category I flight tests were delayed because of difficulties with the J–75 engine and speed restrictions placed on the aircraft. Category II testing, scheduled to start in May 1960, did not begin until 26 December because of the black box modification and other production slippages. The F–105D's airframe and engine had undergone evaluation either on the F–105B or during the D model's Category I tests. This let the Air Force cut short the delayed Category II tests that centered on the instrument display as well as the fire-control and navigation systems. Conducted by the 335th TFS at Eglin AFB, these tests ended on 31 October 1961. Category III flight tests were also reduced and conducted by the 335th but took place at Seymour Johnson AFB, which became the collecting point for all specialized test equipment and spare parts prior to TAC acceptance of the first F–105D. Most of the support problems encountered during the Category III testing of the F–105B were eliminated.

Enters Operational Service **1961[2]**

TAC's 4th Fighter Wing was first to receive the aircraft.

Oversea Deployments **1961–1962**

F–105Ds began reaching USAFE's 36th Tactical Fighter Wing in May 1961. Deliveries to PACAF started in October 1962.

Grounding **December 1961**

All F–105Ds were grounded for inspection after the aircraft's main fuselage frame failed during a routine laboratory fatigue test at Wright-Patterson AFB. Ensuing tests confirmed that the frame

[2] TAC formally accepted the F–105D at Nellis AFB on 28 September 1960, but the aircraft did not enter operational service until the following year.

retained considerable strength after cracking. Republic had suitable adapters and tools to do the corrective work required.

Production Slippages **1962**

Production again slipped because of a labor strike started at Republic on 2 April. A Taft-Hartley injunction ended the strike on 18 June, but production was delayed sufficiently to disrupt concurrent USAF plans.

Significant Operational Problems **1962-1964**

In June 1962, following two major accidents at Nellis AFB, all F-105B and D aircraft were grounded for correction of chafing and flight control deficiencies. The project, referred to as Look Alike and started in July, was expected to be done quickly, but continuous operational difficulties caused it soon to grow into an extensive, $51 million modification program. The 2-year spanned modifications, grouped under Look Alike, were accomplished in two phases, the first of which was completed in November 1962 by the Air Force with the assistance of several technicians from Republic. The second phase, extended to include a dual in-flight refueling capability for the last 20 F-105Ds produced, was done entirely by Republic and did not end until mid-1964.

Support Problems **1962-1964**

Look Alike created a new supply problem. The modifications eliminated the use of many of the items only recently stocked in sufficient quantities.

Continued Operational Problems **1964-1967**

Despite the successful completion of Look Alike, the efficiency of the F-105Ds had not peaked. At the time production ended in early 1964, they experienced a series of accidents due to engine failures, fuel leaks, and malfunctions of the fuel venting systems. This in turn added a shortage of J-75 engines to the similar problems hampering F-105D operations from 1964 through 1967.

SEA Losses **1965-1968**

F-105Ds, flying from Korat AB, began striking carefully selected targets north of the 17th parallel in early 1965. While participating in tactical air strikes over South Vietnam, in 1966 and subsequent years they carried out more strikes against the North than any other USAF aircraft. Operating against ever stiffening defenses, the F-105Ds also led in SEA battle losses. The steady loss of F-105 aircraft to enemy action, accidents, and normal attrition necessitated urgent repairs, cannibalization of the more badly damaged aircraft, and depletion of USAFE and TAC inventories. TAC's resources for training and support of the combat effort were also reduced.

Special SEA Modifications **1965-1971**

The F-105Ds were repeatedly modified to meet changing SEA combat requirements. They were equipped with armor plates, backup flight control systems, X-band beacons, new radar altimeters and ASG-19 gun bombsights. Primarily designed to carry nuclear bombs, their conventional bombing capability was increased. The pilot ejection seat of all F-105 aircraft was improved as were the refueling probes of the early F-105Ds. Modifications, first impeded by sparse funds often were delayed by technical difficulties. A most important and complex modification (putting ECM pods on the aircraft's wings) began in 1966 and consumed several years. Another crucial modification, started in 1966 and hindered by numerous problems, would give 30 F-105Ds improved visual bombing accuracy, a more precise navigation system, and a better blind bombing capability. An overriding problem was the poor reliability and rising cost of the AN/ARN-85 LORAN system first considered. This problem persisted until new testing began at Eglin AFB in September 1969. The T-Stick II/Loran prototype aircraft was then equipped with the AN/ARN-92 (produced by International Telephone and Telegraph) and successfully flight-tested. Still, modification of the 30 aircraft was not completed until late July 1971.

Subsequent Model Series

F-105F

Other Configurations

None. Production of a reconnaissance version of the F-105, after progressing through a February 1954 mockup inspection, was cancelled on 20 July 1956. Amendment No. 2 to the revised GOR of November 1957, published on 7 December 1960, reinstated as well as enlarged the project by calling for a reconnaissance version of the F-105 model series D. The new reconnaissance aircraft, while retaining the strike capability of the F-105D, would be equipped with a podcontaining side-looking radar, infrared sensors and a variety of cameras. In-flight development of films and ejection of film casettes were included in the specific operational requirements issued in December 1960. Revival of the project, however, was of short duration. One year later, on 23 December, the new RF-105 contract was terminated in favor of a reconnaissance version of the F-4C Phantom II, soon to be produced by the McDonnell Aircraft Corporation. SOR 49-2 was cancelled on 30 April 1962, its requirements being transferred to SOR 196, issued for the RF-4C in the spring of 1962.

Acceptance Rates

The Air Force accepted 17 F-105Ds in FY 60, 149 in FY 61, 171 in FY 62, 198 in FY 63, and 75 in FY 64.

Last Acceptance **January 1964**

The F–105Ds began to see action in Southeast Asia 1 year later. Ensuing battle losses were considerable, and reopening of the production line was considered in mid–1967. The project, however, did not materialize.

Total F-105Ds Accepted

610

Flyaway Cost Per Production Aircraft

$2.14 million—airframe, $1,472,145; engine (installed), $244,412; electronics, $19,346; armament, $167,621; ordnance, $19,346.

Average Cost Per Flying Hour

$1,020.00

Average Maintenance Cost Per Flying Hour

$809.00

Phaseout **1971-1973**

Phasing out of remaining F–105Ds (roughly one fourth of some 600 productions) took shape in November 1970, when two ANG units were alerted to their impending conversion. F–105Ds began reaching the 184th Tactical Fighter Training Group, McConnell AFB, and the 192d Tactical Fighter Group (TFG), Byrd Field, Va., in January 1971.[3] Conversion of a third ANG unit, the 113th TFG, Andrews AFB, Md., swiftly followed. By mid–1973 USAF active rolls showed 6 F–105Ds left—two were used for special tests, the other four for training.

Items of Special Interest **1968**

As war losses foretold its gradual removal, the F–105 was increasingly praised for its payload, range, and exceptional speed at low altitudes. It was praised as the "hardest worker" of the Vietnam War by pilots who regretted that the planes were not being replaced.

1970

Loaded with twelve 750–lb bombs, the F–105D was faster than any other available USAF aircraft flying under the same conditions.

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[3] Air Force Reserve units, strictly concerned with the airlift business since 1958, resumed a tactical role in 1972. The 507th TFG at Tinker AFB and the 301st TFW at Carswell AFB acquired F–105Ds in June and August, respectively. In January 1973, the 508th TFG at Hill AFB gave up its C–124As for F–105Bs. This time the aircraft came from the Air National Guard (the 177th TFG, a New Jersey unit converting to F–106s).

F-105F

Manufacturer's Model AP-63-31
Weapon System 306-A

Previous Model Series

F-105D

New Features

Higher tail fin and a 31-inch longer fuselage to accommodate second cockpit. The heavier (by 2,000 lb) F-105F retained many features of the D, including the air refueling probe-drogue and boom receptacle of later ones. A transfer system in the F-105F allowed each crew member to monitor or control all or any of the aircraft's subsystems.

Go-Ahead Decision **May 1962**

The Secretary of Defense decided to go ahead on the basis of the cancellation of the two-place F-105E in 1959 which had left a vacuum in the advanced bombing and navigational training programs. Use of the F-100F for combat proficiency evaluation and transition training of future F-105 pilots, once considered, was impractical because of the cost involved and the scarcity of F-100F aircraft. As an interim expedient, TAC utilized six modified T-39s.

Contractual Arrangements

Republic received $8 million to convert the last 143 single place F-105Ds in production to dual place F-105Fs. No additional aircraft were procured.

Development Engineering Inspection (DEI) **2-5 January 1963**

First Flight **11 June 1963**

The flight took place earlier than expected, and the aircraft reached a speed of 1.15 Mach.

First Acceptance (Production Aircraft) **7 December 1963**

The first production aircraft was assigned to the 4520th Combat Crew Training Wing at Nellis AFB.

Enters Operational Service **23 December 1963**

The F-105F entered operational service with TAC's 4th Tactical Fighter Wing at Seymour-Johnson AFB.

Flight Testing **1963-1964**

As a development of the F-105D, the F-105F did not require an extensive testing program. Category I tests, initiated in mid-1963, were completed in July 1964; Category II tests, 1 month later.

Operational Problems and Modifications **1964-1968**

Because of similarity between the two aircraft, the F-105F experienced all of the F-105D's problems. Both received the safety modifications and improvements dictated by their common SEA mission. In addition, like the F-105D and several other tactical aircraft, the F-105F was modified to increase its capability to attack as well as avoid the North Vietnamese SAM and AAD radar sites.[4] The radar homing and warning modification, started in late 1965, primarily involved the replacement of the AN/APS-107 with the improved AN/APR-25-26.

Special Modifications **1966-1973**

Eighty-six of the RHAW-equipped F-105F aircraft were included in the Wild Weasel program initiated in 1965 to improve the Air Force's electronic warfare capability. The modification, first applied to the F-100F, was extended to the F-105F in January 1966, because of the appearance of a growing number of Russian-built SA-2 Guideline missiles in North Vietnam. Thirteen modified F-105Fs, deployed to SEA in the summer of 1966, were joined by 10 others in the ensuing 3 months. The Wild Weasel III modification (F-105 aircraft, only) was completed in March 1968, 1 month after completion of an additional modification which enabled 14 of the 86 aircraft to launch Standard Arm Mod 0 missiles.[5] Almost concurrently, a new modification was directed, which at first only involved 16 other Wild Weasel F-105Fs. Beginning in November 1968 these aircraft were modified so they could fire the new AGM-78B missile, an improved version of the Standard Arm. In spite of engineering difficulties, the modification of the 16 aircraft was completed in June 1969. In September of the same year this modification (plus other improvements) was programmed for 60 Wild Weasel F-105Fs that would be redesignated F-105Gs.

Oversea Deployments **1966-1972**

The aircraft did extensive and diversified work overseas. For example, five of the first 16 Wild Weasel F-105Fs, scheduled for SEA in the summer of 1966, arrived there in mid-April. Another six (from the 4525th Fighter Weapons Wing) left Nellis AFB for

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[4] A few F-105Fs (dubbed Combat Martins) received unique modifications. They were equipped with QRC-128 VHF jammers to block communications between the MIGs and their ground-control intercept centers. Other F-105s saw modification of their R-14A radars (to expand presentation for sharper target definition) and a rearrangement of the pilot's weapon release switch (enabling the rear seat pilot to control bomb release). These Commando Nail F-105Fs carried out extremely hazardous, night, all-weather, radar low-level bombing missions, the first two flown over North Vietnam on 26 April 1967. Six Combat Martin and six Commando Nail F-105Fs were returned to their previous configuration in mid-1971 to help fill the quota of Wild Weasel F-105Fs—that had or were being modified into Gs.

[5] AGM-78A/B antiradiation missiles manufactured by General Dynamics for the Navy. The Standard Arm missiles require that the carrying aircraft (Navy A-6Bs and USAF F-105Fs) have a sophisticated avionics system to sort and select the signals encountered.

Osan AB, Korea, on 28 January 1968, following North Korean seizure of the USS *Pueblo*. Again, 12 F–105Gs (modified F–105F Wild Weasels from TAC's 23d TFW) joined in Constant Guard I, the first of several USAF deployments to SEA in the spring of 1972. These aircraft left McConnell AFB for Korat in April.

Subsequent Model Series

None. The F–105G, at times considered a separate model, actually came off the production line as an F–105F.

Other Configurations—F-105G

F–105G—a modified Wild Weasel F–105F. This aircraft featured an internally mounted jamming system, an AGM–78 Standard antiradiation capability, a new combat-event recorder, and other improvements (not all expected to be completed before the end of 1973). The Air Force planned an F–105G fleet of 60 but missed its goal by several aircraft.

End of Production **December 1964**

The Air Force took delivery of the last F–105F in January 1965.

Total F-105Fs Accepted

The Air Force accepted 143. More than one-third of this total was brought up to the F–105G configuration.

Acceptance Rates

One F–105F was accepted in FY 63, 83 in FY 64, and 59 in FY 65.

Flyaway Cost Per Production Aircraft[6]

$2.2 million—airframe, $1,524,000; engine (installed), $290,000; electronics, $251,000; armament, $154,000; ordnance, $21,000.

Average Cost Per Flying Hour

$1,020.00 (F and G models)

Average Maintenance Cost Per Flying Hour

$808.00 (F and G models)

Operational Status **Mid-1973**

The Air Force lost many of its F–105Fs. The modification and redesignation of about 60 others nearly exhausted the entire inventory.[7] In mid–1973, only 17 F–105Fs still flew—5 with the Air Force, 12 with the Guard.[8] Forty-eight F–105Gs (reconfigured F–105Fs) were in the active inventory. The Air Force intended to transfer these aircraft to the Reserve Forces beginning in mid–1975—if F–4Ds were available for replacement.

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[6] Applied to both the F–105F and F–105G and did not include development as well as cumulative modification costs.

[7] At the close of FY 1970, 33 F–105Gs were on USAF rolls.

[8] The Air National Guard received its first 8 F–105Fs in FY 1971.

PROGRAM RECAP

The Air Force bought a grand total of 833 F–105 aircraft—355 less than authorized by Congress. Specifically, the F–105 program consisted of 2 YF–105As, 75 F–105Bs, 3 TF–105Bs, 610 F–105Ds, and 143 F–105Fs. F–105Gs were modified F–105Fs.

TECHNICAL DATA

F–105B/D and F–105F

Manufacturer	Republic Aviation Corporation, Farmingdale, N. Y.
Nomenclature	Supersonic Long Range Tactical Fighter-Bomber. F–105F—Supersonic Long Range Tactical Fighter-Bomber/Trainer.
Popular Name	Thunderchief

Characteristics	*F–105B*	*F–105D*	*F–105F*
Length/Wing	64.4/34.9 ft	64.4/34.9 ft	67.0/34.9 ft
Takeoff Weight[9]	52,500 lb	52,500 lb	54,300 lb
Takeoff Ground Run	5,920 ft	5,920 ft	6,356 ft
Average Cruise Speed	726 kn	726 kn	726 kn
Max. Speed	2.08 Mach	2.08 Mach	2.04 Mach
Ferry Range	1,917 nm	1,917 nm	1,623 nm
Engine, Number & Designation	1J–75P–19W with a/b	1J–75P–19W with a/b	1J–75P–19W with a/b
Crew	1	1	1
Combat Ceiling	49,000 ft	49,000 ft	49,000 ft
Radius/Loiter Time	200 nm/15 min	200 nm/15 min	200 nm/15 min
Rate of Climb	34,000 fpm	34,000 fpm	34,000 fpm
Ordnance, No/Bomb	16/750 lb[10]	16/750 lb[11]	16/750 lb[11]

Close Air Support Characteristics	*F–105D*	*F–105F*
Guns & Type	1 M–61 20-mm	1 M–61 20-mm
Ammo (rds)	1,029	1,029
Weapon Load	6/8 CBU–24	6/8 CBU–24
Loiter Time at 100 nm	1.8/1.6 hr	1.8/1.6 hr

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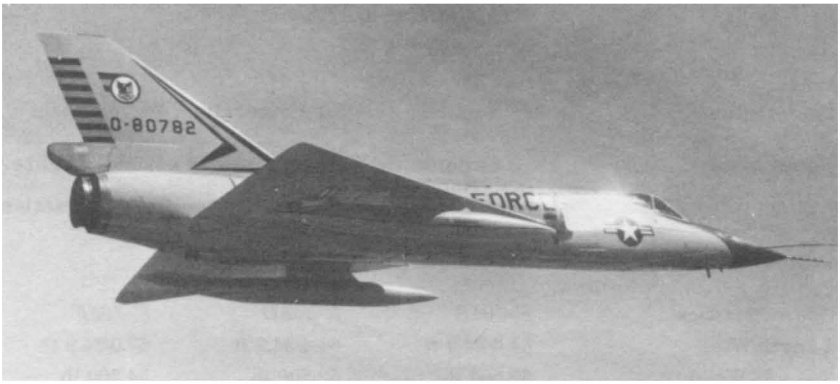
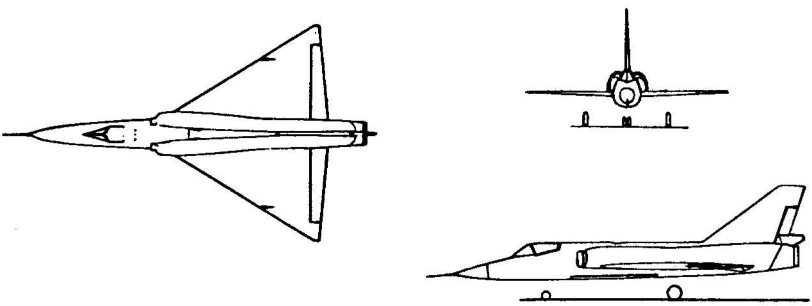
[9] Carrying Bomb Load
[10] or 1 MK–28 or MK–43
[11] or 1 MK–28 or MK–43 (internal), 2 MK–28s or MK–43s (external), or 4 AGM–12Bs.





CONVAIR F–106 DELTA DART

F–106A: After many years of duty, the supersonic delta wing F–106A remained a most competent all-weather interceptor.

F–106B: Aside from the second seat, that took the place of one of the fuel cells of the single-seat F–106A, the two were practically identical.

CONVAIR F-106 DELTA DART

Manufacturer's Model 8-24
Weapon System 201B

Basic Development

Convair F-106, like the preceding F-102, grew out of the company's delta-wing XF-92A—an American application of Germany's wartime theories and preliminary testing. The F-106 and F-102 in fact originated as only one aircraft, the so-called "1954 Ultimate Interceptor."

Advanced Development Objective **13 January 1949**

The ADO of early 1949 called for an advanced, specially designed interceptor that would be operational in 1954—a project which soon became one of the most complicated undertakings in the history of the Air Force.

Production Decision **24 November 1951**

After the customary call on industry and the September 1951 selection of Convair competitive entry, the Air Force decided in November 1951 to expedite production of the 1954 Ultimate Interceptor. The decision did not affect the weapon system concept and Cook-Craigie production outlined in the ADO of January 1949.[1]

Program Change **December 1951**

The production decision of November 1951 also did not ignore the fact that the state of the art would probably preclude the 1954 Interceptor from meeting its operational deadline. Hence, since some sort of advanced interceptor was needed as soon as possible, the Air Force in December 1951 authorized a two-step production of the aircraft. First would come the F-102A, an interim, less ambitious version that would be produced in limited quantity. The Ultimate Interceptor, no longer referred to as the 1954 Interceptor, would follow as the F-102B. The two models would have the same airframe that was to be produced by Convair, as the winner of the MX-1554 airframe competition initially held for the so-called 1954 Interceptor. They would have different engines, however, with the F-102B retaining the high thrust J-67, an American version of the British Bristol Olympus turbojet to be produced under license by the Wright Aeronautical Corporation of America. Finally, only the F-102B would be equipped from the outset with the highly sophisticated electronic control system being developed

[1] The weapon system concept, introduced in the late forties, integrated from the start the design of the entire weapon system to make each component compatible with the other. The offshoot of this concept's failure when first applied was the F-102. The Cook-Craigie production policy called for early tooling, limited production at first, elimination of faults by test flights, and accelerated production thereafter. The F-102 also bared some of this production plan's pitfalls.

by the Hughes Aircraft Company under project MX–1179, a project around which the MX–1554 airframe specifications had actually been drawn.

Program Slippage **1952-1955**

The F–102's two-step development plan, despite its blueprint logic, did not work as anticipated. The decision to produce an interim version of the interceptor (F–102A), with an interim engine and interim fire-control system, devolved from delays in the development of important subsystems. Yet, concentration on new requirements lessened the attention that could be given to these subsystems and to the F–102B as a whole. Another unfortunate consequence of the two-step development plan was that components for the F–102A could be financed from production funds, while development of the F–102B J–67 engine and MX–1179 ECS had to come from less plentiful research money. Meanwhile, problems with the original configuration of the Convair airframe almost obliterated the entire F–102 program. By the end of 1954, when the F–102 fuselage problems were solved, the production-delayed F–102A, after losing its interim status, had acquired further importance at the F–102B's expense.

Development Problems **1952-1955**

While airframe deficiencies hampered the F–102A, technical difficulties and a basic funding problem retarded the F–102B's progress. In mid–1953 development of the MX–1179 ECS (later the MA–1 Automatic Weapon Control System)[2] was slipping badly, and it took another year before a nearly completed experimental sample of the system could be installed in a T–29B for testing. Similarly, although the J–67 showed early promise, in August 1953 Wright was almost a year behind schedule in adapting the engine to the future F–102B, and the Air Force had begun to consider use of another engine. As Wright's trouble with the J–67 did not subside, the Pratt and Whitney J–75 engine (an advanced model of the J–57 eventually used in the F–102A) gained added favor. Its substitution for the J–67 was approved in early 1955.

Initial Procurement **November 1955**

Satisfied with the F–102's new airframe configuration (extensively tested since the successful Hot Rod flight of December 1954), the Air Force awarded Convair new production contracts. One covered 562 F–102As, pushing to 749 the F–102As thus far on order. Another, first of its kind, was for 17 F–102Bs—a far cry from the December 1951 USAF plans, calling for few interim F–102As and large-scale F–102B production.

[2] The MA–1 Automatic Weapon Control System (AWCS)—until 1960 more often referred to as the MA–1 fire-control system or MA–1 ECS—was first used by an F–106A on 18 March 1958.

Mockup Inspection **December 1955**

Of primary interest was the proposed cockpit arrangement for the Hughes MA–1 fire control system (the former MX–1179), a radical deviation from standard cockpits and instrument displays. A recently approved armament change (with more to come) was also discussed.

First Definitive Contract **18 April 1956**

The Air Force finalized the F–102B production contract of November 1955, earmarking the 17 aircraft for testing. Although the aircraft's redesignation was not yet official, this production document basically became the first F–106 research and development contract. One prototype was to be delivered in December 1956, the other in January 1957. Other deliveries would begin in July 1957.

Redesignation **17 June 1956**

The F–102B designation of the ultimate interceptor was changed to F–106. The redesignation symbolized the past technical differences that had distorted the original F–102 program. It also recognized that further changes could be forthcoming.

Production Policy **August 1956**

Two months after the F–102B's redesignation, the Air Force practically re-endorsed the production policy originally outlined for the "1954 ultimate interceptor." On 18 August 1956 it issued a system development directive calling for concurrent development and production of the new F–106—a procedure responsible for several later problems.

Initial Requirements (F-106) **28 September 1956**

As stated in a system development directive, issued by the Air Force on 28 September 1956, the new F–106 would be capable of intercepting and destroying hostile vehicles under all weather conditions, at all altitudes up to 70,000 feet, and within a radius of 375 nautical miles. Interceptions would be accomplished at speeds up to Mach 2 at 35,000 feet. Flight would be "under automatic guidance provided by the ground environment and the aircraft's fire-control system." The F–106 would carry guided missiles and rockets with atomic warheads. It would be available in August 1958—some 4 years past the original deadline of the Mach 1.93, 60,200–ft altitude "ultimate interceptor."

First Flight (Prototype) **26 December 1956**

Convair test flew the F–106 for the first time on 26 December 1956, 38 months after the F–102A (the Air Force's first supersonic delta-wing interceptor) made its first flight. The second F–106 prototype, after being also transported from its San Diego plant to Edwards AFB, was initially flown on 26 February 1957.

Initial Shortcomings **1957**

The first USAF F–106 test flight, made from Edwards AFB on 29 April 1957, showed deceptive results. The F–106 reached a speed of Mach 1.9 and an altitude of 57,000 feet. However, upon completion of the Category II flight tests (started in May 1957 and purposefully accelerated to end in July of the same year), the first F–106 prototype's overall performance (after more than 70 flights) was much less impressive. The F–106's acceleration and maximum speed were both below Convair's estimates and a September preliminary Category II end-report on the second F–106 prototype proved equally discouraging. Mach numbers above 1.7 were not considered tactically usable because of the aircraft's poor acceleration. Under standard conditions, the airplane took almost 4½ minutes to accelerate from Mach 1 to Mach 1.7 and another 2½ minutes to accelerate to Mach 1.8—eating up 2,000 pounds of fuel in the process.

General Operational Requirements **19 June 1957**

The F–106 requirements, underlined in the system development directive of September 1956, were finalized in June 1957. Maximum speed (at least, Mach 2.0) and combat radius (375 nautical miles or better) were unchanged, but the aircraft's required combat ceiling was reduced from 70,000 feet to a minimum of 55,000 feet.[3] The F–106's required capability of operating on 6,000–ft runways was defined as well as its armament. The F–106 would carry one MB–1 air-to-air atomic rocket and four GAR–3/GAR–4 Falcons, launchable in salvo or in pairs. The new interceptor would be provided with TAGAN (tactical air navigation), BROFICON (broadcast fighter control), and an AMTI (airborne moving target indicator) unit that would assure an interception capability at any altitudes between sea level and the aircraft's maximum combat ceiling.

Early Modifications **1957**

The F–106 deficiencies, pinpointed by the first Category II flight tests, although disappointing, came as no great surprise. The Air Force (after reviewing the flight test data obtained during Convair Category I testing of the first F–106 prototype) had already decided that modification of the aircraft's inlet duct cowling and charging ejectors would probably increase speed and acceleration. It planned to modify the aircraft upon completion of the Category II tests and to evaluate the results of these changes during the Category III testing. The Air Force made every effort to hasten the F–106 development/production cycle. In April 1957 it author-

[3] By way of comparison, the performance required of the F–102A called for a speed of Mach 1.2 and a 54,000–ft combat ceiling. The F–102 and F–106 combat radius was later stretched to 566 nautical miles and 633 nautical miles, respectively, by adding external fuel tanks to the aircraft.

ized the conditional acceptance of several aircraft from the Convair flight-test inventory. In September, it quickly approved a Convair engineering proposal to enlarge the capture area of the F-106 ducts and to thin down the duct lips in order to satisfy the J-75-P-9 engine's airflow requirements, higher than anticipated. Hopefully, these changes would reduce drag, raise the aircraft's ceiling by 5,000 feet, and increase maximum speed. Acceleration time (from cruise speed to maximum Mach conditions) would be shortened by perhaps as much as 3 minutes. Meanwhile, there were other problems.

Other Problems **1957**

While airframe modifications were being worked out to satisfy the requirements of the F-106's engine, all was not well with the engine itself. The Pratt and Whitney J-75-P-9 turbojet, substituted for the Wright J-67 in 1955 because of rapid development progress, had also become a source of delay. In June 1957 production was still behind schedule, and upon availability the J-75-P-9 (later replaced by the more powerful 17,000 lb s.t. -P-17) proved to be less reliable than the Air Force would have liked. Another problem of long standing, which reached a climax in 1957, pertained to the F-106 cockpit. After endorsing relocation of the F-106 center-mounted control stick to the side of the pilot to assure his unrestricted view of Hughes proposed-Horizontal Situation Indicator (HSI), the Air Force reversed its decision. It confirmed that both the USAF vertical instrument flight panel and the HSI would be incorporated in the F-106 but announced that the pilot's control stick would be returned to its original center position. This final change proved to be sound, but its delayed approval precluded it from being incorporated in any of the F-106 test aircraft. Altogether, the Air Force's late decision of 1957 concerning the cockpit foretold a $10 million cost increase that could not have been more ill-timed.

Program Reappraisal **1957**

A severe fund shortage caused the Air Force to reappraise many of its plans. While the F-106 program came to the fore because of its great cost, other factors singled it out for reappraisal. Besides the aircraft's disappointing overall performance, its J-75 engine and MA-1 ECS still did not function properly by the spring of 1957. Moreover, as a result of the numerous development delays since the ADO of 1949, other weapon systems—such as the McDonnell F-101B interceptor—had been partially substituted for the F-106, which had long lost the high priority initially afforded to the Ultimate Interceptor. Hence, the Air Force considered giving up the entire F-106 program, or redesigning the aircraft as a long-range interceptor. In its financial dilemma, the Air Force

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finally raised the possibility that the F–101B might have to be dropped if the F–106 was retained. The Air Defense Command liked none of these alternatives. It believed redesign as a long-range interceptor would take so long that it would mean the end of the F–106. If a shortage of funds required buying fewer interceptors, even though the F–101B was cheaper than the F–106, ADC wanted to spread the reduction over each kind, since the two aircraft were complementary.[4] ADC won its case and the F–106 program did survive. However, not without drastic changes.

F-106A

Program Change and Final Procurement — 1957-1958

In mid–1957, when only 120 F–106As had been funded for procurement and Headquarters USAF thought of liquidating the entire program, ADC plans called for an F–106 buildup of 40 squadrons (more than 1,000 aircraft). This total was reduced to 26 squadrons by the end of the year, and another cut took place in September 1958. This last reduction finalized the F–106 force level at little more than one-third of the 1,000 aircraft originally sought by ADC.[5] The decrease was so sharp that the Air Force, despite the extra expense, decided in August 1959 to convert the F–106 test aircraft (35 in all by that time) to operational status.

Enters Operational Service — May 1959

ADC's 498th Fighter Interceptor Squadron at Geiger AFB, Wash., reached an initial operational capability in October 1959 (5 years later than originally planned). Notwithstanding, the 498th on 21st July scrambled five F–106s on a simulated combat mission with remarkable success. All targets were found and destroyed within 10 minutes after takeoff.

Operational Problems — 1959-1960

In spite of the initial achievements of the first F–106s, ADC was not fully convinced that it was getting a combat-ready aircraft.

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[4] At the time, the F–101B had a maximum speed (at 35,000 feet) of about Mach 1.7, a combat ceiling of 50,000 feet, and a combat radius of about 600 nm, compared respectively with the F–106 tentative figures of Mach 1.8+, 53,000 ft, and 350 nm.

[5] Another casualty of the late fifties' financial crisis was the F–108 Rapier, cancelled by the Air Force on 23 September 1959. The F–108, formerly referred to as the LRIX (long-range interceptor, experimental) and officially named the Rapier on 15 May 1959, was being developed by North American Aviation since 1957. As called for by USAF GOR 114 (6 October 1955), the stainless steel, two-place, two-engine, Mach 3, 70,000–ft altitude weapon system for use during the 1963–1970 time period, was designed to launch an atomic missile 1,000 miles from home base and return to base within 30 minutes. Despite encouraging development progress and a satisfactory mockup inspection in January 1959, the Rapier was cancelled before production of the first prototype.

Generator defects, fuel-flow difficulties (particularly acute in cold weather), and fuel-combustion-starter malfunctions were only a few of the frequent problems. In December 1959, after a canopy had been accidentally jettisoned in flight, all F–106s were temporarily grounded. Some of these early problems persisted a year later.

Flight Testing **1957-1961**

Testing of the F–106 was extensive. The Category II flight tests conducted at Edwards AFB, after being first accelerated, were extended and did not end until June 1959. Because of a shortage of aircraft, the Category III tests did not begin until July 1959 (a few months after the F–106 entered operational service with ADC's 498th FIS). They were conducted by another ADC unit, the 539th FIS at McGuire AFB, N. J., with the assistance of that command's interceptor and missile school at Tyndall AFB, Fla., where the ADC pilots learned to fire the new interceptor's armament. Category III testing ended in early 1961, after being somewhat hampered by logistical shortages.[6] Meanwhile, justifying ADC suspicion of the F–106's initial combat readiness, each phase of the test programs gave way to important engineering changes. Yet, each change had to be "defined, engineered, reviewed, and approved for production" before modification of aircraft off the assembly line could begin. Hence, by 1960 ADC possessed so many divergent F–106 configurations that maintenance support was almost impossible—a problem partially due to the Cook-Craigie production policy re-endorsed in August 1956. Moreover, in spite of successive production-line improvements (and an advanced Category III end-report in late 1960 declaring the F–106 operationally suitable) the Air Force still sought ways to enhance the aircraft.

Necessary Retrofit **September 1960**

Two major modification projects were undertaken. Wild Goose (started in September 1960 and completed in exactly 1 year), was designed to standardize the F–106 fleet.[7] It was largely retrofit work, mostly done at ADC bases by roving AMC field assistance teams supported by ADC maintenance personnel. Broad Jump (also initiated in late 1960) was a long-term program to improve the new interceptor. It took the Sacramento Air Materiel Area an

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[6] Despite fire-control problems and a lack of scoring equipment and targets, MB–1 atomic warhead rocket and radar-guided GAR–3 Falcon firing missions of the Category III tests ended at Tyndall AFB in May 1960. The entire Category III testing was completed with a series of GAR–3A and infrared GAR–4A tests.

[7] Early in 1960 ADC could list 63 changes in the F–106's fire-control system and 67 changes in the airframe that would be necessary to give early F–106 productions the same configuration as the most recent aircraft off the assembly line.

average of 60 days per aircraft to apply Broad Jump, which extended through early 1963.[8]

Other Improvements **1960**

Endorsement of the Wild Goose and Broad Jump modifications in the summer of 1960 did not deter the Air Force from seeking further F–106 improvements. Devices for long-range detection and electronic counter-counter measures (CCM), parametric amplifiers, along with angle chaff, silent lobing, and pulse-to-pulse frequency shift techniques were among those recommended and, for the most part, eventually approved. Meanwhile, Convair's struggle to provide the F–106 with a better supersonic ejection seat (one that would also work safely at low speed) had sufficiently progressed to warrant installing the new seat in the last 37 F–106A productions and its future retrofit in all others.[9] In 1960 Hughes flight-tested an infrared search-and-track sight that could operate at low altitudes and against varied backgrounds.[10] Tests were so encouraging that the infrared unit was included in the F–106 program of possible improvements, some of which were developed soon enough to become part of the Broad Jump program.

Other Postproduction Modifications **1961–1964**

In face of Wild Goose and Broad Jump changes—and Dart Board, another retrofit/modification program (August 1961–April 1962)—the F–106 weapon system still had problems. Dart Board had given the aircraft a thermal flash blindness protection hood, provided it with Convair's new Upward Rotational Ejection Seat, and added devices to help correct flameout from fuel starvation (one of the F–106's first deficiencies). But a lot more remained to be done. The MA–1 AWCS, "the most complex, sophisticated and completely integrated automatic weapon control system" designed for an all-weather fighter-interceptor aircraft, remained unrelia-

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[8] Not more than half of any squadron's F–106As were released to Wild Goose and Broad Jump at one time, so as to preserve a measure of combat capability during the $15 million, 800,000–manhour modification period.

[9] Development of the supersonic ejection seats (two-stage boom seats) required by the F–106B, the two-seater trainer variant of the F–106A, took longer, and sled tests did not start until mid–1960. As in the case of the F–106A, the F-106B's ejection seats featured a dual timing system, one for high-altitude/low-speed ejection and one for high-altitude/high-speed ejection. At sufficient flying speed, either seat enabled pilots to escape safely at low altitude.

[10] Hughes infrared search and track sight was an outgrowth of the ASG–18 pulse-doppler fire-control system developed by the same firm for the F–108 interceptor. The F–108 program was no longer in existence, but development of the ASG–18 and its accompanying GAR–9 missile (later designated AIM–47A) continued. The Hughes ASG–18/AIM–47A combination became part of the Lockheed YF–12A interceptor, first publicly displayed on 30 September 1964.

ble.[11] Correction efforts unabated, the Air Force embarked in two new modification programs. One involved the installation of parametric amplifiers in the MA–1 AWCS to up the system's detection and lock-on range by about 30 percent. The other also dealt with the MA–1, mainly to add anti-chaff devices. The two new in-house modification programs, involving 314 F–106s, were to be completed by the end of 1963.[12]

Initial Modernization 1965–1967

After divers modification programs, the F–106, the Air Force's first-line interceptor since 1959, entered its modernization phase. In 1965 the Air Force awarded a $6.2 million contract for producing new tactical air navigation systems for its best interceptor. The new TACAN, the first to use microelectronic circuits, would be one-third the size and weight of the current F–106 navigation system and would provide 450 hours of maintenance-free operation. The Air Force in addition approved in-house modifications that would give the F–106 an in-flight refueling capability for long-range ferrying. The installation of new external wing-mounted supersonic fuel tanks, also authorized, would increase the F–106's radius of operation. These modifications would allow F–106 deployment for air defense of US forces overseas in an emergency. They had been applied to two squadrons of F–106s by the end of 1967—just a few months before the North Korean seizure of the USS *Pueblo*. Modification of the entire F–106 fleet was scheduled for completion by the fall of 1969.

Modernization Planning 1967–1968

The F–106 modernization, begun in 1965, would satisfy neither long-term air defense requirements[13] nor potential short-term ones. The F–106 needed a 20–mm gun (for close-in attack against hostile fighter aircraft). It required a new canopy (for better observation of the air battle), radar homing and warning equipment (to warn the pilot of enemy air/ground radar and missile

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[11] The MA–1 AWCS was made up of 170 "black boxes" and weighed about 1,800 pounds. Practically all the F–106's electronic equipment, including the communication receiver and transmitter, the gyro compass, automatic direction finding and certain electronic counter-counter-measure (ECCM) elements, were part of the MA–1 complex. The nine subsystems of the MA–1 contained about 200 major components.

[12] During the same period, similar modifications were programmed for the MG–13 fire-control system of 431 F–101Bs.

[13] The Air Force directed upgrading of the existing manned interceptor force in the mid–1960's as a stop-gap measure, pending outcome of advanced manned interceptor (AMI) studies such as operational versions of the YF–12A and F–111. Other candidates for the AMI role later included the F–14 (a proposed Navy aircraft), possibly a new interceptor, and the proposed F–106X, a drastically modified F–106.

launches), and a device to show when maximum turn angle of attack had been reached. In addition, the F-106 could fire its air-to-air missiles in salvo or in pairs, but not singly, and missile preparation took too long. The F-106 weapon system nonetheless remained the best interceptor available, and ADC (still intent upon making it more reliable and easier to maintain) readied for USAF approval a program which was called Simplified Logistics and Improved Maintenance (SLIM). This original SLIM improvement package carried in September 1967 a price tag of $120 million. The Secretary of Defense's decision on 23 November 1967 to discontinue F-12 development and to select the F-106X as the future interceptor to complement a new airborne warning and control system (AWACS)[14] altered ADC planning.[15] The SLIM program was put aside in favor of a more costly one—nearly $1 billion—for the so-called (but as it proved out, never-to-be) F-106X.

Oversea Deployments **March 1968**

As part of the Korean buildup stemming from the *Pueblo* crisis, a series of F-106 deployments to Korea began. The first F-106s deployed from McChord AFB and conducted in-flight refueling en route—the first such refueling of F-106s.

Other Modernization **1969-1973**

When it appeared in late 1968 that the F-106X would not materialize,[16] ADC renewed its efforts to modernize the entire F-106 weapon system which, it believed, had become one of the Air Force's most competent fighters. The original $120 million SLIM program of September 1967 was revived and further simplified. It eventually emerged in mid-1969 as the cheaper Minimum Essential Improvement in System Reliability (MEISR) program ($91 million for 250 F-106A/B aircraft). MEISR would still significantly improve the radar, automatic flight control and DC power system of the F-106[17] and it was quickly approved by the Air Force. Though MEISR modifications were to be done by AFLC[18] person-

[14] Approved for development in November 1967.

[15] On 15 January 1968 the Air Defense Command became the Aerospace Defense Command.

[16] As estimated in mid-1969, the F-106X would require the expenditure of more than half a billion dollars ($626.2 million), but money alone probably did not decide its fate. The impasse between the Department of Defense (pro-F-106X) and Congress (supporting the Air Force-preferred F-12) most likely also contributed to the demise of the F-106X program.

[17] Overall weapon control system mean time between failures (MTBF) would be increased by 80%, and annual maintenance would be reduced by more than 50%. Intercept success rates would increase from 75% to 87% with primary armament; from 58% to 85% with secondary armament.

[18] The Air Force Logistics Command (the former Air Materiel Command) came into being on 1 April 1961.

nel at Hamilton AFB (where ADC's F–106s would be rotated through the 4661st Air Base Group), budgetary constrictions would probably delay completion until sometime in 1973. Despite austere funding, the Air Force in 1969 also endorsed most of Sixshooter—an ADC project outlined in February 1967, after the F–106 had shown the speed and maneuverability for a fighter-to-fighter role. Foremost among the Sixshooter F–106 modernization projects were addition of a 20–mm. gun (M–61), a lead-computing gunsight, a clear cockpit canopy, electronic countermeasures gear, and a RHAW device. The Air Force spent $1.5 million for a Sixshooter "feasibility demonstration" with generally satisfactory results, but eliminated the ECCM improvements recommended by ADC. All other Sixshooter modernization projects were approved, but technical as well as financial difficulties slowed their progress. The Air Force decided in October 1969 that something better than the current (and, in any case, extremely scarce) RHAW equipment would have to be developed to cope with increasingly sophisticated enemy radars. Similarly, installation of the clear-top canopy was not expected to begin until January 1972, and testing of the new gunsight, not before mid–1972.[19]

Special Testing **1972-1974**

In June 1972 one F–106 entered a Convair flight-and-fatigue test program to recertify the aircraft for longer service life—8,000 flight hours instead of the current 4,000. This program, expected to run through mid–1974, would also further evaluate the F–106's new stretched-acrylic, clear top canopy.

Subsequent Model Series

F–106B

Other Configurations

None. Production of two other F–106 model series, the F–106C and F–106D, was first considered, then dropped. The proposed F–106C would have featured a new engine (JT4B–22), a new fuselage structure, and a variety of technical changes. For example, a new 40–inch radar that would only slightly decrease the aircraft's absolute altitude and combat radius, but would appreciably increase its "kill" probability by extending search range a minimum of 50 percent. While the F–106D never went past the planning stage, the Air Force in mid–1957 anticipated the production of at least 350 F–106Cs. Two F–106C prototypes were built and accepted by the Air Force in December 1958—a few months after cancella-

[19] The Air Force approved on 27 January 1972 Air Force Academy development of the new gunsight that would complement the F–106's forthcoming M–61. While contractor gunsight engineering costs were estimated at something over $6 million, the Academy required only an initial $100,000 to get its work under way.

tion of the F–106C program.[20] Some 10 years later a third configuration, the so-called F–106X,[21] received considerable attention. The F–106X was a basic F–106 that would feature a new radome and a larger radar antenna. It would also receive, among other things, a modified fire-control system (providing "look-down" capability) and a new air-to-air missile with "shoot-down" capability. Like the superior Lockheed F–12,[22] the so-called F–106X did not materialize.

End of Production **December 1960**

With delivery of the last eight F–106As.

Total F-106As Accepted

The Air Force accepted 275 F–106As, including the first production aircraft earmarked for testing (later modified for tactical use) and the two F–106s used as prototypes.

Acceptance Rates

Two F–106As (designated YF–106As) were accepted in FY 57, 16 in FY 58, 45 in FY 59, 150 in FY 60, and 62 in FY 61 (during the second half of 1960).

Total RDT&E Costs[23]

$1.0 million

Flyaway Cost Per Production Aircraft

$4.7 million—airframe, $2,090,000; engine (installed), $274,000; electronics, $1,300,000; armament, $950,000; ordnance, $102,000.

Average Cost Per Flying Hour

$1,600.00 (maintenance included)

Operational Status **Mid-1973**

The Air Force in mid–1973 retained 174 of the 340 F–106s produced, the last of which had been delivered in December 1960. Seventy-three other F–106s were flown by the Air National Guard, ADC's increasingly close partner. Moreover, modernization of the versatile F–106 was in process. Obviously, the upgraded F–106 would be around for many years to come.

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[20] F–106Cs and F–106Ds were deleted when Headquarters USAF limited on 23 September 1958 the F–106 production program to a total of 340 aircraft (F–106Bs, included). Two YF–106Cs, already funded, were accepted.

[21] A somewhat misleading designation. The "X" implied that a new model would be created, which was never intended to be the case.

[22] As demonstrated by available YF–12As, the F–12 could fly faster than Mach 3 and reach an altitude of 70,000 feet with ease. It was the most advanced aircraft during the late 1960's but fabulously expensive.

[23] Prorated, this amounted to $2,941 that were reflected in the flyaway cost of each F–106. By contrast, cumulative modification costs of $659,603 (spent on each F–106A by 30 June 1973) were excluded.

Record Flight **15 December 1959**

An F–106 jet interceptor at Edwards AFB set world speed record of 1,525.695 mph on 11–mile straightaway course, eclipsing the Russian mark of 1,483.84 mph set in an "E–66" delta-wing aircraft.[24]

Other Milestones **December 1967**

F–106s flew nonstop from McChord AFB to Tyndall AFB for the first extended-range interceptor flight marked by inflight refueling and missile firing. In early 1968, air-refueled F–106s flew from Richards-Gebaur AFB, Mo., to Elmendorf AFB, Alaska.

F-106B

Manufacturer's Model 8-27
Weapon System 201B

Previous Model Series

F–106A

New Features

Tandem two-seat cockpit, redesigned fuselage tank area, and Hughes AN–ASQ–25 fire-control system—equivalent to the F–106A's MA–1.

Go-Ahead Decision **3 August 1956**

The Air Force authorized production of a trainer version of the F–106A. A late August decision not to confine the aircraft to a trainer role prompted its redesignation. The future TF–106A became the F–106B, a two-seater packing the F–106A's tactical punch.

Development Engineering Inspection **13 September 1956**

One day after that of the F–106A.

Mockup Inspection **September 1956**

The first of several, chiefly concerned with the aircraft's cockpit. The second inspection of the F–106B's cockpit, also at the Convair Fort Worth plant, was conducted in mid-December.

Contractual Arrangements **April 1957**

Procurement of the F–106B was included in the third F–106A contract, but the F–106B definitive contract was not finalized until 3 June 1957.

First Flight (Prototype) **9 April 1958**

The Air Force accepted the aircraft during the same month.

[24] Design of the basic E–66 was attributed to Artem Mikoyan, who worked with Mikhail Gurevich in designing the MIG–15, the first really-modern Soviet jet-fighter. The delta-wing E–66, powered by a single turbojet engine, seemed a version of the MIG–21 Fishbed, one of the many configurations progressively developed from the MIG–15. The MIG–21 was first seen in the Soviet Aviation Day display at Tushino Airport, Moscow, on 24 June 1956.

First Flight (Production Aircraft) **October 1958**

Basically similar to the F–106A, the F–106B shared the former's development and production vicissitudes. The Air Force accepted nine F–106Bs between April and December 1958, but did not initially release any of them to the operational forces.

Initial Operational Capability **July 1960**

Eight months after ADC achieved an IOC with the A model. The first F–106B, earmarked from the onset for the operational inventory, was accepted from Convair in February 1959.

End of Production **December 1960**

Production ended with delivery of the last two F–106Bs.

Total F-106Bs Accepted

63

Acceptance Rates

One F–106B (prototype) was accepted in FY 58 (April 1958), 11 in FY 59, 36 in FY 60, and 15 in FY 61 (during the last 6 months of 1960).

Flyaway Cost Per Production Aircraft[25]

$4.9 million—airframe, $2,200,000; engine (installed), $274,000; electronics, $1,350,000; ordnance, $24,000; armament, $1,089,000.

Average Cost Per Flying Hour

$1,600.00 (maintenance included)

Modification/Modernization Programs **1960–on**

The F–106B, of necessity, participated in all F–106A modification and modernization programs. Like the 35 F–106As initially allocated to testing, the first 12 F–106B productions were eventually brought up to the tactical standards of the entire F–106 fleet. In the process, they exchanged their original J75–P–9 turbojet engine for the more powerful J75–P–17. All 64 F–106Bs received Convair's new ejection seats (two-stage boom seats) after production.

Operational Status **Mid-1973**

Each ADC and ANG F–106 squadron had several two seaters for normal intercept missions as well as combat proficiency training and checks. Hence, the F–106B's operational life was likely to last as long as that of the F–106A.

PROGRAM RECAP

The Air Force accepted a grand total of 340 F–106s—275 F–106As, 63 F–106Bs, and 2 YF–106Cs. Included in the F–106A total were the 2 prototypes, first referred to as YF–102Bs, and early productions marked for testing but later modified for operational use.

[25] Excluding modification costs totaling $59,251 by 30 June 1973.

TECHNICAL DATA

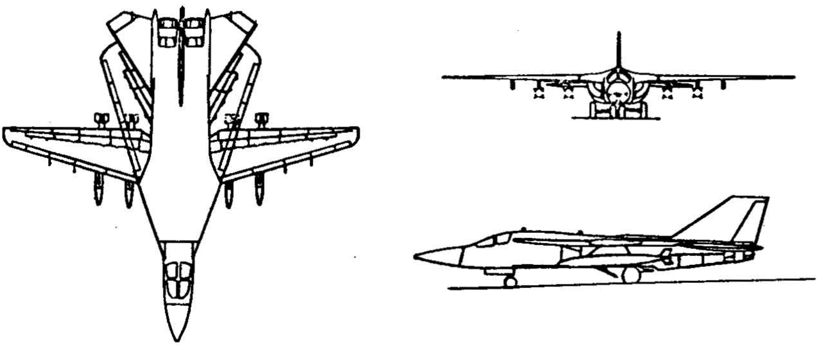
F-106A and F-106B

Manufacturer	Convair Division of General Dynamics Corporation, San Diego, Calif.
Nomenclature	Supersonic, all-weather, fighter-interceptor.
Popular Name	Delta Dart

Characteristics	*F-106A Point Interceptor*	*F-106A Area Interceptor*	*F-106B Point Interceptor*
Takeoff Weight	36,000 lb	38,700 lb	36,500 lb
Length Fuselage[26]/Wing	70.″7′/38.″3′	70.″7′/38.″3′	70.″7′/38.″3′
Max. Speed	1,100 kn	1,100 kn	1,100 kn
Radius (combat)	NA	633 nm (w/ external fuel tanks)	633 nm (w/ external fuel tanks)
Engine, Number & Designation[27]	1J75-P-17	1J75-P-17	1J75-P-17
Takeoff Ground Run	3,000 ft	3,600 ft	3,200 ft
Rate of Climb (sea level)	39,800 fpm	7,170 fpm	39,400 fpm
Combat Ceiling	52,000 ft	52,000 ft	51,400 ft
Crew	1	1	2
Ordnance/Armament	1 AIR-2A Genie, plus 4 AIM-4F Falcons, or 4 AIM-4Gs, or 2 AIM-4Fs & 2 AIM-4Gs	1 AIR-2A Genie, plus 4 AIM-4F Falcons, or 4 AIM-4Gs, or 2 AIM-4Fs & 2 AIM-4Gs	1 AIR-2A Genie, plus 4 AIM-4F Falcons, or 4 AIM-4Gs, or 2 AIM-4Fs & 2 AIM-4Gs

[26] Including nose boom

[27] Pratt & Whitney; 17,200 lb s.t. (24,000 lb with afterburner).



GENERAL DYNAMICS F-111

F-111A/B/D/E/F: The variable-sweep wing could be positioned in flight at various angles between the full forward and aft positions—enabling all F-111 tactical fighters to operate from relatively short runways, fly at supersonic speeds at low altitudes, and reach Mach 2.5 above 60,000 feet.

FB-111A: Longer fuselage, extended wing tip, stronger undercarriage and landing gear, extra and bigger fuel tanks, were some of the distinctive features of the FB-111A medium range strategic bomber.

GENERAL DYNAMICS F-111

Manufacturer's Model 12
Weapon System 324A

Basic Development

Much of the F-111 design technology evolved from Bell's potbellied X-5—America's first swingwing airplane—and US Navy's Grumman XF-10F. The F-111's two-pivot, variable-sweep wing, as opposed to the single-pivot used in previous experiments, spelled the success of the variable-wing idea.[1] It was discovered in 1959 by engineers at the Langley Research Center of the National Aeronautics and Space Administration.

General Operational Requirements — 27 March 1958

The GOR called for Weapon System 649C—a 1964 Tactical Air Command Mach 2 +, 60,000-ft altitude, all-weather fighter, capable of vertical and short takeoff and landing (V/STOL). The Air Force cancelled its March 1958 GOR (No. 169) on 29 March 1959, on the belief that, after all, vertical takeoff had not yet arrived.

System Development Requirement (SDR) — 5 February 1960

As issued by the Air Force, SDR No. 17 encompassed most of the cancelled GOR's requirements, except for vertical takeoff and landing (VTOL). Combined with TAC's revised specifications and a delayed operational due-date, it allowed the subsequent definition of specific requirements for a new weapon system—WS 324A.

Specific Operational Requirements (SOR) — 14 July 1960

This was SOR 183, a follow-on to the SDR of February 1960. It called for Weapon System 324A, an air superiority, Mach 2.5, 60,000-foot-plus altitude, all-weather, day and night, two-crew, STOL fighter (that could take off or land, even on sod fields, in less than 3,000 feet), with an 800-mile low-level radius (including 400 miles close to the terrain at Mach 1.2 speed), carrying either conventional or nuclear weapons. The unrefueled 3,300-nm ferry range and 1,000-lb internal payload (in addition to a lifting payload

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[1] From the days of Leonardo Da Vinci men had dreamt of flying with flapping wings. Experiments with the variable-sweep wing began in France in 1911 and the practical idea of moveable wings was introduced at a Rome scientific convention by Dr. Adolf Busemann, a young German designer. The Busemann theory and ensuing research by Dr. Albert Betz of the Gottingen Aerodynamics Research Institute spurred Messerschmitt in 1942 to begin work on a sweep-wing design dubbed the P-1101. Perhaps because contemporary engines could not give fighters high-enough speed for the variable wing to make any appreciable difference, the war ended before Messerschmitt's completion of the first German swingwing aircraft. The captured prototype (transported intact to the United States and soon loaned to the Bell Aircraft Company) led to design studies in 1948 which gave way, 3 years later, to the X-5's first flight.

between 15,000 and 30,000 pounds), also required by SOR 183, put the so-called fighter[2] in the fighter-bomber class—like the TAC F-100Ds and F-105s that it was expected to begin replacing in 1966. The Air Force considered that a variable-sweep wing and a forthcoming, improved turbo-fan engine would satisfy SOR 183. A reconnaissance version (six squadrons) of Weapon System 324A (expected to equip a minimum of six tactical wings) was part of the Air Force requirements.

Requests for Proposals **October 1960**

The Air Force prepared to inform industry of its new fighter requirement, but the Office of the Secretary of Defense (OSD) asked in November 1960 that the October RFPs be withheld for further review of SOR 183. The deferred project acquired a new status in December, becoming the TFX (Tactical Fighter Experimental), a name later embroiled in controversy.

New Requirements **7 June 1961**

The October RFPs stayed in abeyance. Believing a triservice fighter would save money, Secretary of Defense Robert S. McNamara on 16 February 1961 asked the Air Force to determine with the Army and Navy if the TFX could provide close air support (CAS) to ground troops; air defense of the fleet; as well as interdiction of enemy logistics—the Air Force's primary objective. The Army and Navy wanted a simpler CAS airplane, preferably the Navy-sponsored VAX (attack aircraft, experimental). The Air Force did not go along with this thinking, but it did agree that the TFX was not the plane for close air support. Army and Navy CAS objections to the TFX finally prevailed in May. Notwithstanding, Secretary McNamara remained convinced that the TFX could satisfy other Navy and Air Force needs. In June he instructed the Air Force to "work closely" with the Navy in tying the two services' requirements into a new, cost-effective TFX configuration.

Go-Ahead Decision **8 September 1961**

The decision by OSD was accompanied by a revised SOR 183, reflecting Secretary McNamara's arbitration of Air Force and Navy unreconciled requirements.[3] The September 1961 SOR 183

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[2] As a rule, fighters were designed to climb and maneuver rapidly, but they lacked payload and range. The weapon system called for by SOR 183 became the first aircraft specifically built to reverse the historic trend toward specialization. It achieved a versatility that justified reference as strike, attack, advanced tactical fighter, and the like.

[3] In spite of their unreconciled requirements, Admiral George Anderson, Chief of Naval Operations, and General Curtis LeMay, Air Force Chief of Staff, with the Secretary of Defense's approval, had publicly announced their endorsement of a new tactical fighter program on 1 September.

called for a wider fuselage (to satisfy Navy needs for more internal fuel and a panoramic nose antenna), with overall dimensions and weight kept to the maximum acceptable for carrier operation. The Air Force's TFX version could have a gross takeoff weight of 60,000 pounds (20,000 less than anticipated), compared to the Navy's 55,000. The airframe would not figure in the 5,000-lb difference in gross takeoff weight. Nor would heavier Navy avionics (offset by the weight of Air Force loads and armament).

New Requests for Proposals **29 September 1961**

These replaced the October 1960 RFPs and were sent to Boeing, Chance-Vought, Douglas, General Dynamics, Grumman, Lockheed, McDonnell, North American, Northrop, and Republic. Only Northrop turned down the USAF invitation, and nine responses were received in early December. The Air Force Selection Board and a Navy representative endorsed the Boeing proposal on 19 January 1962, but the Air Force Council rejected it. In late January Air Force and Navy agreed that none of the contractor proposals were acceptable, but that two—the Boeing and General Dynamics—deserved further study. A February, $1 million letter contract to each of the two solicited more design data. Meanwhile, the bi-service TFX was renamed.

Official Designation **December 1961**

The Air Force's future version of the TFX was designated F–111A; the Navy's, F–111B.

Contractor Selection **24 November 1962**

The LCs of February 1962 did not solve the competition problem. In May both the Air Force and Navy Secretaries disapproved the two contractors' second proposals for lack of sufficient data. Third proposals, appraised in late June, brought another impasse. The Air Force endorsed the Boeing input, but the Navy "refused to commit . . . unequivocally with this program until after the design had been defined." Secretary McNamara on 1 July ordered a final runoff on the basis of open "pay-off points" for performance, cost, and commonality. After receiving an additional $2.5 million apiece, Boeing and General Dynamics submitted in September their fourth and last proposals. The Air Force Selection Board as well as the Air Force Council again chose the Boeing design, but on 24 November the OSD publicly ruled in favor of General Dynamics.[4]

Initial Procurement **21 December 1962**

The Air Force initiated procurement of 23 RDT&E F–111s (18 F–

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[4] The decision spurred a congressional investigation, the long-drawn TFX Hearings that required Secretary McNamara's written testimony. Justifying his contractor selection, the Secretary underscored the fact that the General Dynamics proposal was closer to a single design, required only minor modifications to fit Navy and Air Force requirements, and embodied a more realistic approach to the cost problem.

111As and 5 F–111Bs), without awaiting the time-consuming negotiation of a definitive contract, by amending the LC that initially covered General Dynamics' second competitive proposal. The $28 million amendment of December 1962[5] made possible urgent subcontracts[6] and a November 1963 agreement with Grumman (the number one subcontractor, actually part of the General Dynamics team) for development and production of the Navy F–111B.

Mockup Inspection **September 1963**

Following separate inspections of the engine in July, and of the airframe in August.

Definitized Contract (RDT&E Aircraft) **1 May 1964**

The amended LC of February 1962 was finalized as a fixed price incentive fee (FPIF) contract (AF 33–657–8260), with a 90/10 percent sharing arrangement. The ceiling price ($529 million) was based on 120 percent of the $480.4 million target cost for 23 RDT&E F–111s. This included flight testing, spares, ground equipment, training devices, static and fatigue test data. The FPIF development contract of May 1964 contained cost, schedule, performance, and operational clauses, plus a provision for the "correction of deficiencies."

F-111A

First Flight (RDT&E Aircraft) **21 December 1964**

The flight was made from Carswell AFB, Tex., by the first test F–111A that had rolled out of the General Dynamics' Fort Worth plant on 15 October—37 months after the OSD go-ahead decision, 22 months after the program's actual beginning, and 2 weeks ahead of schedule.[7] Although performance restrictions had been

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[5] Plus $22 million obligated to the Navy for development and hardware of a Pratt and Whitney engine—the TF–30. The Air Force assumed this Navy responsibility in late 1967, after the TF–30 had undergone several transformations.

[6] By the spring of 1964 AiResearch, AVCO, Bendix, Collins Radio, Dalmo Victor, General Electric, Hamilton Standard, Litton Systems, McDonnell Aircraft, Texas Instruments, and seven other major subcontractors had become involved in the F–111 program and were doing business with 6,703 suppliers in 44 states. An associate prime contract for the F–111B's Phoenix missile system had also been signed by the Navy and the Hughes Aircraft Company.

[7] The 15 October roll-out ceremonies prompted Secretary McNamara to remark: "... the Air Force, the Navy, and General Dynamics and its subcontractors ... have produced a plane which will fly faster at any altitude than our best current fighter—a plane with several times the payload and twice the range of any previous fighter-bomber. One F–111 will have the fire power of five World War II flying fortresses. ... For the first time in aviation history, we have an airplane with the range of a transport, the carrying capacity and endurance of a bomber, and the agility of a fighter pursuit plane. ..."

set before the flight (and the flight was shortened to 22 minutes because of flap malfunctions), overall results were satisfactory. The aircraft immediately entered Category I testing. During this early testing period, the F–111A achieved Mach 1.3, and maintenance proved comparatively simple. On its maiden flight (25 February 1965), a second F–111A swept its wings from a 16° to a 72.5° aft position (as designed). These were the only test F–111s accepted by the Air Force (each on its first flight's date) prior to the initial production agreement.

Program Change **1965**

A cost rise from an estimated $4.5 to $6.03 million per aircraft led the OSD in early 1965 to cut the F–111 program sharply. Accrued USAF requirements likewise shaped the program. These included improved avionics (formally directed by the OSD in January 1966) and a strategic F–111 bomber to replace B–52C through F aircraft (OSD-endorsed in June 1965 but not made official until December). Development of a reconnaissance F–111 (approved in October 1965, but eventually cancelled) was also a factor.

Letter Contract (Production Aircraft) **12 April 1965**

The Air Force started procurement of the F–111 productions as it had the RDT&E aircraft. As publicly announced by the OSD, it gave General Dynamics an April 1965 fixed price incentive fee LC, authorizing the production of 431 F–111s—a more than 50-percent reduction of the total aircraft initially planned. The production LC also authorized negotiation of an unusually large number of subcontracts—mostly with firms already involved in the F–111 development.

Flight Testing **1964–1973**

The 1965 program change added eleven F–111A productions to the already extensive F–111A RDT&E program and expanded it. The Category I flight tests (started in December 1964) did not end until 31 March 1972. At that time, Category II tests (begun in January 1966) were still going on. Several postponements slipped the Category III tests to 1969. They were finally cancelled as operationally unnecessary.

Initial Problems **1964–1967**

Engine malfunctions and weight increases were the main drawback.[8] The Pratt and Whitney P–1 (production version of the afterburning turbofan TF–30) was first flown in an F–111A on 20 July 1965. Despite thorough testing (like that for the experimental TF–30), problems soon arose. The first 30 F–111As (each equipped with two P–1s) had numerous engine stalls, particularly at high

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[8] Not unusual during the development of high-performance aircraft, even less revolutionary than the F–111A.

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Mach numbers and high angles of attack. Other F–111As received the P–3, an improved P–1 that became available in 1967. The new engine (later retrofitted in several of the first 30 F–111As) was accompanied by an air diverter (Triple Plow I). The P–3/Triple Plow I combination did not cure the stall problem. However, it helped enough, required little airframe modification, and led to further progress. Efforts to control the aircraft's weight were less successful. The F–111A's final takeoff weight for conventional missions (92,000 lb) exceeded the OSD September 1961 specification by 30,000 lb, but USAF expectations by only 10,000 lb.

First Flight (Production Aircraft) — 12 February 1967

Two F–111A productions first flew on the 12th. By August the Air Force had accepted these two and nine others, sending them on to testing. All were part of the 30 productions, initially equipped with P–1 engines.[9]

Special Tests — April-May 1967

Every facet of the F–111A's widened testing proved to be crucial. Yet, the Combat Bullseye I tests, conducted in the spring of 1967, had the greatest immediate impact. They confirmed the superior bombing accuracy of the aircraft's radar and prompted the F–111A's early deployment to Southeast Asia—a project that acquired overriding priority.

Definitized Contract (Production Aircraft) — 10 May 1967

The production LC of 1965 was replaced by a multi-year, FPIF contract (AF 33–657–13403) in May 1967. Production was then raised to a total of 493 F–111s—24 Navy F–111Bs (later, practically cancelled); 24 F–111Cs for Australia; and 445 F–111s of one kind or another (including 50 first earmarked for the United Kingdom) for the Air Force. Unlike the development contract, the production contract of May 1967 (the only one through mid-1970) had an initial ceiling price based on 130 percent of the target cost. This percentage, however, was to be renegotiated for each engineering change. Initial contract profit was still set at 9 percent, but the cost sharing formulas (75/25 sharing to 107 percent and 85/15 from 107 to 130 percent of the ceiling cost) also differed.[10]

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[9] Engine problems, notwithstanding, an RDT&E F–111A had reached top design speed of Mach 2.5 on 9 July 1966.

[10] By mid-1970 (after more than 2,000 engineering changes), overall ceiling was nearer 127 percent than 130. Profit for all follow-on work was also variable. Hence, overall profit rate "before" overtarget settlement was 8.06 percent; "after" overtarget settlement, only 4.46. On the other side of the ledger, the cost of the contract's first batch of aircraft (about one-third of the 493 on order) had almost doubled, with each F–111A priced at $11 million.

First Flight (31st Production Aircraft) — 24 September 1967

The first F-111A (31st production), featuring the P-3 engine/Triple Plow I air diverter combination successfully concluded the flight. This aircraft and subsequent F-111As were the only ones directly earmarked for the operational inventory.

Enters Operational Service — 16 October 1967

A handful of aircraft were assigned to the 428th, 429th, and 430th Tactical Fighter Squadrons of TAC's 474th Tactical Fighter Wing. The 474th, Cannon AFB, N. Mex., moved to Nellis in early 1968.

SEA Deployment — 15 March 1968

The Combat Bullseye I tests of early 1967 clinched the Air Force decision to rush a small detachment of F-111As to Southeast Asia (Combat Lancer). This would boost night and all-weather attacks while testing the aircraft's overall combat capability. Combat Lancer was preceded by Harvest Reaper, started in June 1967, to temper known F-111A shortcomings and prepare the aircraft for combat. The Harvest Reaper modifications (mainly more avionics and electronic countermeasures (ECM) equipment) would enter the F-111A production lines, if successfully combat proven. Combat Lancer looked to another precombat project (Combat Trident) for trained pilots, Trident running up 2,000 flying hours and 500 bombing sorties in the face of a critical aircraft shortage. Yet, despite engineering changes, perfected penetration aids, and Combat Trident (completed on 6 March, only 9 days before the Combat Lancer deployment), the F-111A's entry into combat was not a success.

Combat Lancer Attrition — March/April 1968

The six Combat Lancer F-111As departed Nellis AFB on 15 March and reached Takhli Royal Thai Air Base on the 17th. At month's end, after 55 missions that centered on North Vietnam targets, two aircraft had been lost. Replacements left Nellis, but the loss of a third Combat Lancer aircraft on 22 April halted F-111A operations.[11] However, the aircraft remained poised for combat despite the first two losses and the marginal success of sorties flown prior to the third combat loss. Even so, the Combat Lancer detachment (Det I of the 428th TFS) saw little action before its November return to the United States.

Initial Operational Capability — 28 April 1968

The 428th TFS of the 474th Tactical Fighter Wing reached an initial operational capability in the spring of 1968. There followed

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[11] Keen interest of the nation's press in the controversial F-111 stepped up. In articles, the aircraft became McNamara's "Flying Edsels." Occasionally defended, it was also accused of being a potential "Technological Gold Mine for the Reds."

Harvest Reaper modifications (validated by the Combat Lancer testing operation), other modifications (mostly unexpected), plus a clutch of problems (technical and financial). The wing was therefore not operationally ready until July 1971.

Postproduction Modifications **1969**

The Harvest Reaper improvements (tailored to the Combat Lancer F–111As), although approved for production in April 1968, were delayed. The Air Force decided that the improvement program should include modifications possibly called for by Round Up—a 3-month evaluation of Combat Lancer. Round Up ended in August, but it took longer than expected to tie the Combat Lancer crashes to malfunction of the aircraft's tail servo actuator in one case, and poor mounting of the M–61 gun and pilot error in the two others. Similarly, F–111 testing and training incidents (including two crashes in early 1968) dictated a detailed evaluation that became quite involved. Moreover, on 27 August (1 day after the beginning of the F–111A's Category II fatigue tests)[12] an F–111 wing-carry-through-box failed during a ground fatigue test.[13] Hence, General Dynamics' overall improvement of the F–111 (particularly, additional Harvest Reaper avionics) did not go as planned. It started in January 1969 and required extensive retrofits because most F–111As had cleared the production lines. Still, where necessary, retrofit modifications were integrated into the production of later F–111s.

Grounding **1969–1970**

The Air Force lost its 15th F–111A on 22 December 1969,[14] due to

[12] The beginning of the F–111A's fatigue test program slipped from February 1965 to July 1968 because of design and weight reduction changes that had to be reflected by the test airframe to assure realistic testing; also, because of General Dynamics late submission of acceptable testing procedures. A final 3-month delay was due to late modifications, as called for by the new Triple Plow I air diverter, a deficient carry-through-box (that had failed during early static tests) and an unsatisfactory tail pivot shaft fitting.

[13] In early 1969 General Dynamics discovered that Selb Manufacturing, who made the defective steel boxes, was paying off inspectors for approving unauthorized weldings. An FBI investigation followed. A federal grand jury indicted General Dynamics in 1972 for destroying $114,000 worth of flawed boxes and filing a claim with the Air Force for repayment—instead of charging the loss to Selb. A trial jury acquitted General Dynamics in 1973.

[14] The accident triggered renewed criticism of the aircraft. In congressional testimony on 17 March 1970, the Secretary of the Air Force admitted difficulties but pointed out ... "this plane per thousand hours flown, has fewer accidents than any other Century series aircraft ..." In February 1972, after 150,000 hours, the F–111 still had the lowest accident rate of the nine most recent USAF/USN high-performance tactical aircraft, even though a large percentage of its work was on the deck (200′-to-500′ above the terrain), and much of it at night. The F–111 accident rate in early 1972 was 40% under that of the F–106—USAF's next safest aircraft.

failure of the forged wing pivot fitting (a part of the basic wing structure, sitting next to the wing-carry-through-box). It grounded all F–111s the next day, except for a few used in flight tests. The grounding was lifted on 31 July 1970.

Modernization **1970-On**

The December 1969 accident casted doubt on the F–111's structural integrity and compounded the aircraft's modernization. The January 1969 improvement program (and delayed addition of Harvest Reaper avionics) had already been expanded to include wing-carry-through-box structural modifications that would extend fatigue life to the 10-year contractual design requirement.[15] Investigation of the most recent F–111A crash now dictated a thorough structural inspection and proof testing program. This was Recovery, a $31.2 million,[16] non-destructive, cold-proof testing and modification effort, started in the spring of 1970. The Air Force believed that blending this project with the F–111's overall modernization, should restore the F–111s to operational status in early 1971. Little slippage occurred. TAC returned a first F–111A to General Dynamics in April 1970 and by December 1971 the last of 340 F–111s (counting 125 F–111As) had been processed. The Recovery testing of each F–111 covered more than a dozen structural components—4 of which required load-proof testing at a temperature of minus 40° F. A few bolts broke, which was not surprising, yet no forging defects appeared in more than 3,500 units inspected. But still cautious, the Air Force in August 1971 scheduled a further (Phase II) structural in-house inspection of every F–111 model. Each F–111A had to undergo Phase II processing before reaching 1,500 flying hours.[17] The first F–111A entered Phase II at the Sacramento Air Materiel Area on 16 May 1973.

Oversea Redeployment **27 September 1972**

F–111As were returned to SEA not long after a crash and another 8-day grounding. In fact, two F–111A squadrons (429th and 430th) were in combat 55 miles northwest of Hanoi—33 hours after

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[15] Cyclic loads ground testing of a modified wing-carry-through-box were resumed in December 1969. They gave the box a test-life of 24,000 hours (equivalent to a safe service-life of 6,000 hours). Even so, the Air Force authorized General Dynamics on 18 May 1970 to give North American a development contract for a titanium box.

[16] This amount would cover nonrecurring costs for materials and equipment, plus the recurring costs for labor to see the aircraft through inspection and testing. The Air Force wanted General Dynamics to do this under the contract's correction of deficiencies clause. Approved aircraft procurement took care of inspection and proof testing funding (the Air Force covering it by dropping several F–111Fs from follow-on buy).

[17] F–111E and D aircraft fell under this criterion. The F–111F and FB–111A could pile up 2,000 and 2,500 hours, respectively, prior to Phase II.

leaving Nellis AFB. Flying again from Tahkli (the Combat Lancer deployment base of 1968), F–111As also attacked Laotian targets in the midst of the monsoon season. They fought without "Iron Hand" electronic countermeasure escort aircraft, EC–121s to vector them, or KC–135 tankers (as needed by the F–4s which they replaced). F–111As flew 20 strikes over North Vietnam on 8 November, in weather that grounded other aircraft.

SEA Operational Problems **1972–1973**

Four F–111As could deliver the bomb loads of 20 F–4s (an operating cost saving of no small significance). Yet, all was not well. Shortly after returning to SEA, an F–111A experienced double engine rollback after entering heavy rain, a critical problem since the aircraft were to serve as all-weather fighters. Crucial shortages of spares (such as brakes, wheels, and struts) arose. Added to this were continued problems with both the terrain-following radar (TFR) and attack radar sets. Malfunctions of the internal navigation and weapons release systems also cropped up. The loss of several F–111As brought about Constant Sweep, a team effort that found no single factor for the SEA losses but identified several real and potential deficiencies. Temporary Constant Sweep flying restrictions were removed in January 1973. There followed a 17 February midair collision of two F–111As near Udorn and the next day loss of a single F–111A.[18] The squadrons' maintenance and supply practices thereupon came under closer scrutiny. When seven of the 52 fully-equipped F–111As were lost in SEA, TAC had to remove penetration aids from later models (F–111Fs) to equip replacements. Still, more than 3,000 F–111 missions preceded the Paris peace accords of January 1973. Meanwhile, aircrew enthusiasm for the aircraft continued to grow.

Subsequent Model Series

F–111B (Navy's)

Other Configurations

RF–111A[19]—an F–111A equipped with a removable sensor pallet. Sensor imagery testing of the converted F–111A (between December 1967 and October 1968) achieved good results. However, it took days (not hours, as the OSD had hoped) to make the conversion. Return of the converted F–111A to its basic configuration proved equally impractical. Consequently, the Air Force again tried to obtain a separate, more sophisticated reconnaissance force of F–111s (RF–111Ds)—as long preferred, but much smaller than originally planned. Dearth of funds killed the high-cost RF–111D in

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[18] A 20 March midair collision of two F–111Ds, near Holbrook, Arizona, brought several procedural changes. TAC prohibited formation flying until 4 April.

[19] The flyaway cost of the sole RF–111A was set at $12.1 million.

September 1969. This time the OSD decision was final. The Air Force's fall-back reconnaissance alternative (modification of 52 F-111As to an austere sensor configuration) fared no better and was dropped in March 1970.

F-111C—a modified F-111A, specifically designed for the Royal Australian Air Force (RAAF). Modifications included new, longer wings, and a heavier gear (similar to that of the FB-111A).

F-111K—an F-111A featuring more advanced avionics and the FB-111A's undercarriage. Two of 50 programmed F-111Ks came into being. Never flown, they were salvaged following Great Britain's cancellation of its order in January 1968.

EF-111A—modified F-111A featuring a version of the AN/ALQ-99 noise-jamming system employed on the EA-6B. The Air Force expected the EF-111A would have an on-station loiter time of 8 hours (when operating 100 miles from home base) compared with 2.5 hours for the Navy/Grumman EA-6B. This added endurance would make the EF-111A available for successive strikes. Improved survivability, due to the EF-111A's Mach 2.2 speed, was another plus. Two EF-111A prototypes were under contract in mid-1973, General Dynamics and Grumman each having received one F-111A for modification.

End of Production **30 August 1969**

With delivery of the last F-111A.

Total F-111As Accepted

The 158 aircraft accepted included 17 of the 18 RDT&E F-111As ordered in December 1962. The 18th test F-111A was used as bomber prototype and charged to the FB-111A program.

Acceptance Rates

Four RDT&E F-111As were accepted in FY 65, 8 in FY 66, and 5 in FY 67. The Air Force accepted 5 F-111A productions in FY 67, 36 in FY 68, 86 in FY 69, and 14 in FY 70. Monthly acceptances averaged 3 F-111A productions until July 1968, when they rose to 7.

RDT&E Total Cost **Mid-1973**

$1.657 billion—$200,000 more than concurrently estimated by General Dynamics, but $1.176 billion over the target cost of May 1964.

Procurement Costs **Mid-1973**

$5.479 billion for 541 F-111s[20] (excluding the 23 RDT&E F-111s—18 for the Air Force and 5 for the Navy). The contractor's lower

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[20] In late 1973, it seemed the F-111 program would be held to 529 F-111s (plus the 23 RDT&E aircraft). After 1970 the Congress had insisted on funding 48 additional late models of the aircraft (F-111Fs). The Air Force, however, had bought just 36 and hoped to defer acquisition of the remaining 12 indefinitely.

figure ($5.431 billion) still represented an overall target cost increase of $3,228 billion.

Flyaway Cost Per Production Aircraft[21]

$8.2 million—airframe, $4,304,000; engines (installed), $1,354,000; electronics, $1,688,000; ordnance, $7,000; armament, $925,000.

Average Cost Per Flying Hour

$1,857.00

Operational Status **Mid-1973**

Though grounded often, the F–111A after 6 years showed an ever-increasing potential. In face of losses in SEA and elsewhere, the aircraft's rate of attrition remained low. The F–111A was assured of an important role in USAF long-range planning.

Other Uses **Mid-1971**

The Air Force awarded a $2.5 million letter contract to General Dynamics for design and fabrication of a "supercritical" variable-sweep wing. Total value of ensuing cost-plus-incentive fee contract, including F–111 airframe modification costs, was expected to reach $12.9 million. This decision followed NASA testing of supercritical wings up to low supersonic speeds, using a North American Rockwell T–2 trainer and an LTV Aerospace F–8 fighter. Flight tests of the modified F–111's new wings were set for mid-1973. They would be part of an Air Force/NASA program at Edwards AFB, run by NASA's Flight Research Center.

Other Countries **1973**

The last 6 of 24 F–111Cs, bought by Australia for some $250 million, left the United States on 26 November 1973. This was nearly 10 years after the two countries signed a June 1964 F–111 agreement, and more than 5 years since General Dynamics delivered the first F–111C on 6 September 1968. Engineering changes separating the F–111C from the basic aircraft did not get under way until August 1966, but this did not slow the program. What first delayed it was the F–111A's wing carry-through box failure. Incorporation of fixes on production aircraft slipped delivery of the remaining 23 F–111Cs to late 1969. The entire F–111 fleet was then grounded. In April 1970, a joint agreement deferred Australia's acceptance of the purchased F–111Cs pending vertification of their structural integrity. It specified that the RAAF lease F–4E aircraft; new wing carry-through boxes be installed on all F–111Cs; and the aircraft be delivered in mint condition. More than a million manhours went into the F–111C modification and refurbishment program started by General Dynamics on 1 April 1972.

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[21] Excluding some $2.8 million spent for RDT&E and about $800,000 worth of modification, bringing the actual cost of each F–111A to more than $11.8 million.

As the aircraft were released, Australian crews flew them from the contractor's Convair Aerospace Division in Fort Worth. Tex., to McClellan AFB. Once at McClellan, each F–111C completed between 4 and 6 training missions before departure. The first F–111Cs reached Australia on 1 June 1973, replacing the RAAF's Canberra bombers in use since the early 1950's.

Milestones **May 1967**

An unrefueled F–111A set a flight record of 7 hours and 15 minutes on 1 May. On the 22d, two F–111As attained a fighter-type aircraft unofficial record for transatlantic flight without refueling and external tanks. The two (on their way to the Paris Air Show) flew from Loring AFB, Maine, to Le Bourget Airport in 5 hours and 54 minutes. They covered 2,800 nautical miles at an average speed of 540 mph, their wings extended most of the time in cruise position.

F-111B

Previous Model Series

F–111A

New Features

Shorter fuselage nose radome with retractable long-range panoramic radar for interceptor role. Longer wing tips for improved low-speed ferry and loiter performances.[22] Enlarged ventral fin, housing carrier arrester hook. P–12 engine (another version of the TF–30), carrying maximum thrust of 20,250 pounds with afterburner—1,700 pounds more than the F–111A's P–3. Six AIM–54A air-to-air Phoenix missiles, developed by Hughes specifically for the Navy.[23]

Basic Development **1961**

F–111B development, like that of the USAF F–111A, mirrored Secretary McNamara's September decision to meet each service's long-range requirements with one plane. The biservice F–111 would replace the F–105, as basically called for by the Air Force's SOR of July 1960. It would also succeed the carrier-based F–4H, eliminating the Navy's chances for getting the F–6D Missileer as the F–4H's replacement.[24]

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[22] The F–111B's overall length of 66 feet and 9 inches was about 6 feet under the F–111A's; its 70-foot wing span was 7 feet longer than the F–111A's.

[23] The Phoenix's fire-control system owed much to the USAF ASG–18 system (developed in the early 1960's) for launching nuclear-tipped AIM–47A air-to-air missiles—then known as GAR–9 Falcons. Originally meant for the North American F–108 Rapier (cancelled by OSD in September 1959), the Hughes ASG–18/AIM–47A combination could fit later interceptors, including the YF–12A, ADC badly wanted.

[24] The F–4H, topping all Navy interceptors in speed, altitude, and range, was introduced into the Fleet in January 1961, only a few months before the OSD rejection of the single mission Missileer interceptor.

Contractual Arrangements **November 1963**

Design, development manufacturing, final assembly and delivery of the F–111B were delegated to the Grumman Aircraft Corporation. The Air Force authorized General Dynamics to negotiate the subcontract in September, 2 months before its official ratification.

First Flight (Prototype) **18 May 1965**

A modified RDT&E F–111A (powered by the initial TF–30–P–1 engine) flew for 1 hour and 18 minutes after taking off from Grumman's Peconic, N.Y., facility. It had rolled out of the subcontractor's Bethpage, N.Y., plant 7 days earlier. The Air Force immediately accepted for the Navy the first YF–111B, sending it to the Patuxent Naval Air Test Center in Maryland, where all F–111Bs would be tested.[25] The aircraft reached supersonic speed on 1 July.

First Flight (RDT&E F-111B) **May 1966**

F–111B's development took longer than the F–111A's mainly because of difficulty in integrating the Phoenix missile system with the aircraft.[26] The F–111B also shared the F–111A's engine problem. The Navy believed these would be solved with the P–12 (one more engine version of the TF–30), which would equip F–111B productions and retrofit RDT&E F–111Bs, beginning in late 1966.

Configuration Changes **11 March 1967**

The F–111's crew module lacked sufficient forward visibility for a carrier-based aircraft. The OSD, in March 1967, authorized a new module for the F–111B, even though this would mean aerodynamic changes and widen differences between the F–111A and F–111B.[27] Meanwhile, continued USAF and USN efforts to check F–111 weight increases proved futile. The first F–111B prototype flown (modified F–111A), weighed 69,000 pounds;[28] the first F–111B

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[25] The F–111B's Phoenix missile system would undergo tests in California, at the Hughes Culver City Plant and at the Naval Point Mugu Missile Center.

[26] The F–111B's first successful launch of the AIM–54A Phoenix took another 6 months.

[27] Differences (first authorized in 1962 to meet the aircraft's operational needs) were few—the Navy accepting a heavier aircraft, with a longer fuselage and smaller panoramic radar than desired; the Air Force, a lighter, two-crew aircraft, with a Navy side-by-side sitting arrangement instead of the usual tandem configuration. Hence, commonality, a prime OSD requirement from the onset of the F–111 program was relatively high through January 1966. However, redesign of the F–111A's aft fuselage structure (to fit the new P–3 engines) and modification of the same section on the F–111B (to accommodate the P–12s) decreased commonality. The overall percentage of common parts, once around 80, fell below 70. Redesign of the F–111B's crew module (including pilot elevation and increased windshield slant) was another factor.

[28] Too much to permit the aircraft's operation from carriers smaller than the *Forrestal*.

production (due to fly in 1968), 75,000—about 20,000 pounds more than originally planned.

Definitized Contract (Production Aircraft) **10 May 1967**

It was signed by the Air Force—24 Navy F–111Bs were included in the 493 F–111s covered by the contract.

First Delivery (Production Aircraft) **30 June 1968**

Grumman delivered the first one to the Air Force, for the Navy.

Production Hold Order **9 July 1968**

The Air Force stopped work on the F–111B after the House Armed Services Committee joined the Senate in disapproving a $460 million appropriation requested by the Defense Department for further development and procurement of 30 aircraft.

Program Cancellation **August 1968**

Projected, but now cancelled, F–111Bs went to the USAF program.[29] Still, the Navy's withdrawal (on the heels of the British government's cancellation of its F–111K purchase) forced the Air Force to adjust its plans. For instance, by fiscal year 1970, the May 1967 contract's buy of 493 F–111s over 4 years had been stretched to 6 years.

End of Production **28 February 1969**

With delivery of the seventh and last F–111B.

Total F-111Bs Accepted

7—5 RDT&E F–111Bs and 2 productions.

Flyaway Cost Per Production Aircraft

$8.7 million—as estimated in early 1968. In light of later F–111 cost increases, this was probably far below the aircraft's potential cost.

Subsequent Model Series

F–111E—the F–111B should have been followed in the USAF inventory by the F–111C, but the latter was put aside for Australia. The F–111D, next in line, was preceded by the less-sophisticated F–111E and the strategic FB–111A bomber.

Other Configurations

None—the RF–111B, called for by Navy SOR TW–35–10 in August 1963, was abandoned 2 years later.

Other Uses

Two F–111Bs were lost in crashes and a third was severely damaged in landing. The Navy used the remaining 4 to continue testing the Phoenix missile system and P–12 engine. Both would

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[29] Cancellation of the Navy F–111B led General Dynamics to sever its relationship with Grumman and Hughes. The latter, as associate contractor under Navy contract, developed the Phoenix missile system.

equip the F–111's successor—the VFX (Grumman F–14), authorized for development by Congress in July 1968.[30]

F-111E

Previous Model Series

Navy's F–111B[31]

New Features

Triple Plow II air inlets, improving engine operation at high speed and high altitude; stores management set, corresponding to the one planned for the F–111D and F–111F aircraft.[32]

Go-Ahead Decision **27 February 1968**

The decision underscored the F–111's urgency. Since the sophisticated F–111D could not be had quickly, the Air Force had to approve a simpler configuration for its second tactical wing. Designated F–111E, the aircraft closely resembled the F–111A.

Program Slippage **1969**

Triple Plow II (a development of the General Dynamics Triple Plow I air diverter that accompanied the F–111A's P–3 engines) spelled the main difference between the E and A models. Still, F–111E production was postponed for 6 months at the outset. This afforded time for F–111A modifications[33] (begun in January 1969) to become part of the General Dynamics F–111E production line.

First Flight (Production Aircraft) **20 August 1969**

Concurrent with delivery of the last F–111A.

Enters Operational Service **30 September 1969**

TAC's 27th Tactical Fighter Wing at Cannon AFB reached initial operational capability in the fall of 1969. The wing had 29 F–111Es by December, but these flew under restrictions until the Air Force was convinced the longerons were perfectly safe.

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[30] The Navy planned to utilize the F–4J while awaiting its new interceptor.

[31] The F–111E, authorized for production after the F–111C, F–111D, and FB–111A, was the first of the three to reach an operational capability, beating the FB–111A by 1 month.

[32] All F–111s shared similar air-to-ground radios, intercommunication systems, navigational radios, instrument lending systems, and central air data computers. They also had like identification equipment, flight control, and radar altimeter subsystems, as well as extensive electronic countermeasure and penetration aid equipment. Remaining avionics were quite different. For instance, the Mark I system (consisting of attack radar, navigation-attack system, and a lead computing optical sight), common to the F–111A, C, and E models, could not be compared to the Mark II that was being developed.

[33] These included Harvest Reaper, Round-Up, and wing-carry-through box improvements.

Testing **1969-1972**

Special tests (requiring additional equipment on two of the 5 first F-111Es, reserved for testing) delayed the program, already affected by production slippages. The Category I and II flight tests, started in October 1969, extended through July 1971; others,[34] through 1972.

Second Program Slippage **1970**

The F-111E program slipped another 6 months, following the December 1969 loss of the 15th F-111A. The Air Force refused to accept any F-111 delivery until the end of July 1970, when the fleet grounding was lifted. All F-111Es (accepted before and after the grounding) went through the Recovery Program and other structural inspections stemming from the December 1969 accident.

Oversea Deployments **September 1970**

The F-111E had an integral radar homing and warning and electronic countermeasures capability.[35] It was greatly needed overseas. The United States Air Forces in Europe counted on the F-111E for the all-weather and night work its F-4s were not equipped to do. Despite the program's initial slippage, the first two of the 79 F-111Es,[36] slated for USAFE's 20th Tactical Fighter Wing, arrived in England on 11 September. The 79th, one of the wing's three squadrons, reached an IOC in December. The wing became fully operational in November 1971.

Operational Problems **1969-1973**

The F-111E shared most of the operational and support deficiencies of the F-111A—the Air Force learning much from F-111E accidents. A 23 April 1971 F-111E crash, during a Category II flight test, uncovered a malfunction of the recovery parachute (part of the excellent escape module[37] that kept down the F-111

[34] F-111E category II system evaluation tests were concluded on 23 July 1971, after showing that the aircraft's major subsystems worked well. Category I separation testing for nuclear weapons was completed in April 1972; stability and control tests, in June.

[35] The F-111A was the Air Force's first tactical weapon system to have this equipment built in from the start.

[36] Out of the total 90 aircraft (counting the five productions allocated to the testing program). Remaining F-111Es stayed with TAC. The 442d squadron at Nellis used them to train F-111 pilots, including USAFE pilots.

[37] General Dynamics believed the F-111's crew module (first known as "boiler plate" crew escape capsule) ranked alongside the F-111's variable-sweep wing and fan-afterburning engine as major advancements in aircraft design. Developed by the McDonnell Aircraft Corporation and initially tested in February 1966, the F-111's crew module was fully automated. When forced to abandon his aircraft, the pilot only had to "press, squeeze, or pull" one lever. This caused an explosive cutting cord to shear the module from the fuselage; a rocket motor ejected the module upward and it parachuted to the ground or sea. There it could serve as a survival shelter, like the Mercury and Gemini capsules of the US early space programs.

accident's death rate). Another F–111E crashlanded in Scotland on 18 January 1972. This accident pointed out the need for an audio and visual stall warning system.[38]

Other Problems **1969–1973**

Early F–111A and F–111E aircraft had deficient windshields. On 29 May 1969, an F–111 on a training flight at Nellis crashed at low altitude when the windshield bulged down from the top of the canopy bow and instantly crazed. TAC replaced 50 F–111 windshields in 1969; 93, the following year. However, this did not solve the bird-strike problem, shared by all F–111s and older high-speed aircraft. By September 1971, 52 F–111s suffered damage from bird strikes—2 F–111s being lost.[39] This reaffirmed the urgent need for a stronger windshield. TAC wanted one that could withstand the impact of a 4-lb bird at 500-knot airspeed, but exorbitant costs killed this proposal. In mid-1973, development of an improved, reasonably priced windshield still showed scant progress.[40] Meantime, the Air Force tested a Navy helmet that promised some windblast protection because of its polycarbonate faceplate—possibly more than the current Air Force acrylic faceplate. Individual helmet liners (foamed-fitted to the pilot's head) were obtained. They helped considerably in preventing crews from losing their helmets when their windshield broke. The Air Force also continued evaluating strobe lights to reduce bird strikes. Fifty F–111s took part in the program.

End of Production **28 May 1971**

With delivery of two last F–111Es.

Total F–111Es Accepted

94

Acceptance Rates

The Air Force accepted 31 F–111Es during FY 70 (August through December 1969; none during the ensuing 6 months). Deliveries resumed in July 1970, with 63 F–111Es accepted during FY 71.

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[38] F–111 pilots could not determine approaching stalls by feel, mistaking rudder pedal's vibrations for airframe buffet. Sacramento Air Materiel Area would make the stall warning engineering change. (SMAMA handled all needed modifications and the Phase II structural in-house inspection of all F–111s programmed by the Air Force in August 1971).

[39] The two aircraft remained airworthy prior to crashing. Unprotected from the wind, the crews could not see, communicate, or control the planes. Such losses, in 125,000 flying hours, augured ill of the future, unless something was done about it.

[40] It would likely be the following year before a contract was let, and testing would certainly consume another year or so.

Flyaway Cost Per Production Aircraft[41]

$9.2 million—airframe, $4,756,000; engines (installed), $1,511,000; electronics, $1,945,000; ordnance, $7,000; armament, $1,060,000.

Subsequent Model Series

F–111F, but the delayed F–111D and the FB–111A became operational after the F–111E and before the F–111F.[42]

Other Configurations

None

Operational Status **Mid-1973**

Most of the F–111Es in the USAFE area were combat ready. Nonetheless, like the F–111As, the aircraft had not yet realized their full potential.[43]

Other Uses **1973**

USAF testing of new aircraft was always extensive. Still, the F–111's radical departure from standardized configurations generated a program far more involved than usual. Spin-testing, one of its most crucial aspects, dated back to 1964, but a related accident 8 years later spurred another series of tests.[44] Aided by General Dynamics, the Air Force would test an F–111E for 4 months. Centering on the F–111's stall inhibitor and landing warning systems, the tests ended in May 1973—their results not to be known for several more months.

FB–111A

Weapon System 129A

Previous Model Series

F–111E—only in terms of operational availability.[45]

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[41] Plus $2.826,500 of RDT&E cost and $24,771 worth of modification per aircraft, bringing actual F–111E unit cost to $12,130,271.

[42] This out-of-sequence was not rare. Technical problems often delayed a model's production in favor of a later model in the series.

[43] Landing gear problems and cracked struts still hampered F–111A and F–111E operations. A titanium nose wheel developed for the F–111A was yet to be tested; improved aluminum alloy strut pistons would not be available for another year or so.

[44] NASA started spin-testing of an RDT&E F–111A in late 1964, the first contractor stall and spin test occurring 1 year later. Unsuccessful attempts to use a B–52 drag parachute (or one similar to it) slowed the program until mid-1969, when marked progress began. Yet, a 10-month Category II stall and spin prevention program, begun by the Air Force Flight Test Center in August 1972, was marred in September when an F–111A pilot lost control of his aircraft at 35,000 feet. Deployment of the recovery parachute at 20,000 feet did not help because of the aircraft's 220-knot airspeed. The parachute failed and separated from the plane, the crew ejecting safely at 11,500 feet.

[45] An FB–111A prototype actually flew almost a year before the decision to develop a simplified F–111E.

New Features

Longer fuselage (75′6″, against the F–111A's 73′5″), extended wing span of 70 feet (a 7-foot increase), stronger undercarriage and landing gear, extra and bigger fuel tanks, and P–7 engines.[46] The FB–111A also featured the Mark IIB avionic subsystem. This subsystem comprised an improved F–111A attack radar, an inertial navigation system, digital computers, and some advanced displays of the later Mark II that equipped the delayed F–111D. The Mark IIB controlled the new AGM–69A short-range attack missile (SRAM).

Basic Development **1963–1965**

The slow progress in the Advanced Manned Strategic Aircraft (AMSA) program and fear of earlier-than-expected B–52 failures spurred the Air Force to search for an interim bomber.[47] It began considering the F–111A for this role in the spring of 1963—General Dynamics suggesting two strategic versions in November. A series of wind tunnel tests ensued, funded separately from the F–111A development. To hasten availability, on 2 June 1965 the Air Force after much debate settled for the least-modified version of the F–111A. This would be the FB–111A interim strategic bomber. The Air Force also settled for only 263 FB–111As (210 to equip 14 squadrons, each with 15 aircraft; 20,[48] for combat crew training; the others, for support and testing), but wanted them quickly, the first to become operational during fiscal year 1969.[49]

Go-Ahead Decision **1965–1966**

Secretary McNamara publicly announced plans to develop the FB–111A on 10 December 1965[50]—6 months after endorsing the Air Force proposal to replace at the earliest possible date 345 B–

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[46] The P–7 was a new version of the Pratt & Whitney TF–30 turbofan engine. It had a maximum thrust of 20,350 pounds with afterburner—1,800 pounds more than the P–3 engine of the F–111A and F–111E, but only 100 pounds more than the Navy F–111B's P–12.

[47] Another option was to resume B–58 production (which had ended late in 1962) and to procure 250 of these costly supersonic bombers.

[48] Reduced to 15 in 1969.

[49] The Air Force would have liked more and larger FB–111As, but could spare neither the time nor the money. The latter was a perennial problem of the Air Force's chief goal—the AMSA program.

[50] Early in the year, the OSD had completed a study of the comparative costs and performance of the proposed FB–111A, B–52, and B–58 strategic bombers; also, of the cost effectiveness of a force of some 200 FB–111As.

52s (C through F models) with minimum-modified F–111As.[51] The Secretary, however, did not authorize immediate implementation of the new program. This was postponed until February 1966, when the FB–111A was added to the basic F–111A RDT&E contract of May 1964 and after Congress had approved on 26 January an Air Force reprogramming request for $26 million of development funds.

Additional Requirements **1965-1966**

Development of a minimum-modified F–111A bomber was short lived. In November 1965 (3 months before the 7 February 1966 amendment to the development contract of May 1964) Secretary McNamara decided to delay the FB–111A program 6 months to equip the aircraft with more advanced avionics than originally planned.[52] The Secretary asked the Air Force in January 1966 to begin contract definition on Mark II avionics systems for both the FB–111A and the delayed F–111D—maximum commonality of the two systems being a key requirement. As also requested, the Air Force on 10 February directed the integration of the planned AGM–69A SRAM missile with the FB–111A's Mark II version (Mark IIB).[53]

First Critical Design Review (CDR) **November 1966**

Basic configuration changes (geared toward extra range) were approved in the review at General Dynamics' Fort Worth plant. However, the Air Force asked for and OSD granted extra funding to take care of several other vital SAC needs. Added were weapons bay tanks, turbine starter, horizontal situation display (HSD) and lunar white cockpit lighting. The last two would first enter the 53d

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[51] Reminiscent of Congress' misgivings in November 1962 (when General Dyanmics, rather than Boeing, was handed the F–111A contract), two factors fueled another round of Congressional concern. One was replacement of the oldest B–52s by a lesser number of unproven FB–111As; the other, Secretary McNamara's surprise announcement of late 1965 to retire (by 30 June 1971) all 80 of the B–58s—SAC's only supersonic bomber.

[52] Even though the B–52 retirement schedule would be adjusted, the Strategic Air Command strongly objected to Secretary McNamara's decision. The FB–111A's whole purpose had been to provide an interim bomber quickly, hence with least possible modification. SAC also argued (to no avail) that, when available, more advanced avionics could be retrofitted in earlier FB–111A productions.

[53] The Air Force on 23 June 1966 awarded the Mark II contract to the Autonetics Division of the North American Rockwell Corporation, which became another of General Dynamics' many F–111 subcontractors. In October the Boeing Company was selected as production contractor for the AGM–69A SRAM missile, planned solely for the future AMSA. Adapting the SRAM development program to the FB–111A schedule would now raise missile development costs to an estimated $170 million. Preparing retained B–52s for eventual use of the SRAM (also announced by Secretary McNamara) would further run up costs and jeopardize the future AMSA.

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FB–111A production line—the initial aircraft of the second operational wing.[54]

Initial Problems **1966–1967**

One of the major problems of the future FB–111A, also covered in the November 1966 CDR, centered around the aircraft propulsion. The TF–30–P–3 engines[55] of the tactical F–111As (and subsequent F–111Es) had incurable shortcomings and not enough thrust for the heavier FB–111A. The Navy F–111B's new P–12 engine appeared more promising, but it was just being released in November 1966 and would take a while to obtain. Still, by mid-1967, the Air Force had selected the P–12. It would be configured with semi-actuator ejector (SAE) nozzles and be known as the P–5.[56]

First Flight (Prototype) **31 July 1967**

A modified RDT&E F–111 (No. 18, still equipped with TF–30–P–1 engines and the tactical F–111A landing gear) served as FB–111A prototype. The aircraft flew for 45 minutes on its maiden flight and achieved Mach 2. Accepted at once by the Air Force, it was left with General Dynamics for further testing.[57]

Other Development Problems **1967–1968**

Development of the costly and technically risky SAE nozzles was given up in late 1967. Instead, the Variable Ejector (VE floating tail feathers) with blow-in doors would accompany still another version of the basic TF–30 engine, the P–7.[58] Pending availability of the P–7, FB–111As would receive P–12A engines (USAF version of the Navy P–12, first flown in an FB–111A in October 1968) and these engines would be subsequently brought up to the P–7 configuration.[59] SAC noted, however, that despite the approved airframe changes, the FB–111A's shortened range (inherent in conversions from tactical to strategic aircraft) would not be helped. Moreover, an early 1968 decision to give the aircraft a built-in Triple Plow II air diverter (to prevent engine stall) would curtail

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[54] Retrofit of earlier FB–111A productions was not planned, but SAC intended to request a retrofit modification later.

[55] Improved P–1s, unavailable until 1967.

[56] Development of the P–12/P–5 engine hinged upon the US Navy effort. Pratt and Whitney, however, lacked a firm production go-ahead—reduction, if not elimination of the Navy F–111B, being already under consideration.

[57] Category I testing, a prime contractor's responsibility, started on 19 July 1967 and lasted through November 1971.

[58] The P–5 with a variable flap ejector nozzle and the P–12, with a fixed shroud and blow-in-door ejector nozzle, were development milestones for the FB–111A's P–7 and the delayed F–111D's P–9 engines.

[59] The programmed modification of 43 P–12A engines began in December 1969, 4 months before completion of the P–7 production.

its range even more.[60] Other unavoidable changes (including redesign of the aft fuselage) would also limit the FB–111A's maximum speed to around Mach 2. The most vexing problem, however, was that the Mark IIB avionic program, which during the first half of 1967 appeared to be on schedule, was beginning to slip.

First Flight (Production Aircraft) **13 July 1968**

The Air Force accepted the aircraft on 30 August and a second FB–111A production on 25 October. Subsystem problems, mainly with the Mark IIB,[61] slowed further deliveries—the Air Force not accepting another FB–111A until 23 June 1969. This third FB–111A differed from the previous two in that it featured a fully developed Triple Plow II air diverter, a complete Mark IIB avionics system, and the new P–7 engines.

Flight Testing

Increased sophistication of the FB–111A, as OSD-directed in November 1965, meant more testing. The Air Force, therefore, raised the number of aircraft for the formal testing program to 7[62]—the first 6 FB–111A productions included, to revert eventually to their original combat purpose. Ensuing FB–111A reductions did not shorten testing (for they had no bearing on the aircraft's configuration), but the shortage of aircraft hindered operational units in raising combat readiness. Category II tests[63] were still going on when Category III testing started (October 1971) and when it ended (31 July 1972).[64]

Program Changes **1968-1969**

A program of 263 planes was projected when the FB–111A development began. This dropped to 126 on 28 November 1968, because of problems with the basic F–111, production delays, and rising

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[60] Extension of ferry and combat range would chiefly rest on larger tanks (and air refueling).

[61] Autonetics delivered initial Mark II avionic units to General Dynamics on 21 November 1967. Flight testing, started on 31 March 1968 with a modified F–111A (No. 25), showed good results. Problems cropped up during the first full system test in June, when various components began to interfere with each other.

[62] Use of modified F–111As was confined to few special tests.

[63] Category II testing started on 4 September 1968 (14 months after the beginning of the Category I tests) in the desert at Edwards AFB. The third FB–111A production was also allocated to the Category II tests.

[64] The Category III tests were conducted at Pease AFB in New Hampshire. Immediate (if not unsurmountable) problems developed. Brakes failed to work in the cold as the brake fluid froze. Because of poor insulation, frozen valves prevented transfer of fuel from auxiliary to main tanks.

costs.[65] The second and final cut took place in March 1969, when the total FB–111A purchase dipped to 76.[66]

Enters Operational Service **8 October 1969**

This was the 7th FB–111A production and the Air Force's first new strategic bomber since 1 August 1960 (SAC had then accepted an initial B–58 in similar ceremonies, also held at Carswell AFB). This FB–111A[67] and the next 14 productions would go to a squadron of the 340th Bomb Group at Carswell, responsible for FB–111A combat crew training (CCT). Hence, even though the FB–111A was officially operational, it had yet to reach the combat forces.

Program Slippage **1969-1970**

Problems with the FB–111A's wing longerons and terrain-following radar slowed production. The 4007th CCT Squadron of the 340th Bomb Group was still short 7 aircraft when the Air Force stopped all General Dynamics deliveries in late 1969. Caught up in the mandatory Recovery Program, the few FB–111As already flying were returned to General Dynamics. In April 1970, the first of the CCT FB–111As left Carswell to undergo a 75-day test and structural inspection, receive necessary modifications, and somehow be ready for reassignment to the 4007th in July.[68]

Other Testing **1970-1971**

The Air Force-directed Recovery Program interfered little with the FB–111A testing of the SRAM, begun on 27 March 1970.[69]

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[65] The reduction followed cancellation of the F–111K (once, practically sold to Great Britain) and the end of the Navy F–111B. Money, however, was the main factor. The cost of 263 FB–111As was estimated at $1.7 billion in 1966. In mid-1969, this amount was pared to $982.6 million—an approximate reduction of $700.00 million. More spectacular was the decrease in aircraft, sinking from 263 to 76 FB–111As, while unit costs soared from $6.45 million to $12.93 million.

[66] The May 1967 production contract for the 493 F–111s, ordered by Secretary McNamara, included 64 of the projected 263 FB–111As. In addition, 48 of the 50 cancelled F–111Ks on this contract were redesignated as FB–111As. During the closing weeks of the Johnson Administration, Deputy Secretary of Defense Paul Nitze announced further amendment of the May 1967 contract to add 14 FB–111As (for a total of 126 aircraft). This was a more than 50 percent reduction, since Nitze indicated no other F–111 strategic bombers would be built. Melvin R. Laird, President Nixon's first Defense Secretary, made the last cut. Some of the money saved would speedup development of the AMSA (redesignated B–1 in April 1969).

[67] Bearing serial number 677193A, it had been actually assigned to the 340th Bomb Group on 25 September.

[68] The last FB–111A production emerged from the Recovery cold-proof tests on 20 January 1971.

[69] Separation of a dummy air-to-surface SRAM missile from an FB–111A (at Mach 0.9 and 25,000 feet altitude) had first occurred on 19 October 1968 at Eglin AFB. First launch of an operational SRAM from an FB–111A occurred in 1974.

Nevertheless, these tests started poorly. In almost 1 year, there were only seven successes out of the 11 launches conducted at the White Sands Missile Range in New Mexico. But the trend shifted in early 1971. The 15 successes out of 19 launches during the entire FB–111A/SRAM test series seemed well worth the $140 million spent in mating the two.[70]

Initial Operational Capability **January 1971**

Four months after the Carswell CCT Squadron received the last of its 15 FB–111As[71]—a final slippage due to the F–111 crash of December 1969 and resulting Recovery Program. Meanwhile, on 16 December 1970, the 509th Bomb Wing at Pease AFB got its first FB–111A. The 509th, after many difficulties,[72] was fully combat ready in October 1971. The 380th Strategic Aerospace Wing (the second of SAC's only two wings of FB–111As) at Plattsburg AFB, N. Y., became combat ready the following year.

End of Production **1 June 1971**

With the Air Force acceptance of the last FB–111A. This aircraft (Serial No. 68–291) was delivered to SAC on 30 June.

Total FB–111As Accepted

76, consisting of 75 productions (the 76th crashed before delivery), plus 1 prototype (an F–111A, modified and charged to the FB–111A program).[73]

Acceptance Rates

The FB–111A prototype (modified F–111A) was accepted in FY 68.

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[70] Development and production costs of the SRAM started as a low-risk effort with a 1965 bottom estimate of $167.7 million. Nevertheless, in 1971, it was expected to peak at $1.76 billion—$440.6 million for RDT&E and $1.32 billion for production through FY 1975 (as called for by other aircraft's prospective use of the missile).

[71] One year after reaching IOC, the 4007th CCTS (its major training effort completed) relocated from Carswell to Plattsburgh and became part of the 380th Strategic Aerospace Wing. Retaining its original designation, the squadron's strength and number of assigned aircraft declined.

[72] Bad weather (an important factor at both Pease and Plattsburgh during the winter) and supply shortages (resulting in high NORS hours and excessive NORM and cannibalization rates) were two of the culprits. Although the FB–111A's supply and maintenance shortcomings were not unusual for a relatively new weapon system, they were magnified by the concurrent shortage of aircraft. The training program at Pease was hampered by the nonavailability of FB–111As and training sorties. The Category III tests, primarily conducted with men and equipment of the 509th Bomb Wing, received a lower priority as the wing strove for full combat ready status. The Category III testing program, renamed as the operational test and evaluation (OT&E) program on 15 April 1972, finally ended on 31 July with generally satisfactory results.

[73] One of the 75 FB–111A productions crashed on 7 October 1970 and another on 8 January 1971. (Both aircraft had been stationed at Carswell.)

The Air Force accepted the FB–111A productions as follows: three in FY 69 (two in the fall of 1968 and one in June 1969); 6 in FY 70 (between July and December 1969, when all F–111s were grounded); and 66 in FY 71 (between August 1970, when the grounding was lifted, and June 1971).

Flyaway Cost Per Production Aircraft[74]

$9.8 million—airframe, $4,201,000; engines (installed), $1,735,000; electronics, $2,550,000; armament, $1,342,000.

Average Cost Per Flying Hour

$1,479.00

Subsequent Model Series

F–111D—a delayed tactical model of the Air Force's F–111s.

Other Configurations

None

Operational Problems **1971-1973**

Landing gear malfunctions of the FB–111A and other F–111s, persisting through mid-1971, were finally solved by a simple field modification. This did not mean the end of problems, however. As demonstrated by a no-notice Operational Readiness Inspection (ORI) in late 1971, weapons delivery was still marginal, reflecting materiel failures in the Inertial Navigation System of the aircraft's Mark IIB avionics. In mid-1972, with the worst logistics shortages about over, new problems appeared. The most serious was engine flameout following use of the afterburner—probably caused by moisture in the engine sensing line.

Postproduction Modifications **1972-1973**

While taking care of the FB–111A's latest operational malfunctions, the Air Force tried to enhance the aircraft's combat effectiveness. In April 1972 the Sacramento Air Materiel Area began to install new SRAM-carrying equipment on the FB–111A and to replace the pyrotechnique devices used for ejecting the crew-escape module. After being completed on 22 aircraft, the replacement of devices was temporarily suspended, because the original devices lasted longer than first estimated. The SRAM modification, however, were uninterrupted, the last FB–111A being so modified in March 1973. The FB–111A during the same period entered a new SMAMA modification program—LASPAC (Landing Gear, Avionics, Systems Package). LASPAC encompassed the main landing gear retractor actuator, avionics equipment, inspection for cracks, and the reinforcement of wing tips. Seventeen

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[74] Excluding $2,043,000 of RDT&E costs and $628,811 worth of modication per bomber. In mid-1973 the actual cost of each FB–111A was set at $12.5 million—$400,000 less than anticipated in late 1969.

aircraft had undergone LASPAC by June 1973. At that time, 46 other FB–111As were scheduled for new pyrotechnique devices, along with their LASPAC modification.

Modernization **1972–1973**

Modifications notwithstanding, the FB–111A still needed modernization. As SAC pointed out in early 1971, the aircraft's threat warning system, like the B–52's, was growing obsolete. An F–111 at Eglin had now begun to flight-test an improved threat warning radar, but a lot remained to be done. Modernization of the FB–111A's entire ECM subsystem (as recommended by the OSD and formalized in early 1973) was another must, one component (the QRC–536 transmitter) also being flight-tested at Eglin. If workable, it would jam over a wider frequency range. Replacement of the ECM subsystem's AAR–34 infrared receiver did not fare so well. SAC liked none of the new infrared receiver designs.

Operational Status **Mid-1973**

SAC's FB–111A squadrons possessed most of their authorized aircraft, but they were not all combat ready. The FB–111As, shared by two wings, were still located at Pease and Plattsburgh, where KC–135s were also stationed.

Milestones **1970–1971**

In November 1970 the FB–111A took top honors in bombing and navigation during SAC's combat competition at McCoy AFB, Fla. In April 1971 two Pease FB–111As entered a Royal Air Force-sponsored bombing and navigation meet at Marham RAF station. This marked the aircraft's first oversea deployment.

F-111D

Previous Model Series

FB–111A, for operational availability, but the F–111D's true predecessor was the F–111E.

New Features

Mark II avionics system,[75] environmental control system, and P–9 engines.[76]

Go-Ahead Decision **January 1966**

The decision was made when Secretary McNamara directed the Air Force to begin contract definition on Mark II avionics systems for both the strategic (FB–111A) and tactical F–111s. Insofar as the F–111A was concerned, the Secretary's decision met the Air Force Advanced Development Objective (No. 53) of March 1964.

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[75] Sometimes referred to as the Mark IIA avionics subsystem.

[76] The Pratt and Whitney TF30–P–9 turbofan engine had a maximum thrust of 20,840 pounds with afterburner—only 500 more pounds than the P–7 of the strategic FB–111A, but 2,340 pounds more than the tactical F–111E's P–3.

This ADO reflected a November 1963 recommendation of the Air Force Scientific Advisory Board. It called for an improved avionics system (Mark II) to control in any weather the release of various air-to-air missiles against high- and low-altitude targets.

Official Designation **March 1967**

The future Mark II-equipped F–111A was designated F–111D—1 year before endorsement of the earlier F–111E.

Program Approval **May 1967**

The "D" got under way on 10 May, when the definitive contract (for a total of 493 F–111s) replaced the basic production LC of April 1965. A concurrent System Management Directive (SMD) specified the Mark II avionics system for 132 F–111s,[77] starting with the 236th production.[78]

Additional Requirements **26 May 1967**

Another USAF SMD gave the Mark II-equipped F–111D the radar-controlled AIM–7G–1 (Sparrow) air-to-air missile. This would be over and above an improved, infrared, heat-seeking, air-to-air missile,[79] similar to that of the F–111A (and, as it turned out, the F–111E). The request for adaptation of the new (and later cancelled) Raytheon-developed YAIM–7G Sparrow to the Mark II's fire-control radar came after the 23 June 1966 Mark II contract award to Autonetics, a division of the North American Rockwell Corporation.

Engine Change **1968**

The May 1967 acquisition program of necessity gave the future Mark II-equipped F–111A airframe (F–111D) the P–3 engines of the basic aircraft. Concurrent (and quickly successful) efforts to devise a more reliable and higher-thrust engine for the FB–111A interim bomber changed this planning. The Air Force decided in mid-1968 that the future F–111D would be equipped with the P–9, still another version of the Pratt and Whitney TF–30 turbofan. The new engine (first flight-tested with an F–111A on 10 July 1968) entered production in early 1969. The P–9 featured the small afterburner of the P–1 and P–3 engines for greater thrust,[80] the

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[77] A June 1966 advanced contract change notified General Dynamics of this requirement.

[78] The F–111B, C, K, and FB–111A aircraft were counted in the 493 productions under contract, but not in the USAF tactical production sequence.

[79] The Hughes AIM–4D (Falcon) and the Philco-Raytheon AIM–9D (Navy Sidewinder), were considered, but dropped in favor of the familiar Philco-General Electric AIM–9B (Sidewinder IA) of the F–111A, F–111E, and many other USAF fighters.

[80] The P–9's thrust surpassed the P–3's by over 10 percent—significant, but well below the engine thrust the Air Force would have liked for the F–111D.

nozzle of the FB–111A's P–7 for more efficient thrust control, and the fan and low-pressure compressor of the Navy F–111B's P–12 for operating at higher engine temperatures.

Program Reduction **Mid-1969**

Cost increases in the Mark II system[81] and a stringent budget pared the F–111D program to one wing. The Air Force disclosed on 12 September that, as agreed upon in July by the Senate Armed Services Committee and the Air Force Chief of Staff, it was ordering Autonetics to limit Mark II production to the level called for by 96 aircraft.[82] The balance of F–111Ds under procurement would receive a cheaper avionics package and be known as F–111Fs.

Other Changes **1969-1970**

The Air Force decided in December 1969 to put FB–111A tires on the F–111D's main and nose landing gears. F–111D main landing gear's axles, axle pins, stabilizer rods, as well as attachment pins and nuts, would also be replaced with FB–111A hardware.[83] This would allow the new aircraft to carry more fuel and a heavier weapon load. A less attractive decision in March 1970 cancelled development of the Raytheon AIM–7G Sparrow—leaving the future F–111D armed like other tactical F–111s with 6 air-to-air AIM–9B Sidewinders (at least for the time being) and one 20-mm M–61A1 Gatling gun (mounted on the right inside of the weapon bay).[84]

First Flight (Production Aircraft) **15 May 1970**

By the first F–111D production (Serial Number 68–085), 6 months after USAF preliminary evaluation of the aircraft's avionics system.[85] The first F–111D (equipped with the new P–9 engine, but without a complete Mark II system) was accepted by the Air Force

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[81] In early 1968 the Mark II was expected to add $1.5 million to the cost of each F–111D—an off-the-cuff estimate quickly revised to $2.2 million. By mid-1972 actual RDT&E costs of each F–111D already ran over $4 million.

[82] The 96 F–111Ds would equip the 27th TFW's four squadrons (522d, 523d, and 524th TFS, along with the 4429th Combat Crew Training Squadron) with 18 aircraft each, leaving 24 F–111Ds for testing, replacement, and support.

[83] F–111Ds already off the production line (but not released for lack of Mark II avionic systems) would be retrofitted, as would all F–111A and F–111E aircraft. F–111F would also benefit from the Air Force decision—the engineering changes being introduced into the first F–111F production.

[84] Externally, all F–111s could carry 40 different stores (33 conventional weapons, 3 nuclear bombs, fuel tanks, and two types of electronic countermeasure pods—the QRC–160–8 and the QRC–335–4). These stores had to be selected for different loading configurations to carry out the F–111's level and dive-bombing missions.

[85] At the General Dynamics' Fort Worth plant, where Category I testing was underway.

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on 30 June. This followed by 1 day the lifting of the 6-month F–111 delivery hold-order, imposed after the F–111A crash of 22 December 1969.

Flight Testing **December 1968-on**

Primarily geared to test the aircraft's new avionics, the whole program slipped. The Category I tests set for October 1967 (an optimistic date to begin with) did not start until December 1968.[86] Development problems deferred Autonetics' delivery of a first and incomplete prototype of the Mark II system to June 1968. General Dynamics flew the prototype on an F–111A for the first time on 2 December—14 months late. Slippage of the Category II tests was worse—26 months. The Air Force further intended to use an F–111A to begin Category II testing. However, the mid-1968 decision to give the F–111D a new engine (and to incorporate in the airframe the Triple Plow II air diverter devised by General Dynamics for the forthcoming F–111E) changed this planning. The Air Force earmarked five early F–111D productions for testing—accepting the first on 30 June 1970. This aircraft had undergone most of the cold-proof, structural tests required by Recovery (the program instigated by the F–111A loss of December 1969). Yet, a few tasks remained to be done. Hence, the Category II tests, forecasted for July 1968, finally slipped to September 1970.

Program Slippage **1970–1973**

The Air Force accepted one F–111D in June 1970, none in the ensuing 12 months. The unavailability of Mark II avionics systems accounted for the delay.[87] Despite every effort, F–111D deliveries, when they resumed in July 1971, proceeded slowly. Only 24 of 96 F–111Ds were available in June 1972— 2 years past the time when the 27th Tactical Fighter Wing should have been operationally ready.[88] That goal was yet to be reached in mid-1973.

Avionics Problems **1966-on**

The revolutionary Mark II system, ordered in June 1966, counted 7

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[86] In September 1970 (almost 2 years later), additional Category I flight testing was authorized to evaluate the Mark II's Integrated Display Set (IDS) in a new production configuration.

[87] The F–111Ds were not exempted from the Recovery program (which increased General Dynamics workload), but were produced on a schedule independent of the Mark II's availability. By late 1970, General Dynamics had completed most of the F–111D airframes—the last 50 receiving the Recovery inspections during production. Lacking an avionics system, a first increment of 40 airframes was parked at the Fort Worth plant in mid-1970, awaiting the outcome of a new round of Mark II contractual and production arrangements.

[88] The 27th TFW, Cannon AFB, received F–111Es beginning in September 1969. These aircraft went to USAFE's 20th TFW 1 year later, but there were no F–111Ds to take their place at Cannon.

main components.[89] Not surprisingly, development difficulties arose, either with individual or juxtaposed components interferring with each other. Far more unexpected was the seriousness of several such problems. For instance, the Autonetics attack radar needed improvements in its initial design; Norden's Integrated Display Set required extensive changes. While the IDS changes were underway, the radar problems were solved, but not without redesign of the radar doppler unit. This was significant, for the redesigned IDS refused to work with the improved radar and Norden had to come up with even more changes. By late 1969 a complete Mark II avionics system was still not to be had, and the system's escalating cost[90] had reduced the F–111D program to 96 aircraft—against 315 once slated for production. In mid-1970 the integrated display set, plagued by problems from the start, remained the Mark II system's chief setback. Despite a normally binding fixed-price contract with Autonetics, Norden stopped production on 31 October,[91] assembling only 5 more IDSs for Air Force testing. Norden concurrently suggested an immediate year-long development program that would include qualification testing of integrated display sets based on more realistic specifications. The contractor also proposed production and delivery of 98 new, fully proven IDS units over 18 months, beginning in March 1972. Norden delivery of two new IDS prototypes to General Dynamics in December 1970[92] was immediately followed by thorough Air Force tests, which yielded much better results than expected. Lacking a more palatable solution, the Air Force in February 1971 promised Norden an extra $63.2 million (a lot less than asked) to

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[89] Inertial Navigation Set and Attack Radar, produced by North American Rockwell's Autonetics Division (General Dynamics' subcontractor for the complete Mark II system); Computer, International Business Machines' Federal Systems Division; Converter and Panels, Kearfott Division of Singer-General Precision, Inc.; Integrated Display Set, Norden Division of United Aircraft Corporation; Doppler Radar, Commercial Products Division of Canadian Marconi Company; Horizontal Situation Display, Astronautics Corporation of America; and Stores Management Set, Fairchild Hiller Corporation's Space and Electronics Division.

[90] Redesigns, engineering changes, additional requirements, and the like accounted for the cost overruns. But the economy-dictated F–111D reduction boomeranged—component costs swelled as mass production slumped.

[91] Norden officials claimed that the IDS's original specificatins were beyond the state-of-the-art, the error being shared by upper level subcontractors, the Air Force, and themselves. Norden costs as of late October 1970 reached almost $81 million; the company contract's current value, $47.4 million. Should Norden go on without contractual or legal relief, total losses would climb to some $128 million.

[92] The corporation reorganized its divisions between 19 August and 22 September. The Fort Worth Division became the Convair Aerospace Division.

complete the IDS program, using the revised specifications.[93] Still irked, the Air Force insisted that General Dynamics deliver the first fully Mark II-equipped F–111D in July 1971 and the last 96th in February 1973.[94]

Enters Operational Service **1 November 1971**

It saw first service with the 27th TFW at Cannon. The aircraft (the 6th F–111D produced), accepted by the Air Force on 28 October, had been first flown on 28 September. It was equipped with a full Mark II avionics system, featuring one of Norden's early IDS productions.

Initial Operational Capability **September 1972**

By one of the 27th wing's three tactical fighter squadrons—35 months later than hoped for.

End of Production **28 February 1973**

With delivery of the last F–111D.

Total F-111Ds Accepted

96

Acceptance Rates

The Air Force accepted one F–111D in FY 70, none the following fiscal year. Deliveries resumed in July 1971, totaling 28 in FY 72, and 67 in FY 73.

RDT&E F-111D Unit Cost[95]

$4.3 million, compared with some $2.8 million for each F–111A and F–111E aircraft and almost twice the RDT&E cost of each FB-111A bomber.

Flyaway Cost Per Production Aircraft[96]

$8.5 million—airframe, $3,895,000; engines (installed), $1,229,000; electronics, $2,530,000; ordnance, $6,000; armament, $844,000.

Subsequent Model Series

F–111F

Other Configurations

None. Sixty RF–111Ds programmed for procurement were can-

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[93] The Air Force formalized the Norden settlement on 19 March 1971.

[94] The Air Force did not like the way General Dynamics and its Convair Division handled the Norden fiasco. General Dynamics support of the delinquent contractor lacked any technical or legal analysis.The primary contractor (bent on stepping aside if any dispute arose during negotiation) suggested the Air Force endorse the Norden proposal.

[95] Excluded from the F–111D's flyaway cost.

[96] A post-FY 73 accounting revision showed a decrease of $87,800 in RDT&E for each F–111D. At the same time, it upped the overall price of every F–111D to $13.5 million—$188,807 below the unit cost once predicted.

celled in September 1969 in favor of cheaper RF–111As (which were in turn cancelled).

Operational Problems **1972–1973**

TAC's few F–111Ds through mid-1972 were crippled by avionics problems.[97] Foremost, was the lack of spares.[98] Also, delivery of field ground equipment was late and depot support poor, SMAMA being unable to handle more than 18 percent of the Mark II repairs. A specialized repair activity (SRA), setup at Cannon in late 1971, brought together the various Mark II contractors with their test equipment and spare parts. The small SRA cut down transit time to and from SMAMA, but achieved little more in 1 year of operation. Category II testing was then suspended,[99] releasing some ground equipment. This lowered the NORS rate, but inexperienced maintenance now prevented any improvement in operational readiness. Meanwhile, the continued shortage of F–111Ds caused concern. The Air Force approved Norden's production speedup of the integrated display set and head-up displays but questioned General Dynamics' slow F–111D deliveries.[100]

Operational Status **Mid-1973**

The 27th TFW increased its monthly average strength of F–111Ds from 30 to 79, but its percentage operationally-ready only went from 28.8 to 53. Maintenance and logistics support improved, but not enough—tight budgets getting in the way. Costly war readiness spares kits were scarce and several problems were yet to be resolved. A serious flaw in the environmental system ducting pushed the F–111D abort rate above that of other F–111s. Finally,

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[97] One of the most failure-prone of the Mark II line replaceable units was the horizontal situation display, with a field reliability life of 50 hours. Moreover, the core of the Mark II system was Norden's integrated display set (AN/AVA–9), which comprised the primary flight-control instrumentation. The AN/AVA–9 IDS included five line replaceable units—the vertical situation display, multisensor display, signal transfer unit, and two head-up display units. Norden, however, delivered the IDS with only one head-up display until mid-1972, when production finally caught up with requirements. This was after Norden instituted a two-shift, 6-day workweek in order to deliver all IDSs by February 1973—as called for by the contractual settlement of February 1971.

[98] Rarely could relief be gained from other stocks of F–111 spares. Commonality (with FB–111A avionics, in particular), a prime requirement of the Mark II systems envisioned by Secretary McNamara in 1966, had long disappeared. Technical problems, remedial cures and expedients had left the F–111D with a complex, highly integrated, one-of-a-kind, avionics system.

[99] After an interim report indicated the Mark II system could deliver weapons, as required.

[100] General Dynamics took some 30 days to install incoming avionics components (which was perhaps justifiable, considering the Mark II's sophistication), spending 50 workdays to prepare F–111D productions for final acceptance inspection. The Air Force thought the time could be cut.

the F–111D's landing gear still needed working on, as did several of the Mark II's components. It was improbable that the 27th TFW would be operationally ready before January 1974.

F-111F

Previous Model Series

F–111D

New Features

Avionics package (sometimes called the Mark IIF system) combining F–111D[101] and FB–111A navigation and digital computer systems, numerous other FB–111A components (such as the AN/APQ–144 attack radar), and some simpler, less costly avionics of earlier F–111s (the F–111E's stores management set included). The F–111F also featured an improved landing gear, a "Safe Life" wing carry-through box, and the Pratt and Whitney new TF–30–P–100 engine.

Go-Ahead Decision **12 September 1969**

When the Air Force disclosed that "increased cost estimates," forced it to limit Autonetics production of the Mark II electronics and that future F–111s would have "a simpler and less costly system."

Official Designation **September 1969**

A logical outgrowth of the F–111 model sequence. Procurement of stripped-down F–111Ds (already known as F–111Fs) was in the fiscal year 1970 budget that took effect on 1 July 1969. This was the first time the F–111F was formally identified by the Air Force.

Production Approval **19 June 1970**

Approval came several months after the aircraft's endorsement and for only 82 of 219 F–111Fs expected—58 to be purchased in FY 70 and 24 in FY 71. Even so, the fate of the F–111F was yet to be settled.[102]

Contractual Arrangements **1960-1971**

A definitized contract (AF33–657–70–C–1130A), signed by General Dynamics on 1 July 1970, called for 24 F–111Fs—to be paid from FY 71 funds. Like the basic May 1967 production contract (AF33–657–13403) under which the initial 58 F–111Fs would be carried,

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[101] Excluding the AN/APN–189 Doppler Radar Set of the F–111D's navigation system.

[102] The Air Force in mid-1960 wanted six F–111 tactical wings. This was cut to five in mid-1967 (one wing of F–111As, one of F–111Es, and three of F–111Ds). In 1969 the three F–111D wings dwindled to one, with the remaining two wings due to be equipped with cheaper F–111Fs. At year-end, another money-saving change slashed the F–111 tactical program to four wings.

this second contract was of the fixed-price, incentive-fee type. It had a target profit of 9 percent, a ceiling price of 127 percent of target cost, and an over-target sharing agreement of 80/20. Like the first contract, it also contained a clause for the correction of deficiencies. Furthermore, each of the contract's 24 F–111Fs would carry a 1-year warranty. The terms of the contract were agreed upon, but the contract's total value was not. The Air Force in the fall of 1970 eliminated penetration aids to lower F–111F costs, reducing the contract's ceiling value to $156 million. This was still too high. New price negotiations got under way in March 1971 and soon the Air Force dropped half of the 24 F–111Fs on order.[103]

Engine Problems **1971-1972**

Believing the thrust of the F–111D's P–9 engine did not do the aircraft justice,[104] the Air Force in September 1968 ordered development of the still more powerful P–100,[105] first earmarked for the 107th F–111D. It further decided in September 1969 (when the F–111D program was held to 96 aircraft) that the P–100 would equip subsequent stripped down F–111 productions (F–111Fs). The P–100, initially tested on an F–111A between January and March 1971, worked. Engine and airframe were compatible, which reduced the engine's Category I flight tests by almost 40 percent. Ground tests did not fare so well (the engine failing after 147 hours), but the three engineering changes required were not expected to affect the engine delivery schedule. On 18 June 1971, however, a turbine blade broke during a P–100 production engine's checkout at the Convair plant. This left no alternative but to equip early F–111Fs (due for delivery, beginning in September) with P–9 engines. The Air Force thought only 31 F–111Fs would be involved, but additional technical problems slipped delivery of the new P–100 engines[106] to the spring of 1972. By then, the Air Force had accepted 49 P–9-equipped F–111Fs. These were retrofitted with P–100 engines as soon as possible—Convair completing the task on 3 July 1972.

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[103] The contract's target and ceiling prices as of 30 June 1973 were 107.3 and 124.5 (Year Dollars in Millions), respectively. General Dyanmics estimate of 12 F–111Fs' price at completion was $102.2 million; the Air Force, $102.4.

[104] Although the P–9's thrust surpassed that of the P–3 of the F–111A and F–111E aircraft, it could not give the F–111D all the maneuverability the Air Force would have liked.

[105] Sixth in the Pratt & Whitney series of TF–30–P turbofan engines appearing at one time or the other on some kind of F–111 aircraft.

[106] The TF30–P–100 engine could generate a 25,100-lb thrust with afterburner—4,260 more pounds than the P–9. It boosted takeoff thrust by 40 percent. To reduce drag, it utilized an adjustable nozzle buried in the engine exhaust section.

Flight Testing **1971**

On 13 October 1971, a modified F–111A started the F–111F Category I flight test program conducted by the Convair Aerospace Division. As for the F–111D, testing focused on the aircraft's avionics, but airframe and engine compatibility were not overlooked. A problem met with during the program was overheating of the aft centerbody fuselage, corrected by an engineering change. By 17 December an F–111F had chalked up 15 flights. This ended a 2-week preliminary evaluation at the Air Force Flight Test Center.

Enters Operational Service **20 September 1971**

With the 347th Tactical Fighter Wing at Mountain Home AFB, Idaho.[107]

Additional Procurement **1971-1972**

The 12 F–111Fs, cancelled in March 1971 for lack of money, were reinstated under a new contract (AF33–657–70–C–1130B) signed on 7 December. A fourth production contract (AF33–657–72–C–0630), signed on 31 July 1972, assured the Air Force of another 12 F–111Fs, to be produced through 1974.[108]

Initial Operational Capability **January 1972**

One squadron of the 347th TFW reached IOC a few months after the F–111F entered operational service. The entire wing became operationally ready in October 1972—1 month ahead of the latest schedule.

Operational Problems **1972-1973**

Significant F–111F difficulties stemmed from the P–100 engine. Afterburner stalls, one of several problems believed to be solved, reoccurred with the onset of cold weather at Mountain Home. Modification of the culprit (a plastic diaphragm in the afterburner turn-on switch, operating poorly in low temperatures) was completed by 11 November 1972. Several other engine deficiencies (tail-feather seal leakage, inlet guide vane cracking, and the like) were also corrected before the end of the year. Meanwhile, the

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[107] At first the F–111Fs were tagged for the 31st TFW at Homestead AFB. However, the Chief of Staff on 3 December 1970 approved TAC's request to send the aircraft to the 347th.

[108] In addition to the special provisions of the previous ones, these contracts were also fixed-price incentive contracts with firm target prices (adjustable to inflation). As of 30 June 1973, the December 1971 contract showed a target price of $88.3 million, a ceiling price of $102.6 million, and a contractor estimated completion price of $92.6 million, against an Air Force estimate of $94.9 million. The cost figures tied to the July 1972 contract, which also called for only 12 F–111Fs, were much higher. The target price was $136.5 million; the ceiling price, $146.8. General Dynamics estimated price at completion was $136.3 million; the Air Force, $141.6.

inspection of two P-100 engines with 300 hours of flight time disclosed an accumulation of atmospheric dust in the engine's blade cavity. The dust harmed neither the engine's life nor its operation for 450 hours, but it caused other damage, particularly to the second turbine inner air seal. A new blade, with a drilled hole in its tip, let the dust escape, and by 30 June 1973 the P-100's operational life had risen to 600 hours.[109] Remaining problems and improvements awaited a forthcoming engine's update program.

End of Production — **December 1974**[110]

When the last of the F-111Fs on order as of mid-1973 was scheduled for delivery.

Total F-111Fs Accepted — **30 June 1973**

76 of 94 then programmed—a total finally raised to 106.[111]

Acceptance Rates

The Air Force accepted 70 F-111Fs in FY 72 (September 1971 through June 1972); none, during the first half of FY 73. Deliveries resumed in January 1973 at a monthly rate of one aircraft. This was low enough to keep production flowing for quite a while.

RDT&E Unit Cost[112]

$2.8 million

Flyaway Cost Per Production Aircraft[113]

$10.3 million—airframe, $5,097,000; engines (installed), $2,026,000; electronics, $1,711,000; ordnance, $6,000; armament, $1,529,000.

Subsequent Model Series

None

Other Configurations

None

Operational Status — **Mid-1973**

The wing at Mountain Home (with no immediate change of station in view) had fewer supply problems with its F-111Fs than the

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[109] One month later Pratt & Whitney indicated that the time between overhauls (always too short for hard-to-get new engines) could be extended to about 2,000 hours by cutting the P-100's maximum thrust to 23,000 pounds.

[110] This projection proved to be wrong. Eventually, production completion was set for late 1976.

[111] Congress' desire to keep the production line open outweighed Department of Defense reluctance to release more F-111 money.

[112] This amount (later reduced to $2.7 million) was not included in the F-111F's flyaway cost.

[113] A post-FY 73 cost increase of the F-111F airframe raised the aircraft unit price to $10.9 million. Added to the RDT&E costs, this gave the F-111F a price tag of $13.7 million. This still could vary, however, since production was not completed.

wing at Cannon with more complex F–111Ds. Moreover, the operational rate at Mountain Home exceeded that of the longer-established F–111A and F–111D wings. The F–111F, last in the F–111 program, was the sole F–111 model still under the Air Force Systems Command. With F–111D production over, management had shifted from AFSC to AFLC on 1 May 1973. This was routine procedure for all aircraft out of production.

PROGRAM RECAP

By mid-1973 the Air Force had accepted 533 of a future grand total of 563 F–111s. The 533 comprised 158 F–111As (18 of them RDT&E aircraft); 7 F–111Bs for the Navy (5 RDT&E and 2 productions); 24 F–111Cs (sold to Australia); 2 F–111Ks (salvaged from the cancelled British order); 94 F–111Es; 96 F–111Ds; 76 FB–111A medium-range strategic bombers (1 destroyed before delivery); and 76 F–111Fs (with 30 more to come).

TECHNICAL DATA

F-111A, F-111E, F-111D, and F-111F

Manufacturers	(Airframe)	General Dynamics Corporation, Convair Aerospace Division, Fort Worth, Tex.
	(Engine)	United Aircraft Corporation, Pratt and Whitney Aircraft Division, East Hartfort, Conn.
Nomenclature	(F-111A/E/D/F)	Tactical Fighters.
	(FB-111A)	Medium Range Strategic Bomber.
Popular Name		None

Technical and Operational Characteristics
(Best Demonstrated Performances)

Technical	*F-111A*	*F111E*	*F-111D*	*F-111F*
Length/Span (ft)	73.5/63.0	73.5/63.0	73.5/63.0	73.5/63.0
Folded Wing Span (ft)	32.0	32.0	32.0	32.0
Takeoff Weight (lb)	82,632	84,433	85,406	85,161
Engine, Number & Designation	2TF-30-P-3	2TF-30-P-3	2TF-30-P-9	2TF-30-P-100
Max Thrust (sea level static, lb)	18,500[114]	18,500[114]	19,600[114]	25,100[114]
Military Thrust (sea level static, lb)	10,750[114]	10,750[114]	12,000[114]	14,560[114]
Crew (side by side seating)	2	2	2	2
Armament	1M-61A1 Gatling gun	1M-61A1 Gatling gun	1M-61A1 Gatling gun	1M-61A1 Gatling gun
Ordnance[115]				

[114] Achievement of Contractual Guarantees.

[115] Nuclear and Non-Nuclear (6 AIM-9B missiles, special stores, bombs, rockets, and dispensers).

Operational	*F–111A*	*F–111E*	*F–111D*	*F–111F*
Combat Ceiling (ft)	57,900	53,300	55,150	58,500[116]
Basic Nuclear Mission Radius/ Dash (nm)	800/30	800/14	800/16	800/20
Ferry Range (nm)	2,750	2,585	2,500	2,597
Max. Speed (Mach)	2.2	2.4	2.4	2.4[116]
Sustained Speed at Altitude (Mach)	2.2[116]	2.2[116]	2.2[116]	2.2[116]
Sustained Speed at sea level (Mach)	1.2[116]	1.2[116]	1.2[116]	1.2[116]
Takeoff Distance (ft) Basic Nuclear	3,820	4,230	4,020	3,120[116]
Navigation Accuracy (nm/hr)	1.16	1.16	0.39	0.39
Landing Distance (ft) Over 50 ft Obstacle	2,275[116]	2,640	2,750[116]	2,720[116]

[116] Achievement of Contractual Guarantees.

TECHNICAL DATA

FB-111A

Technical and Operational Characteristics (Best Demonstrated Performances)

Technical	*FB-111A*
Length/Span (ft)	75.6/70.0
Folded Wing Span (ft)	34.0
Takeoff Weight (lb)	107,000
Engine, Number & Designation	2TF-30-P-7
Max Thrust (sea level static, lb)	20,250[117]
Military Thrust (sea level static, lb)	12,290[117]
Crew (side by side seating)	2
Armament	None
Ordnance[118] Maximum Tonnage	20.7

[117] Achievement of Contractual Guarantees.
[118] 50 M-117s; various nuclear and conventional.

Operational	*FB-111A*
Refueling Altitude (ft)	20,000[119]
Basic Nuclear Mission Total Range (nm)	5,669
Basic Nuclear Mission Low Level (nm)	1,236
Sustained Speed at Altitude (Mach)	2.2[119]
Sustained Speed at sea level (Mach)	1.1[119]
Takeoff Distance (ft) Over 50′ Obstacle	7,600

[119] Achievement of Contractual Guarantees

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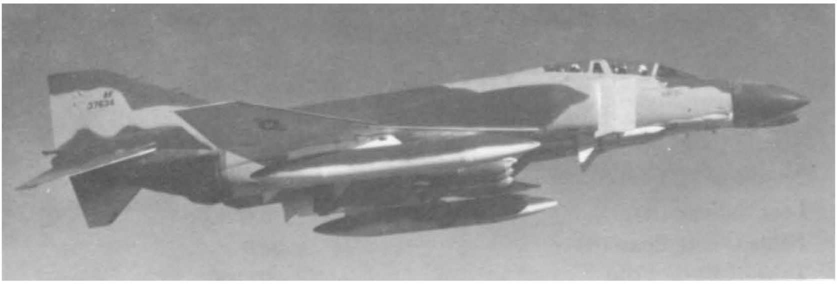

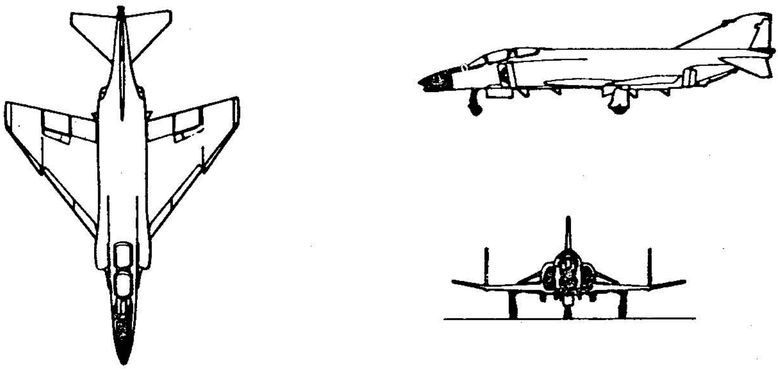

McDONNELL F-4 PHANTOM II

F-4C: The Air Force's two-seater, twin-engined F-4C tactical fighter was very similar to the F-4B, the Navy's first major production type.

RF-4C: Cameras and other reconnaissance gear were fitted in a longer nose—almost as long as the nose of later F-4Es.

F-4D: The F-4D was an improved F-4C. They both looked the same.

F-4E: The F-4E was the definitive Air Force Phantom II. In contrast to the F-4C and F-4D, the F-4E carried a nose-mounted Vulcan gun. All Phantoms had low, sweptback wings that could be folded for ease of storage.

McDONNELL F-4 PHANTOM II

Manufacturer's Model 98DE
Weapon System 327A
Navy Equivalent: F-4B

Basic Development **1953**

McDonnell Aircraft Corporation's[1] drawing of a single-seat twin-engined shipboard fighter attack aircraft for which a 1954 development contract was awarded by the US Navy with the designation AH-1. This aircraft was to emerge as the F4H-1 in 1955, after extensive redesign. In 1962, the F4H-1, powered with General Electric J79-GE-2A engines, was redesignated F-4A.[2] The next production—a two-seater, like the F-4A and later models in the series—received the more powerful J79-GE-8 engine. It became the carrier-based F-4B interceptor, with an additional interdiction capability.

Go-Ahead Decision **March 1962**

Formalized by the Office of the Secretary of Defense, after being publicly announced by Secretary McNamara on 17 January. The Air Force version of the Navy F-4B would include only changes dictated by the mission of the Tactical Air Command.

Letter Contract **March 1962**

The McDonnell F-4 contracts were issued by the Navy for the Air Force.[3] Fixed price incentive contracts (FPIs) followed the LC of March 1962. Air Force requirements were provided to the Navy by means of Military Interdepartmental Purchase Requests (MIPRs). The Air Force issued fixed-price redeterminable contracts of the A type (FPRAs), modified with incentive provisions, to General Electric for the (J79-GE-15) engines of the F-4Cs.

Mockup Inspection **April 1962**

Specific Operational Requirements **29 August 1962**

This was SOR 200, covering the entire tactical mission—close air support, interdiction, and counter air. F-4 configurations for Air Force use, first defined in November 1961, differed from the Navy's air superiority fighter (the F-4B). Fitted for boom air-to-air

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[1] Became McDonnell-Douglas Corporation on 28 April 1968.

[2] This was in line with the Department of Defense's standardization of aircraft designations on 3 August 1962. The directive was implemented by Joint Regulation on 18 September.

[3] On 22 February 1963 the OSD directed the Air Force to furnish F-4 supplies for both the Air Force and Navy versions. This was the first attempt to merge logistical support of the two services on a major weapon system. The Air Force assumed F-4 purchasing responsibility about 10 years later. This followed completion of Navy F-4 procurement and signing of a 1972 Memorandum of Understanding by the Navy on 24 July, the Air Force on 29 August.

refueling, the Air Force's F-4C (initially designated the F-110A) would carry Sparrow and Bullpup missiles, napalm, as well as conventional and nuclear bombs. If needed, an air cannon (mounted on centerline brackets) could be carried.

F-4C

First Flight (Production Aircraft) **27 May 1963**

The F-4C's first flight exceeded Mach 2. The Air Force accepted the aircraft immediately—65 days ahead of the production schedule. Back in February, the Air Force had received the first of 27 F-4Bs on loan from the Navy. These were used in a training program for instructor pilots and maintenance crews. As the number of F-4Cs grew the B models were returned to the Navy.

Flight Testing **1962**

Category I testing was the longest, extending from April 1962 to July 1964. Category II continued from September 1963 to December 1964. Category III lasted only during August-October 1964.

Enters Operational Service **20 November 1963**

At MacDill AFB, Fla., with the 4453d Combat Crew Training Wing. The 12th Tactical Fighter Wing (also at MacDill) received the first of its new aircraft in January 1964, was fully equipped in July, and operationally ready in October.

Revised Requirements **17 November 1964**

SOR 200 (issued 2 years before) was amended to substitute the AIM-4D Falcon infrared missile for the AIM-9B and -D Sidewinders of early F-4Cs.[4] A number of technical changes were also confirmed or spelled out. Some would affect F-4Cs yet to be produced; a few would be retrofitted in others. Actually, most changes were meant for the upcoming D model of the F-4.

Deployment to SEA **1965**

F-4Cs went to Southeast Asia in early 1965.[5] On 10 July two F-4C crews shot down their first two MIG-17 jet fighters over North Vietnam with Sidewinder missiles. By March 1966, 7 F-4C squadrons were in South Vietnam and 3 in Thailand—war tolls also rising. During 1965 and 1966 the Air Force lost 54 F-4Cs in SEA combat.

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[4] This change, however, did not reach the F-4C until mid-1968. In any case, F-4Cs (like subsequent models in the series) had a wide choice of weaponry: 4 AIM-7D or -7E Sparrow air-to-air missiles on fuselage; 4 AIM-9B or -9D Sidewinders (removed in mid-1968 but returned a few months later) or 4 AIM-4D Falcon air-to-air missiles on wing pylons; 4 AGM-12B, 2 AGM-12C (Bullpup), 4 AGM-45A (Shrike) or 2 Hill Genie guided air-to-ground rockets on wing stations, plus Navy-developed air-to-surface glide Walleyes (after 1971); also, special or conventional weapons on centerline and wing stations.

[5] One squadron rotated to the Far East in December 1964.

Initial Shortcomings **1965-1966**

The F-4Cs of the first units in SEA lacked the guns of a complete fighter system. Addition of SUU-16A gun pods with M-61A1 20-mm guns compensated for the lack of internal guns, but degraded aircraft performance. A number of F-4Cs had been modified and equipped with a radar homing and warning system.[6] However, retrofitting the aircraft for Wild Weasel duty ran into serious technical problems.[7] This delayed the planned mid-1966 deployment of at least 4 Wild Weasel F-4Cs to SEA.

Operational Problems **1965-1966**

Early F-4Cs sprung wing tank leaks that required resealing after each flight. Eighty-five F-4Cs had cracked ribs (and stringers) on outer wing panels.[8] Critical shortage of spares also arose. Early F-4C operations in SEA were sustained by collocation of units or by designation of hard-core support bases.

Subsequent Model Series

F-4D

Other Configurations

RF-4C—intended to replace the programmed RF-105, cancelled in early 1962.

End of Production **April 1966**

With delivery of the final two F-4Cs.

Total F-4Cs Accepted

583

Acceptance Rates

One F-4C was accepted in FY 63, 128 in FY 64, 280 in FY 65, and 174 in FY 66.

Flyaway Cost Per Production Aircraft[9]

$1.9 million—airframe, $1,388,725; engines (installed), $317,647; electronics, $52,287; armament, $139,706.

Average Cost Per Flying Hour

$924.00

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[6] The programmed modification (done on 476 of the variety of 2,676 tactical aircraft scheduled in 1966) provided the aircrews with visual and audio signals of enemy radars.

[7] The special electronics gear enabled RHAW-equipped, two-place fighters to act as killer pack leaders for air strikes on radar and surface-to-air missile (SAM) sites.

[8] New F-4s came with a heavy stringer and an additional rib. All F-4Cs in service were repaired by the Air Force.

[9] Excluding $116,289 in modification costs, accrued by mid-1973.

Average Maintenance Cost Per Flying Hour

$545.00

Postproduction Problems **1967-1968**

The Air Force lost six F–4s between June 1966 and December 1967, because of defects in cylinder barrels controlling the ailerons. By mid-1968, an inferior potting compound was discovered in various electric connections and relays of 385 early productions (mostly F–4Cs and RF–4Cs).[10] Despite all efforts, it took more than a year to solve either one of these two problems.

Modification Slippages **1968-1969**

The F–4C's Wild Weasel prototype installation did not begin until June 1968—2 years after the scheduled deployment of Wild Weasel F–4Cs to SEA. Modification of the Wild Weasel aircraft was completed in October 1969, the first of these being sent to the Pacific Air Forces.

Other Modifications **1969-1973**

Several F–4s were lost because of fire in the engine bay. This triggered a major reconfiguration of both engine and bay, that would be standard for all F–4s and RF–4Cs. The project lasted from January through October 1970, at which point the Air Force Logistics Command was directed to begin a new modification. The latter stemmed from F–4 accidents due to aircrew spatial disorientation. The new modification would put a standby, self-contained attitude indicator in the entire F–4 fleet. It would consume at least a year and require careful husbanding of available kits. In addition, F–4Cs would benefit from Rivet Haste,[11] a 1972 improvement program centering on later models of the F–4. Finally, beginning in 1974, the F–4C—like the other F–4s—would undergo structural modifications to stretch its service life.

Operational Status **Mid-1973**

Of 583 F–4Cs produced, only 291 remained.[12] Six squadrons were overseas (4 with USAFE, 2 with PACAF). TAC used 100 other F–4Cs for training. Ten had been transferred to the Air National

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[10] This compound deteriorated with age, was affected by high temperature and humidity, and eventually reverted to a liquid that leaked out. The aircraft's use in SEA magnified the trouble because the climate speeded the reversion to liquid.

[11] One Rivet Haste goal was to enable all F–4s to fire improved AIM–9 Sidewinders.

[12] Many F–4Cs in SEA were replaced by more efficient F–4Ds after mid-1967. Nevertheless, F–4Cs did bear a heavy share of the war. They flew night harassment missions, day strikes, and for a while were the Air Force's best in air-to-air clashes with the MIGs.

Guard in FY 72. Also, F–4Cs would soon equip the 57th Fighter Interceptor Squadron at Keflavik, Iceland.[13]

Milestones **2 December 1964**

Four F–4Cs set a new unofficial endurance record for jet fighter aircraft. They touched down at MacDill AFB after an 18-hour flight of nearly 10,000 miles, during which they were refueled by KC–135 jet tankers.

RF-4C

Manufacturer's Model 98DF
Weapon System 326A
Navy Equivalent: RF-4B

New Features

Longer nose section to house cameras and other reconnaissance gear: optical, infrared, and electronic sensors; forward-looking radar for ground-mapping and low-level penetration; side-looking radar; and high frequency equipment in lieu of the shorter-ranged UHF.

Specific Operational Requirements **29 May 1962**

This was SOR 196, calling for the RF–4C, an all-weather reconnaissance version of the F–4C (then known as the F–110A). Like the F–4C, this aircraft would be fitted for dropping nuclear weapons visually. However, it would chiefly fly reconnaissance in support of both tactical air and ground forces.[14]

Contractual Arrangements **1962-1970**

Procurement was begun in May 1962 by a Navy LC covering 6 F–4Bs—a time-saving expedient due to the lack of F–4Cs. The Navy planes would be given the reconnaissance configuration by McDonnell and be used by the Air Force for development and evaluation. Ensuing RF–4C contract followed the F–4C procurement pattern, being issued by the Navy as called for by USAF MIPRs. The Air Force personally handled fixed price redeterminable contracts with General Electric (the engine contractor) and fixed price contracts with Texas Instruments for the RF–4C's side-looking radar.

Mockup Inspection **29 October 1962**

The Mockup Review Panel requested nearly 150 configuration changes. Most of them would ease servicing and maintenance of the aircraft's components—for example, better access to cameras

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[13] The previously selected F–4Es needed leading edge slat modifications.

[14] SOR 196 was amended in July 1962 to delete a component (the QRC–189) of the RF–4Cs electronic intelligence (ELINT) pod. Fifteen of these pods were programmed for the future RF–4Cs of TAC, PACAF, and USAFE.

and to infrared and side-looking radar sensors. The Air Force also endorsed a less sophisticated forward-looking radar.

First Flight (RDT&E Aircraft) **8 August 1963**

The flight occurred 23 days ahead of the McDonnell reconfiguration schedule. The Air Force took delivery of the aircraft in the same month. A second reconfigured Navy F–4B (featuring high and low panoramic and frame cameras) began flying on 30 September; a third (equipped with forward-looking radar, inertial navigation, and radar altimeter), on 18 November.

First Flight (Production Aircraft) **18 May 1964**

Almost 1 month sooner than expected. The aircraft differed from the reconfigured Navy planes. It featured the changes introduced in the tactical F–4C, basic reconnaissance modifications, and almost all needed components. It nevertheless lacked fully qualified sensors and equipment.[15]

Flight Testing **1963–1966**

None of the aircraft used in the first Category I tests (February 1963-August 1966) had a complete sensor package. Moreover, 17 RF–4C components were yet to be qualified by the end of 1963. The Category II tests (October 1964-December 1965) slipped due to late instrumentation of the test aircraft. Category III testing (October-December 1965) also lagged because the planes still carried only partially qualified equipment.

Enters Operational Service **24 September 1964**

The RF–4C entered operational service at Shaw AFB with TAC's combat training group. True operational capability, however, took until August 1965, when TAC's 16th Tactical Reconnaissance Squadron (TRS) became combat ready. Even then, early RF–4Cs continued to lack components and to carry unqualified equipment.

Oversea Deployments **1965**

Deficiencies notwithstanding,[16] a nine-plane force first deployed to SEA on 31 October 1965. Hurried deployment of 11 more RF–4Cs

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[15] The October 1962 Cuban crisis and early SEA operations had disclosed serious reconnaissance deficiencies. This led the Air Force to re-evaluate the entire reconnaissance process. Redefining of RF–4C requirements and publishing a Systems Package program (19 December 1963) resulted in configuration changes and the usual cost hikes. In the meantime, the need for special sensors (to transmit air-ground data) had not been overlooked, but their steep price stood in the way.

[16] These comprised sensors that did not meet specifications, shortages of tools and spare parts, and too few skilled maintenance men. On the positive side, the RF–4Cs already featured infrared sensors; Tan Son Nhut AB could eke out support; and all command levels were aware of these problems.

to Tan Son Nhut AB followed on 28 December.[17] Additional RF-4Cs arrived in July 1966, and by October 1967 four squadrons were formed. One of these replaced an inactivated RF-101 unit at Udorn AB.[18]

Inherent Shortcomings **1966-1968**

The RF-4C's infrared sensor (AN/AAS-18), later replaced by the AN/AAS-18A, had to be improved. The KS-72 cameras of the RF-4Cs needed lighting to record ground objects at night. Reconnaissance crews therefore released photo flash cartridges that were ejected from the aircraft fuselage just forward of the empannage. The flashes, however, alerted the enemy. In-flight film processing and casette ejection also proved impractical.[19] The RF-4C, in addition, shared with the F-4C the frequent groundings due to dripping potting compound. Lastly, airframe vibrations (first detected during the Category II tests and already suspected of causing sensor malfunctions) continued to distort images of the optical sensors in the camera bays.

SEA Commitments **1966-1971**

Despite its short range and other failings, the RF-4C posted an impressive record during the most intense years of the war. Fierce defenses in North Vietnam accounted for many losses. But, all things considered, these losses were low.

Modernization **1972-on**

Fund shortages and the search for finer equipment slowed both modification and modernization of the RF-4C. Since 1968 TAC had given a high priority to refairing of the RF-4C nose section for better sensor resolution. Yet, modification of the entire fleet did not begin until mid-1972 and was programmed to take 4 years. Similarly, improvement of the RHAW system, added to tactical and recon F-4s, only started in January 1973. By mid-year, 253 of these aircraft were modified, the RF-4Cs included in this group exchanging their APR-25/26s for the superior ALR-46s. Lack of money, however, would stretch modification of the remaining aircraft over several years. Another major project gave some RF-4Cs[20] new side-looking radar (SLR)[21] by mid-1973. It was nonethe-

[17] Almost concurrently, early RF-4Cs of Shaw's 16th TRS joined the USAFE, the 16th being re-equipped with 20 fully-configured new productions.

[18] The planes of the inactivated squadron beefed up other RF-101 units.

[19] Immediate postflight film processing and readout were provided by photo processing vans deployed to SEA in early 1965. Later models (WS-430B vans) began to arrive in August 1967.

[20] The handful of aircraft, all earmarked for the USAFE, reached West Germany in June.

[21] The new, but interim SLR was part of a system involving installation of additional components to WS-430B processing vans and associated ground equipment. The entire system was to be fully operational in September 1973.

less an interim effort to bolster all-weather reconnaissance until 1976, when a more efficient SLR was expected.

Subsequent Model Series

None

Other Configurations

RF-4E—similar to the RF-4C, except for some subsystem changes and two J79-GE-17 engines in lieu of the less powerful -15s. All RF-4Es would go to foreign military sales.

End of Production **December 1973**

As scheduled in mid-1973

Total RF-4Cs Accepted **30 June 1973**

499 (including the 6 reconfigured Navy F-4Bs used for testing), against 505 ordered and funded.

Acceptance Rates

Four RF-4Cs were accepted in FY 64, 56 in FY 65, 124 in FY 66, 110 in FY 67, 68 in FY 68, 44 in FY 69, 58 in FY 70, 17 in FY 71 (second half), 6 in FY 72 (first half),[22] and 12 in FY 73 (one per month).[23]

Flyaway Cost Per Production Aircraft[24]

$2.3 million[25]—airframe, $1,679,000; engines (installed), $276,000; electronics, $293,000; armament, $73,000.

Unit R&D Costs

$61,200—cumulative through mid-1973 and included in the RF-4C's flyaway cost.

Average Cost Per Flying Hour

$867.00

Average Maintenance Cost Per Flying Hour

$545.00

Operational Status **Mid-1973**

The Air National Guard began receiving RF-4Cs in fiscal year 1971—having 58 in mid-1973 against the Air Force's 324. The Air Force planned to keep the bulk of its RF-4Cs for many more years.

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[22] During 1971 no RF-4Cs were produced for the Air Force, but it did accept 86 RF-4Es for the FMS. These were over and above eight similar aircraft, produced and accepted in the last 4 months of 1970.

[23] Procurement of RF-4Cs for the Air Force was expected to end in fiscal year 1972 (when the last 12 aircraft were funded). Yet, since the late 60's, Presidential budgets had supported a "one per month" RF-4C rate to keep production lines open longer.

[24] Subject to change, the aircraft being still in production in mid-1973.

[25] $55,217 spent for Class V modification, excluded.

Other Countries

Of 94 RF–4Es produced, 6 were purchased by Israel. West Germany bought the remainder, receiving its 88th aircraft in June 1972.

F-4D

Manufacturer's Model 98EN

Weapon System 327B

Previous Model Series

F–4C

New Features

An improved bombing capability by supplying radar slant range to the bombing computer. Better air-to-air range from a stabilized lead computing gunsight. Redesigned equipment cooling system and number 1 fuel cell.[26] From the start, F–4Ds featured AIM–4D Falcon infrared air-to-air missiles.[27]

Contractual Arrangements **1964–1966**

The Navy procured the F–4D for the Air Force as it had the F–4C. Purchase of the first 52 F–4Ds, funded by Congress in fiscal year 1964, was initiated by a March 1964 letter contract. Procurement ended 2 years later in favor of the subsequent F–4E. Navy fixed-price contract (N00019–67–C–0095), definitized in August 1966, covered both the last F–4Ds (funded in fiscal year 1966) and the first F–4Es.

First Flight (Prototype) **June 1965**

First Flight (Production Aircraft) **8 December 1965**

The Air Force accepted the aircraft in the same month.

Flight Testing **1965–1966**

Category I, June 1965-March 1966; Category II, March 1966-October 1966. To save time, the 8-month Category II testing also evaluated the F–4D under simulated combat conditions. This eliminated formal Category III tests.

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[26] Specified in a first 20 February 1964 amendment of SOR 200, these improvements were not retrofitted in the F–4Cs.

[27] These replaced the AIM–9 Sidewinders of the preceding F–4C (as called for by SOR 200's third amendment of November 1964). Even though no Sidewinders remained on the F–4Cs as of mid-1968, they were returned to the aircraft by April 1969 and added to the D in June. From mid-1969 on, the F–4Ds could fire both Sidewinders and Falcons as well as the basic all-weather, radar-guided Sparrow III air-to-air missiles. (Four Sparrows were carried semi-submerged under the fuselage.) Other F–4D weaponry resembled that of the earlier F–4C, including the Walleye (first carried by the D).

Enters Operational Service **April 1966**

TAC assigned its first 16 F–4Ds to the Fighter Weapons School at Nellis AFB. It was 21 June before the aircraft reached a combat unit (the 33d TFW at Eglin).

Initial Shortcomings **1966**

The nonavailability of certain components and incomplete testing of others slowed the beginning of F–4D production. Early deliveries lacked multiple and triple ejection racks and carried deficient fire-control systems, weapon release computers, and ECM equipment. Limited space to house these items posed another problem.

Urgent Modifications **1966–1967**

The F–4D, like many SEA-bound fighters, required special equipment.[28] It urgently needed a RHAW system. Moreover, some F–4Ds also had to be modified for Combat Eagle and Wild Weasel duty. Modifications lagged from the outset. Combat Eagle was delayed almost a year, because no new Walleye missiles were available. Wild Weasel fared no better, due to time-consuming difficulties in installing the new APS–107 radar in the RHAW system. Furthermore, new problems arose once the aircraft arrived overseas.

Oversea Deployments **May 1967**

In spite of modification slippages, an initial F–4D contingent reached Southeast Asia on schedule. The 555th TFS at Ubon received the first of these aircraft. Other Thailand-stationed F–4C squadrons exchanged their aircraft in October and were combat-ready in late November. In January 1968, three F–4C squadrons at Da Nang were also re-equipped.

Operational Problems **1967–1968**

The sophisticated APS–107 radar of RHAW-equipped F–4Ds promised greater accuracy than the APR–25/26 system of other RHAW fighters. It was also due to work with Navy-developed AGM–78A and B standard antiradiation missiles (SARMs).[29] Yet, the APS–107's operational debut in SEA proved unreliable and erratic. The Walleye, pioneered by the F–4D in August 1967, was likewise a

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[28] One of the F–4D's first modifications under Project Skyspot (previously Combat Proof) gave a ground-directed bombing capability to SEA aircraft, operating at night or in bad weather. The airborne segment of the Skyspot system utilized the Motorola-developed SST–181 X band radar transmitter; the ground portion, the AN/MSQ–77 radar.

[29] The OSD released the AGM–78B for production in March 1968, with initial operational capability scheduled for 1 year later. Also being developed for use with the F–4 were 2 flak-suppression missiles—the XAGM–79A and XAGM–80A self-guided standoff weapon. They contained an altimeter fuze for airburst and bomblet dispersion.

disappointment at first.[30] The aircraft itself had problems, having retained most of the F–4C's deficiencies.

End of Production **February 1968**

With Air Force acceptance of 7 F–4Ds, the last 3 of which reached TAC in April.

Subsequent Model Series

F–4E

Other Configurations

None

Total F-4Ds Accepted

793—excluding 32 accepted by the Air Force for the FMS program.

Acceptance Rates

Sixty-eight F–4Ds were accepted in FY 66, 519 in FY 67,[31] and 206 in FY 68.

Flyaway Cost Per Production Aircraft

$1.7 million[32]—airframe, $1,018,682; engines (installed), $260,563; electronics, $262,101; ordnance, $6,817; armament, $133,430.

Average Cost Per Flying Hour

$896.00

Average Maintenance Cost Per Flying Hour

$545.00

Postproduction Changes **1969-1973**

As a war-rushed product (almost 800 aircraft built in less than 2 years), the F–4D proved successful. Nonetheless, it bore many F–4C failings and received similar modifications. As forerunner to the F–4E (ordered in mid-1966), the F–4D benefited from Rivet Haste, Pave Spike, and several other E modifications. The F–4E in turn shared some D improvements.

Other Special Improvements **1969-1973**

The most significant improvements came during the second half of 1969. In July, 90 F–4Ds were programmed for the new Wild Weasel APR–38 advanced avionics system. The first D fitted with the new system flew on 27 November 1972.[33] Again, as early as November

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[30] Fifty percent of the AGM–62A Walleyes received at Ubon malfunctioned. This triggered a USAF investigation in late 1967 of the contractor's quality control and production line test procedures.

[31] Monthly production soared to 50 during January-June 1967.

[32] Excluding $233,458 in Class V modification costs, accrued by mid-1973. This brought the price of each F–4D to more than $1.9 million.

[33] Barring unexpected problems, this Advanced Wild Weasel System would probably be installed later into several of the more modern F–4Es.

1969 a LC to Philco-Ford started Project Pave Knife. It put a removable pod-mounted laser designator on 6 F–4Ds.[34] The first 3 of them (with support equipment and personnel) arrived at Ubon during March 1971. Immediate combat evaluation proved Pave Knife's worth. Although no additional pods were procured, 6 other F–4Ds were given the Pave Knife configuration. Moreover, in early 1972 all 12 planes enjoyed low-light-level television and better laser warmup. A third decision in December 1969 expanded the number of F–4Ds featuring the long-range navigation weapon delivery system.[35] Moreover, these planes were further enhanced by mid-1971. Another key decision in late 1969 proved difficult to carry out. For better acquisition, lock-on, and launch of electro-optical weapons, the Air Force wanted scan converter television displays put on 344 F–4Ds.[36] The Air Force also wanted an October 1971 IOC. In handling this $15 million modification project, Hazeltine (the contracting company) faced technical difficulties from the start and could not deliver qualified scan converters on schedule. Yet, by the end of 1972—after the number of F–4Ds involved had been cut to 285—the project appeared to be getting off the ground, as testing of still unqualified converters disclosed few reliability problems. Nevertheless, the new system would undergo more improvements prior to the final 200-hour mean time before failure tests in July 1973.

Redeployments **1971-1972**

The Ds were the first of the F–4s to go home under the United States SEA withdrawal program.[37] F–4Ds of the 12th TFW's 389th TFS, in South Vietnam since March 1966, started leaving Phu Cat Air Base in late October 1971.[38] However, Constant Guard III sent 4 F–4D squadrons to Takhli RTAFB, in May 1972—TAC's biggest single unit deployment ever during a crisis.

Modernization **Mid-1973**

In spite of concurrent modifications, the F–4D would still lack the

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[34] Twelve F–4Ds (4 to begin with and 8 in early 1969) had previously received a less sophisticated but related modification under Paveway. Illuminators were mounted on the aircraft canopy to guide MK–84 bombs equipped with KMU-351B laser guidance kits.

[35] A previous LORAN system never went past the Igloo White F–4Ds. The system worked poorly and occupied too much aircraft space.

[36] The D's scan converter (also programmed for the F–4E) would resemble that of the F–111D's Mark II Integrated Display Set.

[37] The Ds were also first in joining the F–105Fs deployed to South Korea in early 1968—following North Korea capture of the U.S.S. *Pueblo*.

[38] The inactivated squadron left quite a record—downing 6 MIGs in early combat over North Vietnam and flying more than 13,000 sorties during its last 3 years in SEA.

lower speed and higher attack angle of the slat-equipped F–4E.[39] Yet, desirable as it was, retrofit of the D appeared remote. There would be no modernization money for such project until at least past 1974.

Operational Status **Mid-1973**

The USAF inventory stood at 515 F–4Ds (against total procurement of 793), 14 of which were used for testing. Altogether, 15 of 19 fully-equipped F–4D squadrons were overseas.[40] Wherever the place, the Air Force planned to retain most Ds for many years.

Other Uses **December 1969**

The Air Force used the F–4D to flight test the AGM–65A Maverick, a new tactical air-to-ground missile for hard targets, such as tanks and field fortifications. The first launch resulted in a direct hit on an M–41 tank.[41]

Other Countries **1968-1969**

Thirty-two of the Air Force F–4Ds were sold to Iran in 1968. Deliveries, started in 1968, were completed in 1969.

F-4E

Manufacturer's Model 98GV-1
Weapon System 327C
Navy Equivalent: F-4J

Previous Model Series

F–4D

New Features

General Electric Vulcan armament system (M61A1, 20-mm gun) mounted in the aircraft's nose;[42] AN/APQ-120C fire-control system; two J–79–GE–17 turbojet engines (17,900-lb thrust with afterburner); and slotted stabilator. Also (beginning with the 1972 productions), leading edge slats (LES);[43] and fittings for mounting armorplate over certain aircraft systems and armor on the rear of the fuselage.

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[39] The thin aluminum, hydraulically operated slats were 9 feet long and 15 inches wide. Two (one retractable; the other, semifixed) were mounted on the edge of each wing. The slat kits, manufactured by McDonnell-Douglas were costly—$93 million for 350, ordered in April 1973. The Air Force intended to use them for the early F–4Es.

[40] All F–4Ds were expected to leave Thailand before the end of 1973, but the number stationed in Korea was due to rise.

[41] The Air Force liked the new missile and bought 3,000 of them in FY 1973. $112 million (for twice that many) was included in the FY 1974 defense budget.

[42] The nose was much like the RF–4C's and 5 feet longer than that of the tactical F-4C and D.

[43] F–4Es produced before 1972 would be retrofitted with LES.

Basic Development **1964**

Followed the 17 June completion by the Air Force of a DOD-directed study. It probed the known limitations of the F–4C and yet-to-be-flown F–4D. It covered every facet of the tactical mission and—as requested—the cost effectiveness of various means to improve air-to-air, all-weather, and low-altitude performance. The study's chief recommendations were: (1) delete installation of an infrared search and track set (the gain would not justify the cost); (2) substitute the cheaper and more versatile Hughes AIM–4D infrared Falcon for the Navy (Philco-developed) AIM–9D Sidewinder; (3) do without data link equipment (too costly for limited tactical use); and (4) defer any final decision until the coherent-on-receive doppler system (CORDS) was tested.[44] If CORDS did not work, give up the whole project and end the F–4 program with the forthcoming F–4D.[45]

Go-Ahead Decision **22 July 1966**

By the Secretary of Defense some 18 months after CORDS's initial flight test. The first F–4E was set for production in August 1967; the 35th was to include the new APQ–120 and Hughes CORDS.

Contractual Arrangements **1966–1973**

A Navy LC in late July 1966 and a Navy fixed price contract in August started the F–4E procurement, as requested by the Air Force. Ensuing fixed price and incentive contracts were issued by the Navy until fiscal year 1973, when the Air Force took over. It then ordered 76 more F–4Es for the FMS and another 48 for itself.

Development Problems **1966–1967**

Hughes successfully flight-tested the CORDS in February 1965. However, the system soon became so erratic that McDonnell (the prime contractor) had to put off Hughes's production contract. Programmed for the 35th F–4E, CORDS would at best appear on the 120th.

First Flight **30 June 1967**

Immediately accepted by the Air Force, this first F–4E was neither a prototype nor a typical production. It had undergone contractor-conducted Category I tests since April, and was tagged for continued testing. Yet, it was not actually a test aircraft, being accounted for as the first F–4E production.

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[44] CORDS, a component of the AN/APQ–120's microminiaturized radar, promised better detection of low-flying aircraft, even of ground moving targets.

[45] A later and less drastic conclusion suggested use of another, but related, system. This quickly became academic, since CORDS made a brilliant (if ephemeral) debut.

Enters Operational Service **3 October 1967**

Although TAC had only received a first few F–4Es,[46] testing began at the Nellis Fighter Weapon Center on 23 October. Soon afterwards, the 33d Wing at Eglin (TAC's first F–4E combat unit) got its initial aircraft.

Flight Testing **1967–1970**

The F–4E testing program was extensive and unconventional. Category I started on the ground in April 1967. It formally ended in August 1968 but lingered through December 1969. Category II, initiated in November 1967, was completed in June 1968, with follow-on tests extending through May 1970. Category III (officially called combat evaluation) was expedited because of the aircraft's urgent need in Southeast Asia. For the same reason, these tests began in November 1967, concurrent with the beginning of Category II (a not too common procedure). TAC cut short the F–4E combat evaluation in July 1968, as the aircraft's oversea deployment became imminent. Also, the lack of modified engines (to cure demonstrated stalls and flameouts) made further testing meaningless. All told, testing showed that the F–4E excelled the F–4D. Despite failings, the new J–79–GE–17 turbojet seemed basically sound. The aircraft's inside gun worked well. Still, flight testing of the few early APQ–120s available pinpointed deficiencies. Most likely, the problems turned up by the F–4E evaluation would hamper the plane for a time in actual combat.

Revised Requirements **1968**

Although still needed, CORDS failed to work out. Headquarters USAF cancelled it on 3 January and directed fresh effort towards an F–4E look-down capability—without major modification of radar and fire-control. The Air Force forbade any production commitment until the new component had definitively proved out.[47] Further, in May 1968, the Air Force stopped the installation of the trouble-ridden APS–107, flown by the RHAW F–4Ds. F–4Es already equipped would be retrofitted with the APR–36/37, which would be on forthcoming F–4Es.

Oversea Deployments **13 November 1968**

These F–4Es (18 by January 1969) were the first of many sent to Southeast Asia. To meet PACAF's most urgent requirements, they were fitted with Skyspot radar beacons, together with the APX–76 and strike/documentation camera systems. Special modifications let them carry more ECM pods at the same time. They

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[46] Eleven were on hand by the close of October.

[47] Hughes again attacked the problem, while Westinghouse studied it from a different angle. Prototype development, if approved, was not expected before mid-1970.

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could also fire AIM–9B Sidewinders as well as the AIM–4D Falcons and AIM–7 Sparrows (both provided during production). However, the target identification system approved for 4 of the first F–4Es was missing.[48] By mid-1971 only 72 F–4Es were in SEA—the deployment program having slipped.[49] Meanwhile, a few F–4Es went to Europe, first appearing on USAFE inventory in July 1969.

Engine Problems **1968–1972**

Early F–4Es (beginning with those going overseas) were modified to prevent engine stalls and flameouts. Yet engine problems of all sorts remained. Like previous F–4s, the Es delivered through November 1969—before necessary changes reached the production lines—had to be modified to avoid engine bay fires. Moreover, the J–79–17 at first did not live up to its billing. The new engine could not exceed 2.15 Mach by mid-1970—the Air Force citing General Electric for not reaching the specified 2.24 Mach. Meanwhile, engines remained hard to obtain. In the summer of 1969, engine failure rate rose, while engine life expectancy declined to 608 hours. A 4-month strike in October did not help matters. Depot stocks sunk so low that TAC raided assets at McDill to deploy an Eglin squadron to SEA on time. Ensuing progress was short-lived. In early 1972, just before the Constant Guard F–4 deployments, spare engines were again scarce; engine overhaul money, limited. Another problem also loomed. Engine stalls appeared likely as LES-equipped F–4Es (delivered after April) began flying at lower speed and higher attack angle. Finally (despite several years of effort by G.E., the Navy, and the Air Force), engine smoke trails in every model of the F–4 persisted—alerting the enemy from miles away.

Other Problems **1968–1972**

Early F–4Es had no or incomplete AN/APQ–120 fire-control systems. Even though the APQ–120 passed through several modifications, it was still imperfect in late 1972. Aerospace ground equipment for both the new APQ–120 and the M–61A1 gun was initially

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[48] This was the AN/ASX–1 Target Identification and Electro-Optical (TISEO) System. It had been requested by Southeast Asia Operational Requirement (SEAOR) 118 on 8 April 1967. By mid-1970 the TISEO had not yet been flight-tested, but when proved out progress came swiftly. The Air Force definitively decided on this system for the F–4E in March 1971, three months before winding up Pave Scope flight tests of TISEO and the Mark 84 weapon (Pave Scope sought to integrate target acquisition aids with electro-optical weapons on a tactical fighter). McDonnell got a preproduction TISEO in December and a production version in April 1972. The Air Force received the first TISEO-equipped F–4E production in June—83 more would be forthcoming.

[49] The 4th and 421st TFSs at Da Nang each had 18 F–4Es; the 34th TFS and 469th TFG at Korat, 36.

short. Then, too, troubles existed in several new missiles and in the overall F–4E weapon system.[50] In January 1969, the Air Force began to correct deficiencies arising when the AIM–7E Sparrow was combined with any model of the F–4. Its project to mate AIM–7F missiles with the F–4E had made little headway by December 1972. On the other hand, the Air Force had modified the AIM–9B Sidewinder and shipped the first newly configured AIM–9Es to SEA in early 1969. These missiles were used by all F–4s, as were the AGM–45A Shrike antiradiation missiles (retrofitted with improved warheads and new rocket motors).

Attrition **1972**

The F–4, by 1 January 1972, ranked second to the F–105 in SEA combat losses—362 (all models), most of them downed by the enemy.[51] Later, in F–4Es alone, the Air Force lost eight in 2 months of intensive combat.

Redeployments **1972**

By 30 January, F–4 strength in SEA stood at only 11 squadrons—8 in Thailand, 3 in South Vietnam. Massive North Vietnamese attacks, on the heels of the United States withdrawal, swiftly brought back US air power (a move that later proved to be both successful and crucial). In the Constant Guard I deployment,[52] F–4Es were among the first to depart from the United States. The 334th and 336th squadrons of TAC's 4th Tactical Fighter Wing left Seymour Johnson AFB, N. C., in early April. Under Constant Guard II, the Homestead-based 308th TFS and the 58th TFS from Eglin departed Florida later in the month. These Constant Guard I and II F–4Es went to Thailand—36 each to Ubon and Udorn. Alternately flying day and night missions, the F–4E squadrons struck enemy targets around the clock. By 30 June they had lost 8 aircraft.

Modernization **1973**

The Air Force decided to go ahead with Pave Spike in May, having made sure in 1972 that the program's technical problems would not disrupt SEA operations.[53] Pave Spike, estimated to cost $81

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[50] A weakness common to all F–4s was the egress system. A new ejection seat, installed in fiscal year 1969, worked better at low speed and low altitude. Sequence controls prevented both crewmen from being ejected at the same time. Even so, TAC believed that the new ejection seats could be improved. Hence, modifications were either in progress or planned.

[51] This total did not include RF–4C losses since October 1965.

[52] All Constant Guard movement orders specified a deployment of not more than 179 days.

[53] Optic jitter, pod head hangup at supersonic speeds, and erroneous ballistic computation plagued the contractor-maintained test pods. Ground equipment was also inadequate.

million,[54] called for Westinghouse to produce 156 (AN/ASQ–153) pods, and for modification of 317 aircraft (106 F–4Ds and 211 F–4Es).[55] These modified aircraft and pods would provide a self-contained day tracking and laser target designator for delivery of laser-guided weapons. Another long-range project had been launched in April 1973. It would improve the structure of all F–4s and RF–4Cs (late F–4Es productions were excluded, their structural integrity requirements being covered by the Leading Edge Slat Program). The structural improvement program (prompted by the January loss of an early F–4E) would cost $5 million, but it would stretch the aircraft's service life from 3,000 to at least 4,500 hours. The Air Force figured the structural modifications would begin in May 1974 (upon delivery of the first kits) and end in June 1977. The work would be done during regular depot maintenance.

Subsequent Model Series

None

Other Configurations

F–4F, flown by the Federal German Luftwaffe; and *F–4E (J)*, being produced for the Japanese Air Self Defense Forces.

End of Production **1976**

In June 1972, the Air Force expected to receive the last of its 740 F–4Es in December 1974. Additional procurement (48 in FY 73, and 24 in FY 74) changed all this. Now, the USAF portion of F–4E production would most probably end with acceptance of the 812th aircraft, due for delivery in the spring of 1976. An upturn in F–4E sales also promised to extend FMS production by several years.

Total F–4Es Accepted **30 June 1973**

734,[56] against 812 ordered and funded.[57]

Acceptance Rates

The Air Force accepted one F–4E in FY 67, 145 in FY 68, 242 in FY

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[54] Including funds already earmarked for modifying 38 F–4Ds and procuring 19 Pave Spike pods. The total likewise covered equipment to support 12 squadrons, a special repair activity, and the remaining 137 pods (planned for delivery beginning in early 1975). Costs for up-grading the first 19 pods (authorized for production in late 1972) were also part of the estimate.

[55] The first modified F–4D arrived at Ubon on 29 December 1972, 1 month ahead of any production pod. Although 4 of the 19 operationally acceptable but unperfected Pave Spike pods were delivered in January 1973, all 19 pods were not yet available by mid-1973.

[56] Thirty-four F–4Es were diverted to the Israeli Air Force. Israel would pay back the 34 planes from future FMS production—the USAF total purchase of 812 F–4Es remaining intact.

[57] USAF F–4E procurement, ordered and funded, totaled 99 in fiscal year 1966; 191, FY 67; 245, FY 68; 145, FY 69; 24 FY 71; 36, FY 72; 48, FY 73, and 24, FY 74.

69, 186 in FY 70, 105 in FY 71, 25 in FY 72 (December 1971 through May 1972), and 30 in FY 73 (all during the first 6 months of 1973).

Flyaway Cost Per Production Aircraft[58]

$2.4 million—airframe, $1,662,000; engines (installed), $393,000; electronics, $299,000; ordnance, $8,000; armament, $111,000.

Unit R&D Costs

$22,700—cumulative through mid-1973 and included in the F–4E's flyaway cost.

Average Cost Per Flying Hour

$896.00

Average Maintenance Cost Per Flying Hour

$545.00

Operational Status **Mid-1973**

Of 734 F–4Es accepted, 614 remained, with 78 still due. There were 438 F–4Es in 22 squadrons. Ten of these units served overseas—mostly with the USAFE. The Air Force planned to use F–4Es a long time. However, F–15s (also by McDonnell-Douglas) might replace some F–4Es after 1975.

Other Countries **Mid-1973**

While few F–4s were funded under the MAP (18 in FY 69), many went to the FMS—mostly F–4Es,[59] some slightly modified. The F–4F program, estimated at $750 million, fell under the latter category. It would give the Luftwaffe 175 F–4Fs. The first 2 were to be delivered in August 1973 at Jever AB, West Germany, by the Air Force's 2d Aircraft Delivery Group. As for the F–4E (J),[60] it was also a modified E to be used solely for air defense. Twelve of the 128 F–4E (J) interceptors due by 1980 were operational in mid-1973.[61] Meanwhile, stateside production of FMS F–4Es grew. As of 30 June, the Air Force had accepted a total of 89 F–4Es for Israel and 36 for Iran. Delivery of F–4Es to Greece was set for April 1974; to Turkey, later in the year.

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[58] Excluding $7,995 in Class V modification costs, accrued by mid-1973. This gave each F–4E a price tag of $2,480,995. But this could change, the aircraft being still in production.

[59] The exceptions were 36 early F–4Cs (all delivered to Spain by the fall of 1972) and the 32 F–4Ds, sold to Iran in the late sixties.

[60] The F–4E (J) would be made in Japan, by licensing agreement between McDonnell and the Mitsubishi Heavy Industries. The F–4F would be produced in the United States; its J–79–17 engines and inertial navigation systems in West Germany (under licensing agreements with US manufacturers).

[61] Two of these came off McDonnell lines, 8 had been assembled in Japan from "knockdown kits," and 3 had already been produced by Mitsubishi.

Other Uses **1969**

As planned since early 1967, the Air Force re-equipped its aerial demonstration team with F–4Es during the summer of 1969. The Thunderbirds expected almost the impossible of their aircraft. Structural cracks quickly developed, requiring reinforcement of the outer wing panels. F–4Es also took part in Red Baron II, a 2-year project begun in mid-1968. It would compare the merits of USAF planes with what was known of current or programmed Soviet aircraft.

Items of Special Interest **July 1970**

Under Peace Reef—devised in April 1970, after Australia deferred acceptance of 24 F–111Cs—the Air Force leased that country 24 F–4Es. The first six were delivered on 9 September, after the Air Force furnished ground equipment and a 1-year supply of spares. The last of the 24 leased F–4Es were returned by Australia in June 1973.

June 1972

The NATO dual-based, F–4E-equipped 4th TFW was the first to receive the new AGM–65 Maverick (initially flight-tested by an F–4D). By 30 June, 24 of the wing's F–4Es were fitted to carry the missile, and aircrew training was underway.

PROGRAM RECAP

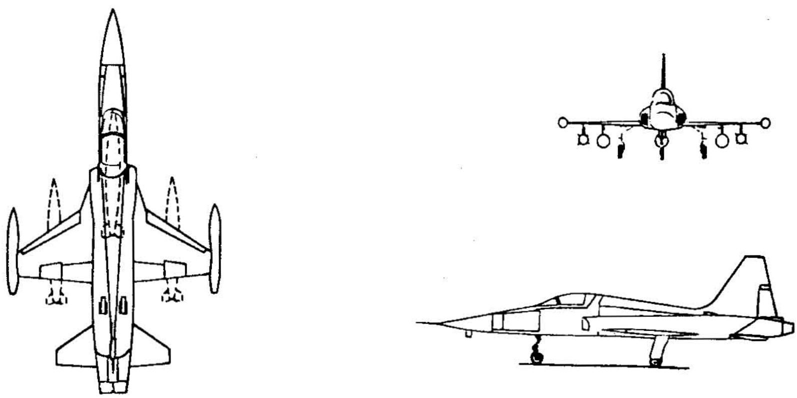
By mid-1973 the Air Force had accepted 2,609 tactical and reconnaissance F–4s of divers kinds, against 2,693 ordered and funded. Except for 18 of these, diverted to MAP, all were for the Air Force's own use. Total deliveries counted 583 F–4Cs, 499 RF–4Cs (with 6 more to come), 793 F–4Ds, and 734 F–4Es (78 less than programmed). The Air Force in addition had already received 16 F–4Ds and 94 RF–4Es for the FMS. And an increase in Phantom foreign sales was a sure thing.

TECHNICAL DATA

F-4C, F-4D, F-4E, and RF-4C

Manufacturers	(Airframe)	McDonnell-Douglas Corporation, St. Louis, Mo.
	(Engine)	General Electric Company, Evandale, Ohio.
Nomenclature	(F-4C/D/E)	Tactical Fighters.
	RF-4C)	Tactical Reconnaissance Aircraft.
Popular Name		Phantom II

Characteristics	*F-4C*	*F-4D*	*F-4E*	*RF-4C*
Engine, Number & Designation	2J79-GE-15	2J79-GE-15	2J79-GE-17	2J796GE-15
Length/Span (ft)	58.2/38.4	58.2/38.4	63.0/38.4	62.9/38.4
Crew	2	2	2	2
Performance				
Type Mission	HI-LO-HI	HI-LO-HI	HI-LO-HI	High Alt Recon
Takeoff Weight (lb)	51,688	51,482	53,814	52,823
Payload	(4)SP III+1 (MK-26 + 2 370-gal tanks	4SP III+1 MK-28 + 2 370-gal tanks	4 AIM-7E + 1 MK-28+ 2 370-gal tanks	1,398 lb Recon Equip
Takeoff to clear 50′	3,800 ft	3,770 ft	4,490 ft	3,990 ft (max. power)
Combat Radius (nm)	421	396	367	673
Avg Cruise Speed (kn)	501	501	506	510
Max. Speed	2.16 Mach	2.16 Mach	2.24 Mach	2.2 Mach
Combat Weight (lb)	38,606	38,706	41,135	40,267
Combat Ceiling (ft)	55,400	54,950	57,200	55,200
Max. Rate of Climb at sea level (fpm)	45,800	45,700	41,300	44,800
Max. Speed at Specified Altitude (kn/ft)	1186/40,000	1186/40,000	1221/40,000	1204/40,000
Landing Weight (lb)	33,888	34,205	36,831	33,598
Ground Roll at Sea Level (ft)	3,125	3,150	3,680	3,100
Ferry Range (nm)	1,528	1,469	1,401	1,418



NORTHROP F–5 FREEDOM FIGHTER

F–5A: The small F–5A logged in one year more than 1.75 million miles without any accident.

F–5B: The two-place F–5B trainer entered service ahead of the basic F–5A.

F–5E: The F–5E retained the simplicity of its predecessors, but it was a bit bigger and quite more powerful.

NORTHROP F-5 FREEDOM FIGHTER

Manufacturer's Model N-156F
Weapon System SS-420A

Basic Development **1955**

The N-156 concept was generated by a 1954 governmental study of European and Asian needs for a lightweight and inexpensive fighter of high performance, and Northrop began designing its N-156C in 1955. After 2 years of private development, the contractor obtained USAF interest in a trainer version, the N-156T, which resulted in the 1961 production of the T-38. Northrop developed the single-seat N-156F Freedom Fighter in parallel with the T-38.

First Flight (N-156C Prototype) **30 July 1959**

Powered by two General Electric YJ85-GE-1 turbojet engines, the first N-156C prototype exceeded Mach 1 on its maiden flight. Two other protypes were built, one of which was equipped with more powerful engines (two J-85-GE-13s) and completed to F-5A standard. The three flying prototypes were funded by the Air Force under a research and development contract formalized in July 1959.

Go-Ahead Decision **23 April 1962**

The Secretary of Defense approved the Air Force selection of the Northrop N-156C as the FX aircraft (subsequently identified as the F-5) for support of the Military Assistance Program.

Specific Operational Requirements 199

The original FX configuration, specified in SOR 199, provided only minimum fighter capability. Additional requirements were directed by the Secretary of Defense, following his approval of the Air Force selection. These changes, calling essentially for the addition of two internal 20-mm guns and provisions for nose fuel tank and cameras, were incorporated in a mid-1964 revision of SOR 199.

F-5A

Contractual Arrangements **October 1962**

Production was initiated by a $20 million fixed price firm (FPF) contract. A second contract was signed on 27 August 1963. The two initial orders called for a total of 170 F-5A and B aircraft. Like subsequent contracts, they were negotiated under the sole source method of procurement.

First Flight (F-5A Prototype) **May 1963**

First Flight (Production Aircraft) **October 1963**

First Acceptance **January 1964**

Flight Testing **1962–1965**

Category I testing took place October 1962-May 1965, first using an N–156C aircraft. Categories II and III followed in February 1964-October 1964. These tests were conducted simultaneously, after an initial delay of 4 months caused by the added requirement of installing internal guns on the single-seat F–5A. A mixture of F–5A and B aircraft participated in all tests.

Enters Operational Service **August 1964**

The first aircraft saw operational service with TAC's 4441st Combat Crew Training School (CCTS) at Williams AFB.

Significant Operational Problems

None. In its first year of operation, the F–5 logged more than 1.75 million miles without any accident.

Subsequent Model Series

F–5B—trainer variant of the F–5A. The F–5B actually entered operational service ahead of the basic F–5A.

Other Configurations

RF–5A

End of Production **March 1972**

Production ended with delivery of the last F–5A.

Total F–5As Accepted

621—almost all for recipient countries of the Military Assistance Program; the others, for the foreign military sales program.

Flyaway Cost per Production Aircraft

$756,000—airframe, $578,000; engines (installed), $155,000; electronics, $11,000; ordnance, $2,700; armament, $9,300.

Average Cost Per Flying Hour

$326.00

Average Maintenance Cost Per Flying Hour

$187.00

Items of Special Interest

Originally developed to provide unsophisticated allied air forces with a modern, versatile tactical aircraft, the F–5 was tested in Southeast Asia to determine its potential under combat conditions. The tests and evaluation, which became known as Project Skoshi Tiger, were directed by the Air Force in mid-1964 and were conducted by a 12-aircraft unit of TAC's 4503d Tactical Fighter Wing. The aircraft used were diverted from MAP production, modified for air-refueling, and equipped with armor plate, jettisonable pylons, additional avionics and camouflage paint. The 4503d unit was deployed to Da Nang in October 1965, and within 4 months flew more than 2,500 hours in close support, air- to-air, interdiction, and reconnaissance missions over South Vietnam and the Laotian panhandle. During February 1966 the unit moved to Bien Hoa AB, and the 4503d pilots began flying interdiction, armed reconnaissance, and MIG CAP missions over North Vietnam. In March, the 4503d unit built its size to 18 aircraft, became the 10th Fighter Commando Squadron, and was assigned to the 3d Tactical Fighter Wing at Bien Hoa. At the same time, the Air Force directed the Tactical Air Command to initiate immediately a training program for F–5 pilot replacements. The 4441st CCTS at Williams AFB began this training on 15 April, although the base's training facilities were already saturated by the school's undergraduate program.

Other Countries

Modernization of the South Vietnamese Air Force with F–5 aircraft began in March 1967. The in-country aircraft, modified for the Air Force's Skoshi Tiger tests,[1] were first transferred under the service-funded program of 31 March 1966—a program similar to the one implemented during the Korean conflict. Iran, Greece, and Korea were the initial countries to receive F–5 aircraft under the Military Assistance Program. The Philippines, Nationalist China, and Turkey were next. Norway and Libya were the first to buy F–5s through the Foreign Military Sales Program; Iran and Nationalist China followed. By mid-1972, the MAP and FMS programs had provided at least 15 nations with F–5 aircraft.

F–5B

Manufacturer's Model N–156F
Weapon System SS–420A

Previous Model Series

F–5A

New Features

Two seats in tandem for dual fighter/trainer duties. The internal guns of the single-seat F–5A were not installed on the F–5B.

Contractual Arrangements **October 1962**

Procurement of the F–5B was initiated with that of the A model series. The first two contracts issued by the Air Force called for a production ratio of one two-seater for every nine single-seat F–5As.

First Flight (Production Aircraft) **24 February 1964**

The Air Force began accepting F–5Bs during the following month.

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[1] These tests led to the F–5A's nickname of "Tiger." The F–5A's successor was dubbed "F–5E Tiger II." The F–5A was eventually called "F–5A Tiger I."

Enters Operational Service **30 April 1964**

The F–5B became operational 4 months before the F–5A, with the 4441st CCTS at Williams AFB.

Significant Operational Problems

None

Subsequent Model Series

F–5E

Other Configurations

None

End of Production

Originally due to phaseout in April 1973, F–5B production was extended in May 1972 on the basis that future F–5E sales might boost FMS requirements for the F–5B trainer. No firm commitment for additional productions was made at the time, however.

Total F–5Bs Accepted

By mid-1973, the Air Force had accepted 84 of 88 F–5Bs destined for the Military Assistance Program (Grant Aid). It had also received, between fiscal years 1967 and 1970, 13 FMS F–5Bs (2 bought by Libya, 6 by Norway, and 5 by Iran). Two more, sold to Jordan, were expected in early 1974.

Flyaway Cost Per Production Aircraft

$1.2 million—airframe, $856,000; engines (installed), $218,000; electronics, $22,000; ordnance, $6,000; other (including armament), $81,000.

Average Cost Per Flying Hour

$326.00

Average Maintenance Cost Per Flying Hour

$187.00

Items of Special Interest

During the F–5 training course, which lasted 45 days, students flew 38 sorties, participated in 56 events, and gathered 40 hours of flying time in addition to 182 hours of academic and ground training. The first foreign students to enter the F–5 training program—from Iran, Greece, and Korea—completed training in March 1965. A longer training course was developed for pilots due to enter combat operations. The course, specially designed for the South Vietnamese Air Force (VNAF), featured 92 hours of flying time in 103 training days. The first VNAF group of 33 A–1 qualified pilots commenced conversion to F–5s in October 1966.

RF–5A

Manufacturer's Model N–156F
Weapon System SS–420A

Previous Model Series

F–5A

Development Directive **October 1963**

The directive called for a daylight tactical reconnaissance version of the single-place F–5A for support of the Military Assistance and Foreign Military Sales programs. The photographic reconnaissance capability of the new F–5 configuration would be patterned on that of the MAP's RF–104G aircraft.

New Features

Four KS–92A cameras—all located in the airplane's nose.

First Flight **May 1968**

First Delivery **June 1968**

The first country to purchase RF–5As through the FMS was Norway, which received 16 of the first 32 RF–5As accepted by the Air Force through 1969. The other first RF–5As were allocated to MAP. Libya and Morocco were the next FMS customers on line.

End of Production **June 1972**

Production ended with delivery of the last RF–5A.

Total RF–5A Accepted

89

Flyaway Cost Per Production Aircraft

$890,000—airframe, $676,000; engines (installed), $175,000; electronics, $33,000; ordnance, $2,700; $3,300.

F–5E

Manufacturer's Model F–5–21

Previous Model Series

F–5B

New Features

Maneuvering flaps; landing-edge extensions at wing roots; hikeable nose gear; extra internal fuel (10 percent more than the F–5A and F–5B); integrated fire-control system; and J–85–GE–21 engines (with afterburner), yielding 5,000-lb thrust, a 20-percent increase over the J–85–GE–13 of the earlier F–5s.

Basic Development **1969**

Northrop developed the F–5E from the F–5A—the intervening F–5B being nothing more than a two-seat version of the basic tactical fighter.

Program Slippage **1969–1970**

Several factors accounted for the delay of almost 2 years which pre-empted the F–5E's acquisition. First, neither the Secretary of Defense nor the Air Force would endorse Northrop's unsolicited proposal for an advanced version of its F–5 until flight tests had demonstrated the inherent advantages of an improved engine. The new fighter had to retain the simplicity of earlier F–5s—for it would also be operated and maintained by nations with little modern technological experience. Yet, its primary purpose would be to fly air superiority missions against enemy aircraft as advanced as the Soviet-built MIG–21 Fishbed. F–5B testing of a prototype J–85–GE–21 had clearly established by August 1969 that the new engine could boost performance over that of earlier F–5 configurations. Nevertheless, further delay was to occur. Before appropriating FY 70 funds for the so-called Advanced International Fighter,[2] Congress required a competitive selection of the contractor. Hence, the Air Force had to solicit proposals from other aerospace corporations. This took more time than dealing solely with Northrop, as first intended.

Competition and Selection **February–November 1970**

The Air Force solicited proposals from eight aerospace corporations on 26 February. Four (including Northrop) responded in March, each with a variation of a fighter it had produced.[3] After a 6-month USAF evaluation of the four proposed aircraft, the Secretary of Defense approved the contractor in November 1970.

Go-Ahead Decision **20 November 1970**

The Air Force publicly announced selection of Northrop as prime contractor for the International Fighter Aircraft.

Initial Contract **8 December 1970**

This was a definitive fixed-priced-incentive contract calling for development and production of 325 aircraft—officially designated F–5Es on 28 December 1970. The contract's terms set a 120-percent ceiling on costs and a 70/30 government/Northrop share-ratio on additional costs between 100–120 percent. The Air Force believed at the time Northrop's cost estimates were too low. It expected that the program (including $96.1 million for research, development, test and evaluation, plus $54.1 million worth of initial spare parts) would reach $695 million. This total would still fall below the program's cost ceiling but above Northrop's target costs. In any case, Northrop's incentive award would await the last delivery, tentatively scheduled for January 1977.

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[2] Applied by the Air Force in December 1969, the name was finally changed a few months later to International Fighter Aircraft (the F–5E also carried the nickname of Tiger II).

[3] McDonnell-Douglas offered a stripped version of its F–4E; Lockheed, an F–104 variation; Ling-Temco-Vought, a variant of its F–8; and Northrop, the advanced version of the F–5 (previously proposed).

Program Change **November 1971**

The F–5E program's urgency prompted the Air Force to increase the F–5Es allocated for development from 5 to 6.[4] This would accelerate flight testing.

Development Problems **1971–1972**

Difficulties pushed up costs, justifying USAF belief that the F–5E estimates were unrealistic. To keep weight down, Nortrop used expensive titanium in the aft fuselage section (the engine/exhaust shroud area).[5] Solving these problems, moreover, slowed the program slightly.

Testing **1972–1974**

Following engine static tests in May 1972, the Air Force approved the J–85–GE–21. When malfunctions occurred in August, the Air Force suspended F–5E flight tests from 21 September–16 December, pending General Electric's correction of the most serious deficiencies. Reapproval of the J–85–GE–21 followed completion of new static tests on 25 April 1973. The Air Force now estimated that the F–5E flight tests would extend through February 1974.

First Flight (Production Aircraft) **11 August 1972**

The flight took place four months earlier than the target date set in November 1970 and 6 weeks before flight testing had to be stopped. During a 50-minute flight from Edwards AFB, the first F–5E attained an altitude of 20,000 feet and 230 knots air speed. The aircraft (rolling out of Northrop's facility at Hawthorne, on 23 June 1972) was not accepted by the Air Force until April 1973.

Enters Operational Service **4 April 1973**

TAC's 425th Tactical Fighter Training Squadron at Williams AFB, where operational testing had begun, put the F–5Es into service. TAC wanted a fully equipped squadron of 20 F–5Es to support its foreign pilot training program by October 1973.

Total F–5Es Accepted **Mid-1972**

The Air Force accepted 13 F–5Es in FY 73[6]—6 for testing and 7 for TAC training. It planned in mid-1972 to give TAC 13 more F–5Es and to allocate foreign nations the remainder of the 325 F–5Es under contract since December 1970. South Vietnam, South Korea,

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[4] Northrop planned to refurbish and include all test aircraft in the operational inventory upon completion of the development tests.

[5] Cancellation of the Boeing supersonic transport program also affected the F–5E's program price. This was due to Northrop's having used its anticipated SST subcontracts in computing a production base for estimating fighter aircraft costs.

[6] Optimistic late 1970 delivery schedules projected 26 aircraft in FY 72, 71 in FY 73, 120 in FY 74, and 108 in FY 75.

and Thailand would get the first of these aircraft through the Military Assistance Service Fund/Military Assistance Program.[7] The Air Force also planned an amendment of the December 1970 contract to fill FMS orders for 226 F–5Es, purchased by Taiwan, Saudi Arabia, and Iran.

End of Production **Unknown**

Date would depend upon orders from foreign governments.

Subsequent Model Series

F–5F. Northrop proposed a two-seat version of the F–5E. The Air Force, with Congressional approval, decided on 15 May to allocate $3.1 million ($1.9 million of FY 73 funds and $1.2 million of FY 74 funds) to further look into the Northrop proposal. Meanwhile, TAC would keep using the two-seat F–5B for training.

Other Configurations

None

Flyaway Cost Per Production Aircraft[8]

$2.1 million[9]—airframe, $1,625,000; engines (installed), $426,000; electronics, $47,000; ordnance, $5,000; armament, $17,000.

Milestones **May–June 1973**

One production F–5E flew at the Paris Air Show as part of a world trip to promote foreign military sales.

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[7] The Military Assistance Service Fund supported combat in SEA by Asian allies who were otherwise assisted through the Military Assistance Program.

[8] Including $703,000 of R&D costs.

[9] The F–5E program was originally funded every fiscal year—$2.5 million each for the first small lot of F–5Es, $2.1 million for the second. These costs were higher than Northrop had hoped for, but cheaper than the Air Force had expected. And, in spite of an agreed-upon price escalation of 3.6 percent (compounded annually), the F–5E unit cost went down as production grew.

PROGRAM RECAP

As of mid-1973 the Air Force had accepted 621 F–5As and production of this model was discontinued. It had also taken delivery of 97 F–5Bs, against 106 on order, and further procurement was a possibility. Production of the RF–5A was completed with 89 deliveries—all allocated to the Military Assistance or the Foreign Military Sales Programs. Against 325 F–5Es under contract since December 1970, only 13 had been accepted by 30 June 1973. These 13 F–5Es, and 13 more to come, were the only ones earmarked for USAF use. Final F–5E deliveries were scheduled for January 1977, but additional foreign sales might keep the program going even longer. Production of the two-seat F–5F had not started. Yet, there was little doubt that it would soon materialize.

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TECHNICAL DATA

F–5A/B and RF–5A

Manufacturer		Northrop Corporation, Norair Division, Hawthorne, Calif.
Nomenclature	(F–5A)	Supersonic Tactical Fighter.
	(F–5B)	Supersonic Tactical Fighter/Trainer.
	(RF–5A)	Supersonic Tactical Reconnaissance Aircraft.
Popular Name		Freedom Fighter

Characteristics	*F–5A*	*F–5B*	*RF–5A*
Length/Span[10]	47.1/25.3 ft	46.5/25.3 ft	47.1/25.3 ft
Engines, Number & Designation	2GE–J–85–13	2GE–J–85–13	2GE–J–85–13
Max. Takeoff Weight	19,736 lb	19,736 lb	19,736 lb
Takeoff Ground Run	6,750/2,550 ft	6,750/2,550 ft	6,750/2,550 ft
Average Cruise Speed	480 kn	480 kn	480 kn
Max. Speed	1.4 Mach	1.35 Mach	1.4 Mach
Range (tanks dropped)	1,400 nm	1,400 nm	1,400 nm
Combat Ceiling	50,000 ft	50,000 ft	50,000 ft
Rate of Climb (Max.)	28,700 fpm	28,700 fpm	28,700 fpm
Radius H-L-H[11]		475	
Crew	1	2	1
Ordnance—Max. Tons[12]	2.95	2.95	2.95
Guns (internal)	2 M–29s (Colt-Browning)	None	2 M–39s (Colt-Browning)

[10] Span included a 50-gal nondroppable tank at each wing tip.

[11] Full internal and external fuel plus 1,990-lb payload.

[12] Including combination of missiles (AIM–9B Sidewinder AAMs, AGM–12B Bullpup ASMs), rockets (LAU–3/As and LAU–10/As) and bombs (MK–84s, MK–83s, M–117s, BLU–1/Bs, MK–82s, and MK–81s).

TECHNICAL DATA

F-5E

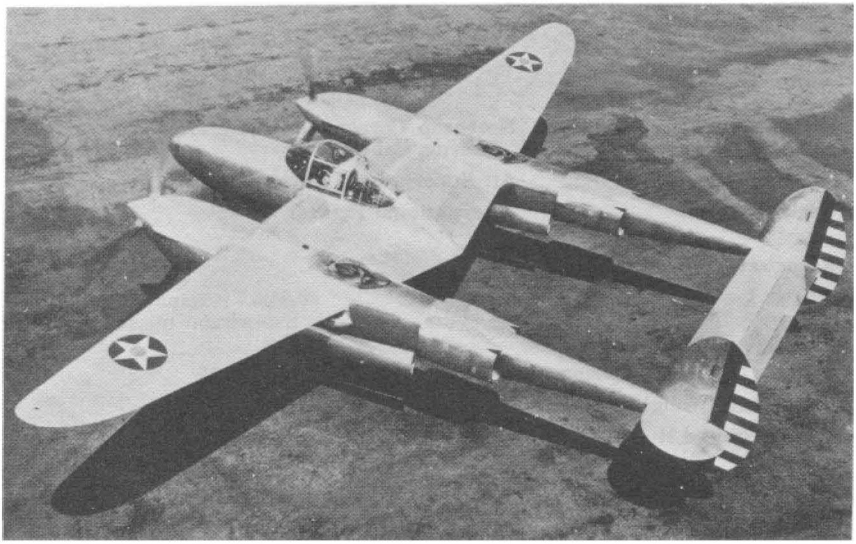
Manufacturer	Northrop Corporation, Aircraft Division, Hawthorne, Calif.
Nomenclature	Air Superiority Fighter Aircraft.
Popular Name	International Fighter

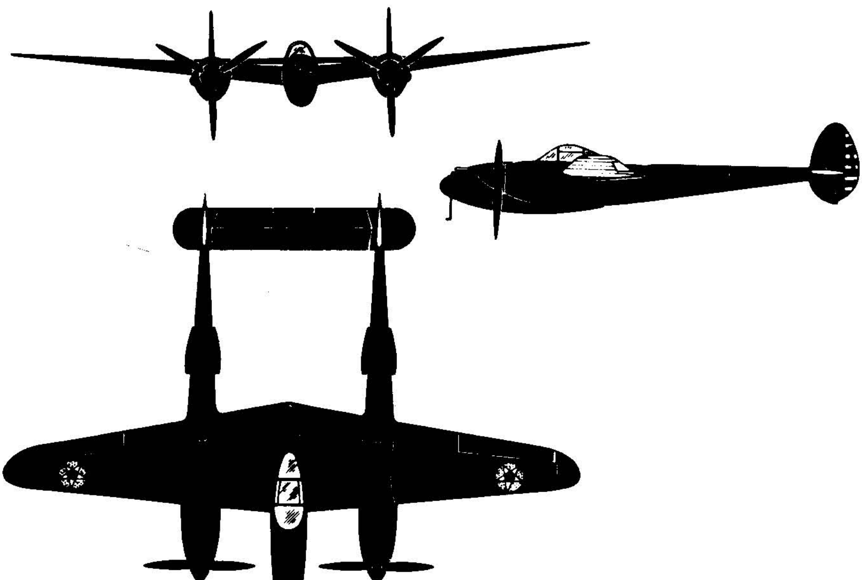
Characteristics

Length/Span (ft)	48.2/26.7 (excluding AIM-9E Sidewinder missiles on wing tips)
Engines, Number & Designation	2J85-GE-21
Max. Takeoff Weight (lb)	24,018
Takeoff Ground Run (ft)	1,800 (at 15,292 lb)/5,100 (at 24,018 lb)
Average Cruise Speed (kn)	500
Max. Speed	1.51 Mach
Ferry Range (nm), w/3 275-gal tanks	1,555 (AIM-9 missiles on wing tips)
Combat Ceiling (ft)	52,500
Rate of Climb (fpm)	33,500
Radius (nm)[13]	415 (w/1 275-gal tank)
Crew	1
Ordnance—Max. Tons[14]	3.08
Guns (Internal)	2 M-39s (Colt-Browning)

[13] Combat Air Patrol (subsonic intercept); AIM-9 missiles on wing tips.

[14] Combination of missiles (AIM-9E Sidewinders), rockets (LAU-3/As and LAU-59/As), bombs (MK-84s, MK-1117A1s, CBU-24/49s, BLU-27/Bs, BLU-32/Bs, and MK-82s), and ammunition (20-mm).





LOCKHEED P–38 LIGHTNING

First flown across the Nation from California, to a crack-up landing at Mitchel Field, Long Island, on 11 February 1939 (with Lt. Ben Kelsey as pilot).

APPENDIX I

WORLD WAR II FIGHTERS IN THE POST-WAR PERIOD

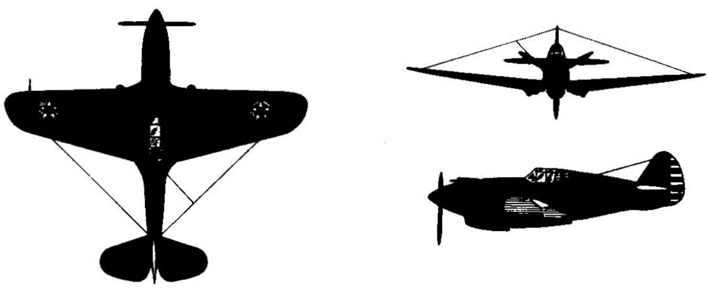
LOCKHEED P-38 LIGHTNING

One of the best known WW II fighters, produced in various configurations and used in a variety of roles. Redesignated F–38 in mid-1948, a few Lightnings (F–38J and F–38L) survived the post-war years until 1949, when they were declared surplus.

First Flight	February 1939
First Deliveries	June 1941
Total P–38s Accepted	9,395
Flyaway Cost Per Production Aircraft	$134,284

TECHNICAL DATA

	P–38J	P–38L
Length/Span (ft)	52/37.10	52/37.10
Empty Weight (lb)	12,780	12,800
Gross Weight (lb)	21,600	21,600
Engine, Number & Designation	2V–1710–89/91	2V–1710–111/113
Max. Speed (kn) (at 25,000 ft)	359.5	359.5
Service Ceiling (ft)	44,000	44,000
Range (nm)	391	391
Armament	1 20-mm gun 2 0.50-in machine-guns 2 1,600-lb bombs	1 20-mm gun 2 0.50-in machine-guns 2 1,600-lb bombs
Crew (enclosed cockpit)	1	1



CURTISS P–40 WARHAWK

Curtiss developed the P–40 from its P–36. The experimental P–40 flew for the first time on 14 October 1938.

CURTISS P-40 WARHAWK

Evaluated at Wright Field, Ohio, in May 1939 in competition with other pursuit prototypes. Immediately selected for procurement under a first contract worth nearly $13 million—the largest order placed at the time for a US fighter. The entire P–40 fleet, however, was phased out prior to 11 June 1948, when the newly formed United States Air Force renamed all pursuit aircraft as fighters.[1]

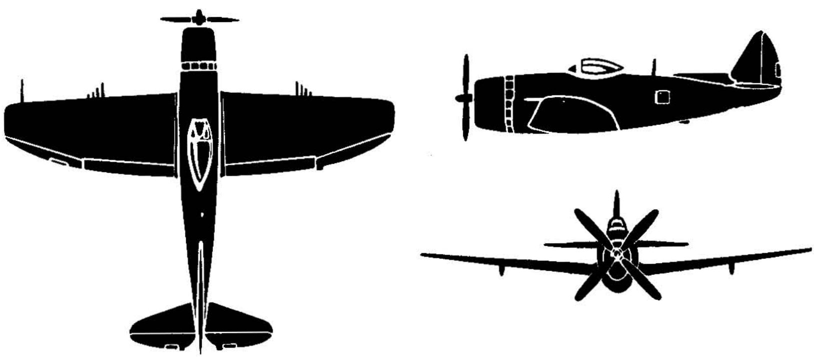
First Deliveries	May 1940
Total P–40s Accepted	12,302
Flyaway Cost Per Production Aircraft	$60,552

Technical Data[2]

	P–40	P–40N–20
Length/Span (ft)	31.9/37.4	33.4/37.4
Weights: Empty (lb)	5,376	6,000
Gross (lb)	7,215	8,850
Engine, Number & Designation	1V–1710–33	1V–1710–81
Max. Speed (kn at ft)	310/15,000	328/10,500
Service Ceiling (ft)	32,750	38,000
Range (nm)	826	208.6
Armament	2 0.50-in machine-guns	6 0.50-in machine-guns 1 500-lb bomb
Crew (enclosed cockpit)	1	1

[1] Allocation of the F prefix to the Douglas A–24 attack bomber was an exception. A few F–24s remained in the USAF inventory until 1950.

[2] First and last models.



REPUBLIC P-47 THUNDERBOLT

Toward the end of WW II, better than 40 percent of all AAF fighter groups serving overseas were equipped with the rugged P-47s.

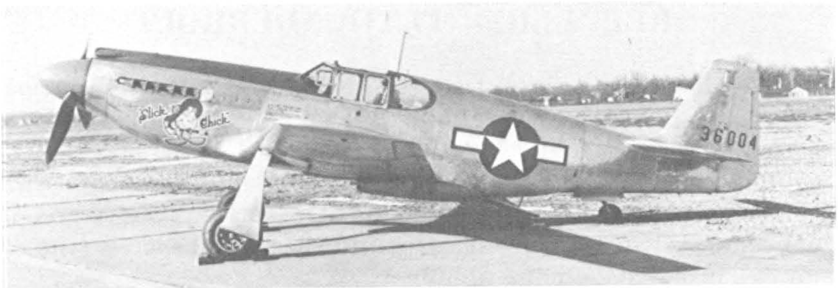
REPUBLIC P-47 THUNDERBOLT

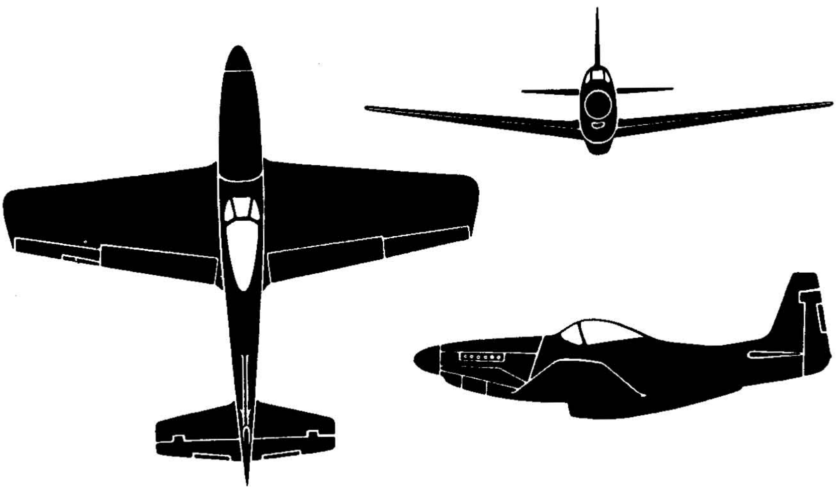
Single-engined, single-seat escort fighter and fighter-bomber. Conceived, tested, produced, and put into action wholly within the period of World War II. P-47 Thunderbolts (F-47Ds and F-47Ns) equipped SAC, TAC and ADC squadrons for a number of postwar years. They subsequently reached the Air National Guard and did not completely pass out of service until 1955. The F-47 was the Air Force's last radial-engine fighter.

First Flight (prototype)	6 May 1941
First Deliveries	1942
Total P-47s Accepted	15,686
Flyaway Cost Per Production Aircraft	
First 733	$113,246
Others	$83,000

Technical Data

	P-47D-25	P-47N
Length/Span (ft)	36.1/40.9	36.1/42.7
Empty Weight (lb)	10,000	11,000
Gross Weight (lb)	19,400	20,700
Engine, Number & Designation	1R-2800-59	1R-2800-77
Max. Speed (kn at ft)	372/30,000	405/32,500
Service Ceiling (ft)	42,000	43,000
Range (nm)	413	696
Armament	8 0.50-in machine-guns 2 1,000-lb bombs	8 0.50-in machine-guns 2 1,000-lb bombs
Crew (enclosed cockpit)	1	1





NORTH AMERICAN P–51 MUSTANG

The single-engine, low-wing P–51 monoplane flew its first long escort mission on 13 December 1943—490 miles to Kiel and back—which was the record to date.

Following the capture of Iwo Jima in February 1945, the P–51s added to their already secure reputation as the world's best escort by aiding the B–29s in their mounting assault on Japanese targets.

NORTH AMERICAN P-51 MUSTANG

The P–51 was developed in record time to satisfy a British World War II requirement. The first prototype, minus engine, rolled out at Inglewood, California, only 117 days after work on the design had begun. The United States adopted the plane for its own use in 1942, ordering 2,000 P–51Bs. These were a ground attack variant of the Royal Air Force P–51 single-seat fighter. The P–51B was followed in the AAF inventory by the P–51D, its numbers exceeding all other P–51 models combined.

P–51s of one kind or another saw service far beyond WW II. Two models (F–51B and F–51K) equipped active operational forces until 1951. Moreover, two other types of the redesignated P–51 (F–51D and F–51H) were flown by Air Reserve and Air National Guard units for several more years.

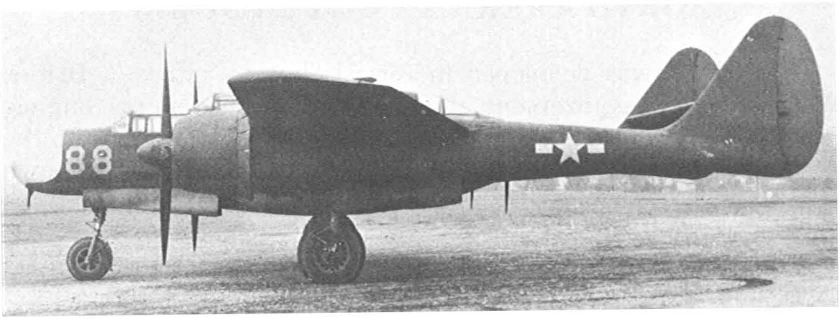
The F–51 was one of the first USAF fighters to participate in the Korean War, arriving in the fall of 1950. Twenty-two ANG units also served there, flying combat F–51s and their reconnaissance counterparts (RF–51Ds and RF–51Ks). The obsolete and tired F–51 finally withdrew from combat on 26 January 1953. The ANG retired its last propeller-driven F–51s in 1957.

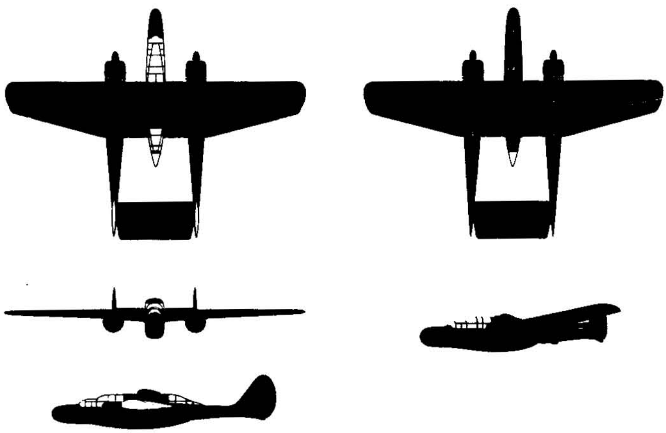
First Flight (prototype)	October 1940
First Flight (Production Aircraft) ...	October 1941
Enters Operational Service (P–51Bs)	December 1943
Total P–51s Accepted	14,068
Unit Cost (1945)	$50,985

Technical Data

	P–51B	P–51D/K	P–51H/M
Length/Span (ft)	32.3/37	32.3/37	33.4/37
Empty Weight (lb)	6,985	7,125	6,585
Gross Weight (lb)	11,800	11,600	11,054
Engine, Number & Designation	1 V–1650–3	1V–1650–7	1V–1650–9
Max. Speed (kn at ft)	382/30,000	379/25,000	434/25,000
Service Ceiling (ft)	41,800	41,900	41,600
Range (nm)	348	826	739
Armament	4 0.50-in machineguns 2 1,000-lb bombs	6 0.50-in machineguns 2 1,000-lb bombs	6 0.50-in machineguns 2 1,000-lb bombs or (10) 5-in rockets
Crew (enclosed cockpit)[3]	1	1	1

[3] Pilot and instructor in tandem in TP–51.





NORTHROP P–61 BLACK WIDOW

The two-engine P–61, which saw service during the last year of the war, was an all-metal monoplane with a twin fuselage and a twin tail, somewhat resembling the P–38 but much larger.

The most notable feature of the P–61 was the large quantity of radar and communications equipment it carried in order to permit effective night operation.

The P–61 proved to be highly maneuverable, more so than any other AAF fighter.

NORTHROP P-61 BLACK WIDOW

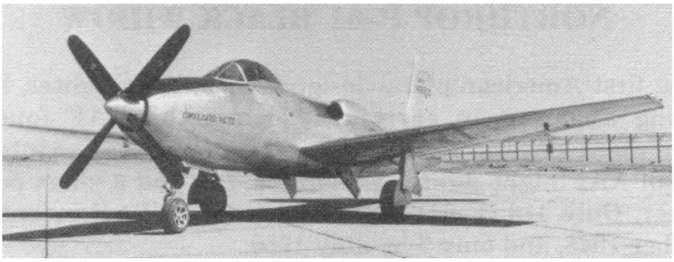
The first American plane designed as a night fighter, its need becoming apparent in early 1940, when the RAF fought off German night attacks. The P–61 quickly supplanted the interim P–70s in all AAF night fighter squadrons, but had a short post-WW II career. Only 116 (F–61s) remained in the USAF inventory by December 1948, and only 2 by July 1950.

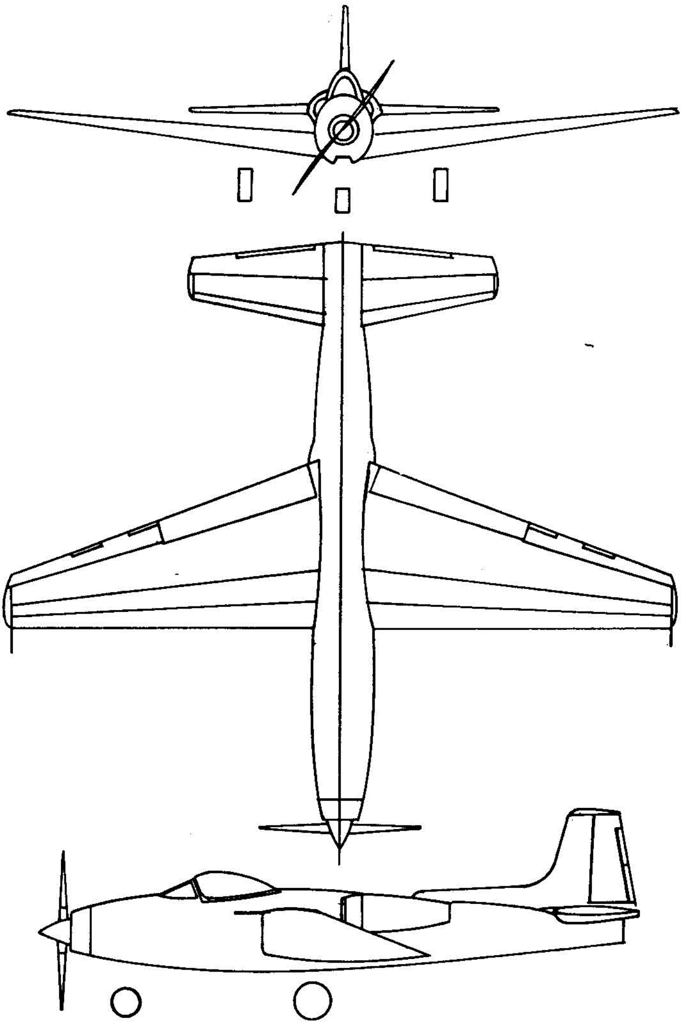
First Flight (XP–61)	26 May 1942
First Deliveries	July 1943
Total P–61s Accepted	704[4]
Average Unit Cost	About $190,000

Technical Data P–61B

Length/Span (ft)	49.7/66
Empty Weight (lb)	22,000
Gross Weight (lb)	29,700
Engine, Number & Designation	2R–2800–65 piston radials
Max. Speed (kn at ft)	317.8/20,000
Service Ceiling (ft)	33,100
Ferry Range (nm)	2,608.6
Armament	4 0.50-in machineguns, forward firing 4 20-mm guns, in remote-controlled top turret 4 1,600-lb bombs, under wings
Crew	3 (pilot, radar operator and gunner)

[4] Including prototypes and test aircraft, but excluding 36 reconnaissance models. These were accepted as F–15As, redesignated RF–61Cs in 1948, and phased out by 1952.





CONSOLIDATED-VULTEE XP-81

First American turboprop-powered aircraft to fly, its most significant features were the incorporation of a turboprop engine in the nose and a turbojet engine in the rear.

The two test aircraft completed a total of 89 hours and 45 minutes of flying time.

APPENDIX II

POST-WW II EXPERIMENTAL AND PROTOTYPE JET FIGHTERS

CONSOLIDATED-VULTEE XP-81

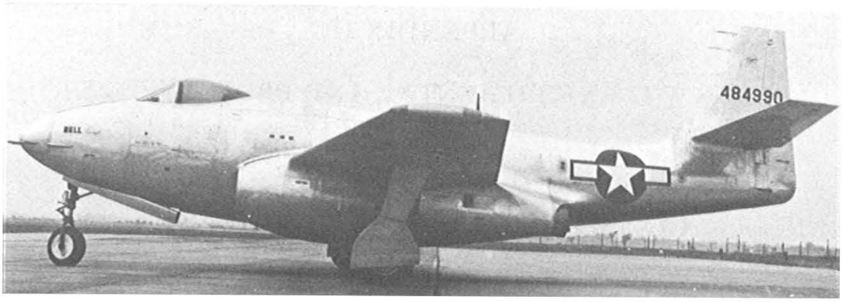
Low-wing monoplane to satisfy AAF escort fighter requirements of September 1943.

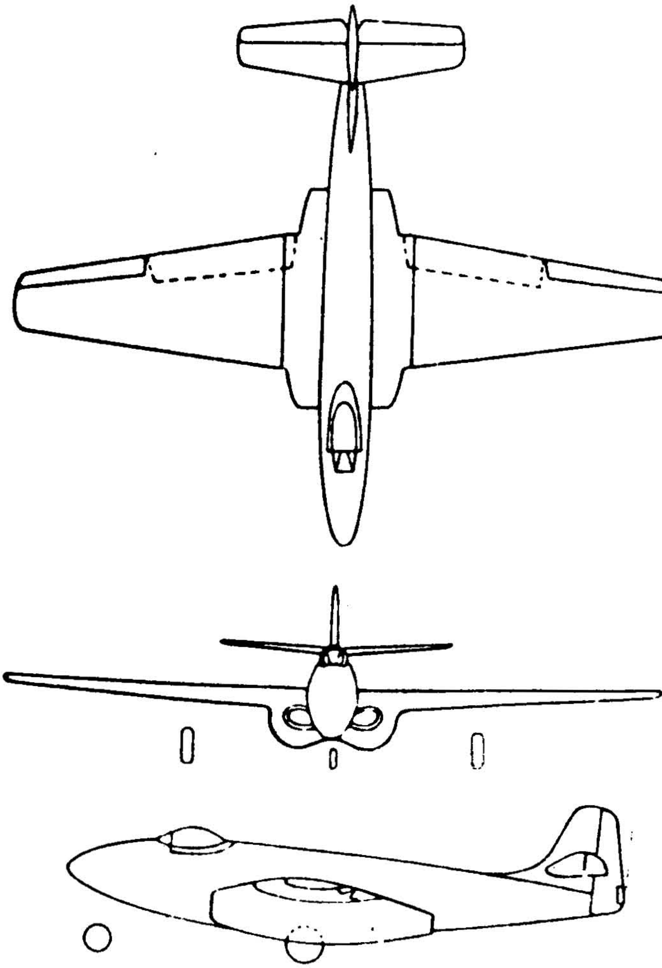
Initial Contract Date	18 January 1944
First Flight (experimental)	7 February 1945
Quantity on Order	2 XP–81s, 11 YP–81s
Total Aircraft Accepted	2 XP–81s
RDT&E Costs	$4.6 Million
Status (11 YP–81s)	Cancelled

Technical Data

Length/Span (ft)	44.10/50.6
Loaded Weight (lb)	24,650
Engine, Number & Designation	2J–33–GE & XT–31[1]
Max. Speed (kn)	440
Crew	1

[1] The high-fuel consumption of early jet fighters prompted Convair to equip the XP–81 with a turboprop and jet combination. A Rolls-Royce Merlin V–1650 engine, manufactured by Packard, replaced the yet to be available General Electric TG–100 (XT–31) turboprop during the initial tests.





BELL XP-83

A "blown-up" version of the jet-propelled Airacomet, first flown on 1 October 1942. The XP-83 featured heated wings and a pressure cabin. Its engines were mounted under the wings, by the fuselage side. It would normally be armed with six .50-caliber machineguns.

The XP-83's bulky shape allowed the proposed escort to carry huge quantities of fuel internally. External fuel tanks would increase the XP-83's range even further.

BELL XP-83

A development of the Bell Aircraft Corporation's disappointing P–59 Airacomet jet fighter. The proposed P–83 pressurized escort fighter did not see service.[2]

Initial Contract Date	11 March 1944
First Flight (experimental)	25 February 1945
Quantity on Order	2 XP–83s
Total XP–83s Accepted	2
RDT&E Costs	$4.2 Million

Technical Data

Length/Span (ft)	44.10/53
Loaded Weight (lb)	24,090
Engine, Number & Designation	2J–33–GE–5
Max. Speed (kn)	468
Crew	1

[2] The fact that a plane did not go into production did not necessarily mean the design was bad. Numerous experimental projects were dropped merely because the war was over. Tight budgets became the rule even after the start of the Korean War, when most funds were spent on operational forces. Moreover, there was an amazing surge in technology that brought forth complex weapon systems of staggering cost. Research and development had to continue, but many factors entered into the selection of later Air Force weapons.

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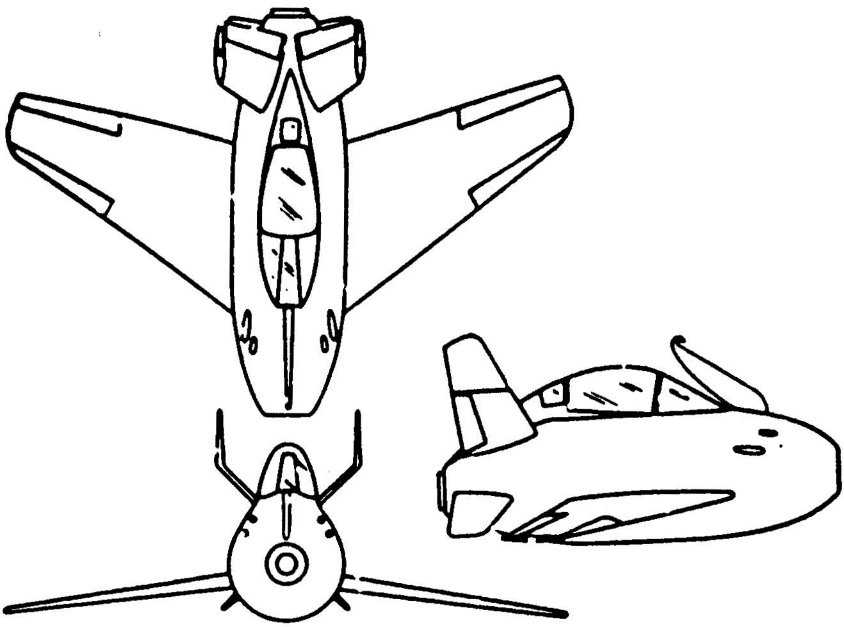
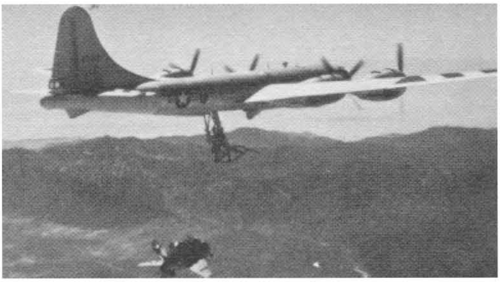


McDONNELL XF–85 GOBLIN

Perhaps no aircraft ever was better nicknamed as the little, short Goblin.
It took four years to develop the XP–85. But, in spite of its small size and high speed, the plane performed well.



McDONNELL XP-85 GOBLIN

Developed as the XP–85, this folding-wing escort pursuit fighter was intended to be carried into combat by the huge B–36.[3] The project survived,[4] but use of the Goblin was abandoned after test drops from a B–29.

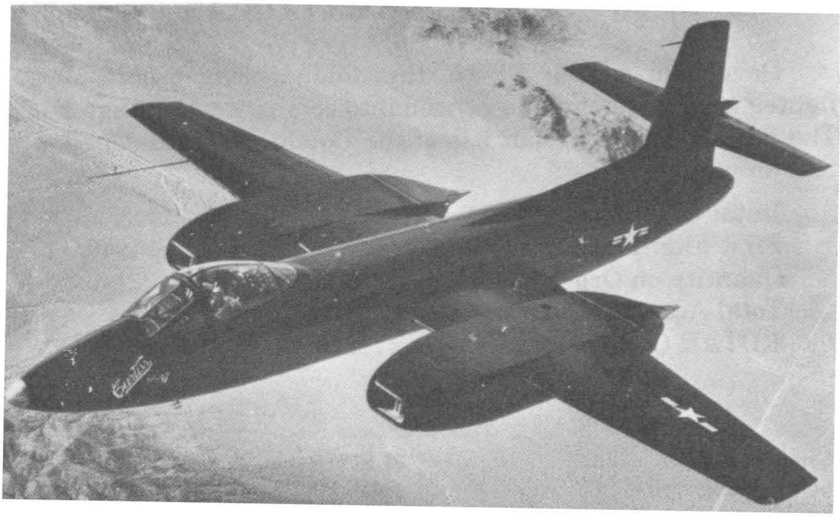
Inital Contract Data	October 1945
First Flight (experimental)	23 August 1948
Quantity on Order	2 XP–85s
Total Accepted (XF–85s)	2
RDT&E Costs	$3.1 Million

Technical Data

Length/Span (ft)	14.10/21.2
Loaded Weight (lb)	4,836
Engine, Number & Designation	1XJ–34–WE–22
Max. Speed (kn)	451.5
Crew	1

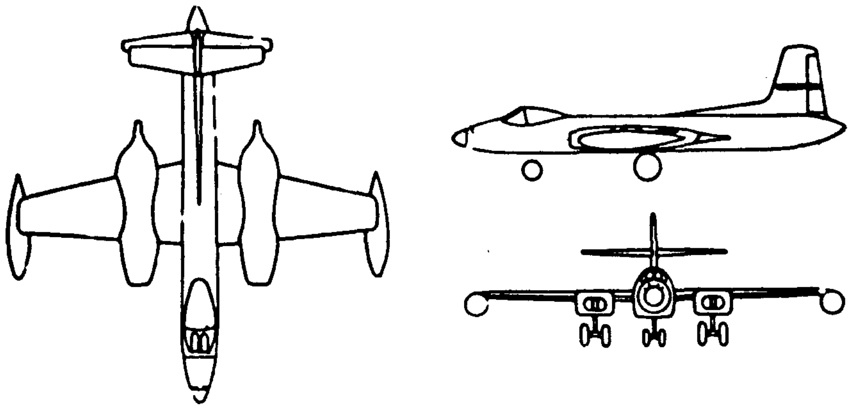
[3] Although not new, the idea of a bomber carrying its own defending fighter was still fraught with danger. If the bomber was destroyed before the fighter was launched, both would be lost. If the bomber was shot down after the launching, the fighter lacked the range to make it back home. Finally, retrieving the fighter in the heat of battle would be no small feat.

[4] It shifted to reconnaissance, with the successful launch in May 1953 of an RF–84 from a modified B–36.



CURTISS XF-87 BLACKHAWK

It took 34 months to develop the big, sleek Blackhawk—last of the Curtiss-built planes.



CURTISS XF-87 BLACKHAWK

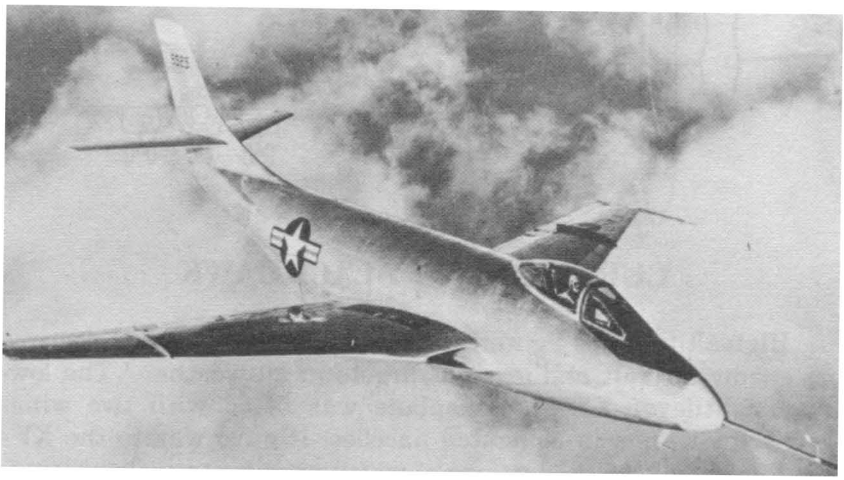
High-altitude jet fighter, capable of seeking out and destroying enemy aircraft and ground targets in all weather.[5] The low-wing, cantilever XF–87 monoplane was fitted with two wing-mounted jet units in elongated nacelles. It gave way to the XF–87A Blackhawk, 80 productions of which were tentatively ordered, but later cancelled in favor of the Northrop F–89. The XF–87A was never flown.

Initial Contract Date	26 December 1945
First Flight (experimental)	15 February 1948
Quantity on Order	2
Total Accepted	2
RDT&E Costs	$11.3 Million

Technical Data

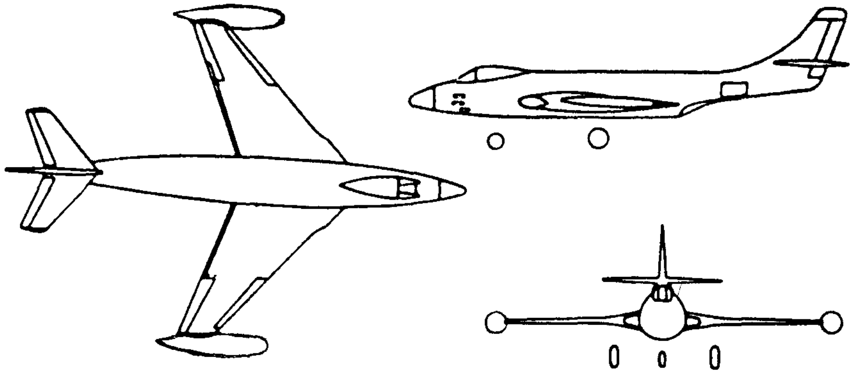
Length/Span (ft)	65.6/60
Loaded Weight (lb)	49,687
Engine, Number & Designation	4J–34–WE–7
Max. Speed (kn)	451.5
Crew	2 (pilot and radar observer)

[5] As called for by the military characteristics of 23 November 1945. A subsequent set of military characteristics required the aircraft to operate at night as well as in inclement weather. This would be the XF–87A, a modified XF–87, equipped with J–33 engines. A reconnaissance version of the Blackhawk was also seriously considered.



McDONNELL XF-88 VOODOO

Four years of development accounted for the XF-88 that later became the F-101—the two shared the same nickname.



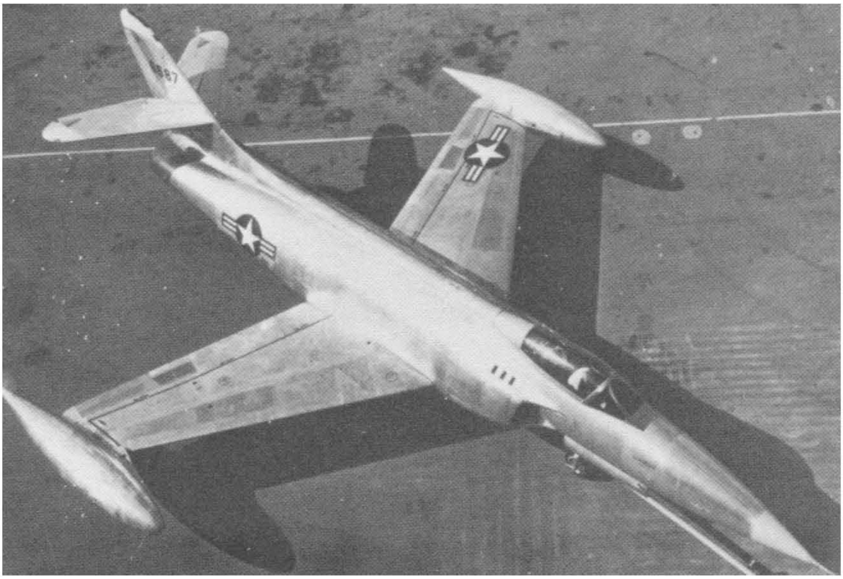
McDONNELL XF-88 VOODOO

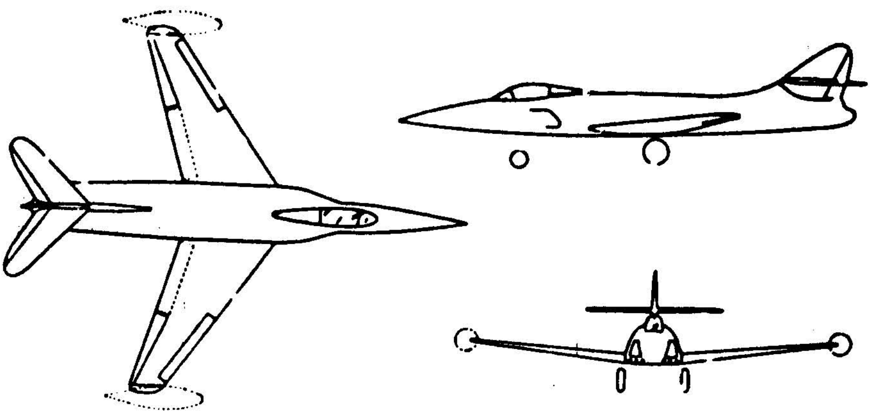
A penetration fighter, reconfigured by May 1951, and redesignated F–101 on 30 November. The Voodoo program did fairly well after a bad start. When production ended in 1961, 705 F–101s of various types had been built.

Initial Contract Date	13 June 1946
First Flight (experimental)	20 October 1948
Quantity on Order	2
Total Accepted	2
RDT&E Costs	$6.6 Million

Technical Data

Length/Span (ft)	54.2/39.8
Loaded Weight (lb)	18,500
Engine, Number & Designation	2J–34–WE–13
Max. Speed (kn)	556.6
Crew	1





LOCKHEED XF-90

After 37 months of development and 13 months of flight tests, the one-man XF-90 never went to production.

LOCKHEED XF-90

A heavy penetration fighter, the needle-nosed XF–90 broke the sonic barrier 15 times. Nonetheless, the engines did not give the expected thrust, even with afterburners. The XF–90 lost out to McDonnell's reconfigured XF–88 Voodoo in the Air Force design competition of May 1951.

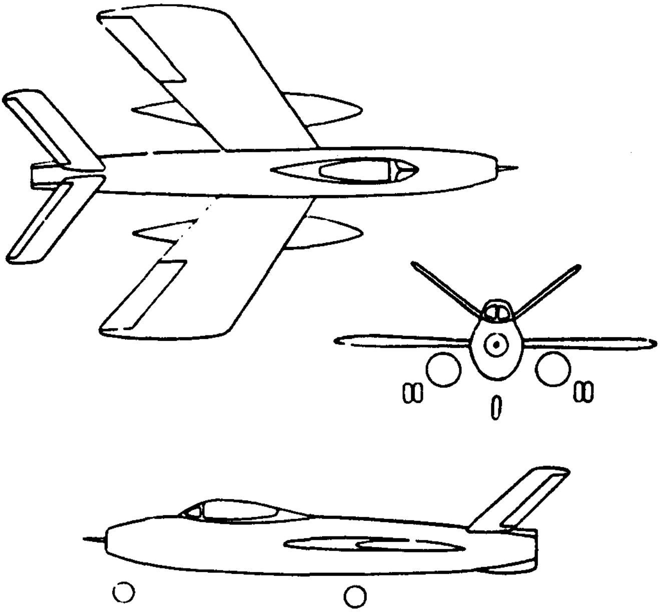
Initial Contract Date	20 June 1946
First Flight (experimental)	4 June 1949
Quantity on Order	2
Total Accepted (XF–90s)	2
RDT&E Costs	$5.1 Million

Technical Data

Length/Span (ft)	56.2/39.2
Loaded Weight (lb)	26,900
Engine, Number & Designation	2J–34–WE–11/22
Max. Speed (kn)	616.5
Crew	1

REPUBLIC XF–91

A novel feature was the proposed use of built-in rocket engines to augment the thrust of the XF–91's basic turbojet.



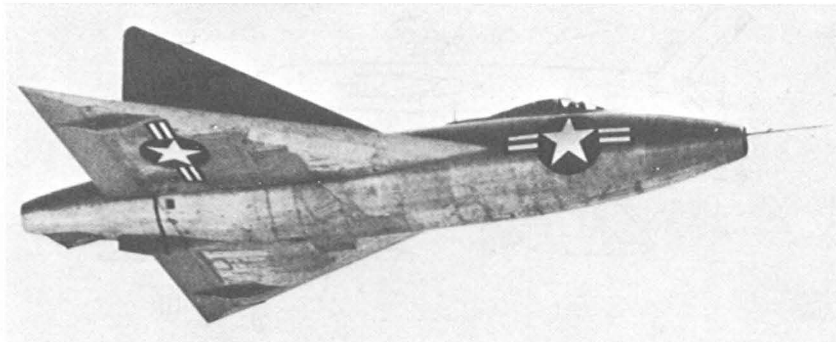
REPUBLIC XF-91 THUNDERCEPTOR

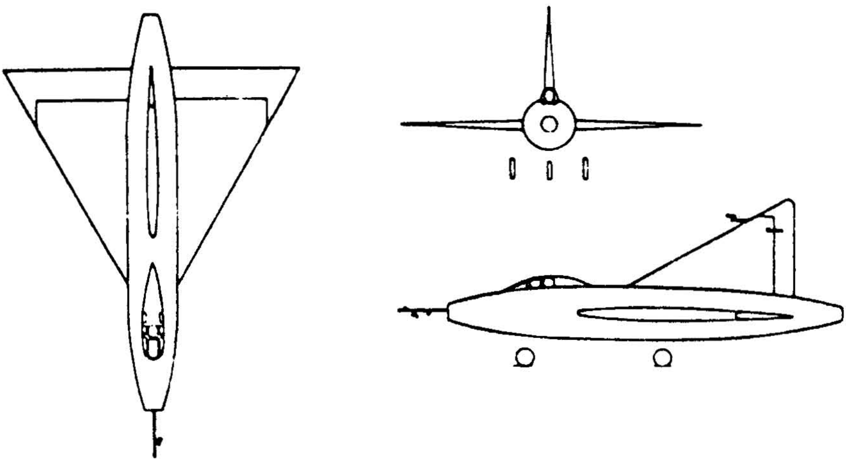
First developed as a penetration fighter, then considered as an interim interceptor. The Republic interceptor design was characterized by variable incidence (adjustable wing angle of attack) and inversely tapered wings. The Air Force's decision in 1951 to speed up the Convair interceptor program halted further development of the experimental F–91A interceptor. Work stopped in October, following the mockup inspection. The two XF–91s, already available, had completed performance capability tests utilizing turbojet and afterburner power. The Air Force used the two planes as high-speed armament test vehicles, after augmenting their engines with rocket motors—a proposed built-in feature of the cancelled XF–91A.

Initial Contract Date	March 1946
First Flight (experimental)	9 May 1949
Quantity on Order	2
Total Accepted (XF–91s)	2
RDT&E Costs	$11.6 Million

Technical Data

Length/Span (ft)	43.3/31.3
Loaded Weight (lb)	28,516
Engine, Number & Designation	1J–47–GE–3
Max. Speed (kn)	642.5
Crew	1





CONSOLIDATED VULTEE XF–92A

In the XF–92A the Allison J–33–A23 turbojet took the place of the 18 rocket engines proposed for the XF–92—a rocket-propelled, piloted missile that was never built.

CONSOLIDATED-VULTEE XF-92A

The first American delta-wing aircraft flown. Dr. Alexander Lippisch, World War II leader of the German delta-wing program, assisted in its design. The XF-92 was the forerunner of the Convair F-102 interceptor.[7]

Initial Contract Date	16 May 1949
First Flight (XF-92A)	18 September 1948
Quantity on Order	3—XF-92As[8]
Total Accepted (XF-92As)	1[9]
RDT&E Costs	$4.3 Million

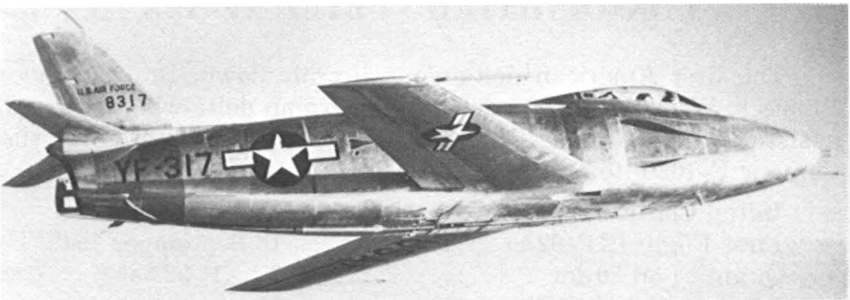
Technical Data

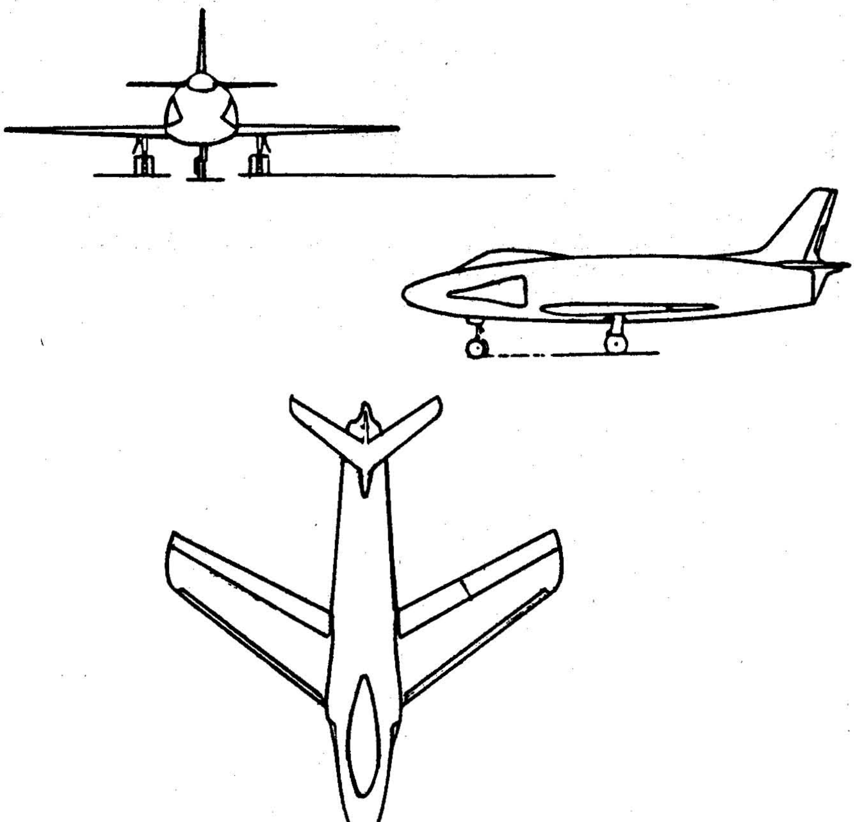
Length/Span (ft)	42.5/31.3
Loaded Weight (lb)	13,000
Engine, Number & Designation	1J-33-A-23/29
Max. Speed (kn)	547
Crew	1

[7] Consolidated-Vultee merged with General Dynamics, becoming the Convair Division of that corporation on 29 April 1954.

[8] The first XF-92A flew in October 1949. The other two were cancelled.

[9] The Air Force handed over the plane to NACA in 1952.





NORTH AMERICAN YF-93A

The F-86C was redesignated as the F-93A in September 1948; committed to production in February 1949; and cancelled in June.

NORTH AMERICAN YF-93A

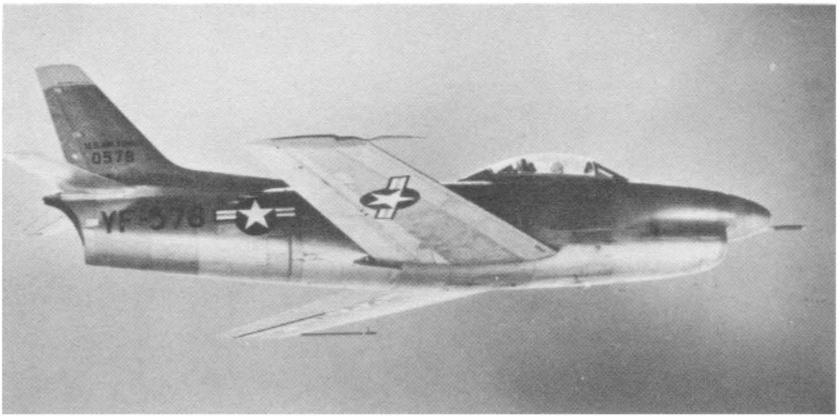
This plane was meant to become the F–86C, with 118 productions on order since 9 June 1948. But its design departed so drastically from the basic F–86 Sabre, it was redesignated F–93A. This led to the cancelling of the productions and the subsequent order of two prototypes. During the Air Force competition of May 1951 the North American YF–93A (like the Lockheed XF–90 penetration fighter) lost out to McDonnell's reconfigured Voodoo.

Initial Contract Date	February 1949
First Flight (prototype)	25 January 1950
Quantity on Order	2
Total Accepted (YF–93As)	2[10]
RDT&E Costs	$11.5 Million

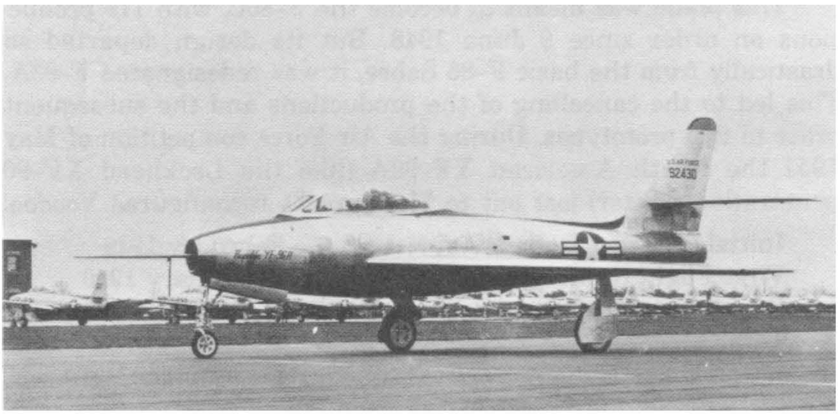
Technical Data

Length/Span (ft)	44.1/38.9
Loaded Weight (lb)	25,500
Engine, Number & Designation	1J–48–P–3/6
Max. Speed (kn)	615.6
Crew	1

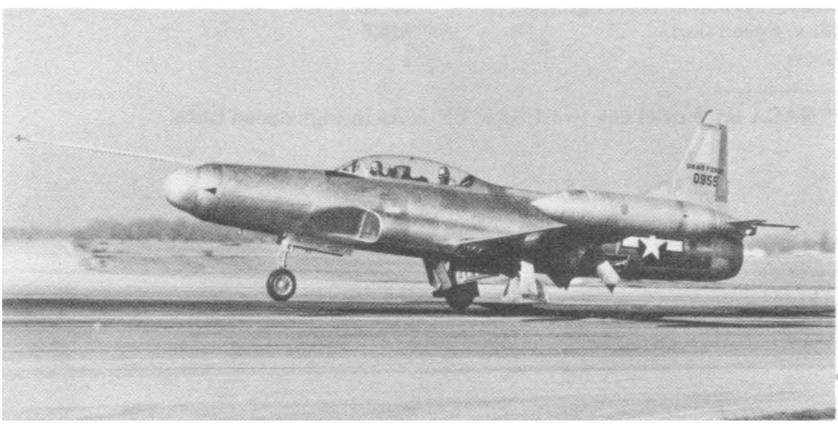
[10] NACA later used the two USAF YF–93As in high-speed tests.



XF-95A



YF-96A



YF-97A

NORTH AMERICAN XF-95A

The XF–95 appeared on the contractor's drawing boards in March 1949. Its story proved a complete reversal of the North American YF–93A's. The single-seat XF–95A, successfully flown in September 1949, was basically a F–86 with a nose radar and engine afterburner. Although in the operational inventory less than a year, the F–86A was considered the best USAF jet fighter. Hence, the Air Force quickly endorsed the North American YF–95A and redesignated it F–86D. Some 2,500 F–86Ds were built, a few remaining in the active forces until April 1958.

REPUBLIC YF-96A

A swept-wing fighter-bomber, proposed by Republic in November 1949, when USAF development funds were at the lowest ebb. The Republic drawing, based on a standard F–84E fuselage, gave hope that available tooling could be used at considerable savings. The Air Force in consequence returned one F–84E to the contractor for prototype development. This so-called YF–96A was flown on 3 June 1950, but it took the Korean War to prompt its production. The Air Force then requested that the plane be given a better engine and a more logical designation. A new prototype flew in February 1951, 5 months after being relabeled the YF–84F. More than 2,300 of this swept-wing, single-seat fighter-bomber were eventually built.

LOCKHEED YF-97A

Lockheed began work on this prototype in early 1949, using a converted F–94A. The YF–97A flew in January 1950, becoming the first straight-wing aircraft (other than experimental) to exceed the speed of sound. Hard-pressed to get a better interim interceptor, the Air Force in February 1950 placed a tentative production order for 110 F–97As (renamed F–94Cs in September). The program for this third, biggest, and last of the F–94 model series did not fare as well as expected.

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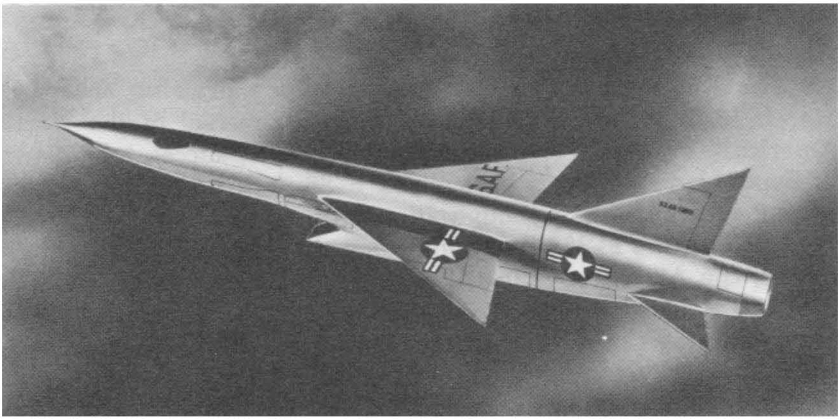
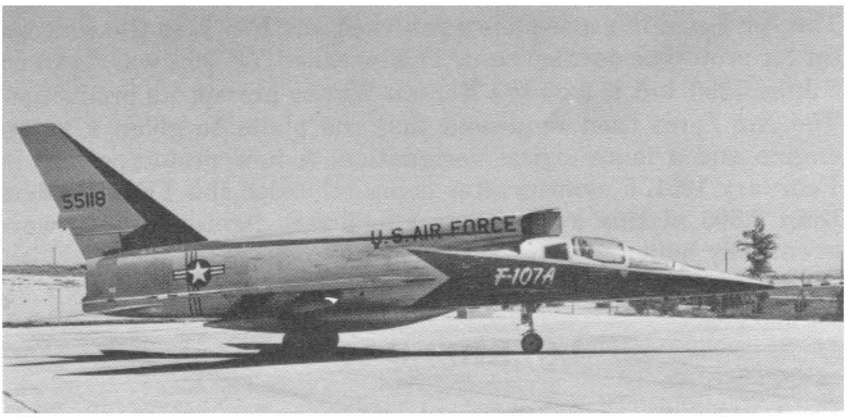


XF-103



YF-107A

REPUBLIC XF-103

The experimental and never flown F–103 originated in early 1948 with the Republic AP–44A design for an all-weather, high-altitude defense fighter. The contractor sent its design to the Air Force in January 1951, and in September received a Phase I development contract for the highly sophisticated plane, listed on Air Force books as Weapon System 204A.

A full-scale mockup on 2 March 1953 brought a major configuration change,[11] an 18-month extension of the Phase I contract, and further state-of-the-art studies of titanium fabrication, high-temperature hydraulics, escape capsules, and periscopic sights. The Air Force also decided to keep the program going with scarce research and development money. This would include prototype and flight testing, usually covered by procurement support funds. Republic finally obtained a contract for three XF–103s in July 1954. However, progress inched along, hindered by low titanium priority, difficulties in the making of titanium alloy, engine development problems, and critical funding.

The XF–103 program was pared to one plane and two flight engines early in 1957. In September the contract for the Mach 3, 80,000-ft altitude delta-wing XF–103 was cancelled,[12] development being too slow to justify further expense. The program had cost $104 million over 9 years.

NORTH AMERICAN YF-107A

This plane was conceived in 1953 as the second model of the F–100 Sabre series. It was due to differ from the basic F–100A tactical fighter by being able to also serve as a bomber. But new requirements in December 1954 generated such extensive changes that the projected F–100B designation was dropped—the proposed plane being renamed F–107A before the prototype flew.[13] The promising F–107A tempted the Air Force in mid-1956 to cancel the Republic contract for the F–105, which had run into production problems. It held off, however, because even under ideal conditions the F–107A could not be available as soon as the F–105. NASA finally used the USAF YF–107As in supersonic research. One was later returned for permanent display in the Air Force Museum.

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[11] The mockup inspection called for replacement of the canopy by a flush cockpit with periscope.

[12] So was the contract for the Wright MX–1787 dual-cycle turbojet-ramjet.

[13] The F–100B was skipped. The F–100A was followed by the F–100C, which embodied numerous features of the original F–100B design.

Initial Contract Date	29 February 1956
First Flight (experimental)	10 September 1956
Quantity on Order	12 (prototypes and test aircraft)
Total Accepted (YF–107As)	3
RDT&E Costs	None[14]

Technical Data

Length/Span (ft)	61/36
Takeoff Weight (lb)	38,000
Engine, Number & Designation	1 J–75–P–9 with afterburner
Max. Speed (kn)	Over Mach 2
Service Ceiling (ft)	Above 50,000
Crew	1

NORTH AMERICAN XF-108 RAPIER

First known as the LRIX (long-range interceptor, experimental), development of the XF–108 followed USAF GOR 114, dated 6 October 1955. The North American letter contract of 6 June 1957 called for an all-weather, two-man, two-engine, long-range interceptor, with a combat speed of at least Mach 3 and swift maneuver at 70,000 feet. The aircraft would carry two or more air-to-air missiles with nuclear or conventional warheads. The armament bay was to house a number of weapon combinations.

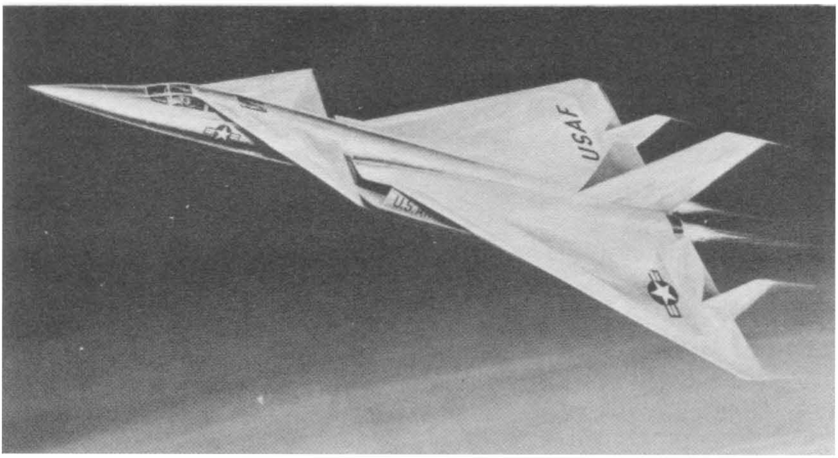
The Air Force expected a lot from the complex new plane.[15] It wanted an early 1963 operational date, 1,000-nm cruise speed with 5 minutes of combat at Mach 3, and a cruise speed of Mach 3 for 350-nm and 10 minutes of combat time (also at Mach 3). Finally, the F–108 should be able to fly to a specified point at supersonic speed, loiter for about an hour, and speed on to the target.

A mockup inspection on 26 January 1959 disclosed few needed changes. Nonetheless, the XF–108 (nicknamed the Rapier on 15

[14] The YF–107A program from the start was paid with procurement support funds. Total cost (flight testing included) had reached $105.8 million, when production of the nine planes remaining on order was cancelled.

[15] Many subcontractors were involved. Hughes Aircraft Corporation would provide the aircraft's fire-control system and GAR–9 missiles; Convair, the wing; Marquardt, the air induction control system; Hamilton Standard, the air conditioning and pressurization; Federal Division of the International Telephone & Telegraph Co., the mission and traffic control system; and Electronic Speciality Co., the antenna system. The Air Force would take care of the engine, the General Electric J–93 turbojet (first developed as the X–279E).

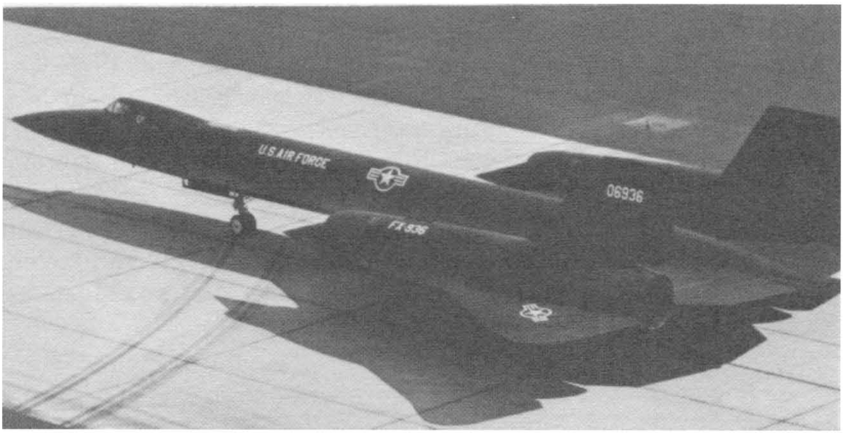
May 1959) never flew. The Air Force in 1957 had programmed for more than 480 F–108s, but the pinch in funds wiped out the whole project on 23 September 1959.[16] Total RDT&E expenditures then stood at $141.9 million.



XF-108 RAPIER

[16] The Air Force believed the F–108 would have been a good mobile missile launcher to intercept enemy aircraft far away from their intended targets. This was a role the B–70 bomber (being also built by North American and later consigned to the XF–108's fate) could not perform.

F-110A



YF-12A

McDONNELL F-110A[17]

This was to be the Air Force's first version of the Navy F4H Phantoms. The OSD decision on 3 August 1962 to standardize all Department of Defense aircraft designations, changed this planning. McDonnell's F4H–1 for the Navy became the F–4A, while the Air Force's first configuration of the basic F4H–1 was the F–4C.

LOCKHEED YF-12A

As a variation of the Lockheed A–11, the YF–12A interceptor (like SAC's SR–71s) originated in November 1959. This was 1 month after the OSD had cancelled the stainless steel XF–108, but let work continue on several of the aircraft's components.[18]

The Lockheed A–11 had a long narrow fuselage, twin engines, and a fixed delta-wing. Its first flight came in July 1962, only 32 months after the development contract was awarded. President Lyndon B. Johnson revealed the plane's existence on 29 February 1964. Designated YF–12A, this interceptor version of the almost all-titanium A–11[19] was unveiled at Edwards AFB on 30 September. The Air Force in October (SOR 220) set forth performance standards surpassing those first imposed on the North American Rapier. Specifically, it required from this IMI (improved-manned-interceptor) a combat radius up to 1,200 nm, Mach 3+ speed, and swifter maneuver at high altitude.

On 1 May 1965, two F–12A prototypes established nine world speed and altitude records that were unbroken 7 years later.[20] Nonetheless, the OSD discontinued development of the F–12 program on 27 November 1967, but ordered in the same month a new airborne warning and control system (AWACS). The OSD believed that the future AWACS and so-called F–106Xs (later cancelled in favor of a further modernization of existing F–106s) would be more

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[17] After being earmarked in turn for several projects (all abandoned), the F–109 designation was never used. The General Dynamics F–111, endorsed by the OSD in September 1961, was the last plane identified under the individual service scheme.

[18] The Hughes ASG fire-control system and GAR–9 missiles (later designated XAIM–47As), flight-tested in 1960 with a modified Convair B–58 Hustler.

[19] A titanium alloy airframe would withstand the high temperatures at more than three times the speed of sound. This was a metallurgic first in the world of aviation. Also noteworthy were the YF–12A's ASG–18 pulse doppler fire-control system and XAIM–47A missiles. In contrast to other interceptor subsystems, they were designed to operate with little or no ground control.

[20] These records had previously been held by a Russian E–166 aircraft (1,665.89 mph and sustained horizontal flight at 74,376.49 ft).

cost-effective. The F–12A would have been expensive (between $15 and $18 million if 100 were ordered). Only three prototypes were built—the third being converted to a two-place SR–71 trainer, designated SR–71C.

The 4786th Test Squadron was the sole USAF unit involved with the YF–12A. When it ceased operations at Edwards AFB on 5 May 1972, USAF participation in a joint test program with NASA also ended. They had worked together on this project since mid-1969.

Technical Data

Length/Span (ft)	107.5/55.7
Gross Weight (lb)	136,000
Engine, Number & Designation	2 65,000-lb thrust J–58 turbojets w/ afterburners
Ceiling (ft)	80,000
Max. Speed	Mach 3+
Crew	2

McDONNELL-DOUGLAS YF-15 EAGLE

As an air superiority replacement for the F–4, the F–15 (first known as the F–X) originated in late 1965. In a simpler but still advanced configuration, with a projected 1970 IOC, the F–X had been first discussed in the fall of 1964. (The appearance of a Soviet prototype fighter a short time before led to this discussion.) But many factors hindered progress.[21] Not until December 1969 and after several rounds of design proposals[22] did the OSD give the go-ahead. Once approved, however, the F–15 development was fast.

Displayed at the contractor's St. Louis plant on 26 June 1972 (when it was christened the Eagle), the YF–15 made a 50-minute first flight over Edwards AFB on 17 July. Rigorous flight tests in the 20-aircraft program followed, numbering 1,000 as of November 1973. By then, the YF–15 had flown above 60,000 feet at Mach 2 + speed.

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[21] The war in Southeast Asia, the calls for new planes (F–5 and A–7), tight budgets, and the OSD drive to convince the Navy and Air Force to use similar tactical aircraft ("commonality").

[22] The Air Force first sent requests for proposals (RFP's) to 13 aerospace companies on 18 December 1965. It again solicited bids for F–X design studies on 11 August 1967, but only from seven companies. Two (General Dynamics and McDonnell-Douglas) received study contract awards in December. The others (Fairchild-Hiller, Grumman, Lockheed, and North American) stayed in the race at their own expense—Boeing had dropped out. By 1969 the field had been narrowed down to Fairchild-Hiller, North American, and McDonnell-Douglas. They all submitted technical proposals in mid-1969, and cost proposals on 30 August. Revised cost proposals, forwarded by the three late in the year, established McDonnell-Douglas as the undisputed winner.

Initial Contract Date (Total System Development)	January 1970
Critical Design Review	April 1971
First Flight (prototype)	July 1972
Production Approval	February 1973
Quantity on Order:	
Prototypes/Test Aircraft	20
Production Aircraft	30[23] (against 729 programmed)
Projected IOC	1975
Total Aircraft Accepted (as of 30 June 1973)	7 (prototype/test aircraft)
RDT&E Estimated Costs	$1.7 billion
Procurement Unit Cost (estimated)	$8.2 million

Technical Data

Length/Span (ft)	64.11/42.8
Takeoff Weight (lb)	40,000
Engine, Number & Designation	2 23,000-lb thrust P&W F100 turbofans w/afterburners
Max. Speed	Mach 2+
Cruise Radius (nm) (Designed Mission)	200
Crew	1 (2 in the TF-15 trainer)
Armament	AIM-7 Sparrow, AIM-9 Sidewinder, M61A1 Vulcan 20-mm cannon, plus options

[23] Sudden engine problems caused the number to be temporarily held at 30.

YF-15 EAGLE

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GLOSSARY

AAF	Army Air Forces
ADC	Air Defense Command, Aerospace Defense Command
ADO	Advanced Development Objective
AFB	Air Force Base
AFCS	Automatic Flight Control System
AFLC	Air Force Logistics Command
AFR	Air Force Reserve
AMC	Air Materiel Command
AMI	advanced manned interceptor
AMSA	Advanced Manned Strategic Aircraft
AMTI	airborne moving target indicator
ANG	Air National Guard
APG	Air Proving Ground
APGC	Air Proving Ground Command
ARDC	Air Research and Development Center
ATC	Air Training Command
AWACS	airborne warning and control system
AWCS	automatic weapons control system
BROFICON	broadcast fighter control
CADC	central air data computer
CAP	combat air patrol
CAS	close air support
CCM	counter-counter measures
CCT	combat crew training
CCTS	combat crew training squadron
CDR	critical design review
CONAC	Continental Air Command
CONUS	Continental United States
CORDS	coherent-on-receive doppler system
CPFF	cost-plus-a fixed fee
CSAF	Air Force Chief of Staff
CSD	constant speed drive
CSTI	control surface tie-in
DEF	development engineering inspection
DOD	Department of Defense
ECCM	electronic counter-counter measures
ECM	electronic counter-measures
ECS	electronic control system
ELINT	electronic intelligence
FAI	Fédération Aéronautique Internationale
FEAF	Far East Air Forces
FFAR	folding fin aerial rocket

FICON	Fighter-Convair
FIS	fighter-interceptor squadron
FMS	foreign military sales
FPF	fixed-price firm
FPI	fixed-price incentive
FPIF	fixed-price incentive firm
fpm	feet per minute
FPRA	fixed-price redeterminable contract of the A type
ft	foot, feet
FY	fiscal year
GFAE	government-furnished aeronautical equipment
GOR	General Operational Requirements
HSD	horizontal situation display
HSI	horizontal situation indicator
HVAR	high velocity aircraft rocket
ICI	initial capability inspection
IDS	integrated display set
ILS	instrument landing system
IOC	initial operational capability
IRAN	inspection and repair as necessary
IOC	initial operational capability
kn	knot
LABS	low altitude bombing system
LARA	low altitude radar altimeter
LASPAC	Landing Gear, Avionics, Systems Package
lb	pound
LC	letter contract
LES	leading edge slat
LORAN	long-range navigation
MAP	Military Assistance Program
MAS	Military Assistance Sales
MASF	Military Assistance Service Fund
MDAP	Mutual Defense Assistance Program
MEISR	Minimum Essential Improvement in System Reliability
Mfr	manufacture, manufacturer
MIPR	Military Interdepartmental Purchase Request
MTBF	mean time between failures
NACA	National Advisory Committee for Aeronautics
NADAR	signal data recorder
NASA	National Aeronautics and Space Administration
NATO	North Atlantic Treaty Organization
nm	nautical mile
No	number
NORAD	North American Air Defense Command

NORM	not operationally ready-maintenance
NORS	not operationally ready-supply
ORI	operational readiness inspection
OSD	Office of the Secretary of Defense
OST	operational suitability test
OT&E	operational test and evaluation
PACAF	Pacific Air Forces
PCS	pitch control system
RAAF	Royal Austrialian Air Force
RAF	Royal Air Force
RAFS	Royal Air Force Station
RCAF	Royal Canadian Air Force
R&D	research and development
RDT&E	research, development, test and evaluation
RFPs	request for proposals
RHAW	radar homing and warning
SAC	Strategic Air Command
SAE	semi-actuator ejector
SAGE	Semi-Automatic Ground Environment
SAM	surface-to-air missile
SARM	standard antiradiation missile
SDR	System Development Requirement
SEA	Southeast Asia (Republic of Vietnam, Thailand, Laos, and Cambodia)
SEAOR	Southeast Asia Operational Requirement
SL	sea level
SLAR	side-looking airborne radar
SLIM	Simplified Logistics and Improved Maintenance
SLR	side-looking radar
SMAMA	Sacramento Air Materiel Area
SMD	System Management Directive
SOR	Specific Operational Requirements
SRA	Specialized repair activity
SRAM	short-range attack missile
TAC	Tactical Air Command
TACAN	tactical air navigation
TFG	tactical fighter group
TFR	terrain following radar
TFS	tactical fighter squadron
TFW	tactical fighter wing
TFX	Tactical Fighter Experimental
TISEO	Target Identification and Electro-Optical System
TRS	tactical reconnaissance squadron
U.K.	United Kingdom
UN	United Nations

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USAFE	United States Air Forces in Europe
VAX	attack aircraft, experimental
VNAF	South Vietnamese Air Force
V/STOL	vertical and short takeoff and landing
VTOL	vertical takeoff and landing
WS	weapon system
ZELMAL	Zero Length Launch and Mat Landing

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MARCELLE SIZE KNAACK rejoined the Office of Air Force History in 1970, after serving on two occasions as Deputy Chief Historian of the United States Air Forces in Europe. She became a senior historian in 1980. Born and educated in France, Mrs. Knaack graduated from the College d'Artois and attended the University of Lille, where her interest focused on foreign policy and international relations. Her first book was *Post-World War II Fighters, 1945–1973,* Vol I, *Encyclopedia of U.S. Air Force Aircraft and Missile Systems* (Office of Air Force History, 1978).

Foreword

The second in a series of encyclopedias of U.S. Air Force aircraft and missile systems, this volume covers the development and fielding of bomber aircraft between 1945 and 1973, commencing with the Convair B–36 Peacemaker and ending with the development of the Rockwell International B–1A. Marcelle Knaack's detailed and comprehensive discussion of each bomber type provides a wealth of technical material painstakingly extracted from official Air Force sources. The researcher will find the information readily available and easy to use.

Equally critical to our understanding of bomber development, however, is the author's treatment of the policy issues and the technological decisions that molded each bomber program. During the postwar years, the nation's emerging nuclear capabilities placed new emphasis on developing bombers capable of delivering the atomic weapon. Subsequent military needs in Korea and Southeast Asia, however, required a return to conventional weapons. New technologies continually spawned modifications in the weapons systems. And throughout, the Air Force adapted developmental programs and modified production aircraft to fit new roles, from strategic reconnaissance to tactical operations for the Southeast Asia theater.

These pages contain essential data for a wide spectrum of audiences inside and outside the U.S. Air Force. Mrs. Knaack's exacting research and her ability to translate difficult and often conflicting documentation into clear and concise capsule histories will enable planners and those engaged in the research and development of aircraft to benefit from the Air Force's experience. As she points out, the success of the postwar bomber program has been the result of the Air Force's willingness to consider several different developmental pathways simultaneously, to modify existing aircraft as technology permits, and above all, to assume continually the development risks required to keep the service at the forefront of technology.

Richard H. Kohn
Chief, Office of Air Force History

Preface

This reference volume compiles basic information on all Air Force strategic, tactical, and experimental bombers developed or produced between World War II and 1973. The book begins with the Convair B-36 Peacemaker, the first long-range, strategic atomic carrier, and closes with the development of the Rockwell International B-1A. The main narrative covers eight bomber types, most of which weathered some 30 years of world crises and two wars—the conflicts in Korea and Southeast Asia. Included is the premier B-52 Stratofortress, due to remain a prime asset of the Strategic Air Command through the 1980s.

The volume's first appendix considers the Douglas B-26 Invader and the Boeing B-29 Superfortress, aircraft of World War II vintage which made important contributions in subsequent years. Appendix II, Experimental and Prototype Bombers, deals with 10 aircraft, including the controversial Northrop XB-35 and YB-49; the ill-fated North American XB-70A; and the Advanced Manned Strategic Aircraft (AMSA), redesignated as the B-1A in April 1969.

The origin of each bomber is traced as well as, whenever applicable, its most significant development, production, and operational problems. Also noted are production decision dates, program changes, test results, procurement methods, production totals, delivery rates, prominent milestones, and brief descriptions of special features of new aircraft versions and configurations. Selected technical data and operational characteristics are provided at the end of each section.

This volume follows the pattern established in *Post-World War II Fighters, 1945–1973,* Vol I, *Encyclopedia of U.S. Air Force Aircraft and Missile Systems* (Office of Air Force History, 1978). Like the first encyclopedia, the bomber volume does not provide complete consistency of data. This is particularly understandable in the bombers' case because every program was highly individual and far more complex than the fighter programs. Nevertheless, as the specific bomber programs evolved, their respective *raison d'être* and the planned interlacing of the various programs became obvious.

One cannot anticipate history's ultimate assessment of the Air Force's achievements through the mid-1970s. The passage of time seldom worked in favor of the young service. Caution did not always pay off: when at long last operational, the B-36 was obsolete. Conversely, rising world tensions prompted the hurried production of unsuitable B-47s, which had to be reworked. The threat, never ceasing to exist, assumed many guises. In the rapidly changing environment, the very factors that fueled the growth of specific weapon systems could also alter their intrinsic modes of operation. A case in point is the B-52. Singled out for the atomic role, these bombers in 1972 found themselves flying conventional bombing missions against military targets in the Hanoi and Haiphong areas of North Vietnam.

This volume's sketchy compendium of data does not do justice to the Air Force, which met extraordinary challenges from the start. At the end of World War II, the operational forces were sharply reduced, then increased, only to be cut again. Besides hindering planning, such changes disrupted the aircraft industry and made it far more difficult to procure, given the many variables, the best weapon systems possible, in timely fashion. Money was continually in short supply. New administrations might shift the emphasis afforded to certain weapons—whether missiles or manned aircraft—but the tight budgets remained a constant limitation. Undoubtedly, the Air Force made mistakes. Yet, the service did place a premium on getting the greatest return from each dollar spent. The knowledge gained from canceled experimental programs was quickly put to other uses. Old aircraft were stripped and sold. Valuable surplus equipment and still serviceable engines were carefully retained, and savings routinely ensured.

In the early and mid-sixties, recurring world crises and the high cost of new weapon systems and space programs added urgency to the demand for cost-efficiency. Moreover, as the tempo of activities rose in Southeast Asia, the Air Force's task grew even more difficult. Improvisation and versatility became the order of the day. Refurbished aircraft and their heroic crews soon proved their worth; and the Air Force again met its commitments. Above all, the Air Force's greatest achievement was its success in coping with revolutionary technological developments. This is not to say, as 1973 came to an end, that technology had reached a plateau. Scientific progress was not likely to stop. Still, the foreseeable future appeared to be more settled, concentrating on the refinement process. The pioneering spirit of the three turbulent decades following World War II was giving way to a new equilibrium.

This volume is based essentially on U.S. Air Force sources, and I alone am responsible for the many omissions, and possible distortions, in this compilation.

Marcelle Size Knaack

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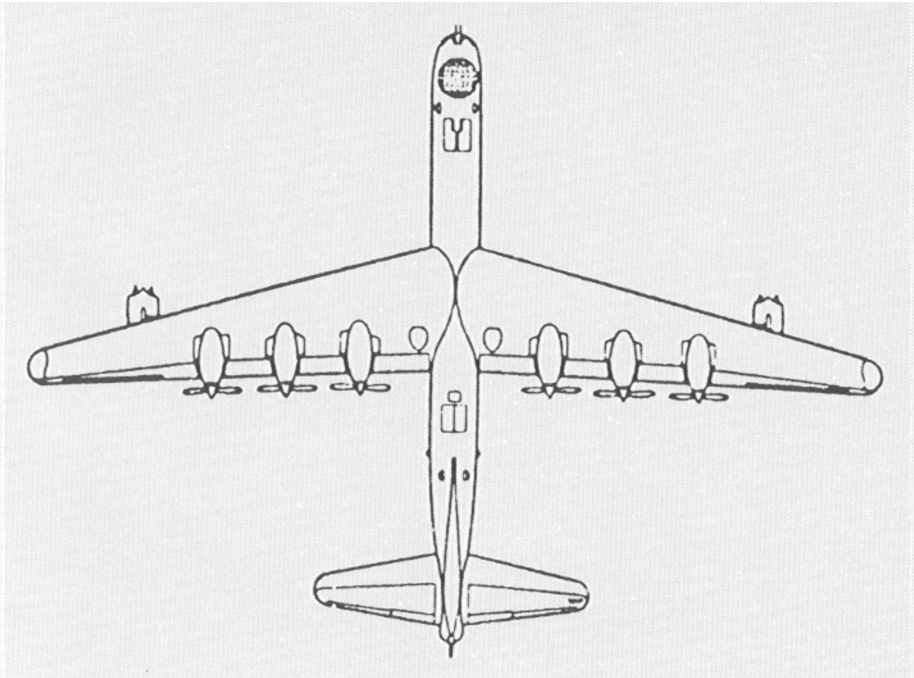
Consolidated Vultee Aircraft (CONVAIR) Corporation



B-36 PEACEMAKER
CONVAIR

Manufacturer's Model 36

Overview

The development of the B-36 was triggered by Nazi Germany's aggression and subsequently by the Japanese attack on Pearl Harbor. The Army Air Forces (AAF) required a long-range bomber to carry the war to the enemy. Despite the sense of urgency, the B-36 program progressed slowly. Existing technology failed to satisfy the military requirements of 1941, early wartime demands exceeded materials, and weapons more readily available received the highest priority during the war.

Military setbacks in 1942 led the AAF to concentrate on the Boeing B-29 (under production order since September 1941) at the expense of the B-36. However, growing concern in the spring of 1943, as China appeared near collapse, reversed the situation. Believing the B-36 might be the only bomber capable of attacking the Japanese homeland, the AAF called for 100 production model B-36s. Meanwhile, the contractor continued to struggle with various development troubles, serious engine problems, and significant weight increases. In mid-1944, engine problems reached a climax. Still, Convair's request for consideration of another engine was ignored because of the cost, time involved, and technical unknowns. In any case, the military position was no longer critical after the capture of Pacific bases and the deployment of the B-29, which would ultimately devastate Japan's home islands.

Yet, the B-36 did survive in the postwar environment. The United States Air Force (established as an independent service in September 1947) needed a long-range aircraft to carry the atomic bomb, and to further its claim on the atomic mission.

As the cold war intensified, deterrence through fear of atomic retaliation became the linchpin of American national security policy. Until air-refuelable, jet-powered bombers were operational, only the B–36, with its vast bombload capacity, could strike the Soviet Union, America's previous ally and now potential adversary. No matter the cost in effort or money, the B–36 had to be made to work. Just the same, the B–36 required technical innovations that were beyond the state-of-the-art. The experimental flight of August 1946, nearly 6 years after signature of the development contract, confirmed that the new bomber was underpowered. Improvement of the original R–4360 engine yielded little relief, and Convair's attempts to fit the engine with a variable discharge turbine failed. In 1949, the engine problem was somewhat alleviated by mounting turbojets under each of the B–36's wings. Still, throughout its entire operational career, the B–36 heavy bomber remained too slow, a shortcoming that increased its vulnerability and necessitated the protection of escort fighters.

In the early fifties, after modification of the landing gear, correction of the electrical system, and elimination of fuel tank leakages, the first B–36 remained highly troublesome. Other production models were not faring much better: the gunnery system was operationally unsuitable, the defensive armament was poor, and its fire-control system was barely adequate. At long last, in 1954, so-called "Featherweight" B–36s came into being. Whether new or reworked production models, the Featherweights proved fairly problem-free. The B–36s were also used for reconnaissance and served effectively. Perhaps the aircraft's most important contribution, though impossible to measure, lay in deterring a general war during the difficult years of its active life.

Basic Development — 1941

Development of a long-range bomber was spurred by Nazi Germany's spectacular campaigns at the outset of World War II.[1] Even though the scheduled invasion of the British Isles had been postponed, they seemed far from secure in the fall of 1940. The loss of Britain would leave the United States without European allies and with no bases outside the Western Hemisphere. The Air Corps[2] therefore needed a long-range bomber that could carry the war to any enemy from this continent. The early successes of the German offensive against Russia in June 1941 further deepened America's concern.

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[1] It took Hitler just 20 days to crush the Polish army in September 1939 and but a few weeks for the German forces to speed across the Low Countries and France in 1940. (The western campaign started on 10 May; the French surrendered on 22 June).

[2] The Army Air Forces was not formally established until 20 June 1941.

Requests for Proposals — 11 April 1941

The Air Corps opened a design competition for a truly intercontinental bomber—a fast, high-altitude airplane with a heavy bombload and unprecedented range. Invitations for preliminary design studies were sent to the Consolidated Aircraft Corporation[3] and to the Boeing Aircraft Company on 11 April. Northrop Aircraft, Incorporated was contacted on 27 May, when it was also asked for further design studies on a "flying wing" bomber having a range of 8,000 miles at 25,000 feet, with 1 ton of bombs.[4] Not long afterwards the Douglas Aircraft Company took part in the long-range bomber competition.[5] Solicited much later, the Glenn L. Martin Company declined the invitation due to a shortage of engineering personnel.[6]

Revised Military Characteristics — 19 August 1941

The preliminary characteristics set forth in the Air Corps requests for proposals of April 1941 called for a bomber with a 450-mile-per-hour top speed at 25,000 feet, a 275-mile-per-hour cruising speed, a service ceiling of 45,000 feet, and an overall range of 12,000 miles at 25,000 feet. These characteristics were revised during a conference on 19 August attended by Robert A. Lovett, Assistant Secretary of War for Air, Maj. Gen. George H. Brett, Chief of the Air Corps, and ranking officers of the Air Staff. Since the conference's main purpose was to accelerate the bomber project, the conferees decided to scale down their requirements. But their revision was

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[3] The Consolidated Aircraft Corporation and Vultee Aircraft, Inc., merged on 17 March 1943. The new Consolidated Vultee Aircraft (Convair) Corporation became the Convair Division of the General Dynamics Corporation on 29 April 1954.

[4] Until the early 1950s, the range and speed of aircraft were usually shown in statute miles. Afterwards, the Air Force began to measure speed in knots and range in nautical miles. Speed records, however, continued to be in miles per hour and distances were expressed in kilometers. (A knot—nautical mile per hour—is 1.1516 times swifter than a statute mile per hour. A nautical mile represents around 6,080 feet and is 800 feet more than the statute mile.)

[5] Douglas Aircraft had been given a contract on 19 April 1941 to check if the Allison 3420 engine could be used in bombardment type aircraft—clearly a closely related project. Douglas had also been working for several years on the XB-19—just recently flown and the largest aircraft ever built in the United States. The Air Corps planned to use the XB-19 as a flying laboratory to gather information that would help the design and construction of future giant aircraft.

[6] The Glenn Martin Company had been engaged in a new bomber (the XB-33, under contract since June 1941), before becoming involved in the Northrop "flying wing" program. In addition, by 1943 the company had been approached by the Navy for participation in a new production project.

still a tall order—a minimum overall range of 10,000 miles, and an effective combat radius of 4,000 miles with a 10,000-pound bombload.[7] This was about 4 times the combat radius of the Boeing B–17, the AAF's newest and best bomber. The conferees further specified that the future intercontinental bomber should have a cruising speed between 240 and 300 miles per hour, and a 40,000-foot service ceiling (5,000 feet less than originally requested).

Contractor Selection — 3 October 1941

After a review of preliminary data from Boeing, Consolidated, and Douglas, the Materiel Division of the Air Corps suggested prompt action on the Consolidated study, which covered several long-range bomber designs, both 4- and 6-engine pusher and pusher-tractor types.[8] This endorsement of Consolidated was in no way a rejection of either Boeing or Douglas services.[9] Yet, it proved to be a turning point in the intercontinental bomber program.

Development Decision — 16 October 1941

The decision was made by Maj. Gen. Henry H. Arnold, Chief of the new Army Air Forces, on the recommendation of Brig. Gen. George C. Kenney, Commanding Officer of the Air Corps Experimental Division and

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[7] Although the word "range" is often qualified, in this context it indicates how far an aircraft can fly under given operating conditions from the moment of takeoff to the time when its fuel supply is exhausted, as in "the aircraft's range was 7,000 miles, enough to fly nonstop from San Francisco to London." The "combat radius" is the radius of action for any given airplane on a combat mission with a specified load and flight plan. The "radius of action" differs from "range" in that the aircraft is always considered to return to the point at which it takes off. It is like the radius of a circle, and represents the maximum distance at which a given airplane can operate, under given conditions, from the center of the circle and still return to the center. This distance, under combat conditions, is considerably less than one-half the distance that the aircraft can fly under noncombat conditions.

[8] Consolidated, after specializing for many years in seagoing aircraft, reentered the landplane field early in 1940, with development of the B–24 Liberator. Keenly aware of the Air Corps's interest in large bombers with extended ranges, the company at this time had begun work on a number of design possibilities.

[9] Douglas Aircraft stated in late 1941 that it did not desire to undertake an "out-and-out 10,000-mile airplane project." It proposed instead the development of Model 423, a 6,000-mile bomber, which was rejected. As for Boeing, the AAF believed as late as April 1942 that the company was "overly conservative" and had not yet "really tackled the [long-range] airplane design with the necessary degree of enthusiasm." Two Boeing bomber designs (Models 384 and 385) submitted in September were never developed.

Engineering School at Wright Field, Ohio. General Kenney's recommendation rested on a detailed proposal (drawings and bid were submitted by Consolidated on 6 October), which asked for $15 million plus a fixed-fee of $800,000 for research and development, mockup, tooling, and production of 2 experimental long-range bombers (Model 35). Delivery of the first airplane would be 30 months after approval of the contract; that of the second, 6 months later. Consolidated also stipulated that the project could not be "entangled with red tape" and constantly changing directives.

Initial Contract Date — 15 November 1941

The initial contract (W535 ac-22352) of 15 November 1941 met Consolidated's terms. On 22 November, 7 days after the contract's approval, Wright Field Engineering Division concluded that the 6-engine rather than the 4-engine design should be adopted. This posed no problem, since it had been one of the options offered by Consolidated. On 10 December,[10] Model 35 was redesignated Model 36 to avoid confusion with the Northrop "flying wing," by then known as the B-35. There was yet no sign of the difficulties soon to come.

Mockup Inspection — 20 July 1942

After more than 6 months had been spent in refining the chosen design, exerting every effort to control weight, reduce drag, and eliminate the various developmental kinks of a new airplane, the B-36 mockup was inspected. Controversy generated by the inspection nearly caused cancellation of the experimental program. The Mockup Committee wanted to reduce firepower and crew to make the B-36 meet its 10,000-mile range requirement. But some members argued that such changes would render the airplane tactically useless and in fact superfluous, since the Experimental Engineering Division already had a "flying laboratory" (XB-19). If these reductions were necessary, the AAF should stop the project and channel the manpower into more productive bomber programs. The Mockup Committee eventually agreed to delete "less necessary" items of equipment from the aircraft. This reduced weight and saved the future B-36—at least temporarily.

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[10] Three days after the Japanese attack on Pearl Harbor. The United States declared war on Japan on 8 December 1941; on the 11th, Germany and Italy declared war on the United States. The U.S. war declaration was made on the same date.

Development Slippage 1942–1943

A month after inspection of the B-36 mockup, Consolidated suggested shifting the XB-36 project from San Diego, California, to its new government-leased plant in Fort Worth, Texas. Even though the move was completed in September 1942, less than 30 days after being approved by the AAF, development was set back several months. Innumerable problems remained to be solved, but Consolidated asked the AAF to place a contract for a production quantity of the new aircraft. The contractor claimed that 2 years could be pared from the development cycle if preliminary work on production B-36s started without waiting for completion of the experimental planes. Consolidated's request was ill-timed. Military setbacks during 1942, especially in the Pacific, plus the fact that even under the best circumstances the B-36 could not soon become operational, prevented the AAF from diverting scarce resources for its production.

Another Consolidated request in the summer of 1942 fared somewhat better. The AAF agreed to development of a cargo configuration of the XB-36, provided that 1 of the 2 experimental bombers was produced at least 3 months ahead of the cargo plane (referred to as the XC-99). Consolidated actually wanted the XC-99 to test the engines, landing gear, and flight characteristics of the forthcoming XB-36s. The contractor also believed the XC-99 could be ready to fly much sooner than either of the 2 XB-36s because armament and other military gear would be left out. The AAF conditions were accepted, however, and a $4.6 million contract was approved by year's end.[11]

Production Go-Ahead 19 June 1943

While engineers kept on wrestling with weight increases and various developmental troubles,[12] war problems suddenly boosted the importance of the B-36. Military setbacks that had hampered the program in 1942 assumed a new dimension in the spring of 1943 as China appeared near collapse. The

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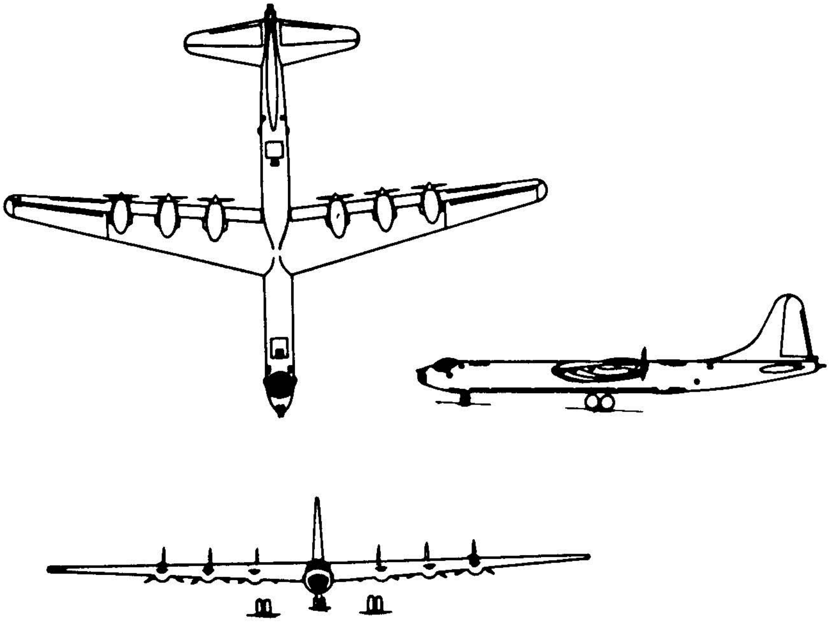
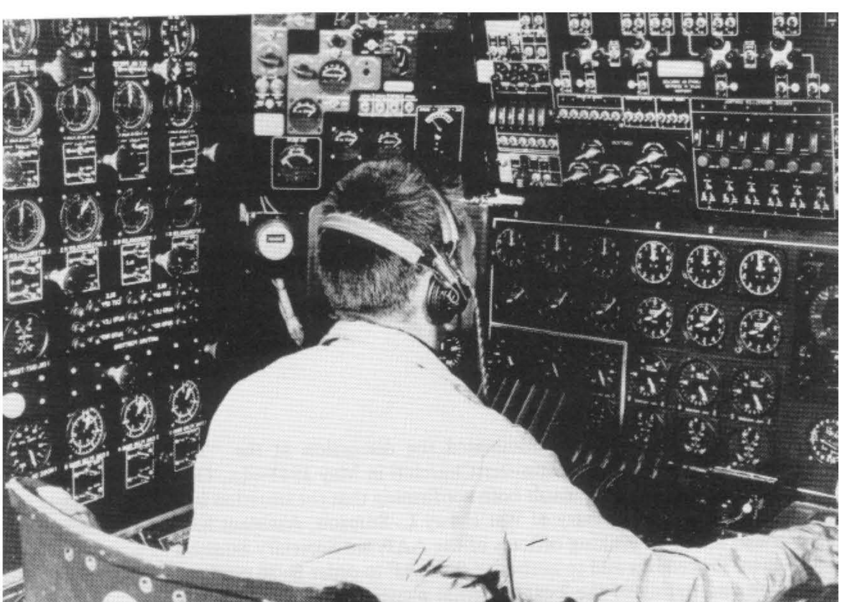
[11] The proposed C-99 could have carried 400 fully equipped troops or more than 100,000 pounds of cargo, but only a single XC-99 was built. It was delivered in 1949 and remained in the inventory until 1957.

[12] The B-36's twin tail was to be deleted in favor of a single vertical one. This would decrease weight by 3,850 pounds, stabilize direction, and lower drag. The modification was approved on 10 October 1943, when the initial development contract (W535 ac-22352) was amended by Change Order No. 7. This change order (previous ones were insignificant) also allowed the contractor a 120-day delay in delivery. So at best the AAF would not get its first XB-36 until September 1944.





A flight engineer at his station in the CONVAIR XB-36.

B-17 and the B-24 had insufficient range to operate over the vast distances of the Pacific. The Boeing B-29 was in the early stage of production, but was experiencing more problems than usual.[13] The parallel development of the Convair B-32 (Consolidated until mid-March), generally considered by AAF as an "insurance plane," in case the B-29 failed, did not progress as well as hoped for. The B-32 seemed much less promising than the B-29, on which higher priorities had been concentrated. Moreover, even if production delays could be overcome, neither of these planes could reach Japan, for battles had to be won before the Mariana Islands could become a base for B-29 or B-32 operations. Speeding up B-36 development might provide a way, possibly the only one, for attacking the Japanese homeland and at least would immediately bolster Chinese morale.[14] Therefore, on 19 June General Arnold[15] directed procurement of 100 B-36s. The order, however, would be cut back or canceled in the event of excessive production difficulties. The AAF letter of intent for 100 B-36s was signed by Convair on 23 July.

New Setbacks 1943-1944

In spite of its elevated status, the B-36 program made scant progress. Essential wind tunnel tests of the new design were postponed until the spring of 1944, because other projects had retained higher priorities and no alternate testing facilities were available. Meanwhile, besides usual engineering difficulties, Convair was greatly concerned over the growing weight of the Pratt & Whitney X-Wasp engine selected for the experimental B-36. In Convair's opinion, tying the XB-36 to a single engine design was a mistake. Yet, further study of the Lycoming BX liquid-cooled engine (noted for lower fuel consumption) had been discontinued on the belief that development of the BX engine would demand manpower, materiel, and facilities that could not be spared. The AAF also insisted that development of a new engine would only delay "expeditious prosecution"of the B-36 design. In any case,

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[13] Appendix I, pp 482, 484.

[14] The war in the Pacific dominated the discussion at the "Trident" conference of President Roosevelt and Prime Minister Churchill in May 1943—Lt. Gen. Joseph W. Stilwell and Maj. Gen. Claire L. Chennault both confirming that the situation in China was desperate. Ensuing talks between Secretary of War Henry L. Stimson, Assistant Secretary of War Robert P. Patterson, and high-ranking officers of the AAF, led Secretary Stimson to waive customary procurement procedures and to authorize the AAF to order B-36 production without awaiting completion and testing of the 2 experimental planes then under contract.

[15] General Arnold became Commanding General of the AAF in March 1942 and was promoted to 4-star general 1 year later.

before much of anything could be done, the B-36 was relegated to a secondary position. This time, the Convair B-32 had to come first.[16]

Definitive Production Contract 19 August 1944

The letter of intent of 23 July 1943,[17] supplemented by Letter Contract W33-038 ac-7 on 23 August 1943, gave way 1 year later to a definitive contract. This $160 million contract (including a $6 million fixed fee and the cost of all spare parts and engineering data) continued to cover the production of 100 B-36s, but no longer carried any priority rating. Delivery schedules, however, were unchanged. The first B-36 was due in August 1945; the last, in October 1946.[18]

Program Reappraisal 1945

With victory in sight,[19] war contracts were scrutinized for cancellation or drastic cutback. Aircraft production was actually cut by 30 percent on 25 May, a reduction of 17,000 planes over an 18-month period. The review left the B-36 contract untouched. There was no question that a long-range bomber was needed. The proof was in the terrible price paid in lives and materiel to win advanced bases in the Pacific. The atomic bomb, unlikely to remain an American monopoly, was another strategic justification. Inasmuch as U.S. retaliation would have to be quick, there would be no time for conquering faraway bases. And, realistically, a long-range bomber could be the best war deterrent for the immediate future. From the economic standpoint, the B-36 also looked good. It out-performed the B-29 and the

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[16] The military situation in the Pacific improved materially by mid-1944. The Marianas campaign neared its successful conclusion, and the forthcoming use of bases on Saipan, Tinian, and Guam urgently called for medium-range bombers. Production troubles with the B-29 were almost solved, and it was now left to Convair to accelerate the B-32 program. B-36 work would continue, but only as a safety measure.

[17] The U.S. Government was not liable should a letter of intent be canceled. This was not so for the more often-used letter contract which obligated funds.

[18] Not surprisingly, these delivery dates were subsequently changed, as was the $160 million contract— increased by $61 million on 26 August 1946, when Change Order No. 10 was approved.

[19] The German surrender was officially ratified in Berlin on 8 May 1945; Japan surrendered unconditionally on 14 August, but the Japanese Emperor did not sign the Potsdam requirements for surrender until 2 September.

B-35 "flying wing" for long-range missions and was cheaper by half to operate than the B-29 in terms of cost per ton per mile. On 6 August 1945, General Arnold approved the Air Staff recommendation to keep the B-36 production contract intact.[20]

Unrelenting Problems 1945-1946

While the fate of the B-36 program vacillated with changing wartime priorities, the aircraft's development remained painfully slow. By 1945 Convair still worried over the weight of the R-4360-25 engine—Pratt & Whitney's third version of the original X-Wasp. Adding nose guns required extensive rearrangement of the forward crew compartment. A mockup of the new nose section had been approved in late 1944 and would become a prototype nose for the second XB-36. Yet, the radio and radar equipment in the new nose would augment gross weight by at least 3,500 pounds—more, if the antenna of the AN/APQ-7 radar could not be installed in the leading edge of the wing. This and the 2,304-pound increase for the 6 new engines could present a serious problem. Nor was it easy to select wheels for the aircraft's landing gear. The rationale for dual main wheels was simplified maintenance without a need for special tools. The single-wheel type had other merits. These arguments ended in mid-1945 when Maj. Gen. Edward M. Powers, Assistant Chief of Air Staff for Materiel, Maintenance, and Distribution, recommended that a new landing gear be devised to distribute the aircraft weight more evenly, thus reducing the need for specially built runways.[21]

Meanwhile, faulty workmanship and use of substandard materials were discovered in the experimental B-36. AAF inspectors also noted the dearth of qualified workers at the beginning of the project and the failure of the airfoil contour of the aircraft wing to conform to specifications. In fairness to Convair, substituting materials was a generally accepted practice in urgently awaited experimental planes. As for other discrepancies, the contractor was not altogether to blame but promised to correct them promptly. Progress was made, but labor strikes at the Fort Worth plant in

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[20] Lt. Gen. Hoyt S. Vandenberg, then Assistant Chief of Air Staff for Operations, Commitments, and Requirements, advocated formation of 4 "Very Heavy" groups equipped with B-36s to constitute an "effective, mobile task force for our postwar air force." General Vandenberg's recommendation was embodied in the AAF's postwar 70-group program. This program remained a constant, though unreachable goal until the start of the Korean War.

[21] The four-wheel truck-type gear eventually adopted was 1,500 pounds lighter than the one previously considered. It also enabled the B-36 to use any airfield suitable for the B-29.

October 1945 and in February 1946, a normal part of postwar adjustment, delayed the program for several months. On 25 March General Powers indicated that the structural limitations of the forthcoming XB-36 might make it useless, other than as a test vehicle for the initial flight.

First Flight — 8 August 1946

In spite of every effort, the all-metal, semimonocoque XB-36 did not fly until almost 6 years after signature of the development contract. The initial 37-minute flight of 8 August was deemed successful, but the wing flap actuating system and the aircraft's overall performance fell below the original expectations. Besides its known structural limitations, the XB-36 had an already obsolete single-wheel landing gear, carried only a minimum of components, and lacked the nose armament designed for the second XB-36. Still, a beginning had been made. After being grounded in late 1946 for modification, the XB-36 was test-flown for 160 hours by pilots of the Air Materiel Command (AMC).[22] The plane was then sent to the contractor for further testing,[23] and the United States Air Force (USAF)[24] retrieved it in mid-1948. As predicted by General Powers, the experimental B-36 had limited operational value and was used by the Strategic Air Command (SAC)[25] for training.

Third Program Review — December 1946

On 12 December 1946, General Kenney, who had been promoted to 4-star general in March 1945 and headed SAC since April 1946, suggested reducing the procurement contract for 100 B-36s to a few service-test

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[22] The lineage of AMC reflected the many reorganizations following the establishment on 17 July 1944 as the AAF Materiel and Services Command (Temporary), the parent organization. On 31 August 1944, the Materiel and Services Command (Temporary) became the AAF Air Technical Service Command, which became the Air Technical Service Command on 1 July 1945. AMC was created on 9 March 1946, and on 1 April 1961, it became Air Force Logistics Command.

[23] Convair pilots made 53 test flights with the XB-36 (Serial Number 42-13570), logging a total of 117 flying hours.

[24] The United States Air Force was established on 26 July 1947, when the National Security Act of 1947 became law. It began functioning as a separate service, coequal with Army and Navy, on 18 September 1947.

[25] The Strategic Air Command was established by the Army Air Forces on 21 March 1946.

aircraft. After studying available performance estimates on the B-36, the SAC Commander believed it to be inferior to the forthcoming B-50,[26] a Boeing development of the famed B-29. The B-50 and the B-36 were to become the only 2-piston-powered bombers produced in the postwar era of jet bombers. Among the B-36 shortcomings cited by General Kenney were a useful range of only 6,500 miles, insufficient speed, and lack of protection for the bomber's gasoline load. Neither the Air Staff nor Lt. Gen. Nathan F. Twining, Air Materiel Command Commanding General, agreed with General Kenney.

General Twining said that the B-36 could not be judged from the XB-36, which had just entered testing. All new airplanes encountered developmental problems, as exemplified by the B-17 and other successful aircraft. Moreover, many improvements could soon be expected, and the B-36 was the only suitable aircraft far enough along to serve as an interim long-range atomic carrier until the B-52 arrived.[27] Gen. Carl Spaatz, the AAF's new Commander, wholly agreed with General Twining. Thus once more, the B-36 contract was retained in full.

Engine and Other Improvements   December 1946–July 1947

Even though the B-36 program seemed to undergo one crisis after another, engineers kept on forging ahead. By mid-1947 Convair was confident that the 4-wheel landing gear would be ready for the first B-36 production model (B-36A). And while this B-36A and 21 others would retain the R-4360-25 engine of the XB-36, conversion of this engine had been approved in December 1946. The new water-injection R-4360-41 engine with its 3,500 horsepower (500 more than the -25 engine) would allow ensuing productions (B-36Bs) to take off within a shorter runway distance. It would also yield slightly better performance at both high and cruising speeds. Nevertheless, more improvements appeared in order. Hence, an even more powerful version of the R-4360 engine, fitted with a variable

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[26] Known as the B-29D in July 1945, when 200 were ordered. This number was almost immediately reduced to 60. The future B-29D was redesignated B-50 in December because the many design changes resulted in a nearly new airplane. Except for the B-36, the B-50 was the only piston-powered bomber produced in the postwar era of jet bombers.

[27] General Twining also argued that the normal desire for the best could be deceiving. Keeping pace with the speed of technological advances was a tricky business. The Boeing B-52, then in the design stage, would probably become a better plane than the B-36, but a promising development could not be abandoned every time a better one appeared on the horizon.

discharge turbine (VDT), was under development.[28] Convair claimed that the VDT engine (also proposed for the B-50) would give the B-36 a top speed of 410 miles per hour, a 45,000-foot service ceiling, and a 10,000-mile range with a 10,000-pound bombload. To offset the cost of adapting the VDT engine to the B-36, Convair suggested financing the airframe modification for 1 prototype B-36 with the VDT engine by slashing 3 B-36s from the current procurement contract. This was approved by the Commanding General, AAF, in July 1947. Although Convair hoped additional VDT-equipped B-36s (B-36Cs) would be ordered if the prototype proved successful, a decision on this matter was deferred.

Fourth B-36 Reappraisal — August 1947

The creation of an independent Air Force obviously meant more authority and greater responsibility in the choice of basic weapon systems. General Vandenberg, Deputy Chief of Air Staff,[29] therefore wasted no time in forming the USAF Aircraft and Weapons Board. Through this forum, senior officers would recommend the weapons that would best support long-range plans for the Air Force's development and gradual buildup. The board first met on 19 August and, because of the advent of the atomic bomb, the role of strategic bombing and the means of accomplishing such missions took precedence. The B-36 was the only bomber that could launch an immediate atomic counterattack without first acquiring overseas bases. Although vulnerable to enemy fighters because of its fairly low speed, the B-36 did offer an important advantage: its great range would promote the crew's chances of completing their mission. On the other hand, future supplies of atomic bombs were expected to be sparse. Hence, plans had to cover the possible use of conventional bombs.[30]

The board members differed on how to solve these complex problems. Some considered the B-36 obsolete and favored buying fast jet bombers—an obvious gamble since these would have insufficient range and would not be available for years. Others wanted to increase the B-36's speed with the new

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[28] Convair also offered in February 1947 to install 8 Curtiss-Wright T-35 gas turbine engines in one B-36. The installation was expected to cost less than $1.5 million and to be completed by April 1948. The proposal was turned down. The T-35 engine was too far in the future for the B-36, and the Curtiss-Wright delivery estimates were overly optimistic.

[29] General Vandenberg became Vice Chief of Staff of the United States Air Force, with 4-star rank, on 1 October 1947.

[30] Large stocks of wartime B-29s were still in the inventory for economic reasons, although the Superfortress's range was inadequate without overseas bases.

B-36 Peacemaker at Eglin AFB, Florida, September 1950.

VDT engine and also use it as an all-purpose bomber. Still others preferred the B-50, because it was faster than the B-36 and could attain even greater range and speed with the addition of VDT engines. After prolonged discussion, a consensus emerged to retain the B-36 as a special purpose bomber. This special purpose B-36 would eventually be replaced by the B-52,[31] if the latter proved satisfactory and no better means for delivering the atomic bomb came on the scene. Since the endorsed B-36 would be for specialized use, there were several reasons for not installing the VDT engine in a prototype B-36. No additional B-36 procurement would be needed. And even though the promised improvements were tempting, any retrofit with VDT engines would delay completion of the 100 B-36s on order and run up costs. General Spaatz[32] promptly approved the board's recommendations and the VDT-equipped B-36 prototype was canceled on 22 August.

Unsolved Dilemma 1947

Concern with weapon selection left many problems unanswered. Limited B-36 procurement was one solution; finding some use for the

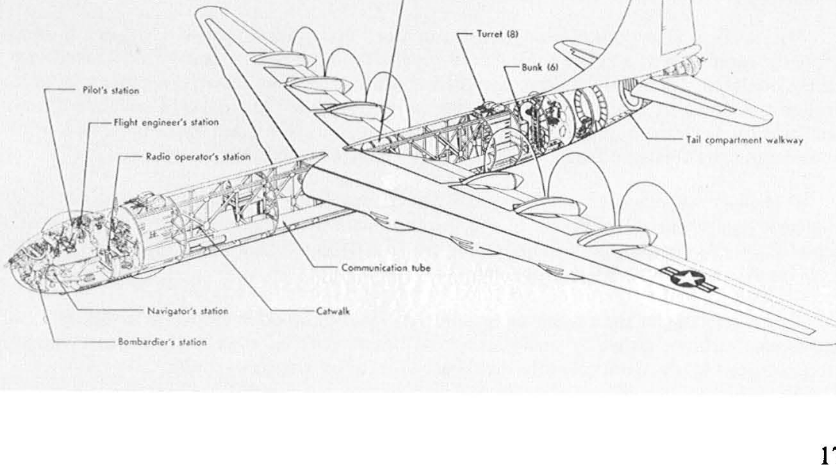
[31] At best not to be expected before 1953.

[32] In September 1947 General Spaatz was appointed by President Truman as the first Chief of Staff of the new United States Air Force.

government-owned Fort Worth plant, soon to be idle, was another problem. The Air Force could not stand by as Convair's dejected B-36 work force sought and probably secured more stable employment before completion of the B-36 program.[33] There were further complications. Funds had been appropriated during the war for the 100 B-36s, but any amount unspent by the end of June 1948 would have to be reappropriated by a Congress that might be of a different mind. Production speedup was one solution. If Convair turned out 6 aircraft every month, the hundredth B-36 would be delivered in January 1949. This would leave but 7 months of production (July 1948–January 1949) for which new funds would have to be provided. Chiefly because of shortages of government-furnished equipment, accelerating production proved impossible.[34] This was just as well since it would have hastened the end of the Fort Worth activities. But the monthly production rate of 4 B-36s, as later endorsed, carried another pitfall—post-

[33] In mid-1948 the Air Force convinced Northrop that production of the future RB-49 (a development of the experimental YB-49 "flying wing") should be sub-contracted to Convair. To begin with, this would keep the Fort Worth plant in operation upon completion of the B-36 program. Of perhaps greater import, this cooperation would blend Northrop's engineering skill and Convair's experience in quantity production of large aircraft. Cancellation of the RB-49 project in January 1949 wiped out all this planning, although Northrop received a go-ahead from Air Materiel Command for completion of a YRB-49 prototype, which was extensively flight-tested.

[34] Production was also slipping (and more delay later occurred) because of defective propellers, landing gear door problems, corroded hinges, unsatisfactory magnesium castings, deficiencies in turret installations, and occasional malfunctions of the constant speed drive. Meanwhile, the government was spending $150,000 a day to keep the plant operating.



poning delivery of the last B-36 to November 1949. This would extend by 10 months the production time for which Convair would have to plan with no assurance that money would ever be available to complete the program.[35] Aware of the contractor's predicament, the Air Force in late December 1947 promised to request a reappropriation of B-36 funds when Congress reconvened in early 1948.

First B-36A Delivery — 30 August 1947

This B-36A and the next 12 productions were known for a while as YB-36As. All, save the first one, eventually reverted to the B-36A designation (some even before leaving the production line). The exception was earmarked for static tests.[36] This decision had been made in mid-1946, after a convincing argument by General Twining. The general admitted that much might be known about a given structure, but deemed it wise to static test one to destruction.[37] He said, "Experience has shown that we would have been unable to use our bombers efficiently had we not had this policy in effect in the past. The B-17, originally designed for a gross weight of 37,000 pounds, fought the war flying universally at 64,000 pounds. This could never have been done without accurate knowledge of the strength of the component parts."

Contractor New Proposal — 4 September 1947

The post-World War II years spelled trouble for the aircraft industry. Competition was fierce, and no contractors could afford to forego any significant prospects. Cancellation ofthe VDT-equipped B-36 prototype,

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[35] Convair was responsible for payment of work under subcontracts. Payments incurred before the expiration of a prime contract (30 June 1948 in the B-36's case) could be recovered, but the contractor's capital would remain tied up during the long drawn-out process of going through the Court of Claims. The other alternative (and one the Air Force certainly did not want) was for Convair to throttle down the flow of supplies, trim plant operations, and lay off workers until the financial future of the B-36 program was straightened out.

[36] Hence, the plane could dispense with various items of still hard-to-get or highly unreliable equipment. Completion of the true productions was another story. Delivery of a second B-36 slipped another 8 months, and the last B-36A (of 22 finally produced) did not reach the Air Force until September 1948.

[37] Static testing is the testing of an aircraft, missile, or other device in a stationary or hold-down position, either to verify structural design criteria, structural integrity, and the effects of limit loads, or to measure the thrust of a rocket engine or motor.

therefore, did not deter Convair from reopening the project a few weeks later. The contractor this time proposed to offset the cost of installing VDT engines in the last 34 of the 100 B-36s under contract by simply reducing the contract's total to 95. No extra money would have to be found, other than enough to cover necessary government-furnished equipment. Convair further offered to produce the new B-36s (B-36Cs) without delaying the current contract by more than 6 months (November 1949-May 1950). The possibility of retrofitting the remaining B-36A and B-36B aircraft was suggested, inasmuch as both types were much nearer completion. Afforded immediate attention, the Convair proposal of September 1947 was approved on 5 December, except for retrofitting the 61 B-36s, which could be dealt with later. SAC alone totally disagreed, having lost faith in the B-36 as a long-range bomber. As a whole, SAC officials generally believed the relatively slow aircraft could better serve in such tasks as sea-search and reconnaissance. For these purposes, General Kenney emphasized, the extra speed promised by the VDT engines was of no real importance. As it turned out, mating the VDT engine with the B-36 failed completely.[38] The project died in early 1948, but not without repercussion.

First Flight (YB-36) — 4 December 1947

This plane (Serial No. 42-13571), the second of the 2 experimental B-36s ordered by the AAF, had been chosen as the production prototype on 7 April 1945.[39] It was equipped with few components, but featured the many configuration changes so far approved.[40] Convair was expected to retain the YB-36 for 6 to 12 months to test its configuration and identify future production line changes. During its third flight on 19 December 1947, the YB-36 reached an altitude of more than 40,000 feet—a rewarding event at the time. Nevertheless, it stayed with Convair much longer than anticipated and was not accepted by the Air Force until 31 May 1949. The aircraft reached SAC in October, but was returned to Convair 1 year later (October

[38] There was nothing wrong with the engine itself (it was the basic R-4360 used in other B-36s), nor with the variable turbine that boosted the engine power. The problem stemmed from the cooling requirements (generated by the aircraft's high-operating altitude), which degraded the engine's rated performance.

[39] Following approval of Change Order No. 11 to the initial contract of November 1941. This order also relegated complete performance tests to the second B-36A production (temporarily designated YB-36A and due to be fully equipped).

[40] Included were new landing gear, bubble canopy (for better vision), reversible pitch props, nose guns, and redesigned forward crew compartment.

1950) to be fitted for reconnaissance. The YB-36's operational life ended after 2,050 flying hours.[41] In the spring of 1957, it was placed in the Air Force Museum at Wright-Patterson AFB, Ohio.

Fifth Near-Cancellation April–June 1948

When it became obvious that a faster B-36 (equipped with VDT engines and due to be known as the B-36C) could not be obtained, the Air Force once more thought of canceling the entire B-36 program. Yet, various factors had to be considered. Twenty-two of the basic and relatively slow B-36s were nearly completed, and a great deal of money had already been spent on the controversial program. The Air Force, therefore, decided to postpone any decisions. It instructed the Air Materiel Command to waive the modification of several shop-completed B-36s that had been awaiting adjustments, and to expedite their delivery. This would allow Convair to speed up the aircraft's flight test program, as consistently recommended by the Air Force. In addition, new yardsticks were established to compare the basic B-36's performance with that of other bombers under similar conditions. The new yardsticks measured the 4 most important and interdependent characteristics of any given bomber— speed, range, altitude, and load capacity.

Test results, although not spectacular, favored the basic B-36. They showed that the slow B-36 surpassed the B-50 in cruising speed at long range, had a higher altitude, larger load capacity, and a far greater combat radius than the B-50 or B-54—a B-50 variant then being considered, but canceled in 1949. It now seemed that the B-36 might become a much better plane than had been expected. If so, any hasty reduction of the contract might wreck the program just as it was about to pay off. The beginning of the Russian blockade of West Berlin on 18 June 1948 spared the Air Force further indecision. On the 25th, Air Force Secretary W. Stuart Symington and other top USAF officials, deeply concerned by the Soviets' aggressiveness, unanimously agreed to stay with the B-36.[42] The proposed VDT-

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[41] Thirty-six Convair test flights accounted for 97½ hours; Air Force pilots flew the remainder.

[42] The Berlin blockade of June 1948 came at the time the administration decided to give high priority to building an atomic deterrent force. The crisis increased the decision's urgency, and the concurrent cancellation of any important military program would have been psychologically unsound. Finally, the B-36 was the only intercontinental bomber available, and its shortcomings, whatever they were, were not that obvious. These facts undoubtedly prompted General Kenney to join in the decision, even though a month before he had still recommended that the B-36 production be halted.

equipped B-36C (34 of them) would revert to the B-36B configuration, assuring the Air Force of getting 95[43] of the 100 B-36s under contract since June 1943.

Initial Delivery 18 June 1948

This B-36A, officially accepted by the Air Force in May 1948, was delivered on 18 June to the Air Force Proving Ground Command[44] to undergo extensive testing. It was a true production aircraft, whereas the first B-36A (accepted in August 1947 and permanently designated as the YB-36A) had few components, was stripped of its engines, and never went past static testing.

Enters Service 26 June 1948

SAC's 7th Bomb Wing at Carswell AFB, Texas, received the first 5 B-36As.[45] These and ensuing B-36A deliveries were unarmed and were used mainly for training and crew conversion. They did not join the operational forces until converted to the reconnaissance configuration.

Total B-36As Accepted 22

Included in this total was the first B-36A (YB-36A) that had been earmarked for static tests.

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[43] There could be no B-36Cs, but the 5-aircraft reduction remained necessary to meet the price rise and to pay for the ill-fated VDT engine installation.

[44] At Eglin AFB, Fla.

[45] By that time, the very heavy bomber designation, previously applied to the B-36, had been dropped. The change dated back to 18 September 1947 (the same day the United States Air Force started functioning as a separate service), when all USAF bombers had been reclassified into 3 categories. In effect, range, rather than weight, had become the primary classification factor. Hence, bombers with an operating radius of more than 2,500 miles were categorized as heavy; those with an operating radius between 1,000 and 2,500 miles were medium bombers, and all those with operating radius of less than 1,000 miles were designated as light bombers. Under these provisions, the B-36 and B-52 became heavy bombers; the B-29, B-50, B-47, and B-58, medium bombers; and the B-45, B-57, and B-66, light bombers.

Acceptance Rates — 1947-1949

The Air Force accepted the first B-36A (YB-36A) in August 1947 and 20 other B-36s in 1948—1 in May, 5 in June, 5 in July, 4 in August, and 5 in September. The twenty-second and last B-36A was accepted in February 1949.

End of Production — September 1948

Five months before the last acceptance.

Flyaway Cost Per Production Aircraft — $2.5 million

This prorated figure reflected the original contract cost for 100 B-36s, as amended on 26 August 1946. It did not include the post-production cost of reconfiguring each B-36A for reconnaissance.

Subsequent Model Series — B-36B

Other Configurations — RB-36E

All RB-36Es were converted B-36As. The YB-36, first flown 4 December 1947, was fitted for reconnaissance in lieu of the YB-36A, bringing the RB-36E total to 22. During the reconfiguration, the B-36A's 6 R-4360-25 engines were replaced by 6 R-4360-41s—the more powerful engines already installed in the B-36Bs. Equipped with cameras like the K-17C, K-22A, K-38, and K-40, the RB-36E also received some of the B-36B's more advanced electronics. The E-model featured equipment vital to its intrinsic missions—all-purpose strategic reconnaissance, day-and-night mapping and charting, as well as bomb damage assessment. Its normal crew was 22, which included 5 gunners to man the 16 M-24A1 20-millimeter guns.

Phaseout — 1950-1951

Convair began adapting the B-36A to the reconnaissance configuration in early 1950. The B–36A's phaseout was fairly fast, the Air Force taking delivery of the last RB–36E in July 1951.

Milestones 30 June 1948

A B–36A dropped 72,000 pounds of bombs during a test flight on 30 June, demonstrating the aircraft's vast capacity.

B-36B

Previous Model Series B-36A

New Features

In the B-36B, R-4360-41 engines with fluid injection supplanted the B-36A's R-4360-25s. The B-36B also offered better and more electronics equipment, including the AN/APQ-24 bombing-navigation radar (substituted for the B-36A's APG-23A). The B-36B could carry 86,000 pounds of bombs (a 14,000-pound increase). Of greater importance, it could carry atomic bombs weighing perhaps as much as 43,000 pounds.[46] Eighteen of the B-36Bs could handle remote-controlled VB-13 "Tarzon" bombs (2 per bomber).

First Flight 8 July 1948

The plane, flown by Convair, performed well—far better than expected. Several later tests by Convair and AMC pilots showed more rewarding results. On 5 December 1948, a long-range mission of 4,275 miles was flown at high altitude. Save for climb and descent, an average cruising speed of 303 miles per hour was maintained during the entire 14-hour flight at 40,000 feet. This was surpassed during a similar mission on 12 December, when the average speed rose to 319 miles per hour. Then on 29 January 1949, a B-36B dropped two 43,000-pound bombs on a practice target, the first from 35,000 and the second from 40,000 feet.

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[46] The bombs were 364 inches long and had a diameter of some 54 inches. To carry these bombs internally, bomb bays needed to be rearranged. Although approved in 1945 as the "Grand Slam Installation," this modification did not reach the production line until all B-36As had been built. There were good reasons for the delay. When B-36 production first started, the high secrecy given to the atomic bomb kept the necessary engineering specifications from reaching the contractor. The Air Force at the time did not know how many atomic bombs were available, and lacked other data on which to base firm carrier requirements. The B-36As could have been retrofitted to carry the crucial weapons, but the modifications appeared senseless since these early bombers were highly deficient.

Enters Operational Service November 1948

The B-36Bs joined the B-36As of SAC's 7th Bomb Group at Carswell AFB in November 1948. On 7-8 December, one of these new B-36s flew a nonstop, round-trip, simulated bombing mission from Carswell to Hawaii. On the way back, the aircraft's 10,000-pound bombload was dumped a short distance from Hawaii. The distance flown in 35½ hours exceeded 8,000 miles.[47] Yet, because many "bugs" had to beworked out, the B-36 did not become truly operational until several years later. In 1951, many B-36s were available and, if called upon, were capable of accomplishing their long-range, high-altitude bombing mission, with either conventional or special weapons. However, the aircraft were in a constant state of flux, either being reconfigured or awaiting modification. In reality, full operational capability was not achieved before 1952.

Additional Procurement 1949

The Air Force possessed 59 groups in the fall of 1948, when the B-36 was just entering the SAC inventory. The soundness of the postwar 70-group objective had been confirmed,[48] and a 66-group force seemed possible within a near future. Hence President Truman's decision to hold the 1949 defense budget to a ceiling of $11 billion had been a drastic blow.[49] The job of rebuilding the Air Force had to be done all over again, and this time from the opposite direction. The problem was no longer how to procure additional airplanes for 70 groups, but how to whittle current forces to 48 groups with the least possible harm to national security. Canceling the aircraft already on order, with minimum loss to the government, was the other difficult task facing the Air Force in early 1949. The B-36 actually gained from the crisis. The Air Force canceled the purchase of various bombers,

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[47] A B-50, another of SAC's newly assigned bombers, made the flight over a much longer route of 9,870 miles in 41 hours and 40 minutes, receiving 3 inflight refuelings from KB-29 tankers.

[48] A Civilian Air Policy Commission (headed by Thomas K. Finletter) was established by the President in 1947. At the same time, a Joint Congressional Aviation Policy Board was formed. Both thoroughly investigated the weaknesses of the Air Force as it began functioning as a separate service. The 2 reports (published on 1 January and 1 March 1948 respectively) recommended orderly but prompt expansion of the forces towards a minimum goal of 70 groups.

[49] The $14 billion budget was to be parceled almost equally among the 3 military services. This prompted Secretary Symington to compare it to throwing a piece of meat into a lion's den and letting the animals fight over it—a remark fully justified by later events.

fighters, and transports in mid-January. At the time, however, it endorsed the urgent procurement of additional B-36s,[50] as recommended by Gen. Curtis E. LeMay, SAC's Commanding General since October 1948. A second augmentation of the program was approved in the spring, when RB-54s were canceled in favor of still more B/RB-36s, as again recommended by General LeMay.[51] The President authorized the recertification and release of funds for the first increase on 8 April; for the second, on 4 May.

Sixth and Last Near-Cancellation 1949

Curtailment of the defense budget brought interservice disagreements to a boil. The Air Force and the Navy had long recognized that whichever service possessed the atomic mission would eventually receive a larger share of the budget. Thus, they had grown more and more wary of each other's strategic programs. Meanwhile, the B-36 atomic carrier had been the target of much criticism, even though few people had seen it—let alone flown it.[52] In early 1949, the B-36's censure grew ominous and could not be brushed aside. An anonymous document began making the rounds in press, congressional, and aircraft-industry circles charging that corruption had entered into the selection, and that the aircraft's performance did not live up to Air Force claims. In August, a second unsigned paper accused the Air Force of having greatly exaggerated the importance of strategic air warfare. The charges of corruption and favoritism were investigated by the Armed

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[50] The Air Force proposed to spend $172 million (of some $270 million released by the cancellation of other aircraft) to buy 39 additional B-36s and to improve or reconfigure those already under contract. This was in line with General LeMay's testimony before the Board of Senior Officers hastily convened on 29 December 1948 by General Vandenberg, who had replaced General Spaatz as Chief of Staff of the Air Force on 30 April 1948. General LeMay insisted that the safest course called for an increase of 2 groups of B-36 heavy bombers (at the expense of 2 medium bomb groups), plus 1 strategic reconnaissance group of B-36s (in lieu of RB-49s).

[51] General LeMay was sure that the B-36 could do everything as well as, and in most cases better than, the B-54. The big B-36 required more parking apron space, but this was not a serious problem. Its maintenance so far had been surprisingly easy. Therefore, it was not impossible to raise the 18-aircraft authorization of every B/RB-36 group to the 30-aircraft level of each medium bomb group. This would slash personnel costs and boost SAC's offensive power. A larger B-36 fleet, General LeMay asserted, together with the approved stepped-up production of Boeing's forthcoming B-47, was the best strategic way to face the near future.

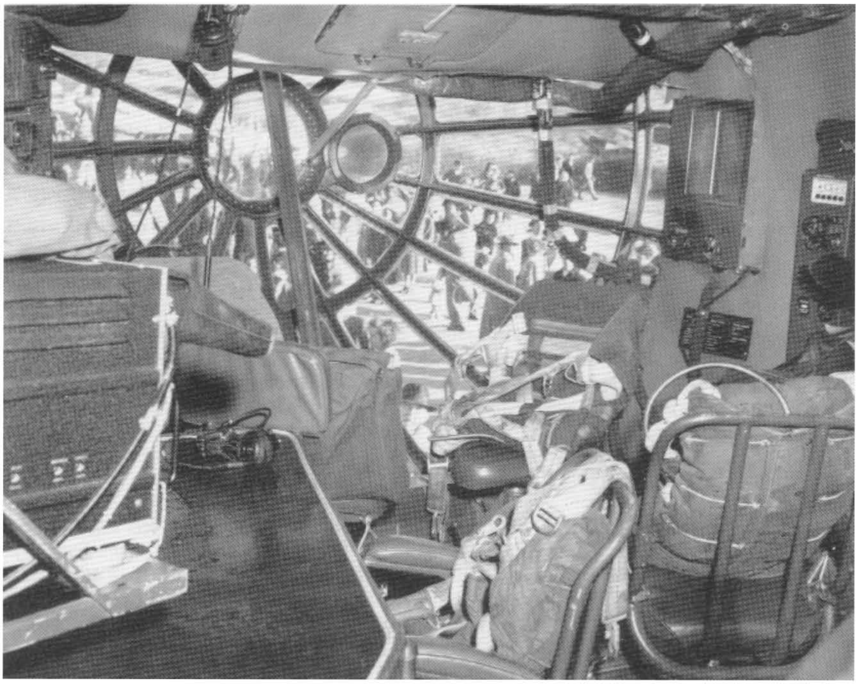
[52] The B-36 had been accused of being as slow as the ancient B-24 and far more vulnerable. Some critics claimed that under the most favorable conditions it would take up to 12 hours to ready the aircraft for flight. Others, with obvious relish, wrote that the connecting tunnel between the B-36's pressurized cabins was too small for a fat sergeant.

Services Committee of the House of Representatives and quickly proven false. On 25 August the investigation closed, after completely clearing the Air Force. However, hearings on the B-36 resumed in October. Briefly stated, the committee had to decide, at least for the time being, whether the nation should rely on massive retaliation with intercontinental bombers in case of attack, or depend upon the Navy's fleet and air arm to defend the North American continent. Even though there were doubts about the B-36's ability to evade fighters, the Air Force emerged triumphantly from the October debates. Yet, the argument between the 2 services over roles and missions was far from settled.[53]

Initial Deficiencies 1949-1950

In contrast to the B-36As, the B-36Bs were equipped from the start

[53] August 1949 amendments to the National Security Act of 1947 had enlarged and strengthened the Office of the Secretary of Defense and severely weakened the authority of the service secretaries. Interservice rivalry nevertheless persisted.



The front section of a B-36, which accommodated the navigator, bombadier, radar operator, and nose gunner.

with remote retraction turrets and 20-millimeter guns. Unfortunately, this was no asset. The B-36Bs in their original configuration would be long gone before either the turrets or guns worked properly.[54] Also, the R-4360-41 engines of the B-36Bs demanded extra fuel tanks. Even though the new bomb-bay tanks were supposedly self-sealing, their leaks lasted throughout the B-36B's short life.

Other Problems 1949-1950

Many of the B-36B's initial troubles resembled those of any other new aircraft. Minor adjustments were needed and— as so often the case—parts shortages were acute. Although the Air Force frowned on cannibalization as never affording a lasting solution, stripping parts from one B-36 to keep another flying became fairly common. Shortages of equipment, such as empennage stands, dollies, jacks, and related items, hampered maintenance. Because there was no money for new equipment, maintenance crews utilized as well as they could some of the tools used for the old B-29s. Personnel turnover further hampered progress. All these problems persisted through 1950.

Post-Production Conversions 1950-1951

Even though the B-36's performance since mid-1948 kept on exceeding early expectations, the aircraft's relatively slow speed continued to cause concern. Tests had shown that altitude was very important in protecting a bomber.[55] Nonetheless, a bomber putting on a burst of speed over a target

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[54] The B-36's defensive armament system, furnished by the government, was designed and built by General Electric according to Air Materiel Command specifications. At first, obvious gun and turret defects postponed the system's installation. Then, lack of ammunition, also government-furnished, delayed testing until mid-1949. And, obviously, the guns had to be air-fired before remaining deficiencies could be found and corrected. As the Eighth Air Force Commander bluntly put it in February 1950: "There is no use driving a B-36 around carrying a lot of guns that don't work."

[55] Locating, intercepting, and shooting down a bomber flying at 40,000 feet was not easy, even if the bomber's speed was no faster than that of the B-36B with its 3,500-horsepower engines. General Kenney had long been disenchanted with the B-36, but admitted in an October 1948 interview, "How are you going to shoot down a bomber at night flying at 40,000 feet with a solid overcast?" Most likely, General Kenney's words could be challenged. During World War II, the Luftwaffe had caused heavy attrition of the Royal Air Force's Bomber Command over the night sky in Europe. On the other hand, it should be noted that General Kenney's interview was conducted on the eve of the Armed Services Committee investigation of the B-36. The Air Force could hardly belittle an aircraft which had acquired a symbolic dimension in the Air Force's and Navy's dispute over the atomic mission.

or while under attack increased its chances of survival. This could have been achieved with the substitution of VDT engines, had this project not failed. A step-up in speed could also be gained, Convair insisted, by mounting 2 General Electric turbojet engines under each of the B-36's wings. These engines could be cut in to boost the power of the B-36's regular ones. Using the proven twin jets already selected for the future B-47 would trim development and testing, while raising the B-36's top speed over the target from 376 to 435 miles per hour. Unlike the extensive changes needed to install the VDT engines, only minor modifications of the aircraft would be required to mount wing nacelles. In fact, Convair was confident that a prototype B-36 with jet-assist engines would be ready to fly less than 4 months after Air Force approval.

The Air Force did not question the merits of the jet pod installation proposed by Convair as early as October 1948. Approval was delayed because of the budgetary restrictions looming in December 1948 and the decision a month before to convert some B-36s for reconnaissance. A prototype B-36 with jet pods was not authorized until 14 January 1949—far too late to allow changes on the B-36B assembly line. Hence, B-36Bs that had barely become operational had to leave the inventory to be equipped with jet pods. But the modification was simple, and most of them soon rejoined the SAC forces as B-36Ds. Eight of the aircraft were also brought up to the reconnaissance configuration, becoming RB-36Ds.

Total B-36Bs Accepted 62

Convair actually built 73 B-36Bs, but the Air Force directed modification of 11 prior to formal acceptance. Four of the 11 appeared on USAF rolls as B-36Ds, and 7 as RB-36Ds.[56]

Acceptance Rates

The Air Force accepted 31 B-36Bs in fiscal year (FY) 1949; 30 in FY 50, and a last one in September 1950 (FY 51).

End of Production September 1950

With delivery of the sixty-second B-36B.

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[56] Convair kept on listing the planes as B-36Bs. Consequently, the Convair B/RB-36D production totals never did match the USAF B/RB-36D acceptances. These discrepancies resulted from different accounting methods and proved of no real importance.

Flyaway Cost Per Production Aircraft **$2.5 million**

As in the B-36A's case, this was a prorated figure based on the estimated procurement costs of 100 B-36s. The price the Air Force paid to bring the B-36B to the B-36D configuration as well as other post-production modification expenses were not included.

Subsequent Model Series **B-36D**

Phaseout **1951**

The B-36B phaseout was fast, almost as quick as that of the B-36A. Twenty-five B-36Bs were already undergoing conversion during the first half of 1951.

B-36D

Previous Model Series — B-36B

New Features

The B-36D featured 2 pairs of J47-GE-19 turbojets (in pods, beneath the wings) to assist the basic 6 R-4360-41 engines; K-3A bombing and navigation system (in lieu of B-36B's APG-24 radar)[57] to allow a single crew member to act as radar operator and bombardier; AN/APG-32 radar (instead of APG-3) to control the tail turret; and higher takeoff and landing weights (370,000 and 357,000 pounds, respectively).[58] The aircraft was fitted with snap-action bomb-bay doors, as opposed to the sliding type of the preceding B-36As and Bs. The new bomb-bay doors opened and closed in 2 seconds.

First Flight (YB-36D) — 26 March 1949

Flown even sooner than Convair expected, the prototype B-36D was a converted B-36B. It differed notably from ensuing B-36Ds by carrying in its pods 4 Allison J35 jet-assist engines, in place of the later standard J47-GE-19s.

First Flight (Production Aircraft) — 11 July 1949

The first true B-36D flew on 11 July 1949, but the Air Force did not accept any of these aircraft for another year.

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[57] The K-1—not the K-3A—at first equipped most B-36Ds (new productions as well as converted B-36Bs). This K-1 system was little more than a refined APQ-24. It likewise had its share of problems, chief among them the random failure of vacuum tubes. In fact, soon after the B-36s entered the inventory, more than 25 percent of their aborts were due to radar deficiencies.

[58] Forty thousand more takeoff pounds than the B-36B and a 29,000-pound landing weight increase.

Enters Operational Service 1950

The first B-36Ds accepted by the Air Force in August 1950 went to Eglin AFB for testing, but SAC received some of the new productions much later. By December, the command's operational bombers included 38 B-36s—several B-36Ds and about 24 B-36Bs (soon to be brought up to the D configuration). The aircraft equipped units of the Eighth Air Force's 7th Bombardment Wing.

Overseas Deployments 1951

Except for the sole B-36 simulated bombing mission to Hawaii in December 1948, no B-36s were flown overseas before 1951. Then on 16 January, 6 B-36Ds went to the United Kingdom, landing at Lakenheath Royal Air Force Station, having staged through Limestone AFB, Maine. The flight returned to Carswell on 20 January. A similar flight was made to French Morocco on 3 December, when 6 B-36s of the 11th Bombardment Wing touched down at Sidi Slimane, having flown nonstop from Carswell.

Remaining Deficiencies 1951

Despite 2 years of engineering test flights and high priority modifications, many of the problems in early productions remained unsolved.[59] Undoubtedly, progress was being made through gradual changes and carefully devised fixes. The aircraft were nearly combat ready by 1951, but far from perfect. In October, for example, the B-36's gunnery system remained operationally unsuitable. In fact, SAC viewed the "gunnery and defensive armament as the weakest link in the present B-36 capability."

Operational Improvements 1952-1953

Improved containers and better sealants reduced fuel tank leakages.

[59] An early major B-36 problem was the recurring leaks in the aircraft's fuel system. The unreliable electrical system and the dangerous flight conditions that could result were also of deep concern through the end of 1949. Engine troubles were still frequent in 1950, compounded by the fact that an engine malfunctioning at a given altitude could check out in perfect order on the ground. Hence, the Air Force on 15 September approved a SAC request for "immediate procurement and installation of airborne ignition analyzers together with necessary spares and supporting equipment for all B-36, B-50, and C-124 type aircraft assigned to this command."

Changes in the electrical system had pared fire hazards during ground refueling operations. Landing gear and bulkhead failures were almost totally corrected. Nevertheless, the Air Force was not satisfied. In April 1952 it ordered a series of gunnery missions for both B-36 and RB-36 aircraft. Known as Far Away, this test was completed in July. It showed that malfunction of the B-36's defensive armament system was due in part to poor maintenance and gunnery crew errors.[60] This prompted Test Fire, a field service exercise begun in September by a RB-36 squadron of the 28th Strategic Reconnaissance Wing. Test Fire ended in December, having attained its main purpose of helping to standardize maintenance and operational procedures.

As anticipated by the Air Force, Test Fire also confirmed the overall conclusion of Fire Away that the B-36's defensive armament was nearly as bad as ever. Various pieces of equipment needed to be redesigned and the fire-control system was barely adequate. In light of this, Hitmore was launched in early 1953. This third project pooled the efforts of the Air Force, General Electric, and Convair (the prime contractor). It required the modification of 6 B-36s to further assess the actual airborne accuracy of the fire-control system. In addition, these planes made separate test flights to gauge the operational efficiency of the gunnery system. The Hitmore results proved encouraging. By mid-year no critical problems had been uncovered. The B-36's defensive armament could be made to work well, after numerous but minor modifications.

Special Modifications — 1954

Several B-36Ds received the special modifications initially applied to a number of the B-36Js (sixth and last of the B-36 model series). Approved in February 1954, the modification contract extended over 11 months. The first modified B-36D, flown in June by Convair, was returned to the Air Force the same month. The modified B-36Ds were identified as Featherweight B-36D-111s. Like other featherweight B-36s, they were to be used for high-altitude operations. Hence, they had been stripped of all armament except the tail turret. Convair had also removed all non-essential flying and crew comfort equipment from the modified planes. To shed even more

[60] The problem of caring for new and highly sophisticated equipment came as no surprise to the Air Force. In early 1949, the Sperry Company had opened a school to train personnel in proper maintenance of the K radar system. SAC, however, was reluctant to let its few trained radar men attend the 8-month course, and it was just as hard to recruit qualified students.

weight, the Featherweights carried a 13-man crew, 2 fewer than the standard B-36D.

Total B-36Ds Accepted 26

Just 26 B-36Ds came off the production lines,[61] but modification of most of the B-36Bs accepted by the Air Force gave SAC a sizeable B-36D contingent.

Acceptance Rates

Except for 1 B-36D received in fiscal year 1952 (August 1951), all B-36Ds were accepted by the Air Force in FY 51—5 in August 1950, 5 in September, 1 in October, 2 in November, 1 in December, 3 in January 1951, 6 in March, and 2 in April.

End of Production June 1951

Production ended in June and the Air Force accepted its twenty-sixth B-36D in August.

Flyaway Cost Per Production Aircraft $4.1 million

Airframe, $2,530,112; engines (installed), $589,899; propellers, $184,218; electronics, $55,974; ordnance, $30,241; armament, $747,681.

Subsequent Model Series B-36F

Other Configurations RB-36D, GRB-36D, and RB-36D-111

Phaseout 1956-1957

In December 1956, SAC's operational inventory counted 250 B/RB-36s of

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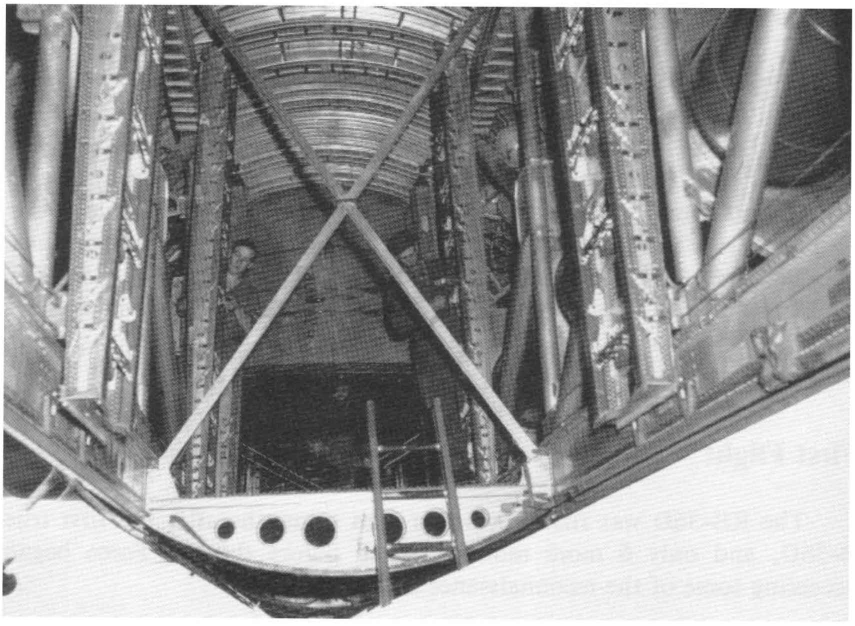
[61] Including 4 planes accounted for by Convair as B-36Bs.

one kind or another. Only 11 B-36Ds remained, after some 6 years of service. It was merely a matter of months before the last of the Ds would be gone.

Milestones 1953

In August and September, B-36s of the 92d Heavy Bomb Wing completed the first mass flight to the Far East, visiting bases in Japan, Okinawa, and Guam. Nicknamed Operation Big Stick, this 3-day exercise came shortly after the end of hostilities in Korea and demonstrated U.S. determination to try every means possible to keep peace in the Far East. On 15 and 16 October, the 92d Heavy Bomb Wing left Fairchild AFB, Washington,[62] bound for Andersen AFB in Guam and 90 days of training. This was the first time an entire B-36 wing was deployed to an overseas base.



Two airmen at work on a portion of a B-36 bomb bay.

[62] Fairchild's severe winter climate adversely affected the 92d Wing's combat readiness. The B-36Ds were still prone to fuel cell leaks, and their usual staging from Fairchild to even colder areas made matters worse. The wing had not yet been able to trade its Ds for either Hs or Js that promised better fuel cell sealant.

RB-36D

New Features

The RB-36D carried cameras (similar to those on the RB-36Es) and electronics, as required by the aircraft's principal missions—all-purpose strategic reconnaissance, day and night mapping, charting, and bomb damage assessment. The RB-36D carried a crew of 22; the B-36D, a crew of 15.

Basic Development 1949

Development of the RB-36D coincided with that of the jet pod-equipped B-36B—later identified as the B-36D. As in the bomber's case, General LeMay strongly influenced the procurement decision that soon followed.[63] He had commanded the B-29 strikes against Japan in World War II, and one of his first actions upon taking charge of the Strategic Air Command was to insist on a quick supply of strategic reconnaissance planes. Speedy conversion of the B-36As and delivery of the RB-36Es ahead of the RB-36Ds attested to the urgency of the SAC Commander's request.

First Flight 18 December 1949

The RB-36D was first flown less than 6 months after the first true B-36D, and only 6 more months passed before the Air Force began accepting some of the reconnaissance aircraft.

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[63] Only 3 strategic reconnaissance candidates remained in November 1948, when the Board of Senior Officers met to review the Air Force's needs for long-range reconnaissance aircraft. The jet pod-equipped B-36 emerged as the board's first choice. The B-47 was second, as also favored by the SAC Commander. The B-54, officially canceled within several months, was third and last. The RB-49, once a strong contender, was not even discussed. Its fate had been sealed during the summer, when problems had arisen in testing the B-49—Northrop's latest tactical configuration of the unconventional B-35 "flying wing."Moreover, development of the RB-49 would have been time-consuming and expensive, 2 commodities the Air Force could not afford.

Enters Operational Service June 1951

Due to severe materiel shortages, the new RB-36Ds did not become operationally ready until nearly half a year after delivery to SAC.

Problems and Improvements 1951-1953

Being virtually alike, the B/RB-36Ds shared the same problems and received similar improvements.

Special Modifications 1954

As in the B-36D's case, some RB-36Ds were changed to the featherweight configuration. These RB-36D-111s retained a large crew, 19 instead of 22. The Convair modification contract extended from February 1954 to the following November. The first modified RB-36D-111 was flown in August, and returned to the Air Force in the same month.

Total RB-36Ds Accepted 24

The Air Force carried these 24 aircraft as RB-36D productions. In contrast, 8 of them initially appeared on the contractors' records as B-36Bs.[64]

Acceptance Rates

The Air Force took delivery of 3 RB-36Ds in June 1950. It accepted the other 21 in FY 51—between July 1950 and May 1951. The Air Force never acquired more than 3 RB-36Ds in 1 month.

End of Production May 1951

Delivery of the 24th RB-36D spelled the end of this aircraft's production.

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[64] The fine line between Convair and USAF ledgers was of no consequence—it did not affect costs nor the aircraft's operational capability.

Flyaway Cost Per Production Aircraft

The RB-36D carried the $4.1 million price tag of the B-36D.

Subsequent Model Series B-36F

Other Configurations GRB-36D-111/RF-84F

The GRB-36D/RF-84 combination, better known as the FICON (*fi*ghter *con*veyor) or carrier-parasite program, came into being in the early fifties. The RB-36s were becoming more and more vulnerable, and no new form of defense was readily available. The Air Force therefore looked to the past for solutions. As a result, it planned in 1951 to put a parasite RF-84 in the RB-36's bomb bay.[65] The parasite plane would be released about 800 or 1,000 miles from the target and within a relatively safe area. The pilot of the RF-84 would continue on to the target, obtain high- or low-level photography as desired, then return to the mother aircraft. An alternate FICON mission would be long-range, high-speed bombing. No real problems arose, but it took longer than thought to bring the FICON project to fruition.

Flown in January 1952, the FICON composite prototype comprised a modified, standard RB-36D and a straight-wing Republic F-84E Thunderjet. Extensive flight tests soon demonstrated the FICON concept was practical. The parasite's straight wings posed no great difficulties. Sweeping down the tail of a forthcoming F-84 prototype (YF-84F) would enable it to fit in the RB-36 bomb bay. Elimination of the YF-84F's tail flutter by using faired bomb-bay doors removed the last stumbling block.

Contracts awarded Convair and Republic in the fall of 1953 called for modifying 10 RB-36Ds and 25 RF-84Fs, respectively. This was far below the

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[65] A carrier-parasite combination had been tried before for somewhat different purposes. It had long been known that heavily laden bombers could not cope with interceptors. Studies undertaken in 1944 to afford some protection to the then yet-to-be flown B-36 envisioned a pilotless, remote control, fast fighter that could be carried to the battle area in one of the bomb bays of the huge long-range bomber. However, this was given up in favor of a pilot-operated fighter that would be more maneuverable in facing repeated attacks. The tiny, folding-wing XF-85 Goblin which ensued was developed by the McDonnell Aircraft Corporation in late 1945 and first flown in August 1948. Because no B-36s were readily available, it was test-dropped from a B-29. The project, however, never went past the experimental stage. The Goblin production was abandoned for a number of technical and financial reasons, but danger was the primary obstacle. The Air Force believed the odds of retrieving a fighter in the midst of a raging battle were poor. Moreover, if the bomber was shot down before the fighter was launched, both crews would be lost. Finally, if the bomber was destroyed after the launching, the short-range Goblin would also be doomed.

number of aircraft SAC had in mind—30 RB-36s and 75 RF-84s. Still, modification of only 35 was to take time. To begin with, the carrier RB-36Ds turned out to be featherweight configurations of the big reconnaissance bomber, and none of these were available before 1954. Furthermore, the reconfigured planes had to be modified to carry the additional mechanisms for stowing, aerial servicing, releasing and retrieving the F-84F parasites.[66] Specifically, this meant that each carrier was equipped with a straight beam extended down from the bottom of the airframe. Each modified parasite featured a retractable probe, mounted on the forward top fuselage section to ease hook-up. Actually, the technical operation of FICON was simple. Carriers and parasites could fly out of different bases. The parasite could be picked up in midair enroute to the target area, or by ground hook-up prior to takeoff. Night operations were also possible. The first GRB-36D-111 carrier was delivered in February 1955, 6 months ahead of the first parasite RF-84F (subsequently identified as the RF-84K). The FICON B-36s served with SAC's 99th Heavy Strategic Reconnaissance Wing.

Phaseout — 1956-1957

The RB-36D followed the B-36D's phaseout pattern. That of the FICON aircraft was much the same.[67]

[66] The FICON carriers retained all their ferret electronic countermeasures components, which were relocated aft of the bomb bays. New APX-29 rendezvous equipment was added.

[67] By mid-1957, SAC's strategic and reconnaissance fighters, the RF-84Ks included, were on their way out.

B-36F

Previous Model Series — B-36D

New Features

The only telling difference between the B-36F and the preceding B-36D lay in the substitution of more powerful engines—R-4360-53s in lieu of R-4360-41 engines.

First Flight (YB-36F) — 18 November 1950

The prototype B-36F and B-36F production models were equipped from the start with six 3,800-horsepower R-4360-53 engines. Each generated 300 more horsepower than a B-36D engine, but still failed to bring the B-36F's performance up to par.[68]

Enters Operational Service — 1951

The Air Force accepted a first B-36F in March 1951 and a few more in the months that followed. No B-36Fs reached SAC until August.

Operational Problems — 1951-1952

The B-36F's R-4360-53 piston engines were not wholly satisfactory because of excessive torque pressure as well as ground air cooling and

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[68] Production plans early in 1951 projected a normal growth in the B-36 employment through use of even more powerful engines. Adoption of the Pratt & Whitney R-4360-57 reciprocating engines would stretch the combat radius of a B-36 with a 10,000-pound bomb load from 3,360 to 4,200 nautical miles. It would also jump the bomber's average speed from 186 to 300 knots. These plans were dropped in August 1952, when the Air Force decided that no more B-36s would be built other than those now in production. The announcement coincided with USAF statement that Boeing's all-jet, 8-engine B-52 would replace the B-36 heavy bomber, and that Boeing had been awarded a letter contract to build 70 of the new bombers.

combustion problems. Pratt & Whitney, Convair, and the Air Materiel Command joined forces to solve these deficiencies quickly.

Post-Production Modifications 1954

As in the case of other B-36 model series, a number of the new B-36Fs were brought up to the configuration introduced by the Featherweight B-36J-111. Approval of the Convair modification contract in February 1954 was followed by delivery of the first B-36F-111 in May. The B-36F featherweight modifications were completed in December, on schedule.

Total B-36Fs Accepted 34

Among the 34 B-36Fs bought by the Air Force was the B-36F prototype, later completed as a true production model.

Acceptance Rates

The Air Force took delivery of the first 4 B-36Fs toward the end of fiscal year 1951—1 in March 1951, 1 in May, and 2 in June. The other 30 B-36Fs were accepted in FY 52—2 in July 1951, 5 in August, 4 in September, 8 in October, 6 in November, 4 in December, and 1 in January 1952.

End of Production October 1951

The Air Force did not get its last B-36Fs until several months after production was over.

Flyaway Cost Per Production Aircraft $4.1 million

The B-36F carried the price tag of the B-36D. Airframe, engines, electronics, all cost the same.

Subsequent Model Series B-36H

Other Configurations RB-36F and YB-60

RB-36F: The Air Force ordered and took delivery of 24 long-range reconnaissance versions of the B-36F. The first 4 RB-36Fs were accepted in fiscal year 1951 (all in May); the 20 others in FY 52 (between August and December 1951). Cost records listed both the B-36F and the RB-36F at $4.1 million each.

YB-60: This B-36 configuration never went past testing. First known as the YB-36G, this apparent successor to the B-36F, was redesignated YB-60 in mid-1951 because it so obviously differed from the B-36. At the same time, Convair's plans to bring existing B-36s to the G configuration were given up. The swept-wing, pure-jet YB-60, with its new needle-nose radome and new type of auxiliary power system, soon found itself competing with the future B-52. Both used the same jet engines (Pratt & Whitney J57-P-3s), but in comparison the YB-60's performance test results proved disappointing, and the program was canceled in January 1953. The cost of building and testing the 2 B-60 prototypes (accepted in the fall of 1951) ran around $15 million.

Phaseout 1958-1959

In mid-1958, 46 RB-36s remained in the active inventory. SAC identified 19 of them as RB-36Fs. No B-36Fs were listed, although USAF rolls still reflected 32 B-36s. Total phaseout was imminent in any case.

Items of Special Interest 1954-1955

On 16 June 1954, SAC's 4 RB-36-equipped heavy strategic reconnaissance wings were given a primary mission of bombing. They did limited reconnaissance as a secondary mission. Then on 1 October 1955, the RB-36 reconnaissance wings were redesignated heavy bombardment wings, while retaining a latent reconnaissance capability.

B-36H

Previous Model Series — B-36F

New Features

The B-36H had a rearranged crew compartment and additional twin tail radomes to store the components of the AN/APG-41A radar.[69]

First Flight (YB-36H) — November 1950

The B-36H and B-36F prototypes were first flown at almost the same time. Yet, B-36H deliveries did not start until December 1951, when the Air Force already had most of its 34 B-36Fs. The B-36H's marked improvement over the F accounted for the delay between production. The Air Force bought 156 B/RB-36Hs—more than double the production total of any other B-36.

Enters Operational Service — 1952

Once underway the production flow of B/RB-36Hs was steady, averaging 8 aircraft per month during 1952, and 6 monthly between January and September 1953.

Operational Problems — 1952

By 1952, engineering on the B-36 was little more than correction of rather minor deficiencies showing up in service. The B-36H (like the B-36F) had 6 R-4360-53 engines, but the early troubles of these new engines were virtually under control. Other problems arose, however. During a few months in 1952, all B-36s were restricted to an altitude of 25,000 feet after

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[69] The AN/APG-41A was far superior to the AN/APG-32 gun-laying radar employed by the preceding B-36Ds and B-36Fs.

an RB-36 accident at 33,000 feet was traced to a faulty bulkhead. This restriction remained in effect until all deficient bulkheads were discovered and replaced.

The B-36's original propeller blades carried flight restrictions that hampered performance. A new blade, made by a special flash-welding process, could be used freely except for landing and takeoff. This blade weighed an extra 20 pounds, but its greater efficiency promised to compensate for the loss in aircraft range. A batch of 1,175 was ordered for prompt installation.

Grounding — 1952

In March, defective landing gears caused a series of accidents. After 2 crashes, the Air Force grounded all B-36s except the first 152. This meant that almost all of the last half of B/RB-36F productions and some 30 B/RB-36Hs already accepted by the Air Force could not be flown. Investigations from the start had blamed the aircraft's landing gear pivot shaft. Since a heavier bar could be devised and serve until a permanent alteration could be made, the grounding orders were soon lifted.

Post-Production Modifications — 1954

Some B-36Hs and B-36H reconnaissance versions were reconfigured by Convair in 1954. They were returned to SAC in the same year as B/RB-36H-111s, having undergone the same stripping and overall modification as other featherweight B/RB-36s. No troubles were met with during the fulfillment of the B/RB-36H or other featherweight modification contracts. The crew of each aircraft so modified was cut. For high-altitude operations, B-36s carried only a crew of 13 (a decrease of 2); RB-36s, a crew of 19 (a decrease of 3).

Total B-36Hs Accepted — 83

Acceptance Rates

The Air Force accepted 32 B-36Hs in fiscal year 1952—7 in December 1951, 5 in January 1952, 3 in February, 5 in March, and 4 in each of the next 3 months. It received 43 B-36Hs in FY 53—4 in July 1952, 4 in August, 7 in September, 3 in October, 4 in November, 2 in December, 4 in January 1953, and 3 during each of the next 5 months. The last 8 B-36Hs were accepted in FY 54—3 in July 1953, 3 in August, and 2 in September.

End of Production — July 1953

All B-36Hs, including the last one built, had been accepted by the end of September.

Flyaway Cost Per Production Aircraft — $4.1 million

In round figures, the B-36H and B-36F prices were alike. In reality, the B-36H cost an additional $11,321. Airframe costs were much lower, but the price of the engines showed a steep increase. Armament, electronics, and propeller cost also had gone up. The new costs were: airframe, $2,077,785; engines (installed), $874,526; propellers, $214,186; electronics, $80,272; ordnance, $30,241; armament, $872,436.

Subsequent Model Series — B-36J

Other Configurations — RB-36H and B-36H (Tanker)

RB-36H: The Air Force bought 73 long-range reconnaissance versions of the B-36H. Twenty-three were accepted in FY 52 (all during the first 6 months of 1952); 42 others in FY 53 (between July 1952 and June 1953). The last 8 were delivered in FY 54 (3 in July 1953, 3 in August, and 2 in September). The RB-36H price matched that of the B-36H and did not include the featherweight modification costs of 1954.

B-36H (Tanker): Searching for a tanker that could refuel jet aircraft at higher altitudes and higher speeds, SAC in early 1952 became interested in a readily convertible B-36 bomber-tanker. The Air Force therefore asked Convair to equip one B-36 with a probe and drogue refueling system. The modification contract was approved in February 1952 and the work was completed in May. Testing, postponed to the end of the month because of the late delivery of one B-47 receiver aircraft, was satisfactory enough. Yet, no other tests took place until January 1953, after a new and vastly

The NB-36H—modified to be a test bed for a nuclear reactor.

improved British-made probe and drogue refueling system was installed.[70] The converted B-36H tanker subsequently flown could refuel one or more receiver aircraft. The 9-crewmember tanker could be returned to its standard bomber configuration in some 12 hours. But the B-36's bomber commitments never really allowed SAC to exploit these features.

Phaseout 1956–1959

Conversion of SAC's heavy bomb wings to B-52 aircraft began in June 1956, with the B-36H-equipped 42d Wing at Loring AFB, Maine.[71] Nonetheless, like the final B-36Js, the much-improved B-36Hs were among the last to go.

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[70] The British had developed refueling techniques to the point where they were actually in use on commercial airplanes, and the Air Staff in late 1947 had already begun to consider adapting the British technique to combat aircraft refueling. This would allow short-range but relatively speedy bombers of the B-50 type to get to a distant and heavily defended target with the atomic bomb—a task allocated to the B-36, but especially hazardous due to that long-range bomber's slow speed.

[71] The 93d Bomb Wing at Castle AFB, Calif., fully equipped with B-52s in April 1956, had been a B-47 outfit prior to conversion.

Other Uses 1952-1955

One B-36 was modified by Convair in 1952 to carry guided air missiles (GAMs), specifically the GAM-63 Rascal,[72] under development by the Bell Aircraft Corporation since 1946. A mockup inspection of the B-36/Rascal prototype disclosed no major obstacles, and 11 other B-36s were programmed to be modified as director aircraft (DB-36s) for the new missiles.[73] Several factors soon dictated changes in USAF plans. The principal ones were ongoing Rascal difficulties, imposition of new technical requirements, and reorientation of the program to achieve the best aircraft/missile operational combination. Although testing with the DB-36 would go on for awhile, the Air Staff decided in mid-1955 that it definitely wanted the B-47, not the B-36,[74] to carry the Bell rocket-powered GAM-63. Time lessened the decision's importance, the Rascal program being canceled in November 1958.[75]

1955-1957

One B-36H (Serial No. 51-5712) never reached SAC. The Air Force reserved it for special tests that might lead to the design of the world's first atomic-powered plane. The future nuclear-propelled B-36 (temporarily labeled the X-6) did not materialize. Even so, the modified and redesignated B-36H (NB-36H) saw extensive duty as a nuclear-reactor test bed. Forty-seven test flights were made, yielding valuable data on the effects of radiation upon airframe and components. The NB-36H had undergone various modifications prior to testing. The most important one added a crew compartment to the fuselage nose section. This shielded all crew members from radioactive rays, when the nuclear reactor in the aft bomb bay operated. Composed of lead and rubber, this compartment completely surrounded the crew. Only the pilot and copilot could see out through the

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[72] The name Rascal derived from the guidance system used during the missile's dive on the target. This system was called a *Ra*dar *Sca*nning *L*ink, and the word Rascal was formed by combining the underlined letters of the 3 words.

[73] Such aircraft as the B-29, B-50, B-47, and even the B-52 were considered or modified as Rascal carriers, either for experimental or operational use.

[74] Most of the DB-36 modification contract was canceled. Convair completed only 3 aircraft and reimbursed $1.6 million to the Air Force.

[75] At a top speed of Mach 2.95, the Rascal could carry a 3,000-pound nuclear warhead 90 nautical miles. Still, it remained unreliable and was overtaken by technological progress.

foot-thick, leaded-glass windshield. A closed-circuit television system enabled the crew to see the reactor as well as other parts of the aircraft.

Milestones 6 April 1955

A B–36 launched a guided missile with an atomic warhead from 42,000 feet. The explosion took place 6 miles above Yucca Flat, Nevada. It was the highest known altitude of any nuclear blast at the time.

B-36J

Previous Model Series — B-36H

New Features

The B-36J had 2 additional tanks, 1 on the outer panel of each wing, allowing an extra fuel load of 2,770 gallons. It also had a much stronger landing gear, permitting a gross takeoff weight of 410,000 pounds.[76]

First Flight (YB-36J) — July 1953

The prototype flight was swiftly followed by the September flight of the first B-36J production model. The latter was immediately accepted by the Air Force.

Enter Operational Service

SAC received its full contingent of B-36Js in less than a year.

Production Modifications — 1954

The last 14 B-36Js entered the operational inventory as lightweight B-36J-111s. In contrast to other B-36 featherweights (modified after production), Convair made all necessary changes before completing the aircraft. This delayed delivery for a month (too short to disrupt SAC's plans) and saved more than $100,000.

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[76] This had long been a SAC goal. The Air Force and Convair as early as 1952 discussed how to increase the takeoff weight of available B-36s without compromising safety—USAF engineers arguing that the structural integrity of some of the aircraft's new components was unknown. Takeoff weight was raised to 370,000 pounds in June 1952. But still cautious, the Air Force's authorization covered only B-36s that already had somewhat stronger landing gears.

Operational Problems 1953–1958

SAC had no critical problems with the B–36Js. For that matter, the entire B–36 fleet showed improvement, largely because of Project SAM-SAC. This program, initiated in 1953, required the cyclic reconditioning of all operational B–36s (215 as of September 1954) and constantly tied-up 25 aircraft in depots. Yet, the intensive maintenance paid off for both the older B–36s and the latest and final B–36Js. In the same vein, the crew-to-aircraft ratio (too low for many years) began to improve as the number of combat-ready crews grew steadily.

Other Improvements 1953–1958

The B–36 was certain to be entirely outmoded by mid-1955.[77] Until then, however, it remained SAC's primary atomic bomb carrier and perhaps the Nation's major deterrent to Soviet aggression. Meanwhile, the Air Force found ways to keep enhancing its effectiveness. Ever resourceful, the service set up the Quick Engine Change Program, which combined an engine and accessories in a power package that could be field-installed in no time. Applied to other aircraft as well, the change program for B–36s ran from 1953 until September 1957. Another ingenious and long-lasting project was Big-Kel (devised by the San Antonio Air Materiel Area at Kelly AFB, Texas), which replenished the flyaway kits of B–36 spares utilized in SAC wing rotation overseas.

Planning Changes 1957–1958

Defense funds cutbacks in fiscal year 1958 compelled the Air Force to alter plans for every USAF program at every echelon. SAC did not escape the crisis. The B–52 procurement was stretched out and the B–36 service-life extended. Although the worldwide flying hours of the 2 bombers were reduced, these changes were fraught with complications. To begin with, phasing out the giant B–36s was a large undertaking. Because it could "find no other use for them," the Air Force had ordered the $1 billion fleet

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[77] Phaseout of the B–36 was settled before 1953. All kinds of technological advances called for it. Withdrawing B–36s from the inventory would also make it possible to do away with the strategic fighters that were to accompany the cumbersome bombers on most of their missions.

scrapped.[78] Still, the B-36s were to remain first-line strategic bombers up to their final day. As a rule, B-36s flew from their last operation straight to the Arizona storage base for reclamation and destruction.[79] The shortage of B-52s forced the withdrawal of B-36s from several reclamation contracts. By then, the Air Force had made it a practice to support the B-36s still in service with components from out-of-service planes. Moreover, to conserve the most in money and manpower, only required items were saved and unneeded reclamations were avoided. Hence, the reactivated B-36s obviously posed problems.

Total B-36Js Accepted 33

Acceptance Rates

The Air Force accepted 28 B-36Js in fiscal year 1954—2 in September 1953 and 2 in October, 3 each month from November 1953 through March 1954, none in April, 4 in May, and 5 in June. Five more B-36Js were accepted in FY 55—4 in July 1954 and 1 in August.

End of Production August 1954

The Air Force received the last B-36J on 10 August and delivered it 4 days later to the 42d Heavy Bomb Wing at Loring AFB.

Flyaway Cost Per Production Aircraft $3.6 million

The B-36J cost half a million dollars less than the preceding

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[78] The scrapping of the first 200 B-36s was due to yield a return of $93.5 million, but the Air Force recouped much more. Various configurations of the B-36's basic R-4360 engines equipped other USAF aircraft (KC-97s, B-50s, C-119s, and C-124s) and $22,000 worth of parts (mainly, crankshafts and cylinders) was removed from each B-36 engine. This was no small savings because 4,000 engines (1,200 of the early R-4360-41s and 2,800 of the more powerful -53s) became surplus as a result of the B-36 phaseout.

[79] B-36s began arriving at Davis-Monthan in February 1956. Reclamation and destruction were handled by the Mar-Pak Corporation, Painesville, Ohio. Mar-Pak had reclaimed 161 B-36s by December 1957 and processed the last B-36 in April 1959.

B-36H—airframe, $1,969,271; engines (installed), $639,651; propellers, $214,186; electronics, $77,691; ordnance, $32,036; armament, $707,379.

Subsequent Model Series — None

Other Configurations — None

Phaseout — 1958-1959

In December 1958, only 22 B-36s (all B-36Js) remained in the operational inventory. Symbol of global airpower during the early days of the United States Air Force, the B-36 Peacemaker neared its end. On 12 February 1959, the last of SAC's giant bombers and the final B-36J built by Convair left Biggs AFB, Texas, where it had seen duty with the 95th Heavy Bomb Wing. The plane (Serial No. 52-2827) was flown to Amon Carter Field in Fort Worth and put on display as a permanent memorial.

Milestones — 12 February 1959

Retirement of the last B-36 marked the beginning of a new era—SAC's becoming an all-jet bomber force on that day.

Program Recap

The Air Force accepted a grand total of 385 B-36s (prototype, test, and reconnaissance aircraft among them). As recorded by the Comptroller of the Air Force, the program consisted of 1 XB-36, 1 YB-36, 22 B-36As, 62 B-36Bs, 26 B-36Ds, 34 B-36Fs, 83 B-36Hs, 33 B-36Js, 24 RB-36Ds, 24 RB-36Fs, 73 RB-36Hs, and 2 swept-wing, all-jet B-36 prototypes (known for a while as YB-36Gs but redesignated and flown as YB-60s). Be that as it may, these listings were far afield from most operational counts. Modifications and reconfigurations sharply altered the B-36 program. The Air Force accepted only 26 true B-36D productions, but conversion of the B-36Bs gave SAC another 50 B-36Ds. Similarly, the B-36A reconfiguration gave the reconnaissance forces 22 RB-36Es, not reflected in production data. Pinning a price on the B-36 was not so involved. Some true productions, like the B-36Hs, ran as high as $4.15 million, but early B-36s were far cheaper. The Air Force estimated the entire program (research, development, prototypes, and production) at $1.4 billion. Prorated, this came to $3.6 million per aircraft. Omitted from every unit cost, however, were the expenses incurred for all engineering changes and modifications, added on after approval of a basic contract.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

B/RB-36 AIRCRAFT

Manufacturer (Airframe) Consolidated Vultee Aircraft Corp.
Fort Worth, Tex.

(Engines) The Pratt & Whitney Aircraft Division of United Aircraft Corporation, East Hartford 8, Conn., and The General Electric Co., Schenectady, N.Y.

Nomenclature Strategic Heavy Bomber and Reconnaissance Aircraft.

Popular Name Peacemaker

	B-36A	B-36B	RB-36E	B-36D	B-36D-111	B-36F	B-36H	B-36J	B-36J-111
Length/Span (ft)	162.1/230	162.1/230	162.1/230	162.1/230	162.1/230	162.1/230	162.1/230	162.1/230	162.1/230
Wing Area (sq ft)	4,772	4,772	4,772	4,772	4,772	4,772	4,772	4,772	4,772
Weights (lb)									
Empty	135,020	140,640	164,238	161,371	161,264	167,646	168,487	171,035	166,165
Combat	212,800	227,700	238,300	250,300	244,400	254,300	253,900	266,100	262,500
Max Takeoff[a]	311,000	328,000	370,000	370,000	370,000	370,000	370,000	410,000	410,000
Engine: Number, Rated Power per Engine & Designation	(6) 3,000-hp R-4360-25	(6) 3,500-hp R-4360-41	(6) 3,500-hp R-4360-41 & (4) 5,010-lb st J47-GE-19	(6) 3,500-hp R-4360-41 & (5) 5,010-lb st J47-GE-19	(6) 3,500-hp R-4360-41 & (5) 5,010-lb st J47-GE-19	(6) 3,800-hp R-4360-53 & (4) 5,010-lb st J47-GE-19	(6) 3,800-hp R-4360-53 & (4) 5,010-lb st J47-GE-19	(6) 3,800-hp R-4360-53 & (4) 5,010-lb st J47-GE-19	(6) 3,800-hp R-4360-53 & (4) 5,010-lb st J47-GE-19
Takeoff Ground Run (ft)									
at Sea Level	6,000	6,030	4,400	4,400	4,400	3,990	3,990	5,290	5,290
Over 50-ft Obstacle	8,000	8,520	5,685	5,685	5,685	5,110	5,110	6,820	6,820
Rate of Climb (fpm) at Sea Level	502	500	970	960	970	920	920	720	780
Combat Rate of Climb (fpm) at Sea Level	1,447	1,510	2,140	2,210	2,330	2,060	2,060	1,920	1,995

Service Ceiling (ft) (100 fpm Rate of Climb to Altitude)	—	28,500	32,200	33,100	33,400	33,000	33,000	27,400	28,500
Combat Ceiling (ft) (500 fpm Rate of Climb, Max Power, to Altitude)	—	38,800	40,000	40,700	41,300	40,900	40,800	39,900	39,500
Average Cruise Speed (kn)	189	176	190	193	192	204	203	198	197
Max Speed at Optimum Altitude (kn/ft)	300/31,600	331/34,500	348/36,500	353/36,200	363/37,300	363/37,100	361/36,700	357/36,400	363/37,500
Combat Radius (nm)	3,370	3,740	3,057	3,065	3,260	2,807	2,705	2,955	3,465
Total Mission Time (hr)	35.6	42.43	31.7	31.5	33.7	26.7	26.4	29.4	34.6
Armament	16 20-mm guns	16 20-mm guns	16 20-mm M24A1 guns	16 20-mm M24A1 guns	16 20-mm M24A1 guns	16 20-mm M24A1 guns	16 20-mm M24A1 guns	16 20-mm M24A1 guns	2 20-mm M24A1 guns
Crew	15	15	22	15	13	15	15	15	13
Max Bombload[b] (lb)	72,000	72,000	None[c]	72,000	72,000	72,000	72,000	72,000	72,000

Abbreviations

fpm	= feet per minute	mm	= millimeter
hp	= horsepower	nm	= nautical miles
kn	= knots	st	= static thrust
max	= maximum		

[a] Limited by the strength of the aircraft's main landing gear. The maximum takeoff gross weight of a number of B-36Bs was restricted to 278,000 pounds. B-36s with higher takeoff weights (370,000 pounds or more) were equipped with stronger landing gears (modified after production) or new landing gears (installed on the production line).

[b] The basic mission bombload was 10,000 pounds. Bombloads could be made of various combinations—WW II box fins, interim conical fins, and so-called new series. Except for the B-36As, all B-36s could carry bombloads of 86,000 pounds (e.g., two 43,000-lb bombs), when their gross weight did not exceed 357,500 pounds.

[c] Like other B-36s in the reconnaissance configuration, the RB-36E was equipped with 23 cameras (mostly K-22As, K-17Cs, and K-38s) and carried 80 T-86 photo flashes.

Basic Mission Note

All basic mission performance data were based on maximum power, except as otherwise indicated.

Combat Radius Formula:

B-36A—Not applicable, since this model was used mainly for training and crew transition.

B-36B—Warmed up, took off, climbed on course with normal power to 10,000 feet, cruised at long-range speeds at altitudes for best range (10,000 feet minimum). Climbed to arrive at 25,000 feet, 30 minutes prior to target. Cruised long-range speeds for 15 minutes, conducted 15-minute normal-power bomb-run, dropped bombs, conducted 5-minute evasive action plus 10-minute escape at normal power. Returned to base at altitudes for best range using long-range cruise-climb technique. Range-free allowances included 10-minute normal-power fuel consumption for warm-up and take-off, 5-minute evasive action at normal-power fuel consumption, and 5 percent initial fuel for landing and endurance reserves.

B-36D—Warmed up, took off, and climbed on course to 5,000 feet at normal power; cruised out at long-range speeds to point of cruise-climb operation. Began climb to combat altitude, using long-range climb powers, to arrive at cruise ceiling 500 nautical miles from target. Cruised at long-range speeds at combat altitude, using best engine (reciprocating-jet) combinations; 15 minutes from target, conducted 10-minute engine normal-power bomb-run, dropped bombs, and conducted 2-minute evasive action and 8-minute escape from target at normal power. After leaving target area, cruised back at long-range speeds, using best engine combinations, until 500 nautical miles from target. Descended to optimum cruise altitude and cruise-climbed back to base. Range-free allowances included 10-minute normal-power fuel consumption for reciprocating engines and 5-minute normal-power fuel consumption for jet engines for starting and take-off, 2-minute normal-power fuel consumption at combat altitude for evasive action, 30-minute fuel consumption for long-range speeds at sea level (reciprocating engines only), plus 5 percent of initial fuel load for landing and endurance reserves.

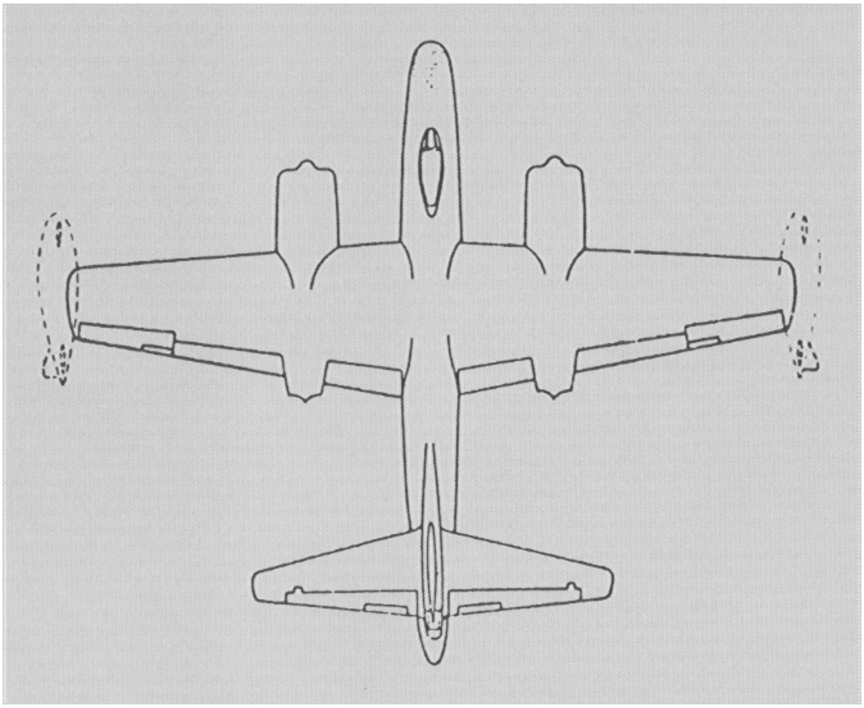
B-36D-111—Same as B-36D.

B-36F, B-36H, B-36J, and B-36J-111—Same as B-36D and B-36D-111, except also dropped chaff.

RB-36E—Same as B-36D and B-36D-111, except "conducted 10-engine normal-power photo-run" (instead of bomb-run), and "dropped flash bombs" (instead of bombs).

B-45 Tornado

North American Aviation, Incorporated



B-45 Tornado
North American

Manufacturer's Model 130

Overview

In 1943, aware of Nazi Germany's advances in the field of jet propulsion, the Army Air Forces (AAF) asked the General Electric Company to devise a more powerful engine than its prospective axial turboprop. This was a tall order, but it eventually brought about the production of the J35 and J47 turbojets. In 1944, 1 year after the jet engine requirements were established, the War Department requested the aircraft industry to submit proposals for various jet bombers, with gross weights ranging from 80,000 to more than 200,000 pounds. This was another challenge, and only 4 contractors answered the call.

Pressed for time, the AAF in 1946 decided to skip the usual contractor competition, review the designs, and choose among the proposed aircraft that could be obtained first. The multi-jet engine B-45, larger and more conventional than its immediate competitor, won the round, with the understanding that if a less readily available bomber was to prove superior enough to supplant it (which the Boeing XB-47 did), that aircraft would also be purchased.

Testing of the XB-45 prompted pre-production changes. North American Aviation, Incorporated, redesigned the nose panel, increased the aircraft's stabilizer area, and lengthened the tailplane by nearly 7 feet. In August 1948, 22 of the 90 B-45s, ordered less than 2 years before, reached the newly independent Air Force. However, the B-45's increased weight, excessive takeoff distance, and numerous structural and mechanical defects generated scant enthusiasm.

Meanwhile, the B-47's future production had become certain, and in mid-1948 the Air Staff actually began to question the B-45's intrinsic value as well as its potential use. Soon afterwards, as President Truman's budgetary axe slashed Air Force expenditures, the programmed production of B–45s was reduced to a grand total of 142, a decrease of 51 aircraft.

Although continuously plagued by engine problems, component malfunctions, lack of spare parts, and numerous minor flaws, the B–45 regained importance. Like all bombers produced after the end of World War II, the B–45 was designed to carry both conventional and atomic bombs. In mid-1950, when U.S. military commitments to the Korean War reemphasized the vulnerability of the North Atlantic Treaty Organization forces in Europe to Soviet attack, the Air Force made an important decision. Since the U.S. planned to produce large quantities of small atomic and thermonuclear weapons in the near future, the use of such weapons, heretofore a prerogative of the strategic forces, would be expanded to the tactical forces, particularly in Europe.

The program that ensued, under the code name of Backbreaker, entailed difficult aircraft modifications because several distinct atomic bomb types were involved and large amounts of new electronics support equipment had to be fitted in place of the standard components. In addition, the 40 B–45s allocated to the Backbreaker program also had to be equipped with a new defensive system and extra fuel tanks. Despite the magnitude of the modification project, plus recurring engine problems, atomic-capable B–45s began reaching the United Kingdom in May 1952, and deployment of the 40 aircraft was completed in mid-June, barely 30 days behind the Air Staff deadline.

All told, and in spite of its many valuable secondary functions, the B–45 did not achieve great glory. The entire contingent, Backbreaker and reconnaissance models included, was phased out by 1959. Yet, the B–45 retained a place in aviation history as the Air Force's first jet bomber and as the first atomic carrier of the tactical forces.

Basic Development 1944

Like the trouble-plagued but eventually successful and long-lasting B–47, the B–45 officially originated in 1944, when the War Department called for bids and proposals on an entire family of jet bombers, with gross weights ranging from 80,000 to more than 200,000 pounds. These were ambitious requirements considering the kind of airplanes being planned at the time in the United States and elsewhere. Yet, the emergence of unrealistic requirements was a common practice that would endure for decades.[1]

[1] From experience, government officials most likely rationalized that inflating the requirements was the only way to get at least the minimum acceptable. Late in 1948, engineers

Unofficially, the roots of both the B-45 and B-47 aircraft could be traced to 1943, when the Army Air Forces, aware of Nazi Germany's advances in the field of jet propulsion, asked the General Electric Company to design something better than the TG-100 axial-flow turboprop engine that was being developed for the Consolidated-Vultee's 2 experimental P-81 escort fighters (the mass production of which did not materialize). The AAF's demands were met with General Electric's development of the 4,000-pound-thrust TG-180 and the TG-190 engines,[2] of which various models were to power subsequent bomber and fighter aircraft. For its part, North American began to attempt satisfying the AAF's requirements for a jet bomber with a design for an easy-to-build airframe, conventional in concept and straightforward in its aerodynamic form. Model 130, as the design was labelled in early 1944, was a mid-wing monoplane with dihedral tailplane and a retractable landing gear. North American planned to propel its new bomber with 4 jet units, grouped in horizontal pairs, 1 pair on each side of the fuselage outboard of the tailplane.

Initial Procurement — September 1944

The AAF initiated the procurement of the future B-45 with Letter Contract AC-5126. This document, issued on 8 September 1944, called for the development and testing of 3 experimental B-45s,[3] all of which were to be based on North American design 130. In time, as production of the

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of the Air Materiel Command began to point out the pitfalls of this practice. But their concern did not prevail. In 1952, many in the Air Staff also recommended caution and their efforts achieved some degree of success. Nevertheless, as the "weapon system concept" gained momentum, it became evident that the Air Force believed increasingly that mission objectives had to come first and that technology could be made to satisfy such objectives. (For details, see B-58, p 354 and pp 373-374).

[2] The TG-180, eventually built in large quantities by the Allison Division of the General Motors Corporation, became the J35; the TG-190, continuously produced by the General Electric Company, became the J47.

[3] The basic terminology of military aircraft underwent little change throughout the years. For the United States Air Force (as well as the preceding Army Air Forces), an experimental aircraft is a vehicle in a developmental or experimental stage, which is not established as a standard vehicle for service use. The experimental aircraft may be built to try out an idea, or to try for certain capabilities or characteristics. It may embody a new principle or a new application of an old principle. The status of such aircraft is indicated by the prefix, or classification letter X. In contrast, the prototype aircraft is a preproduction vehicle procured for evaluation and test of a specific design. The prototype status is indicated by the letter Y. This prefix symbol is acquired by the first complete and working aircraft made of a given model or model series, intended to serve as the pattern or guide for subsequently produced members of the same class.

aircraft appeared probable, North American altered the overall configuration of 1 of its 3 XB-45s. The selected vehicle was actually completed as a tactical model and, although seldom referred to as YB-45, assumed the role of a standard prototype.

Production Decision 2 August 1946

The AAF originally intended to schedule a formal competition between the various contractors working on projects to satisfy the War Department's requirements of 1944. In 1946, since the early production of a jet bomber seemed highly desirable, the AAF decided to forgo the planned competition. Instead, available designs would be reviewed to determine which model could be obtained first. Four contractors were involved: North American, working on the XB-45; the Boeing Airplane Company, engrossed in the development of the swept-wing, 6-jet XB-47; the Consolidated Vultee Aircraft Corporation (Convair), engaged in the XB-46; and the Glenn L. Martin Company, builder of the XB-48.[4] But while the XB-45 and XB-46 were nearing completion and flights of these aircraft were scheduled for 1947, the XB-47 and XB-48 in 1946 were still in the early stages of development, and 2 years might elapse before the end of their fabrication and initial flight testing. Pressed for time, the AAF opted to appraise the XB-45 and XB-46 immediately and to postpone consideration of the XB-47 and XB-48 until they flew. Then, if either the XB-47 or the XB-48 proved superior enough to supplant the new bomber being produced (which the XB-47 did) that aircraft would be bought.[5] On 2 August 1946, the AAF

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[4] The military characteristics, issued by the AAF on 17 November 1944 (see B-47, pp 101-102) and embodied by the 4 projects, were specific but not restrictive. The B-45 and B-47 aircraft, the only 2 programs that went beyond the experimental stage, stemmed from the same requirements but ended having very little in common. Both were ordered as "medium" bombers, but in contrast to the B-47, which retained its medium bomber designation, the B-45 became a light bomber. The fact that the B-45, weighing 47,000 pounds and having a combat radius of 764 nautical miles, was finally listed as "light" also showed how swiftly concepts changed. Five years before, the World War II B-17G Flying Fortress, which weighed 37,672 pounds and had a combat radius of 873 nautical miles, was considered "heavy."

[5] The AAF anticipated that the B-47's performance characteristics would exceed those of the B-45, but realistically believed that the swept-wing, underslung engine nacelles, bicycle-type landing gear, and other experimental features of the Boeing design would require an extended period of development. The XB-48, although more conventional than the XB-47, featured a 3-engine installation in each wing and would incorporate the bicycle-type landing gear of the B-47. The XB-48 might prove to be superior to the XB-45, but any potential production of the Martin design remained several years away.

endorsed the immediate production of the B-45.[6] Several factors accounted for the selection. First, the AAF concluded that the XB-46's projected performance most likely would be inferior to that of the XB-45. Second, the XB-46's fuselage was not configured to hold all required radar equipment. Finally, since the XB-45's design only departed slightly from proven configurations, it was the most logical choice prior to testing of the experimental model. The AAF's decision of 2 August prompted within 1 week the negotiation and signature of Contract AC-15569, which called for an initial lot of 96 B-45As (North American Model N-147), plus a flying static test version of the experimental type (NA Model N-130). The cost of the contract was $73.9 million.

First Flight (XB-45) — 17 March 1947

On 17 March 1947, the first of the 3 experimental B-45s made its initial flight. The 1-hour flight, from Muroc Army Airfield, California, was conducted under stringent speed restrictions because the aircraft's landing gear doors did not close properly when the landing gear was retracted. This problem could have been avoided by installing new and available landing gear uplocks, but this time-consuming installation was postponed.[7] Nevertheless, the XB-45's demonstration was impressive. No large multi-engine jet bomber had ever been flown before.[8] And, of primary importance from the manufacturer's standpoint, even though a B-45 production order had already been secured, the XB-45 flight preceded that of the still potentially competitive XB-46.

Initial Testing — March 1947-August 1948

The Air Materiel Command planned an extensive test program for the

[6] The decision did not specifically spell the end of the XB-46, but it was a poor omen. Already reduced to only 1 plane, the experimental B-46 program actually lingered until August 1947, when the AAF terminated the whole venture.

[7] As soon as World War II ended, most manufacturers had to compete fiercely for the few, limited orders. This was reason enough for North American not to delay the XB-45's flight.

[8] Douglas's experimental twin-jet B-43, an outgrowth of the company's XB-42 Mixmaster, flew almost 1 year before the XB-45, but the XB-43 was very small and the 2 could not be compared. In the same vein, 2 German developments appearing in 1944 presented no true challenge. One of them, the Arado Ar-234, introduced by the Luftwaffe as a jet-bomber, was so tiny that it rightly belonged to the fighter category. The Junkers Ju 287 only flew as a prototype designed to test a radical wing, Germany's nearing collapse presumably preventing completion of the aircraft.

3 experimental airplanes developed by North American; each of the 3 was to be instrumented for a specialized phase of the program.[9] The testing, however, was marred at the start by an accident that killed 2 of North American's crack test pilots and destroyed their aircraft. This accident was attributed to an engine explosion, but other contributing factors later came to light. These accounted for most of the changes specified in the B-45's production articles. Meanwhile, flight testing of the remaining XB-45s went on. Air Force pilots did not participate extensively in the initial tests. They flew only about 19 hours, while the contractor logged more than 165 flight hours on the 2 surviving aircraft. This total was accumulated in 131 flights, conducted before the Air Force took delivery of the planes. The Air Force accepted 1 XB-45 on 30 July 1948; the other, on 31 August. The acceptances were conditional because the pressurization systems of both planes did not function.

Other Experimental Testing 1948-1950

After North American fixed the pressurization of the XB-45 cabins, additional tests were undertaken. Air Force pilots flew a total of 181 hours in 1 XB-45 between August 1948 and June 1949, when an accident damaged the aircraft beyond economical repair. The remaining XB-45, although constructed to serve as a prototype, had limited testing value due to an initial shortage of government-furnished equipment. Still, the Air Force put another 82 hours of flying time on the plane. A USAF flight test crew delivered the airplane to Wright-Patterson AFB, Ohio, where equipment was installed for bombing tests at Muroc AFB, California. Unfortunately, the YB-45 proved to be an unsatisfactory test vehicle because it required excessive maintenance. Only 1 mission was accomplished between 3 August and 18 November 1949, and that mission was to evaluate the long-awaited components. The airplane was used for high-speed parachute drops after November 1949, but on 15 May 1950, it was transferred to the Air Training Command to serve as a ground trainer.

Pre-Production Changes 1947-1948

As might be expected, the crash of an XB-45 precipitated a thorough

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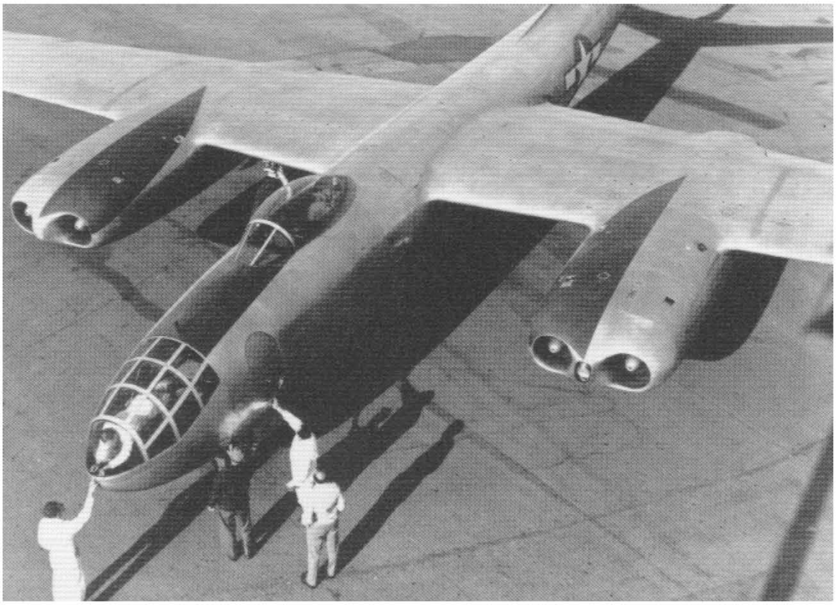
[9] In the late fifties, the various testing phases to which all aircraft were submitted were supplanted by testing categories. However, the changes affected the testing program's terminology more than its scope. (For specific information, see B-52, pp 224-225).

Close-up of 2 of the 4 jet engines that powered the XB-45.



An XB-45 undergoes a taxi test at Muroc Army Airfield, California.

investigation. As suspected, special wind tunnel tests confirmed that the aircraft's insufficient stabilizing area had contributed directly to the accident. The lack of ejection seats, moreover, had practically eliminated the pilot and co-pilot's chances for survival. As a result, 2 ejection seats were installed in the other experimental planes, while an advanced ejection system was being devised for the forthcoming production aircraft. In addition, future B-45s would be equipped with wind deflectors, placed in front of the escape doors from which the other 2 crew members (bombardier-navigator and tail gunner) would have to bail out in case of an emergency. North American also altered the structural configuration of the production vehicle. Most noticeable was a redesign of the nose panel. Finally, the aircraft's stabilizer area was increased, and the tailplane was lengthened from 36 to almost 43 feet.

B–45A

Manufacturer's Model NA–147

New Features

The B–45A differed from the experimental B–45s in featuring improved ejection-type seats for the pilot and co-pilot and safer emergency escape hatches for the bombardier-navigator and tail gunner. Communication equipment, emergency flight controls, and instruments, installed at the co-pilot's station, also were new. Other improvements included the E–4 automatic pilot, a bombing-navigation radar, and A–1 fire-control system, all of which were provided as standard equipment. Some of the B–45As were equipped with the AN/APQ-24[10] bombing-navigation radar system and such sophisticated electronic countermeasures components as the AN/APT–5; other B–45As only provided for the easy retrofit of this equipment. The first B–45As featured versions of the Allison-built J35 jet engines (in most cases, 4 J35–A–11s), but later aircraft were fitted from the start with the higher-thrust jets developed by the General Electric Company, either 2 J47–GE–7s or 2 J47–GE–13s, and 2 J47–GE–9s or 2 J47–E–15s.

First Flight (Production Aircraft) — February 1948

The initial production model of the XB–45 flew in February 1948, less than a year after the first flight of the experimental aircraft.

First Production Deliveries — April 1948

The Air Force began taking delivery of the initial batch of B–45As, 22 of them, in April 1948. These aircraft were identified as B–45A–1s to distinguish them from the subsequent 74 B–45As, known as B–45A–5s. Among other improvements, the B–45A–5s were equipped with more powerful

[10] The AN/APQ-24 bombing-navigation radar system made its operational debut with the Convair B-36B.

J47 engines. As soon as possible, the Air Force assigned 2 B-45A-1s to an accelerated service test program, which was already progressing well by mid-July. Under this program, each of the 2 planes accumulated 150 hours of rigorous testing under day and night operating conditions—test results actually accounting for some of the improvements featured by the B-45A-5s. Three additional B-45A-1s were deployed to Muroc AFB[11] to serve as transition trainers in support of the accelerated service test program. In effect, most of the early B-45As were relegated to the training task and became known as TB-45A-1s. In later years, however, priorities were to dictate that a few TB-45s be brought up to the combat configuration.

Unexpected Problems — 1948

From the start, the introduction of the B-45 was hindered by a misunderstanding about the number of USAF pilots who were to be "checked out" in the aircraft at Muroc AFB by personnel of North American Aviation. In June 1948, delays in production made matters worse for the 47th Bombardment Wing, which was earmarked as first recipient of the new multi-jet bombers. Late in the year, the pioneer wing's training problems were aggravated by shortages of several months' standing in ground handling equipment and special maintenance tools. Structural or mechanical defects in a number of the few available B-45s did not help.

Program Uncertainty — Mid-1948

Although available records do not disclose any serious consideration of canceling the entire B-45 production, the program apparently ran into

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[11]Among the base's predecessors was the Materiel Command Flight Test Base (ca 1942), which was redesignated Muroc Flight Test Base in 1944. In 1946, the Muroc Flight Test Base on the north end of Muroc Dry Lake and the Bombing and Gunnery Crew Training Base on the south end of the dry lake were merged into a single flight test center at Muroc Army Airfield under the jurisdiction of the Air Materiel Command. Muroc Army Airfield was redesignated Muroc AFB in February 1948 and became Edwards AFB 1 year later in honor of Captain Glen W. Edwards, a USAF pilot killed on 5 June 1948 while testing a prototype jet bomber of the Northrop Aviation's unconventional B-49 "flying wing." Officially dedicated on 27 January 1950, Edwards AFB remained under the Air Materiel Command until April 1951, when the Air Research and Development Command, established as a new major air command in January 1950, assumed jurisdiction. The Air Research and Development Command activated the Air Force Flight Test Center at Edwards AFB on 25 June 1951. The installations, as well as the research and development functions previously assigned to Air Materiel Command, were retained by Air Research and Development Command until 1961, when the newly formed Air Force Systems Command took over.

trouble even before any of the aircraft became truly operational.[12] As early as June 1948, at a meeting held in the office of General Hoyt S. Vandenberg, Air Force Chief of Staff since 30 April, doubts were expressed as to the B-45's value and its future utilization. It was decided (a decision evidently later rescinded) that no contract beyond the current one would be let, that production would go on as planned up to the 119th article, and that the funds already made available for a new contract would be used for another purpose.[13] One group would be equipped with the operational type, the initial 90 aircraft; the remaining aircraft would be placed in storage to cover the group's eventual losses. At the time, officials of the Tactical Air Command (TAC) were asked whether or not they liked the Northrop B-49 prototype, which had an empty weight of 88,000 pounds, almost twice that of the B-45. Shortly afterward, Gen. Muir S. Fairchild, USAF Vice Chief of Staff since 27 May, asked the Aircraft and Weapons Board[14] to determine if

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[12] Some B-45 records were destroyed; others provided a surprising amount of conflicting information. Throughout the years, Air Force historians in attempting to answer certain B-45 queries could only point out that early systems were acquired in many different ways and that variances in methods of documentation complicated matters. For instance, the date on which the B-45 reached an initial operational capability (IOC) could not be ascertained. Other historical data such as the B-45's first production delivery, total USAF testing hours, and the identification of the XB-45 initially destroyed, remained unclear. North American Aviation provided its testing hour total, but the figures did not agree with those obtained from Air Force sources. The most striking examples of the inadequacy of old records undoubtedly pertained to test data—not only on the B-45 bomber, but on other early aircraft as well. This was understandable to some degree because Air Force tests were accomplished at numerous bases and for a great variety of purposes. In any case, all dates and information supplied on the B-45 are based upon documentary evidence. Bits and pieces included in the B-45 coverage are provided in the belief that they may be significant to users.

[13] Obviously, the quantity of B-45s first ordered had been increased, but the contract amendment's date as well as other details are no longer known. A second contract (AC-18000) had been issued in February 1947, either on the 7th or 17th day of that month. This contract dealt with another version of the B-45 (see p 88), but the information also is sketchy. Reportedly, a third contract (W33-038 AC-21702) came into being in June 1948, when the Air Force as a whole showed scant enthusiasm for the aircraft, only to be canceled on an unknown later date.

[14] The Aircraft and Weapons Board was established in August 1947. It made recommendations on problems submitted by the Air Staff and the commands. Composed of the Deputy Chiefs of Staff and major air commanders, the board proved too cumbersome and in December 1948 was replaced by the USAF Board of Senior Officers which included the Vice Chief of Staff, Deputy Chief of Staff for Operations, Deputy Chief of Staff for Materiel, and the Commanding General, Air Materiel Command. The dormant Aircraft and Weapons Board was discontinued in the fall of 1949. However, the establishment of the Air Council in April 1951 was accompanied by the formation of 4 additional boards: the Force Estimates Board; Budget Advisory Board; Military Construction Board; and a new USAF Aircraft and Weapons Board which replaced the Senior Officers Board. The reactivated Aircraft and Weapons Board lasted for over a decade. (For details, see Herman Wolk, *Planning and Organizing the Postwar Air Force*).

the weight of the various types of aircraft earmarked for or already in production could be reduced. Several conferences ensued, special attention being devoted to the B–45, with some board members suggesting that elimination of the co-pilot position, of the AB/ARC–18 liaison set installed in that position, and of the B–45's tail bumper would take 700 pounds off the aircraft's empty weight. There were other suggestions, some of them equally haphazard. Col. William W. Momyer,[15] who represented TAC at these conferences, discovered that the Air Staff labored under the false impression that TAC did not consider the B–45 suitable for bombardment operations, a conclusion probably based upon previous studies by the command on the aircraft's excessive take-off distances. In the early fall of 1948, by which time 190 B–45s were tentatively scheduled for production, the program's future still remained uncertain. Headquarters USAF wanted to know if TAC needed a reconnaissance aircraft, and if so would a reconfigured B–45 be satisfactory? If this should be the case, all B–45s would be converted to the reconnaissance role. TAC's answers came promptly. Indeed the command needed a new reconnaissance aircraft, but a reconnaissance version of the B–45 would not fulfill its requirements. TAC believed the Air Force would accrue more benefits by equipping 2 groups with the B–45 in order to determine the tactics and limitations of jet bombers. The merits of TAC's recommendations became academic, as budgetary restrictions and other unexpected developments altered all planning.

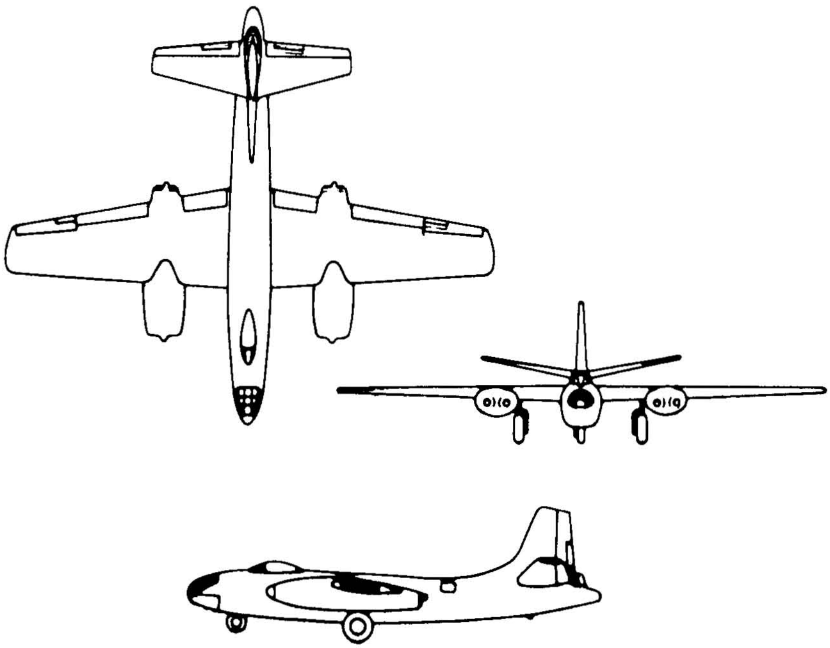
Enters Operational Service — November 1948

B–45A–5s began reaching squadrons of TAC's 47th Bombardment Wing at Barksdale AFB, Louisiana, in the fall of 1948. Despite slippages, 96 B–45As were completed by March 1950. Unfortunately, during the intervening months financial problems had already begun to take their toll on the B–45 program.

Program Reduction — 1948–1949

The budgetary axe that slashed the fiscal year 1949 defense expenditures did not leave the B–45 program unscathed. According to plans, 5 light bomb

[15] Twenty years later, immediately after serving in Southeast Asia as Deputy Commander for Air Operations, Military Assistance Command, Vietnam, and simultaneously as Commander, Seventh Air Force, General Momyer, now a full general, assumed command of Tactical Air Command.



The B–45A, first flown in February 1948.

groups and 3 light tactical reconnaissance squadrons were included in the Air Force's goal of 70 groups.[16] The reduced Air Force program dictated by continued financial restrictions and, more specifically, by President Truman's budget for fiscal year 1950 brought into focus the Air Force's dilemma. The shrunken B-45 program called for only 1 light bomb group and 1 night tactical reconnaissance squadron, which meant that the procurement of the aircraft had to be scaled-down or that a substantial number of the aircraft would have to be placed in storage upon acceptance from the factory. Neither solution was attractive, but the Aircraft and Weapons Board quickly decided to cancel 51 of the 190 aircraft on order. Over $100 million would be released for crucial programs, and sufficient B-45s would be left to equip 1 light bomb group, 1 tactical reconnaissance squadron, plus a much-needed high-speed tow target squadron. Moreover, there would still be extra B-45s to take care of attrition throughout the aircraft's first-line life.[17]

Other Planning Changes 1948-1949

Five light bomb groups were included in the 70-group force planned by the Air Force. In reprogramming available forces to meet the 48-group composition and deployment imposed by current funding limitations, only 1 light bomb group was authorized. This group, the Air Force tentatively decided, would be allocated to the Far East Air Forces (FEAF) and would be equipped with B-45s. Specifically, the Air Force intended to inactivate Barksdale's 47th Group and to replace the B-26s of FEAF's 3d Light Bomb Group, at Yokota Air Base in Japan, with the B-45s of the defunct group. Maintenance personnel of the 47th also would be transferred to Yokota so that FEAF would benefit from the B-45 "know how" gained by the aircraft's first recipient. But even logical and simple plans could go astray. Available and in-coming B-45s could not carry sufficient fuel to fly to Hawaii, and equipping the aircraft with additional fuel tanks, a probable

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[16] See B-36, pp 25-26.

[17] The first-line life of an aircraft cannot be predetermined, only predicted. As a rule, an aircraft remains "first-line" as long as it is "operational," "modern," and "capable of being used to perform critical and essential Air Force missions." Conversely, an aircraft becomes "second line," when its limitations for combat or other military use have been formally recognized. However, second-line aircraft may be called for first-line duty under certain circumstances—in emergency, and in services for which first-line aircraft are not available.

feature of future B–45 models, was at the time impossible.[18] Of course, it might have been practical to move the B–45s to Japan by sea. If a minimum of 10 feet could have been removed from each of the aircraft's wings, a rather impractical expedient, 3 B–45s could be deck-loaded on a Liberty or Victory ship, for a transport fee of approximately $4,000 per aircraft. The use of other sea transports might also have proved possible, but further investigation came to a halt. Early in 1949, the Deputy Chief of Staff for Materiel stated that the overseas deployment of B–45s was out of the question for the time being as well as the immediate future. To begin with, the B–45s were not truly operational. They had no fire-control or bombing equipment, and a suitable bomb sight was yet to be developed for the aircraft. Structural weaknesses, such as cracked forgings, had been uncovered in some of the few B–45s already available. And until corrected, such deficiencies certainly precluded any deployment abroad. Still another impediment arose. As reported by Air Materiel Command (AMC), the new J47 engine due to equip most of the B–45s suffered from serious problems. The engine had to be inspected thoroughly after 7½ hours of flying time; if found still serviceable, it could only be flown an additional 7½ hours before requiring a complete overhaul. Lack of money prevented the purchase of sufficient spare engines to ensure that, if deployed overseas, the B–45s could be kept flying. AMC anticipated difficulties, even for those aircraft that remained in the U.S., not far from the depots where the engines had to be inspected and overhauled. By mid-year, the home-based B–45s were expected to need 900 spare engines, none of which would be available. The shortage was compounded by the fact that F–86 requirements for J47s had first priority.[19] Little relief could be expected, AMC concluded, until jet engines could be used for almost 100 hours between overhauls. At best, this meant that no jet aircraft could be stationed out of the country for another year.

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[18] B–45A–1s, equipped with J35 engines, had a ferry range of 2,120 miles and a take-off weight of 86,341 pounds that included 5,800 gallons of internal fuel. Almost half of the fuel was contained in two 1,200-gallon bomb-bay tanks and no additional fuel space was available. Incoming B–45–5s, equipped with J47 engines, had a similar take-off weight and a negligible range increase of 30 nautical miles. Obviously, General Fairchild's interest in weight reduction retained its validity, but there were no simple solutions. Ferry ranges were computed on the basis that the aircraft's wing tip tanks and bomb-bay tanks were retained when empty. If an increase of the weight figure was desired by a using agency, a reliable rule of thumb up to 1,000 pounds, Air Materiel Command engineers pointed out, was that every extra pound of weight induced a range decrease of 0.025 nautical miles. A corresponding small increase in range could be achieved by weight reduction.

[19] The 1-engine F–86 Sabres, also produced by North American, began entering operational service in 1949, but did not go overseas before December 1950.

Deficiencies and Malfunctions 1949–1950

Difficulties encountered by B–45 units, while impairing further the training of jet pilots, posed serious operational problems. The B–45's flaws varied in importance, but were numerous. High speeds affected the Gyrosyn compass[20] and the E–4 automatic pilot, when the aircraft's bomb-bay doors were open. The emergency brake, which was tied to the B–45's main hydraulic system, was unreliable. Because of poorly designed bomb racks, the bomb shackles became unhooked during certain maneuvers. The B–45's airspeed indicator was inaccurate, and the aircraft's fuel pressure gauges were both difficult to read and erratic. Another safety hazard derived from the engines which, when first started, often caught fire because the aspirator system worked improperly. The temperature gauge of the aircraft's tail pipe, moreover, was so poorly calibrated that it could not indicate the temperatures experienced at high altitudes.

Special problems, with many ramifications, stemmed from the B–45's AN/APQ–24 bombing-navigation radar system, and the fact that hardly any B–45s had already received such equipment did not minimize present or future difficulties. Malfunctions of the pressurization pump limited the altitude at which the APQ–24's receiver and transmitter component could operate. The modulator component of the system was not pressurized at all and likewise limited the APQ–24's utility. In addition, the faulty position of the radar antenna affected the coverage of targets as soon as the APQ–24 had to operate at an altitude of 40,000 feet. In fact, the radar system's overall location left a great deal to be desired, a shortcoming shared by several other components. When utilizing the APQ–24, the B–45 observer had to manipulate 2 mileage control dials, placed to his right and about 1 foot behind his back, while observing the radar scope directly in front of him. The layout of the B–45's radar system was not any better from a maintenance standpoint. The Air Force still lacked sufficient qualified personnel for maintenance and repair, and it took 8 hours just to remove and replace the APQ–24's modulator, one of the system's numerous troublesome links. Contributing to the dismal maintenance situation were shortages of spare parts, special tools, and ground handling equipment as well as engine hoists, power units, and aero stands.

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[20] The trade name for a compass that consisted of a directional gyro synchronized with the horizontal component of the earth's magnetic field by means of a flux gate—the flux gate detecting the direction of the lines of force and transmitting the information electrically to a procession device.

Decision on Nuclear Capability 1950

Prior to 1949, the Air Force did not consider seriously the tactical employment of atomic weapons apart from their use for strategic air warfare. The most important reason was the AAF and Air Force's allegiance to the primacy of strategic air warfare per se.[21] Another factor was the belief that atomic weapons, because of their great cost and the scarcity of fissionable material, would remain relatively few in number. When the

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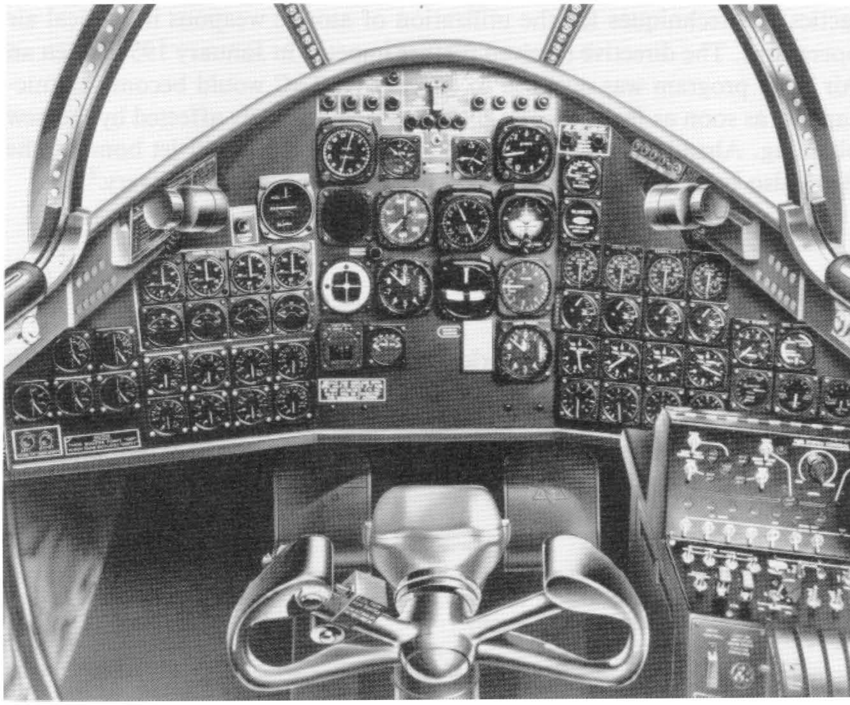
[21] After the German surrender, AAF leaders declared their long-held theory of strategic bombing had been proved— that massive bombing of selected vital targets in a nation's interior could cripple its war-making capabilities and seriously weaken the people's will to resist. Critics argued that strategic bombing had failed to achieve its objectives, that its cost was excessive, and that tactical air power had made the greater contribution to Allied victory. Despite the controversy, it soon became obvious that Boeing's spectacular B-17 Flying Fortresses and subsequent B-29 Superfortresses had a greater impact on U.S. policy than the best known World War II fighters.



The cockpit of the B-45 Tornado, specially designed so the pilot could view all indicators at a glance.

development and large quantity production of small nuclear weapons became probable, the Air Force earmarked such weapons again for strategic use, especially as warheads for proposed guided missiles. Nevertheless, the Weapons Systems Evaluation Group conducted a study on the use of the atomic bomb on tactical targets, after evaluating the effect of the bomb on such targets as troops, aircraft, and ships massed for offensive operations, as well as naval bases, airfields, naval task forces, and heavily fortified positions. Concluded in November 1949, the study found nuclear bombs to be effective on all targets. Although informal in nature, the Weapon Systems Evaluation Group's study was noted by the Air Staff. Yet no action was taken until mid-1950, when the outbreak of the Korean War underlined the weakness of the North Atlantic Treaty Organization forces, should the Russians decide to seize the opportunity to attack in Europe. From then on events moved promptly. The lion's share of the atomic responsibilities, including the retardation mission that normally would fall under the tactical sphere of activities, was retained by the Strategic Air Command (SAC),[22] but the use of atomic or thermonuclear weapons would become Air Force-wide. On 14 November 1950, the Air Staff directed TAC[23] to develop tactics and techniques for the utilization of atomic weapons in tactical air operations. The directive received further impetus in January 1951, when an Air Staff program was outlined to ensure that TAC would become atomic-capable as soon as feasible. The B-45 was tremendously affected by the new planning. Already established as the Air Force's first multi-jet bomber, the B-45 also became the first light bomber fitted for atomic delivery.[24]

Immediate Setback 1950

Ordered in the wake of World War II as a SAC medium bomber, the B-45 was designed to carry the A-bomb.[25] But the secrecy surrounding the production of the first atomic weapons created difficulties for which neither the contractor nor the AAF could be blamed. Because of faulty informa-

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[22] The retardation mission consisted of bombing operations to slow or stop the advances of ground forces. The latter rightly belonged to the fleeting target category, and SAC did not retain the retardation mission permanently.

[23] TAC, part of the Continental Air Command since December 1948, regained major command status on 1 December 1950.

[24] The deterrent impact of the B-45 remained unknown. Moreover, the aircraft represented but a tiny segment of the Air Force's early atomic armada.

[25] For details, see B-47, pp 111-112.

tion, the B-45 from the start could not have been used as an atomic carrier without significant internal modifications, the principal obstacle being a large spar extending laterally across the aircraft's bomb bay. However, the problem had become moot quickly, the small, short-range B-45 being reclassified as a light bomber in September 1947 and reallocated to TAC.[26] Ironically, the decision to extend the use of atomic weaponry to all combat forces meant that most of the B-45s acquired by TAC would no longer remain under the command's direct control. It also meant that TAC, now due to develop tactical operational techniques with the new weaponry, would have to do so with too few aircraft. In the meantime, the Air Force faced other problems. While the post-World War II achievements in the atomic field had been spectacular, and safer and lighter atomic bombs entered the stockpile much sooner than expected, intensive secrecy again had accompanied the new developments. Hence, as in the case of the old atomic bomb, the B-45 would be unable to carry any of the new weapons without first undergoing extensive modification.

Special Modifications 1950-1952

The special modification program, spurred by the Air Force's decision of mid-1950, was not allowed to linger. In December 1950, 5 months after tentatively earmarking 60 B-45s for atomic duty,[27] the Air Staff directed AMC to modify a first lot of 9 aircraft to carry the small bombs for which designs were then available. This initial project would allow suitability tests by the Special Weapons Command,[28] and give TAC at least a few test aircraft to undertake its new tasks. As a beginning, 5 of the 9 aircraft would be equipped with the scarce AN/APQ-24 system; the remaining 4, with the AN/APN-3 Shoran navigation and bombing system, plus the visual M9C Norden bomb sight. North American would bring the 9 light bombers to the required special weapons configuration for a total cost of $512,000. In mid-1951, the program for operational use of the B-45 in potential atomic operations was established. The aircraft in this program were nicknamed

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[26] See B-36, p 21.

[27] Enough for 3 squadrons of 16 aircraft each, plus 12 attrition aircraft. This total, reduced to 40 aircraft in mid-1951, was re-increased in mid-1952, when 15 other B-45s were added to the special modification program.

[28] A separate command of short duration. Established in December 1949, the Special Weapons Command was redesignated Air Force Special Weapons Center and assigned to Air Research and Development Command in April 1952, losing major command status at that time.

Backbreaker and included, in addition to the B-45 light bombers, 100 of the many F-84 fighter-bombers built by the Republic Aviation Corporation.[29] Moreover, the program was accorded a priority second only to a concurrent and closely related modification program involving various SAC bombers. In the early fall of 1951, the program received further impetus. The Air Staff confirmed that modified B-45s, equipment, and allied support had to be supplied to enable units of the 47th Bombardment Wing in the United Kingdom to achieve an operational atomic capability by 1 April 1952. In addition to the first lot of 9 aircraft, the program would count 32 B-45s, the latter aircraft's modification cost being set at $4 million.[30] The Air Staff wanted 16 of the planes to be ready by 15 February 1952; the remainder, by 1 April. These were ambitious plans. Remodeling the B-45 aircraft to the Backbreaker configurations was an extensive operation. Equipment had to be installed in the aircraft for carrying 3 distinct bomb types, and this necessitated some structural modifications to the bomb bay.[31] Then too, a large amount of advanced electronics support equipment had to be added, in place of the standard equipment. Also, the aircraft had to be fitted with a new defensive system and extra fuel tanks. North American and the Air Materiel Command's San Bernardino Air Materiel Area, in San Bernardino, California, shared modification responsibilities for the B-45 Backbreaker program. In early 1952, the 9 B-45s, already brought to a limited Backbreaker configuration by AMC and North American, were sent by TAC to San Bernardino for completion of the modifications. Complete reconfiguration of the other 32 B-45As also took place at the San Bernardino Air Materiel Area during the first 3 months of 1952, with North American furnishing all necessary kits. That the work was done without significant delay was noteworthy, for all parties had to overcome serious difficulties. Much of the electronic and support components required for the Backbreaker configuration, being new and of advanced designs, were in very short supply. The requirement for the AN/APQ-24 radar was in direct competition with a SAC special program. Also, the few available AN/APQ-24 sets had to be adapted to the special weapons configuration. Shoran sets, as well, were not readily available, and a quantity had to be diverted from Far East Air Forces' and TAC's B-26 programs. There were other challenges. Some of the new equipment could not be installed before

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[29] The aircraft were modified F-84Es, identified as F-84Gs.

[30] One B-45A was destroyed by fire in February 1952 and not replaced, thus reducing the total from 41 to 40. Of the $4 million allocated to the project, some of the funds came from other Tactical Air Command projects which had to be canceled.

[31] Special cradles were provided for the 3 types of bombs; and special hoisting equipment was required for loading each type of bomb on the Backbreaker B-45.

connecting parts were manufactured. In addition, some needed components simply did not exist. For example, the bomb scoring device, which consisted of a series of switches and relays, was actually manufactured at San Bernardino. The Air Materiel Area also made parts for the A-6 chaff dispenser, including a removable chute for easier maintenance. In the same vein, a special fuel flow totalizer was produced by North American, which likewise manufactured special tie-in equipment for the AN/APG-30 radar and the rest of the Backbreaker B-45's tail defense system. Finally, the Fletcher Aviation Corporation of Pasadena, California, produced the extra fuel tanks, while AMC's Middletown Air Materiel Area in Middletown, Ohio, built the special slings that had to be used to carry some of the new bombs.

Overseas Deployment 1952

Atomic-capable B-45As began reaching the United Kingdom on 1 May 1952, and deployment of the 40 aircraft was completed on 12 June. This

Tornadoes of the 47th Bombardment Group, Langley AFB, are prepared for deployment to the United Kingdom, July 1952.

schedule fell about 30 days behind the Air Staff deadline, but was a remarkable achievement considering the project's magnitude. Not only had the Backbreaker modifications proven exacting, but the Air Force had to cope with various engine problems. As reported by the General Electric Company field representatives servicing the 47th Bombardment Group throughout most of 1951 the J47s powering the Backbreaker aircraft shared some of the flaws of the aircraft's initial engines. Turbine buckets of the new J47s ruptured like those of the Allison J35s. Tail cones fractured just as easily when the J47s functioned improperly. Oil leaks appeared, which meant that the engines had to be removed for repairs and test runs. The Air Force did not expect any new engine to be problem-free from the start, but the urgency surrounding the Backbreaker program made these difficulties more significant. Besides, TAC had to take care of many other tasks. The B-45 deployment called for a somewhat more integrated atomic weapons support system than that used by SAC. TAC had immediately envisioned a concept that actually emphasized the mobility, flexibility, and speed characteristic of tactical air operations. While the TAC concept and the demands it necessarily entailed were not all approved, the Air Staff had endorsed the salient points of the command's proposal. As a result, after being activated on 31 August 1951, the 1st Tactical Support Squadron moved to Europe in the spring of 1952. Once overseas, the support squadron was attached to the 47th Bombardment Wing,[32] now a Third Air Force unit of the United States Air Forces in Europe. Like the Backbreaker modification program, the logistic organization and supply system devised by TAC had required much work. Still the system soon was accused of being unwieldy, wasteful of personnel, and unsuited to the support of delivery operations from widely dispersed bases. Modified during the ensuing year, TAC's revised atomic weapons support system was expected to allow greater dispersion in weapon storage and to provide the flexibility essential for varied theater requirements.

New Modifications and Retrofit 1952–1953

In July 1952, the Air Force decided to increase the number of atomic B-45 aircraft by 15. The endorsed configuration was to be that of the Backbreaker aircraft, plus improvements. In short, some electronic changes were needed, the Backbreaker aircraft's tail defense system had to be upgraded, and the fuel flow totalizer, which had been required for the first

[32] TAC's 47th Wing was at Langley AFB, Virginia, in early 1952. The B-45 overseas deployment prompted the wing's relocation to Royal Air Force Station Sculthorpe, England.

40 Backbreaker B-45s but had not been installed because of production delays, was to be added. Another important change, perhaps the most important, called for relocation of the supports required by a specific type of atomic bomb. The supports had to be moved into the forward bay to allow the installation of a 1,200-gallon fuel tank in the rear bay, since theextra fuel would give the aircraft a range increase of almost 300 nautical miles.

In September 1952, after conferring with North American, the Air Force decided on the improved Backbreaker configuration and established a program for procurement and installation of the necessary kits. The Air Force allocated $2.2 million for modification of the 15 additional B-45s, and $3 million for retrofit of the first 40 Backbreaker aircraft. Logically, the San Bernardino Air Materiel Area was to take care of the new modifications and would also provide all necessary kits for the Backbreaker retrofit, which would be done in the field. Although less involved than the original Backbreaker modifications, the new program slipped. During the second half of 1952 the Air Materiel Command was in the process of decentralizing responsibilities from its headquarters to the various air materiel areas. Hence, delays occurred in processing engineering data and purchase requests which, in turn, retarded kit preparation and delivery by North American.

Contractual problems, too, occurred at North American, as the contractor was no longer tooled for the B-45 and was working to capacity on other products. As a result, kit deliveries did not start until July 1953, pushing installation back 4 months. In September 1953, the Air Force added 3 B-45s to the modification program, but as 2 of the original aircraft had been deleted and 1 had crashed, the total still remained at 15. Because no more B-45As were available, 3 of the subsequent models in the B-45 series were modified, postponing the program's completion to March 1954.

Remaining Shortcomings 1953-1954

While the Backbreaker modifications and retrofit enabled the B-45s to handle several types of small atomic bombs, the modified aircraft were not fitted to deliver the special atomic bombs needed for the retardation mission.[34] In 1953, because of the increasing availability of atomic weapons, the Air Force thought of relieving SAC from the retardation responsibility. However, the matter again was dropped, since no tactical aircraft would be able to satisfy the retardation requirements until the Douglas B/RB-66s

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[34] The retardation mission covered the slowing down of enemy troop movements or lines of supply by air interdiction, in this case, tactical bombing.

Subsequent Model Series — B/RB-45C

Other Configurations — B-45B and TB-45A

B-45B—A basic B-45 offering new radar and fire-control systems. This projected variant did not reach production.

TB-45A—Some of the early B-45As, bare of most components and equipped with Allison engines until re-fitted with more powerful J47s, were used to teach pilots the tricky new skill of jet flying. Occasionally referred to as TB-45As, a few of them were brought up to the Backbreaker configuration.

Phaseout — 1958

In January 1958, less than 50 B-45s remained in the Air Force's operational inventory. These multi-jet bombers, the first ever assigned to a combat unit, belonged to the 47th Bomb Wing (Tactical) which, 10 years before, had also been the first to fly them. However, the wing's conversion to Douglas-built B-66s was underway, spelling the B-45's end. By July 1958, the obsolescent B-45s had left Sculthorpe Air Station for other bases in Europe and North Africa, where they were briefly used for fire fighting training. Late in the summer of 1958, a few B-45s stood under the hot Spanish sun at Moron Air Base, where they were to be junked and sold for scrap.

Other Uses

One B-45A, designated JB-45A,[37] served as an engine test bed for a

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costs subsequent to approval of basic contract. As was often the case, the Air Force endorsed this price formula because of fluctuations of costs and cost arrangements during the production period of the entire program.

[37] The classification letter J, like the classification letters X and Y (see p 63) symbolizes the special status of a vehicle, be it an aircraft, a ship, or a missile. The letter or prefix symbol J shows that the vehicle is assigned to a special test program. This program may be conducted in-house, or may require a formal loan contract usually referred to as bailment contract. In either case, whatever modifications are made to accommodate testing are temporary. Upon test completion, the vehicle is returned to its original configuration, or returned to standard operational configuration. The same status prefix symbols, or classification letters, are used by all services of the Department of Defense.

entered the TAC inventory, a prospect several years away.[35] Other possibilities were entertained in 1953 and 1954. Quantum technological jumps made it likely that small thermonuclear weapons would be obtainable sooner than anticipated. Since modified B-45s and a whole family of fighter-bombers could now carry some of the small atomic bombs, modified B-45s and other aircraft presumably could also be made to deliver, within their range limitations, thermonuclear weapons of similar weight and dimensions. Such possibilities, as sound as they later proved to be, in the B-45's case did not go past the theoretical stage.

End of Production — March 1950

The B-45A production ended in March 1950, when the Air Force took delivery of the last aircraft.

Total B-45As Accepted — 96

The Air Force accepted its 96 B-45As over a period of 24 months, the first deliveries being made in April 1948.

Flyaway Cost Per Production Aircraft — $1.1 million

The $73.9 million procurement contract of 1946 provided for 96 B-45As, which would put the aircraft's unit cost below $800,000. However, the basic cost of each B-45A was finally set at $1,080,603—airframe, $682,915; engines (installed), $189,741; electronics, $81,907; ordnance, $552; armament (and others), $125,488. The same price tag was assigned to every model of the B/RB-45.[36]

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[35] Although the A3D, from which the B/RB-66 derived, served well in the tactical role for the Navy, the Air Force bought it without illusions, knowing the Douglas aircraft could not become the tactical bomber truly needed by the Tactical Air Command (TAC). Similarly, the B-57 was ordered for TAC in 1951 as an interim recourse. The Martin B-57, a night intruder bomber primarily, was first earmarked for atomic operations only because the number of B-45s was limited. And as with other post-World War II planes, the alternate use of reconnaissance models of the B-57 and B-66 as atomic bombers also was being planned. In any case, not only did production of the B-57 and B-66 slip but the 2 programs proved troublesome, which hardly lessened TAC's predicament.

[36] The B/RB-45's identical unit price represented an average reached regardless of contractor or fiscal year procurement and did not reflect engineering change and modification

Westinghouse development. The B-45 light bomber was also tentatively earmarked for a special duty. Believing that utilization rather than aircraft design and construction determined whether a plane was a tactical or a strategic tool, TAC thought the B-45 might be used for close air support operations. There were good reasons for the command's investigation. Sufficient close support of ground forces could not be mustered from the tactical units available in early 1950. Moreover, the bombardment classification of an aircraft in no way obviated the aircraft's potential close air support role. Still, the project was killed in infancy. To begin with, the B-45 was not rugged enough to accomplish the necessary ground attack maneuvers. In addition, modification costs to equip the aircraft properly would be quite high. Finally, the extra equipment would compromise the B-45's capability for level bombing.

B/RB-45C

Manufacturer's Model NA-153

Previous Model Series B-45A

New Features

Few new features separated the B-45C from the B-45A. The B-45C was equipped for air refueling[38] and fitted from the start with wing tip tanks.[39] The RB-45C also looked like the B-45A, except for a small bump on the tip of the aircraft's nose, where a forward oblique camera was enclosed. The RB-45C in addition featured a water injection system for increased take-off thrust that utilized two 214-gallon droppable tanks suspended beneath the nacelles by means of assisted take-off suspension hooks. If preferable, the RB-45C could make use of 2 droppable assisted take-off rockets located on the underside of the nacelles. The RB-45C included sweeping internal changes. Five stations were provided, and these stations could mount 10 different types of cameras. However, the crew could not move to the aft camera compartment when the RB-45C was flying; in-flight access to the bomb bays was possible, but only if the bomb bays were empty, the bomb-bay doors were closed, and the pressurized compartments were depressurized.

Basic Development 1947 and 1949

North American began working on the B-45C design on 22 September 1947, 2 months after the AAF had endorsed the aircraft's production.

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[38] The air refueling arrangement consisted of a boom receptacle located on the top of the fuselage, about midway, and of a single-point refueling receptacle on the left side aft of the bomb bays.

[39] The B-45C was often flown with 1,200-gallon wing tip tanks; when full, each fuel tank weighed some 7,500 pounds.

Design of the RB-45C was initiated in January 1949, when the entire B-45 program was significantly reduced.[40]

Production Decision — 1947 and 1949

The Air Force decided to buy a sizable fleet of B-45Cs on 3 July 1947 and signed the necessary document (Contract AC-18000) in October of the same year. But after only 10 B-45Cs were completed, numerous change orders were issued that drastically altered the October contract. Procurement was limited to the 10 B-45Cs already built, plus 33 airframes that were to be modified on the production lines to serve as photo-mapping and reconnaissance aircraft.[41] As it turned out, the RB-45C order marked the end of the B-45 production run.

First Flights — 1949 and 1950

The B-45C first flew on 3 May 1949; the RB-45C in April 1950.

Enters Operational Service — 1950-1951

The Air Force started taking delivery of the B-45C in May 1949 and of the RB-45C in June 1950. Even though a few of the aircraft were deployed overseas in late 1950, no B/RB-45C unit reached an initial operational capability (IOC) before 1951. The RB-45Cs were earmarked for SAC, primarily. The command's inventory reached a peak of 38 aircraft in 1951, some B-45s being included in this total. However, no B/RB-45 aircraft remained on the SAC rolls in 1953. Yet, this did not spell the RB-45's end.

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[40] The additional production of 2 B-45Cs and 49 RB-45Cs (Manufacturer's Model NA-162), under contract since 17 June 1948, was canceled either in late 1948 or early 1949. Although money was a factor, the Air Force's belief that a reconnaissance version of the B-47 would be superior to the best RB-45 nailed the cancellation.

[41] Lt. Gen. Curtis E. LeMay replaced Gen. George C. Kenney as Commander of the Strategic Air Command on 19 October 1948. SAC's new Commanding General had commanded the B-29 strikes against Japan during World War II and lost no time in re-emphasizing to Air Force officials at the highest level the importance of reconnaissance. In fact, every bomber produced after World War II had a genuine reconnaissance counterpart, or could be used for reconnissance. In the latter case, it might take but a few hours to prepare a given aircraft for the reconnaissance role, or to bring back the reconnaissance bomber to its original configuration. Sometimes the 2 versions of 1 aircraft were assigned to the same unit.

Like the B-45As, the aircraft served other Air Force commands for several more years.

War Commitments 1950-1951

The B/RB-45s were not officially committed to the Korean War,[42] but 3 TAC B/RB-45s reached the Far East in the fall of 1950. The small detachment, TAC personnel and civilian technical representatives included, departed for Japan in late September for the express purpose of measuring the reconnaissance capability of a configuration which had not yet been given the most telling of all tests, that of actual combat. Arrival of the RB-45s was well timed, as the RB-29s of the 91st Strategic Reconnaissance Squadron were no longer able to perform with impunity the special missions ordered by Far East Air Forces or the targeting and bomb-damage assessment photography desired by its Bomber Command. Eager to maintain its reconnaissance capability in the face of the Soviet-built MiG jets, Bomber Command on 31 January 1951 took control of the RB-45 detachment and attached it to the 91st Squadron. The RB-45 crews managed to outrun and outmaneuver the MiGs for several months. Yet, on 9 April 1951, 1 of the too few RB-45s barely escaped a numerically far superior enemy. In the ensuing months, while the RB-29s were no longer allowed to enter northwestern Korea, even with escort, the RB-45s could still go into the MiG-infested area if they had jet fighter escort. However, after another harrowing experience on 9 November 1951, the RB-45s also were restricted by Far East Air Forces from entering the sensitive areas of northwestern Korea in daylight. In January 1952, the 91st Squadron was directed to convert to night operations, but testing soon showed that the squadron's RB-45s could not be used for night photography because the aircraft buffeted too badly when its forward bomb bay was opened to drop flash bombs. In any case, deficiencies confirmed soon after the RB-45s had reached Japan,[43] plus the many commitments levied on the 33 aircraft, had foretold the eventual end of the RB-45's Korean experience.

End of Production 1950 and 1951

Production of the B-45C was completed on 13 April 1950, that of the RB-45C in October 1951, when the last aircraft were delivered.

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[42] The B/RB-45s were not shown on the Air Force listing of aircraft which participated in any fashion in the 3-year conflict.

[43] The 91st Strategic Reconnaissance Squadron thought the RB-45s were so unsafe for ditching that a Japan-based rescue plane held a station orbit over the Sea of Japan each time these planes crossed to Korea.

Total B/RB-45Cs Accepted 43

The Air Force accepted 10 B-45Cs and 33 RB-45Cs between May 1949 and October 1951.

Flyaway Cost Per Production Aircraft $1.1 million

The Air Force prorated the basic cost of the entire program. Consequently, the B/RB-45Cs carried the price tag of the B-45As.

Subsequent Model Series None

Other Configurations TB-45s

Some B-45s, after undergoing in-production modifications, assumed a training role usually assigned to elderly, surplus aircraft. This unusual project took shape early in 1949, when Secretary of the Air Force W. Stuart Symington informed Secretary of Defense James V. Forrestal that future technological trends in aircraft and weapons development called for various types of special training. Even though the procurement of aircraft had been cut, in line with President Truman's fiscal policy, steps had to be taken to keep improving the striking power of the Air Force within the approved 48-group structure. Hence, Mr. Symington recommended and Mr. Forrestal approved the conversion of 16 B-45Cs for tow target duty in order to teach anti-aircraft gunners high-speed, high-altitude firing. The B-45C conversion project, accomplished by North American, was allocated $1.6 million. Broken down, this meant that the modification of each aircraft cost about $80,000 and that $20,000 covered the spare components required by every plane. Targets and reels were supplied from current Air Force stocks. But as Mr. Symington had pointed out, there was no exact troop basis for the computation of tow target requirements. The 16 TB-45Cs proved insufficient for antiaircraft gunnery practice, so a few early B-45As were also converted as tow target airplanes. Unfortunately, the low thrust of the Allison J35 engines of the first B-45As prevented the additional conversions from performing well, and the TB-45A association with the tow target program was of short duration.

Phaseout 1958

The B/RB-45C phaseout followed the B-45A pattern. In mid-1959, only 1 RB-45C remained in the Air Force inventory.

Other Uses — JB-45C and DB-45s

In early 1950, the Air Force considered using some B-45s as aerial tankers for F-84s carrying special weapons. TAC wanted to know in particular the speed at which refueling, by means of the probe and drogue system, could best be accomplished. The command also asked how much extra fuel could be carried by the B-45, taking into consideration the weight of refueling gear and tanks. Although no actions were taken following these investigations, the Air Force determined that Republic F-84s could operate with a B-45 "Mother" aircraft as a "cell." The most serious handicap would be the necessity for lights during night formation. Without lights, night formation could be conducted with reasonable safety only under bright moonlight. It was also determined that, as a tanker, 1 B-45 aircraft could service 4 planes as well as 2, with the exception that the fuel available for each fighter would be proportionally reduced.

JB-45C. One B-45C, designated JB-45C after its temporary reconfiguration, served as engine test bed for Pratt & Whitney J57 and J75 engines.

DB-45. One B-45C and another unspecified B-45 model, designated DB-45s after conversion, were used as director aircraft in connection with the development of guided weapons.

Milestones — 1950 and 1952

The first air-to-air refueling of a jet aircraft was accomplished in 1950,

The RB-45C (left) was the first jet aircraft to be refueled in the air in this country. The tanker (right) is a KB-29A. 1950.

with a SAC RB-45C and a Boeing KB-29B tanker. On 29 July 1952, a 91st Strategic Reconnaissance Wing RB-45C (Serial Number 48-042), a SAC aircraft commanded by Maj. Louis H. Carrington, made the first nonstop, trans-Pacific flight from Elmendorf AFB, Alaska, to Yokota AB, Japan. This flight, made possible by 2 KB-29 inflight refuelings, earned Major Carrington and his 2-man crew the Mackay Trophy for 1952.

Program Recap

The Air Force accepted a grand total of 142 B-45s—XB-45s and reconnaissance versions included. Precisely, the B-45 program counted 3 experimental airplanes (one of which completed as preproduction article and sometimes referred to as prototype), 96 B-45As (some of them singled out as B-45A-5s because of in-production improvements), 10 B-45Cs, and 33 RB-45Cs. The entire small contingent (51 aircraft less than originally ordered) was produced by North American Aviation, Incorporated, of Inglewood, California, with most of the aircraft actually being built in a former Douglas facility at Long Beach, California.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

B/RB-45 AIRCRAFT

Manufacturer (Airframe)	North American Aviation, Inc., Inglewood, Calif.
Manufacturer (Engines)	The General Electric Co., Schenectady, N.Y.
Nomenclature	Light Tactical Bomber and Day or Night Photo-reconnaissance Aircraft.
Popular Name	Tornado

	B-45A	B-45A (Backbreaker)	B-45C	RB-45C
Length/Span (ft)	75.3/89	75.3/89	75.3/89	75.9/89
Wing Area (sq ft)	1,175	1,175	1,175	1,175
Weights (lb)				
Empty	45,694	47,022	48,969	50,687
Combat	58,548	67,820	73,715	73,200
Takeoff[a]	91,775	92,745	112,965	110,721
Engine: Number, Rated Power per Engine & Designation	(2) 5,500-lb st J47-GE-7 or -13 & (2) 5,000-lb st J47-GE-9 or -15	(2) 5,500-lb st J47-GE-7 or -13 & (2) 5,000-lb st J47-GE-9 or -15	(2) 5,000-lb st J47-GE-7 or -13 & (2) 5,000-lb st J47-GE-9 or -15	(2) 5,000-lb st J47-GE-7 or -13 & (2) 5,000-lb st J47-GE-9 or -15
Takeoff Ground Run (ft)				
at Sea Level	3,400	4,950	6,900	6,100
Over 50-ft Obstacle	4,930	7,570	8,960	8,070
Rate of Climb (fpm)				
at Sea Level	4,050	2,950	2,500	2,700
Combat Rate of Climb (fpm) at Sea Level	5,950	4,300	4,550	1,020

Service Ceiling (ft) at Combat Weight (100 fpm Rate of Climb, to Altitude)	46,400	1,700	41,250	41,500
Combat Ceiling (ft) (500 fpm Rate of Climb, Max Power, to Altitude)	32,800	8,000	37,550	37,800
Average Cruise Speed (kn)	408	401	405	404
Maximum Speed at Optimum Altitude (kn/ft)	496/3,500	492/Sea Level	498/Sea Level	495/4,000
Basic Speed at Altitude (kn/ft)	438/35,000	434/35,000	436/35,000	436/35,000
Combat Radius (nm)	463	764	876	916
Total Mission Time (hr)	2.4	3.9	4.47	4.6
Armament	2 .50-cal machine guns in tail turret	2 .50-cal M3 guns in tail turret	2 .50-cal machine guns in tail turret	2 M-7 .50-cal machine guns in tail turret
Crew	4	4	4	4
Maximum Bombload (lb)**	22,000 (1 Grand Slam) (1 12,000-lb Tall Boy) (2 4,000-lb general purpose bombs) (4 2,000-lb gp; 14 1,000-lb gp; 27 500-lb gp; & 16[b] 500-lb gp)	22,000 (1 Grand Slam) (27 100-lb M38A2 special bombs)	22,000 (1 Grand Slam) (1 12,000-lb Tall Boy) (2 4,000-lb general purpose bombs) (4 2,000-lb gp; 14 1,000-lb gp; 27 500-lb gp; &16[b] 500-lb gp)	25 M-122 Photo Flash, 188-lb each; Cameras, in various stations, 12 (3 K-17Cs, 1 K-38, 1 K-37, 1 T-11, 1 S-7A, 1 K-22, 2 K-37s, 2 K-38s)

Abbreviations

cal	=	caliber	kn	=	knots
fpm	=	feet per minute	nm	=	nautical miles
gp	=	general purpose	st	=	static thrust

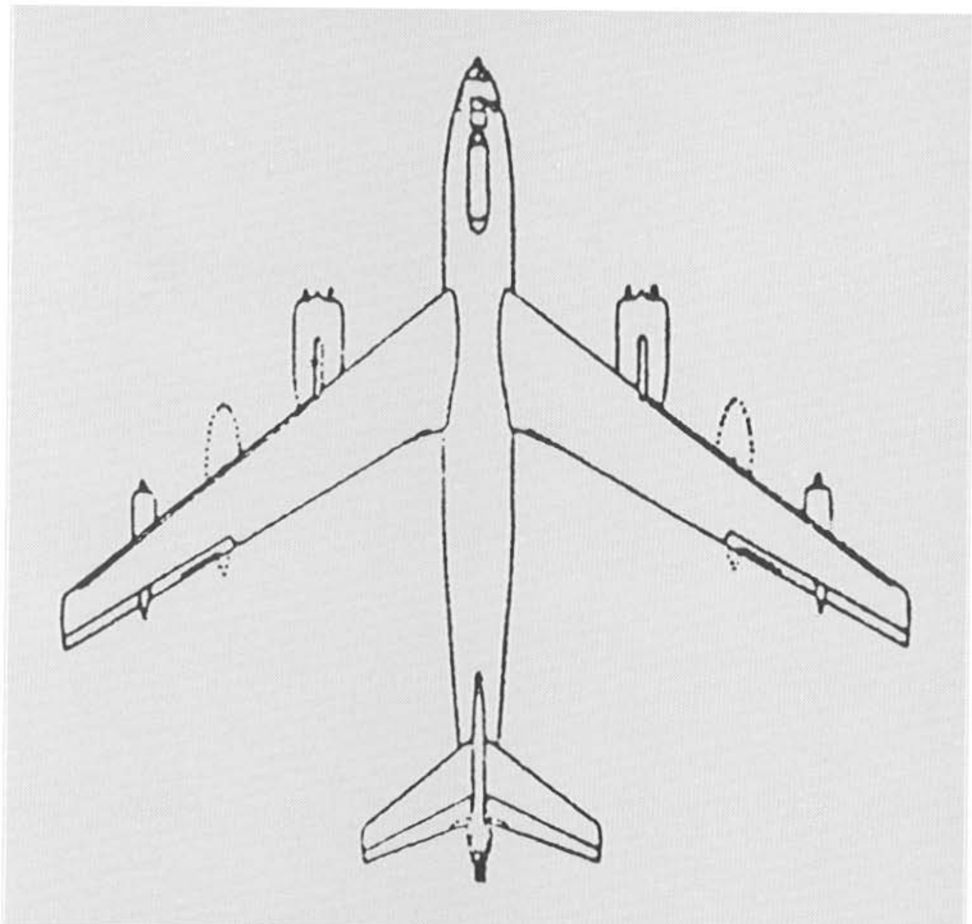
[a] Limited by space.

[b] Loading allowed for 1 bomb-bay tank.

Basic Mission Note

All basic mission's performance data is based on maximum power. B-45 Backbreaker and B/RB-45C's combat radius formula: took off and climbed on course at maximum power to cruise ceiling, the latter being defined as that altitude at which the aircraft had the performance potential of making a 300-foot-per-minute rate of climb using normal thrust at momentary weight. Cruised at long-range power at cruise ceiling; 15 minutes prior to target, power was increased to normal power and bomb run was made to target. Dropped bombs, conducted 2-minute evasive action followed by an 8-minute normal power run out from target. Continued flight to base at long-range speeds at cruise ceiling. Under nacelle tanks and droppable bombing tanks were dropped when empty.

B-47 Stratojet
Boeing
Airplane Company



B–47 Stratojet
Boeing

Manufacturer's Model 450

Weapon System 100A

Overview

The B–47's production was spurred in 1944 by the War Department's demand for jet bombers. In contrast to the B–45, and other concurrent proposals, the B–47 design, as finally approved, included radically new features. Foremost were the aircraft's thin swept wings which, coupled with 6 externally mounted jet engines, promised a startling, high-speed bomber, probably capable of carrying out effective operations for the foreseeable future despite an enemy's fighter air defense. Undoubtedly, the B–47 lived up to expectations. More than 2,000 production models were bought, and some B–47 versions, true production models or post-production reconfigurations, remained in the operational inventory for nearly 2 decades. Yet few aircraft programs witnessed as much development, production, and post-production turbulence as the B–47 did. To begin with, there were arguments about cost and plant location and after 1947, complaints by Boeing that the newly independent Air Force had laid additional requirements that changed the concept of the overall program. Also, the secrecy which shrouded the development of atomic weapons, long after the atomic attacks on Japan, increased the difficulty of preparing the B–47 to handle every new type of special weapon—a problem shared by the B–36 and B–45. Ensuing events only compounded the initial disarray.

As it had for the B–36, the Truman Administration's stringent financial restrictions worked in favor of the B–47. Pressed for money, the Air Force decided to buy more B–47s instead of purchasing additional B–50s or future B–54s, since neither one of those rather expensive bombers had any growth potential. Hence, even though the B-47 was yet to fly, the initial production order of 1948 was increased in mid-1949. The subsequent Korean War, rising world tensions, and mounting urgency to build an atomic deterrent force raised the tempo of the B-47 program. In December 1950, the Air Force foresaw a monthly production of 150 B-47s, but still recommended changes, making it almost impossible to settle on an acceptable type. Other factors made matters worse.

The B-47 was the first USAF bomber to receive a weapon system designation, a move prompted by the Air Force recognition that the rising complexity of weapons no longer permitted the isolated and compartmented development of equipment and components which, when put together in a structural shell, formed an aircraft or missile. However, this was as far as the B-47 benefited from the new developmental philosophy. The Boeing airframe was built without adequate consideration for its many crucial components. In turn, the components, subcontracted or furnished by the government, were behind schedule and when provided, did not match the sophistication of the high-performance B-47.

In 1951 alone, the Air Force took delivery of 204 B-47Bs, none of which were suitable for combat. The aircraft's canopy was unsafe; the B-47B had no ejection seats (a deficiency shared by 200 successive B-47s); the bombing and navigation system was unreliable; a new tail defense system was needed; and the jet engines were creating unique development problems such as fuel boil-off at high altitudes, which reduced the aircraft's range—already shorter than anticipated. In sum, the hasty production of an aircraft as revolutionary as the B-47 proved to be costly, generating extensive, unavoidable modification projects like Baby Grand, Turn Around, High Noon, and Ebb Tide. Yet once accomplished, the B-47 modifications worked.

Finally deployed overseas in mid-1953, the B-47s totally replaced the obsolete, atomic-carrier B-50s by the end of 1955, when new B-47 production models were delivered that could carry larger fuel loads and thus had greater range. After the B-47 demonstrated that it was rugged enough for low-altitude bombing, some of the aircraft were again modified to satisfy a new set of requirements levied in 1955. These modifications also worked, and in 1957, the Air Force publicly demonstrated its new low-altitude, strategic bombing tactics, an achievement marking the beginning of an era in aeronautics.

Despite its convoluted start, the B-47 program proved successful. The aircraft served in various roles and was involved in many experimental projects, some connected to the development of more sophisticated atomic weapons, like Brass Ring, or with the development of air refueling or other endeavors of great significance to the Air Force. Strategic Air Command's last B-47s went into storage in early 1966, while a few converted B-47 bombers and reconnaissance models kept on paying their way for several more years, remaining on the Air Force rolls until the end of the 1960s.

Basic Development 1943

Development of the B-47 can be traced back to June 1943, when an informal Army Air Forces (AAF) request led several aircraft manufacturers to begin design studies of multi-jet aircraft that could be used for fast photographic reconnaissance or medium bomber missions.[1] General Electric's successful development of an axial flow jet engine, easier to install in wing nacelles than previous jet types, came at the same time. This undoubtedly was important. Boeing and several other companies quickly included the new engine in their planning. But more crucial to the aircraft's development was Boeing's use at war's end of captured German research data on the design of swept-back wings. This led in 1947 to the sensational XB-47.

Design Competition 1944

The informal requirements of 1943 became official on 17 November 1944. The AAF issued military characteristics for a jet-propelled medium bomber with a range of 3,500 miles, a service ceiling of 45,000 feet, an average speed of 450 miles per hour, and a top speed of 550. Besides the Boeing Airplane Company of Seattle, Washington, the other firms—North American Aviation, Incorporated, Convair, and the Glenn L. Martin Company—entered the design competition prompted by these requirements. The Boeing entry (Model 432), designated the XB-47 by the AAF, was a straight-wing design resembling a B-29 with much thinner wings and carrying 4 of the new General Electric axial flow jet engines. To overcome problems experienced with the engine pod-nacelles of a previous design, Boeing had buried the new engines inside the fuselage of Model 432. All

[1] Requirements had to be readied and money had to be found before a formal announcement could be made. Yet the procedure followed in June 1943 was not unusual and could only benefit the AAF. In this case, it might also have had the distinct advantage of keeping Boeing engineers busy and preventing them from drifting to Navy projects upon completion of their work on the development of a long-range bomber. The AAF already knew that Convair had pretty well clinched the long-range bomber program (a B-36 production order had just been issued) and that the concurrent procurement of a similar bomber was out of the question. (Boeing did not receive a study-contract for its "long-range" XB-52 until mid-1946.)

designs submitted by the other companies featured wing nacelles for housing the jet engines.[2]

Letter Contract — 1 February 1945

This letter contract authorized Boeing to spend up to $150,000 (against an estimated $1.5 million set aside for development) in a Phase I (wind tunnel) study of Model 432, Boeing's first entry in the recently opened medium bomber competition. The model nevertheless was rejected on the grounds that the location of the engines could be unsafe. The AAF actually thought that Boeing engineers should do more research in the basic jet problems associated with high-speed bombers. To achieve superiority in the air would require a new concept superior to any of the current bomber designs. Early in September, Boeing revised the original configuration of Model 432 and proposed its first swept-wing bomber design. Labeled Model 448 (the AAF designation remained XB-47), the new aircraft featured a thin wing swept back and 2 more engines—a total of 6 engines. The AAF liked the wing configuration of Model 448, but still insisted that housing engines inside a fuselage created a fire-hazard. Besides, externally mounted engines were easier to maintain and replace, which could add years to the service life of an aircraft. Boeing's hasty return to the drawing board resulted in Model 450, which carried 6 jet engines hung under the wings in pods—2 pairs in strut-mounted inboard nacelles and single units attached directly under the wing, at a distance of 8 feet from the wing tip. The AAF promptly approved Model 450 in October 1945.

Development Decision — December 1945

In December, a technical instruction authorized contractual negotiations for the development of 2 experimental aircraft. The AAF endorsed Boeing's proposal to build and test 2 flyable XB-47's for $9,357,800, counting the $1.5 million that had been set aside for development of the straight wing design (Model 432) initially submitted by Boeing. The proposed planes would be bare of any tactical equipment, but necessary space would be provided. The subsequent discovery that more equipment space was needed and that some structural changes had to be made raised

[2] Letter contracts for development and mockups of the 3 designs were awarded in the fall of 1944, resulting in the North American XB-45, Convair XB-46, and Martin XB-48. Of these, only the North American XB-45 went into production.

Boeing's original quotation to $9,441,407. This figure also was approved, after the Wright Field price control experts concluded that the XB–47's cost of $95 per airframe-pound was reasonable and considerably lower than the corresponding costs of the XB–45 and XB–48 bombers. Nonetheless, the letter contract of February 1945 was not officially amended until 17 April 1946 (after completion of the XB–47 mockup).

Mockup Inspection — April 1946

The XB–47 mockup was completed, inspected, and approved in the spring of 1946. Army Air Forces personnel attending the XB–47 mockup seemed impressed. Just the same, the Mockup Committee suggested major changes in the nose compartment, pilot and co-pilot seating, and landing gear arrangement. The Chief of the AAF Requirements Division cautioned that any additional weight would cut down the speed of the XB–47, thus defeating the purpose for which the plane was designed.

Development Slippage — April 1946–September 1947

Even though the XB–47 mockup had been well received, development of the experimental plane took longer than expected. Actual work began in June 1946, but progress was hampered by problems with the aircraft landing gear,[3] control surfaces, as well as bottlenecks in power plant installations. The initial lack of overtime pay for the Boeing personnel did not help. All told, a 6-month slippage occurred.

Definitive Development Contract — 10 July 1947

It took a year and a half to complete the contractual negotiations initiated by the technical instruction of December 1945. The definitive fixed-price contract (W33–038 ac–8429) of July 1947 called for 2 stripped XB–47s, spare parts, mockups of the completed airplane and fuselage, wing tunnel tests, and research data at a total cost of almost $9.7 million—about $25,000 more than the cost of the amended letter contract of April 1946,

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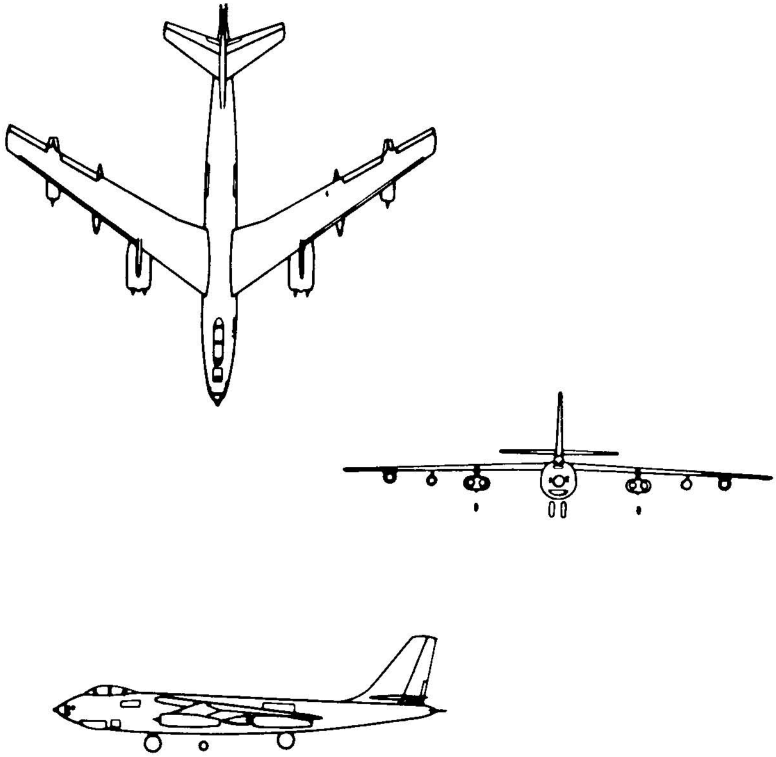
[3] The XB–47's thin swept wing eliminated any possibility of suspending a landing gear or retracting one into it. The problem was solved, however, with the installation of a tandem gear, fairly similar to the type previously tested on a Martin B-26. The new arrangement had an additional advantage: reducing the XB–47's weight by 1,500 pounds.



First large American jet featuring swept wings—the XB-47.

which the fixed-price contract superseded. Moreover, the AAF estimated that post-test flight changes most likely would raise the aggregate cost of the contract to more than $10.5 million—a prediction that did materialize. By February 1950, numerous change orders had brought total costs near the $12 million mark.

XB–47 Roll-out — 12 September 1947

The first XB–47 rolled out of the Seattle factory in the same month that the United States Air Force was established. The plane was even more startling than the spectacular B–17 Flying Fortress had been 12 years before. The swept wing had already been used experimentally by the Bell Aircraft Corporation on 2 modified P–63 Kingcobras and by North American on the XP–86, first flown in October 1947, but this was the first time the design appeared on a large American jet.

First Flight (XB–47) — 17 December 1947

The experimental B–47 was flown from Seattle to nearby Moses Lake AFB, Washington, to begin a series of extensive flight tests. Bad weather delayed the flight until 17 December—44 years to the day after the Wright brothers' first manned flight at Kitty Hawk, North Carolina.

Testing — 1948–1954

The Air Force flew the first XB–47 (Serial No. 46–065) for about 83 hours, including nearly 38 hours of Phase II flight tests that were accomplished between 8 July and 15 August 1948. The contractor tested the XB–47 during most of the aircraft's 6 years of life, accumulating more than 330 hours of test flights in the process. In 1954, having been stripped of wings and engines, the experimental B–47 was cut in 2 and exhibited at Palm Beach AFB, Florida.

Appraisal — 1948

The Boeing pilots that first flew the XB–47 liked it. After completion of the first phase of testing, a Boeing pilot remarked, "The plane still is doing much better than anyone had a right to expect. We're still exploring one thing at a time, but every door we've kicked open so far has had good things inside." Just the same, the XB-47's overall performance proved disappointing. Its maximum altitude was 2,500 feet below the 40,000-foot ceiling proposed by Boeing and 7,500 feet lower than originally required by the AAF. Its speed was also slower than expected. In fact, in mid-1949 the XB-47 exchanged its six J35-GE-7/9 engines for the larger 5,200-pound thrust J47-GE-3s that equipped the second XB-47 from the start.

Acceptances 1948

The Air Force accepted the first XB-47 conditionally (minus certain equipment to be installed later by Boeing) on 29 November 1948. The second XB-47, first flown in mid-1948, was accepted the following month, under the same conditions. The Air Force took delivery of the experimental planes in December 1948, but lent them to the contractor in subsequent years. Like its predecessor, the second XB-47 was extensively tested. Boeing logged almost 100 hours of test flights; the Air Force, over 237.

B-47A

Manufacturer's Model 450-10-9

Production Decision — September 1948

The Air Force began to plan for the procurement of B-47 productions in December 1947—at about the same time the experimental version first flew—and planning in the following months centered on the production of 54 B-47s (13 B-47As and 41 B-47Bs). A serious misunderstanding arose during the ensuing negotiations. The Air Force assumed $35 million would pay for 10 aircraft and enough tooling for the production of an additional 44. Boeing thought tooling and plant expenses to build 54 B-47s would reach $31 million, without counting the actual cost of each plane. In any case, when Boeing received an official production go-ahead in September 1948, it was only authorized to proceed with the engineering, planning, tool design, procurement of tool materials, and placing of subcontracts for 10 B-47s, in an amount not to exceed $35 million. Moreover, production would not take place in Seattle, as Boeing wished, but at a government-owned plant in Wichita, Kansas—a shift that accounted in part for the slippage that later occurred.

Production Letter Contract — 22 November 1948

This letter contract (W33-038 ac-22413) covered a first order of 10 B-47As for $28 million and the future procurement of 3 additional B-47As and 41 B-47Bs, at a cost still to be negotiated. In keeping with routine procurement practices, the letter contract of November 1948 was amended more than once. First, the 3 additional B-47As were canceled; then on 28 February 1949, the number of B-47Bs on order was raised from 41 to 55.[4]

[4] The Air Force had interrupted Boeing's testing earlier in the month and flown the first XB-47 to Andrews AFB, Maryland, where it was shown to members of the House Armed Services Committee. The 3-hour flight from Moses Lake AFB, Washington, on 8 February 1949 averaged 602.2 miles per hour over a 2,289-mile course and set an unofficial transcontinental speed record. Evidently, the XB-47 was capable of reaching great speeds, but the Air Force still considered its combat speed too slow.

The Air Force also ordered the design and construction of a ground test rig for the prototype jet-assisted take-off system that it believed future B-47s would need.

Program Reappraisal 1949

As in the case of the B-36, President Truman's decision in late 1948 to hold down defense expenditures worked in favor of the B-47. Pressed for money, the Air Force had to evaluate carefully its limited options. It finally decided to buy more B-47s, an aircraft that General LeMay, also a strong supporter of the B-36, much preferred to the B-50 or future B-54 (almost immediately canceled). The B-47 program increase was reflected in a June 1949 amendment of the basic production letter contract of November 1948. This noteworthy amendment (No. 8) authorized the expenditure or obligation of about $60 million (twice the original amount) for the purchase of 15 B-47s (10 B-47As, plus 5 B-47Bs) and follow-on procurement of 97 B-47Bs (not yet priced). Amendment No. 8 also covered the modification of the 2 XB-47s for use as partial prototypes of production aircraft. Production deliveries were scheduled for the period April 1950 through December 1951.

Definitive Production Contract 14 November 1949

It took months of hard bargaining to arrive at a fair price for the B-47Bs covered by the letter contract of November 1948, as amended in June 1949. The definitive $208.7 million contract (W33-038 ac-22413) of November 1949 was actually a compromise. The Air Force settled for 87 B-47Bs (15 less than planned during the preceding June), and Boeing's fixed fee was reduced. The contract still required that the B-47B be developed according to the new specifications that had been issued in September 1948. These called for single-point refueling (through 1 opening), tactical type assisted take-off (ATO) installation, external fuel tanks, increased gross weight (202,000 pounds after in-flight refueling), the K-2 bombing and navigational system (also earmarked for the B-47A), and an unmanned radar-controlled tail turret—all of which would require some redesign of the wing, body and landing gear. Delivery schedules, however, remained unaltered. The 10 B-47As were due between April and November 1950; the 87 B-47Bs, between December 1950 and December 1951.

First Flight 25 June 1950

Even though deliveries had been scheduled to start in March 1950, Boeing did not fly the first B-47A until 25 June. It took another year to deliver all 10 B-47As on order to the Air Force.

Testing[5] 1950-1951

Continued flight testing of the B-47A and of the first XB-47 revealed that neither plane was safe, mainly because both were underpowered. Also, critical braking problems occurred following refused takeoffs, and after gross weight landings on wet runways. In addition, after refused landings, go-arounds were hazardous owing to the jet engines' poor acceleration. The answer lay in equipping B-47 productions with higher thrust engines and drogue parachutes that would act as in-flight air brakes. But these remedies were not yet available. Modifications of subsequent B-47As yielded sufficient improvements, but not without considerable delay. Yet none of the changes recommended by a March 1950 USAF engineering inspection reached any of the B-47As.[6]

Enters Service May 1951

The B-47A entered service at MacDill AFB, Florida, with the 306th Bombardment Wing, Medium. The 306th had been told to prepare for the combat crew training of its own aircrews well in advance of the receipt of its first new plane, also that the 306th aircrews in turn would train the crews of other future B-47 wings. The arrangement, considered temporary since late 1950 when the B-47 program was almost doubled, lasted through December 1951. The Air Training Command then took over most of the training task, which in time proved even more complex than anticipated.

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[5] Runways of adequate length were available at Wichita, Kansas. Hence in line with the change of production location, testing was shifted from Seattle in the fall of 1949. Moses Lake AFB was transferred to the Continental Air Command at about the same time.

[6] Many factors accounted for the production slippage that plagued the B-47 program from the start. The XB-47's flight to Andrews in February 1947 set back Boeing tests for several weeks. Relocation from Seattle to Wichita took time. Modification of the second XB-47 in August 1950 and allocation of the aircraft to Operation Greenhouse (a Pacific atomic test scheduled for 1951) was another testing handicap. Still, Boeing claimed that the principal reason for the B-47A production delay was that the concept of both the B-47A configuration and the overall B-47 program had been changed by the Air Force in September 1948 (when the production decision was made). The Air Force, on the other hand, pointed out that the requirements of 1948 barely affected the B-47As. Also, the engineering changes requested in March 1950 were to be made on a "no delay" basis on the B-47Bs and had no bearing on the B-47As.

Subsequent Model Series — B-47B

Other Uses — 1951-1952

None of the B-47As saw operational duty. Never considered as true production aircraft, the B-47As were unarmed and at first practically bare of components; upon delivery, only 4 of the 10 were equipped with the K-2 Bombing-Navigational System. One of their few advantages probably lay in their crew ejection seats, a controversial feature deleted from the first B-47B lots.[7] In addition to their training role, the B-47As were used in extensive tests. Some stayed with the Air Proving Ground Command. Two were designated to try out the A-2 and A-5 fire-control systems.

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[7] Boeing had problems from the start with B-47 ejection seat equipment. Canopy ejection technology in the early planes was reconsidered after an XB-47 accident in which the pilot was killed. Boeing then proposed an additional escape hatch and bail-out spoiler (much like the one eventually featured by the B-47B).

B-47B

Manufacturer's Model 450-11-10

Previous Model Series B-47A

New Features

The B-47B differed from the B-47A in many ways. It carried J47-GE-23 engines (6 of them) and solid fuel rockets for assisted take-off. It had a Nesa[8] glass windshield with rain repellant (in lieu of impractical windshield wipers); hydraulic boost on all control surfaces; a spoiler door (at the aircraft's main entrance) to ease in-flight escape, plus a single-point ground and air-to-air refueling receptacle. Finally, it featured a 2-gun tail turret controlled by radar sight; a B-4 fire-control system; K-4A bombing-navigational system; AN/APS-54 warning radar, and many other improved electronic components, including AN/APT-5A electronic countermeasure devices.

Initial Design September 1948

Design of the B-47B started 5 years after Boeing began work on a multi-jet aircraft for photoreconnaissance and bombing missions with conventional weapons. The informal photographic reconnaissance requirements of 1943 were dropped the following year, when the need for a new medium bomber was clearly established. But by the time Boeing received a production go-ahead, circumstances had changed. The Air Force now wanted its new jet bomber to carry atomic weapons as well as conventional bombs.[9] In

[8] Trade name of glass coated with a transparent chemical conductor of electricity. Nesa glass, therefore, was easily kept free of ice.

[9] The mounting urgency to build an atomic deterrent force despite the lack of funds posed grave problems in the fall of 1948. While the B-36 program was no longer in jeopardy, other programs had to be canceled or drastically reduced. Faced with far-reaching decisions, the Air Force opted for the faster production of a more versatile and atomic-capable B-47. This approach was not new. Back in 1946, the AAF had decided that all new planes capable of

addition, the photo-reconnaissance requirements of several years past were revitalized.

Developmental Problems 1948–1952

Deficiencies identified in the XB–47 and subsequent B–47As complicated the B–47B's development. It was one matter to devise fixes for a handful of B–47As, but far more difficult and time-consuming to come up with definite production line modifications. In any case, there were other deep-seated problems that later became obvious. The B–47 was the first USAF bomber to receive a weapon system designation, which meant in theory that all systems to equip and maintain the plane were designed exclusively for the B–47. In effect, however, the Boeing airframe was developed without adequate consideration for such crucial components as engines and bombing systems. Then, too, rising world tensions and the outbreak of the Korean War led to the hasty production of the B–47, before quality and performance were assured. Even though the B–47B was yet to be flown, the Air Force as early as December 1950 foresaw 149 aircraft per month coming off the assembly line. As in World War II, new contractors were selected to pool production.[10] This haste in the long run hampered both development and production. By August 1950, the Air Force had recommended some 2,000 changes, making it almost impossible to settle on an acceptable production type. Meanwhile, Boeing had begun to step up production. By mid-1951, B–47Bs were flowing in ever-increasing numbers from the Wichita line but had to await the modifications and equipment that would make them suitable for combat.[11]

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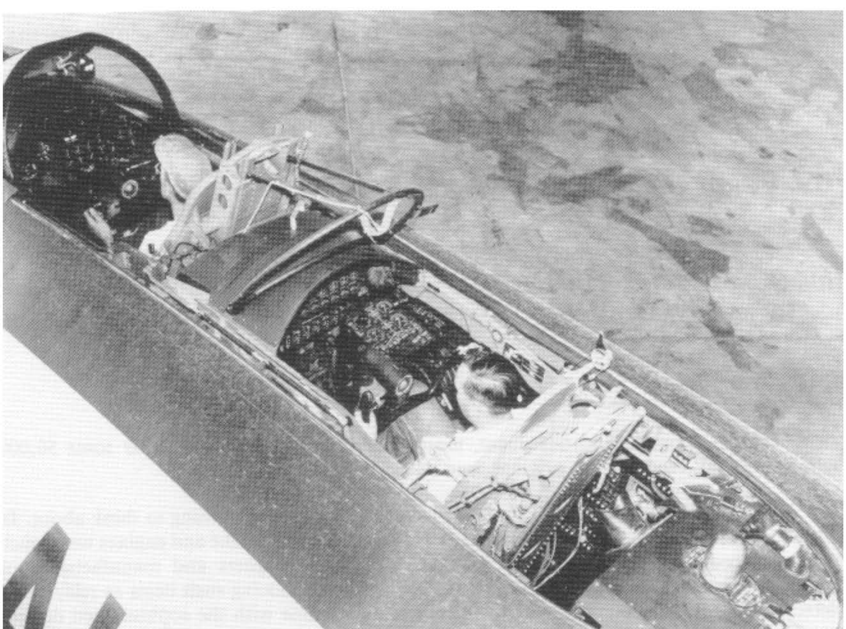
carrying bombs as heavy as the atomic bomb should be able to carry the A-bomb itself. Yet, long after the atomic attacks against Japan, the secrecy shrouding the bomb persisted. As in the B–36's case, this would be of no help to B–47 development.

[10] Douglas Aircraft Co., was awarded a production letter contract in December 1950; Lockheed Aircraft Corp., soon afterwards. This would allow production to start without awaiting the definitive contracts that were signed in October 1952. The Air Force's determination to solve unexpected B–47B problems promptly changed this planning. As a result, neither the Douglas plant at Tulsa, Okla., nor the Lockheed facilities at Marietta, Ga., started production before 1953.

[11] Despite an overall production slippage of nearly a full year, components subcontracted by Boeing as well as government-furnished equipment and parts were still behind schedule. General LeMay was adamant in pointing out that failure to develop component systems in phase with production of the new bomber was an indication of bankruptcy in USAF procurement policy. The SAC Commander also thought that the USAF Armament Laboratory was not capable of satisfying the Air Force's needs.

A Stratojet on a jet-assisted take-off, Wright-Patterson AFB, Ohio.



Front and rear cockpits of a B–47, canopy removed.

By mid-1952, the B-47 development was still under way. Requirements kept expanding, special mission modifications were requested, and the Air Force again considered various redesigns of the aircraft's propulsion system.

Testing 1948-1954

In view of the B-47's sweeping new features, it was envisioned from the start that development and testing would be involved as well as lengthy.[12] The XB-47's early flight tests quickly confirmed this expectation. Hence, the Air Force on 7 April 1950 endorsed an unusual operational suitability test, known as Project WIBAC (Wichita Boeing Aircraft Company). This meant that before the B-47 could be delivered to SAC's operational units, the aircraft and its equipment would be thoroughly tested at Wichita by Air Proving Ground Command and SAC personnel.[13] Besides, WIBAC promised to provide statistics on parts consumption, parts failures, and engine life. Guiding data on service testing, maintenance procedures, base facilities, and training needs were also part of the deal. The ambitious WIBAC task soon proved overwhelming. While no B-47Bs had reached WIBAC by mid-1951, the project was already in trouble. In August, WIBAC requested review of the whole B-47 program—production, allocation, requirements, and operational deficiencies.

First Flight (Production Aircraft) February 1951

The Air Force accepted this plane in March and 87 similar productions within a year.[14] Testing by WIBAC in late July 1951 verified that the new B-47Bs could not possibly meet the Strategic Air Command's require-

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[12] The development and test phase, mostly completed in mid-1953 (after some 50,000 flight-test hours), exceeded the original time estimate by almost 4 years.

[13] Early WIBAC appraisals of the B-47 gave the Air Force something to think about. In mid-1951, SAC observers liked the airplane, but noted that the airframe and engines were much more advanced than the component systems. Moreover, designers and manufacturers of component parts, as well as the numerous subcontractors producing such items as relays, fuel selector valves, booster pumps, and the like, were not in tune with the sophisticated designs necessary for such a high-performance aircraft. As a result, Boeing was forced to fit the B-47 with the same type of equipment that had caused so much difficulty in the B-29s and B-50s.

[14] The 88 planes, like the B-47As, featured 6 J47-GE-11 engines until re-fitted with the more powerful J47-GE-23s that equipped subsequent B-47Bs.

ments.[15] In September, USAF test pilots pointed out that the plane's weight gain, from 125,000 to 202,000 pounds, had badly affected its flying qualities, making it unstable at high altitude and generally hard to maneuver.

Modification Planning — October 1951

The impasse reported by WIBAC led to a conference in October 1951, attended by many top Air Force generals. Most conferees seemed to believe that WIBAC, and more specifically the office of the B-47 project officer, had been given an impossible job. Opinions differed, however, on how some of the difficulties encountered could have been avoided or at least reduced. Maj. Gen. Bryan L. Boatner, Commanding General of the Air Proving Ground, thought better results could have been secured had Air Research and Development Command and Air Materiel Command (AMC) contributed technical personnel and stationed them permanently at WIBAC as Strategic Air Command (SAC) and Air Proving Ground did. Lt. Gen. Earle E. Partridge, who headed the research and development command, commented that the concentration of all B-47 tests at Wichita had been a mistake. Generals Partridge and Boatner agreed that the B-47 was a very complicated piece of equipment and that the production problems were the greatest ever experienced. Then, General Twining (Vice Chief of Staff since October 1950) said that the B-47 problem fell to the Air Staff and that it would be solved. To this end, a so-called refinement program was set to begin in early 1952 at the USAF Grand Central Plant in Tucson, Arizona. The minimum modifications to make the B-47 combat ready were lined up, SAC alone suggesting close to 50. Maj. Gen. Thomas S. Power, SAC's Vice Commander, pointed out that his command was more familiar than most with the bomber's deficiencies. He announced that an engineering operational program in the 306th Wing would get under way in early 1952. This program, General Power stated, should help significantly in speeding up progress.

Additional Procurement — 1951-1952

Advanced procurement plans were finalized in November 1951—on the heels of the October conference—by a definitive contract for 445 additional

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[15] The first SAC B-47B (Serial No. 50-008) was flown on 23 October 1951 from Wichita to MacDill by Col. Michael N. W. McCoy, Commander of the 306th Wing. Even though the plane was not combat ready, a beginning had been made and this was celebrated on 19 November, when the aircraft was named "The Real McCoy." Six more B-47Bs programmed for the 306th during that month were refused because of serious deficiencies, but a total of 12 were accepted before the end of the year.

productions. This number was reduced to 395 in March 1952, after more realistic production schedules were endorsed.[16] Nonetheless, new procurement soon followed. Fifty-two RB-47s and 510 B-47Bs were ordered in June 1952, and 3 other production contracts were issued during the year—1 in September called for 540 B-47Bs; 1 in October, for 70 RB-47s; and 1 in December, for another 193 B-47Bs. As it turned out, the Air Force reduced the number of B/RB-47s (1,760 aircraft) ordered in 1952, and most of these aircraft came off the production line as B-47Es.

Basic Safety Deficiencies 1951-1952

Explosive decompression tests in 1951 proved the B-47's original canopy unsafe for high altitude combat operations. A sectionalized canopy was the answer, but would not be available for some time. Another major problem was the lack of ejection seats in the B-47B. SAC long believed that ejection-type seats were the safest method of egress from high-speed aircraft. Boeing studies on the subject had shown it would be impossible to get out of an uncontrolled B-47 without ejection seats. Escaping under controlled flight conditions would even be hazardous without them. Although the 10 B-47As had ejection seats, these were operationally marginal. Therefore, in the interest of saving weight—at least until the B-47 reached a 4,000-nautical mile range—a group of senior officers (including some from SAC) had decided to dispense with the seats. SAC's ensuing objections were to no avail, but its request in mid-1950 for reinstatement of the seats was finally approved. Still it became obvious in December 1951 that ejection seats would not be incorporated in production for quite a while.[17] As many as 400 B-47s would not have any, and this was far more than SAC had been

[16] As the B-47 bomb bay was designed to carry atomic bombs, no additional framework installation was required. Bomb racks, sway braces, hoists, and other equipment items were attached from the start to the airframe, specifically to the bomb-bay fuel tank floor. Just the same, production and operational difficulties with the aircraft itself prompted a further cutback in the B-47B's atomic capability in April 1952. The Air Force decided at the time that the first 89 B-47Bs would not be required to carry any atomic bombs, and that the next 80 aircraft would only be expected to handle 2 specific types of bombs. While some of this early planning changed, a directive that all subsequent B-47Bs would be able to carry low-density atomic bombs could not be satisified. Despite all efforts, the high-speed B-47s proved unable to release subject bombs at altitudes below 30,000 feet.

[17] Providing satisfactory ejection seats for the B-47's 3-man crew entailed the relocation of important pieces of equipment. Air Material Command estimated this might require as many as 26,000 engineering manhours. In addition, much more was involved to ensure crew safety. In fact, high-speed testing of the approved seats (upward for pilot and co-pilot; downward for the navigator) was still going on in December 1952.

prepared to accept. Since retrofit of the aircraft then seemed economically impossible, the only alternative was to settle for the next best means of egress. To begin with, this called for development of a redesigned dinghy.[18]

Other First Shortcomings 1951-1952

The K-2 bombing and navigation system, like the early K-1 of many B-36s, was unreliable and hard to maintain.[19] By mid-1952 the K-2 had been made to work somehow, but still needed improvement even after additional modifications had brought about its redesignation as the K-4. The Emerson A-2 tail defense system, earmarked for the B-47,[20] was canceled before the end of the year in favor of the General Electric A-5. The decision, based on Project WIBAC's recommendation, proved sound but posed an immediate problem. No A-5 fire-control systems were available and none were to be expected much before 1953. In the meantime, it was mandatory for SAC that a makeshift system be devised. Retrofit of early B-47s with a 2-gun turret and an N-6 optical sight was the chosen solution. This would at least give the aircraft some kind of defense. Although contrary to plans, the extra modification was included in the refinement program that had been endorsed during the conference of October 1951. Not surprisingly, further pioneer difficulties were

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[18] It was difficult to maneuver from the crew positions to the escape hatch with the present dinghy attached to the parachute harness. Yet, in an emergency, there seldom was time to attach the raft after leaving one's seat.

[19] The 1,600-pound K-2 counted 41 major components, totaling some 370 vacuum tubes and close to 20,000 separate parts. Since the B-47 was compact, the K-2 equipment had been scattered throughout the aircraft. Many of the system's parts were outside of the plane's pressurized area. Hence, no inflight maintenance was possible and high abort rates were to be expected. Maintenance on the ground was nearly as difficult. Pre-flight checking took too long—8 hours, compared to 1 hour for checking almost the same system on the B-36.

[20] Development of the system could be traced back to 1946, when the XB-47 was first reviewed by the AMC's armament laboratory—the same laboratory General LeMay still took to task in 1951. Engineers believed that the Emerson-built tail turret, referred to as the A-1 fire-control system and intended for the North American B-45, could be fitted into the B-47 without altering the turret's basic mechanism. With Boeing's concurrence, the Air Force in June 1948 asked Emerson to design for the B-47 a turret gunner cab similar to that of the B-45, but providing sufficient comfort for missions of long duration. The project quickly became so complicated that it was given up. A remote controlled system that would be operated by one of the flight crew members appeared more feasible. This gave way to the A-2 fire-control system, a system eliminating the need for a tail gunner. This A-2 was due to provide accurate defensive fire for protection of the B-47 and to perform, although not simultaneously, both search and track. The A-2, after being fitted into the tail of a B-29, was successfully tested under Project Hornet. Moreover, in theory, the A-2 was superior to the APG-32 built by the General Electric Company for the B-36. In practice, however, while major APG-32 problems could be solved, the A-2's basic suitability for the B-47 remained too questionable to warrant its retention.

encountered. One was fuel boil off and fuel purging, found more critical in jet bombers. The B–47 was designed for maximum speed and range at a high altitude, and the sooner it reached that altitude, the better. Yet, at high altitudes fuel boil and loss of fuel occurred, reducing the aircraft's range which, in any case, remained far shorter than required in early 1944. Development of JP–4 fuel, after numerous experiments, appeared to solve much of the problem, but production quantities would not be available until January 1952. Again, purging fuel tanks required the use of dry ice, which would be difficult to purchase in areas where the B–47s were expected to operate, especially when the aircraft would be operating overseas. Development of portable dry ice manufacturing equipment was a partial answer. A new exhaust gas purging system, being devised by AMC, would be more dependable and less hazardous. It would require no additional maintenance and provide greater and longer protection for more fuel volume than the dry ice system. This was all for the best but, as with every new system, the AMC development would take time.

Slippage Impact 1951–1952

There were extenuating circumstances for the topsy-turvy B–47 program. As Maj. Gen. Albert Boyd, the Wright Air Development Center's Commander, explained in 1952:

> There is a limit to what we can do, or for that matter, what anyone can do, toward developing a radically new airplane in record time, and we, no more than anyone else, are capable of pulling a rabbit out of our hats or cranking out a new aircraft that meets all the desires of the operating activities.

Yet, the impact of the B–47 slippage was serious from the start. To prepare for, operate, and maintain a weapon system as revolutionary as the B–47 presented a tremendous challenge.

SAC confronted numerous problems,[21] some of them crucial. To begin

[21] Bases had to be prepared for the B–47, particularly by lengthening runways. Since the aircraft's range did not meet requirements, air refueling was a necessity. This complicated matters. Extra troop housing, maintenance facilities, equipment and supply were needed to support B–47 squadrons and their accompanying KC–97 tankers. Training problems came to the fore. Even the first 90 B–47s, finally earmarked for Air Training Command, were fitted with receptacles to teach both B–47 and KC–97 trainees the ticklish air-refueling mating of a fast jet and a slow tanker. Briefly stated, the all-jet B–47, with its crew of 3, played havoc with SAC personnel policies. Large numbers of people became excess, whereas hundreds of others were needed to fill specialties peculiar to jet aircraft. All kinds of mechanics and supervisors had to be retrained for the B–47. Moreover, SAC and other USAF commands never had used pilot-observers. Since the B–47 demanded quadruple-rated aircrewmen, ATC had to turn pilots into proficient navigators, bombardiers, and radar operators.

with, the production delay meant that conversion plans had to be shuffled many times over.[22] Then, slippage of the refinement program, which now appeared unavoidable, would further dilute the command's readiness. Each month lost forced SAC to be ready to fight with even more outmoded B-29s and B-50s. To make it worse, everyone knew that when at long last available, the modified B-47Bs would give SAC only a basic combat aircraft and that considerable modifications were still to come.

Refinement Program 1952-1953

The program, due to begin in January 1952, involved the modification of 310 B-47Bs.[23] SAC expected its first modified planes in July and a monthly input of 75 by year's end. This was optimistic. As predicted by AMC, the Grand Central Depot of Tucson could not possibly handle such a workload without greatly expanding facilities and manpower. This would take time and money, and neither could really be spared. The Air Force found a way out of its new dilemma. Boeing agreed to modify 90 of the aircraft (for about $10 million) and Douglas was also asked to help.[24] The original modification schedule nevertheless slipped. First, it proved difficult to assemble the necessary modification kits. Then, there were not enough kits. In September 1952, SAC's few B-47s were grounded because of serious fuel cell leakages. This again slowed the refinement program, since it obviously required an extra inspection of the aircraft being modified.

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[22] SAC was told in 1949 to get ready for the early conversion of certain units to B-47 aircraft. It learned in September that 108 B-47s would be forthcoming during the years 1950 and 1951. In the spring of 1950, when, as some put it, if the Air Force was in the "jam," it was because of the B-47, SAC refused to get into further trouble programming for conversions too far in advance of aircraft delivery dates. The command chose to go ahead with the 306th and 305th conversions, but to postpone deciding which other wings would convert to B-47s and in what order. Meanwhile, SAC had inherited a new problem. After both air and ground crew training had been rushed, SAC wondered how to keep crew proficiency when it had no planes to fly or to look after. Of small consolation, no such overages existed in the K system and armament category where, besides technical factors, personnel training lagged for lack of tools, test equipment, and parts.

[23] Instead of 400, the first 90 aircraft went to Air Training Command as they were. The command later received 90 other B-47s. These planes had been through the refinement program, but their modification did not include the addition of the interim B-4 fire-control system that was fitted in every B-47 modified for SAC.

[24] Douglas agreed to modify 8 aircraft per month in Tulsa. Boeing promised to fix the planes in Tucson, but saturation of the existing facilities changed this planning. To keep its commitment, Boeing shifted the work to Wichita. The contractor was actually able to modify 40 of the planes directly on the assembly line.

Yet, despite its shaky start, the program fulfilled its requirements. SAC received its first batch of modified B-47s in October—a 3-month slippage that was to prove of slight importance. The last modified B-47s flowed from the Douglas modification center in October 1953.

Enters Operational Service — Fall of 1952

As a beginning, SAC received 8 modified B-47Bs in October 1952, 23 in November, 34 in December, and 13 in January 1953. The aircraft immediately went to the 306th and 305th Wings.

Production Improvement — 1952-1953

Back in late 1951, mechanical failures and a myriad of minor obstacles had caused the B-47 production to slip again. Yet, in the face of persistent shortages of contractor-furnished equipment and government-furnished parts, production took a turn for the better in the spring of 1952. The improvement soon gained momentum. By mid-1953, production was running smoothly and Boeing was rolling out new configurations (B/RB-47Es). Just getting started, Douglas, Tulsa, had already built 10 B-47Bs; Lockheed, Marietta, 7. In addition, two projects were in progress since January 1953. The first and most important one was Baby Grand. It was conducted by Boeing and would add the A-5 fire-control system in 54 new B-47s (units 400-454). The other, Field Goal, was in the hands of Douglas. It would improve 86 (units 1-86) of the 90 unmodified B-47s, first allocated to Air Training Command.

Standardization Decision — April 1953

Even though all modifications covered by the refinement program were incorporated into the production line of the 410st and subsequent B-47's, much remained to be done. Despite the Baby Grand modification, these aircraft, as well as the modified B-47Bs, did not meet the Air Force's expectations. There were other problems. In the hope of improving performance quickly, complex engineering changes had been introduced into the production line at approximately every fifth aircraft. This had essentially resulted in making the aircraft's maintenance far more difficult and its logistical support almost nightmarish. A standardization conference was held at Wichita in April 1953. There, Boeing's 731st B-47 production, a

B–47E referred to as WIBAC Unit 731, was established as the SAC standardization bomber.[25] In the same month, Headquarters USAF approved Turn Around, an AMC modification plan that would bring 114 new B–47s (units 617–730) to the 731st configuration. The Turn Around plan was clever. The Air Force would conditionally accept the 114 aircraft, but leave them at the Boeing plant for modification. The same procedure could be followed on other occasions. In this first case, it would save more than $7 million by eliminating the costly process of bringing back 114 aircraft for modernization after delivery. Turn Around, however, did not address the problem presented by in-service B–47s. This was to be covered by High Noon, a major modification and IRAN (inspect and repair as necessary) maintenance program, approved before the end of May.

Overseas Deployment — June 1953

SAC was always the first to seek further B–47 improvement. In the meantime, however, the command intended to make ample use of its newly assigned planes. After testing exhaustively in early 1953 the modified B–47B under simulated combat conditions, SAC decided the 306th (its first fully equipped wing) was ready for a 90-day rotational training mission to England. The 306th's deployment originated at MacDill and involved equal flights of 15 B–47s on 3, 4, and 5 June. Establishing a precedent that would be followed many times in the future, the B–47s staged through Limestone AFB, Maine, where they remained overnight before going on the next day. They landed at Fairford Royal Air Force Station on the 4th, 5th, and 6th of June. The 306th Air Refueling Squadron's KC–97s,[26] crammed with support personnel and equipment, deployed on the same dates as the B–47s.[27] They stopped overnight

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[25] In June the Air Council reaffirmed the April decision and officially endorsed Boeing's WIBAC Unit 731 as the "improved combat configuration." It took the other 2 contractors little more than a year to follow suit. Douglas Unit 125, delivered in September 1954, and Lockheed Unit 128, delivered 1 month before, were the same as WIBAC Unit 731.

[26] MacDill's 306th Air Refueling Squadron was the first unit to begin equipping with the KC–97 tanker. Its first aircraft, a KC–97E, was delivered on 14 July 1951. Outfitted with a flying boom and loaded with fuel tanks, the 4-engine, propeller-driven KC–97 could fly fast enough to match the minimum speed of the B–47. It transformed the B–47 into an intercontinental bomber. Each KC–97 squadron was authorized 20 aircraft.

[27] As far as SAC was concerned, proper support of the B–47s was of prime importance. In this regard, past production slippage had alleviated anticipated problems. Lagging supply programs had been able to pull abreast, and in some cases exceed wing requirements. For instance, the 306th had on hand nearly 90 percent of its equipment items by the end of 1951. Later, Snowtime, a project conceived by SAC, minimized supply difficulties. Snowtime required storage in only 1 depot (Rome, Griffiss AFB, N.Y.) of parts and equipment that would

Two B-47Bs, equipped with 6 J47-GE-23 engines.

at Ernest Harmon AFB, Newfoundland, and then flew on to Mildenhall Royal Air Force Station. Maintaining 1 or more bomb wings in the United Kingdom was nothing new. B-29 and B-50 wings had been rotating there since 1948. Just the same, the 306th rotational deployment was a milestone. Although a handful of specially modified B-45s had arrived in England in 1952, the move of the 306th there was the first routine deployment of a fully operational jet bomber wing. Moreover, the policy of maintaining at least 1 B-47 wing in England at all times would continue until early 1958.[28]

Aircraft Retrofit 1953-1957

Although modified B-47Bs were indispensable either at home or overseas, the Air Force did not lose sight of its April 1953 standardization

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be needed at B-47 bases at the time of conversion. Sea Weed, a similar project for the overseas B-47 bases, after a tough debut, also helped.

[28] Once started, the deployments were uninterrupted. When the 306th's 90-day rotation was over, the 305th was ready. By the time the 305th's tour was nearing its end, the 22d Bomb Wing had completed the transition to B-47s and was poised for departure.

decision. Yet, SAC operational priorities made it necessary to adjust the High Noon program that was due to modernize the bulk of the early airplanes. As finally approved in June 1953, 165 (units 235-399) of SAC's 289 modified B-47s would first go to High Noon.[29] To the maximum extent possible, the rest of the early planes, including those remaining in SAC's inventory, would also be brought to the 731st configuration. This would be done under Ebb Tide,[30] now organized as High Noon's second phase, but would not affect the AMC's 2-year IRAN maintenance program that had been attached to High Noon from the start.

The High Noon contract was assigned to Boeing. The choice was logical since the first 399 B-47s had all been assembled by Boeing from Boeing parts. Moreover, AMC was confident Boeing could do the work better, faster and cheaper than anyone else. High Noon was essentially a retrofit kit installation. Nevertheless, it was a complicated task, calling for removal, rebuilding, and reinstallation of many component-systems, as well as major revisions of the aircraft nose and cockpit. B-47s earmarked for High Noon began arriving at WIBAC in June 1954, and 36 of them had entered the modification line by February 1955. The first renovated B-47 emerged from its "face lifting" operation on 2 March. It featured ejection seats for all crew members, a bombing-navigation system with improved reliability,[31] water-alcohol injection for thrust augmentation, an expanded rack for rocket-bottle take-off assist units, a modified bomb bay that could house the single-sling, high-density, thermonuclear bomb as well as more general purpose bombs, a reinforced landing gear for increased take-off weight (202,000 pounds), the A-5 fire-control system (in place of the B-4), the AN/ARC-21 long range-liaison radio,[32] and better electronic countermeasures equipment. There were no major problems during the High Noon modification of SAC's 165 B-47Bs. The Boeing contract met its early 1956 completion date and was immediately replaced by Ebb Tide, which also took

[29] High Noon was the code name assigned to the major modification and maintenance program, approved in May 1953.

[30] Ebb Tide was another code name, the use of which, like that of High Noon, simplified matters when dealing with a complicated standardization project of exceptional scope.

[31] This was still the K system, but it had become more dependable as a result of Reliable, a separate modification project that had also simplified its installation and maintenance.

[32] The problem of obtaining a satisfactory high frequency radio dated back to 1950 and remained of great concern to General LeMay in 1954. Because the AN/ARC-21 long-range liaison radio was not available and its production continued to slip, 13 SAC wings used the Collins 18S-4. The command, however, did not relish having more aircraft fitted with this interim equipment. Fortunately, Project Big Eva, an accelerated test of the AN/ARC/21, concluded in February 1955 that the set perfomed creditably and would not require new maintenance skills.

place in Wichita. Ebb Tide addressed itself to the first 324 B-47s built by Boeing.[33] Of these, 66, selected from units 135-234, would undergo the same transformation as the High Noon planes and return to SAC in the configuration of WIBAC Unit 731. Another 108 of the early productions, out of units 1-134, would be modernized for Air Training Command.[34] In the process, they would exchange their J47-23 engines for the more powerful J47-25s of the other B-47Bs. Finally, 30 planes would be brought to the High Noon standard and be converted to director aircraft (DB-47Bs) for the forthcoming Rascal missiles.[35]

Total B-47Bs Accepted 397

Ten of these aircraft were built by Douglas, 8 by Lockheed, and all others by Boeing.

Acceptance Rates

The Air Force accepted 2 B-47Bs in fiscal year 1951 (1 each in April and May 1951); 204 in FY 52; 190 in FY 53, and a last one in FY 54 (July 1953).

End of Production June 1953

The Air Force took delivery of the plane the following month.

Flyaway Cost per Production Aircraft $2.44 million

Airframe, $1,767,094; engines (installed), $283,082; electronics, $43,835; ordnance, $5,336; armament, $350,109.

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[33] The program did not cover all the aircraft. Only specific lots, or about two-thirds of the 324 planes, went to Ebb Tide.

[34] The Air Training Command planes, subsequently known as TB-47s, closely resembled SAC's B-47s, but they carried no defensive armament or electronic countermeasures equipment. They could not be air-refueled and could not drop bombs. Also, take-off and range were unimproved.

[35] The DB-47Bs would carry the missiles to within 90 nautical miles of the target before launching and guiding them.

B-47B

Subsequent Model Series — B-47E

Other Configurations — RB-47B and YRB-47B

Design of the RB-47B was started in March 1951. Based on experience, the aircraft's first flight was expected 2 years later. The Air Force at the time also figured that delivery of the new reconnaissance planes could well begin in mid-1953. Yet, in March 1952, the many problems associated with the bomber configuration implied that the reconnaissance B-47 the Air Force had in mind was a long way off. In fact, it was decided shortly before October 1952 that the plane would feature the scarce A-5 fire-control system and the still experimental J47-GE-25 engines. The aircraft, therefore, most likely would not be completed until 1954 and when available, it would have little in common with the basic B-47B. Closely resembling the new E-model, it would come to be known as the RB-47E.

While this marked the production demise of the RB-47B (which never appeared on the Air Force's financial accounts), so-called RB-47Bs and YRB-47Bs came into being to fill SAC's reconnaissance vacuum of the early fifties. These planes, however, were nothing more than converted B-47Bs, equipped with special reconnaissance pods.[36] The Boeing-developed, 8-camera pod could easily be installed in the forward bomb bay, but only provided daylight photographic coverage. The 91st Strategic Reconnaissance Wing (Medium) received its first YRB-47 in April 1953; the 26th, 3 months later. Most of the 90 converted reconnaissance planes were subsequently used as crew trainers for operational RB-47Es.

Phaseout — 1957

In effect, the B-47Bs ceased to exist in 1957. By then, most of these aircraft had been brought up to the 731st's configuration or, as in the TB-47's case, sufficiently transformed to acquire new designation.

Other Uses — DB-47A and QB-47B

As General Boyd later pointed out, multiple demands were pinned on the B-47 from the start. Because it was the fastest bomber, the Air Force

[36] The RB-47Bs were pre-1953 conversions carrying, in principle, a dual bomber-reconnaissance mission. The YRB-47Bs were later conversions, more specifically intended for training.

called on it for Brass Ring,[37] a project concerning the delivery of thermonuclear weapons by unmanned aircraft. The Brass Ring project, spurred around 1949, was immersed in secrecy and of such importance that it was designated as "Special" by the highest authorities. Yet, Brass Ring was handicapped even before it began. In the late forties, technology was taking giant steps, but these steps went in many highly complex and expensive directions. Meanwhile, there was just a trickle of cooperation between the Atomic Energy Commission, which was building the atomic bombs, and the Air Force, which had to carry them. Early in 1950, as the Air Force looked for better ways to deliver the A-bomb, the forthcoming thermonuclear device (the hydrogen, or H-bomb) changed future carrier requirements. At first glance, it appeared that only a guided missile could handle the new weapon.[38] However, the time element—2½ years for a completely operational system—ruled out all missiles the Air Force had under development. The sole alternative seemed to be an aircraft that could assume the guise of a drone or missile. There were not many planes which could meet the required criteria. The aircraft had to be inexpensive, dependable, hardly vulnerable to enemy counter-actions, easily stabilized for automatic control, and quickly available. Only 3 candidates, the B-36, B-47, and B-49,[39] satisfied the basic load and range requirements. Of those, the B-47 was the best despite its high cost. The big B-36 was even more expensive and much too slow. The single point in favor of the B-49, should it ever reach production, was that its high-altitude performance would decrease its vulnerability. Hence, there was little dissension over selection of the B-47 as the H-bomb's first carrier. The Air Force made up its mind quickly.[40] It decided early in 1950 that 1 of the 10 B-47As (finally expected in by 1951) would be returned to Boeing and be converted into a director aircraft (DB-47A). Boeing also agreed on 27 September to modify 2 future B-47Bs

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[37] This name was not officially adopted until April 1951.

[38] The H-bomb was expected to produce a lethal area so great that, were it released in a normal manner, the carrier would not survive the explosive effects.

[39] The prototype B-49 represented Northrop's effort to establish a tactical use for a turbojet-powered version of its experimental B-35 "flying wing." The Air Force halted testing of the YB-49 in February 1950 and of its reconnaissance counterpart 2 years later.

[40] The Air Force, nevertheless, made it clear that any B-47 alterations had to be viewed as just one phase of a much larger program. In short, all delivery methods of possible merit had to be weighed. There were good reasons for such reservations. Lt. Gen. Kenneth B. Wolfe, Air Force Deputy Chief of Staff for Materiel, was not alone in believing that a piloted aircraft should be able to drop the new weapon and withdraw in comparative safety. As far as the B-47 was concerned, General Wolfe insisted, thrust could be added to increase the aircraft's turning speed. Moreover, there should be some way to slow down the H-bomb's rate of fall to enhance the carrier's margin of safety. Time soon proved the wisdom of these arguments.

to missile carrier (MB-47) or drone (QB-47) configurations.[41] Still, the project remained full of uncertainties. The Brass Ring MB-47 might become a true missile and dive towards its target. It might also be equipped with a mechanism to trigger the bomb free, as in a normal bombing run, while another gadget would ensure the missile's self-destruction shortly after the bomb release. Little information was available regarding the weight and size of the future H-bomb. All the Air Force knew was its new "emergency" carrier would have to cover more than 4,000 nautical miles with a load that would have to be dropped within a narrow radius of the target. So most likely, the Brass Ring MB-47 would have to be air-refueled several times. In any case, it would be manned until the last refueling operation. The crew would then bail out over friendly territory and the deserted MB-47 would go on towards its targets through automatic control by air director, stellar tracker, and auto-navigation. The scheme was sound, but getting a fully automatic, non-jammable guidance and bombing system to deliver the new weapon with accuracy would not be easy. It became obvious by 1952 that neither the North American nor Sperry guidance systems could be ready for the Brass Ring operational date, even though the latter had been slipped to July 1954.[42] The problem was so serious that the Air Force had begun to envision a director aircraft "mothering" a B-47 drone all the way to the target. Although the director-drone version could be made to work without a complex autonavigator,[43] it presented other difficulties. To begin with, B-47Bs would have to be modified as directors, since the DB-47A's range was too short for a full-scale Brass Ring mission with an unmanned H-bomb carrier. By mid-1952, however, Brass Ring was in far deeper trouble. General Wolfe's predictions had come true: Brass Ring was not the only way to

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[41] In accordance with the terms of the contractual agreement, Boeing subcontracted 3 major items to other companies. Under these arrangements, North American Aviation, Inc., (involved in an autonavigation development that had been started by the Hughes Aircraft Company) became responsible for the principal guidance system for Brass Ring. The Sperry Gyroscope Company was to supply the automatic flight control system; the Collins Radio Company, guidance equipment. If needed, the Sperry autonavigator—the alternate to North American's—would be supplied as government-furnished equipment.

[42] Continued development of North American's autonavigator was canceled in mid-1952, after costing the government some $850,000. Sperry's work was stopped, as part of Brass Ring, but allowed to resume for a different project. There was ample justification for the decision. In 1953, no other autonavigator had reached as advanced a stage as Sperry's. Also, $2.3 million had already been spent, and not much more was needed to get a finished product.

[43] The lack of a satisfactory autonavigator precluded testing of the original Brass Ring setup. The director-drone combination fared better. The first flight of the carrier, utilizing remote flight control and stabilization equipment, was made on 7 May 1952. By 30 June, both the B-47 drone aircraft and its director, with but part of the required equipment, had flown several test runs with rewarding results.

handle the new thermonuclear device.[44] For instance, testing had shown that a B-36 could deliver a parachute-equipped H-bomb about as accurately as a conventional bomb. Moreover, whether a B-36 or B-47 carried out the operation, the degree of safety would be more than adequate.[45] Against this background, Brass Ring's advantages faded. The acquisition of friendly bases in Europe, Asia, and Africa diminished the importance of range. Availability, a primary Brass Ring plus, also lost merit since the program was slipping. Forecast costs, swelling from $4.9 million in 1950 to $10.3 million in 1952, sealed Brass Ring's fate. The program was officially canceled on 1 April 1953. Despite an appeal by the Wright Air Development Center,[46] the Air Staff's decision stood firm.

DB-47B

The Air Force early in 1952 definitely considered using some bomber types to carry, launch, and guide air-to-surface missiles.[47] This would allow the destruction of enemy targets miles away from the carrier's utmost range. Most importantly, it would prevent the exposure of bombers and crews to hostile ground fire. The Bell Aircraft Corporation's Rascal (GAM-63) was the chosen missile. It was a 20,000-pounder (including an atomic warhead of some 3,000 pounds), with a range of 100 nautical miles. Under development since 1949,[48] the Rascal was earmarked for the Convair B-36, for the B-60

[44] Various delivery methods were investigated several months before the first full-scale thermonuclear explosion of November 1952. (The explosion took place at Eniwetok, an atoll of the Marshall Islands, designated by the Atomic Energy in 1947 Commission as permanent mid-Pacific proving ground for atomic weapons.)

[45] B-36s became the first bombers capable of handling thermonuclear weapons. Necessary modifications were accomplished under the code names of SAM-SAC and Featherweight. B-47s were modified soon afterwards as part of High Noon. Thermonuclear-capable B-47s could easily be reconverted in the field to carry the initial atomic weapons.

[46] The Wright Air Development Center was convinced that the $5.9 million spent on Brass Ring was worthwhile. As an emergency carrier of the thermonuclear bomb, the Brass Ring role might be eroded, but the program had many ramifications. The director-drone technique remained a crucial element of strategic air power. An additional $2.5 million would have provided 2 B-47 carriers, 1 B-47A director (with their associated equipment), plus engineering and hardware for 3 B-47B directors.

[47] This separate project came up shortly before Brass Ring took a turn for the worse. The Air Force had already learned much from the ill-fated program and this knowledge quickly served many other developmental endeavors.

[48] The Rascal's origin actually went back to 1 April 1946, when the AAF fathered Project MX-776, which called for a subsonic air-to-surface pilotless parasite bomber carrying a substantial warhead over a distance of 300 miles. After 18 months of study, Bell concluded that

(a jet-powered version of the B-36, built and flown but never placed in production), and for the Boeing B-47 and B-52. In March 1952, the candidate list was reduced to the B-36 and B-47, with the latter's modification assigned first priority. In spite of SAC's dislike of the Air Staff decision, Boeing before year's end was given a letter contract covering the modification of 2 B-47Bs into prototype Rascal carriers. In addition, following testing of the YDB-47s, 17 B-47Bs were to be converted to the DB-47B configuration finally approved. Not prone to give up easily, SAC began to urge that it be allowed to substitute B-50s for the B-47s. In the fall of 1953, after its latest appeal was turned down, SAC again pointed out that equipping the B-47 with the Rascal degraded the aircraft's performance, enough to make the combination of doubtful value. Moreover, it probably would never work well, since guidance of the missile added more complex electronic circuits to the already electronically complicated B-47. Then, too, modification costs (nearing $1 million per B-47 carrier) seemed out of line in view of the missile's current stage of development. Finally, SAC considered it unwise to commit strike aircraft and to train personnel before the Rascal problems were resolved and the missile's worth proved.[49]

The command did not win its case, but recurring Rascal slippages were to work in its favor. After completion of 1 mockup and 2 DB-47 prototypes, the letter contract of 1952 stayed in limbo until March 1955. The definitive contract then signed gave Boeing $3.7 million for completion of the work originally scheduled, bringing the conversion cost of each plane slightly below SAC's first estimate. In June 1955, the Air Force decided the B-47 alone would carry the rocket-powered Rascal, and the B-36 modification contract was canceled. Thirty B-47Bs, earmarked for Ebb Tide, now would also be converted and would emerge from Ebb Tide as DB-47s. Yet, despite a successful first Rascal launch from a YDB-47E carrier in July of the same year, the entire project seemed to falter. Technical problems continued to plague the GAM-63 missile (System 112L), and money was short. The Air Staff informed the Air Materiel Command in early 1956 that production

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a rocket power plant was not feasible for a 300-mile missile of the size contemplated. Even though the range requirement was pared to 100 nautical miles, other problems quickly surfaced, spurring development of a test vehicle that would be similar, but much smaller and cheaper than originally specified. This became the Shrike, a missile of canard configuration that was powered by 2 liquid rocket motors. The Shrike eventually boasted a cruising speed of Mach 2 and a range of some 50 nautical miles. First fired on 12 December 1951, it contributed much to the development of the Rascal, which was initially flight tested at Holloman AFB, N. M., on 30 September 1952. The 2 missiles, however, soon parted company.

[49] SAC's misgivings were not solely confined to the B-47. The command surmised that of all the B-36s, the H might not be the one best suited to carry the Rascal. As in the past, SAC insisted that the B-52s be kept out of the Rascal program. On this point, the command succeeded.

requirements for DB-47Es would be limited to 2 airplanes—Boeing Units 928 and 929. In May 1957, it was announced that the operational inventory would get 1 instead of 2 DB-47/GAM-63 squadrons. This was still too much, SAC reiterated, because the Rascal would be outmoded by improved Soviet defenses by the time it became operational. Nonetheless, at year's end, crews of the command's 321st Bomb Wing were engaged in Rascal training. Meanwhile, other factors, including persisting fund shortages, seemed to justify SAC's steadfast opinion. Rascal facilities at Pinecastle AFB, Florida, from where the wing's 445th Bombing Squadron would operate, were yet to be built early in 1958. In August, a review of the last 6 months of Rascal testing revealed a gloomy picture. Out of 64 scheduled launches, only 1 was a complete success, more than half were canceled, and most of the others were failures. The Air Staff officially ended the Rascal program on 29 November 1958,[50] after finally agreeing that ensuing savings could be put to better use.

KB-47G and KB-47F

Early in 1953, 2 47Bs were converted for trials with the British-developed probe and drogue refueling system. The resulting tanker was designated KB-47G; the receiving aircraft, KB-47F. The first air refueling between jet-powered aircraft occurred in September. Despite this success, the project remained just an experiment. From the inception of the B-47 program, SAC had recognized the necessity of developing in-flight refueling for the new but fairly short-ranged plane. The command nevertheless insisted that it made more sense to use cargo aircraft as tankers than to convert expensive and critically needed strike B-47s for this role. SAC also realized the drawbacks of using cargo aircraft. The propeller-driven KC-97 picked for the task could not climb to the B-47's best altitude. This forced the bomber down to the tanker's level, wasting both time and fuel. The B-47 had a tendency to stall at slow speed, a problem which persisted for several years. To keep the bomber from stalling during refueling, the slower KC-97 at times had to begin a shallow dive to gain momentum—a nerve-racking procedure when the 2 aircraft were linked by the refueling boom. The experiment of 1953 was revived in mid-1956, not on SAC's behalf but because the KB-50s of the Tactical Air Command lacked both the altitude and speed to air-refuel new tactical fighters of the Century series. The Air Force on 23 July authorized development of a KB-47 2-drogue prototype tanker and also tried to equip the basic B-50 tanker with 2 auxiliary jet

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[50] AMC was directed on 18 November to dispose of the 78 experimental and 58 production Rascals accepted by the Air Force.

engines. The KB-50 modification soon exceeded expectations. For that matter, work on the new KB-47 prototype also went well, except for one problem—money. By October, Boeing's initial estimate of the KB-47's price had doubled, reaching $2.7 million in April 1957. The cost was too high for a tanker never meant to be more than an interim solution. After making sure than not even Air Research and Development Command had a special need for a 2-drogue KB-47, the Air Force stopped work on the unfinished prototype and canceled the entire program on 11 July 1957.

XB-47D

Design of the XB-47D was initiated in February 1951, and 2 months later Boeing received a contract for the conversion of 2 B-47Bs. The Air Force pinned some hopes on gaining a high speed, long-range turboprop jet bomber from the project, but this was not its primary goal. The XB-47D was essentially developed to test a jet engine-prop combination and to provide data on the installation of turboprops in swept-wing aircraft.

The XB-47D closely resembled a B-47B, retaining the outboard J47-GE-23 jet engines, while a single Curtiss-Wright YT49-W-1 engine,[51] a turboprop version of the J65 Sapphire, occupied each of the inboard nacelles (in place of the paired J-47s). A successful technical inspection in January 1952 made it seem likely that an early 1953 first flight was possible. This, however, did not materialize. To begin with the Curtiss-Wright prototype engine, with its 4-bladed propellers 15 feet in diameter, failed to pass the 50-hour qualification run. The Air Force then estimated that it would take another year before testing could resume. Continuing troubles with the engine-prop combination and shortages of government-furnished equipment delayed further progress. The first XB-47D was not flown until 26 August 1955; the second, not until 15 February 1956. Even though both aircraft accumulated a good many flying hours, no prototypes were ordered. Having served its basic purposes, the program never went beyond the experimental stage.

YB-47C

The B-47C, normally due to follow the B-47B, did not reach production. In contrast to the XB-47D, this plane was definitely intended to answer

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[51] The prototype T-49 was a 1-spool engine; the final article, designated T-47, a 2-spool system.

SAC's requirement for an "ultimate" B-47—a bomber and reconnaissance plane having a combat radius of over 2,000 miles without air refueling. The Air Force hoped that the B-47B (Boeing's 88th production) set aside for the experiment would be ready for flight testing in late 1951. When the thrust of the selected new engines (Allison-built J35s) proved insufficient, more powerful ones had to be found. It was finally decided that the new version, now known as the YB-56, would be powered by 4 Allison J71-A-5 turbojets (still in the prototype stage). The Air Force also considered replacing some of the steel and aluminum in the airframe with titanium and magnesium (lighter materials, just as strong, but far more expensive), and of stripping the plane of its normal bombload in favor of reconnaissance equipment for a future RB-56A. The YB-56 reverted to its YB-47C designation as yet another engine later came into consideration. This final effort signaled the aircraft's doom because the engine in question was the Pratt and Whitney YJ57, yet to be available and already earmarked for the B-52. Because the prototype still lacked suitable engines and its cost could top $8.7 million, the Air Force stopped further work in December 1952. Cancellation of the YB-47C marked the end of the proposed YB-47Z—an improved version of the YB-47C, featuring side-by-side pilot seating and space for a fourth crewman. The projected RB-56As also fell by the wayside.

A specially modified Stratojet—the XB-47D—was used to test the Curtiss-Wright YT49 turboprop engine.

B-47E

Manufacturer's Model 450-157-35

Previous Model Series B-47B

New Features

Boeing's 400th production included crew ejection seats in a revised nose section, more powerful J47-GE-25 engines,[52] and the General Electric A-5 fire-control system. This configuration, first classified as an Air Force standard, was designated B-47E. A modified landing gear allowing heavier takeoff weight appeared on the 521st and subsequent B-47Es. This configuration was labeled B-47E-II. A far stronger landing gear was incorporated in the 862d B-47 production. This last configuration of the B-47E model series was identified as the B-47E-IV. The armament of all B-47Es was changed to two 20-mm cannons, and the 18-unit internal jet-assisted take off system of early B-47Es was soon replaced by a jettisonable rack containing 33 units, each with a 1,000-pound thrust. Increasingly more efficient components equipped the B-47E and B-47E-II aircraft. Still, many later acquired the improved MA-7A bombing radar, AN/APS-54 warning radar, AN/APG-32 gun-laying radar, and other highly sophisticated electronic devices first carried by the B-47E-IV.[53] The under surfaces and lower portion of the fuselage of most B-47Es were painted a glossy white to reflect the heat from nuclear blasts.[54]

First Flight (Production Aircraft) 30 January 1953

The Air Force accepted this plane in February and took delivery of 127 similar productions before mid-year.

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[52] Already refitted in several B-47Bs.

[53] In later years, a number of B-47E-IV bombers featured the improved MD-4 fire-control system instead of the A-5.

[54] This reflective paint was applied retroactively to some B-47Bs.

Enters Operational Service — April 1953

The B-47E first went to SAC's 303d Medium Bomb Wing, at Davis-Monthan AFB. The 22d Wing at March AFB, California, upon transfer of its early B-47Bs to Air Training Command, would be next to receive the B-47E. The new planes fell far below the improved combat configuration (WIBAC Unit 731) endorsed by the Air Force in the same month. Yet, strides were being made. Besides the added safety of ejection seats, the B-47E from the start featured an approach chute to increase drag, a brake chute to decrease landing roll, and an antiskid braking device. The discarded B-4 fire-control system could at best spray fire in the general direction of an enemy, but the new A-5 could automatically detect pursuing aircraft, track them by means of radar, and correct the firing of its two 20-mm cannons.

Program Change — September 1953

Early in 1953, just as the B-47 program was being revitalized, it seemed new and much bigger problems were on the way. President Eisenhower's defense and fiscal policies did affect the Air Force's development and procurement plans. In September, the 143-wing program was reduced to an interim 120 wings. As anticipated, the B-47 did not emerge from the crisis unscathed. Yet, all things considered, it fared well. Peak procurement, once expected to reach almost 2,200,[55] was cut by 140. But a further reduction of 200 aircraft, considered in October, was avoided. Instead the Air Force instituted a 20-month stretchout of production, pending full-scale rolling of the B-52 lines. In contrast to the B-36 program—so often on the verge of collapse—no significant attempt was ever made to cancel the B-47 production.

Force Conversion — 1953-1956

The production improvement, achieved with the B-47B in 1953, did not falter. Once underway, B-47E deliveries stayed on schedule. By December, SAC had 8 B-47 Medium Bomb Wings; 1 other wing was partially equipped; 5 more had no B-47s assigned, but were scheduled to receive the

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[55] Ten contracts—7 negotiated and 3 pending—had projected total B-47 procurement to be 2,190. Naturally, as design prime contractor, Boeing had the major portion of the business—4 contracts versus Douglas's 1 and Lockheed's 2. The 3 companies similarly farmed out 50 percent of the B-47 parts to various subcontractors scattered throughout the country.

new aircraft. In December 1954,[56] three months after total retirement of the B-29 bombers, the inventory counted 17 fully equipped B-47 wings. Marking the beginning of an all-jet medium bomb force in SAC, the last propeller-driven bombers (B-50s of the 97th Wing) were phased out in July 1955. Six months later, 22 medium bomb wings had received their B-47 contingents, and another 5 wings were getting ready for the new bombers. Conversion of the SAC forces did not necessarily mean that the B-47s were totally free of problems. Nevertheless, it only took until December 1956[57] for SAC to accumulate 27 combat-ready B-47 wings, a phenomenonal increase from 12 wings in July of the same year.

Flying training 1953-1956

In addition to materiel failures and component shortages, training problems limited the combat readiness of SAC's B-47 wings. Some argued that the B-47—be it the earliest B-47A or the latest B-47E—was not inherently hard to fly. Others more realistically emphasized that the flying techniques for the new jet aircraft differed vastly from those for conventional bombers. By 1954, the B-47 had the lowest major accident rate per 100,000 flying hours of any jet aircraft. Still, 55 percent of the B-47 accidents were traced to human error—43 percent to pilots, and 12 percent to maintenance crews. First the size of the crew was unusually small for this type of aircraft—3 men performing the functions of pilot, copilot/gunner, and bombardier/navigator. And although the 10 or 12 crewmembers of a B-29 worked with 130 instruments, the B-47's 3-man crew confronted more than 300 gauges, dials, switches, levers, and the like. Moreover, as a true expert noted, the B-47 was relatively difficult to land and terribly unforgiving of mistakes or inattention. Although often admired, respected, cursed, or even feared, the B-47 was almost never loved.[58] Even so, training progressed. In June 1954, Boeing indoctrination teams began keeping crews up to date on the B-47's limitations and stresses, and teaching techniques that would assure maximum performance under safe conditions. This new program was received with such enthusiasm that it was promptly expanded.

[56] The 3 contractors achieved monthly peak production in 1954—Boeing rolled out 29 planes in September; Douglas, 11 in March, and Lockheed, 13 in May.

[57] SAC at the time had 1,204 combat-ready B-47 crews and 1,306 B-47 aircraft assigned.

[58] These observations were made in 1975 by Brig. Gen. Earl C. Peck, Chief of the Office of Air Force History. He knew the B-47 well, having achieved the unusual tour-de-force of saving his B-47 on take-off despite the crucial loss of one of the plane's 6 engines. Promoted to 2-star rank in 1976, General Peck became SAC's Deputy Chief of Staff for Operations in April 1977.

The radar-controlled tail turret of the B-47E featured twin 20-mm cannon.

A Boeing B-47E, with its reconfigured nose section.

Heavyweight Modifications 1955-1959

The Air Force received its first B-47E-IV in February 1955. The reinforced landing gear of this "heavyweight" production and subsequent ones permitted heavier take-off weights, a significant achievement in the Air Force's quest for range extension.[59] The B-47E-IV had a take-off weight of 230,000 pounds—precisely 28,000 pounds more than previously permissible. Since the additional weight was largely allotted to fuel load, the B-47E-IV had a combat radius of 2,050 nautical miles. This was almost twice the distance demonstrated 5 years before by the initial B-47s and about 300 nautical miles farther than earlier B-47Es, already equipped with somewhat stronger landing gears.[60] The Air Force decided in March 1955 that in the next 4 years all active B-47s would be brought up to the heavyweight configuration. The modifications consisted of changing the aft landing gear and adding an emergency elevator boost system to ensure safe flights in spite of the increased weight. The forthcoming post-production changes were priced at $9.2 million, but the Air Force deemed them well worth the cost.

New Operational Requirements 1955-1956

About the time the much improved heavyweight B-47E-IV entered the inventory, more requirements were levied on the aircraft. Early in 1955,[61] after initial escape-maneuver tests had convinced SAC that the B-47 might be rugged enough for low-level bombing, the command requested a

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[59] This had been a tricky undertaking from the start. Normally, range extension meant weight reduction. Yet, back in 1952, while some engineers tried to reduce the aircraft's weight, others needed to add equipment to improve mission performance. The solution at the time appeared to rest on better engines and lighter airframe materials, as proposed for the B-47C. When this did not succeed, SAC suggested modification of the B-47's tandem landing gear.

[60] The B-47E-II, the first range-extended B-47, reached the Air Force in August 1953, after being also brought up to the improved combat configuration that had been endorsed earlier in the year. After flight-testing the stability of the modified plane, the Air Force flew it to find out if still higher gross weight take-offs could be possible. This paved the way for the heavyweight B-47E-IV.

[61] The year started auspiciously. The B-47E-IV was available, and the first B-47 for thermonuclear weapons had been delivered in January. Although the production-line modification of the aircraft had been made without awaiting the results of a concurrent flight test, the Air Force was not overly concerned. Most of the essential equipment had been installed on the aircraft, and only minor changes would be needed to ready it for combat. Justifying the Air Force's confidence, more than 1,100 B-47s could handle the new thermonuclear bombs by the end of April 1956.

further immediate check. There were many potential benefits. High-speed B–47s, flying at low-level, would be less vulnerable—more difficult for enemy radars to track and less likely to be intercepted by fighter aircraft, ground fire, or surface-to-air missiles. Increasingly sophisticated enemy defenses would be double-tasked, facing both high- and low-level attacks. The Air Staff swiftly endorsed SAC's request, but testing came to an abrupt halt after the loss of a low-flying B–47 over Bermuda. Low-level flight tests were not resumed until Boeing and the Air Research and Development Command assured Air Proving Ground Command that the B–47's structural integrity was not in doubt. In June a 6,000-pound dummy bomb was successfully released during a 2.6G-pullup from level flight, and an 8,850-pound practice bomb was properly dropped from a 2.5G-pullup in another flight. In both instances, release took place during the early portion of an Immelmann turn and the low-altitude bombing system functioned respectably.[62] In December 1955, SAC asked that 150 B–47s be modified by Boeing for low-level flight. This was authorized in May 1956.[63] At the time, however, the Air Staff reserved approval of the same modification for other B–47s, even though SAC pointed out that AMC might do the work as part of the aircraft's IRAN program.

Special Training 1955–1959

The B–47's low-level flying task entailed special training requirements. These had been anticipated by SAC in Hairclipper, a training program begun in December 1955. Adverse weather, excessive maintenance requirements due to low-level flying, and personnel losses to other training programs combined to hamper progress. Unexpected and serious LABS deficiencies in the low-altitude bombing systems, as well as several accidents in December

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[62] Development of the low-altitude bombing system dated back to 1952, and the low-level bombing tactic was not new. SAC's fighter-bomber pilots had been trained to fly at low-level and the command's F–84s had been modified for this purpose. But this did not really create a precedent. One could hardly compare the 200,000-pound (design loaded weight) B–47 with aircraft of the F–84 type. The B–47's thin wings covered a span of more than 116 feet. Empty, the B–47E weighed almost 80,000 pounds. In contrast, the F–84 had a wing span of about 36 feet and its empty weight was under 12,000 pounds.

[63] One year later, the Air Force made public its revolutionary strategic bombing tactic. Use of the B–47 for "toss bombing" was revealed at Eglin AFB in May 1957, during aerial firepower demonstrations before a joint civilian orientation group. (In a toss-bombing attack, the plane entered the run at low altitude, pulled up sharply into a half loop with a half roll on top, and released the weapon at a predetermined point in the climb. The bomb continued upward in a high arc, falling on the target at a considerable distance from its point of release. Meanwhile, the maneuver allowed the airplane to reverse its direction and gave it more time to speed away from the target.)

1957, were the final blows. General Power, SAC's Commander in Chief since 1 July 1957,[64] officially discontinued Hairclipper on 5 March 1958. Yet, demise of the training program did not signify the end of low-level flying. Pop Up, a related training program that took advantage of concurrent advances in weapons developments, fared better.[65] Interrupted in April 1958, when fatigue cracks in the wing structure of some B-47s led to severe flying restrictions, Pop Up resumed in September after the aircraft had been thoroughly checked. Going strong in 1959, this program had practically reached its training goal by year's end.

Structural Modifications 1958-1959

The discovery of fatigue cracks in the B-47's wings and a rash of new flying accidents in early 1958 triggered an immense inspection and repair program. Nicknamed Milk Bottle and started in May 1958, the program involved all 3 manufacturers, although AMC manpower and facilities carried the largest load. More likely to suffer fatigue because of extensive low-level flying training, B-47s of the 306th and 22d Bomb Wings were the first to enter the Milk Bottle program—receiving an interim fix in advance of the permanent repair being devised by Boeing. The interim fix called for a major inspection of suspect areas. After dissassembly to reveal the affected structures, each bolt hole was reamed oversized. A boroscope and dye penetrant were used to locate possible cracks. If any were found, the holes were reamed again. The same kind of procedure was used on the milk bottle fittings. B-47s with no further problems—457 of them—were returned to service after receiving the interim fix, which generally required about 1,700 manhours per bomber. Optimistically, as it turned out, Boeing estimated these planes would last about 400 hours before requiring further modifications. The so-called "ultimate" or permanent Milk Bottle repairs were far more involved, leading to no less than 9 technical orders. Briefly stated, the repairs covered primarily the splice that joined outer and inner wing panels; the area where the lower wing skin met the fuselage and, finally, the milk bottle pin (for which the program was named) and surrounding forging located on the forward part of the fuselage, near the navigator's escape hatch. The entire endeavor proved time consuming as well as expensive—

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[64] General Power succeeded General LeMay, who became Air Force Vice Chief of Staff in July 1957.

[65] The Pop Up tactic also put much less stress on the B-47's flexible wings than low-altitude toss-bombing. In the Pop Up maneuver, the aircraft swept in at low-level, pulled up to high altitude, released its weapon, then dove steeply to escape enemy radars.

fund obligations reaching $15 million by mid-year. But there were results. By the end of July, 1,230 B-47s had been through Milk Bottle, and 895 of them had already been returned to operational units. Considering its magnitude, Milk Bottle proceeded remarkably well, with most of the fleet modified by October. When the program ended in June 1959, only a few of the interim-repaired aircraft still needed work, which could be done during the regular inspect-and-repair-as-necessary cycle. While Milk Bottle did not solve all problems, it put safety back into the workhorse B-47, an aircraft badly needed at the time.

Unsolved Problems 1958-1959

The engineering fixes devised by Boeing for Milk Bottle showed that it was possible to identify the parts in an aircraft that were most likely to fail, but left many questions unanswered. No one could explain why primary structures in the B-47 were affected by maneuvers that the aircraft was designed to perform. General Power saw no use in turning to other aircraft unless SAC was assured they would survive low-level flying. General Power insisted that despite Boeing's evaluation of the B-47's structural life since 1956, not enough was known about aircraft service span. General LeMay agreed that weapon system producers had to give the Air Force more information on operation and its effect on metal fatigue. In addition, the Air Force and aircraft industry needed to combine their efforts. They had to expand existing programs to collect statistical maneuver-loads data, to conduct cyclic testing, and to develop better instrumentation and analytical techniques.[66] The knowledge to be gained, General LeMay thought, together with judicious application of engineering skills and maintenance funds would prevent the early retirement of aircraft, an extremely expensive alternative.[67] Yet, in any aircraft's life cycle, there was a point beyond which further repair became uneconomical. Perhaps, General LeMay noted, all that could be done to keep the aged B-47 combat ready was to correct anticipated problems.

Final Assessment 1958-1959

Devising the Milk Bottle repairs was just a beginning. While the repairs

[66] Wright Air Development Center was already considering the B-47's fatigue problem in May 1958 and was flight-testing a Douglas B-66 light bomber to learn more about low-altitude turbulence. Moreover, closely related projects were either in being or soon to start.

[67] Some 15 years later, low-flying B-52s continued to attest to the concept's value.

were underway, Boeing had to develop a broad structural-integrity program to determine the modification's impact on the B-47's service life. Moreover, any other potential problem areas had to be uncovered. The collapse of Boeing's cyclic test aircraft in August 1958 revealed for instance that the B-47's upper longerons—the beams running lengthwise along the fuselage—were susceptible to fatigue when the aircraft approached 2,000 hours of flying time.[68] Similar cyclic tests by Douglas and the National Aeronautics and Space Administration (NASA) did not disclose any serious deficiency until December, when NASA ceased testing after a fracture appeared near one of the B-47's wing stations. Boeing tests continued until January 1959, without duplicating NASA's discovery. But when Douglas stopped in February, after almost 10,000 test hours, its B-47 had also developed a 20-inch crack. If the cyclic testing of the late fifties truly simulated flight conditions, NASA and Douglas's findings were relatively important, since SAC's B-47s had never been individually tagged for 10,000 flying hours. In any event, there were gaps in other crucial research. The low-altitude flying program, using oscillograph recorders to track the stresses and strains of lower levels on the B-47, was far from complete. Still a decision had to be made without delay, if only to justify the purchase of other aircraft. In mid-1959, the Air Force cautiously assigned the B-47 a life expectancy of 3,300 hours.[69]

Other Setbacks 1959-1960

SAC initially wanted 1,000 B-47s modified for low-level flying. This meant fitting the aircraft with absolute altimeters, terrain clearance devices,[70] and doppler radars—the type of new equipment that would require extensive testing and lots of money. In 1959, it became evident that the B-47 would survive the Milk Bottle crisis only to face other severe problems. Because of development testing slippages and the money-saving phaseout of some B-47 wings, SAC scaled down its low-altitude requirements by half. The command did stress, however, the urgency of modifying the 500 B-47s now earmarked for low-level flying. SAC again pointed out

[68] This led to further inspections, the identification of 11 B-47s with defective longerons, and the Air Material Command's eventual modification of all the aircrafts' support beams.

[69] Implied was the requirement for regular rigid inspections. In addition, the Wright Air Development Center admitted that this figure was based on technical consideration only. It could change, because service life did not reflect economic or operational factors.

[70] The kind SAC needed to fly low at night or during periods of reduced visibility did not even exist in 1956.

that the aircraft lacked missile penetration aids and was marginally suited for high altitude strikes. Against improved enemy defenses, the B–47 would be obsolete in 1963 if not properly equipped for low-level flight. The Air Staff did not question SAC's justifications, but fund shortages dictated harsh decisions. Hence, in lieu of 500, only 350 B–47s would be modified for low-level flying, and the aircraft would receive simpler and much less costly equipment than asked for by SAC.[71] Obviously, the end of the B–47 was in sight.

Total B–47Es Accepted 1,341

Boeing built 691 of the 1,341 B–47Es; Douglas, 264; and Lockheed, 386.

Acceptance Rates 1953–1957

The Air Force accepted 128 B–47Es in FY 53, 405 in FY 54, 408 in FY 55, 280 in FY 56, and 120 in FY 57.

Flyaway Cost Per Production Aircraft $1.9 million

Airframe, $1,293,420; engines (installed), $262,805; electronics, $53,733; ordnance, $6,298; armament, $253,411.

Average Cost Per Flying Hour $794.00

Average Maintenance Cost Per Flying Hour $361.00

End of Production 1957

The final B–47E (Serial No. 53–6244) was delivered on 18 February to

[71] The Air Force had canceled in late 1958 the B–47's use of the GAM–72 Quail, a short-range decoy missile, mainly because of dollar limitations. Procurement of the GAM–67 Crossbow had already been dropped, and modification of the B–47 to protect it from infrared missiles was abandoned in mid-1959.

the 100th Bomb Wing at Pease AFB, New Hampshire. The famous "Bloody Hundreth" of World War II was the 29th and last SAC wing to be equipped with B-47s.[72]

Subsequent Model Series — RB-47E

Other Configurations — EB-47E, EB-47L, ETB-47E QB-47E and WB-47E

EB-47Es—Several B-47Es were fitted with additional electronic countermeasures equipment, primarily jammers. These EB-47Es, sometimes referred to as E-47Es, normally called for a crew of 5; otherwise, they were identical to the B-47E bombers which they were expected to accompany.[73] The EB-47Es fulfilled many different tasks. Some of the aircraft carried a special electronic countermeasures equipment rack in the bomb bay. Known as Blue Cradle EB-47Es, they only required a 3-man crew.

EB-47Ls—A number of B-47Es received communications relay equipment to allow them to serve as airborne relay stations for command post aircraft and ground communications systems. The EB-47Ls, requiring a 3-man crew, were replaced in the mid-sixties by more modern aircraft.

ETB-47E—After 1959 some B-47Es were used for training. As in the TB-47B's case, the converted ETB-47E featured a fourth crew seat for the instructor.

QB-47E—In this configuration, all armament items and non-essential equipment were removed from the B/RB-47E. Unmanned and radio-controlled, the aircraft served as missile targets. These QB-47Es were considered as nonexpendable, because of their $1.9 million unit cost, and the guided missiles used against them were programmed to make near misses. A few 3-crew QB-47Es featured telemetric and scoring devices.

WB-47E—Converted B-47Es featured nose-mounted cameras that recorded cloud formations. WB-47Es also differed from the B-47Es by carrying air-sampling and data-recording equipment in place of nuclear weapons.

Adaptation of the B-47 bomber to the weather role dated back to 1956.

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[72] One of these wings, the 93d, had converted to B-52s in 1955.

[73] The prefix letter "E" is assigned to any aircraft equipped with special electronics for employment in a variety of related roles, such as electronic countermeasures or airborne early warning radar.

It followed General Precision Laboratories' successful modification of a SAC B-47B—a project prompted by Congress as a result of the disastrous 1954 hurricane season. The Air Weather Service of the Military Air Transport Service[74] used the modified B-47B to penetrate hurricanes and to perform other weather duties. In November 1958, the aircraft also began to help checking the accuracy of the weather satellite Tiros II. The WB-47B logged 126.5 hours of flying time before retirement in 1963, when more efficient WB-47Es became available. The weather service received the first of 34 WB-47Es on 20 March 1963. These former B-47Es, no longer needed by SAC, were modified by Lockheed at its Marietta plant. The WB-47Es began to be replaced by WC-130 and WC-135 aircraft in 1965, but total phaseout took another 3 years. The last WB-47E—the final operational B-47 in the Air Force's inventory—was delivered to Davis-Monthan AFB on 31 October 1969.

Phaseout 1957-1966

Delivery of the last B-47E coincided with the beginning of the aircraft's phaseout. Both occurred in 1957, shortly after the 93d Bomb Wing started exchanging its B-47s for more modern B-52s. The Air Force, nevertheless, expected the B-47 to be around for many years. The aircraft's accelerated retirement, as directed by President John F. Kennedy in March 1961, was delayed on 28 July by the onset of the Berlin crisis of 1961-1962. In the following years, B-47s were gradually committed to the Davis-Monthan storage facility, but it took Fast Fly, a project initiated in October 1965, to hasten the demise of the elderly plane.[75] SAC's last 2 B-47s went to storage on 11 February 1966.[76]

Item of Special Interest December 1956

Spurred by the Suez crisis of 1956, SAC demonstrated its potential ability to launch a large striking force on short notice. Within a 2-week period in early December, more than 1,000 B-47s flew nonstop, simulated

[74] The Military Air Transport Service was established on 1 June 1948. It became the Military Airlift Command on 1 January 1966.

[75] SAC's last KC-97s were retired on 21 December 1965.

[76] Some RB-47s remained with the 55th Strategic Reconnaissance Wing, but not for long. However, several B-47 conversions saw many more years of duty.

combat missions, averaging 8,000 miles each (a total of 8 million miles) over the American continent and Arctic regions. Commenting on the spectacular mass flights, General Twining, Air Force's Chief of Staff since 30 June 1953, said the operation showed that the ability to deliver nuclear bombs had clearly taken the profit out of war.[77]

Record Flights 1957-1959

25 January 1957—A B-47 flew 4,700 miles from March AFB, California, to Hanscom Field, Massachusetts, in 3 hours and 47 minutes, averaging 710 miles per hour.

14 August 1957—A 321st Bomb Wing B-47 under the command of Brig. Gen. James V. Edmundson, SAC Deputy of Operations, made a record nonstop flight from Andersen AFB, Guam, to Sidi Slimane Air Base, French Morocco, a distance of 11,450 miles in 22 hours and 50 minutes. The flight required 4 refuelings by KC-97 tankers.

30 November 1959—A B-47, assigned to the Wright Air Development Center, broke previous time-and-distance records by staying aloft 3 days, 8 hours and 36 minutes and covering 39,000 miles.

Other Uses

1954—The Air Force set aside 17 B-47Es, already equipped with the necessary alternators, to test the new MA-2 bombing system earmarked for the forthcoming B-52s. The decision's purpose was 2-fold. To begin with, it would speed up testing of the MA-2. Of equal importance, the relatively large number of aircraft involved would allow the training of a cadre of MA-2 technicians. And this, in turn, would provide skilled personnel for SAC's B-52 units much sooner than otherwise possible.

1968-on—As SAC's EB-47Es neared retirement, the United States Navy acquired 2 of the planes and Douglas began modifying them in mid-1968. In addition to their Blue Cradle equipment, these 2 EB-47Es

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[77] The United States exploded its first "droppable" hydrogen bomb in the Marshall Islands on 1 March 1954. A second U.S. thermonuclear device was successfully tested on the 20th. The tests (part of Operation Castle, an Atomic Energy Commission endeavor) confirmed that it was possible to make light-weight, high-yield thermonuclear weapons. This technical advance obviously would make aerial bombing easier. (It also had an immediate impact on the Convair surface-to-surface Atlas missile. The Atlas's restrictive performance characteristics were loosened to the point where only the "state of the art" bound the missile's continued development.)

received more passive and active electronic systems. Long-range external wing tanks were replaced with a variety of pods filled with electronic countermeasures gear. More chaff dispensers were also added. The modified EB-47Es were redesignated SMS-2 and SMS-3 as they became part of the Navy's Surface Missile System, where they were expected to be used for almost 10 years to sharpen the electronic countermeasures skills of the Fleet. The 2 were due to be retired in the late seventies and to join some other 20 B-47s on display around the country.

RB-47E

Manufacturer's Model 450-158-36

Weapon System 100L

New Features

The RB-47E differed outwardly from the B-47E in that its nose was 34 inches longer. An air-conditioned compartment in the aircraft's redesigned nose housed cameras and other sensitive equipment. Included were an optical viewfinder, photocell-operated shutters actuated by flash lighting for night photography, and intervalometers for photographs of large areas at regularly spaced intervals. The RB-47E had no bombing equipment, but the 20-millimeter tail armament and A-5 fire-control system of the B-47E were retained. A photographer/navigator replaced the bombardier in the aircraft's 3-man crew. The RB-47E also featured the internal jet-assisted take-off system of the earliest B-47Es.

First Flight (Production Aircraft) — 3 July 1953

The RB-47E flew sooner than expected. Nonetheless, the problems and delays anticipated by the Air Force in March 1952 (when many B-47Bs were modified for reconnaissance) did occur. It took almost another 2 years for the RB-47E to become a real asset.

Initial Shortcoming — 1953-1955

An initial RB-47E was assigned to an operational unit in November 1953. This plane featured an interim camera control system that was also due to equip temporarily the next 134 RB-47Es. The sophisticated Universal Camera Control System,[78] designed by the Air Force's Photographic

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[78] The Universal Camera Control System provided for the simultaneous automatic operation of cameras. It also controlled shutter speeds, aperture settings, and image compensation according to ground speed, light, and altitude preset data.

Reconnaissance Laboratory, already tested on the RB-47B, and earmarked for the entire RB-47E contingent, would first appear on the 136th RB-47E. Problems with the interim camera control system soon altered the USAF plans. Because of the system's repeated failures, the Air Proving Ground Command recommended early in 1954 that further operational suitability tests of the available RB-47Es be canceled. No meaningful testing could be conducted, Air Proving Ground Command stated, without a RB-47E equipped with the universal system. This fell in line with General LeMay's thinking. The SAC Commander had already advised Maj. Gen. Clarence S. Irvine, AMC Deputy Commander for Production, that the day-and-night photo capability of the reconnaissance B-47E was unsatisfactory, be it at low or high altitude. General Irvine was quick to point out that minor improvements had been made to the interim camera control system. He willingly admitted, however, that the RB-47E's problems would not be entirely solved prior to the October delivery of the first Universal Camera Control System-equipped RB-47E production. Further discussion of the matter ended in May 1954, when the Air Staff decided that the first 135 RB-47Es would receive a simplified camera control system. This seemed to indicate that the aircraft would not undergo retrofit as originally planned and that SAC would be saddled with 2 RB-47E configurations. Although the Air Staff reversed its decision later in the month, this did not mean that all difficulties were over. Shortages of government-furnished equipment, chiefly of Universal Camera Control Systems, continued to hinder the program. The Air Force nearly reached its production total of RB-47Es by mid-1955, but many of the aircraft were not fully equipped. Yet phaseout of the 91st Strategic Reconnaissance Wing—recipient of the earliest RB-47Es—was only 2 years away.

End of Production — August 1955

The Air Force took delivery of the 4 last RB-47Es in August 1955.

Total RB-47Es Accepted — 255

Acceptance Rates

The Air Force accepted 97 RB-47Es in FY 54, 139 in FY 55, and 19 in FY 56.

Flyaway Cost Per Production Aircraft **$2.05 Million**

Airframe, $1,409,441; engines (installed), $258,159; electronics, $49,163; ordnance, $6,303; armament and special equipment, $333,847.

Average Cost Per Flying Hour **$794.00**

Average Maintenance Cost per Flying Hour **$361.00**

Subsequent Model Series **RB-47H**

Other Configurations **RB-47K**

On 5 November 1954, the Air Force officially agreed that 15 of SAC's RB-47Es would be fitted with special equipment for both weather and photo-reconnaissance operations at low and high altitudes. These new configurations, featuring high-resolution and side-looking radars, were designated RB-47Ks.[79] The first RB-47K was delivered in December 1955, as scheduled. In essence, the aircraft was an airborne weather information gathering system. SAC wanted the RB-47K to sense, compile, record, and make inflight radio transmissions of weather data. All these tasks were to be done automatically. The RB-47K was also expected to determine the size of clouds as well as to wind speed and direction. This was a large order, and severe equipment problems remained after mid-1956, when the 55th Strategic Reconnaissance Wing reached an initial operational capability. The 55th Wing's 15 RB-47Ks were flown all over the world to provide weather data for SAC and to sample fallouts from foreign nuclear blasts. They were phased out in the early sixties, when some of the last and more efficient B-47Es were modified to assume the weather role.

[79] USAF delivery ledgers did not list the RB-47Ks because the 15 aircraft were conditionally accepted as RB-47Es, but Boeing accomplished the complex modification before the aircraft left the Wichita plant. This saved time and money. The entire work was done in 5 months and cost less than $5 million.

Phaseout 1957–1967

The RB–47E phaseout followed the B–47E's pattern, and the first RB–47E (Serial No. 51–5272) was sent to storage at Davis-Monthan AFB on 14 October 1957. Nevertheless, a number of reconnaissance B–47s (mostly RB–47Hs) kept on serving SAC for another decade.

RB-47H

Manufacturer's Model 450-172-51

Previous Model Series RB-47E

New Features

A separate pressurized compartment in the area formerly occupied by the short bomb bay housed the aircraft's new electronic reconnaissance and electronic countermeasures equipment as well as 3 operators—bringing the RB-47H's crew to a total of 6.

Basic Development June 1951

General requirements for electronic countermeasures were established in mid-1951. A detailed configuration was made firm in 1952 because, as Lt. Gen. Laurence C. Craigie, Deputy Chief of Staff for Development, put it, "losses to the potential enemy air defense system would be very high," unless the B-47 possessed the capability to counter them. As initially set up, the Air Force's electronic countermeasures program reflected postwar technological advancements as well as state-of-the-art limits. Five phases were planned. Phases I through IV would provide successively more effective self-protection equipment, such as transmitters and chaff for jamming enemy signals. Phase V would install a 2-man pod in the B-47's bomb bay for escort protection. This beginning, as modest as it might seem, would not come easily. Yet, the urgency was great. On 29 December 1952, General Twining, Air Force Vice Chief of Staff, wrote Boeing's President, William M. Allen, to urge that "the necessary engineering leading to an effective capability be accomplished as speedily as possible." SAC, nonetheless, kept on believing that procuring the desired B-47, specially equipped for electronic countermeasures would take several years. In any case, other requirements needed to be addressed.[80]

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[80] As previously indicated, most of these requirements were fulfilled between 1953 and 1955. As of 1956, 978 B-47s incorporated basic electronic countermeasures devices. Others carried so-called Phase 2, Phase 3, or Phase 4 equipment. Twelve reconnaissance RB-47s featured the removable Phase V, 2-man capsule, initially requested.

On 25 June 1953, General Power, SAC's Vice Commander, stressed that the command actually needed more advanced technology than promised by Phase V. In short, a so-called Phase VII electronic reconnaissance apparatus had to be permanently installed in a number of B-47s in place of the planned 2-man pod. These electronic B-47s would ferret out enemy radar defenses and would replace the RB-50s, RB-36s, and modified B-29s which lacked the speed to do such work.

Program Changes 1953-1955

As requested by SAC, the RB-47H program was amended. The RB-47H's initial 2-man pod was replaced by a permanent pressurized compartment that enclosed equipment and 3 additional crew members—then referred to as electronic countermeasures observers. In 1955, the number of aircraft in the program was brought to 35—a 5-aircraft increase.

Enters Operational Service 1955-1956

The first RB-47H reached the 55th Strategic Reconnaissance Wing, Forbes AFB, Kansas, on 9 August 1955, after considerable slippage due to production difficulties. Although most of the RB-47Hs had been received by the end of 1956, the 55th Wing still had problems. Besides its operational commitments, the 55th was responsible for "organizing and training a force capable of immediate and sustained strategic electronic reconnaissance and air-to-air refueling on short notice in any part of the world, utilizing the latest technical knowledge, equipment, and techniques." Combat crew training was delayed from the start by the aircraft's late deliveries. Faulty engines in the first available RB-47Hs and the fuel leaks of subsequent aircraft likewise hampered training. Excessive noise in the aircraft's pressurized compartment did not help either. By the end of 1956, many of these problems had been ironed out, but none of the RB-47Hs was fully and effectively equipped.

Post-Production Modifications 1956-1957

The absence of an automatic electronic direction finder was the RB-47H's most crucial deficiency. Two pioneer productions of the required direction finder finally became available in December 1956. Each was immediately installed by Douglas (at the company's Tulsa plant), and the 2 newly equipped RB-47Hs reached the 55th Wing in January 1957. As could be expected, the many relatively untested components in these direction finders caused more problems. Their seriousness resulted in the establishment of a joint military and civilian committee to assist testing and operation.[81] Additional direction finders were received in March and the RB-47H's first modification program began. Basically, it called for the installation of 1 automatic electronic direction finder in each RB-47H. Numerous related adjustments were necessary, however. Just the same, the work was done promptly, on base, by Douglas personnel.

Total RB-47Hs Accepted — 35

Boeing built the 35 planes.

Acceptance Rates — 1956-1957

The Air Force accepted 30 RB-47Hs in FY 56 and 5 more during the following fiscal year—the last 2 in January 1957.

Flyaway Cost Per Production Aircraft[82] — $2.1 million

Airframe, $1,588,723; engines (installed), $273,449; electronics, $54,877; ordnance, $8,271; armament, $201,597.

Average Cost Per Flying Hour — $794.00

Average Maintenance Cost Per Flying Hour — $389.00

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[81] Members of this committee included representatives from the Boeing Aircraft Company, the Federal Telecommunications Laboratory, the Strategic Air Command, the Wright Air Development Center, and the Oklahoma Air Materiel Area. Within a month, the committee's work led to the selection of proper test equipment, the development of appropriate maintenance procedures, and the design and manufacture of an oscilloscope calibration instrument to reduce maintenance time.

[82] As noted earlier, the flyaway cost of any production aircraft never included the engineering and modification cost incurred after approval of a basic contract.

End of Production — 1957

The Air Force took delivery of its last 2 RB-47Hs in January.

Major Retrofit — 1960–1962

Although the RB-47H's post-production modifications of 1957 were satisfactory and the aircraft was practically unique, SAC had to keep pace with incessant technological advances. New requirements and the development of more sophisticated equipment soon required a reconfiguration of the RB-47H's special compartment. A mockup inspection in September 1959 was followed in August 1960 by the first flight of a refitted RB-47H. The plane, besides its 6 radar sets, carried some of the most modern electronics. The RB-47H prototype of 1960 was put together by Boeing, but other RB-47Hs were retrofitted in Tulsa by Douglas. The first reconfigured aircraft was returned to the 55th Wing in November 1961.[83]

Subsequent Model Series — None

Other Configurations — EB-47H/ERB-47H

The EB-47H, for a time designated ERB-47H, was an RB-47H that carried special electronic "ferret" equipment. As such, the 3 planes so modified by Boeing before the end of 1957 were able to detect, locate, record, and analyze electromagnetic radiations.

Phaseout — 29 December 1967

On 29 December, SAC's last B-47 type aircraft, an RB-47H (Serial No. 53-4296) of the 55th Wing, was flown to Davis-Monthan AFB for storage. Completion of the RB-47H phaseout came exactly 20 years after the initial flight of the experimental B-47.

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[83] Seventeen months before, an RB-47H flying over the Bering Sea had been shot down by Soviet fighters. This RB-47H loss closely followed the U-2 incident of May 1960.

Program Recap

The Air Force accepted a grand total of 2,041 B–47s (including the first 2 experimental planes and the prototype of a never-produced configuration). Specifically, the B–47 program comprised 2 XB–47s, 10 B–47As (mostly used for testing), 397 B–47Bs, 1 YB–47C, 1,341 B–47Es, 255 RB–47Es, and 35 RB–47Hs. All other B–47s in the Air Force's opertional inventory, be they weather reconnaissance aircraft (WB–47Es), ETB–47E combat crew trainer, QB–47 drones, or others, were acquired through post-production reconfigurations.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

B/RB-47 AIRCRAFT

Manufacturer (Airframe)	Boeing Airplane Co., Seattle, Wash.; Douglas Aircraft Co., Tulsa, Okla.; Lockheed Aircraft Corp., Marietta, Ga.
(Engines)	The General Electric Co., Schenectady, N.Y.
Nomenclature	Strategic Medium Bomber and Reconnaissance Aircraft
Popular Name	Stratojet

	B-47A	B-47B	B-47E-IV	RB-47H
Length/Span	106.8/116	106.8/116	107.116	108.7/116.3
Wing Area (sq ft)	1,428	1,428	1,428	1,428
Weights (lb)				
Empty	73,240	78,102	79,074	89,230[a]
Combat	106,060	122,650	133,030	139,000[a]
Takeoff[b]	157,000	185,000	230,000	195,133
Engine: Number, Rated Power per Engine & Designation	(6) 5,200-lb st J47-GE-11	(6) 5,910-lb st J47-GE-23	(6) 7,200-lb st J47-GE-25 or 25A	(6) 7,200-lb st J47-GE-25
Takeoff Ground Run (ft)				
At Sea Level	6,000	9,100	10,400	7,800
At Sea Level with Assisted Take-Off	Not Applicable	7,200	7,350	
Over 50-ft Obstacle	7,210	10,650	12,000	9,300
Over 50-ft Obstacle with Assisted Take-Off	Not Applicable	8,650	8,800	
Rate of Climb (fpm) at Sea Level	3,375	2,560	1,850	2,500
Combat Rate of Climb (fpm) at Sea Level	6,200 (mil power)	4,775 (max power)	4,350 (max power)	3,700
Service Ceiling (ft) (100 fpm Rate of Climb to Altitude)	38,100	33,900	29,500	31,500
Combat Ceiling (ft) (500 fpm Rate of Climb to Altitude	44,300	40,800	39,300	37,600
Average Cruise Speed (kn)	424	433	435	424
Max Speed at Optimum Altitude (kn/ft)	521/8,800	528/16,300	528/16,300	516/15,000
Combat Radius (nm)	1,350	1,704	2,050	1,520
Total Mission Time (hr)	6.45	8.27	9.42	6.4
Armament	None	2.50-cal guns	2 20-mm M24A1 guns	2 20-mm M24A1 guns
Crew	3	3	3	6
Max Bombload[c] (lb)	22,000	25,000	25,000	845[d]

Abbreviations		
cal	=	caliber
fpm	=	feet per minute
kn	=	knots
max	=	maximum
mil	=	military
mm	=	millimeter
nm	=	nautical miles
st	=	static thrust

[a] Pod and strut included.

[b] Limited by the strength of the aircraft's landing gear.

[c] Bombloads could be made of various combinations—World War II box fins, interim conical fins, and so-called new series. The B-47B was also capable of carrying one 25,000-pound general-purpose bomb.

[d] Instead of bombs, the RB-47H carried cameras and 845 pounds of chaff.

BASIC MISSION NOTE

All basic mission performance data based on maximum power, except as otherwise indicated.

Combat Radius Formula:

B-47A—Not applicable, since this model was used mostly for testing.

RB-47H—Not available.

B-47B—Took off and climbed on course to optimum cruise altitude at normal power. Cruised out at long-range speeds, increasing altitude with decreasing airplane weight. Climbed to reach cruise ceiling 15 minutes from target. Ran-in to target at normal power, dropped bombs, conducted 2-minute evasive action and 8-minute escape from target at normal power. Cruised back to home base at long-range speeds, increasing altitude with decreasing airplane weight. Range-free allowances included 5-minute normal-power fuel consumption for starting engines and take-off, 2-minute normal-power fuel consumption at combat altitude for evasive action, and 30 minutes of maximum endurance (4 engines) fuel consumption at sea level plus 5 percent of initial fuel load for landing reserve.

B-47E-IV—Took off and climbed on course to initial cruising altitude. Cruised at long-range speeds and altitudes, dropping external tanks when empty. Climbed to cruise ceiling and conducted a 15-minute level-flight bomb run at normal-rated thrust. Dropped bombload and chaff and conducted a 2-minute evasive action and 8-minute escape at normal-rated thrust. Returned to base at long-range speeds and altitudes. Range-free allowances were: fuel for 5 minutes at normal-rated thrust at sea level for take-off allowance, 2 minutes at normal-rated thrust at combat altitude for evasive action, and 30 minutes at maximum endurance airspeeds at sea level plus 5 percent of initial fuel loads for landing reserve.

B-50 Superfortress

Boeing
Airplane Company

B–50 Superfortress
Boeing

Manufacturer's Model 345–2

Overview

The B–50's development was approved in 1944, when the aircraft was known as the B–29D. Still in the midst of war, the Army Air Forces (AAF) wanted a significantly improved B–29 that could carry heavy loads of conventional weapons faster and farther. As World War II ended, the production of thousands of B–29s was canceled. The B–29D survived, but its purpose was changed. Redesignated as the B–50 in December 1945, the improved bomber was now earmarked for the atomic role. The decision was prompted by the uncertain fate of Convair B–36, the first long-range, heavy bomber produced as an atomic carrier. Of course, some of the B–29s that had been modified to carry the atomic bomb remained available, and surplus B–29s were being reconfigured for the atomic task. Just the same, the B–29s of war vintage were nearly obsolete. Hence, they would have to be replaced by a more efficient, atomic-capable bomber pending availability of the intercontinental B–36 or of another bomber truly suitable for the delivery of atomic weaponry.

While the short-range B–50 was immediately recognized as a stopgap measure, the magnitude of the aircraft's development problems proved unexpected. The B–50's first difficulties stemmed from its bomb bay which, like that of the B–29, was too small to house the new bomb and its required components. The fast development of special weapons created more complications, since the individual components of every single type of bomb had to be relocated within the bomb bay's narrow confines.

In keeping with the usual vicissitudes accompanying the development of any new or improved aircraft, the B–50 soon exhibited engine malfunctions. Then, cracking of the metal skin on the trailing edge of the wings and flaps dictated extensive modifications. And while these problems were being resolved, new requirements were levied on the aircraft. In 1949, as the proposed RB-36 remained a long way off, and because of the older RB-29's deficiencies in speed, range, and altitude, some B-50s had to be fitted for the reconnaissance role. To make matters worse, fuel tank overflows, leaking fuel check valves, failures of the engine turbo-chargers, generator defects, and the like continued to plague every B-50 version.

Meanwhile, contrary to plans, most B-50s came off the production lines without the receiver end of the new air-to-air refueling system being developed by Boeing. Additional, and successful, modifications therefore ensued. Nevertheless, the Strategic Air Command (SAC) had no illusions. The B-50, along with the B-36 (first delivered in June 1948), would be obsolete in 1951. That the B-50 did not start leaving the SAC inventory before 1953 was due to the production problems and many modifications of its replacement: the subsonic B-47.

Basic Development 1939

As an outgrowth of the B-29, the B-50 can be traced back to July 1939, when Boeing Airplance Company introduced Model 334A, the B-29's first direct ancestor.[1] Specifically, however, the B-50 bomber stemmed from a B-29 conversion, initiated in 1944.[2]

Initial Procurement February 1940

Requirements for the B-29 Superfortress, from which the B-29D (later known as the B-50) derived, were issued in February 1940, when the Army Air Corps asked the aircraft industry to submit designs for a "Hemisphere Defense Weapon." Boeing Model 345 (a further development of Model 334A) was adjudged best of all proposals for bombers with very-long-range

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[1] Model 334A was actually started in March 1938, when the Army Air Corps asked Boeing to design a pressurized version of its B-17 Flying Fortress. Development of the new pressurized model with tricycle undercarriage was hampered by the Army's lack of money in pre-war years. But Boeing, being aware of the Air Corps' interest, went ahead with the project and managed, still without government funds, to build a mockup of the more refined Model 334A.

[2] The single Boeing Model Number 345 was used for all production versions of the B-29, which in 1942 was the heaviest aeroplane in the world to go into production. The B-29B was the highest designation assigned to a production B-29 model. The B-29C designation was intended for a B-29, earmarked to test new developments of the R-3350 engines, but the project did not materialize. All higher designations identified the purposes of the basic aircraft's various reconfigurations.

characteristics, and the company was authorized in September 1940 to produce the first very heavy bomber to incorporate pressure-cabin installations and other radical changes in design and armament. Development of an improved version of the famed B-29 began in 1944, as a so-called Phase II evolution of the basic design. No specific requirements ensued, but the main intent was to equip the improved bomber with the new Pratt & Whitney R-4360 Wasps and to do away with existing and often troublesome versions of the Curtiss-Wright R-3350 radial engines. The B-29A assigned to the Phase II development project, once reconfigured with the new Wasp engines, was flown by Boeing as the YB-44 prototype. The AAF approved within a few months a production version of the YB-44, which was then designated as the B-29D, and ordered 200 production models of the improved bomber in July 1945.

Procurement Reduction — December 1945

Japan's surrender on 14 August, 3 months after the defeat of Nazi Germany, prompted the cancellation of military procurement. In the process, the 200 B-29Ds on order since July 1945 were reduced to 60 in December of the same year.

New Designation — December 1945

The B-29D became the B-50 in December 1945. Officially, the aircraft's new designation was justified by the changes separating the B-29D from its predecessors. However, according to Peter M. Bowers, a well-known authority on Boeing aircraft, "the redesignation was an outright military ruse to win appropriations for the procurement of an aeroplane that by its designation appeared to be merely a later version of an existing model that was being canceled wholesale, with many existing examples being put into dead storage."[3]

In any case, the former B-29D featured many changes. The redesignated aircraft, built with a stronger but lighter grade of aluminum, had larger flaps, a higher vertical tail (that could be folded down to ease storage in standard size hangars), a hydraulic rudder boost, nose wheel steering, a more efficient undercarriage retracting mechanism, and a new electrical

[3] Restoration of peace, as precarious as it already appeared to be, prevented the production of nearly 5,000 B-29s (still on order in September 1945), and thousands of operational B-29s became surplus—at least, temporarily.

device to remove the ice from the pilot's windows. The new aircraft's wings and empennage also could be thermally de-iced. Finally, the 4 higher-thrust Pratt & Whitney R-4360 engines that replaced the standard B-29's R-3350s gave a power increase of 59 percent, and electrically controlled, reversible-pitch propellers allowed the use of engine power as an aid to braking on short or wet runways. There was also some rearrangement of the crew. Yet, no matter what designation, there was no doubt that the piston-powered B-29D/B-50 would seem antiquated in the post-war era of jet bombers.[4]

Program Change 1945-1947

The AAF began to plan for an atomic strike force in the first few months of peace that followed the end of World War II. It ordered that 19 additional B-29s be reconfigured as atomic carriers in July 1946,[5] six months after the improved B-29D had become the B-50. Most likely, the AAF already planned that the redesignated bombers would first supplement the reconfigured B-29s and then replace them until a better atomic carrier became available. But the AAF at the time was not in a particularly strong position to press for what it believed to be essential.[6] Hence, the true purpose of the B-50 program did not become official until the spring of 1947.

Production Decision 24 May 1947

The decision to produce the B-50A, first model of the B-50 series, was confirmed on 24 May 1947, nearly 2 years after the aircraft's initial procurement had been authorized.

Procurement Data 1946-1949

Official records revealed that 60 B-29s were authorized for procurement

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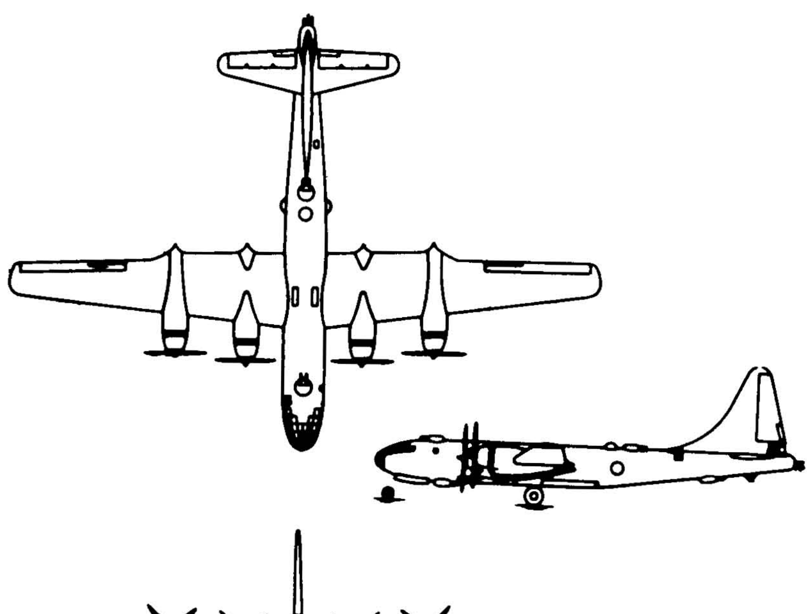
[4] See B-36, pp 11-12.

[5] Modification of the B-29 aircraft to carry the first atomic bombs began early in 1944. Less than half of the 46 modified B-29s remained operational by November 1946. Unlike the first modifications, which were handmade, improvement of the additional B-29s would consist essentially of a standard installation.

[6] The AAF was still subordinate to the War Department prior to its recognition as a separate department within the National Military Establishment in September 1947.

The Boeing B-50, an improved version of the B-29 adapted to carry atomic weapons.



in fiscal year (FY) 1946; 73 B-50s in FY 47; 82 in FY 48, and 132 in FY 49. Production of the last B-50 type, a trainer, as decided on 4 May 1951, did not entail any new procurement, only the amendment of an order previously increased for a different model. This order involved an extra 24 aircraft, the quantity eventually built in the trainer configuration. Procurement logs did not reflect such transactions, but the lack of specific procurement data, contract identifications, exact dates, and the like was not unusual.[7] The aircraft's historical documentation in the immediate post-World War II period often proved meager. In the B-50's case, however, the paucity of details was most likely due to the secrecy which shrouded the project from the start. Nevertheless, the B-50 program's production total was accurately recorded. This total reached 370 aircraft, including the first 60 planes ordered as B-29Ds, but excluding 1 prototype, taken out of the FY 47 procurement order, built in 1949, and paid for with development funds.

Testing 1947-1957

Officially, there were no experimental or prototype B-50s. In actuality, 7 of the 79 B-50As produced by Boeing were allocated to testing.[8] The first B-50A, Serial No. 46-002, initially flew on 25 June 1947, was accepted by the Air Force on 16 October and delivered on the 31st. The airplane was salvaged at Eglin AFB, Florida, on 12 July 1957, after being finally used to verify a stellar monitoring inertial bombing system. Little remains known of the first aircraft's use during the interim 10 years. It was flown a grand total of 769 hours, of which Boeing logged 324 hours and 13 minutes in 176 flights. The aircraft was also lent to the Bell Aircraft Corporation, which flew it 69 times for a total of 199 hours. The test aircraft then stayed with the A. C. Spark Plug Company of Detroit, Michigan, for almost 2 years, from 26 February 1954 to January 1956. During this time, more than 156 hours were accumulated in 43 flights. Air Force pilots flew the remaining 89 hours, and available reports revealed that Air Materiel Command (AMC) made 4 flights of about 6 hours at the Boeing plant before the aircraft's delivery in October 1947. The first B-50A accepted by the Air Force was reclassified as an EB-50A in March 1949, a classification assigned to any aircraft being modified for the electronic countermeasures role or other related purposes. The aircraft retained this classification until January 1956, when it became

[7] See B-45, p 71.

[8] Numerous other B-50s underwent many tests, but in contrast to the 7 aircraft specifically earmarked for testing, they eventually became part of the operational forces.

known as a JB-50A, indicating that the aircraft was then used for the testing of special instrumentation.

The second B-50A, Serial No. 46-003, accepted by the Air Force also in October, followed its predecessor's path. It was designated EB-50A in November 1947, 1 month after being formally accepted, sent back to Boeing in October 1949, returned to the Air Force on 15 February 1950, and again lent to Boeing in June of the same year. The second EB-50A continued to be tested at the Boeing plant until January 1952, but was retained by the Air Force from then on. The rest of the airplane's operational life was given over to testing, by both Air Research and Development Command and AMC. Most of this was done at Aberdeen, Maryland, where the aircraft was involved in a fatal crash on 24 November 1952. Available records indicate that Air Force pilots only flew the plane 59 times.[9] Five of the other B-50As, earmarked for testing from the start, were obviously used to devise the special modifications required by the upgraded and highly classified atomic program. Basic testing data, therefore was also highly classified and strictly disseminated. An extra and vastly improved B-50A[10] was entirely confined to testing in order to develop the canceled B-54.

Production Slippage — 1947-1948

The AAF thought that some B-50s would be available in September 1947, and that 36 of the aircraft would be immediately delivered to the Air Materiel Command for atomic modification. It was also believed the programmed modifications would be easier to accomplish than the latest performed on the B-29s, because part of the work would have already been done in production. These estimates proved wrong. Slow delivery of the B-50 postponed the beginning of the modification program to 1 February 1948, and the time spent modifying each B-50 jumped from an estimated 3,500 to some 6,000 manhours. In retrospect, however, there seems to have been scant ground for criticism. The B-50 modification program, together with that of the B-29, promised all along to be complex. As it turned out, the project became far more involved than anticipated.

Special Modifications — 1948-1949

As an improved version of the B-29, the modifications of the B-50 were

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[9] This figure was obtained from test reports on record at the Air Force Flight Test Center and the Federal Records Center at St. Louis, Mo.

[10] Air Force ledgers excluded the plane from the B-50A total. This was the aircraft that was logged as a prototype and paid for with development funds.

of necessity closely interlaced with those performed on the basic aircraft. For the same reason, aware that the B-50's performance would be only slightly better than that of the B-29, the Air Staff by late 1949 had ceased to contemplate large-scale production of the plane.[11] The B-50 was to be a stopgap, to be used until an aircraft more suitable for the delivery of atomic weapons became available. Its extended operational life in this role was dictated by circumstances, not by choice. Therefore, additional, unanticipated modifications became necessary and proved costly.

As directed by the Joint Chiefs of Staff in January 1948—when the B-36 program appeared once again on the verge of collapse[12] and only 3 B-50s had been delivered—the large-scale atomic project to improve SAC's operating capability called for numerous separate projects. Modification of bombers to carry new atomic bombs was the primary requirement, but other required changes were important. The bombers needed a greater range, which meant that they would have to be modified for in-flight refueling and tankers would be needed. In addition, the bombers would have to fly in the worst climate, which also meant that most of them would have to be winterized. Finally, the Joint Chiefs' project required that several bombers be fitted with electronics that could withstand the cold weather of the arctic, and that other significant modifications be made to various types of aircraft in order to make sure that the atomic carriers would be given the best chances of survival.[13]

Inevitably, estimates of modification costs proved highly unrealistic. To make matters worse, the many extra modifications directed by the Joint Chiefs of Staff took place when money was particularly scarce.[14] For example, in August 1948 lack of funds nearly stopped the B-50 modifications being done at the Boeing-Wichita Plant. Moreover, as time went by

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[11] The Strategic Air Command at the time was increasingly concerned by the long-term problem of developing an atomic carrier of great effectiveness. The command had already admitted that the B-50 (along with the B-36) would become obsolescent after 1951, and that no practical means existed to extend the B-50's life (as well as that of the B-29) beyond 1955. The initial production slippage, various deficiencies, and limited speed of the subsonic B-47, due to supplant the B-50, were serious. SAC's predicament was compounded by the arguments clouding the development of the B-52, which the command believed was the aircraft best suited not only to take over the B-36's task but also to assume most facets of the overall atomic mission.

[12] See B-36, pp 20-21.

[13] There were delays, but these goals were reached. Reactivated B-29s were modified as refueling tankers; reactivated B-29s and incoming B-50s were modified for reconnaissance; F-80 and F-84 escorts were prepared to provide the required protection, and new C-97 transports were bought to support the bombers.

[14] See B-36, pp 25-26.

and a variety of more sophisticated bombs entered the stockpile, the program's complexity grew and new modifications were needed. Obviously, overall costs also rose.

Meanwhile, three-fourths of the additional bombers earmarked by the Joint Chiefs to carry new atomic bombs had received the necessary primary modifications by 15 December 1948. In addition, except for 15 B-50As, all modified bombers had received new standard electronics. Every one of the 72 B-50As involved in the project had been winterized; 57 of them had been fitted for air refueling, and 15 had been given arctic electronics. Production difficulties, program changes, and funding uncertainties delayed some of the modifications. But, save for a few minor exceptions, the Air Force met the Joint Chiefs' extended completion deadline of 15 February 1949.[15]

As usual, modification of the B-50As and of other aircraft connected with the project was split into 2 phases. The contractor, Boeing in the B-50's case, installed all items that became an integral part of the bomber, while removable parts were furnished as "kits" to Strategic Air Command units which then completed the installation.[16]

Enters Operational Service 1948-1949

B-50A deliveries to SAC's 43d Bombardment Wing, at Davis-Monthan AFB, Arizona, began in June 1948,[17] and by the end of the year 34 B-50As were on hand. Nevertheless, a true initial operational capability was not gained until 1949. Problems of all sorts contributed to the delay. In June 1948, the 43d Wing had only 25 percent of the parts required for the new aircraft, and most of the available parts consisted of bolts, nuts, and gaskets. Even though about 25 percent of the B-50A parts were interchangeable with B-29 parts, and some others could be manufactured locally, the wing considered its parts shortages intolerable. Expedients, such as pilot pickup of parts either from the factory or from AMC depots, would "not be feasible with a large number of aircraft." In addition, since only 60 percent

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[15] Besides the B-50As, B-29s, B-36s, F-80s, and C-97s were included in the first modification package directed by the Joint Chiefs of Staff. The overall cost was high. It took $35.5 million to rejuvenate, modify, or adapt a grand total of 227 aircraft.

[16] Certain classified portions of the bombers' new configurations were assembled by the Sacramento Air Materiel Area of the Air Materiel Command into special kits, designated "X" kits. These kits also were installed in the field by personnel of the Strategic Air Command.

[17] A single B-50A (Serial #46-017) reached the 43d Wing on 20 February 1948. The plane was flown from Seattle, Washington, by a 43d Wing crew, who had been checked out in the B-50 aircraft at Eglin Field, Fla.

of all special tools and equipment had reached the wing, much time and many manhours were lost in getting any work done. In late 1948, the overall situation was getting worse.

Other Early Problems 1948–1949

Because of its atomic bombing mission, the 43d Bombardment Wing was accorded various prerogatives: war-strength manning was one of them.[18] The percentage of effective manning was 97.8 percent for officers and airmen by the end of 1948. In addition, the wing's personnel overages could not be used to fill lower priority requirements which ensured that, once the wing acquired its full complement of aircraft and was brought to complete war strength, such personnel would take over the additional assignments. Meanwhile, however, the wing was particularly short of electronics, air control, and photo interpretation officers. Among the airmen, there were shortages of airplane electrical mechanics, airplane and engine electrical accessories repairmen, and camera technicians.

As early as February 1948, 3 Boeing representatives had come to Davis-Monthan and organized classes to teach personnel how to service in-coming B-50As. Operation of a B-50 Mobile Training Unit had actually started in March—regular squadron maintenance slowing down appreciably in the months that followed because of the time maintenance crews had to devote to learning how to take care of the new aircraft. Also, in keeping with the global concept of the upgraded atomic forces, the maintenance of aircraft operating in extreme cold weather had received major attention from the start. Much time was therefore spent preparing and sometimes slightly modifying the aircraft before they left the United States for less clement environments. Also time-consuming was the training of personnel this preparation entailed.

As extensive as these preparations were, the rotation of B-50 bombers overseas, initiated in November with the deployment of 5 aircraft, disclosed unsuspected problems. Once in Alaska, 1 of the B-50As crashed, the other 4 being grounded until the cause of the crash was determined. Although no definite conclusions were reached, the congealing of oil in the small-sized tubing of the aircraft's manifold pressure regulator appeared to be the correct assumption, and modified regulators, successfully tested by AMC,

[18] The same privilege was given to the 509th Bombardment Wing, entirely equipped with B-29s, but remained meaningless throughout the forties, because the Air Force did not have any extra personnel resources. Hence, the 509th had to function with a limited peacetime manning until additional qualified manpower could be provided.

were installed in all B–50s. Also, in keeping with the usual vicissitudes accompanying the introduction of any new aircraft, the B–50As soon exhibited engine malfunctions. In addition, faulty constant speed drive alternators significantly increased the heavy workload of maintenance crews. But progress was made, and the B–50A's performance steadily improved during 1949.

Special Training 1948–1950

Although generally satisfied with the B–50A's initial improvements, SAC knew that forthcoming modifications, program changes, and the reconfigurations usually dictated by such changes, would create new difficulties. These problems could become insurmountable if skilled personnel remained at a premium. The command, therefore, in early 1948 began to plan an extensive cross-training program.[19] As established, the program required that all bombardiers be trained as radar operators, while all radar operators were to master the difficult bombardment skill. Moreover, all pilots were to be trained as loran operators; all navigators, as radar operators; all co-pilots, as flight engineers; all flight engineers, as crew chiefs, and all crew chiefs, as assistant flight engineers.

"Precision bombing" also occupied a place in the overall training program outlined by the Strategic Air Command. In the late forties, because of the limited supply of atomic bombs, "precision bombing" was scrutinized by the highest Air Force authorities. In July 1948, as the SAC training program was just beginning to take shape, the Air Staff underlined the importance of "precision bombing" by pointing out that ". . . each bomb must be employed as though we had a rifle with but one (1) cartridge per man and very few men, thereby placing all the emphasis on the single 'shot' where decisive results will be dependent upon the accuracy with which these few 'shots' are placed." Even though the supply of bombs increased as time passed, the Air Force continued to emphasize bombing accuracy.

Old and New Deficiencies 1948–1950

In November 1948, as a few B–50As were already available and an all out effort was being made to upgrade SAC's atomic striking power, Lt. Gen.

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[19] The cross-training program included many pre-World War II practices, some of which were poorly received by SAC's rated personnel. Hence, as finally established, the program proved to be of short duration.

Curtis E. LeMay, in charge of the command since October, took a dim view of the overall program.[20] "I am shocked," he wrote to Gen. Hoyt S. Vandenberg,[21] "by the deficiencies of air bases and forward airfields earmarked for the new forces . . . . as we are responsible for dropping the atomic bomb, I maintain that to be unable to dispatch aircraft into and out of these fields at night during marginal weather is ridiculous." Most places, General LeMay pointed out, were without even elementary operational facilities such as suitable control towers, radio aids, night lighting, crash and fire fighting equipment, and the like. In short, regardless of the severe shortages of funds, a minimum of construction money had to be found, and this project was to receive top priority until more permanent improvements could be made. Closely related to the necessary upgrading of the special bases was the development of standardized procedures to prevent the disaster of an accidental atomic detonation. The SAC Commander's demands could not all be satisfied with dispatch, but progress was made in all cases. And of primary importance, the achievements realized did sustain the test of time.[22]

Meanwhile, as base facilities were being improved and strict safety procedures were devised, new problems began to plague the B-50As. At the end of 1949, the planes were prohibited from flying above 20,000 feet, because of turbosupercharger deficiencies. Then, cracking of the metal skin on the trailing edge of the wings and flaps dictated unexpected modifications. Later on, failure of the rudder hinge bearing caused the temporary grounding of every B-50A. To complicate matters, while these problems were being worked out, new requirements were levied on the aircraft.

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[20] In the process, SAC's new Commander did not overlook some of the cross-training program's weaknesses. While retaining several of the pre-war practices, General LeMay focused his attention on the morale problem within SAC and made training more realistic and worthwhile. In order to familiarize personnel with operating conditions outside the United States, SAC units were deployed on a rotational schedule for limited periods of time to selected oversea bases. Accuracy of high altitude bombing was substantially improved. Combat crew proficiency was raised through the system of "lead-crew" training which had proved so successful during World War II. In 1949, a lead-crew school was established at Walker AFB, New Mexico. Being a lead-crew member enhanced promotion chances and, in later years, became the basis for immediate advancement to higher rank.

[21] General Vandenberg succeeded Gen. Carl Spaatz as USAF Chief of Staff on 30 April 1948.

[22] SAC's nuclear safety record, based on procedures promoted by General LeMay, remained remarkably good in view of the difficulties associated with any type of atomic operations. Nevertheless, accidents occurred. One, in January 1966, when 2 aircraft collided and crashed near Palomares, Spain, generated a great deal of adverse publicity. (See B-52, p 279).

Additional Modifications 1949-1953

Despite its substantial cost—$35.5 million—the modification ordered by the Joint Chiefs of Staff in January 1948 turned out to be a mere preamble. Growing international tension heightened the urgency of the whole endeavor. Hence, on 16 October 1948, the Air Staff directed a new round of special modifications for 1949.[23] Once again, the Air Materiel Command was instructed to give the highest priority to the project, a priority that even the outbreak of the Korean War would not affect.

Even though the entire modification project was carefully outlined, changes occurred. At first, 15 B-50As that did not have air refueling capability were to be fitted with receivers and other necessary equipment. A directive in early 1949 changed this in favor of equipping these 15, plus 5 more B-50A atomic carriers, for a reconnaissance role. As foreseen, this was about the extent of the B-50A's involvement in the second portion of the atomic project. Additional modifications were reserved for subsequent versions of the B-50As and for different aircraft—mostly B-29s, but also some C-97 transports, and new B-36Bs. Later on, however, as the B-47 program faltered, new requirements arose that directly affected the B-50As.

In January 1952, Sacramento area teams began working on the B-50As to allow 50 of them to carry 2 new types of atomic bombs, and Boeing undertook the preparation of the necessary kits. But the B-47's shortcomings created workloads of staggering proportions for both the Air Force and the contractor. For example, 180 additional B-29s left from World War II had to be reactivated and modified for the atomic task.[24] Although Boeing

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[23] The Air Staff passed on its requirements to the Air Materiel Command, which also dealt with the various contractors, but the highest governmental levels were again involved. In fact, in fiscal year 1949 the President personally approved the release of $35 million (the sum had nothing to do with the $35.5 million previously spent and was added to the only $2 million so far available) to carry the Joint Chiefs of Staff's atomic modification project one step farther. Nevertheless, the Air Force was not a mere agent; its responsibilities kept on growing as the complexities of the modifications increased. The Air Force's task acquired a new dimension in mid-1948, when its resources were needed for the Berlin airlift, which was thus in direct competition with the crucial atomic project.

[24] The Air Materiel Area assigned the work of reconditioning and rehabilitating the 180 B-29s to the Grand Central Aircraft Company of Tucson, Arizona. This sudden modernization program proved difficult. The bomb-bay doors of the reactivated aircraft had to be modified to the B-50's pneumatic type. Bombsights, radars (AN/APQ-7s, AN/APQ-13s or -23s, according to availability), and other components had to be added even though, when reconfigured, the 180 B-29s would still be inferior to other B-29 atomic carriers. Upon completion of the contracted modifications, the aircraft went back to AMC, which was still responsible for the installation of all kits. To speed matters, 2 air materiel areas (Sacramento and Oklahoma City) became involved, but new problems arose, Boeing bearing the brunt of most of them. Under the pressures of World War II, the Bell Aircraft Corporation, the Glenn L. Martin Company, and other contractors besides Boeing, each had been involved in the

was placed on a 24-hour day, 7-day week schedule to supply B-50A and B-29 kits, established deadlines could not be met. The modifications to the B-50As, due to be completed in May, slipped several months. Still, the last B-50A, a straggler, was finished before November 1952.

End of Production — January 1949

Production of the B-50A ended in January 1949 with delivery of the last 3 aircraft.

Total B-50As Accepted — 79

The Air Force accepted a total of 79 B-50As within a 16-month period.

Acceptance Rates

The Air Force accepted 30 B-50As in FY 48 (starting in October 1947 and ending in June 1948), and 49 B-50As in FY 49 (from July 1948 through January 1949).

Flyaway Cost Per Production Aircraft — $1.14 million

The B-50A's unit cost was set at $1,144,296—airframe, $684,894; engines (installed), $193,503; propellers, $65,496; electronics, $71,369; ordnance, $5,524; armament (and others), $123,060. Except for the program's last model, the TB-50H, every B/RB-50 version was assigned the same price tag.[25]

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fabrication of the aircraft. The 180 B-29s therefore differed from each other in various respects, which meant that special kits had to be developed to fit every configuration. Boeing's difficulties snowballed as each kind of kit required separate prototyping and separate engineering approval. In the long run, slippages in kit deliveries postponed completion of the new B-29 project to the fall of 1953, a 6-month delay.

[25] The identical unit price of most B-50s represented an average reached regardless of contractor or fiscal year procurement. This average unit cost did not include the engineering change and modification costs incurred after approval of a basic contract. The Air Force often endorsed such price formulae because of the fluctuations of costs and cost arrangements during the production period of many programs, aircraft, missiles, and other weapon systems alike.

Subsequent Model Series — B/RB-50B

Other Configurations — TB-50A

As indicated by the prefix letter T, the TB-50As were B-50As that had been modified as bombing-navigation trainers. Eleven B-50As, equipped with the hose-type inflight refueling system, underwent such conversion, and were primarily used for training crews of the B-36, even though this aircraft could not be refueled in the air. Like most B-50s, the redesignated TB-50As, after undergoing further modifications,[26] ended their service life as KB-50J tankers.

Phaseout — 1954-1964

The B-50As began phasing out of SAC in mid-1954, when the 93d Bombardment Wing started receiving eagerly awaited B-47s. But retirement from SAC did not mean that the B-50A's operational life was over. Under one designation or another, many of the B-50 aircraft remained in the Air Force's active inventory for about another decade.[27]

Milestones — 2 March 1949

On 2 March, Lucky Lady II,[28] a B-50A (Serial No. 46-010) of the 43d Bomb Group, completed the first nonstop round-the-world flight, having covered 23,452 miles in 94 hours and 1 minute. Carswell AFB, Texas, was the point of departure and return. Lucky Lady II was refueled 4 times in the air (over the Azores, Saudi Arabia, the Philippines, and Hawaii) by KB-29 tankers of the 43d Air Refueling Squadron.[29] For this flight, the B-50A crew

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[26] A difficult modification since the aircraft had to be stripped of all armament (tail guns excepted), and large single tanks had to be installed in the bomb bay.

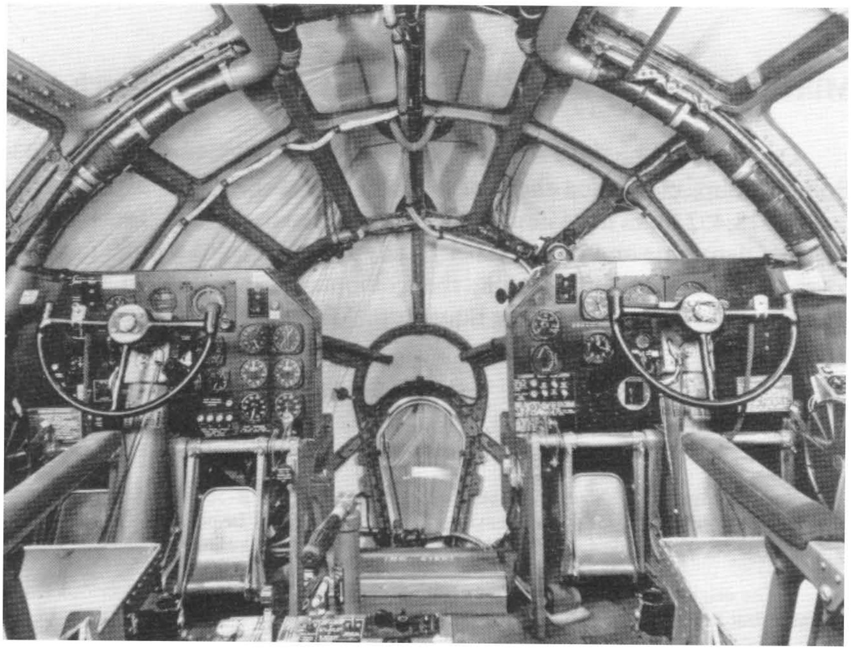
[27] Available records showed that once released by SAC, 134 B-50s were modified for the tanker role. Some of these aircraft remained in the operational inventory until 1964; other B-50s, after reconfiguration, served the Air Weather Service until almost the end of 1965.

[28] The original Lucky Lady was a wartime B-29, which participated the previous year in a similar but unsuccessful round-the-world flight.

[29] The 43d and 509th Air Refueling Squadrons were the first air refueling units in the United States Air Force. Beginning in late 1948, the 2 squadrons were equipped with World War

of 14, commanded by Capt. James Gallagher, received numerous awards and decorations. Foremost among these were the Mackay Trophy, given annually by the National Aeronautic Association for the outstanding flight of the year, and the Air Age Trophy, an Air Force Association award given each year in recognition of the air age. The Air Age Trophy was later renamed the Hoyt S. Vandenberg Trophy in honor of the second U.S. Air Force Chief of Staff.

II B-29s that had been modified to carry and dispense fuel in the air through the use of trailing hoses and grapnel hooks, a refueling system developed by the British. These modified B-29s were known as KB-29M tankers.



Pilot and co-pilot stations in a Boeing B-50.

B/RB-50B

Manufacturer's Model 345-2

Previous Model Series B-50A

New Features

An increase in gross weight, from 168,480 to 170,400 pounds, a new type of fuel cell, and a few minor improvements were the basic differences between the B-50B and the preceding B-50A. The B-50B, however, was immediately reconfigured for the reconnaissance role. In this capacity, the RB-50B featured 4 camera stations (numbering a total of 9 cameras), weather reconnaissance instruments, and extra crew members housed in a capsule that was located in the aircraft's rear bomb bay. In addition, the RB-50B carried fittings for two 700-U.S. gallon underwing fuel tanks.

Planning Changes 1948-1949

The Air Force had planned to use its next lot of 45 B-50s as atomic carriers. It also expected that the forthcoming aircraft, identified as B-50Bs, would be capable of carrying both the Mark 3 and Mark 4 bombs.[30] However, neither plans nor expectations materialized. Indeed, besides the 45 non-atomic capable B-50Bs, 35 subsequent B-50 models would also fail to incorporate from the start the B-50A's initial post-production improvements. Meanwhile, the older RB-29's deficiencies in speed, range, and altitude prompted the Air Force to endorse the immediate reconfiguration of its 45 new B-50Bs. The decision did not reflect the Air Force's preferences. Ideally, reconnaissance aircraft should be superior in performance to the bomber type dependent upon their information. But limited funds had not permitted the development of such a specialized aircraft, and the proposed

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[30] The 81st B-50 was to be the starting point for the necessary production line modifications. (The first 79 B-50s were B-50As; the 80th B-50 was set aside and used as a prototype.)

RB-36B remained a long way off. Acquisition of the RB-50B, therefore, appeared to be the best as well as the only alternative. Although all 45 aircraft were re-fitted for the reconnaissance role, the Air Force's financial ledgers kept on carrying the planes as B-50Bs.

First Flight — January 1949

The first B-50B, initially flown early in January 1949, was accepted by the Air Force on the 18th. Within a short period, 14 B-50Bs were delivered to SAC, the first of the 14 being received by the command on 31 January. This aircraft (Serial No. 47-119) was immediately sent to the Boeing Wichita plant for modification as reconnaissance aircraft, marking the beginning of the B-50B fleet's reconfiguration.

Reconfiguration Task — 1949-1951

Adapting the B-50B to the reconnaissance role became a fairly involved project for a number of reasons. At first, the Air Force thought of exempting 15 B-50Bs from the proposed modifications. Then, because of new requirements, the Air Force decided to reconfigure all the B-50Bs and further, to fit them for a variety of reconnaissance purposes. Eventually, 3 different types of reconnaissance B-50Bs came into being. Although identified from the start as RB-50Es, RB-50Fs, and RB-50Gs, the reconfigured B-50Bs were not formally redesignated until 16 April 1951.

The RB-50E, first of the 3 types, was returned from the Wichita plant in May 1950. The Air Force acquired 14 RB-50Es, all of them in just a few months. Earmarked for photographic reconnaissance and observation missions, the RB-50E normally required a crew of 10. According to the type of mission being flown, the left-side gunner served as weather observer, or as in-flight refueling operator. When at this station, at altitudes above 10,000 feet, the left gunner had to use oxygen and wear heated clothing. As in the case of the original B-29,[31] compartments for the other crew members were pressurized and featured heating and ventilating equipment. The RB-50E's defensive armament, like that of other B-50 models, also dated back to the B-29. The only difference was that the number of .50 caliber machine guns had been increased from 10 to 13, all of which were still housed in 5

[31] The B-29 was the first military aircraft in the world to have pressurized compartments for all members of the crew, including the tail gunner.

electrically operated turrets. The turrets were controlled remotely from the sighting stations.

The RB-50F, the second reconfigured version, was returned from Wichita in July 1950. The Air Force received 14 RB-50Fs, Boeing completing the required modifications in January 1951. The RB-50F closely resembled the RB-50E, but was equipped with the Shoran[32] radar system for the specific purpose of conducting mapping, charting, and geodetic surveys. However, the Shoran radar prevented the RB-50F from making use of its defensive armament, which was identical to that of the RB-50E. To give the weapon system additional versatility, the Shoran radar and associated components were housed in removable kits. Deletion of the kits and a simple adjustment restored the RB-50F's defensive power. Therefore, if needed, the 2 aircraft types could be used for the same basic reconnaissance missions.

The RB-50G, the third and last reconnaissance version derived from the B-50B, entered SAC's inventory between June and October 1951. The 15 reconfigured aircraft (Manufacturer's Model 345-30-25) differed significantly from the RB-50E and RB-50F. Electronic reconnaissance was the principal mission of the RB-50G. The aircraft featured 6 electronic countermeasures stations, an addition which had necessitated a number of internal structural changes. Some external modifications had also been necessary to accommodate the radomes and antennae of the aircraft's new radar equipment. Finally, during the reconfiguration process, the 16-crew member RB-50G had been fitted with the improved nose of the B-50D, the production model which actually followed the B-50B. In contrast to the RB-50F, the RB-50G could use its defensive armament while operating its new radars and electronic countermeasures equipment.

Other Modifications 1949–1950

Reconfiguration of the RB-50s did not necessarily eliminate some of the B-model's flaws. As a result, several modifications were accomplished either before, during, or after the basic aircraft had been adapted to the reconnaissance role. Problems of various importance were identified,[33]

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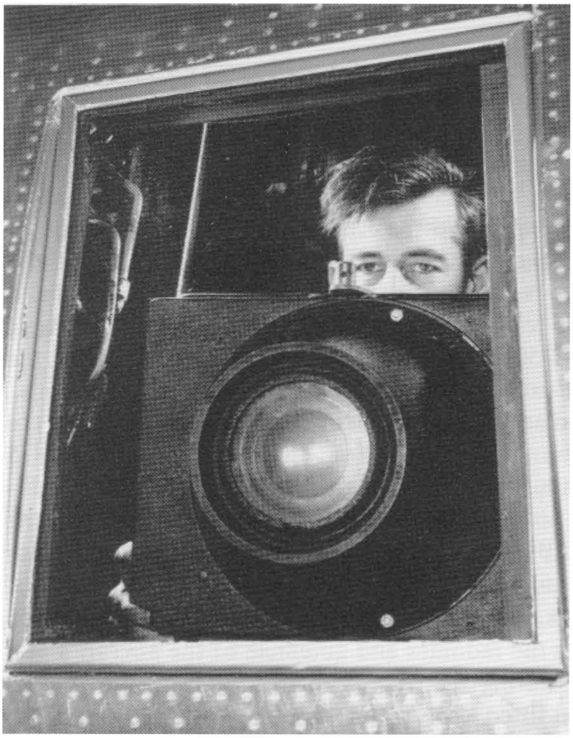
[32] Shoran was originally developed as a *Short Range Navigational* aid to bombing to enable a bomber to strike its target when the target was not visible from the aircraft. This method, first applied in a primitive fashion during World War II, proved very effective within certain limitations. These parameters were primarily the restricted range of the electronic signal from aircraft to ground and return, and later on the frequent lack of a single geodetic survey control system in the region containing the Shoran ground station sites and the targets.

[33] All of the B/RB-50B shortcomings were retained by the subsequent B-50D, and the same corrective measures were applied to this later model.



Looking in a port of a reconfigured RB-50B, one could see the lens cone of a hand-operated reconnaissance camera. This aircraft featured 9 such camera stations.

some of them as soon as the aircraft reentered the Boeing plant. Leaks from fuel cells were an unexpected dilemma—probably attributable to the aircraft's thin, light-weight fuel cells.[34] The B-50A, equipped with heavyweight fuel cells, had not encountered such difficulties. While AMC wrestled with the problem, interim measures were taken, including the tightening of cell interconnect bolts and replacement of defective tanks. In October, instead of improving, the fuel cell problem became worse, "a considerable increase in fuel tanks leaks [being] attributed to the arrival of cool weather." By year's end, AMC decided to replace the defective cells of the B-50B and all subsequent B-50s with a new type of fuel cell, as soon as it became available.[35] Meanwhile, there were other problems. Like the previous B-50As, the new aircraft experienced fuel tank overflows, leaks in

[34] The main fuel cells in the B-50 were located within the wing. Looking forward from the pilot's position there were as many as 17 cells to the left and the same number to his right. On most models only 11 cells were utilized in the right wing and 11 in the left wing.

[35] The B-50D deliveries were actually stopped, pending availability of the new fuel cells.

fuel check valves, failures of the engine turbochargers, warped turbos and warped turbo bucket wheels, generator defects, and the like. In addition, since all B-50 airframes were basically alike, the B/RB-50s shared the B-50A's trailing wing problems. This was not a new experience. Several years before, cracks had also appeared in the metal skin at both forward and trailing edge of the upper side of the B-29's wing assembly. In all cases, stress beyond metal strength had been the most probable cause.[36] The permanent solution, finally endorsed in 1949, was to use heavier metal in the fabrication of future wing flaps. This was a simple enough solution, but not quickly implemented.

Program Reduction 1949

Cancellation of the B-50 program was not seriously considered before the aircraft entered the inventory in substantial numbers, but the program was drastically altered in 1949. An early B-50A, set aside to serve as prototype for the model due to follow the B-50B, did not fare well. Initially known as the YB-50C, this aircraft was expected to feature a longer fuselage, a single bomb bay, larger wings, and 4 new R-4360-43 turbo-compound engines.[37] The YB-50C's take-off weight was tentatively set at 207,000 pounds, a significant 50,000-pound increase over the weight of most B-50 models. By November 1948, the B-50C mockup had been completed, inspection of the prototype was scheduled for May 1949, and 43 production aircraft (14 B-50C and 29 RB-50Cs) were already on order. In late 1948, because of the many changes embodied in its design, the future B-50C became the B-54, the original quantity of aircraft under contract remaining unchanged.[38] The new designation, however, did not help the aircraft's prospects.

President Truman's curtailment of the fiscal year 1949 defense budget forced the Air Force to make some difficult adjustments. While the B-54's high price was known, the cost effectiveness of the aircraft was not clear. Yet for good reasons, neither Secretary of the Air Force W. Stuart Symington nor General Vandenberg wished to give up the new aircraft. No B-54s had been produced, but work was underway by the manufacturer and sub-

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[36] Responsible for 2 recent B-50A accidents.

[37] The Pratt & Whitney development was usually referred to as the VDT (variable discharge turbine) engine (for details, see B-36, pp 14-15 and p 19).

[38] In addition, the next two annual procurement programs provided for 43 and 58 other B/RB-54s, respectively.

contractors. Therefore, the program's cancellation would entail some financial loss and disturb the industry. On the other hand, certain facts could not be overlooked. Whether known as B-50C or B-54, the aircraft had no growth potential; its design represented Boeing's effort to extract the last ounce of performance out of the final development of the basic B-29. Actually, the B-54 configuration provided an undesirable outrigger landing gear requiring wider taxiways than existed at operating bases; jet engines could not be added without designing entirely new wings; and the new K-1 bombing system could not be installed without sacrificing a belly turret or without a drastic alteration of the aircraft's fuselage. Finally, and of great importance, General LeMay[39] wanted no part of the B-54.

On 21 February 1949, while appearing before the Board of Senior Officers,[40] General LeMay again strongly reiterated that the B-54 program should be canceled in favor of additional B-36s, since development of the B-36 with jet pods indicated superior performance in speed, altitude, and range. Pending quantity production of the B-52, the SAC Commander stated, the B-36 provided the best capability to carry out his command's primary mission, a mission vital to national security.

Although Secretary Symington and General Vandenberg did not question General LeMay's expertise, both remained reluctant to terminate the procurement of the B-54. The crux of the problem was that canceling the B-54s and getting more B-36s would alter the medium/heavy bomber group-combination, included in the program recently approved by the Joint Chiefs of Staff. As an alternative, Secretary Symington then suggested substituting less costly B-50s for the B-54s. But the SAC Commander quickly pointed out that the substitution, even if acceptable on the basis of economy, would still be a very bad solution. Instead, General LeMay testified, if all programmed B-54s could not be replaced by B-36s, the best course of action would be to secure extra B-47s, as soon as possible. After weighing and balancing all factors involved, the Board of Senior Officers concluded that production of the B-47 should be accelerated and additional B-36s bought. The board's recommendations were approved by Mr. Symington and General Vandenberg in April 1949, marking the end of the B-54 program.

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[39] General LeMay was promoted to full general on 29 October 1951.

[40] The board's members, convened to review the composition of the 48-Group Program imposed by President Truman's budgetary restrictions, included Gen. Muir S. Fairchild, Vice Chief of Staff, Gen. Joseph T. McNarney, Commanding General of the Air Materiel Command, Lt. Gen. H. A. Craig, Deputy Chief of Staff for Materiel, and Lt. Gen. Lauris Norstad, Deputy Chief of Staff for Plans and Operations.

End of Production 1949

The B-50B production ended in April 1949, with the delivery of 7 aircraft.

Total B-50Bs Accepted 45

The Air Force accepted its 45 B-50Bs within a period of 4 months. All but 1 of the 45 aircraft became RB-50s.

Acceptance Rates

The Air Force accepted 9 B-50Bs in January 1949, 14 in February, 15 in March, and the last 7 in April.

Flyaway Cost Per Production Aircraft 1.14 Million

Like the B-50A, the B-50B's unit cost was averaged at $1,144,296. This amount did not include reconfiguration costs, estimated in September 1948 at $217,000 per aircraft.

Subsequent Model Series B-50D

Other Configurations EB-50B

One of the first B-50Bs accepted by the Air Force was immediately returned to Boeing, where it was flown experimentally with a track-type nose and main landing gear. As indicated by its "E" designation, the aircraft was also equipped with various electronic devices, while on loan from the Air Force.

Phaseout 1954

The RB-50s began leaving SAC's operational inventory in 1954, when modern but still troublesome RB-47s finally became available. SAC had 40 RB-50s in 1951, a peak total reduced to 12 in 1954 and 1955, with the last aircraft leaving the command in December 1956. However, in contrast to the B-50A, phaseout from SAC did not signify the end of the RB-50's primary role. In 1954, although reassigned from the command, several RB-50s, their Shoran equipment greatly improved,[41] still performed photo-mapping missions; in 1957, a few RB-50Es and RB-50Gs continued to be utilized by the Air Force Security Service. However, these were exceptional cases, and the RB-50's primary career came to a close before the end of the decade.

[41] The initial Shoran had been refined and had become known as the Hiran, an abbreviation for *Hi*gh Precision Sho*ran*.

B-50D

Manufacturer's Model 345-9-6

Previous Model Series B-50B

New Features

Externally, the B-50D differed from the B-50A and B-50B only in that it had an all-plastic nose and provisions for droppable wing tanks. Otherwise, the B-50D bomber greatly resembled the B-50A.[42] A different type of equipment for in-flight refueling, larger fuel capacity, more efficient radar, fewer crew members (10 instead of 11, and sometimes only 8), plus other minor improvements completed the list of changes separating the 2 bombers.

First Flight May 1949

Initially flown in May 1949, the first B-50D was accepted by the Air Force on 14 June. Deliveries to SAC began 10 days later, with the arrival of 1 B-50D (Serial No. 47-167).

Enters Operational Service Mid-1949

The B-50Ds entered operational service with SAC in mid-1949, but within 3 months the new planes presented so many major maintenance problems that the command decided to refuse further deliveries and to return those B-50Ds presently assigned whenever possible to the Air Materiel Command. Some 50 B-50Ds were involved, most of which were grounded for extended periods of time during the remainder of 1949 and the first 6 months of 1950, because their main fuel cells, inverters, turbosuper-

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[42] The B-50D's actual predecessor was the B-50B. In practice, since the B-50B was immediately reconfigured for the reconnaissance role, the 2 aircraft could not be compared.

chargers, alternators, generators, and even wing trailing edges carried flaws of one kind or another. As was usually the case, these problems were resolved, but the solution took time, a commodity the Air Force could then ill afford.

Other Initial Shortcomings 1949–1950

Disappointingly, most B–50Ds came out of production without the "receiver-end" of the new flying boom air-to-air refueling system then being developed by Boeing. Yet, adoption of a refueling system had been planned all along.[43] The experimental refueling program, approved by the end of 1947, provided for modification of a prototype tanker and bomber-receiver which, once satisfactorily tested, would be rushed to SAC for the training of crews. Refueling in the air had been carried out as early as 1923, but only the Flight Refueling, Ltd., a British company formed in the 1930s, was manufacturing the necessary equipment. The Air Force in March 1948 had given Flight Refueling a contract to supply 40 complete sets of tanker-bomber refueling equipment, together with technical assistance by British engineers, necessary tools, and installation drawings.[44] The Air Force was willing to pay a high price—in excess of $1.2 million—for a temporary solution to the air refueling problem. Despite the British system's merits and potential for improvement, the Air Force expected that it would soon be supplanted by the Boeing type, which primarily consisted of substituting a mechanical boom for the hose of the British contraption. Boeing's progress however was slower than anticipated. As a result, neither the "receiver-end" nor the feeding apparatus of the new equipment could possibly be installed during the production of a majority of

[43] The Air Force was well aware that the Strategic Air Command's entire atomic capability would rest in the short-range B-29 and B-50 medium bombers until the intercontinental B-36 entered the inventory. This meant, for a few years at least, dependence on carefully selected overseas bases. It also underlined the urgency of the air refueling program. And even though the B-36 was finally considered fully operational in 1951, the number of available aircraft was often limited since the new intercontinental bombers were constantly involved in some of the special atomic project's many modifications. In any case, be it in support of atomic, conventional, or other Air Force missions, air refueling remained a vital capability and top Air Force priority.

[44] The first installation of the British system, employing hose connections and gravity feed, was completed in May 1948. Flight-testing prompted a few modifications, but by September 24 B–29s had been modified, 12 as tankers and 12 as receiver aircraft, and were delivered to SAC. The British hose system permitted the transfer of 2,600 gallons of fuel at a rate of 90 to 100 gallons per minute, thus increasing the receiver aircraft's combat radius by perhaps as much as 40 percent. Still unsatisfied, the Air Materiel Command was already working on the development of a force feed technique to increase the flow of fuel to 200 gallons per minute.

A Strategic Air Command crew was briefed before a mission in a B-50D bomber.

the B-50Ds.[45] This led to several retrofits. The most urgent one entailed giving the aircraft the necessary receivers, since the B-50Ds would serve as atomic carriers until replaced by the B-47s.

Atomic Modifications 1949-1951

As pointed out by the Air Staff in late 1948, the urgency of the second phase of atomic modifications could not be overstated. Many of the additional requirements were specifically addressed to the new B-50Ds. However, the aircraft's participation in the special atomic project started poorly. First, the B-50D deliveries did not begin on time, delaying signifi-

[45] Slippage of the flying boom air-to-air refueling system altered many plans. Forty of 92 B-29s, earmarked for the tanker role, were to receive the new system but were fitted with the British hose type instead. All 92 aircraft were designated KB-29Ms. A later directive of the large-scale atomic project assigned another 116 B-29s, withdrawn from storage, to the refueling task. This time, the aircraft were fitted with the American system, but Boeing did not start the modification before August 1950 and only completed it in 1951. These aircraft, identified as KB-29Ps, were mainly used to air-refuel the B-50D atomic carriers. Soon afterward, Boeing undertook to bring another 185 reactivated B-29s to the KB-29P configuration.

cantly the aircraft's post-production modifications. Then, in addition to their imperfections and because of a misunderstanding between Boeing and the Air Force, the first B–50Ds delivered to SAC had not been adapted on the production line to carry both the Mark 3 and Mark 4 bombs,[46] a production feature of all subsequent B–50Ds. This serious omission created more work and delays, because Boeing had to prepare special kits[47] to be installed by personnel of the 93d and 509th Bombardment Wings, the new aircraft's first recipients.

Meanwhile, incredibly rapid technological developments were beginning to complicate the exacting atomic project requirements of January 1948. On the surface, converting a bomber aircraft to an atomic weapon carrier appeared simple. The basic components needed were relatively few in number. The installation consisted of a shackle or bomb rack capable of suspending and releasing the bomb, sway braces to hold the bomb in place during flight, and a limited number of pieces of equipment bracketed to the airplane and connected by cable to the bomb mechanism. Included were arming controls, the capsule insertion gear, and the T-boxes[48] that controlled, tested, and monitored the bomb. In addition, a pair of hoists, attached to the bomb-bay frame lifted the bomb into place. Ironically, the "simple" conversion proved difficult for several reasons. First, the B–50 was a development of the B–29, an aircraft never intended to carry an atomic payload. The B–29/B–50 bomb bay was too small to house the required components and new bombs. Procurement and development of the B–50 occurred in an era when in-house secrecy almost totally enshrouded spectacular atomic advances. The rapid development of more efficient bombs created additional problems, since every single new type of bomb required that associated components be relocated within the narrow confines of the B–29 and B–50 bomb bay.

Faced with uninterrupted modification crises, the Air Force in March 1950 issued military characteristics for the development of a so-called "universal system," which could hoist, suspend, and release most types of atomic weapons and be easily fitted in the bomb bay of all atomic carriers.

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[46] The Mark 3 was first available in 1948; the Mark 4, in mid-1949.

[47] These kits, called the "auxiliary bombing system," only were to be installed "when and if needed." This qualification, however, did not reduce SAC's extra workload, since field personnel still had to learn how to install the kits.

[48] The T-boxes housed specialized electronics components used for the monitoring, control, and testing of the circuits and equipment that played a role in the atomic operation. As a rule, a T-box (also popularly known as "Black-box" because of the black-color) denotes any unit, as a bombsight, robot pilot, or piece of electronic equipment that may be put into, or removed from, a radar set, an aircraft, or the like, as a single package. Such units are used for ready maintenance.

After many conferences, the requirements were revised, scaled down, and finally dropped in the B-29 and B-50's cases, again because the bomb bay of those aircraft did not provide the necessary space.[49] In the same year, as the new Mark 4 bombs became plentiful, the Air Force ascertained that these bombs, although more efficient than the preceding Mark 3s,[50] were not very satisfactory. Instead the Air Force believed in the necessity of developing a faster-detonating, lighter, safer, and easier-to-handle bomb. From then on, events moved swiftly, with not one, but several new types of bombs entering the atomic stockpile before 1953.[51]

Acquiring several new types of bombs presented a significant advantage for the Air Force, however, ensuring that the bombs could be handled efficiently was a challenge of great magnitude. Tremendous problems soon emerged. First, it appeared that adapting 1 squadron of B-50Ds (15 aircraft) to carry the most advanced of the new bombs would be impossible without destroying the aircraft's capability to handle other types of atomic bombs.[52] Then, the urgent modification of 180 B-50Ds (and 69 B-29s) to prepare these aircraft for the bomb that immediately followed the Mark 4, acquired top priority. A third new type of bomb, fully available before delivery of the most advanced one, also called for prompt and difficult modifications. Finally, and perhaps fortunately, a fourth new type was eliminated from consideration in the B-29 and B-50 bombers, because the bomb was too long to be fitted in the short bomb bay of these aircraft. Meanwhile, the B-50D's many modifications were further complicated by the on-going installation of an improved bombing-navigation radar system, the AN/APQ-24.[53]

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[49] First installed in the large bomb bay of a B-36 in March 1952, the universal system became a standard feature of the intercontinental bombers. The installation of a fairly similar configuration of the system was seriously contemplated for the B-47, but did not materialize.

[50] The Mark 3s were all phased out by early 1951.

[51] Improved versions of those new bombs became available in 1954 and 1955, by which time better coordination between the Air Force and the Atomic Energy Commission had minimized the physical changes required for aircraft to carry new type bombs. And later on, as thermonuclear weapons came into being, the costly chore of transforming bombers into atomic carriers was eliminated.

[52] In June 1951, the Air Staff endorsed SAC's request to extend the new requirement to 16 B-47Bs and 12 B-36Ds. The Air Staff also directed that if the new bombs could not be carried by the aircraft without hampering their other capabilities, then specifically designed kits would be delivered to SAC, so that the command would be prepared either way. Modification of the 15 B-50Ds, or development of the necessary kits, would retain precedence over any similar work for the B-47s and B-36s.

[53] The B-36B was the first recipient of the new AN/APQ-24 and this radar was not authorized for other B-50 bombers or for the older B-29s, which retained the Norden optical sights. In any case, the APQ-24 also proved to be unsatisfactory because of lack of security, high rate of malfunction, and inadaptability during bad weather.

Completion and Appraisal 1952–1953

Adaptation of the B–50D to the atomic carrier role followed the B–50A's pattern. Boeing worked overtime, extra AMC teams were deployed to the SAC bases, and special care was exercised to make sure that SAC's overall atomic capability was not severely strained by the incessant modifications.[54] For example, only the first 4 aircraft of every B–50D wing were modified to carry the most sophisticated atomic bomb of the period, and the modifications,[55] started in January 1952, were completed in May. Similarly, the adaptation of 180 B–50Ds, to accommodate the Mark 4's immediate successor, was carefully scheduled, 4 groups of 45 aircraft undergoing changes at different times. There were some occasional schedule overlaps and several serious delays. Boeing modification of 80 B–50Ds in late 1951 slipped several months, and another B–50D modification, due to be completed by June 1952, was delayed for lack of the necessary kits. In some instances, however, the bombers' modifications were so successfully organized that the B–50Ds were able to handle a new type of bomb as soon as it became readily available.

In March 1953, several months after new requirements had been formulated, the Mark 4 bombs were removed from the atomic stockpile. By late 1953, just as the modifications prompted by the new requirements were being completed, SAC began to replace some of its B–29 and B–50 bombers with new B–47s. These substitutions had long been planned, although the B–47 deliveries were late. Still, some believed that the long modification lead time had more or less nullified the usefulness of the older B–29 and B–50 aircraft.

Criticism of the atomic modification project was not new. Back in 1951, harrassed AMC personnel complained that the magnitude of the modification task was reaching such proportions that the very existence of the weapons system, through which the atomic bombs were to be employed, was being jeopardized.[56] In June 1951, Maj. P. C. Calhoun, an AMC project officer appearing before the Special Weapons Development Board, expressed the same opinion. "These modifications are necessary," Major Calhoun emphasized, "but if the USAF tactical capability is to be maintained, weapon systems programs must be better planned, better phased,

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[54] The same careful timing was extended to the modification of the B–29, B–36, and subsequent B–47 bombers.

[55] As anticipated by the Air Force, the aircraft ended being fitted with a number of permanent parts (so-called Parts A), and special kits were provided.

[56] In addition to the many modification programs, numerous retrofit programs were necessary to add new or improved equipment or to correct deficiencies in installed equipments.

and better executed." In short, the Air Materiel Command as a whole deplored the atomic project's short deadlines, interim solutions, and costly crash programs. Moreover, in continually "butchering" the bombers lay the danger of seriously impairing their operational characteristics. AMC's criticism was valid, but the Air Force had no easy solutions. Counterbalancing these drawbacks, and perhaps too quickly overlooked, the fact remained that the B-29 and B-50 wings comprised a large portion of SAC's atomic arsenal until the end of 1953, when their conversion to B-47s began.

End of Production 1950

The Air Force acceptance of the last 2 B-50Ds in December 1950 marked the end of the aircraft's production.

Total B-50Ds Accepted 222

The Air Force accepted its 222 B-50Ds over a period of 19 months.

Acceptance Rates

The Air Force accepted 15 B-50Ds in FY 49, all during the month of June 1949; 160 in FY 50; and 47 in FY 51, starting in July 1950 and ending in December. A peak number of B-50Ds, 29 of them, was accepted in FY 50, during the month of December 1949.

Flyaway Cost Per Production Aircraft $1.14 Million

The B-50D carried the unit price tag of the B-50A and B-50B. It was set at $1,144,296.

Subsequent Model Series TB-50H

Other Configurations DB-50D, KB-50, KB-50J, TB-50D, WB-50D

DB-50D—Early in 1951, 1 B-50 was modified as a director aircraft, identified as DB-50D, and used to launch the Bell rocket-powered GAM-63

Rascal missile.[57] By August, Air Force planning provided for the activation, sometime in 1953, of 2 squadrons of Rascal carriers, one of B-36s and another of B-50Ds, the latter squadron being programmed to operate from oversea bases because of the B-50's limited range. Adaptation of the B-50D to the DB-50D configuration was to begin in June 1952, ahead of the B-36 modification. However, Rascal deficiencies, as well as other considerations, altered these plans. The DB-50D continued flight testing the new missile until 1955, but activation of both the DB-50D and DB-36 squadrons was canceled.

KB-50—The Air Force planned all along that a total of 134 B-50s,[58] made up of B-50As, RB-50s, and B-50Ds, when no longer needed by the SAC atomic forces, would be converted to tankers. The proposed aircraft, referred to as KB-50s, would feature extensively reinforced outer wing panels, as well as the necessary equipment to air refuel simultaneously 3 fighter-type aircraft by the probe and drogue method. The modifications, assigned to the Hayes Aircraft Corporation, also included deletion of the B-50's defensive armament and replacement of the basic aircraft's aft tail section. Although the completion date of the Hayes modifications was tentatively set for December 1957, the project (ordered in the mid-fifties) proceeded so well that it was ended ahead of time. A first KB-50 flew in December 1955 and was accepted by the Air Force in January 1956, the tankers from then on steadily entering the operational inventory of the Tactical Air Command (TAC). By November 1957, TAC's KB-29s, which the KB-50s replaced, had all been phased out. By year's end, all of the command's aerial refueling squadrons had their full complement of KB-50s. TAC had nothing but praise for the new tankers. The KB-50s presented no serious problems, and their reliability was such that the command considered asking for more of them. Extra KB-50s would come "cheap," TAC calculated, if additional numbers of B-50s were merely added on to the Hayes modification line. Nevertheless, the recommendation remained in limbo, which was just as well since the modification line had already been closed and the superior KB-50J was on its way.

KB-50J—The Air Force tentatively endorsed the KB-50J program in mid-1956, because it believed the KB-50s of TAC's aerial tanker fleet no longer had both the speed and altitude to refuel modern jet aircraft effectively.[59] The KB-50J, first flown in April 1957, was still powered by 4

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[57] See B-36, pp 46-47.

[58] Some records indicated 136 B-50s were involved, a discrepancy probably due to the fact that 2 B-50s, used as prototypes for the forthcoming reconfigurations, were included in the higher total but excluded from the Air Force's operational accounts.

[59] See B-47, pp 130-131.

Pratt & Whitney R-4360-35 piston radial engines, but featured in addition two 5,200-pound thrust General Electric J47-23 turbojet engines that were installed in pods, suspended from pylons at the former locations of the KB-50's auxiliary wing tanks.

Flight testing of the KB-50J, immediately started in April 1957, was completed in December, with rewarding results. The aircraft had made successful hook-ups and transfers of fuel to several types of tactical aircraft at higher altitudes, greater gross weights, and higher airspeeds than possible with the KB-50. The J-model's slightly shorter refueling range was more than compensated by its superior performance. Its jet engines decreased takeoff distance by 30 percent and the time to climb to refueling altitude by 60 percent. Of utmost importance, in contrast to the KB-50, the KB-50J could maintain satisfactory refueling speeds in level flight at altitudes which did not unduly penalize the receiver aircraft. The Air Force, therefore, decided that a great many KB-50s would be brought to the KB-50J configuration. However, only the most modern KB-50s (former B-50Ds) would be eligible for the retrofit. The first such aircraft, withdrawn from Tactical Air Command's 429th Air Refueling Squadron in September 1957, was modified in 4 months' time and returned to the operating forces on 16 January 1958. Reminiscent of the careful procedure applied to the atomic modifications, the KB-50 retrofit was strictly scheduled to make sure that TAC's refueling capability was not seriously impaired. As the Hayes Aircraft Corporation gained more experience, it took 20 fewer days to modify each of the aircraft, and the retrofit project proceeded smoothly.

The Air Force had over 100 KB-50Js by 1959, but its operational requirements had already begun to change. Hence, TAC quickly pointed out that while the KB-50Js were not expected to present major maintenance or

A GAM-63 Rascal missile was attached to a specially modified DB-50D before firing.

supply problems from the start, the retrofitted aircraft should be considered as "interim" refuelers. Tankers were critical to the successful accomplishment of nonstop overseas deployment of the forces, the command insisted, and the often-modified, 12-year-old KB-50J, despite its many merits, was not a high-performance aircraft. In short, TAC wanted to acquire a contingent of the new KC-135, a Boeing tanker assigned to the Strategic Air Command. Still, budget limitations were a problem. Each KC-135 cost about $3.5 million, while the KB-50J's unit price was set at $1.27 million.[60] Although 2 squadrons of KC-135s were eventually programmed to reach TAC in mid-1953, this planning did not materialize. In 1960, the Air Force announced that SAC would get more KC-135s and would serve as the single Air Force manager for tanker support. The decision was to take effect in late 1964 or early 1965. Meanwhile, TAC would retain its KB-50s.

Contrary to anticipation, the elderly KB-50Js began to deteriorate almost as soon as available. In 1959, TAC had to resort to cannibalization to fix some of the retrofitted tankers because tail hose depressor actuators were not readily available. Late in the year, both the Pacific Air Forces and TAC faced more serious difficulties. The inner liner of the KB-50 fuel cells, all of which had been manufactured in 1949 and 1950, began to crack, allowing self-sealing compound to infiltrate the tanker's fuel system. TAC recommended that the defective heavy, self-sealing fuel cells be replaced with new lightweight, bladder-type cells, but the command was overruled by AMC on the grounds that the cost involved could not be amortized over the remaining useful life of the aircraft. In July 1960, Hayes started exchanging all KB-50 fuel cells for new similar ones or for cells that had been removed from B-50s in storage at Davis-Monthan AFB, Arizona. The exchange proved satisfactory, but TAC encountered other problems. Landing gear malfunctions plagued the aircraft, and all sorts of old-age deficiencies began to develop. As a rule, TAC maintenance personnel had to expend every month more than 2,000 manhours of overtime per squadron in order to meet operational commitments, while by-passing certain items vital to the continued KB-50J use. These neglected tasks, including depot overhaul of quick engine change kits, had been expected to sustain the tankers until their scheduled phaseout was completed. The KB-50 inventory was substantially reduced as the aircraft's retirement became closer. In 1964, a few KB-50s saw action in Southeast Asia, but this proved to be the aircraft's last operational commitment.

TB-50D—As in the B-50A's case, 11 B-50Ds were brought up to the

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[60] This figure included the B-50D's basic cost, leaving some $130,000 for the bomber's adaptation to the KB-50 and KB-50J configurations.

trainer configuration, redesignated TB-50Ds, and used for various support duties, including the training of B-36 crews.

WB-50D—Extensive corrosion of the WB-29s prompted the Air Force to decide in 1953 that some B-50Ds, as they became surplus, would be adapted for the weather role and immediately returned to SAC. There these aircraft accomplished "special weather reconnaissance" missions for the 97th Bomb Wing until April 1955, when all WB-50Ds were earmarked for the Air Weather Service.[61] Meanwhile, a much larger reconfiguration program was also approved. In June 1954, the Air Force confirmed that the weather service's WB-29s would be replaced by modified B-50Ds. The modification contract, assigned to the Lockheed Aircraft Corporation, included 78 B-50Ds and specified a completion deadline of November 1955.

Although the new WB-50Ds would represent only be a partial and temporary solution to the range and altitude problems of the deteriorating

[61] The aircraft's withdrawal from SAC left the command with no special weather reconnaissance capability until the end of the year, when the first RB-47K weather aircraft was delivered.

Two student navigator-bombardier-radar operators aboard a TB-50D trainer aircraft.

WB-29s, the Air Weather Service eagerly awaited the forthcoming aircraft. While deficient in overall performance, the modified planes would feature improved equipment and instrumentation of special importance to the weather mission. The APM-82 Automatic Navigator, for example, was a radar navigation device capable of measuring drift and ground speed under all conditions, except a calm and glassy sea. Also included were the ANQ-7 Temperature Humidity Indicator, the ML-313 Psychometer, improved altimeters, and flight indicators. However, the new equipment proved more difficult to install than anticipated, and Lockheed could not meet established modification schedules. The first modified aircraft, or prototype WB-50D, flew on 20 August 1955, and the first production model was delivered to the Air Weather Service in November, when the whole modification program should have been completed. Still, once available, the WB-50Ds performed far better and for a much longer period of time than expected. Like other modified versions of the B-50Ds, the reconfigured aircraft did not avoid some of the problems caused by their near obsolescence. In 1960, after several fuel cells failed in flight, 28 WB-50Ds were grounded. As in the KB-50's case, most WB-50Ds were subsequently retrofitted with new or surplus fuel cells. The modification was well justified, 40 WB-50Ds remaining in the weather service inventory in March 1963. The aircraft's phaseout began shortly thereafter, but the last WB-50D (Serial No. 49-310) was not retired before the fall of 1965.[62]

Phaseout 1953-1955

Some of SAC's 5 wings of atomic-capable B-50s began to exchange their aircraft for new B-47 medium bombers in the last months of 1953, and once underway the delayed conversion proved fairly steady. SAC still possessed 2 wings of B-50s in early 1955, but not for long. The last B-50D (Serial No. 49-330), assigned to the 97th Bomb Wing, Biggs AFB, Texas, was phased out of the atomic forces on 20 October. However, the B-50D retirement from SAC did not spell the end of the aircraft's active life. Like other B-50s, many reconfigured B-50Ds served the Air Force for another 10 years.

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[62] This aircraft was flown to Davis-Monthan AFB, Ariz., for storage. Later it was displayed at the Smithsonian Institution.

TB-50H

Manufacturer's Model 345-31-26

Previous Model Series B-50D

New Features

The TB-50H trainer differred significantly from the B-50D, and other models in the series. First, the TB-50H featured 2 astrodomes, which facilitated training by making it possible for crewmen to trade positions during flight. Also, in another departure from combat aircraft, the trainer had no drop tanks, could not be air-refueled, and carried no defensive armament. The TB-50H was designed to teach B-47 crews how to use the K-system of radar navigation and bombing[63] and to train specialized engineers, multi-engine pilots, bombardiers, navigators, and observers. The trainer normally carried a crew of 12, consisting of pilot, co-pilot, engineer, bombardier, navigator instructor, left navigator trainee, right navigator trainee, right scanner, K-system trainee, K-system instructor, radio operator, and left radar trainee. The TB-50H's rear bomb bay was packed with electronic gear, but the aircraft was lighter and therefore slightly faster than the B-50D.[64]

Production Decision 1951

In the spring of 1951, the Air Force decided to cancel the production of the last 24 B-50Ds, ordering instead an equivalent number of B-50 trainers. The decision, confirmed in April 1951, when the B-50 procurement contract was amended, became official on 4 May. The Air Force at the time also decided that the new trainers, directly developed from the B-50D, would be known as TB-50Hs.

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[63] See B-47, p 117 and p 119.

[64] The TB-50H's basic weight was 82,726 pounds, and its normal take-off weight was 146,756 pounds; the B-50D's corresponding weights were 84,714 and 158,250 pounds, respectively. The TB-50H's maximum speed at the optimum altitude of 31,000 feet was 363 knots, 20 knots faster than the B-50D at 30,000 feet.

First Flight (Production Aircraft) 1952

The first TB-50H was flown in April 1952. Within a few months, several of the aircraft reached the Air Training Command.

Enters Operational Service August 1952

The TB-50Hs entered operational service in August 1952 at Mather AFB, California. They were assigned to the 3536th Observer Training Squadron of Air Training Command's 3535th Observer Training Wing. As intended, the TB-50Hs were used primarily to train B-47 crews. The last of the 24 TB-50Hs arrived at Mather AFB in March 1953.

End of Production 1953

Delivery of one last aircraft in February 1953 marked the end of the TB-50H production, as well as the termination of the entire B-50 program's production run.

Total TB-50Hs Accepted 24

All 24 aircraft were accepted during fiscal year 1953.

Acceptance Rates

The Air Force accepted 2 TB-50Hs in August 1952, 3 in September, 7 in October, 3 in November, 7 in December, and the final 2 aircraft in 1953, one in January and one in February.

Flyaway Cost Per Production Aircraft $1.48 million

The TB-50H's unit cost was recorded at $1,485,571—airframe, $993,100; engines (installed), $203,232; electronics, $68,392; ordnance, $8,790; others (propellers, included), $212,057.[65]

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[65] About $350,000 over the average unit price of other B-50s.

Subsequent Model Series **None**

Other Configurations **KB-50K**

When no longer needed for training, the TB-50Hs were brought up to the KB-50J configuration and identified as KB-50Ks. The KB-50J and KB-50K tankers were identical, except for their origin, which accounted for their different designations. The first KB-50K flew in December 1957, and was accepted by the Air Force in January 1958. All modifications, including the addition of the 2 jet engines, were also accomplished by the Hayes Aircraft Corporation and were completed in less than a year. The KB-50Ks, like most KB-50Js, were assigned to the Tactical Air Command and were still being flown in the early sixties.

Phaseout **June 1955**

The TB-50Hs were phased out of Air Training Command in June 1955, but once reconfigured as KB-50Ks the aircraft served the Air Force for nearly another 10 years.

Program Recap

The Air Force bought 370 B-50 production models and 1 B-50 prototype. Specifically, the B-50 program comprised 79 B-50As, 1 YB-50C (prototype of an improved B-50A), 45 B-50Bs, 222 B-50Ds, and 24 TB-50Hs. Other B-50s, such as the RB-50s, KB-50s, and WB-50s, stemmed from extensive modifications. Such modifications were done either on the production lines after conclusion of the basic contract, or years after the aircraft had been utilized in its intended configuration.

The Air Force added jet engines to a number of B-50s, but others, still only piston-powered and conspicuous in the jet era that followed the end of World War II, remained in the active inventory much longer than expected. For example, some of the B-50As, which were operational in June 1948, continued flying as WB-50s in 1964, acquiring in the process a service life of a quarter of a century.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

B/RB-50 AND KB-50 AIRCRAFT

Manufacturer (Airframe)	Boeing Airplane Co., Renton, Wash.
Manufacturer (Engine)	The Pratt & Whitney Aircraft Division, United Aircraft Corp., East Hartford, Conn., and The General Electric Co., Schenectady, N.Y.
Nomenclature	Medium Strategic Bomber, Reconnaissance Aircraft, and Flight-Refueling Tanker
Popular Name	Superfortress

	B-50A	B-50D	RB-50G	KB-50
Length/Span (ft)	99.0/141.2	99.0/141.2	99.0/141.2	99.0/141.2
Wing Area (sq ft)	1,720	1,720	1,720	1,720
Weights (lb)				
Empty (basic)	85,155	84,714	88,438	90,270
Combat	120,500	121,850	129,209	107,511
Takeoff (max normal)	158,250[a]	158,250[a]	150,000[a]	173,000[b]
Takeoff (max overload)	168,480[c]	173,000[b]	170,400[c]	Not Applicable
Engine: Number, Rated Power per Engine & Designation	(4) 3,500-lb st R-4360-35 & (1) G.E. Turbo Superch CH-7-B1	(4) 3,500-lb st R-4360-35 & (1) G.E. Turbo Superch CH-7-B1	(4) 3,500-lb st R-4360-35 & (1) G.E. Turbo Superch CH-7-B1	(4) 3,500-lb st R-4360-35 & (1) G.E: Turbo Superch CH-7-B1
Takeoff Ground Run (ft)				
At Sea Level	5,940	6,420	6,150	6,350
Over 50-ft Obstacle	7,425	8,025	7,620	7,940
Rate of Climb (fpm) At Sea Level	675	620	630	608
Combat Max Rate of Climb (fpm) at Sea Level (Max Power)	2,260	2,200	1,680	2,210
Service Ceiling (ft) (100 fpm Rate of Climb to Altitude)	26,550	24,000	23,800	23,250
Service Ceiling (ft) at Combat Weight (100 fpm Rate of Climb to Altitude)	37,300	36,900	37,150	39,800

Combat Ceiling (ft) (500 fpm Rate of Climb, Max Power, to Altitude)	36,000	35,650		
Average Speed (kn)	212	212	227	209
Maximum Speed at Optimum Altitude (kn/ft) Max Power	344/30,000	343/30,000	339/29,700 (Opt)	351/30,600 (334 kn with hoses & drogues extended)
Basic Speed at Altitude (kn/ft) Max Power	337/25,000	337/25,000	333/25,000	287/5,000
Combat Radius (nm)	1,905	2,082	2,116	1,000
Total Mission Time (hr)	17.70	19.53	18.69	10.8
Armament	13 .50-cal machine guns (counting 3 in tail turret)	13 .50-cal machine guns (counting 3 in tail turret)	13 .50-cal Colt-Browning M-3 machine guns (counting 3 in tail turret)	None
Crew	11[d]	8[e]	16[f]	6[g]
Maximum Load (lb)	28,000[h] bombs	28,000[h] bombs	10 Cameras (4 K-38s with 36-in lens, or 2 K-38s with 24-in lens; 1 L-22A or K-17; 1 A-6 Motion Picture; 3 K-17Cs; 1 T-11, 6-in lens).	13,821 gal. of fuel (self-sealing wing tanks

[a] Limited by performance.

[b] Limited by strength.

[c] Limited by space.

[d] Pilot, co-pilot, engineer, navigator-radar operator-bombardier, bombardier-navigator-radar operator, radio-electronic countermeasure operator, left-side gunner, right-side gunner, top gunner, tail gunner, and extra crew member.

[e] Pilot, co-pilot, engineer, radio-electronic countermeasures operator, left-side gunner, right-side gunner, top gunner, and tail gunner.

[f] Pilot, co-pilot, navigator, engineer, nose gunner, top gunner, left-side gunner, right-side gunner-radio operator, radar operator, tail gunner, and 6 electronic countermeasures operators.

[g] Pilot, co-pilot, engineer, radar-navigator, and 2 refueling operators.

[h] 20,000 pounds, internally; 8,000 pounds, externally.

Abbreviations

cal = caliber
fpm = feet per minute
GE = General Electric
kn = knots
max = maximum
min = minimum
nm = nautical miles

Basic Mission Note

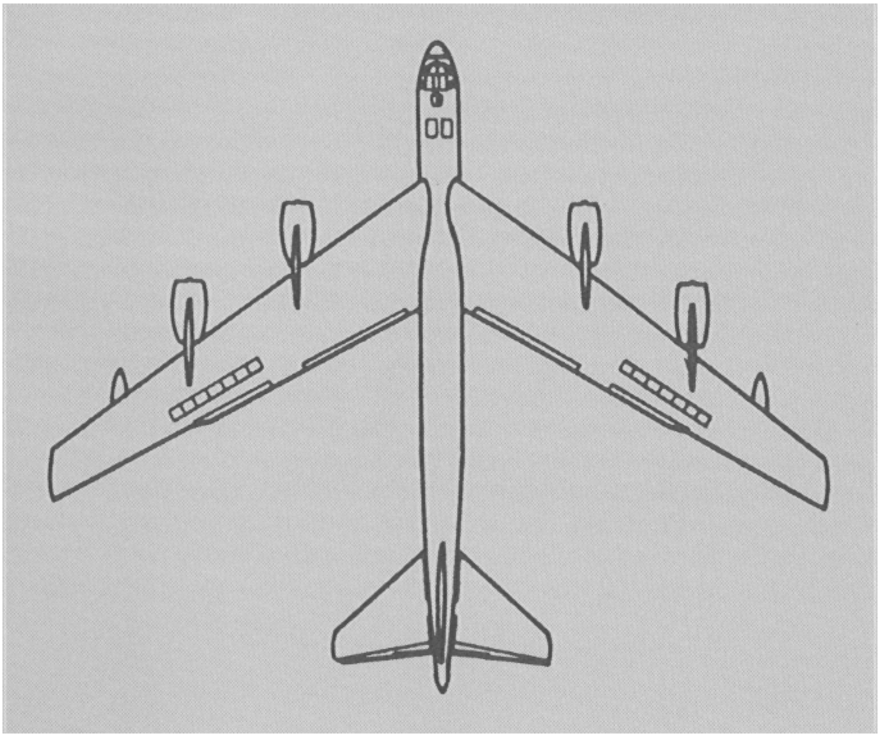
All above basic mission's performance data are based on normal power, except as otherwise noted.

B–50A and B–50D's Combat Radius Formula: Warmed up, took off, climbed on course to 5,000 feet (at normal power), cruised at long-range speeds at altitude for best range but not less than 5,000 feet, climbed on course to reach cruising ceiling 500 nautical miles from target, cruised in level flight to target, conducted 15-minute (normal-power) bomb run, dropped bomb when carried, conducted 2 minutes of evasive action at combat altitude (no distance credit) and an 8-minute run-out from target area (with normal power), cruised at long-range speeds at combat altitude for 50 nautical miles, cruised back to base at long-range speeds at not less than 5,000 feet for best range.

RB–50G's Combat Radius Formula: Took off and climbed on course to 5,000 feet (at normal power), cruised out at long-range speeds. Dropped external and bomb-bay tanks when empty. Climbed to arrive at cruise altitude 500 nautical miles from target. Cruised toward target at long-range speeds, 15 minutes from target conducted normal-power bomb run, conducted 2 minutes of evasive action and 8 minutes of escape from target at normal power. After leaving target area, cruised back at long-range speeds until 500 nautical miles from target, descended to 25,000 feet and cruised back to base at long-range speeds. Climbed to arrive at refuel altitude (cruise ceiling) immediately prior to rendezvous (1 hour at long-range speeds for rendezvous and hook-up, no distance credit), transferred fuel at the rate of 980 gallons per minute while proceeding toward bomber target at normal-rated power, disengaged and returned to base at refueling altitude and long-range speeds. (Mission was planned so that radius at the end of transfer was 1,000 nautical miles.)

B-52 Stratofortress

Boeing
Airplane Company



B–52 Stratofortress
Boeing

Manufacturer's Model 464

Weapon System 101

Overview

Most post-World War II bombers evolved from military requirements issued in the early or mid-forties, but none were produced as initially envisioned. Geopolitical factors accounted for the programs; the military threat, varying in degrees of intensity through the years, never ceased to exist. While these factors justified the development of new weapons, technology dictated their eventual configurations. Strategic concepts fell in between, influenced by circumstances as well as the state-of-the-art. Thus the B–36, earmarked in 1941 as a long-range bomber, capable of bearing heavy loads of conventional bombs, matured as the first long-range atomic carrier. The impact of technology was far more spectacular in the case of the B–52, affecting the development of one of history's most successful weapon systems, and the concepts which spelled the long-lasting bomber's many forms of employment.

As called for in 1945, the B–52 was to have an operating radius of 4,340 nautical miles, a speed of 260 knots at altitude of 43,000 feet, and a bombload capacity of 10,000 pounds. Although jet propulsion had already been adopted for the smaller B–45 and B–47 then under development, the high fuel consumption associated with jet engines ruled against their use in long-range aircraft. But what was true in 1945, no longer applied several years later. After floundering through a series of changing requirements and revised studies, the B–52 project became active in 1948. Air Force officials decided that progress in the development of turbojets should make it possible to equip the new long-range bomber with such engines. The decision, however, was not unanimous. Money was short, B-52 substitutes were proposed, and it took the deteriorating international situation caused by the Korean conflict to ensure production of the jet-powered B-52—the initial procurement contract being signed in February 1951.

While technological improvements received top priority when new weapons were designed, untried technology was a tricky business. Hovering over the B-52 weapon system was the specter of the B-47's initial deficiencies. As a result, the B-52 was designed, built, and developed as an integrated package. Components and parts were thoroughly tested before being installed in the new bomber. Changes were integrated on the production lines, giving birth to new models in the series, a fairly common occurrence. Yet, in contrast to the usual pattern, B-52 testing only suggested improvements, and at no time uncovered serious flaws in any of the aircraft. In fact, Maj. Gen. Albert Boyd, Commander of the Wright Air Development Center, and one of the Air Force's foremost test pilots, said that the B-52's first true production model was the finest airplane yet built.

Initially flown in December 1954, the B-52's performance was truly impressive. The new bomber could reach a speed of 546 knots, twice more than called for in 1945, and could carry a load of 43,000 pounds, an increase of about 30,000 pounds. Still, most of the early B-52s were phased out by 1970, due to Secretary of Defense Robert S. McNamara's mid-sixties decision to decrease the strategic bomber force. However, the later B-52G and H-models, and even some of the earlier B-52Ds, were expected to see unrestricted service into the 1980s.

By mid-1973, the B-52s had already compiled impressive records. Many of the aircraft had played important roles during the Vietnam War. Modified B-52Ds, referred to as Big Belly, dropped aerial mines in the North Vietnamese harbors and river inlets in May 1972. In December of the same year, B-52Ds and B-52Gs began to bomb military targets in the Hanoi and Haiphong areas of North Vietnam, where they encountered the most awesome defenses. Although the B-52s were often used for purposes they had not been intended to fulfill, after decades of hard work they remained one of the Strategic Air Command's best assets.

Basic Development — 1946

Officially, the B-52's development was initiated in June 1946. However, the basic configuration finally approved bore little resemblance to the original Boeing proposal. In reality, the aircraft's genealogical roots reached back to June 1945, when the Army Air Forces (AAF) directed Air Materiel Command (AMC) to formalize military characteristics for new postwar bombers, as prompted by ". . . the need for this country to be capable of carrying out the strategic mission without dependence upon advanced and intermediate bases controlled by other countries . . . ." The timing of the AAF directive of June 1945 was worthy of note. Although total victory in World War II seemed imminent, the directive obviously reflected growing pessimism over the future of international relations and increasing concern with the experimental B–35 and the problem-ridden B–36, both yet to be flown.

Military Characteristics — 23 November 1945

The first in a series of military characteristics for heavy bombardment aircraft was issued in November 1945. This initial document called for a bomber with an operating radius of 5,000 miles (4,340 nautical miles) and a speed of 300 miles per hour (260 knots)[1] at 34,000 feet, carrying a crew of 5, plus an undetermined number of 20-millimeter cannon operators, a 6-man relief crew, as well as a 10,000-pound bombload. Maximum armor protection was another prerequisite.

Request for Proposals — 13 February 1946

A design directive, allowing maximum design latitude, was distributed to the aircraft industry with invitations to bid on the military characteristics of November 1945. Three manufacturers—Boeing Airplane Company, Glenn L. Martin Company, and the Consolidated Vultee Aircraft Corporation—submitted cost quotations and preliminary design data close to requirements.

Letter Contract — 28 June 1946

The AAF concluded that Model 462, the Boeing proposal for a straight-wing aircraft grossing 360,000 pounds[2] and powered by 6 Wright T–35 gas turbine engines with 6 propellers, promised the best performance per dollar cost. The proposed aircraft, with its 3,110-mile radius, fell short

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[1] The range and speed of aircraft were shown in statute miles until the late 1940s; in some cases, until the early 1950s. Afterwards, speed was measured in knots; range, in nautical miles.

[2] Gross weight is the total weight of an airplane fully loaded; take-off weight is the actual gross weight of an airplane at take-off; the main factor limiting an airplane's maximum take-off weight is structural strength.

in range, but experience showed such a deficiency could be alleviated during the course of development. Hence, on 5 June Boeing was informed that it was the competition's winner and in mid-month Model 462, which closely resembled the much lighter B-29, became the XB-52.[3] Because money, never sufficient from the users' point of view, appeared particularly scarce at the time, the letter contract awarded to Boeing on 28 June covered only the initial development (Phase I[4]) of Model 462. Specifically, Letter Contract W-33-03A-ac-15065 asked for a full-scale mockup of the intercontinental XB-52, plus preliminary design engineering, construction of a power plant test rig, gunfire testing, structural testing, and the supplying of engineering data. Boeing could spend not more than $1.7 million on this Phase I work. And while the letter contract allowed the eventual continuation into a second phase, money was not mentioned.

Initial Reappraisal — October 1946

Despite the apparent urgency of the new bomber project, the military characteristics of November 1945 did not prevail long. In October 1946, less than 3 months after Boeing's receipt of a letter contract, discussions began that essentially reflected the AAF's unanimous concern over the "monstrous size" of the proposed XB-52 (Model 462). Maj. Gen. Earle E. Partridge, Assistant Chief of Air Staff for Operations, flatly stated that the XB-52 design failed to meet requirements. Boeing thereupon came up with a different proposal. This was Model 464, a much lighter (230,000 pounds), 4-engine version of the previous 6-engine design. Maj. Gen. Laurence C. Craigie, Chief of the AAF's Engineering Division, recommended adoption of the 4-engine XB-52, but many changes were yet to come. Indicative of the period's difficult times, new and sometimes unrealistic requirements later followed that nearly spelled the program's end.

Program Changes — 1946-1947

In November 1946, General LeMay, then Deputy Chief of Air Staff for Research and Development, while noting that the 230,000-pound XB-52

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[3] The next available bomber designation; Martin's Model 234 (a development of the contractor's winning attack design submitted in February 1946 as the XA-45) being already earmarked as the future (and later canceled) B-51 light bomber.

[4] A "phase" was a stage in the planned development of a program considered in respect both to (a) the nature of the tasks undertaken and (b) the timing.

had merits, stressed that besides extra range the future B-52 should have a higher cruising speed, something in the vicinity of 400 miles per hour. Boeing's ensuing suggestion that a 300,000-pound plane (60,000 pounds less than Model 462) might be the answer became academic, or so it seemed. In December, the AAF asked Boeing to provide design studies for a 12,000-mile range, 4-engine general purpose bomber, capable of carrying the atomic bomb. A 400-mile per hour tactical speed was required, and a gross weight of 480,000 pounds was again authorized. Fully aware of the existing limits of technology and because its first turboprop bomber had fallen far short on range, Boeing gave the AAF 2 very-heavy bomber designs—Models 464-16 and 464-17. Both appeared fairly similar and were to be powered by 4 T-35 turboprop engines of higher horsepower than those earmarked for the earlier 464 version. There was a clear difference, however. The special mission 464-16 model would carry only a 10,000-pound bombload; the general purpose 464-17 model, up to 90,000. While perhaps attractive in theory, the AAF categorically rejected the simultaneous development of 2 new bombers because this would be financially reckless. What it really wanted was an aircraft that could either carry many conventional bombs or be stripped for long-range, special missions. After careful evaluation, the AAF opted for Model 464-17.

Revised Military Characteristics — June 1947

The military characteristics of November 1945 were officially superseded in June 1947. The new characteristics called for a heavy bomber offering the improved performances that had been in the definition process for about 8 months. Except for range, the 464-17 XB-52, as proposed, met requirements. Its degree of success, however, would largely depend on the much improved T-35 engine promised by Wright. Moreover, a new problem had begun to surface. The requirements painstakingly established since October 1946 no longer seemed adequate.

New Setbacks — Mid-1947

The latest XB-52 (Model 464-17) appeared satisfactory, but only temporarily. This came as no great surprise. General LeMay long believed that, even if all went well, this XB-52 would be too large and too costly—possibly limiting procurement to 100 aircraft. General Craigie was also highly critical. In his opinion, the new XB-52 would offer little improvement over Convair's B-36G.[5] And, quite likely, the XB-52 would be obsolete before completion. Soon there was talk of scrapping the whole venture, but General LeMay favored caution. The XB-52 project should be given a 6-month "grace" period pending final decision concerning its future. This was in line with the AAF's thinking. Thus, after the shelving of Model 464-17, Boeing continued to search for means to improve the airplane. The company swiftly drew up a series of preliminary configurations (Models 464-23, 464-25, and 464-27), which finally culminated in Model 464-29. Even though the weight remained the same, high speed increased slightly to 455 miles per hour, and the operating radius jumped to 5,000 statute miles. Still, Model 464-29 was not to be the final answer.

Further Reappraisal — July-December 1947

While Boeing was told to continue development of the XB-52, AMC was reminded that no actual construction could be started without express consent of the AAF's Commanding General. The command was also directed to explore every possible means for delivering the atomic bomb. The use of subsonic pilotless aircraft was given priority, but one-way manned flights were not excluded.[6] In late September, the Aircraft and Weapons Board of the now independent United States Air Force convened a Heavy Bombardment Committee to obtain "a fresh evaluation of the long-range bomber program." In other words, committee members were directed "to study methods for aerial delivery and individual and mass atomic attacks against any potential aggressor nation from bases within the continental limits of the United States." The Heavy Bombardment Committee concluded decisively that speed and altitude were the basic qualities required of a bomber due to carry the A-bomb. This was particularly true when the bomber reached the combat zone. Up to that point, the plane could actually cruise at lower altitude. By the same token, the all-important range could well be extended by air refueling in the non-combat theater. The committee ended its work by preparing preliminary military characteristics that essentially asked for a special-purpose bomber (in lieu of a general-purpose weapon) with an 8,000-mile range and a 550-mile-per-hour cruising speed. More changes ensued, but the committee's recommendations had an

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[5] See B-36, p 42.

[6] The Air Force pursued some of those early projects. Like Brass Ring, spurred by the advent of the hydrogen bomb, none materialized as originally conceived.

immediate impact. Boeing's latest 450-mile-per-hour XB–52 (Model 464–29), obviously too slow to survive in combat, no longer had a chance.

New Military Characteristics 8 December 1947

The military characteristics of June 1947 were officially superseded on 8 December. The new set, as approved by General Vandenberg, Vice Chief of Staff, General Kenney, Commander of Strategic Air Command (SAC), and Gen. Joseph T. McNarney, who now headed the Air Materiel Command, closely resembled the proposal submitted by the Heavy Bombardment Committee. The most telling difference was that the bomber's required cruising speed was reduced—a change endorsed after studies by the AMC and Rand[7] pointed out that the desired 8,000-mile range could be attained only at a speed not in excess of 500 miles per hour.

Near-Cancellation 1947–1948

With the approval of new characteristics, the question arose within the Air Staff whether the Boeing contract should be amended or canceled in favor of a new design competition. The idea of a new competition was tempting. A better bomber might be obtained by again tapping all the engineering brains in the industry. Also, as previously noted by General LeMay, many companies which had failed to bid on the original project were of a different mind now that a large part of the Air Force production funds appeared slated for the future B–52. The Air Materiel Command did not agree with the Air Staff. AMC claimed that Boeing was the best-qualified heavy bomber contractor, that a new competition would consume much valuable time, and that some $4 million would be wasted if the Boeing development contract was nullified. For good reasons, the AMC arguments failed to convince the Air Staff. First, Boeing already had a large share of the Air Force business, and amending the company's contract might cause political repercussions or a public accusation of favoritism. Secondly, if Boeing was truly the best contractor, it would win the competition handily,

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[7] Rand (for research and development) was the code name applied to numerous studies by the Douglas Aircraft Company—a project initiated by the AAF in 1946. In 1948, a grant from the Ford Foundation brought about a reorganization of the project. It became the Rand Corporation, a non-governmental, nonprofit organization dedicated to research for the welfare and national security of the United States. Research by the corporation was conducted with its own funds or with funds supplied by government agencies. The Rand Corporation is located in Santa Monica, Calif., but maintains offices in Washington, D.C.

and little delay would occur because the company had already worked on the XB-52 preliminary design. Therefore, on 11 December 1947, following verbal approval by Under Secretary of the Air Force Arthur S. Barrows, Lt. Gen. Howard A. Craig, Deputy Chief of Staff for Materiel, directed AMC to cancel the Boeing contract. However, the case was not closed. Before the directive could be executed, Boeing's President, Mr. William M. Allen, protested vigorously to Secretary of the Air Force Stuart Symington that the decision was unsound. The Boeing letter stressed that the proposed cancellation and renewal of XB-52 competition would be "a serious injustice to the contractor . . . and provide a 'second chance' to others who would profit from Boeing's progress." The letter also underlined that the company had passed up other projects after entering the heavy bombardment competition in the spring of 1946. Since then, some of its ablest talent had been dedicated to the project. Finally, the bulk of the other Air Force production contracts held by Boeing would be completed before the B-52 production could begin. In all fairness, the Air Force had to admit that many of Boeing's arguments were valid. Thus, it might be best to avoid any rash decision.

Other Alternatives — 1948

In January 1948, Mr. Symington replied to Boeing, giving a keen analysis of the problem facing the Air Force.[8] He considered the heavy bombardment project to be of the greatest importance, and believed the new bomber would play a dominant role in any future war. "For this reason," he emphasized, "the USAF must be assured of the best possible design and configuration. There could be no compromise on this provision." The Secretary said that much scientific progress had been made since the original competition. The technique of air-to-air refueling had been perfected to the point where it should be possible to develop an airplane with the top speed and cruising speed of a medium bomber and with only a slightly higher gross weight. This aircraft should certainly be lighter than previously proposed versions of the XB-52. Another possibility (insufficiently considered, according to the Air Staff) was the flying wing design. Rand studies had noted that this configuration offered definite advantages when applied to long-range, high-speed aircraft. Mr. Symington concluded that, until all avenues had been thoroughly explored, no final decision could be made on the original Boeing contract.

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[8] Concurrent difficulties with the B-36 did not help. This program once again appeared on the verge of collapse—another major decision soon confronting the Secretary.

Go-Ahead Decision — March 1948

In February 1948, after acknowledging the merits of the flying wing being tested by the Northrop Corporation, Boeing noted some of the inherent disadvantages of this type of configuration. Foremost were marginal stability and control. Boeing willingly emphasized that research and experiment with the all-wing aircraft should not be discouraged. But the proposed B–52 had more flexibility for radar and armament installation and none of the "flying wing's" problems. Consequently, the conventional aircraft should be given first developmental priority, "so that the Air Force should not be left without an effective bomber." From its own investigation, AMC's Engineering Division contended that the XB–52 development should be continued. The Air Staff also began to favor the XB–52, believing it to have a higher probability of success and to be easier to maintain than any potential version of the "flying wing." Thus, in March 1948, the Secretary of the Air Force informed Boeing that its present contract would be modified to develop a bomber meeting the military characteristics of December 1947, as already or subsequently revised. In April Boeing presented a complete Phase II proposal for the design, development, construction, and testing of 2 XB–52s (Model 464–35). Although estimated to cost about $30 million, this Phase II proposal received the Air Force's endorsement in July.

Additional Revisions — 1948

During 1948, several revisions were made to the military characteristics of December 1947. The first occurred in March, 2 months after Boeing submitted for the first time Model 464–35—a bomber having the desired range and speed but weighing only between 285,000 and 300,000 pounds. A second revision specified a 360,000-pound plane, with an average cruising speed of 445 miles per hour and a range of 11,635 miles. A final revision on 15 December defined a 280,000-pound bomber that could carry 10,000 pounds of bombs and 19,875 gallons of fuel for 6,909 miles, at a maximum speed of 513 miles per hour at a 35,000-foot altitude. None of the 3 revisions affected the December 1947 requirements for a 5-man crew and tail armament only. But more changes occurred over time and the B–52s eventually carried a crew of 6, as a rule.

Contractual Arrangements — September 1947–November 1948

Boeing's original contract, as initiated by the letter contract of June

1946, was approved on 2 September 1947. By then the contract already reached $4.6 million—$1.7 million for Phase I, the initial development commitment, plus $2.9 million for Phase II, an extension of the Phase I work directed by the existing letter contract. The Phase II funds were provided per supplemental agreement on 13 June 1947. Of necessity, these funds were shuffled around. For a while, the Phase II funds were due to finance the Phase I development of Model 464-17. However, this model's cancellation prompted a second change, the $2.9 million Phase II funds now being earmarked for the Phase II development of yet another configuration—Model 464-35. Meanwhile, as approved by Under Secretary Barrows, an additional $563,766 was allocated on 7 April 1948 for the Phase I development of the same model (464-35), bringing the Phase I investment to a total of $2.3 million. But completion of the Phase II development would prove to be considerably more expensive. In mid-1948, as a result of the revised characteristics of December 1947, the Phase II cost of developing, building, and testing 2 XB-52s (Model 464-35) was estimated at $28.3 million. This did not include $1 million for contractor-selected spare parts or $4.8 million for engineering design improvements and the installation of tactical equipment in the 2 experimental planes. Even spread over several years, the research and development budget could not possibly sustain such expense without jeopardizing other essential projects. Some expedient had to be found. On 17 November 1948, the Air Force approved another supplemental agreement to the definitive contract of September 1947. This time, the agreement shifted $6.8 million of procurement funds to support the first 2 years of the XB-52 development.

Radical Change 1948

In the spring of 1948, after floundering for about 2 years through a series of changing requirements and revised Phase I studies, the XB-52 project finally seemed on its way. Although the Air Force still made it clear that the XB-52 development program must result in the most advanced design possible, Boeing actually prepared to build 2 experimental, turboprop-equipped articles of Model 464-35, its latest bomber proposal. But the plans once again were altered—with more drastic changes yet to come—by recent progress in the development of turbojet engines. The turbojet concept was not new. As early as June 1945, during discussions over the characteristics for strategic bombers, AAF officers had pushed for the development of jet engines suitable for bombers. However, the fuel consumption of jet engines was then so high that this kind of propulsion was discarded in view of the ranges required of the strategic bombers. In 1948 the technological situation was totally different. The Air Force asked Boeing in

May 1948 if it could incorporate jet engines in the proposed XB-52. This resulted in still another XB-52 version (Model 464-40), featuring the Westinghouse J40 engine and a minimum of changes to the turboprop XB-52 under construction. The Air Force received Boeing's preliminary study of its jet-propelled Model 464-40 in late July.

New Controversy 1948

Shortly after Boeing's Model 464-40 was submitted to the Air Force, a new debate arose. In October, General Craig expressed his dislike for the proposal, believing that improvement in heavy bombardment aircraft would come only when the bomber configuration was changed and stating that "unless supersonic propellers become a reality, future aircraft of this class will be powered by turbojet engines, however neither of these developments are sufficiently near at hand that the turboprop step can be eliminated." The Deputy Chief of Staff for Materiel's pessimism proved unwarranted, as Boeing engineers within days of his remarks devised the very solution which led to the development of the remarkable B-52. Still, Boeing did not reap success without toil. On 21 October, after arriving at Wright Field to confer on their XB-52 turboprop aircraft (Model 464-35), Boeing engineering executives were informed by AMC officials that a drastic reappraisal of the XB-52 project seemed in order. In short, AMC wanted a preliminary study of an entirely new airplane which would be powered by Pratt and Whitney Aircraft Division's new J57 turbojet engines. According to popular newspaper accounts, the Boeing representatives retired to a Dayton hotel room over the weekend. Drawing on the experience gained in the B-47 program, they worked around the clock and on Monday morning, 25 October 1948, presented the requested proposal—a 33-page report plus a hand-carved model of their new design—Model 464-49. Perhaps the feat was not as spectacular as it appeared. As exemplified by Model 464-40, Boeing had been considering for quite a while the possible use of jet power plants in bombers far heavier than the B-47. In any case, the Boeing engineers liked Model 464-49, an airplane having 35-degree swept wings, 8 engines slung in pairs on 4 pylons under the wing, and an overall configuration that departed from the B-29 and B-50 for the newer B-47 body style. They were confident that additional range could be gained with "only reasonable increase in weight," and that the new jet engines would provide improved altitude and speed performances. Besides, jet engines would eliminate the many unsolved problems of propeller aerodynamics and control, and probably extend the airplane's operational life. Finally, this jet version of the XB-52 could be available almost as quickly as the turboprop already under development.

Program Reendorsement 1949

The Board of Senior Officers[9] was favorably impressed by most of the operational accomplishments expected of the new 330,000-pound model. When equipped with J57 turbojets (yet to be available), the swept-wing XB-52 promised to reach a top speed of 496 knots (572 miles per hour); to fly 6,947 nautical miles at an average speed of 452 knots (520 miles per hour) without refueling; and to be capable of delivering a 10,000-pound bombload at a comfortable altitude of 45,000 feet. After a final evaluation in January 1949, the board decided to continue development, "with the Boeing Aircraft Company," of the XB-52 as a turbojet in lieu of the turboprop-powered aircraft. This would be done under the same contract, and Boeing was so informed on 26 January. Meanwhile, favorable opinions did not prevail in all quarters. The stringent economy drive directed by President Truman in late 1948 endangered the costly B-52 development program. Concerted attempts were made to equate performance and cost data with present and "soon-to-be" outdated aircraft. In February, the Deputy Chief of Staff for Materiel's Directorate of Research and Development came to the program's rescue. Officials pointed out that the major difference between the B-36 and the proposed B-52 was timing. The B-36 seemed to be the solution to the strategic bombardment problem as it appeared in 1942; the future B-52, as it appeared in 1949. Under existing state-of-the-art limitations, vigorous development of the turbojet B-52 afforded the Air Force its only hope for carrying out the strategic air mission, specifically the delivery of the atomic bomb, should it become necessary over the next 5 years. Surely, the Air Force would be remiss if it failed to develop a successor to the B-36. While the arguments of the Research and Development Directorate were persuasive, a new threat surfaced. In the spring of 1949, the Fairchild Aircraft Corporation forwarded a design proposal for the development of an unconventional strategic bomber.[10] The Board of Senior Officers again reviewed the Boeing airplane's potential growth and agreed to continued development of Model 464-49. However, Fairchild's unconventional design did not disappear, and other contractors soon submitted proposals that further imperiled the new program.

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[9] Established in December 1948, the USAF Board of Senior Officers included the Vice Chief of Staff, the Deputy Chief of Staff for Operations, the Deputy of Staff for Materiel, and the Commanding General, AMC. This board replaced the USAF Aircraft and Weapons Board, which was composed of all Deputy Chiefs of Staff and major air commanders and had proved too cumbersome. The dormant board was discontinued in the fall of 1949.

[10] The Fairchild proposal aircraft, a fuel-carrying wing, indeed appeared revolutionary. It used a railroad flatcar as a launcher. The intent was to provide maximum initial speed and altitude so that the aircraft would conserve fuel and attain sufficient range.

Mockup Inspections 1948-1949

Like the many model configurations considered at one time or another, all mockup inspections scheduled prior to 1948 were canceled. Moreover, the few finally conducted in January 1948 only covered nose sections, where arrangement of the reduced crew presented difficulties. As for Boeing's latest turboprop XB-52 (Model 464-35), although its mockup was essentially complete by October 1948, all work was halted before any formal inspection could be made. Thus, the swept-wing turbojet XB-52 was the first to merit a full-fledged mockup inspection. This was accomplished at the Boeing Seattle plant and lasted from 26 to 29 April 1949. The inspection board of USAF personnel found no special faults with the mockup but noted in its report that the experimental XB-52, with its J40-6 engines, would not match the B-36's 4,000-nautical-mile radius. The board also indicated that expedited development, as well as significant improvement of the J57 turbojet might assure B-52 aircraft of a 4,000-nautical mile combat radius, but this could not be expected before 1954. In any case, the importance of meeting such a requirement had been emphasized to the contractor. The Air Staff approved the board's report on 1 October, with significant reservations. This was obvious when Gen. Muir S. Fairchild, Vice Chief of Staff since 27 May 1948, carefully underlined that the XB-52 mockup report was approved to expedite potential future production, but that such approval "does not include acceptance of any production article not meeting specified range requirements."

Last Near-Cancellation 1949-1950

General Fairchild's "tentative approval" of the XB-52 mockup inspection report was viewed by many as a practical "cancellation of the program as it now exists." Since the J57 engine, in its present developmental stage, would only give the B-52 a combat radius of about 2,700 nautical miles, the bomber would never materialize unless some "mechanical dodge" was devised to extend range. Maj. Gen. Orville R. Cook, the AMC Director of Procurement and Industrial Planning, favored a review of the program and perhaps a revision of the military characteristics and scheduling of another design competition. General LeMay,[11] in command of SAC since October 1948, believed that the solution lay in engine development, that it was unnecessary to accept inferior performance in either speed or range, and

[11] Promoted to full general on 29 October 1951, General LeMay headed SAC until mid-1957.

that a conference on the B–52 airplane was urgently required. Meanwhile, Boeing kept busy. Accelerated engineering and development tests were conducted to solve problems of aero-elasticity, vibration, and control that resulted from the higher wing sweep, greater speeds, and thinner wing. In November 1949, convinced that inadequate range seriously jeopardized the future of its new bomber (Model 464–49), Boeing offered a heavier B–52 (Model 464–67). This 390,000-pound B–52, Boeing said, would have a radius of 3,785 nautical miles for production aircraft anticipated in 1953 and 4,185 nautical miles for a B–52 in 1957. Increased combat radius could be obtained in time and with additional expenditure of money. Boeing concluded that the heavier XB–52 was as technically advanced in aircraft design as possible. The contractor's efforts to safeguard the B–52 program did not go unnoticed. By year's end, SAC officials generally agreed that the contractor had made appreciable progress toward satisfactory development of the airplane. Soon afterwards, the conference suggested by General LeMay took place. However, the meeting's conferees at Headquarters USAF on 26 January 1950 faced a difficult task. Once more, substitutes were proposed for the B–52. Included were new proposals by the Douglas and Republic Aircraft Companies, Fairchild Aircraft Corporation's unusual design, the swept-wing B–36G (later known as the YB–60), a Rand turboprop airplane, 2 new designs of the B–47, and several missile aircraft. Even though General LeMay took a firm stand in favor of the B–52 as the aircraft which would best meet the requirements of the strategic mission, the conference ended before any decision could be reached. But SAC's Commander-in-Chief was not easily deterred. In February, the Air Staff requested from AMC all performance data and tentative production dates of the various combat vehicles recently considered. In the same month, however, General LeMay asked the Board of Senior Officers to accept Boeing Model 464–67 in lieu of Model 464–49. Approved by the board on 24 March 1950, this change eventually led to the production decision General LeMay so badly wanted.

Production Decision — January 1951

Although there were no more direct attempts to sidetrack the B–52 development once Model 464–67 was endorsed, the future of the production program remained uncertain. Some substitutes seemed to regain momentum, with the swept-wing B–36 and long-range B–47Z coming to the fore. SAC opposed both, believing the new B–36 would have lower cruising and target speeds than a future B–52 and that the 3-man crew B–47Z would retain inherent limitations for intercontinental operations. A comparative study of the B–52 and the advanced B–47, SAC officials stated, showed that the B-52 was superior in performance. The B-52's extra crewmen would materially reduce the serious fatigue problems stemming from long missions. Also, electronic countermeasures equipment could be fitted in the larger B-52, thereby ensuring protection against future surface-to-air and air-to-air guided missiles. In spite of such arguments, the Air Staff had made no definite commitment by the fall of 1950, compelling General LeMay to become directly involved once again. And whereas World War II had prompted production of the B-36, another war helped the B-52. General LeMay was quick to point out that the international situation during the Korean conflict was deteriorating rapidly; that SAC's forward operating bases were becoming more vulnerable to enemy attack; and that increasing as well as modernizing SAC's intercontinental bombardment forces should receive priority consideration. Referring again to the B-52, General LeMay said: "Perhaps even more important is the concurrent requirement for the development of a long-range, high-performance aircraft, such as the RB-52, capable of operating alone over highly defended enemy areas in the performance of the reconnaissance mission." Finally convinced, the Board of Senior Officers concurred that the B-52 would be the production successor to the B-36. Also, since the B-52 was not a radical departure from existing stages of aircraft development, procurement could start before completion of the XB-52 testing. General Vandenberg, Chief of Staff since 30 April 1948, approved the board's recommendations on 9 January 1951; Thomas K. Finletter, the new Secretary of the Air Force, on the 24th.

Initial Production Plans 1951-1952

Letter Contract AF33(038)-21096, signed on 14 February 1951 by Boeing and the Air Force, was the first document authorizing production. It covered long lead time items and the production of 13 B-52As, the first of which was tentatively scheduled for delivery in April 1953. The letter contract of 1951 was finalized on 7 November 1952 by a cost-plus-fixed-fee contract. As originally agreed, Boeing's fixed fee remained set at 6 percent of the contract costs. In the interim, there were changes and many more were to follow. An amendment to the first letter contract provided for 17 reconnaissance pods—detachable capsules to be fitted in the early bombers. In July 1951, the Air Staff directed AMC to acquire 4 more B-52s—presumably to match the number of aircraft to the total of reconnaissance pods ordered. The additional planes were to be paid for, like their predecessors, with fiscal year (FY) 1952 funds, but would come from a second Boeing plant—yet to be selected. The directive, however, was soon rescinded, and in October the Air Staff informed AMC that all B-52 production aircraft would be in a reconnaissance configuration. In September 1952, the Air Force gave Boeing a second letter contract—AF33(600)-22119—that called for 43 RB-52s. But none of these early plans materialized due to technical improvements and budgetary restrictions. Ironically, the Korean War, which first worked in favor of the production program, slowed down progress because the industrial situation was confused following the unexpected outbreak of hostilities. Meanwhile, development of the 2 experimental B-52s gradually moved on.

Development Difficulties 1950–1952

As far as General LeMay was concerned, it was difficult enough to persuade the Air Staff to approve Model 464-67, but even more challenging to avoid the frustrating series of events that had marked the B-47 development. The reconnaissance requirements finally stipulated in early 1951 especially complicated matters. Boeing had known for a long while of the Air Force's reconnaissance ambitions.[12] There was nevertheless considerable disagreement between the Air Staff and SAC. Headquarters USAF thought photography should be the RB-52's main mission and that any equipment compromising this function should be excluded. On the other hand, SAC believed the airplane should have a full complement of electronic reconnaissance (or ferret) equipment for operation at night or in bad weather. Furthermore, only a minimum of cameras should be carried to give "local" photographic coverage when light conditions permitted. At any rate, preliminary designs for an experimental RB-52 were completed by mid-1950, but in August Boeing embarked on another approach. The contractor suggested forsaking the RB-52 because it would be simpler and much cheaper to install in the B-52's bomb bays a multi-purpose pod housing reconnaissance equipment. This multi-purpose pod could be replaced by a photo pod or a ferret pod, as needed. At this point, AMC agreed

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[12] Development of a special, long-range reconnaissance airplane, the so-called X or RX-16, became a topic of primary interest soon after the end of World War II. Yet, by 1949 ideas about the equipment required to accomplish the strategic reconnaissance mission remained in constant flux. There was also increasing concern that the cost of building a specific airplane for reconnaissance would be "staggering to the national economy." The Air Force therefore dropped the RX-16 project. It began instead to consider modifying bomber aircraft for the reconnaissance role. A first step toward this goal, the Air Materiel Command stressed, was to determine the type of data needed, then decide on the equipment best fitted to gather such data. The Air Force nevertheless believed that manned aircraft such as the B-36 and B-52 would be required for reconnaissance duty well into the 1960's. There were concurrent talks about parasite aircraft and guided missiles which most likely would some day perform reconnaissance functions.

that the proposal was sound, but cautioned Boeing that the B–52's bombing capabilities could not be jeopardized to satisfy reconnaissance objectives. In response, SAC proposed in June 1951 a reconnaissance B–52, capable of conversion to the bomber configuration. This could be done, according to SAC, by removing the reconnaissance pod and adding bomb racks in its place. An August conference, attended by representatives from the Air Staff, Air Research and Development Command, SAC, AMC, and the Air Weather Service seemed to settle a controversy that centered essentially on priorities. In short, should the aircraft be primarily a bomber with a secondary reconnaissance role, or vice versa? The conferees voted for a B–52 bomber that could be converted to the reconnaissance configuration and returned to its original configuration, as necessary. This "convertibility," the conferees decided, should allow personnel "at the wing level in the field" to do the transformation in a reasonable time. But the lull in the controversy did not last. As already noted, the Air Staff directed in October 1951 that all aircraft "will be of the RB–52 configuration as there is no requirement for a B–52." The directive was misleading since the aircraft would retain conversion features for bombardment operations. In actuality, the Air Staff's decision was a belated approval of SAC's most recent planning. Just the same, the discussions, delays, and production orders of 1952, along with subsequent deletions, did not as a whole expedite the experimental program.

Other Development Problems 1951–1952

Besides the reconnaissance requirements of 1951, various circumstances affected the B–52's development. Early in the year, General LeMay told Boeing that the tandem-seating arrangement featured by the XB–52 mockup was poor. Since it allowed little room for flight instruments, small panel instruments would have to be used, and this had proven unsatisfactory in all types of aircraft. In addition, the tandem arrangment reduced the copilot's role to a flight engineer operating emergency flight controls— obviously limiting his assistance to the pilot. In a plane as important and costly as the B–52, safety was a top priority. General LeMay believed that side-by-side seating of the pilot and copilot would ensure closer coordination between the two, which in some cases might prove vital. The issue of tandem versus side-by-side seating was settled in August. The Air Staff agreed that significant operational advantages would be gained by adopting the side-by-side arrangement. Some slight confusion nevertheless ensued. First, a few of the early B–52 productions would retain the tandem seating configuration; then, only the experimental planes would not be changed. This was decided after Boeing pointed out that the lack of additional facilities made some production delay inevitable. The production time lost could be put to good use, the contractor felt, by incorporating a side-by-side cockpit from the start. This would save SAC the trouble of operating and maintaining 2 B-52 configurations and cut production costs by almost $17 million. There were other protracted discussions. SAC continued to strive for near-perfection, insisting that even greater range was desired to secure better operational flexibility in the dispersal of the B-52 force. Based on earlier experience, SAC also thought that space should be provided in the aircraft to carry the greater bombloads and large missiles anticipated in the future. Finally, there were several arguments about which engines should be used. For instance, SAC asked that an advanced engine, the General Electric X-24A, be made available without delay to permit the B-52 to realize its full potential. But this engine's production was not scheduled until 1957, and no plans were made to phase such an engine into the B-52 program.

First Flight (YB-52) 15 April 1952

Contrary to usual practices, the prototype B-52 took to the air several months ahead of the experimental B-52.[13] Lagging deliveries of engines[14] and pneumatic systems retarded the XB-52's first flight, but the main delay came from an engineering decision to change the aircraft's rear wing spar—a structural modification directly incorporated in the YB-52. In any case, the prototype's flight also slipped 1 month because General Electric did not deliver the pneumatic systems until 1952. Yet, the YB-52's 15 April flight proved well worth the wait. Taking off from Boeing's Renton Field, Seattle, Washington, the plane flew for 2 hours and 51 minutes before landing at nearby Larson AFB. Enthusiastic reports flowed in from engineers, observers, the pilots and, naturally, from the contractor. Pilots of the escort planes which accompanied the YB-52 on its flight reported that its performance was excellent and commented that its slow approach and landing speed were particularly remarkable. At touchdown, the drag parachute was deployed for testing only, as very little braking was required. Of course, there were a

[13] Boeing's original contract called for 2 XB-52s, bare of certain expensive tactical equipment. In mid-1949, Boeing suggested that such equipment be installed in the second XB-52. The contractor justified the costly installation by pointing out that the resultant airplane could serve as production prototype. The Air Force agreed and the second XB-52 became the YB-52.

[14] The Air Force Power Plant Laboratory insisted from the start that Pratt and Whitney had to supply Boeing with prototypes of the J57-P-3 engines for both the X and YB-52s. It believed that since those engines would equip the B-52s, they should also go into the experimental versions of the plane. This would allow Pratt and Whitney to "debug" the engines during the flight test program, while Boeing was "debugging" the airframe.

few minor problems. One of the quadricycle landing gears retracted improperly, the liquid oxygen system failed (due in part to the crew's unfamiliarity with it), and 1 of the engine oil valves leaked, causing a trail of puffy white smoke rings throughout the flight. A second flight on 20 April was even more successful. Remaining below 15,000-foot altitude because of restrictions on engine operation, the YB–52 attained a speed of 350 miles per hour. The restrictions were anticipated. Pratt and Whitney had encountered difficulty in pushing the experimental J57 through the 50-hour qualification run—succeeding only in August 1951, on the third qualification attempt. Whatever the cause, these early problems were swiftly corrected. By October 1952, the YB–52 had flown some 50 hours and had reached speeds of Mach 0.84 without full power at altitudes above 50,000 feet. The Air Force officially accepted the prototype on 31 March 1953 but let Boeing keep it for further testing. The contractor flight-tested the plane for a total of 738 hours, accumulated in 345 flights.[15] The YB–52 remained on loan to Boeing until January 1958, but the contractor kept it in storage during most of 1957. On 27 January 1958, the aircraft was donated to the Air Force Museum, Wright-Patterson AFB, Ohio.

First Flight (XB–52) — 2 October 1952

Although the experimental B–52 rolled out of the factory on 29 November 1951,[16] it did not fly until almost 1 year later—after significant modifications. The Air Force took possession of the XB–52 on 15 October 1952 (13 days after the aircraft's 2-hour first flight), but did not formally accept it until 1953. Because of its late start, the XB–52 barely participated in the contractor's Phase I testing, flying only 6 flights for a total of 11:15 hours. For the same reason, the Phase II flight test program, which was the Air Force's responsibility, began behind schedule. It was entirely conducted on the XB–52 between 3 November 1952 and 15 March 1953—reflecting an additional slippage of almost 2 months because of inclement weather in the Seattle area. Phase II tests revealed a number of deficiencies. The XB–52's engines surged and might shut down if normal throttle accelerations were

[15] Actually, USAF pilots flew the YB–52 8 times for 27 hours from Edwards AFB, Calif., between 5 June and 18 July 1953. Because the plane was on loan to Boeing, flights and flying hours were included in the contractor's totals.

[16] The XB–52 was moved to the flight test hangar under concealing tarpaulins during the night. According to the press, the great secrecy surrounding the whole event was dictated by the Air Force as a means of testing the effectiveness of its latest security policies. Yet, in view of Boeing's competitors and the many proposals still floating around, one could reasonably assume that the contractor was also eager to keep its new plane out of sight.

attempted at high altitude and low engine inlet temperatures. The brake system could not stop the aircraft within the distances guaranteed by Boeing. The XB-52 tended to pitch up and roll to the right just before stalling. Also, during landing roll, the experimental plane required twice the normal distance to stop. There were also problems with the tires, which tended to blow out when cross winds shoved the aircraft to one side. Completion of the Phase II tests prompted the XB-52's return to Boeing—the aircraft remaining on loan to the contractor for several years. In late March 1953 the plane began to undergo Phase III flight tests, but was soon grounded for major rework and did not resume flying until mid-1954. It nevertheless took part in the overall flight test program, finally accounting for 24 flights and a total of 46 flying hours. Boeing returned the XB-52 to the Air Force in early 1957, and in March the plane was assigned to the Wright Air Development Center at Wright-Patterson, to serve as a test-bed. After 893 hours of flight, 2 J75 engines were installed on the outboard struts, the XB-52 becoming a 6-engine airplane since the 4 inboard J57 engines remained. Modifications to the nacelles and installation of the new engines took time, immobilizing the airplane for almost a year.

Testing Program 1952-1962

Perhaps no aircraft would ever be as thoroughly tested as the B-52, nor did such a long-lasting program often start with so many controversies. The Air Force at first wanted to evaluate the aircraft at Edwards AFB's Flight Test Center. Boeing immediately disagreed, insisting that flying time at Seattle was rarely affected by bad weather and that excessive delays and expenses would occur in correcting defects discovered during testing, if the airplanes were not flown from the Boeing field. The Air Materiel Command somewhat reluctantly sided with Boeing in the belief that B-52 testing at Edwards AFB, under the auspices of the Flight Test Center, might lead to costly post-production modifications—a B-47 episode the Air Force did not care to repeat. The Air Research and Development Command, however, advocated testing the B-52 at the Flight Test Center, since that facility was responsible for the task. Although impressed by the research and development command's logic, AMC pointed out that conducted tests at Edwards would require perhaps an extra $20 million. Air Research and Development Command conceded, "partially as a result of the AMC's uncompromising refusal to provide the necessary additional funds." In 1953, contrary to Boeing's claims, the Seattle weather began to hold back testing. In February, after considering the extended Phase II[17] flying period and the hazards of operating in and to Seattle's metropolitan area, the Air Force directed a change in the test site. Initially, Larson AFB was chosen; subsequently, Fairchild AFB (also in the state of Washington) became the test base, with some of the later tests to be flown from Edwards. Meanwhile, other changes were underway, with more anticipated for the future. To begin with, the testing program acquired several extra B-52s. While the Phase I and II tests were conducted with only the X and YB-52s, the contractor's Phase III testing required 6 B-52s besides the YB-52. In the interim, the Air Force accepted 3 B-52As (the only ones built of 13 ordered) and returned the 3 planes to Boeing for Phase IV testing. Phase IV tests began with the third B-52A production (Serial No. 52-003) on 25 January 1955 and ran through the end of November. These tests had two main purposes. The contractor wanted to spot-check the stability data obtained during the Phase II tests of the reworked XB-52, and to compare the performance of the more powerful J57-P-29 engine against that of the J57-P-1W (first installed in the B-52A). The third B-52A, by itself, accounted for more than 288 hours of Phase IV testing accomplished in 60 flights. As expected, the J57-P-29-equipped B-52A demonstrated superior takeoff and climb performances.

Phase VI functional development testing also took place in 1955, ahead of the Phase V tests, which were delayed because of equipment shortages. The Phase VI tests, conducted at Edwards AFB, started on 3 March and made use of 2 B-52Bs (Serial No 52-005 and 52-006). They ended on 6 September, 2 months earlier than forecast, after 157 flights totaling 984 hours. Phase VI was designed to subject the entire strategic bomber weapon

[17] The Air Force used the word "phase" to identify definite facets of the testing program. Phase I testing determined contractor compliance and consisted of some 20 hours of flight testing, during which the aircraft was held at about 80 percent of its design limits. Phase II testing was essentially similar to Phase I, but was done by Air Force rather than by contractor pilots. Phase III testing, called contractor development testing, ironed out most of the "bugs" thus far discovered and incorporated most of the modifications suggested by test pilots. In Phase IV, performance and stability testing, the entire performance range was investigated during some 200 hours of flight. Phase V, all-weather testing, as a rule took place at Wright Air Development Center and Eglin AFB. Phase VI tested functional development, using production models. Pilots of the scheduled using agency tested every part of the weapon system. Usually, this phase made use of 3 to 6 aircraft, each of which flew approximately 150 hours. Phase VII, called "operational suitability," was also performed by pilots of the using agencies. Phase VIII, termed unit operational employment testing, was also accomplished by pilots of the using commands, under the supervision of the Air Proving Ground Command. In the late fifties, there were some superficial changes, affecting the testing program's terminology more than its scope. Three categories supplanted the many pre-1960 phases. Categories I and II were essentially similar to Phases I and II; Category III, and its numerous special tests, covered all other former phases. Obviously, testing had to be flexible to serve its purpose. Often, some tests were extended, while others were scheduled out of order. But the testing program's thoroughness remained constant.

system to the demands of an accelerated program (a speed-up of production being actually recommended on 20 June 1955). One of the primary objectives was to determine the system's durability, maintenance manpower requirements, parts consumption, and compatibility of all support equipment. Completion of the Phase VI tests proved that the B-52 (Weapon System 101) was capable of performing its mission. Each B-52 subsystem had been carefully evaluated, with many improvements being requested. This in no way detracted from the B-52's intrinsic excellence, but attested to the importance of such testing during a period of great technological innovation.

Completion of the Phase VI tests, although a basic milestone, did not spell the end of testing. At least 1 of every B-52 model series was extensively tested, with no less than 1,500 Phase II and III test hours programmed for the last one—the B-52H, still being tested in 1962. Final tabulations showed that 13 B-52 productions were used in the overall testing program. Several of these planes were involved in accidents, and 2 were destroyed. But time would vindicate testing costs and efforts.

Research and Development Costs 1952

The research and development work done over some 5 years, plus the price and early testing of the X and YB-52s totalled about $100 million—1.5 percent of the entire program cost. In the early fifties, this was a shocking sum. Yet, the investment soon paid dividends. No major changes appeared until the last 2 models in the series (B-52G and B-52H), and even though the configuration of the early B-52s remained relatively unaltered, they too were to prove invaluable to the strategic force. In retrospect, the Air Force had to admit that money was seldom so well spent.

B–52A

Manufacturer's Model 464–201–0

New Features

The B–52A differed in several major respects from the prototype B–52. It looked more like an older type of bomber because of its enlarged nose that provided side-by-side pilot seating. To accommodate additional equipment, the forward compartment was extended 21 inches. Other improvements consisted of a 4-gun, .50-caliber tail turret, electronic countermeasures equipment, a chaff dispensing system, and J57–P–1W engines. The engines were fitted for water injection, 360 gallons of water being carried in a rear fuselage tank. Although the A-model was capable of "flying boom" flight refueling, its unrefueled range was increased by providing two 1,000-gallon auxiliary fuel tanks supplementing the normal 35,600-gallon fuel load.

Production Slippage — April 1953–June 1954

Restricted to testing, the B–52As were nevertheless considered as the first B–52 productions. While they were also 14 months behind schedule, extenuating circumstances abounded. As early as 1950, Boeing urged AMC to prepare for production, claiming that 1 year in lead time could be gained by securing tooling, materials, and other items without delay. "I can say in all honesty," Boeing's Vice President wrote, "that I believe the $13 million investment would be the cheapest insurance premium our Government ever paid." That the Air Force did not leap into action made sense at the time, since alternative aircraft remained under consideration. Later, when the XB–52 materialized, the aircraft appeared so complicated that even the contractor doubted that a B–29-type of mass production could be applied to the B–52. Comparing the 2 bombers, Boeing's President was quoted as saying, would be like comparing a kiddie-car and a Cadillac. In fact, designing the B–29 had required 153,000 engineering hours; the B–52, 3,000,000. In any case, it would take until August 1952, long after the

YB-52 flew, to get the rival YB-60 out of potential production;[18] several more months for SAC to dispose of the B-47Z competitor,[19] and until mid-1953 for the B-52 program to get truly under way.

Other Delaying Factors 1951-1954

Had the Air Force endorsed Boeing's early request for tooling, it is questionable whether this would have made much difference. Because of the Korean conflict, the tooling industry was unable to meet the demands of the aircraft manufacturers. Another related problem prevailed, however. After World War II, many trained aircraft personnel of necessity migrated to other jobs. These people had to be regrouped and retrained. And, with industry booming nationwide as a result of the Korean War, military procurement began to compete with commercial production. Although Boeing selected subcontractors in the spring of 1951,[20] (immediately following the production letter contract for 13 B-52As), the low priority assigned to the B-52 by the Air Staff was a formidable handicap.[21] Even more serious, according to

[18] The YB-52 made its first flight on 15 April 1952; the YB-60, on the 18th—Convair flying its modified B-36 only 14 days after receipt of the prototype's eighth engine. The initial scarcity of J57 engines (also used by North American F-100 Super Sabres) presented problems. The worried Boeing contractor was being troublesome and kept on reminding the Air Force that the company had been led to believe that it would receive priority allocations of the new engines—particularly over Convair. The issue, however, did not reach serious proportions. The Air Force lost interest in the YB-60 in August 1952, after the aircraft's performance flaws tarnished its first bright prospects. The B-60 project was officially canceled in January 1953, the 2 experimental planes being scrapped in July 1954.

[19] Boeing B-47Z, also earmarked to receive J57 engines, was the last stumbling block to large-scale B-52 production. SAC won the debate in late 1952, after preparing a convincing new study of the problems at hand. To begin with, the B-47Z had a limited growth potential, but the B-52 was in its comparative infancy. The B-52 could carry more atomic weapons than the B-47Z. The latter, because of its weight limitations, would be less suitable to deliver hydrogen bombs. With almost uncanny vision, the SAC study concluded that it would be a serious mistake not to procure an adequate B-52 force.

[20] Boeing used 2 main criteria for its selection—availability of labor and wartime experience. The major subcontractors eventually picked were the A. O. Smith Co., of Toledo, Ohio, for landing gears; the Kaiser Manufacturing Co., of Richmond, Calif., for profile milling items; the Rohr Aircraft Corporation of Chula Vista, Calif., for drop tanks, power pods, and tail compartments; the Briggs Manufacturing Co., of Detroit, Mich., for rudders, elevators, vertical fin flaps, ailerons, spoilers, and outboard wings; and the A. O. Smith Co., of Rochester, N.Y., for weldments.

[21] At its inception, the program was assigned "S" priority position #63 which was exceedingly low and augured poorly for the successful accomplishment of stated production schedules (1 aircraft per month, at first; 4, later). It was not until September 1952 that the

an Air Force team that analyzed the situation, was "a general inability to adequately plan for the magnitude and complexity of the program." In summary, the protracted B-52 development was caused on one hand by revolutionary changes in aircraft design and propulsion; on the other, by uncertainty within the Air Force as to how far and in what direction it could go in utilizing these changes. As to the early production delays, the program's low priority was an obvious factor. Another cause, the Air Force believed, were defects in the overall organization originally set up by Boeing. Finally, production slipped to allow incorporation of mandatory changes that were identified during the early testing phases of the X and YB-52s.

Program Increase — August 1953

The procurement plans of 1951-1952 underwent many changes. In keeping with almost traditional patterns, the B-52's early production was shaped by deletions, additions, and reconfigurations. The letter contract of February 1951 was amended on 9 June 1952—several months before the definitive contract was signed. Consequently, although 13 B-52As had been initially ordered, only 3 were built. As was usually the case, the second model in the aircraft series bore the brunt of the changes. Against this routine background, important events unfolded. The Air Force, during the first half of 1953, finally endorsed a sizeable B-52 program. Made official in August 1953, the decision called for 282 aircraft—enough to equip 7 SAC wings. Since the Air Force wanted Boeing to deliver the aircraft between October 1956 and December 1958, another plant would be needed. Actually, an additional plant had been approved in mid-1951 and canceled within a few weeks. But this time, the decision stood firm. Harold Talbott, who had succeeded Mr. Finletter as Secretary of the Air Force on 4 February 1953, announced the action on 28 September. Boeing's second facility, established at Wichita, Kansas, eventually surpassed the Seattle plant in B-52 production.

B-52A Roll-Out — 18 March 1954

The Air Force chose to honor its new bomber months before it flew, with a factory roll-out ceremony attended by Gen. Nathan F. Twining, Air Force Chief of Staff since 30 June 1953. Addressing the several thousand

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priority level was raised to #27, but by this time slippages had occurred that were not recoverable.

people assembled at Boeing's Seattle plant, General Twining said: "The long rifle was the great weapon of its day. . . . Today this B-52 is the long rifle of the air age." The very existence of these global jet giants, General Twining stressed, would be a powerful deterrent against attack, for the Stratofortresses were designed to deliver devastating blows deep behind any aggressive frontier.

First Flight (Production Aircraft) 5 August 1954

The Air Force accepted the initial B-52A (Serial No. 52-001) in June 1954—2 months before the aircraft's first flight—and returned it immediately to Boeing for use in the test program. For the same purpose, the other 2 B-52As were also loaned to Boeing as soon as accepted.

Total B-52As Accepted

The Air Force accepted 3 B-52As—the total built by Boeing. The 10 other B-52As, ordered in early 1951, were completed as B-52Bs.

Acceptance Rates

All 3 B-52As were accepted in 1954, 1 each in June, August, and September.

End of Production 1954

B-52A production ended in September, with delivery of the third plane.

Flyaway Cost Per Production Aircraft $28.38 million[22]

Airframe, $26,433,518; engines (installed), $2,848,120; electronics, $50,761; ordnance, $9,193; armament, $47,874.

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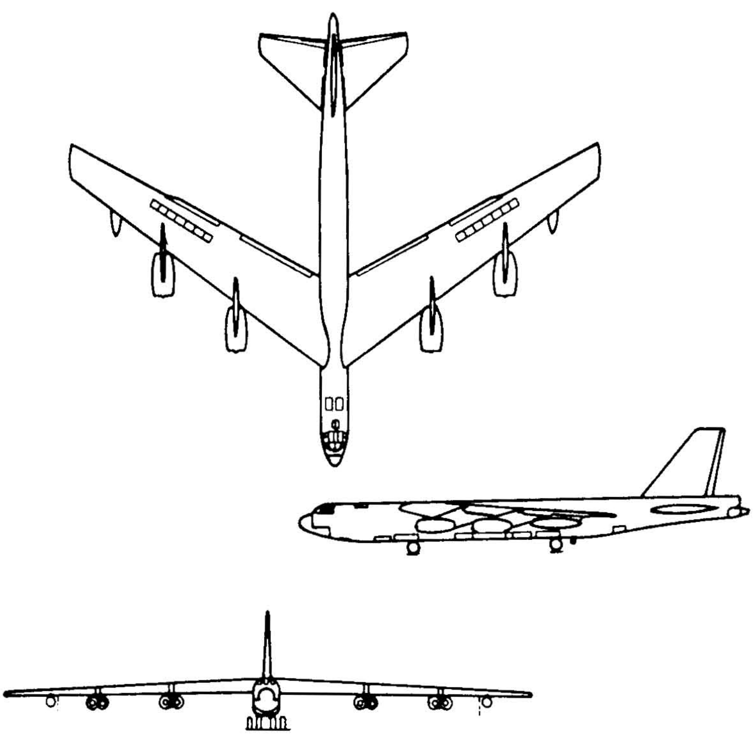
22 Somewhat cheaper than the X and YB-52s, but not much. Air Force records carried the production B-52As at such seemingly fantastic prices because the aircraft were essentially experimental, with much of the initial tooling and new development costs charged against them.

The first B-52A was "rolled out" of the Boeing Seattle plant in March 1954.



Subsequent Model Series — B-52B

Other Configurations — NB-52A[23]

The last B-52A (Serial No 52-003) was redesignated NB-52A in 1959, after being modified to carry the North American rocket-powered X-15. The origin of the X-15 project dated back to the mid-1950s, when the United States became deeply interested in the space age and manned space flight. The program was a joint venture by the National Advisory Committee for Aeronautics,[24] the Air Force, and the Navy, with the X-15 conceived as a means to obtain technical data on hypersonic aeronautics. As it turned out, the immediate beneficiary of the X-15 flights was the manned space program, and the X-15 established itself as a most successful research aircraft. But the NB-52A's mother ship role, although less spectacular, was important and later a second B-52 became involved. For its part, the B-52A had to undergo extensive as well as permanent modifications by North American and USAF technicians. Specifically, a 6- by 8-foot section was cut out of the B-52's right wing flap to make room for the X-15's wedge tail. A pylon to mate the X-15 to the NB-52 was installed between the bomber's inboard engines and the fuselage. Lines and wires that held the X-15 below the NB-52 passed through this pylon. Large liquid oxygen tanks were placed in the B-52's bomb bays for topping off the X-15's liquid oxygen system prior to separation. A closed circuit television system was added so that the B-52 crew could carefully watch the X-15 and its pilot prior to launch. Finally, there was an elaborate launch control system to make sure that the X-15 was released at precisely the right instant. Captive flights to check out the X-15 and X-15/B-52 combination began at Edwards AFB on 10 March 1959. On 8 June, the first true flight occurred, but the rocket was not lit and the X-15 was flown as a glider. The first rocket-powered flight came in

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[23] The letter N was a prefix used by the Air Force to denote that an airplane (bomber, fighter, and other aircraft alike) was assigned to a special test program and that the aircraft had been so drastically changed that it would be beyond practical or economical limits to bring it back to its original or to standard operational configuration. Besides the familiar X and Y, 3 other so-called classification letters were used as status prefix symbols: namely, the letter G, which denoted an aircraft permanently grounded, utilized for ground instruction and training; J, temporarily reconfigured for special tests; and Z, in planning or predevelopment stage. As of late 1973, all 3 services of the Department of Defense still applied this medium to identify the status of their aircraft.

[24] The National Advisory Committee for Aeronautics, a federal agency established by Congress in 1915, did research for the benefit of commercial and military aviation. The advisory committee was absorbed by the National Aeronautics and Space Administration in the fall of 1958, becoming in the process the organizational core of the newly created agency.

September, with the NB–52A eventually participating in 59 of the 199 X–15 flights conducted before the program's end in 1968.

Phaseout 1960

The B–52A phaseout began in 1960, when the first of the 3 aircraft was retired after being test flown from Edwards AFB at take-off weights up to 415,000 pounds.

B-52B

Manufacturer's Model 464-201-3

New Features

Increased gross weight (420,000 instead of 405,000 pounds), the MA-6A bombing navigation system, and more powerful engines were the main differences between the B-52B and the preceding B-52A. Also, in contrast to the B-52As, some of the B-52Bs could be fitted with "capsule" equipment for reconnaissance duties.[25] In the latter case, the 6-man crew B-52B became an 8-man RB-52B crew.

Configuration Planning — February 1951

Boeing started working on the B-52B design in February 1951, concurrent with signature of the first production document.

Design Improvements — 1951-1954

Because the aircraft design was derived from the B-47, the B-52B (as well as the fairly similar B-52A) benefited from the start from hard-earned experience. Always hovering over the program was the specter of the B-47's initial deficiencies and delays. Both the contractor and the Air Force seemed determined that the B-52 would not endure such problems. Characteristics of the intensive B-52 development were 670 days of testing in the Boeing wind tunnel, supplemented by 130 days of aerodynamic and aeroelastic testing in other facilities. In essence, Boeing personnel designed, built, and developed the B-52 as a well-knit, integrated packaged system. Parts were thoroughly tested before being installed in the new bomber. Improvements suggested by the YB-52's early flight tests appeared on B-52B production lines. That these changes were few remained worthy of note. Test reports were generally pessimistic, concerning themselves with every aerodynamic

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[25] The result of another policy reversal. See pp 235-236.

fault, however serious or minor, suspected or real. In 1953, more often than not, the published account of a B-52 test flight included the unusual statement that "no airplane malfunctions were reported." But the B-52B development was lengthy. Moreover, several B-52Bs, although earmarked for SAC, were diverted to the test program before joining the operational forces. The B-52B's early participation in complex flight tests soon pinpointed desirable production improvements—giving way in turn to new models in the series. Nevertheless, the airplane was considered to be outstanding, and the praise of Maj. Gen. Albert Boyd, the Wright Air Development Center's Commander, would long be remembered. General Boyd, who was also one of the Air Force's foremost test pilots, in May 1954 said that the B-52 was the finest airplane yet built. In a lighter mood, the general told his staff that someone should try to discover how "we accidentally developed an airplane that flies so beautifully."

Procurement Changes 1952-1955

Letter Contract AF33(600)-22119 of September 1952, which called for 43 RB-52Bs, gave way to a definitive contract that was signed on 15 April 1953. In May 1954, an amendment to this contract reduced the number of RB-52Bs by 10 (leaving 33 RB-52Bs on order) and directed construction of the canceled planes in the configuration of the next model series (RB-52C). The May 1954 amendment also added 25 other RB-52Cs on the 15 April 1953 contract. Hence, even though a sizeable B-52 program had been approved in mid-1953, Boeing in May 1954 had only 88 airplanes under contract—3 B-52As, 17 RB-52Bs (per definitive contract AF33(038)-21096 of November 1952), 33 RB-52Bs, and 35 RB-52Cs. Moreover, forthcoming procurement would not affect the current program—the first new order in August actually calling for still another B-52 model. Just the same, the modest program so far endorsed was not immune to further changes. Of significance, from the early procurement standpoint, was an Air Force decision, made official on 7 January 1955, that flatly reversed the Air Staff directive of October 1951. It gave the B-52 first priority as a bomber and once again relegated the aircraft's reconnaissance potential to a secondary role.[26] As a result of the new decision, the 50 RB-52Bs and 35 RB-52Cs

[26] The January 1955 decision coincided with a procurement order for several specialized reconnaissance versions of the Martin B-57 Canberra. These planes would all go to the Strategic Air Command, sometime in early 1956. In the ensuing years, SAC also got a contingent of high-altitude, reconnaissance U-2s, developed by Lockheed and first flown in 1955.

were redesignated B-52Bs and B-52Cs, respectively. Besides, as finally built, 23 of the 50 B-52Bs could not be used for reconnaissance.

Production Slippages 1953–1954

As planned in early 1951, B-52 deliveries were due to start in April 1953. A 15-month slippage soon occurred, because of the Korean War and its many implications. Revised production schedules set up in June 1952 called for the B-52Bs to be delivered between April and December 1954, but additional procurement (finalized in April 1953) extended deliveries to April 1956. Meanwhile, the Air Force accepted 2 B-52Bs in 1954—1 in August and 1 in September. However, scheduled deliveries were suspended for 90 days, while Boeing engineers sought to correct cracking in the landing gear trunnion forgings. This second loss of time was never recouped, the last B-52B reaching the Air Force in August 1956—3 months behind schedule. Yet, once the Air Force decided to go ahead with large-scale procurement, the bulk of the production program went forward with few delays.

First Flight (Production Aircraft) December 1954

Boeing first flew the B-52B in December 1954. Like the B-52A (and subsequent models in the series), the B-52B Stratofortress was impressive. The new aircraft had twice the wingspan and nearly 3 times the wing area of the B-17, and its 8 engines delivered 10 times the power of the B-29. The B-52B's tail fin stood as tall as a 4-story building, while the bomber's length of almost 157 feet spanned over half the length of a football field. The B-52B's wingspan of 185 feet represented a greater distance than that travelled by Orville Wright in his historic first flight at Kitty Hawk, North Carolina.

Enters Operational Service 29 June 1955

SAC assigned its first B-52, a B-52B (Serial No 52-8711) that could be converted for reconnaissance, to the 93d Heavy Bomb Wing, at Castle AFB, California. The 93d, a former medium bomb wing flying late model B-47s, used its new aircraft for crew transition training. SAC had planned from the start that the B-52s would be integrated into B-36 units on a 1-for-1 replacement basis—with retired B-36s being salvaged. Also, units would be converted 1 squadron at a time to facilitate B-52 operations and to prevent problems likely to arise in the assignment of maintenance equipment.

Combat ready on 12 March 1956, the 93d Wing regressed to a nonready status 2 months later, when it was authorized 15 additional B-52s. The wing was again fully operational on 26 June 1957, after crew training had become its primary mission.[27] Most of the B-52Bs produced were assigned to the 93d. A few early B-52Bs were first earmarked for testing, but they too ended with the heavy bomb wing.

Initial Problems 1955

Uncertain B-52 delivery schedules precluded proper budget planning, affecting in turn crew training, maintenance scheduling, and stocking of spare parts. There were shortages of ground support equipment, dual bomb racks, crew kits, electronic countermeasure components and training items. Delayed construction of maintenance facilities, the lack of warehouse space to store flyaway kits, as well as shortages of operational facilties for squadron briefings and other functions were serious handicaps. In addition, the failure of B-52 ramps and taxiways together with runway deterioration interfered with operations. These initial problems, practically resolved at Castle AFB by the end of 1955,[28] were to prove far more severe at many of SAC's future B-52 bases.

Early Deficiencies 1955-1956

Fuel leaks, icing of the fuel system, imperfect water injection pumps, faulty alternators and, above all, deficient bombing and fire-control systems were the main troubles of the early B-52Bs. However, these deficiencies as a whole were not as severe as those usually encountered by a new bomber,

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[27] The Air Training Command had no B-52 school, and SAC's new bombers had to become operational as soon as possible. The best way to solve the problem was for SAC to handle the training of B-52 crews with a combat crew training squadron. This did not create a precedent, the same procedure having been used in SAC's B-36 training program at Carswell AFB, Tex. The 4017th Combat Crew Training Squadron was established at Castle AFB on 8 January 1955, as an integral part of the 93d Wing. When the B-52 training task became too great for 1 squadron, the wing's 3 other squadrons took over flight training, with the 4017th assuming ground instruction and the administrative phase of the program. As a rule, the training program consisted of 5 weeks of intensive ground school and 4 weeks of flight training, totaling between 35 and 50 hours in the air.

[28] Castle AFB's parking ramp and runways were strengthened to handle 450,000-pound loads (the forthcoming B-52C's expected take-off weight). The width of the taxi strips was increased 175 feet. In October 1955, postflight B-52 docks, as well as operations and engineering buildings were under construction. A large hangar had been completed.

and far less distressing than those experienced by the B-47 at the same stage of its career. In any case, most of the B-52B's initial problems were not entirely unexpected. Air Research and Development Command and Air Materiel Command had been insisting for months that the aircraft should be perfected before delivery. Strategic Air Command, in contrast, steadfastly objected to further postponement,[29] believing the aircraft should be accepted and modified at a later date—which they were. SAC's objections to more delay were not inconsistent. General LeMay continued to press for the best weapon system for his force. But after approval of a configuration as nearly perfect as possible, the SAC Commander thought too many immediate improvements, refinements, or additional requirements could well be self-defeating. As late as February 1955, SAC protested against "unneccessary changes;" pointed out that operational units would benefit from "more standardization" in the B-52s; and asked to participate in the coordination of all engineering change proposals. While AMC, which was assigned executive responsibility for the new bomber, did not wish to concede any of its engineering prerogatives, SAC did get its way. Some 170 engineering change proposals suggested for the first 20 B-52s were reduced to 60 by the end of March.

Other Temporary Flaws 1955-1956

In October 1955, Boeing engineers had yet to solve the problem of cabin temperatures. The pilots, sitting high in the nose, were comfortable at a given heating setting. However, observer and navigator, sitting with their feet against the bottom of the fuselage, with the metal sometimes reaching 20 degrees below zero, suffered from the cold—the wearing of winter underwear, heavy clothing, and thick flying boots hardly helping.[30] Conversely, if enough heat was turned on to keep the observer and navigator warm, the pilots became overheated. Pilots also criticized the new bomber's high-frequency communications system. First installed in the B-47, the AN/ARC-21 long-range radio was proving even less reliable in the B-52.

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[29] Most in the Air Force seemed to agree that production should wait until research and development had worked most of the kinks out of any new aircraft. Yet different opinions cluttered the key issue of determining at what point an article was ready for full-scale production. One might conclude that SAC, ill-equipped at the time for its awesome responsibilities, wondered how much caution and time it could reasonably afford.

[30] The problem was compounded by another factor for which the B-52 could not be blamed. The development of personal equipment lagged years behind airframe and engine. Crew MC-1 spacesuits, parachutes, and other paraphernalia were uncomfortable. Crew fatigue from flying the new bomber was often insignificant, compared to that caused by wearing all this survival equipment.

Engine Problems 1955-1956

The J57 engines of the B-52 at first presented a serious problem. The principal difficulty persisting in mid-1955, when the aircraft started reaching SAC, was that none of the various J57s performed adequately with water injection, a process due to augment the engine's thrust at takeoff. The YB-52's J57-P-3 engine had been discarded after many modifications failed to keep it from shutting down at high altitude, regardless of speed. In addition, the power-poor and therefore temporary P-3 could not use water.[31] Equally frustrating were concurrent difficulties with other models of the J57, which left the P-1W as the only fully-qualified engine, even though its performance was substandard. Although fitted for water injection, this model had to be used as a dry engine. For lack of anything better, about one-half of the B-52B fleet was fitted with P-1Ws. The J57-P-9W, slated to succeed the P-1, ran into trouble. It was a lighter engine, incorporating titanium components. Unfortunately, the titanium compressor blades cracked as a result of both forging defects and of substandard metal containing too much hydrogen. A return to steel parts, at a weight penalty of 250 pounds, produced the J57-P-29W[32] and J57-P-29WA engines, which equipped most other B-52Bs. However, by mid-1956 the titanium problems had been solved and the P-19W, a higher-thrust version of the titanium-component P-9W, appeared on the last 5 B-52Bs.

Grounding 1956

The Air Force surmised that the first fatal B-52 accident in February 1956 was caused by a faulty alternator. Twenty B-52Bs, carrying the suspect equipment, were immediately grounded. In addition, the Air Force stopped further B-52 deliveries. In mid-May, after Boeing seemed reasonably convinced that the alternator problem was solved, more aircraft were accepted. However, the alternator problem later resurfaced. The B-52Bs were again temporarily grounded in July, this time because of fuel system

[31] Even before the B-52 was built engineers recognized that a serious thrust problem would show up during a fully loaded takeoff, particularly on days when runway temperatures approached 100 degrees Fahrenheit. For a while, it seemed jet assisted takeoff units would be needed to provide reserve auxiliary thrust. The Air Force canceled such a project in April 1954, following Pratt and Whitney's successful development of a water injection system that promised to rectify the thrust deficiency. The unexpected difficulties that followed were serious, but not insurmountable.

[32] The rate of water that could be injected in the P-29W engine was only half that of the P-29WA. Subsequent modifications brought the P-29W to the P-29WA's standard.

and hydraulic pack deficiencies. Although this latest grounding did not last long, the 93d Wing's training program suffered. In mid-year, no combat-ready crews were available for the 42d Heavy Bomb Wing's new B-52s.

Support Achievements 1955–1956

The lessons learned during the B-47 conversion program were put to good use in preventing many B-52 maintenance and supply problems. Specialists associated with jet engines, the repair of fuel tanks, and the maintenance of all kinds of systems (bombing, navigation, hydraulics, electrical, and the like), were dispatched to Air Training Command for schooling on B-52 components, their education proving easier than their original transition from propeller-type aircraft to the jet-powered B-47. Other steps were taken to avoid, or at least to minimize, potential difficulties. After 2 years of bickering with SAC, AMC finally consented to establish special holding accounts at various supply depots for ground support equipment. The "Z" accounts, as they were known by 1955, had two distinct advantages. First, they segregated the various equipment needed by the B-52. Secondly they ensured that the 800 or so B-52 line items, which they eventually comprised, would be used exclusively in support of such aircraft. Once the "Z" accounts were established, SAC made certain that all available support items were in place, whether at Castle or elsewhere, prior to the arrival of any B-52. Yet, the Air Staff agreed with SAC that much more would be necessary to thwart other possible support problems of the B-47 type. As a result, in the summer of 1955 the Air Staff asked AMC to study how to speed up the repair of future malfunctions reported by operational units. The Air Staff's request and ensuing discussions between AMC and SAC representatives gave way to Sky Speed, a program organized by AMC's Oklahoma Air Materiel Area. And, before long, Sky Speed set up 1 contractor maintenance team of 50 people at every B-52 base. The Sky Speed teams did not participate, even indirectly, in the important modification projects subsequently done at the Boeing-Wichita plant. Nor did they take over the depot workload of the San Antonio Air Materiel Area, which was responsible for the B-52 inspect and repair as necessary (IRAN) program. However, the teams did reduce the time B-52s spent at the depot by doing much of the work that would ordinarily await the IRAN cycle. The maintenance teams practically kept the aircraft flying, because they immediately corrected noted safety deficiencies, installed fixes, and performed a great many other technical chores. As a rule, it took an average of 1 week for a B-52 to go through a Sky Speed routine checkup, and each B-52 received at least 1 checkup per year.[33]

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[33] By 1958, Sky Speed had reaped such success that a similar program was being devised for SAC's KC-135s.

Post-Production Modifications 1956–1958

Sunflower, a modernization project handled by Boeing, brought 7 early B–52Bs to the configuration of the next model in the series (B–52C). Started in the summer of 1956 at the Wichita plant, the project involved the installation of approximately 150 kits. Sunflower took time to accomplish; the last modified B–52B was not returned to SAC until December 1957. B–52Bs underwent many other modifications. They participated in such projects as Harvest Moon, Blue Band, and Quickclip, all of which were first initiated for the benefit of subsequent B–52 models.

End of Production 1956

The Air Force took delivery of the last B–52B in August.

Total B–52Bs Accepted 50

The Air Force accepted 50 B–52Bs, 27 of which qualified as RB–52Bs.

Acceptance Rates

The Air Force accepted 13 B–52Bs in fiscal year 1955 (the first one in August 1954); 35 in FY 56, and the last 2 in FY 57 (1 each in July and August 1956).

Flyaway Cost Per Production Aircraft $14.43 million

Airframe, $11,328,398; engines (installed), $2,547,472; electronics, $61,198; ordnance, $11,520; armament, $482,284.[34]

Subsequent Model Series B–52C

[34] Cost breakouts were sometimes undeterminable and occasionally misleading. For instance, contractor-furnished equipment such as electronics might be included in the airframe's cost, instead of being broken out to its proper category. Similarly, the costs of some components and subsystems were often lumped under armament, a category carried on Air Force records as "other, including armament."

Other Configurations RB-52B and NB-52B

RB-52B—Development of the RB-52B, once briefly referred to as the RX-16,[35] dated back to the early part of 1951. The reconnaissance model featured multi-purpose pods[36] carried in the aircraft's bomb bay. Initially, 17 pods were ordered, solely as flight test articles. The pods were pressurized and equipped with downward ejection seats for the 2-man crew. For search operations, the multi-purpose pod contained 1 radar receiver (AN/APR-14) at the low frequency reconnaissance electronic station, and 2 radar receivers (AN/APR-9) at the high frequency station. Each station had 2 pulse analyzers (AN/APA-11A), with which to process the collected data. The pod also housed 3 panoramic receivers (AN/ARR-88), and all electronic signals were recorded on an AN/ANQ-1A wire recorder. Photographic equipment consisted of 4 K-38 cameras at the multi-camera station, and 1 camera (either a T-11 or K-36) at the vertical camera station. For mapping purposes, the pod had 3 T-11 cartographic cameras. A December 1951 mockup inspection of the multi-purpose pod went well, no major changes being requested. SAC wanted a special electronic reconnaissance (or ferret) pod but this project did not encounter the same success. Work at Boeing progressed smoothly. Air Research and Development Command ascertained that 1 ferret pod-equipped aircraft could gather in a single flight all the electronic reconnaissance data formerly obtained by 3 conventional RB-52s. Nevertheless, the Air Staff canceled the project in December 1952, and a second SAC request in 1954 for a separate ferret pod did not fare any better. By 1955, however, the original multi-purpose pods had become "general purpose capsules," carrying the latest search, analysis, and direction-finding devices. While the more modern capsules might not satisfy all of SAC's requirements, they constituted clever, if temporary, cost-saving expedients. The capsule, which could be winched in and out of the bomb-bay, added only 300 pounds to the weight of the basic aircraft. Finally, the capsule's installation was so simple that it took just 4 hours to convert a B-52 to the reconnaissance configuration. First flown at Seattle on 25 January 1955 (actually, several months ahead of latest schedules), capsule-equipped B-52Bs began reaching SAC's 93d Heavy Bombardment Wing on 29 June. Phaseout of the 27 RB-52Bs followed the B-52B's pattern.

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[35] The X-16 or RX-16 designation, first applied to a post-World War II reconnaissance project, was reserved for the test version of high-altitude aircraft and was never permanently used.

[36] A pod is a compartment or container, often streamlined, attached or incorporated into the outer configuration of an airplane or rocket vehicle. The term is usually qualified. For example, a wing pod is a streamlined nacelle slung beneath an airplane's wing, especially for the installation of a jet engine or engines, while a pod gun was a housing for a machine gun.

NB–52B—After undergoing permanent modifications similar to those made on the last B–52A, the eighth B–52 production was redesignated NB–52B. In this configuration, the new bomber was credited with 140 of the 199 X–15 flights resulting from the NB–52/X–15 combination.[37] The NB–52B also participated in many other important projects, including the lifting body research aircraft program sponsored by the Air Force and the National Aeronautics and Space Administration (NASA). Started in 1966, the program's test flights were still going on in late 1973, with Martin-Marietta's needle-nosed X–24 soon to be tested with the NB–52B. The permanently modified B–52B was also used to test solid rocket boosters for the space shuttle. Moreover, as a mother ship, it was expected to play an active role in the remotely piloted research vehicle program, another joint project of the Air Force and NASA. The NB–52B, like the A-model, carried the price tag of the bomber from which it derived. In each case, however, an additional $2 million was spent to fit the basic aircraft for its many experimental tasks.

Phaseout 1965–1966

In March 1965, SAC began retiring B–52Bs that had reached the end of their structural service life, some of the planes going to the Air Training Command for ground crew training. The first B–52B (Serial No 52–8711), received by SAC 10 years earlier, deserved special treatment. On 29 September, it was donated to the Aerospace Museum at Offutt AFB, Nebraska, for permanent display. The remainder of SAC's 2 B–52B squadrons were earmarked for accelerated phaseout in early 1966, and by the end of June all B–52Bs had been sent to storage at Davis-Monthan AFB, Arizona.

Milestones May 1956

On 21 May, an Air Research and Development Command B–52B, flying at 50,000-foot altitude above the Pacific Ocean, dropped a hydrogen bomb over the Bikini Atoll. It was the first time a B–52 was used as a carrier and drop plane for the powerful thermonuclear weapon.

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[37] After being dropped from the wing of the NB–52B mothership, the X–15 flew to altitudes of more than 250,000 feet and reached speeds exceeding Mach 6, with air friction heating its skin to 1,100 degrees Fahrenheit.

Items of Special Interest

November 1956

On 24 and 25 November, in a spectacular operation called Quick Kick, 4 B-52Bs of the 93d Wing joined 4 B-52Cs of the 42d Bomb Wing for a nonstop flight around the perimeter of North America. The most publicized individual flight was that of a 93d Wing B-52, which originated at Castle AFB and terminated at Baltimore, Maryland, covering some 13,500 nautical miles in 31 hours and 30 minutes. SAC promptly pointed out that the flight would have been impossible without 4 flight refuelings by KC-97 tankers. Also, flying time could have been reduced by 5 or 6 hours with the refueling help of a higher, faster flying all-jet tanker, such as the KC-135 then being developed by Boeing.[38]

January 1957

From 16 to 18 January, in another spectacular operation called Power Flite, 3 B-52Bs of the 93d Bomb Wing made a nonstop, round-the-world flight. With the help of several KC-97 inflight refuelings, the lead plane, Lucky Lady III, and its 2 companions completed the 24,325-mile flight in 45 hours and 19 minutes, less than one-half the time required on the Lucky Lady II flight—the first-ever nonstop round-the-world flight, accomplished in February 1949 by a B-50A that was refueled by KB-29M tankers. The National Aeronautic Association subsequently recognized Operation Power Flite as the outstanding flight of 1957 and named the 93d Wing as recipient of the Mackay Trophy.

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[38] SAC's 93d Air Refueling Squadron at Castle AFB received the command's first all-jet tanker on 28 June 1957. The acquisition of KC-135s meant a great deal to SAC. Mating the new tanker and the B-52 would pay high dividends. It would reduce refueling time and increase safety, the latter remaining a constant goal of the command. Specifically, with a KC-135, the refueling rendezvous could be conducted at the bomber's normal speed and altitude. In contrast, using a KC-97, the B-52 had to slow down and descend to lower altitudes than normal to accomplish the hookup—an exacting exercise.

B-52C

Manufacturer's Model 464-201-6

Previous Model Series B-52B

New Features

Increased gross weight (450,000 instead of 420,000 pounds), larger underwing drop tanks, improved water injection system, and white thermal reflecting paint on the under surfaces were the B-52C's main new features.

Configuration Planning December 1953

As a product of the evolutionary process, the B-52C design did not take shape until December 1953.

First Flight (Production Aircraft) March 1956

Less than 30 months elapsed between design and first flight.

Enters Operational Service 1956

All B-52Cs went to the 42d Bomb Wing at Loring AFB, Maine. The 42d received its first B-52C on 16 June 1956, but did not become combat ready until the end of the year.

Avionics Problems 1956-1957

The B-52 (like the B-47) carried only a tail turret for defensive armament. Providing a suitable fire-control system for the aircraft was particularly important, but proved to be a problem from the start. The A-3 system that equipped the B-52A and a few B-52Bs, was capable of both optical and automatic tracking and search, but because of deficiencies, it was replaced by the MD-5. Installed in most B-52Bs, the MD-5 fire-control system did not live up to expectations. Hence, a theoretically perfected A-3, after reappearing on the last 7 B-52Bs, was fitted in every B-52C. Still unsatisfactory, the A-3 was supplanted by the MD-9 in subsequent B-52 models. The bombing-navigation system was another difficulty of the B-52 program. Moreover, the problem promised to be fairly constant, since any progress was likely to be counteracted by enemy technical developments. The problem of bombing navigation was not new. It had plagued Convair's B-36 and still hampered Boeing's B-47. Actually, the Air Force and various contractors had been wrestling for years with the difficulties associated with accuracy, a primary requirement of any bombing system, multiplied many times in importance by the high cost of nuclear weapons. Simply stated, the bombing-navigation system of the atomic age called for greater instrumental accuracy, increased automatic operation to reduce human error, and immunity from more sophisticated defenses. Two main systems remained under consideration as late as 1953:[39] the K-series bombing-navigation system, which relied essentially on radar and optics, and the MA-2 or Bomb Director for High Speed Aircraft system. The MA-2 combined an optical bombsight, a radar presentation of target, and an automatic computer, together with radar modifications designed for use in high-speed aircraft. The MA-2 appeared ideally suited for both the B-47 and the B-52, but SAC did not believe that the system would be tested sufficiently even by the end of 1955. And while the Strategic Air Command was willing to overlook certain minor deficiencies, it stood firm on the issue that no bombing system that had not been tested or fully approved would be installed in any of its bombers. When the B-52s started reaching the Air Force, neither the K-2 or K-4 bombing-navigation systems of most B-47s, nor the B-36's K-3A had proven satisfactory. For lack of any better system, the K-3A was fitted in some early B-52Bs. However, at altitudes above 35,000 feet, the K-3A became almost useless—loss of definition and poor resolution preventing target identification. The Philco Corporation came to the rescue with a "black box" that increased the K-3A's power output by 50 percent. Yet, this development was merely an expedient, rather than the beginning of a new and improved system. It gave way to the MA-6A bombing-navigation system, a modernized K-3A which was installed in all remaining B-52Bs. Meanwhile, after being rushed through intensified flight tests, the MA-2 kept acting up. In mid-1955, the system still did not perform as well as

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[39] The XB-52, YB-52, and B-52As actually came off production without any bombing-navigation system.

expected and its autopilot was particularly deficient. Nevertheless, progress was being made. A vastly improved system, the AN/ASB-15, initially equipped the B-52Cs. However, technical refinements did not cease, and most B-52Cs were retrofitted with the AN/ASQ-48 bombing-navigation system.

Other Problems 1956-1957

In mid-1956, the Air Force and the Thompson Products Company were still working on a permanent fix for the faulty alternators that had been responsible for the fatal crash of a B-52B. A new Thompson model, in use by 1957, was much better but still troublesome. Problems occurred because of defects in the alternator drive's lubricating system, which used grease instead of oil. This was expected to be corrected before the end of the year. Another B-52 malfunction, detected in March 1957, had to do with the trunnion fittings of the main gear. Defective fittings were found in nearly all B-52Cs.

Post-Production Modifications 1958-1962

A special project, Harvest Moon, increased the B-52C's combat potential to that of the next model in the series. Otherwise, as in the B-52B's case, B-52C post-production modifications were parts of large programs that concerned themselves with the overall improvement of the entire B-52 fleet. None of those programs was initiated for the sake of the small contingent of B-52Cs.

End of Production 1956

All B-52Cs were built in 1956, the last 5 reaching the Air Force in December.

Total B-52Cs Accepted 35

The Air Force received 35 B-52Cs, the total finally ordered. All B-52Cs could readily be converted to RB-52Cs.

Acceptance Rates

The Air Force accepted 5 B-52Cs in FY 56; 30 in FY 57. Actually, 1 B-52C was accepted in February 1956; the rest, between June and December.

Flyaway Cost Per Production Aircraft **$7.24 million**

Airframe, $5,359,017; engines (installed), $1,513,220; electronics, $71,397; ordnance, $10,983; armament (and others) $293,346.[40]

Subsequent Model Series **B-52D**

Other Configurations **RB-52C**

The 35 B-52Cs, like some of the B-52Bs, could easily be fitted for reconnaissance. The RB-52Cs were superior to the RB-52Bs, since they were powered from the start by higher-thrust engines—8 J57-P-29Ws. The RB-52Cs also benefited from the other improvements first introduced by the B-52C. Of special importance to the reconnaissance role was the extra fuel carried by the C-model, which significantly extended the aircraft's unrefueled range.

Phaseout **1971**

All B-52Cs were phased out of the active forces in 1971. A B-52C (Serial No 53-402) of the 22d Bomb Wing at March AFB, California, was the last one to be retired. The aircraft reached the storage facility at Davis-Monthan AFB on 29 September, only 3 months later than planned some 5 years before.[41]

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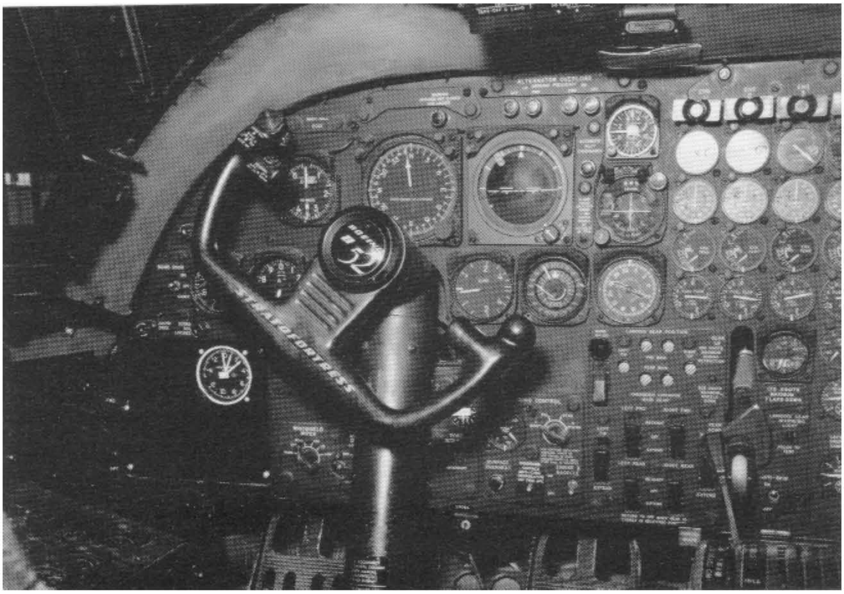
[40] Increased production meant lower unit costs. First beneficiary was the B-52C, acquired at half of the B-52B's price.

[41] In December 1965, a few months after the first B-52Bs started leaving the operational inventory, Robert S. McNamara, Secretary of Defense from 21 January 1961 to 29 February 1968, announced another phaseout program that would further reduce SAC's bomber force. Basically, this program called for the mid-1971 retirement of all Convair B-58s, of the B-52Cs, and of several subsequent B-52 models. Secretary McNamara in December 1965 also stated that 210 General Dynamics FB-111s would be purchased to replace SAC's phased-out bombers. The forthcoming strategic FB-111, closely related to the once highly controversial TFX, was a modified version of the F-111. As such, information on the FB-111 was included in Volume I, *Post-World War II Fighters, 1945-1973*, published by the Office of Air Force History. However, some of the controversies generated by the FB-111 procurement are covered in this volume, in connection with the B-70, AMSA (Advanced Manned Strategic Aircraft), and B-1A projects. See Appendix II, pp 559-593.



View of a B-52 instrument panel.

A Boeing B-52C in flight, its under surfaces coated with white thermal reflective paint.

B-52D

Manufacturer's Model 464-201-7

Previous Model Series B-52C

New Features

In contrast to the B-52C, easily convertible to the reconnaissance configuration, the B-52D was equipped exclusively for long-range bombing operations. This was initially the most telling difference between the two. Like some of the B-52Bs, the preceding B-52Cs, and subsequent B-52 models, the B-52Ds could carry the newly developed thermonuclear weapons, all necessary modifications being incorporated on the production lines.

Configuration Planning December 1953

As in the case of the B-52C that it so closely resembled, the B-52D's design was initiated in December 1953.

Additional Procurement 1954-1956

The B-52D marked the beginning of the B-52 large-scale production. It reflected the mid-1953 decision to raise procurement and Secretary Talbott's final endorsement of a second production plant. The B-52D program also benefited from ensuing program increases, and the "D" became the second most-produced B-52 model. The aircraft were ordered under 4 separate contracts. The first, AF33(600)-28223, finalized on 31 August 1954, covered 50 aircraft; the second, AF33(600)-31267, signed on 26 October 1955, involved 51 B-52Ds and 26 B-52Es—the next model in the series. Like preceding B-52s, the new planes were to be built at the Boeing Seattle plant. The other 2 contracts, AF33(600)-26235 and AF33(600)-31155, finalized on 29 November 1954 and 31 January 1956 respectively, totaled 69 B-52Ds and 14 B-52Es—all to come from Boeing's new production facilities in Wichita, Kansas. The 4 contracts, as well as those that covered other B-52Es and subsequent B-52Fs, were of the fixed price type, with redeterminable incentives.[42]

First Flight (Production Aircraft) — 4 June 1956

The Air Force accepted the initial B-52D, a Wichita production, in June 1956, on the heels of the aircraft's first flight. The new Seattle-built B-52D, first flown on 28 September, joined the testing program immediately.

Enters Operational Service — December 1956

The new B-52Ds did not reach SAC before the fall of 1956. The first few went to the 42d Bomb Wing, at Loring AFB, replacing the wing's initial B-52Cs. Before the end of December, several B-52Ds had also begun to reach another SAC wing, the 93d. However, while the B-52 inventory at the time already counted almost 100 B-52s (40 B-52Bs, 32 B-52Cs, and 25 B-52Ds), combat-ready crews lagged behind, with only 16 in the 42d Wing and 26 in the 93d. But the command did quickly resolve this problem. Less than 2 years later, SAC had 402 combat-ready crews for 380 B-52s.

Operational Problems — 1957-1962

B-52Ds encountered the same initial problems as preceding and subsequent models. They were hampered by fuel leaks, icing of the fuel system, and malfunctions of the water injection pumps. After much frustration, the cause of the pump's failure was uncovered. It was simply due to the fact that the water pumps kept operating when the water tanks were empty. The installation of water sensors was the answer. This was done by Sky Speed teams as part of the water injection system's overall improvement program, which was completed by the spring of 1959. Other problems, however, took longer to solve.[43]

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[42] In 1962, when production ended, 16 definitive contracts had been concluded. In addition, the B-52 program was tagged with at least 25 miscellaneous contracts for special studies, special flight tests, the procurement of mobile training units, of flight simulators, and of other related items.

[43] See B-52F, pp 266-267.

Other Problems 1957–1959

As B–52Ds were becoming more plentiful, B–52Es and B–52Fs were also reaching SAC. Concurrently, the command's base facilities kept deteriorating. The eagerly awaited B–52s put stresses on runways that had been designed for the lighter B–47s or the slower B–36s. SAC's problems were further compounded by the large size of the first B–52 wings, generally composed of 45 bombers and 15 or 20 tankers, all situated on 1 overcrowded base.[44] In mid-1958, paving projects started at 9 of 13 bases which, the command pointed out, needed immediate attention. Paving costs alone were estimated at $25 million. Congress also approved $232 million under the fiscal year 1959 military construction program to cover projects programmed by SAC, but an additional $210 million was denied. While few of the requested alert facilities were affected, drastic cuts were made in other SAC construction projects. Strangely enough, the facilities shortage was alleviated somewhat by another problem. In the late fifties, as the Russian missile threat became more pronounced and warning time shrank, SAC bases presented increasingly attractive targets. The only immediate solution was to break up these large concentrations of aircraft and scatter them over more bases.[45] Existing B–52 wings therefore were broken up into 3 equal-size units of 15 aircraft each. Two units would normally be relocated at bases of other commands, which was not an ideal arrangement since runway deficiencies, as well as other difficulties, would be sure to materialize. In essence, after 1958 each dispersed B–52 squadron became a strategic wing, usually accompanied by an air refueling squadron of 10 to 15 aircraft. The same principle would be followed in organizing and equipping the still growing B–52 force.

"Big Four" Modification Package 1959–1963

Concurrent with the increasing Russian missile threat and the beginning of the B–52 dispersal program, a new difficulty came to light. Namely, there was no longer any doubt that the Soviet Union had developed formidable defenses against high altitude bombers. Of some consolation, enemy defenses were known to be far less reliable and potentially successful against low flying aircraft. Undeterred by the fact that its new B–52s had been

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[44] The early and mid-fifties expansion of the bomber force compelled some of the SAC bases to support as many as 90 B–47s and 40 KC–97 tankers.

[45] In the B–47's case, dispersal was a long-range program. It would be accomplished primarily through the phaseout of wings in the late fifties and early sixties.

designed for high-altitude bombing, SAC wasted no time in planning the best way to face its new challenge. To begin with, all B-52s, except for the early B-52Bs, would have to be capable of penetrating enemy defenses at an altitude of 500 feet or lower, in any kind of weather, and without impairing the bomber's inherent high speed at high altitude. Two other necessary steps were to equip all B-52s, modified for low level, with Hound Dog missiles and Quail decoys, so far due to be carried only by the latest B-52s. SAC's fourth requirement was to add an AN/ALQ-27 electronic countermeasure (ECM) system in every modified B-52. This system, the command believed, would allow the B-52 to automatically counter ground-to-air and air-to-air missiles, airborne and ground fire-control systems, as well as the early warning and ground control interception radars of the enemy. Although the requirements outlined by SAC would involve significant modifications and the addition of complex and costly components, they were approved by Headquarters USAF in November 1959. There was an immediate exception, however. The AN/ALQ-27 production was canceled. The command had wanted 572 B-52s fitted with the new AN/ALQ-27, which promised to integrate all ECM functions into one major subsystem, but this modification alone would cost over $1 billion. The Air Staff chose instead a quick reaction capability (QRC)/ECM combination of black boxes that would cost much less. The B-52H (last of the B-52 model series) would feature this equipment from the start, and it would be retrofitted in other B-52s. However, deletion of the AN/ALQ-27 was not to be the program's only setback. Although eventually successful, the "Big Four" low-level modification—also identified as modification 1000—had to overcome numerous difficulties. First was the lack of money. In early 1960, the Air Staff constantly reiterated that a maximum effort was necessary to eliminate complexities and expensive components that promised only incremental improvements. Meanwhile, low-level modification costs had increased from $192 million in November 1959 to $241 million in March 1960. By July, the cost had risen to $265 million. In August, funds were withheld by the Air Staff pending assurance from the Oklahoma City Air Materiel Area that the work would be completed within the $265 million fund ceiling. At the same time, SAC again emphasized that basic requirements should not be compromised just to keep rising costs down. In any case, technical problems also multiplied. At first sight, the low-level modifications appeared straightforward. They called for improvement of the aircraft's bombing-navigation system, modification of the Doppler radar, and the addition of a terrain clearance radar. Low-altitude altimeters also had to be acquired, and each aircraft had to be equipped to carry its newly allocated missiles. The project was actually far more complicated than it seemed, because it covered different B-52 models. In other words, modifications had to be tailored to fit specific configurations. Airframes had to be strengthened, and they also slightly differed from model to model. As a result, low-level modification costs for each B-52C and B-52D aircraft[46] were almost twice as much as for any other B-52. Finally, development of special terrain clearance radars proved more difficult than anticipated. Nevertheless, most low-level modifications were completed by the end of September 1963. Some ECM improvements, due to be accomplished during the aircraft's regular inspect and repair as necessary program, took longer.[47]

Structural Fatigue 1960-On

The phenomenon of fatigue was yet to be fully understood by 1960, but a great deal had been learned from the B-47's structural problems. For instance, it was well established that takeoffs and landings formed one of the primary sources of fatigue damage. In this case, the B-52, with its wing fuel loads, promised to be especially vulnerable. Moreover, there were other known causes of fatigue: atmospheric gusts, maneuver loads, downwash turbulence from tankers during refueling, taxi, buffet, sonic noise, and stress corrosion. Although flying the B-52 at low level was absolutely necessary, SAC knew there would be a price to pay.

The extent of the damage could not be fully predicted, but gusts at 800 feet were 200 times more frequent than at 30,000 feet. At best, it was believed that low-level maneuvers and gust loads would speed the B-52's structural deterioration by a minimum quotient of 8. Justifying the Air Staff's as well as SAC's opinion, Boeing cyclic testing of a B-52F soon showed that numerous manhours would have to be spent on every B-52F in order to alleviate stress in critical areas of the aircraft. Even though the B-52F contingent was not large, strictly mandatory modifications would total at least $15 million. Meanwhile, following the cyclic tests of a B-52G in early 1960, numerous structural fixes were ordered for the entire B-52 fleet, the B-52Bs included. These modifications, soon carried out as the

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[46] Extra structural modifications accounted for some of the additional expenditure. Another factor was upgrading of the aircraft's initial MA-6A bombing and navigation system, finally replaced in 1964 by the ASQ-48. In any case, the whole project was complex, and modifying the ASQ-38 bombing navigational system of subsequent B-52 models also proved costly.

[47] The ECM improvements were programmed to take place in several phases. Phase I was an emergency modification that provided the necessary minimum ECM equipment to cope with the enemy's radar and surface-to-air missile threat. Phase II was essentially an ECM retrofit that was included in the "Big Four" package. The components installed during Phase II were either equal to or nearly as sophisticated as those introduced by Phase III. The best available ECM equipment, comparing favorably to the deleted AN/ALQ-27, was fitted in Phase III and also featured in the B-52H. Except for the first 18, all B-52Hs were equipped in production for all-weather and low-level flying.

Hi-Stress Program, initially consisted of 2 phases. The Phase I High Stress fixes were scheduled when the aircraft approached 2,000 flying hours;[48] Phase II, when it was nearing 2,500.[49] The Hi-Stress Program was not to interfere with the "Big Four" modification package; it was not allowed to fall behind schedule and was practically completed by the end of 1962. Concurrently, because of the results of the B-52F cyclic tests, an unanticipated third phase was started. The High Stress Phase III consisted of inspecting and repairing, as necessary, wing cracks in all early B-52s. Sky Speed teams and personnel of the Oklahoma and the San Antonio Air Materiel Areas again took care of most of the work. But these modifications, as thorough as they were, only marked a beginning. In the mid-sixties, the B-52 remained SAC's primary bomber and modifications were necessary to offset structural weaknesses caused by aging.[50] In the early seventies,

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[48] Phase I counted 9 fixes. The main ones consisted of strengthening the fuselage bulkhead and aileron bay area. Other important fixes were the reinforcement of boost pump access panels and wing foot splice plate.

[49] Phase II called for modification of the upper wing panel splice inboard of inboard engine pods, reinforcement of lower wing panel supporting inboard and outboard pods, reinforcement of upper wing surface fuel probe access doors, and strengthening of a bottom portion of the fuselage bulkhead. Some work was to be done also on the upper wing panel splice, 8 feet inboard of the outboard engine pods.

[50] An engineering change proposal (ECP 1128), approved in 1964, was scheduled for completion in June 1966. It called for various structural improvements, including replacement

The D-model was equipped solely for bombing missions.

similar projects would be undertaken either to beef up or to modernize selected models of the elderly B-52s.

Big Belly Modifications — December 1965

Less than 6 months after the B-52s became involved in the Vietnam War (B-52Fs were the first to go), the Air Force initiated a special modification program to allow the B-52Ds to carry more bombs. Referred to as Big Belly, the modification program left the outside of the aircraft intact. Modified B-52Ds could still carry twenty-four 500-pound or 750-pound bombs externally, but the internal changes were significant. Reconfiguration of the B-52D bomb bay allowed the aircraft to carry 84, instead of twenty-seven 500-pound bombs, or 42, instead of twenty-seven 750-pounders, for a maximum bomb load of about 60,000 pounds—22,000 pounds more than the B-52F.

Overseas Deployment — April 1966

B-52Ds of the 28th and 484th Bomb Wings, deployed to Guam in April 1966, immediately began to replace SAC's B-52Fs in the Vietnam conflict. All B-52Ds committed to Southeast Asia had been modified to carry more bombs than the planes they relieved. In the spring of 1967 modified B-52Ds began also to operate out of U Tapao Airfield in Thailand. From there, the aircraft would complete their mission without inflight refueling, which was necessary when operating from Guam. This saved both time and money.

Additional Training — 1968

Because of the war, SAC established on 15 April 1968 a Replacement Training Unit within the 93d Bomb Wing's 4017th Combat Crew Training Squadron at Castle AFB. The unit's purpose was to cross-train every B-52 crew, from the B-52E through the B-52H model, in the operation of B-52D aircraft. After 2 weeks of training, the crews were used to augment the cadre units in Southeast Asia. This spread out combat duties more equitably among the entire B-52 force and provided the crews needed to meet the increased bombing effort.

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of the vertical fin spar and skin. It would enable most of the B-52s to resume unrestricted operations, but was expected to cost $230 million.

Other Structural Modifications 1966–1968

When a single B-52, set aside for static testing, was subjected to final destruction back in February 1955, its wings accepted 97 percent of the ultimate up-bending load before failing—an entirely satisfactory outcome for the configuration tested. However, since that time, the B-52 had flown many hours and far more years than expected. Furthermore, many of the hours accumulated by the 10-year-old bomber had been flown at low-level, which put a great deal of extra stress on an aircraft structure, originally intended for high-altitude bombing. Therefore, the structural modifications, approved in the mid-sixties as a result of engineering change proposal 1243, came as no surprise. Started in December 1966, this modification program ensured selected B-52s of an additional 2,000 hours of service life. All Big Belly B-52Ds, reconfigured with high-density bomb bays, were automatically earmarked for the work. The others were chosen according to a very straightforward formula. Namely, B-52C, D, or F models qualified if they were nearing their flying maximum of unrestricted "E" hours and had not been tabbed for upcoming phaseout.[51] The modification program was completed during the second half of 1968, at a cost of approximately $16 million, after replacing fatigued structural parts in the most critical wing areas of the involved planes.

Special Modifications 1969–1971

Because they had already been fitted to carry heavier bombloads, a number of B-52Ds were earmarked for another round of modifications. The changes this time would allow the aircraft to carry extra aerial mines. As requested by Deputy Secretary of Defense David Packard in December 1968, the project had been thoroughly reviewed, the Air Force concluding that the suggested modification of later B-52 models would be less efficient and more costly—$6.9 million instead of $6.3 million. Although the Air Force's selection was approved by the Office of the Secretary of Defense in mid-1969, the B-52D special modifications were only completed in the fall of 1971.[52] Not too soon, it seemed, for President Richard M. Nixon ordered the mining of North Vietnam's harbors and river inlets on 8 May 1972.

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[51] The "E" hour was an equivalent used to indicate the fatigue damage accrued in the wing structure of all B-52C, B-52D, and B-52F bombers.

[52] It also took time to finalize logistics agreements with the Navy for procurement, modification, storage, and delivery of mines.

Southeast Asian Losses 1966–1973

The Vietnam conflict cost SAC 22 B–52Ds. Surface-to-air missiles and other ground defenses accounted for 12 of the losses. Ten B–52Ds were lost in operational accidents of one kind or another.

End of Production 1957

The B–52D production ended in late 1957, the last 6 productions being accepted by the Air Force in November.

Total B–52Ds Accepted 170

The Air Force accepted 101 B–52Ds from Seattle; 69 from Wichita.

Acceptance Rates

Only 1 B–52D was accepted in FY 56 (June 1956); 92 in FY 57 (between July 1956 and June 1957); and 77 in FY 58 (all in calendar year 1957).

Flyaway Cost Per Production Aircraft $6.58 million

Airframe, $4,654,494; engines (installed), $1,291,415; electronics, $68,613; ordnance, $17,928; armament (and others), $548,353.[53]

Subsequent Model Series B–52E

Other Configurations None

Initial Phaseout 1973–1974

In accordance with Secretary McNamara's mid-sixties decision to cut

[53] Another price decrease, almost $700,000 below the B–52C's cost.

down the strategic bomber force by mid-1971, SAC inactivated 3 squadrons of B-52D and B-52E aircraft during the early part of 1967. This action, however, did not spell the immediate retirement of the aircraft that had been attached to the inactivated units. Badly needed elsewhere, the Big Belly B-52Ds were immediately used to bolster the resources of the B-52D wings committed to Southeast Asia. The B-52Ds actually outlived 2 subsequent B-52 models. In 1973, a partial retirement of the B-52D fleet was planned. Based on the age and condition of their airframe, 45 B-52Ds were earmarked for phaseout by September 1974.

Operational Status — Mid-1973

In mid-1973, SAC forces still counted about 130 B-52Ds. Some of these aircraft were on their way out—45 by the fall of 1974 and a few others soon afterward. But 80 B-52Ds were expected to see unrestricted service into the 1980s. The Air Force was negotiating a contract with Boeing for the Wichita fabrication of kits and the reworking of wings that would be installed on the 80 B-52Ds, during the aircraft's regular depot maintenance. The cost of extending the B-52D's operational life seemed high, over $200 million for 80 planes, but the Air Force believed it had no alternative.[54] As approved by the Office of the Secretary of Defense on 30 November 1972, the modification, identified as engineering change proposal (ECP) 1581, promised to be extensive. It included redesign and replacement of the lower wing skin, to make it similar to the B-52G wing, and in the process Boeing was to use a more fatigue resistant alloy. The wing center panel was also to be redesigned and replaced. Finally, ECP 1581 called for new upper longerons and some new fuselage side skins. Also, the pressure bulkhead in the B-52D nose would be changed. Already delayed for lack of money, ECP 1581 had been programmed to take at least 2 years.

Record Flights — 26 September 1958

Two B-52Ds of the 28th Bomb Wing, Ellsworth AFB, South Dakota, established world speed records over 2 different routes. One B-52D flew at 560.705 miles per hour for 10,000 kilometers in a closed circuit without payloads; the other, at 597.675 miles per hour for 5,000 kilometers, also in a closed circuit without payloads.

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[54] As explained by Secretary of Defense Elliot L. Richardson to the Senate Armed Services Committee, without the hi-density B-52Ds, the Strategic Air Command's conventional bombing capability would be at the expense of its other missions.

B–52E

Manufacturer's Model 464–259

Previous Model Series — B–52D

New Features

As rolled out of either the Seattle or Wichita plant, the B–52E hardly differed from the B–52D. It was equipped with more reliable electronics, and the more accurate AN/ASQ–38 bombing navigational system replaced the B–52D's final AN/ASQ–48. The relocation of some equipment and a slight redesign of the navigator-bombardier station increased crew comfort and provided better access to instruments and greater maintenance ease. Other dissimilarities between the 2 models grew from post-production modifications.

Configuration Planning — December 1953

As an improved B–52D, the B–52E development dated back to the end of 1953.

Program Increases — 1954–1956

The beginning of large-scale production, the opening of the Wichita plant, and the 7-wing program endorsed in late 1953 did not satisfy General LeMay. The program's long-range increase to 408 aircraft, as approved in March 1954, remained short of his command's requirements. On 20 June 1955, the Air Force Council recommended that the B–52 program be raised to 576 and that production be accelerated. Secretary Talbott approved the council's recommendation, but pointed out that money remained the limiting factor and only 399 aircraft would be produced on an accelerated basis, beginning in mid-1955. The further increase to 576, the Secretary indicated, would depend entirely on the amount of funds obligated in the coming 2 years.[55] In September 1955, on the

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[55] On 15 August 1955, Donald A. Quarles replaced Harold Talbott as Secretary of the Air Force.

assumption that money would indeed be forthcoming, SAC began to plan the equipping of 11 bombardment wings, each with 45 B-52s. Five command support B-52s would be added to each wing once every unit had been converted as programmed. In the spring of 1956, the Subcommittee on the Air Force of the Senate Armed Services Committee undertook a review of American airpower. Asked for his opinion, General LeMay again urged that the B-52 production be increased. In December, the President's budget set the B-52 program at 11 wings, and reprogrammed procurement to acquire 53 additional B-52Es, starting in mid-1957, when fiscal year 1958 funds would become available.

Additional Procurement 1955-1956

The B-52E procurement was covered by 4 definitive contracts, funded in fiscal years 1956 and 1957. The first one, AF33(600)-31267, concluded on 26 October 1955, was essentially a B-52D contract to which 26 B-52Es were attached. The second, AF33(600)-32863, signed on 2 July 1956, counted 16 B-52Es and 44 further improved productions (B-52Fs). All such aircraft were to be built in Seattle. The other 2 contracts, AF33(600)-31155 of 10 August 1955 and AF33(600)-32864 of 2 July 1956, also involved other B-52s (either D or F models), but covered 14 and 44 B-52Es, respectively. All would come from the new Wichita plant.

First Flight (Production Aircraft) October 1957

The Seattle-built B-52E was first flown on 3 October 1957, 3 weeks ahead of its Wichita counterpart.

Enters Operational Service December 1957

A few B-52Es began reaching the Strategic Air Command in December 1957.

Initial Operational Problems 1958-1964

Besides sharing the initial deficiencies of other B-52s, the B-52E introduced a new problem. The aircraft's new ASQ-38 bombing-navigation system at first was not as accurate as had been anticipated. It was difficult to maintain, and replacement parts were in short supply. The ASQ-38 problems at first appeared relatively minor, but grew in importance as soon as the B–52E entered the Big Four modification program. Moreover, since the same bombing-navigation system would be installed in all subsequent B–52s, extensive engineering changes were initiated to improve low-level terrain avoidance for the long term. The modifications promised to be time-consuming and costly, and they gave way to a special project, Jolly Well, which exchanged major parts of the ASQ–38 and replaced the terrain computer—another critical component of the overall system. Jolly Well was completed in 1964, after successful modification of the ASQ–38 of 480 B–52s—B–52E, F, G, and H models.

End of Production 1958

The B–52E production ended before mid-1958, the last 3 aircraft being accepted by the Air Force in June.

Total B–52Es Accepted 100

Of the 100 B–52Es accepted by the Air Force, 58 came from Wichita which thus began to assume production leadership over Seattle.

Acceptance Rates

All B–52Es were accepted in FY 58, between October 1957 and June 1958.

Flyaway Cost Per Production Aircraft $5.94 million

Airframe, $3,700,750; engines (installed), $1,256,516; electronics, $54,933; ordnance, $4,626; armament (and others), $931,665.[56]

Average Maintenance Cost Per Flying Hour $925.00

[56] The B–52E cost less than any other B–52. Although production kept on increasing, the price of ensuing models did not go down. On the contrary, in-production structural improvements, better engines, more sophisticated components, and other technological pluses boosted costs.

Subsequent Model Series — B-52F

Other Configurations — NB-52E

The second B-52E built (Serial No. 56-632) was assigned from the start to major test programs. It was used for prototyping landing gears, engines, and other major B-52 sub-systems, test results contributing significantly to the improvements featured by subsequent B-52 models. Also, the B-52E test plane underwent permanent modifications in order to participate in highly specialized development projects. Small swept winglets were attached alongside the nose of the reconfigured bomber—NB-52E. A long probe extended from the nose of the modified plane and the NB-52E wings displayed nearly twice the normal amount of controlling surfaces. In addition, traditional mechanical and hydraulic linkages to move the control surfaces were replaced by electronic and electrical systems. Internally, the NB-52E was loaded with a multitude of special electronic measuring systems. The aircraft was first used to develop an electronic flutter and buffeting suppression system. This would decrease the fatigue and stress of aircrews flying at low level. The N configuration participated in another project, known by the acronym LAMS—Load Alleviation and Mode Stabilization. During the LAMS flights, sensors noted gusts and activated the control surfaces to cut down on fatigue damage to the aircraft. In mid-1973, the NB-52E flew 10 knots (11.5 mph) faster than the speed at which flutter normally would disintegrate the aircraft. This was made possible by the aircraft's winglets (canards), which reduced 30 percent of the vertical and 50 percent of the horizontal vibrations caused by air gusts. The NB-52E's contributions were significant, but its cost was relatively low—$6.02 million. Over the years, barely more than $500,000 had been spent to bring the aircraft to its permanent testing configuration. In 1973 its career was nearing its end; the Air Force planned to retire the NB-52E in mid-1974.

Beginning of Phaseout — 1967–1973

The Secretary of Defense's decision to reduce SAC's bomber fleet by mid-1971 affected the B-52Es more than it did the B-52Ds. While the B-52Ds of units inactivated in 1967 went to other operational wings, excess B-52Es were designated non-operational active aircraft. This meant that the aircraft were stored with operational units, maintained in a serviceable condition, and periodically flown. However, no additional crews or maintenance personnel were authorized for these planes. A few B-52Es were permanently retired in 1967, but only because they had reached the end of their operational life by accumulating a specified number of flying hours under conditions of structural stress. This phaseout pattern was retained in the following years. In mid-1973, the Air Force still carried 48 B-52Es in its inventory, but they were not part of the active operational forces.

B–52F

Manufacturer's Model 464–260

Previous Model Series — B–52E

New Features

New J57–43 engines took the place of the B–52E's J57–P–19s or P–29s. Alternators, attached to the left-hand unit of each pair of the J57–P–43W engines replaced the air-driven turbines and alternators in the B–52E's fuselage. The B–52F's only other new feature was a more efficient water injection system.

Configuration Planning — November 1954

Continued improvements of the J57 engine series prompted the November 1954 initiation of the B–52F design. Incorporation of the J57–P–43W engines had to entail some changes. A slight modification of the wing structure also had to be planned in order to install 2 additional wing tanks, which would give the B–52F's injection system an increased water capacity—the system's main overall advancement.

Contractual Arrangements — 1956

B–52F procurement was accomplished by 2 B–52E contracts—AF33(600)–32863 and AF33(600)–32834. One contract called for 44 Seattle B–52Fs; the other, for 45 B–52Fs from Wichita.

First Flight (Production Aircraft) — May 1958

The Seattle-built B–52F first flew on 6 May; the Wichita-built model, on 14 May.

Production Slippages 1958

Whether from Seattle or Wichita, B-52F deliveries lagged a few months behind schedule because authorized overtime for Boeing personnel was curtailed. Fiscal limitations, imposed by the Office of the Secretary of Defense in late 1957,[57] were the cause.

Enters Operational Service 1958

B-52Fs did not start reaching the Strategic Air Command until June 1958. By the end of the month, SAC's 93d Bomb Wing counted 6 B-52Fs.

Initial Problems 1954-1959

Fuel leaks, occurring in the B-52Fs and preceding B-52s, proved difficult to stop. The problem manifested itself from the start. Marman clamps, the flexible fuel couplets interconnecting fuel lines between tanks, broke down on several occasions during the first few weeks of B-52 operation. This caused fuel gushers that obviously created serious flying hazards. Blue Band, a September 1957 project, put new clamps (CF-14s) in all B-52s. Depot assistance field teams did the retrofit well, but Blue Band did not work. The CF-14 aluminum clamps soon showed signs of stress corrosion and were likely to fail after 100 days of service. Highly concerned, the Air Force and Boeing began replacing the aluminum clamps with a Boeing-developed stainless steel strap clamp, the CF-17. Hard Shell, a high-priority retrofit program, put CF-17 clamps in all in-service B-52s. Completed in January 1958, the Hard Shell retrofit was not a fool-proof solution. B-52 operations were again restricted, as several CF-17 clamps ruptured, this time because of deficient latch pins. CF-17A couplings, CF-17 clamps that had been modified to strengthen their latch pins, were used to correct the problem. But neither Boeing nor the Air Force put too much credence on the new modification. This gave way to Quickclip, a new retrofit project started in mid-1958. All B-52s went through Quickclip, which installed a safety strap around the modified clamps. Several cases of broken latch pins were reported before the end of 1958. However, the safety straps prevented the fuel from leaking out, which was Quickclip's whole

[57] Charles E. Wilson was sworn in as Secretary of Defense on 28 January 1953, and served until 8 October 1957. He was succeeded by Neil H. McElroy, who resigned on 1 December 1959.

purpose. Additional B-52Fs, entering the inventory after the fall of 1958, therefore were also fitted with Quickclip safety straps.

Other Fuel System Problems 1954-1962

Fuel system icing posed another initial and long-lasting B-52 problem which had been shared for several years by other jet aircraft. However, little was known about its cause and effect. A B-52 accident in 1958 brought the problem to a climax, while providing a few definite findings. In many previous crashes, icing of the fuel system had been recognized as a probable cause of accident, but the ice had melted in ensuing fires, leaving no concrete evidence. This time, the Air Force could ascertain that icing of the fuel system strut filters and fuel pump screens had caused the engine to flame out and lose thrust. As a remedial step, B-52s were immediately fitted with filters and screens which promised to be less susceptible to icing. The Air Force in addition initiated new fuel draining procedures and directed use of the driest fuel available. A new fuel booster transfer valve came under development during the same period. The B-52 accident of 1958 also speeded research on fuel additives that would prevent the formation of ice in fuel system components. The Air Force, Boeing, and fuel vendors participated in the intensified research program. Nevertheless, progress was likely to be slow. In the meantime, the only meaningful solution was to put fuel heaters in every B-52 and to do so as quickly as possible. Despite troubles encountered during the thermal shock and vibration tests of the heaters, this retrofit project proceeded according to schedule in late 1959. Concurrently, however, a new problem arose. The fuel additive program, after going on unabated, came to a sudden stop because the additives were damaging the fuel cell's inner coating. But this latest problem was resolved in due time. In October 1962, jet fuel additives had proven so successful in eliminating icing problems that SAC was disconnecting the fuel heaters on its latest B-52s (B-52Hs).

Overall Improvement 1962-1964

The B-52F, after participating in the High Stress and Big Four modification programs, was further improved. Again the improvement covered all B-52s, even the early B-52Bs. It consisted of installing the equipment necessary to detect and locate actual and incipient malfunctions in the bombing-navigation and autopilot systems. This equipment was known as MADREC, an acronym for Malfunction Detection and

Recording.[58] The requirement for MADREC had been established in 1961, and its installation was part of a long-range program. The first stage involved the B–52B, B–52C, and B–52D bombers and was completed by mid-1963. The second stage was directed at the more complicated ASQ–38 bombing-navigation system of the B–52E, B–52F, and subsequent B–52s. In essence, the program was closely associated with the Big Four package. MADREC equipment would play an important role in monitoring the Hound Dog missiles that were carried by almost every B–52, as a result of Big Four. The program neared completion by 1965.

Special Modifications 1964–1965

The revised strategy of the early sixties, calling for a greater non-nuclear retaliatory force, did not leave the B–52 untouched. In June 1964, the Air Staff approved the modification of 28 B–52Fs under a project known as South Bay. Completed in October of the same year, the modification program allowed selected B–52Fs to carry twenty-four 750-pound bombs externally—almost doubling the aircraft's original conventional bombload. In June 1965, as the tempo of activities in Southeast Asia began to escalate, Secretary of Defense McNamara requested that 46 other B–52Fs receive similar modifications. Referred to as Sun Bath, the project this time carried a 1-month deadline. Some problems arose. Multiple ejection racks, beams, kits, and supporting aerospace ground equipment were in short supply. To fulfill its many commitments, Air Force Logistics Command's Oklahoma Air Materiel Area, the project's prime coordinator, had to borrow assets from war reserve materiel and from units of the Tactical Air Command. Just the same, Sun Bath was completed 1 week ahead of schedule.

Southeast Asian Deployments 1965

The first B–52 bombers that entered the war in Southeast Asia were B–52Fs. On 18 June 1965, the initial Arc Light bombing mission was carried out from Guam by 27 B–52Fs of the 7th and 320th Bomb Wings. B–52Fs were the only SAC bombers committed to the Vietnam conflict throughout 1965. Even though all deployed B–52Fs had received ahead of time the

[58] B–47Es were also due to be fitted with MADREC equipment.

South Bay or Sun Bath modifications to increase their bombload to 38,250 pounds, they were replaced before mid-1966 by modified B–52Ds.

Southeast Asian Losses 1965

B–52F participation in Southeast Asian operations accounted for the loss of 2 of the planes. The 2 collided in mid-air on 18 June 1965, on their way to the first Arc Light mission.

End of Production 1958

Production of the B–52F, the last model of the B–52 series built in Seattle, ended in November 1958. The Seattle plant, after manufacturing nearly one-half of the B–52F productions, transferred all B–52 engineering responsibility to Wichita.

Total B–52Fs Accepted 89

The Air Force accepted 44 B–52Fs from Seattle; 45 from Wichita.

Acceptance Rates

The Air Force accepted 10 B–52Fs in FY 58 (all in June 1958), and 79 in FY 59 (between July 1958 and February 1959).

Flyaway Cost Per Production Aircraft $6.48 million

Airframe, $3,772,247; engines (installed), $1,787,191; electronics, $60,111; ordnance, $3,016; armament (and others), $862,839.

Average Maintenance Cost Per Flying Hour $1,025.00

Subsequent Model Series B–52G

Other Configurations None

Beginning of Phaseout 1971–1973

Although the 93d Bomb Wing retained every one of its B–52Fs, 1971 marked the beginning of the aircraft's phaseout.[59] Retired planes went to Davis-Monthan for storage. In mid-1973, the Air Force still possessed 62 B–52Fs. Thirty-six of these aircraft were in the inactive inventory. Other B–52Fs were used for training.

[59] The Air Force retired a few B–52Fs in 1967. As in the B–52E's case, these planes were retired only because they had exceeded their service life criteria.

B-52G

Manufacturer's Model 464-253

Previous Model Series B-52F

New Features

Besides an increase in gross weight (488,000 instead of 450,000 pounds), major configuration changes characterized the B-52G. A principal distinction was the "wet wing," as it was often called, which contained integral fuel tanks that significantly increased the aircraft's unrefueled range. The B-52G retained the B-52F's new J57-P-43W, but the engine's water injection system was improved in duration by the installation of a single 12,000-gallon tank in the forward fuselage. There were many other changes, some of them quite noticeable. The nose radome was enlarged, the size of the vertical fin reduced, the tail cone modified, and the ailerons eliminated. The B-52G's redesigned wings supported 700-gallon fixed external fuel tanks that replaced the 3,000-gallon auxiliary wing tanks, carried by several preceding B-52 models. While retaining the AN/ASQ-38 bombing navigational system, the B-52G featured the new AN/ASG-15 fire-control system, improved electronic countermeasures technology, a powered stability augmentation system, and emergency ejection seats for the entire crew, including the gunner who was moved to a rearward-facing seat, next to the electronic countermeasures operator.[60] Finally, in addition to its standard bombload, most B-52Gs were in production equipped to carry 2 Hound Dog missiles,[61] 1 on a pylon under each wing between the inboard

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[60] The location of the bombardier and radar navigator was unchanged. They sat forward facing behind and below pilot and co-pilot. Prior to the B-52G, B-52s and their normal crew of 6 only had 5 ejection seats, none for the gunner.

[61] The North American AGM-28 (formerly GAM-77) Hound Dog was an air-to-surface missile powered by a single Pratt & Whitney J52 turbojet. The AGM-28 was equipped with an inertial guidance system and a nuclear warhead. Launched at high altitude and supersonic speed, the AGM-28 could reach a target 500 nautical miles away; at low altitude and subsonic speed, the distance was reduced to 200 nautical miles.

nacelles and the fuselage. Four Quail decoy missiles could also be fitted in the bomb bay.[62]

Basic Development 1955–1956

The B–52G design was officially initiated in June 1956. Yet the roots of the new aircraft can be traced back to January 1955, when Convair's delta-wing B–58 appeared to be heading for trouble. The Air Force's indecision about the future of the costly, high-risk B–58 program meant that the next decade might not bring new bombers to replace or supplement SAC's B–52s. Development of a much more potent version of the original B–52, Air Research and Development Command stated, would prevent a possible technical obsolescence of the strategic force in the 1960s. As envisioned in May 1955, the new aircraft would be a B–52 fuselage with a redesigned wing, J75 engines, and a number of detailed changes. General LeMay at first was unenthusiastic about the proposal, which brought to mind the Lockheed F–84F and its many early production problems.

While conceding that the Boeing bomber should be improved "as much as possible" during production, General LeMay argued that the B–52 production schedule should not be disrupted. Although he came to favor the "super B–52" somewhat later, General LeMay noted that if "true meaningful improvement" was to result, the B–52 production schedule would inevitably be slowed down. As urgent as it seemed, the B–52G design did not start until June 1956. Delays in providing $1.2 million for Boeing to complete the necessary study was a factor; another was the Air Staff's continued concern about the B–58 and resulting procrastination in formally approving the Boeing project.

Development Engineering Inspection 16–18 June 1956

Once the Air Force finally decided to endorse the B–52 model improvement, events moved quickly. In July, the Air Staff shifted $8.8 million to the project, funds which, in any case, had been allocated to support engineering changes. In the same month, Boeing held an initial development engineering

[62] The McDonnell ADM-20 (formerly GAM-72) Quail was a small delta-wing drone, equipped with 1 General Electric J85 turbojet engine. It had a range of several hundred nautical miles, could match the B–52's performance, and accomplish at least 2 turns and 1 speed change. It contained electronic devices that made it look like a B–52 on enemy radar scopes. The Quail was unique among air-launched missiles in that it was the only decoy missile in the United States Air Force.

inspection at its Seattle plant. The purpose of the inspection was to determine the new configuration of the crew compartment. While the Air Force found no specific faults with the arrangements set up by Boeing, it pointed out that many questions remained unanswered. On 15 August, the contractor submitted for review a model improvement program that was more comprehensive. The Air Staff approved the revised program on 29 August, but specified that its implementation would be only on a "minimum sustaining basis" until more was known about the B-58 program. Possible forthcoming fiscal limitations were another reason for curtailing program's implementation.

Mockup Inspection — October 1956

The Air Force inspected and approved the crew compartment's mockup for the improved B-52 toward the end of October. The new configuration, based on the so-called "battle-station" concept, placed the defensive crew (the ECM operator and gunner) facing aft on the upper deck, the offensive team (bombing-navigation system operators) facing forward on the lower deck, and the pilot and co-pilot (still sitting side-by-side) facing forward on the flight deck.

Production Slowdown — 1957

The impact of unforeseen events, international as well as domestic, often played havoc with the best plans. In 1955, B-58 problems worked in favor of producing an improved B-52 (B-52G). In April 1956, the Air Force wanted the B-52 production increased to a monthly rate of 20. In December, the President set the B-52 program at 11 wings and procurement was revamped to provide a greater quantity of improved B-52s (B-52Es). Money from the next fiscal year (FY 58) would cover the procurement changes, and faster production would take place as soon as practicable. But the progress was short-lived. In early 1957, Secretary of Defense Wilson made it known that B-52 monthly production rates would be held at 15. There were several compelling reasons for the Secretary's decision. As explained by Secretary of the Air Force Quarles, progress was being made on the B-58 development, and Mr. Wilson had already indicated that the B-58 would not only merit some production effort, but would definitely get it in due time. Moreover, a slower B-52 output might give the Air Force a larger number of further improved models, this time perhaps fewer B-52Es and more B-52Fs. Other factors bearing on the decision were revised intelligence estimates, particularly the latest information on Soviet Bison and Bear bomber production

Roll-out of the first G-model Stratofortress at Boeing's Wichita plant, July 1958.

rates, which seemed to have slowed down. Those, as Mr. Quarles pointed out in Secretary Wilson's words, were "a little different, and it looked like we had more time to do an orderly job." Finally, it was Secretary Wilson's belief that "in many cases we get cheaper production by phasing it out over a longer period of time and getting more expert people to work on it." The Air Force had few grounds for argument, even though SAC pointed out that the endorsed lower production rates would delay its conversion program by almost 1 year. As expected, the decision stood.

Contractual Arrangements 1957–1959

Reflecting the evolutionary production process, preceding B–52s were acquired through contracts that covered a variety of models. As a culmination of this process as well as continued developmental efforts, the B–52G was purchased under different conditions. Three procurement contracts were issued—AF33(600)-35992, funded in FY 57; AF33(600)-34670, in FY 58, and AF33(600)-37481, in FY 59. All 3 contracts involved B–52Gs only. The first one, a cost-plus-incentive fee contract with a sliding percentage of 6 percent, was initiated by letter contract on 29 August 1957 and finalized on 15 May 1958. It purchased 53 aircraft. The second and largest one was a fixed-price-incentive-firm (FPIF) contract for 101 B–52Gs. It was started by a letter contract on 14 June 1957, and also finalized on 15 May 1958.[63] The third and last B-52G contract, begun by letter contract on 5 September 1958, was concluded on 28 April 1959. It was a straightforward fixed-price-incentive (FPI) contract for 39 aircraft.

Enters Operational Service 1959

The B-52G entered service with the 5th Bomb Wing at Travis AFB, California. The wing received its first B-52G (Serial No. 47-6478) on 13 February, one day after SAC's last B-36 bomber was retired and the command became an all-jet bomber force. In May 1959, the 42d Bomb Wing also started getting B-52Gs. By the end of June, 41 of the new bombers had been received by SAC. The early B-52Gs and 13 more could not carry the Hound Dog missiles.[64] A post-production modification, completed in 1962, accomplished necessary alterations and fitted the 54 aircraft with the equipment required to support as well as fire the new weapons.

Special Tests 1960

B-52Gs, of necessity, played an important role in the Category III testing of both the Hound Dog and Quail missiles. A B-52G crew of the 4135th Strategic Wing accomplished the first SAC launch of a Hound Dog on 29 February 1960. On 8 June, a B-52G crew of the same wing repeated the performance with a Quail decoy. By the end of 1961, a respectable supply of the new missiles—225 Hound Dogs and 400 Quails—had already reached the SAC inventory. However, although the new AGM-28 Hound Dogs had become an important part of the B-52's striking power, the missiles were still highly unreliable.[65]

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[63] The May 1958 contract, as initiated in June 1957, evolved from the President's budget of December 1956, which set the B-52 program at 11 wings and a total of 603 aircraft. The last B-52G contract, started by letter contract in September 1958, and the subsequent procurement of B-52Hs (the last model) were not part of the 11-wing program. They could be viewed as added bonuses, prompted by new dissatisfaction with the B-58 program, concurrent fiscal limitations, and the B-58's high price.

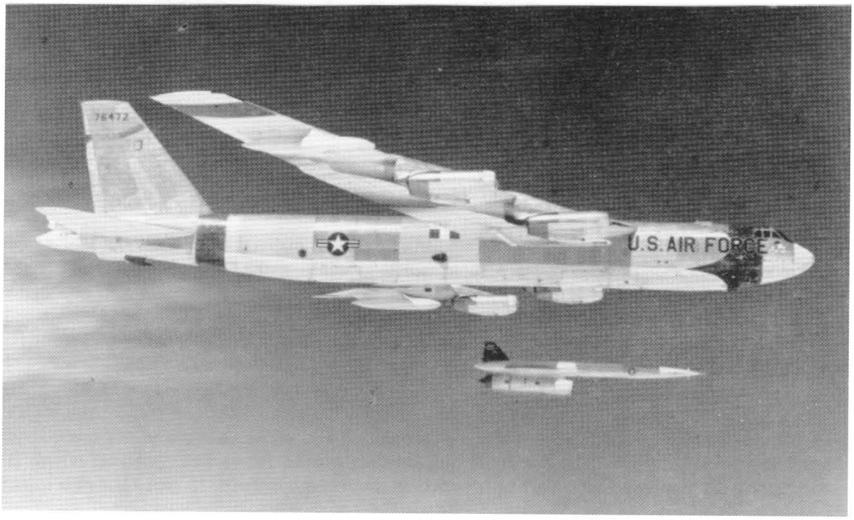
[64] Boeing could not be faulted for the omission. Because of the complexity and high cost of the Big Four modification package, refinement of the many changes under consideration consumed most of 1959. The Air Staff did not decide until the end of that year which B-52 models would be equipped, either in production or through retrofit, to carry the new missiles.

[65] In contrast, the ADM-20 Quail's performance was excellent. In 1963, all Quail decoys were modified for low-level flying. This relatively simple modification added a barometric switch for terrain avoidance and altered the missile's wiring system.

Structural Modifications 1961–1964

Intensive structural testing, conducted by Boeing and the Air Force in 1960, again confirmed that hard usage shortened the structural life of the B-52 aircraft. The B-52Gs and B-52Hs differed significantly from predecessor models, but design changes incorporated in the new bombers made them even more susceptible to fatigue damage. Briefly stated, the changes had been made to extend the aircraft's range, which essentially meant that while the B-52G and B-52H bombers were lighter than preceding B-52s, their fuel loads had been increased. Moreover, the overall decrease in structural weight had been achieved primarily by using an aluminum alloy in the aircraft's wings. While testing did not question the intrinsic strength of the wing, it pinpointed areas of fatigue. No one could forecast accurately when the wing failures would happen, but low-level flying and the structural strains that occurred during air refueling were expected to speed up fatigue considerably.[66] The anticipated problem appeared serious enough for SAC to impose stringent flying restrictions on the new aircraft, pending approval of necessary modifications. In May 1961, the Air Staff endorsed a $219

[66] It was estimated that under fairly similar circumstances, the operating stress placed on the new wing was approximately 60 percent higher than the stress inflicted on the wing of preceding B-52s.



A GAM-77 Hound Dog missile was launched from under a B-52's wing over Eglin AFB, Florida.

million modification program for all B–52G and B–52H wing structures.[67] The program provided for Boeing to retrofit the modified wings during the airplanes' regular IRAN schedule, except for the last 18 B–52Hs, which would get their modified wings on the Wichita production lines. Started in February 1962, the program was completed by September 1964, as scheduled.

Other Structural Improvements 1964–1972

While ECP 1050 had strengthened the wings of the B–52Gs and B–52Hs by September 1964, as already noted, ECP 1128, a major engineering change proposal approved in the same year for the entire B–52 fleet, had just begun.[68] Concurrently, MADREC, a previously described improvement program that also covered most B–52s, was in progress. In addition, various modifications, addressed to specific B–52 models, were either underway or about to start. In spite of such projects, the Air Force believed that major efforts would still be required in the ensuing years to keep extending the structural life of the critically needed B–52G and B–52H bombers. Hence, the Air Staff in October 1967 approved ECP 1195, an engineering change studied by SAC since 1965. Eventually known as the B–52 Stability Augmentation and Flight Control program, the $69 million modifications installed a number of new devices in the bombers. Necessary kits, contracted for in December 1967, began reaching the Air Force in mid-1969, and their installation required 2 years. Meanwhile, ECP 1185, due to cost about $50 million and actually initiated in May 1966, had started to replace the aircraft's fuselage side skin, crown skin fasteners, and upper longerons. Completion of these latest engineering changes, accomplished as usual during the aircraft's regular IRAN schedule, was expected to ensure the structural safety of the B–52G and B–52H airframes through the 1980s.

Special Modifications 1970–1975

In line with current plants to retain the B–52Gs and B–52Hs for years

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[67] The wing structural improvement program, carried out as ECP 1050, replaced the wing box beam with a modified wing box that used thicker aluminum. It also installed stronger steel taper lock fasteners in lieu of the existing titanium fasteners; it added brackets and clamps to the wing skins, added wing panel stiffeners, and made at least a dozen other changes. Finally, a new protective coating was applied to the interior structure of the wing integral fuel tanks.

[68] Shortly before the beginning of ECP 1128, the Air Force had directed that the tail section of all B–52s be reinforced in order to withstand turbulence during low-level penetration tactics. Started in September 1963, this engineering modification (ECP 1124–2) was due to spread over several years.

to come, the Air Force in 1970 decided to equip these bombers with the Boeing-developed AGM-69A nuclear-tipped short-range attack missile (SRAM).[69] Required modifications and the addition of necessary equipment, such as wing pylons, launch gear, rotary launchers, and new avionics would be accomplished by 2 air materiel areas. Oklahoma City would modify all B-52Gs; San Antonio, all B-52Hs. This long-term, $400 million retrofit program began on 15 October 1971, when 1 B-52G entered the Oklahoma City modification center. In March 1972, a SRAM-equipped B-52G was delivered to the 42d Bomb Wing at Loring AFB, Maine. The 42d became SRAM-operational in August, the first of 19 wings programmed to acquire the versatile missiles.[70] Each modified B-52G and H bomber could carry up to 20 SRAMs, 12 externally and 8 inside the rear of the bomb bay.

Southeast Asian Deployment 1972

As SAC strove to preserve the might of its primary bombers, the war in Southeast Asia continued unabated. Since 1965, when the B-52Fs had first arrived in Southeast Asia, B-52 conventional bombing operations had increased from year to year. The purpose of the bombing was not always the same, the theaters of operation also varied, but the task always grew. B-52Gs did not enter the war before mid-1972; yet, their short-lived participation did not prove easy. On 18 December, as ordered by President Nixon, B-52Gs and the older B-52Ds began to bomb military targets in the Hanoi and Haiphong areas of North Vietnam. The bombing operation, nicknamed Linebacker II, ended on 29 December, after a Christmas pause of 24 hours.[71] In this attack on Haiphong and Hanoi, the B-52s encountered awesome defenses. In 11 days, 15 B-52s were shot down by surface-to-air missiles.

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[69] The 2,300-pound AGM-69A SRAM measured 14 feet in length and 18 inches in diameter. The internally guided, solid-propellant missile could be flown at supersonic or subsonic speeds and set to follow either a high-altitude semi-ballistic trajectory or a low-altitude profile. It could strike targets ahead of the launch aircraft or turn in flight to hit installations to the side or behind the bomber.

[70] SAC's 2 wings of FB-111As would also be equipped with the new missiles, at an estimated cost of $43 million.

[71] SAC B-52s terminated over 8 years of conventional bombing operations in Southeast Asia on 15 August 1973, when all U.S. bombing of targets in Cambodia ceased.

Southeast Asian Losses 1972

SAC lost 7 B-52Gs in Southeast Asia, all of them during 1972.[72] Six of the planes were hit by enemy surface-to-air missiles over North Vietnam, with 4 of them going down around Hanoi and the other 2 crashing in Thailand. The seventh B-52G loss was only indirectly caused by the war. The plane, after taking off from Andersen AFB, Guam, crashed into the ocean, presumably because of materiel failure.

Modernization 1972-On

Ensuring the durability of an airframe was a difficult and costly problem; a worse one, on both counts, was to cope with the enemy's technological developments. In the early seventies, many improvements in electronic countermeasures, initially limited to the Southeast Asia-committed B-52Ds, were extended to the B-52Gs and B-52Hs. These various projects centered essentially on the installation of more efficient jammers to ease the penetration of enemy defenses. One project, Rivet Rambler, was a 2-phase modification accomplished on all B-52Ds by 1971 and specifically directed against the SA-2 radars. In 1973 the Rivet Rambler modification of the B-52G and H bombers was almost completed, but the resulting improvements soon would be nearing obsolescence. Because of the experience gained in Southeast Asia, particularly as a result of the Linebacker II strikes against heavily defended targets, SAC wanted more than ever to equip the B-52Gs and B-52Hs with truly advanced ECM transmitters and jammers. An improved warning system was also needed: one that could detect threats from surface-to-air missiles, anti-aircraft artillery, and airborne interceptors. The Air Staff had already endorsed most of SAC's new requirements. Modification 2525, due to provide more efficient airborne early warning countermeasures, had been approved in June 1971; modification 2519, known as Rivet Ace and due to upgrade the aircraft's

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[72] Two B-52Gs had been lost years before in highly publicized accidents. The first occurred on 17 January 1966, when a B-52G collided with a KC-135 tanker during a high-altitude refueling operation and both aircraft crashed near Palomares, Spain. The release of some radioactive material required removal of some 1,400 tons of slightly contaminated soil and vegetation to the the United States for disposal. A lost nuclear weapon, finally located by a U.S. Navy submarine about 5 miles from the shore and approximately 2,500 feet under water, was recovered intact on 7 April. Then, on 22 January 1968, a B-52G with 4 nuclear weapons aboard crashed and burned on the ice of North Star Bay, while attempting an emergency landing at nearby Thule Air Base, Greenland. An extensive clean-up operation to remove all possible traces of radioactive material was completed on 13 September.

radar warning receivers, was approved in December of the same year. However, none of these projects would start before mid-1973, and all were scheduled to take several years. There were many reasons for the implementation delays. Technical difficulties had to be worked out, unexpected requirements were likely to materialize, and new components had to be tested for quality as well as compatibility within any given avionics system. An example was Rivet Ace. Within the span of 2 short years, this fairly unsophisticated modification had become a very ambitious endeavor. In mid-1973, although the transformed modification project was about to start, serious problems remained. Components, due to be added to the aircraft's radar warning receivers, had been tested with success, but the system's new surface-to-air missile detection equipment was still defective. Meanwhile, other projects fared well. B-52s were being modified to carry the SRAM, as scheduled, even though a new modification was being done simultaneously. This additional project would give the aircraft an electro-optical viewing system, which made use of forward-looking infrared and low-light-level television sensors. The new system would make low-level flying much easier, and a B-52H, modified by the San Antonio Air Materiel Area, had already been returned to operational duty by mid-1973. Another improvement considered in mid-1973 consisted of fitting the B-52's bombing and navigation system with automated offset units. Such devices, SAC believed, would ease significantly the synchronized bombing of several targets.

End of Production 1961

B-52G production ended in early 1961. The Air Force accepted the last 2 aircraft in February.

Total B-52Gs Accepted 193

The B-52G was the major production model of the B-52 series. All 193 aircraft were built at the Wichita plant.

Acceptance Rates

Fifty B-52Gs were accepted in FY 59 (between October 1958 and June 1959); 106 in FY 60 (between July 1959 and June 1960); 37 in FY 61 (between July 1960 and February 1961).

Front view of a B-52, showing the television sensors of the new electro-optical viewing system developed to enhance low-level flight.

Flyaway Cost Per Production Aircraft — $7.69 million

Airframe, $5,351,819; engines (installed), $1,427,611; electronics, $66,374; ordnance, $6,809; armament (and others), $840,000.

Average Maintenance Cost Per Flying Hour — $1,025.00

Subsequent Model Series — B-52H

Other Configurations — None

Operational Status — Mid-1973

The Air Force in July 1973 retained 175 of 193 B-52Gs, purchased almost 15 years before. These efficient bombers were undergoing modification, with more changes to come in the future.

Record Flight 1960

On 14 December 1960, a B-52G of the 5th Bomb Wing, Travis AFB, California, completed a world record-breaking flight of 10,078.84 miles without refueling. The flight lasted 19 hours and 44 minutes. The previous closed course record, established in 1947 by a B-29, covered only 8,854 miles.

B-52H

Manufacturer's Model 264-261

Previous Model Series B-52G

New Features

The B-52H did not differ outwardly from the B-52G, except for the shape of its nacelles, slightly altered because of the new engine's larger inlets. Internally, however, there were several important changes. The B-52H featured Pratt and Whitney's 17,000-pound thrust TF-33-P-3 turbofan engines (without water injection system), new engine-driven generators, ECM equipment improved up to the state of the art, and an enhanced fire-control system—the AN/ASG-21. This new system operated a Gatling gun-type of multi-barrel cannon in a remote-controlled tail mounting for rear defense.[73] The AN/ASG-21 also controlled forward-firing penetration rocket launchers. In addition, the B-52H had better cabin arrangements for low-level penetration flights and was equipped to carry the never-to-be GAM-87 Skybolts.[74]

Configuration Planning January 1959

An outgrowth of the B-52G, the B-52H design was initiated in January 1959, 1 month before SAC received its first B-52G. Although no great innovations resulted, some airframe changes had to be made to take care of the new model's special features. The B-52H was due from the start to incorporate the TF-33 turbofan engine, a modified J57 already adopted by

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[73] The Gatling gun, the world's first practical machine gun, dated back to the Civil War. The B-52H's ultra-modern version of this 100-year-old weapon was hydraulically operated and electronically controlled. The 6-barreled gun could spew out a stream of 20-mm shells at the rate of 4,000 rounds per minute.

[74] Instead of Skybolts, the B-52Hs carried decoys and missiles identical to those of the B-52Gs.

commercial jet transports. The new aircraft was also designed to carry 4 Douglas GAM-87A Skybolts, which would be a marked improvement over previous B-52s. Had the Skybolt survived, it would have characterized the B-52H as the first manned bomber capable of serving as a flying platform for launching 2-stage solid propellant ballistic missiles with a range of 1,150 miles, fitted with nuclear warheads.

Final Procurement 1959-1962

Like the B-52Gs, the B-52Hs were bought under individual contracts. Two FPI contracts—AF33(600)-38778, funded in FY 60, and AF33(600)-41961, funded in FY 61—accounted for the entire B-52H lot. The first procurement, initiated by letter contract on 2 February 1959, was finalized the following year, on 6 May 1960. It covered 62 B-52Hs. The second B-52H contract was started by a letter contract on 28 July 1960, but was not finalized until the latter part of 1962. There were good reasons for the delay. This was the end of the B-52 procurement and the contract only purchased 40 more B-52Hs. The Air Force could not be sure this would be enough.[75]

First Flight (Prototype) 10 July 1960

The YB-52H's first flight was entirely successful. Ensuing flight tests showed that the new TF-33 turbofan engines would allow the new plane to surpass the B-52G's range. Take-off would also be improved and require about 500 feet less ground roll than the B-52G.

First Flight (Production Aircraft) 6 March 1961

The Air Force accepted the first B-52H in the same month the plane initially flew, but left it with Boeing for testing. By the end of June 1961, B-52H flight tests had confirmed that the TF-33-P-3 engines were working even better than expected. Moreover, even though the new Emerson ASG-21

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[75] These were difficult times. In September 1962, an Air Force recommendation to expand the North American XB-70 program into a full-scale weapon system development was rejected by Secretary of Defense McNamara. In December, President John F. Kennedy confirmed that further development of the Skybolt, an air-to-surface ballistic missile earmarked for the B-52H, was definitely canceled.

fire-control system and the Sunstrand 120 KVA constant speed alternator drive needed perfecting, they both were tactically operable.

Enters Operational Service — Mid-1961

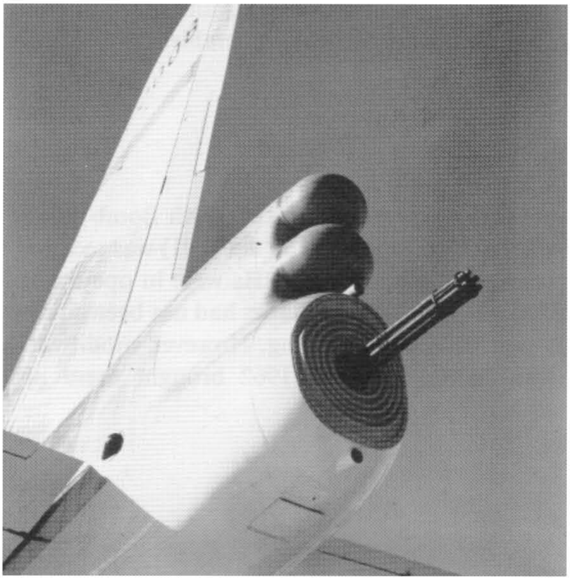
The B-52H entered operational service with the 379th Bomb Wing, at Wurtsmith AFB, Michigan. The first plane (Serial #60-001) was received by the 379th on 9 May. By the end of June, 20 B-52Hs were in operation. In contrast to all other B-52Hs, 18 of those early planes had not been equipped during production for all-weather, low-level flying. However, modifications accomplished between April and September 1962 brought them up to standard.

Engine Problems — 1961-1964

While both the B-52F and B-52G had failed to live up to original range estimates, the B-52H's new TF-33-P-3 turbofan engines gave the aircraft a better range increase than anticipated. Moreover, as indicated by recent B-52H flight tests, some of the new engine's problems appeared to be solved, and remaining malfunctions were being worked out. Yet, despite several engineering fixes, the TF-33 in late 1961 still created difficulties. Throttle creep, hang or slow start, flameout, and uneven throttle alignment were some of the most frequent troubles. In addition, the engine consumed too much oil, turbine blades failed and inlet cases often cracked. By mid-1962, even though most of these early problems had been corrected, Hot Fan, a depot maintenance and overhaul project, was underway. This $15 million modernization effort, involving the accomplishment of 35 technical orders, had 2 essential purposes. The Air Force wanted the TF-33 to be more reliable, and it did not want the engine to fail before 600 hours of operation. Curtailed by the Cuban Missile Crisis of October 1962, when all B-52s stood on alert, Hot Fan was not resumed until January 1963. However, the Oklahoma City Air Materiel Area accelerated its overhaul schedule, and although Hot Fan covered 894 TF-33 engines, the project was practically completed before the end of 1964.

Other Early Difficulties — August 1962

B-52Hs were still being assigned to SAC when a serious and ill-timed problem came to light. In August 1962, again shortly before the Cuban



The ASQ-21 Gatling gun, mounted in the B-52H's tail, provided remote-controlled defense.

A Boeing B-52H, equipped with 4 Douglas GAM Skybolt ballistic missiles.

Missile Crisis, 2 of the B-52Hs at Homestead AFB, Florida, developed cracks where wings and fuselage joined. Boeing and the Air Force focused attention on the taper lock fasteners, which under high stress and in the B-52's operational environment were susceptible to corrosion. They soon determined that the "primary contributing cause for these cracks was the use of taper lock fasteners throughout the forging." In September, Boeing came up with a repair and rework package to take care of the problem. The next month, engineers of Air Force System Command's Aeronautical Systems Division set up requirements to evaluate the impact of stress corrosion on all primary structural materials. Project Straight Pin, the modification package developed by Boeing, was not allowed to linger. Rework centers were immediately established at Moses Lake, Washington; Wichita, Kansas; and at the San Antonio Air Materiel Area's shops. There, maximum interference wing terminal fasteners were replaced with those having extremely low interference, and cracked fitting holes were "cleaned up" by oversize reaming. Although SAC suspended diversion of its airplanes to the modification centers during the Cuban Crisis, Straight Pin was virtually completed by the end of 1962.

Continued Problems 1962-1964

An older stress corrosion problem came to life again in August 1962. Two main landing gear outer cylinders failed on B-52D and B-52F aircraft, the latest in a series of similar incidents with B-52Gs and B-52Hs since the end of 1959. While SAC asked for redesigned cylinders, Air Force engineers noted that a quicker and safer alternative would be to make use of another alloy, one that would be less susceptible to stress corrosion. This gave way to a new study and test program to further investigate current and potential stress corrosion problems. Meanwhile, to prevent other incidents, anti-corrosion coating was applied to all components of the landing gear. Progress was also made to cure most of the B-52H's other early ills. By mid-1962, failure of the aircraft's Sunstrand constant speed drive was becoming a problem of the past. During the same period, a long-standing SAC requirement, only endorsed for the B-52Hs, was finally extended to all B-52s. Started in January 1963 and completed in March of the following year, this retrofit project put 2 cartridge starters in every B-52.[76] The modification was expensive, which accounted for SAC's difficulties in

[76] The installation of cartridge starters was not simple. The aircraft's electrical system had to be modified to accommodate the new starters and new valves. In addition, duct covers had to be redesigned and nickel cadmium batteries had to be added.

getting it approved for the entire B-52 force, but it was important. Besides giving crews the means to start their engines faster, it would allow dispersed or post-strike B-52s to take off from airfields lacking certain ground support equipment, electrical power carts in particular.

Structural and Other Improvements 1964-On

As already noted, all B-52G structural modifications were extended to the B-52Hs. These aircraft were also included in the many B-52G modernization programs of the early seventies. Like the Gs, the B-52Hs were being equipped to carry the new SRAMs; they were being fitted with electro-optical viewing systems, low-light television cameras, and forward-looking infrared scanners. Finally, they were due to receive better electronics and more sophisticated components to improve both their offensive and defensive systems. A new project, initially triggered by the relatively slow start of the B-52H's TF-33 engines, was also underway. Despite the cartridge starter retrofit that had been accomplished between 1963 and 1964, SAC was still dissatisfied with the time it took for the B-52 to take off. The recently approved Quick Start project, now only concerned with the B-52G and H bombers, would make the ground alert force far less vulnerable to surprise attacks. Quick Start specifically consisted of putting a quick start device on each of the aircraft's 8 engines, thereby ensuring take-off in almost no time.

End of Production 1962

Production ended in the fall of 1962,[77] SAC receiving on 26 October the last B-52H (Serial #61-040). This plane went to the 4137th Strategic Bomb Wing at Minot AFB, North Dakota.

Total B-52Hs Accepted 102

The 102 B-52Hs accepted by the Air Force, like the B-52Gs, were built in Wichita.

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[77] This marked the end of a production run which had begun some 9 years before. Wanting to keep the production door ajar, at least for a while, the Air Force negotiated with Boeing a supplemental agreement to the final B-52H production contract—AF33(600)-41961. Signed on 17 October 1962, this $770,283 agreement ensured that Boeing, the prime contractor, would store the Wichita B-52H tooling until July 1963. Selected B-52 subcontractors, using government-owned facilities, would do the same.

Acceptance Rates

The Air Force accepted 20 B-52Hs in FY 61 (from March through June 1961); 68 in FY 62 (between July 1961 and June 1962); and 14 in FY 63 (the last 5 during October 1962).

Flyaway Cost Per Production Aircraft — $9.28 million

Airframe, $6,076,157; engines (installed), $1,640,373; electronics, $61,020; ordnance, $6,804; armament (and others), $1,501,422.

Average Maintenance Cost Per Flying Hour — $1,182.00

Subsequent Model Series — None

Other Configurations — None

Operational Status — Mid-1973

The Air Force inventory in July 1973 still counted 99 B-52Hs—against an initial contingent of 102. Like the B-52Gs, B-52Hs were undergoing modifications to extend their service-life as well as their efficiency.

Record Flights — January 1962

On 10-11 January, a B-52H of the 4136th Strategic Wing, Minot AFB, North Dakota, completed a record-breaking 12,532.28-mile unrefueled flight from Kadena Air Base, Okinawa, to Torrejon Air Base, Spain. This flight broke the old "distance in a straight line" world record of 11,235.6 miles held by the U.S. Navy's propeller-driven "Truculent Turtle." Weighing 488,000 pounds at takeoff, the B-52H flew at altitudes between 40,000 and 50,000 feet with a top speed of 662 miles per hour on the Kadena-Torrejon flight route.

June 1962

On 7 June, a B-52H of the 19th Bomb Wing, Homestead AFB, Florida, broke the world record for distance in a closed course without landing or refueling. The closed course began and ended at Seymour Johnson AFB, North Carolina, with a validated distance of 11,336.92 miles. The old record of 10,078.84 miles had been held by a B-52G of the 5th Bomb Wing since 1960.

Program Recap

The Air Force bought 744 B-52s—prototype, test, and reconnaissance configurations included. Precisely, the B-52 program counted 1 XB-52, 1 YB-52 (first flown on 15 April 1952, almost 6 months ahead of the experimental B-52), 3 B-52As (restricted to testing), 50 B-52Bs (27 of which could also be used for reconnaissance), 35 B/RB-52Cs, 170 B-52Ds, 100 B-52Es, 89 B-52Fs, 193 B-52Gs, and 102 B-52Hs. Six years of development preceded the beginning of production which, after a slow start around 1953, did not end until October 1962.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

B-52 AIRCRAFT

Manufacturer (Airframe)	Boeing Airplane Co., Seattle, Wash., and Wichita, Kans.
(Engines)	The Pratt & Whitney Aircraft Division of United Aircraft Corp., East Hartford, Conn.
Nomenclature	Strategic Heavy Bomber
Popular Name	Stratofortress

	B-52B	B-52C/D	B-52E	B-52F	B-52G	B-52H
Length/Span (ft)	156.6/185	156.5/185	156.5/185	156.5/185	157.6/185	156/185
Wing Area (sq ft)	4,000	4,000	4,000	4,000	4,000	4,000
Weights (lb)						
Empty	164,081	177,816	174,782	173,599	168,445	172,740
Combat	272,000	293,100	292,460	291,570	302,634	306,358
Takeoff[a]	420,000	450,000	450,000	450,000	488,000	488,000
Engine: Number, Rated Power per Engine, & Designation	(8) 11,400-lb st (max) J57-P-1WA	(8) 12,100-lb st (max) J57-P-19W	(8) 12,100-lb st (max) J57-P-19W or -29WA	(8) 13,750-lb st (max) J57-P-43W -WA, or -WB	(8) 13,750-lb st (max) J57-P-43WB	(8) 17,000-lb st (max) TF-33-P-3
Takeoff Ground Run (ft)						
at Seat Level[b]	8,200	8,000	8,000	7,000	8,150	7,420
Over 50-ft Obstacle	10,500	10,300	10,300	9,100	10,400	9,580
Rate of Climb (fpm) at Sea Level	2,110	2,225	2,225	2,300	2,150	3,000
Combat Rate of Climb[c] (fpm) at Sea Level	4,760	5,125	5,125	5,600	5,450	6,270
Service Ceiling at Combat Weight (100 fpm Rate of Climb to Altitude)	47,300	46,200	46,200	46,700	47,000	47,700

Combat Ceiling[c] (ft) (500 fpm Rate of Climb to Altitude)	46,550	45,800	45,800	46,000	46,000	46,200
Average Cruise Speed (kn)	453	453	453	453	453	453
Max Speed at Optimum[a c] Altitude (kn/ft)	546/19,800	551/20,200	551/20,200	553/21,000	551/20,800	547/23,800
Combat Radius (nm)	3,110	3,012	3,027	3,163	3,550	4,176
Total Mission Time (hr)	13.50	13.22	13.27	14.03	15.7	17.50
Armament	4 20-mm M24A1s or 4 50-mm M-3s	4 50-mm M-3 guns	4 50-mm M-3 guns	4 .50-cal M-3 guns	4 .50-cal M-3 guns	1 20-mm M-61 gun
Crew	6	6	6	6	6	6
Max Bombload (lb)	43,000[d]	50,000[e]	50,000[e]	50,000[e]	50,000[f]	50,000[f]

Abbreviations

cal	=	caliber
fpm	=	feet per minute
kn	=	knots
max	=	maximum
nm	=	nautical miles
st	=	static thrust

[a] Limited by structure.

[b] Takeoff power, i.e., maximum power of an airplane's engine or engines available for takeoff.

[c] Military power, i.e., maximum power or thrust specified for an engine by the manufacturer or by the Air Force as allowable in flight under specified operating conditions for periods of 30 minutes duration.

[d] Or 1 MK-6 and 2 MK-21 special weapons.

[e] For example, 27 1,000-lb bombs, 4 1,200-lb ADM-20 Quails, and 2 10,000-lb AGM-28 Hound Dog missiles, or MK-28, MK-41, MK-53, and MK-57 special weapons.

[f] For example, 27 1,000-lb bombs, 4 1,200-lb ADM-20 Quails, 2 10,000-lb AGM-28 Hound Dogs or up to 20 2,200-lb AGM-69A SRAM missiles. Bombload could also consist of MK-28, MD-41, MK-53, and MK-57 special weapons.

BASIC MISSION NOTE

All basic mission's performance data are based on maximum power, except as otherwise indicated.

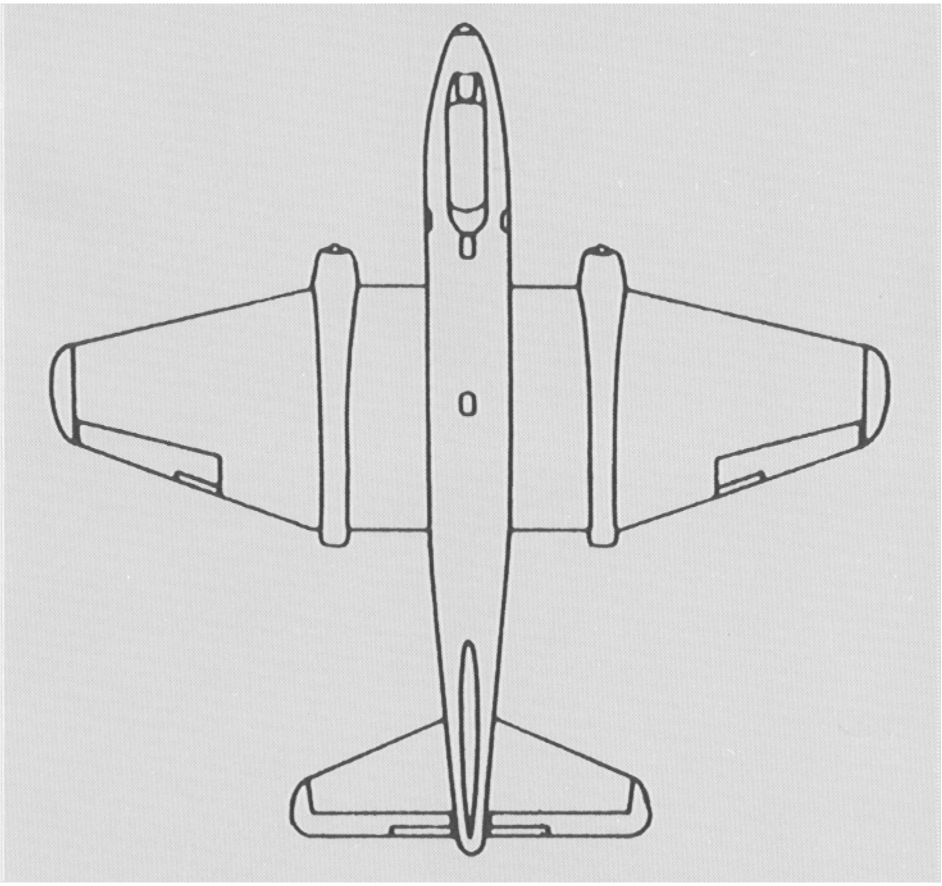
Combat Radius Formula:

B–52B, B–52C, B–52D, and B–52E: Took off and climbed on course to optimum cruise altitude at normal power. Cruised out at long-range speed, increasing altitudes with decreasing weight (external tanks being dropped when empty). Climbed to reach cruise ceiling 15 minutes from target. Ran-in to target at normal power, dropped bombs, conducted 2-minute evasive action and 8-minute escape at normal power. Cruised back to base at long-range speed and optimum altitudes (as an alternate, a 45,000-foot ceiling could be maintained on the return leg with no radius penalty). Range-free allowances included fuel for 5 minutes at normal power for take-off allowance, fuel for 2 minutes at normal power for evasive action, and fuel for 30 minutes maximum endurance at sea level plus 5 per cent of the initial fuel load for landing reserve (the landing reserve range at optimum speed and altitude).

B–52F, B–52G, and B–52H: Took off and climbed on course to optimum cruise altitude at normal power. Cruised out at long-range speed (the long-range speed being maximum speed for 99 percent maximum miles per pound of fuel), increasing altitude with decreasing weight (external tanks being dropped when empty). Climbed to reach cruise ceiling 15 minutes from target. Ran-in to target at normal power, dropped bombs, conducted 2-minute evasive action and 8-minute escape at normal power. Cruised back to home base at long-range speeds, increasing altitude with decreasing airplane weight. Range-free allowances included 5-minute normal-power fuel consumption for starting engines and takeoff, 2-minute normal-power fuel consumption at combat altitude for evasive action, and 30 minutes of maximum endurance (4 engines) fuel consumption at sea level plus 5 percent of initial fuel for landing reserve. The prescribed fuel reserve for the basic mission was equivalent to the following reserve range at best range conditions: B–52F, 810 nautical miles; B–52G, 808 nautical miles (884 nautical miles, Alternate in-Flight); B–52H, 974 nautical miles (1,060 nautical miles, Alternate in-Flight).

B-57 Canberra

The Glenn L. Martin Company



B-57 Canberra
Martin

Manufacturer's Model 272

Overview

The beginning of the Korean conflict on 25 June 1950 and the shortcomings of the weary Douglas B-26, a World War II production originally known as the A-26, accounted for the urgent procurement of a light tactical bomber. The new bomber became the Martin B-57, a by-product of the English Electric Canberra, the first British-built jet bomber, initially flown in 1949.

Adaptation of a foreign-made aircraft to American mass production methods, as well as the use of different materials and tools, could present many difficulties. Another problem, perhaps more critical, centered on the Wright J65 turbojets, due to replace the Canberra's 2 Rolls Royce Avon turbojet engines. The J65 was the U.S. version of the Sapphire, a British hand-tooled production currently scheduled for manufacturing by the U.S. Curtiss-Wright Corporation. The Air Force was fully aware of these potential pitfalls, but had no better option. It had an immediate requirement for a light jet bomber, with a 40,000-foot service ceiling, a 1,000-nautical mile range, and a maximum speed of 550 knots. The new bomber had to be capable of operating from unimproved airfields, at night and in every kind of weather, with conventional or atomic weapons. High altitude reconnaissance was another must. For such purposes, the B-45 was too heavy; the Navy AJ-1, too slow; and the Martin experimental B-51's range too short.

As a result of the outbreak in Korea, the Air Force reached a final decision. The desire for a night intruder was so strong that it took just a few days to set in motion the informal production endorsement of February 1951. Because of its experience with the XB-51, the Glenn L. Martin Company was recognized as the most qualified contractor to assume the domestic production of the British aircraft and to deal with the likely engineering difficulties involved in manufacturing a high-performance tactical bomber.

While the Air Force did not expect the B-57 venture to be free of problems, it did not foresee their magnitude. Testing of the 2 imported Canberras revealed design faults that could affect the safety, utility, and maintenance of the future B-57. Then, one of the British planes crashed; Martin's subcontractors could not meet their commitments; and the J65 prototype engines consistently failed to satisfy USAF requirements. In June 1952, further test flights had to be postponed for a year because of continuing engine and cockpit troubles. As a result, the Korea-bound B-57 did not fly before 20 July 1953, just 7 days before the conflict ended. Production of the crucial RB-57 was also delayed. The reconnaissance version entered service in mid-1954, after testing again confirmed that the more powerful J65 engines, added equipment, and other improvements had increased the aircraft's weight, in turn reducing the speed, distance, and altitude of both the B-57 and the RB-57.

Even though the Douglas B/RB-66s, on order since 1952, were expected to satisfy the tactical bombardment and reconnaissance requirements of the near future, the Air Force handled the disappointing B/RB-57 program with caution. The program was reduced, but there was no talk of cancellation. In keeping with procedures that unfortunately appeared to have become almost customary, steps were taken to ensure that the deficient B/RB-57s would be operational. This turned out to be expensive; later and considerably improved models still carried flaws, but in the long run the program's retention proved sound. In 1955, the B/RB-57s justified their costs when they served overseas pending the B/RB-66 deliveries which, as predicted, had fallen behind schedule. In 1956, much-needed RB-57Ds joined the Strategic Air Command, and various configurations of this model satisfied important special purposes.

Delivered too late for combat in Korea, the RB-57 in May 1963 and the B-57 in February 1965 began to demonstrate under fire in Southeast Asia the basic qualities justifying the Canberra's original selection. In 1970, other reactivated and newly equipped B-57s, known as Tropic Moon III B-57Gs, were deployed to Southeast Asia, where they made valuable contributions until April 1972. Finally, WB-57Fs, either modified RB-57Fs or former B-57Bs, were still flying high-altitude radiation sampling missions in 1973. Concurrently, EB-57Es, and related adaptations of the versatile B-57, continued to play significant roles, with no immediate phaseout in sight.

Basic Development — 1945

The Glenn L. Martin Company's B-57 Canberra was derived from the first British-built jet bomber. This high-altitude radar bomber was developed by the English Electric Company, Limited, in answer to specifications B 3/45, as issued by the British Ministry of Supply in 1945.[1] The first 2-man prototype of the English Electric Canberra was flown in May 1949 at the Wharton airdrome. In September, it was revealed to the aeronautical world at the Farnborough flying display of the Society of British Aircraft Constructors. The plane, like the several variants subsequently developed from its basic design, demonstrated superior characteristics. Not only could the new bomber take off and land in combat configuration on short and easily constructed runways, but it maneuvered well at low and high speeds. The United States, through the Martin Company, eventually bought off-the-shelf 2 B.Mk.2s, English Electric's first true production of the Canberra. The B.Mk.2, in contrast to the May 1949 prototype, carried a crew of 3—a pilot, navigator/plotter, and observer.

Preliminary Requirements — 16 September 1950

Soon after the outbreak of hostilities in Korea,[2] the USAF Board of Senior Officers began discussing how to replace quickly the weary Douglas B-26 Invader with a modern tactical bomber, specifically geared for night operations. To this end, the preliminary requirements of September 1950 called for a light jet bomber with a service ceiling of 40,000 feet, a cruising speed of about 400 knots, a maximum speed of 550 knots, and a range of almost 1,000 nautical miles. The needed aircraft also had to be capable of operating from unimproved airfields, of searching for targets at low speed and low altitude, and of destroying mobile or stationary targets at night or in bad weather, with conventional or atomic weapons. High-altitude reconnaissance was another requirement.

Initial Candidates — October 1950

Few aircraft, either under development or in operation, could be adapted to satisfy the requirements of September 1950 without excessive delay. Hence, the list of U.S. and foreign candidates was short. Specific possibilities were the Douglas B-26 (an improved version of World War II

[1] Britain's first jet bomber was actually conceived in 1944 by W. E. W. "Teddy" Petter, who later designed the Lightning and Gnat interceptors.

[2] The Korean conflict lasted from 25 June 1950 until 27 July 1953.

vintage), the Martin XB-51, the North American B-45 and AJ-1, the Canadair CF-100, and the English Electric Canberra. Much was already known about the new Canberra, but not quite enough. It had favorably impressed the USAF staff officers who had witnessed its first flight at Wharton airdrome in 1949.[3] In the summer of 1950, a committee headed by Brig. Gen. Albert Boyd, Commander of Edwards AFB, had given the plane an "expedited" and "limited evaluation." Therefore, the committee's report of 28 September was not conclusive. It deemed the Canberra suitable for all-weather fighter, tactical reconnaissance, and medium-altitude bomber operations. Yet, the report said the plane had little potential as a ground attack fighter-bomber because it was unstable during close support maneuvers. In the same cautious vein, the committee found that the British plane's tactical utility and ease of production warranted its "consideration" for the Mutual Defense Assistance Program.[4] On the other hand, the Canberra should not be used in the United States Air Force before "rigorous evaluation" of at least 1 aircraft and accelerated service testing of several prototypes. If eventually procured, the plane would require at least 25 changes. Even then, to benefit from the Canberra's design, the Air Force would have to accept the initial airframe, performance, and load capacity.

Subsequent to this appraisal, the Board of Senior Officers organized another committee. It was chaired by Brig. Gen. S. P. Wright, Deputy Commander of the Air Proving Ground, and included several representatives from Air Materiel Command (AMC) and Tactical Air Command (TAC).

Tentative Selection — December 1950

With the Boyd report on hand, the Wright Committee measured the Canberra's performance against that of the 4 remaining candidates, a

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[3] The Canberra flight of 1949 underscored Great Britain's spectacular post-World War II advancements and her superiority in jet propulsion development. It gave credence to the British claim that production of thousands of Canberras was the factor which alone could best provide the tactical airpower necessary to counterbalance Soviet predominance in ground troops.

[4] W. Barton Leach, Special Consultant to Secretary of the Air Force W. Stuart Symington and to Secretary Thomas K. Finletter, Mr. Symington's successor, was among those who visited England in 1949 and 1950 for the primary purpose of reviewing the British jet propulsion accomplishments. Upon his return, Leach discussed the British Canberra proposal with John A. McCone, Under Secretary of the Air Force. While thinking that there might be disadvantages in diverting American production "heavily" to an aircraft of the Canberra type, Leach recognized that such a proposal could not be dismissed lightly, because the whole basic structure of strategic planning was involved. The discussion was to prove academic, since the Martin B-57 production never even reached the 500 mark.

comparison that did not help the North American B-45 and AJ-1. The B-45 was ruled out because it was too heavy; the Navy AJ-1, because it was too slow. While noting that neither the XB-51 nor the Canberra fully met the Air Force's night intruder requirements, the Wright Committee endorsed both. It proposed the immediate purchase of British Canberras for 2 light bombardment groups and future procurement of sufficient B-51s to equip 2 other groups. The Wright Committee's suggestion aroused scant enthusiasm among the Air Staff members. The Board of Senior Officers, after studying the Air Proving Ground Command's latest evaluations, found itself liking the Canberra's performance. In contrast, it seriously doubted that the B-51's range could ever match the Canberra's radius of action.[5] Although aware that the Canberra would need modification for the night intruder role, the board asked Lt. Gen. Kenneth B. Wolfe, Air Force Deputy Chief of Staff for Materiel, to ascertain if the British could furnish enough Canberras and still satisfy Royal Air Force orders. Nonetheless, as recommended by General Boyd, the board felt that no determination could be made until a borrowed Canberra became available. Going several steps further, the board then decided not only to await the plane's arrival, but to make on-the-spot comparisons with every initial aircraft candidate. This evaluation, it believed, together with a review of the night intruder's future role, should ensure the best solution to the present dilemma.

Final Endorsement — 26 February 1951

After hinging for weeks on divergent opinions, the Air Force decision to get a facsimile of the English Electric Canberra was nearly unanimous. As negotiated with the British government, a Royal Air Force Canberra B. Mk.2, bearing USAF insignia, left Northern Ireland on 20 February for Gander Field, Newfoundland. It landed in Baltimore, Maryland, on 21 February—the first jet aircraft to complete an unrefueled flight across the Atlantic Ocean—and arrived at Andrews AFB 2 days later. Ensuing flight demonstrations and ground inspections of the Canberra sealed the fate of other candidates. On 26 February, the Senior Officers and USAF Weapons Boards picked the British plane as the best interim aircraft available for the night tactical intruder role. General Vandenberg, Air Force Chief of Staff,[6] and Secretary Finletter swiftly agreed.

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[5] Martin's 2 XB-51s, under contract since May 1946, did not fly until October 1949. Costing a total of $12.6 million, both aircraft eventually crashed.

[6] General Vandenberg succeeded Gen. Carl Spaatz as Chief of Staff of the Air Force on 30 April 1948.

Program Go-Ahead 2 March 1951

The Air Force wanted a night intruder so badly that it took just a few days to set in motion the informal production decision of 26 February. Since General Wolfe had found out that the British could barely take care of their own Canberra needs, the Air Staff directed AMC on 2 March 1951 to arrange for the aircraft's domestic production. Martin became the chosen contractor. The Air Force was convinced that the XB-51 had given that company a sound background for dealing with the potential problems of a high-performance tactical bomber.

Production Restrictions 2 March 1951

Procurement Directive 51-135, issued by the Air Staff on 2 March, reflected the urgency of bringing into service an American version of the Canberra. The B-57, as the aircraft was to be known, was to go directly into production, a decision tantamount to buying an off-the-shelf airframe with an off-the-shelf engine and installed equipment. Even though the resulting aircraft, 250 of them to begin with, might not be exactly what was needed, configuration changes would be kept to a bare minimum—under the strict control of the Board of Senior Officers.

Testing Agreement 16 March 1951

The British Canberra, exhibited at Andrews AFB, reached the Martin Company on 10 March. This permanent assignment grew out of a Combined Test Project Agreement, formalized with the Royal Air Force on 16 March. Under the same agreement, Martin received a second British Canberra several months later. Although the 2 planes acquired USAF serial numbers (51-17352 and 51-17387), they were carried in the Air Force inventory as Canberras, not as B-57s.

Contractual Arrangements 24 March 1951

The informal production decision of 26 February 1951 was finalized on 24 March by Letter Contract AF 33(038)-22617. This production letter contract asked Martin to deliver 250 B-57s between November 1952 and October 1953. The schedule was predicated on Martin's attaining a peak production rate of 50 airplanes per month.

Other Negotiations March/May 1951

The production letter contract of 24 March covered more than the procurement of 250 B-57s. It authorized Martin to acquire the Canberra manufacturing rights, and gave the company a $6 million advance payment to take care of its most pressing expenditures. The license agreement finally worked out by the British and American firms was signed on 8 May 1951. Martin eventually built 403 B-57s of one kind or another; the English Electric Company, Ltd., in time received royalties topping $3.5 million. Another $1 million was paid for the 2 Canberras secured by Martin during the spring and summer of 1951. The Air Force reimbursed Martin the full cost of the 2 imported planes.

B-57A

New Features

As an intended replica of the English Electric Canberra B. Mk.2, the B-57A featured no outstanding innovations. Nonetheless, because of the American mass production methods, standards, and uses of different materials, tools, gauges, wiring, and techniques, the plane differed from its British pattern in several aspects. The B-57A had a slightly modified cockpit and canopy that afforded better visibility and more room for the crew (reduced from 3 to 2). Two Wright Aeronautical J65 turbojet engines were substituted for the Canberra's 2 Rolls Royce Avon turbojets. Other changes included the addition of wing tip tanks (to increase loiter time) and replacement of the British "clam shell" type bomb-bay doors. Developed by Martin for the B-57A, the pre-loaded revolving bomb-bay door rotated 180 degrees and eliminated the drag caused by an opened bomb-bay compartment during the bombing run.

Pre-Production Planning — 1 July 1951

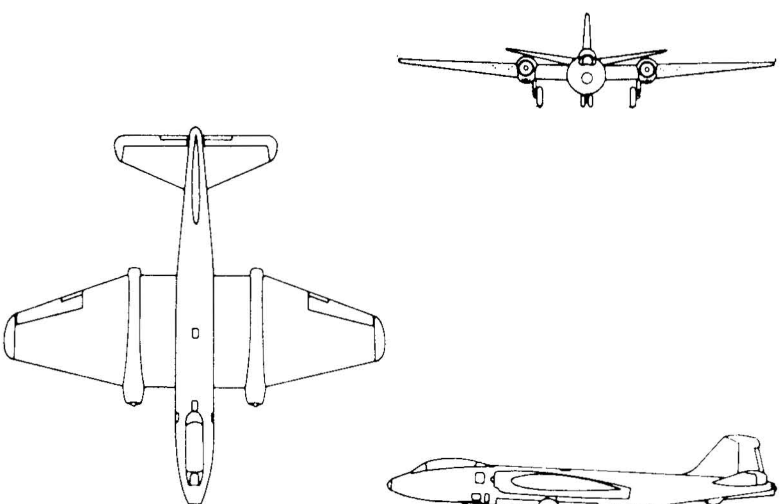
Although the Wright J65 Sapphire engine,[7] due to power the B-57, and some equipment the Air Force wanted on the airplane would be furnished by the government, the urgent delivery schedules specified by the production letter contract of March 1951 presented difficult tasks. As a result, Martin began immediately to plan ahead and on 1 July subcontracted 60 percent of the actual production work. Its principal subcontractors were the Kaiser Products of Bristol, Pennsylvania, for the wings and special weapons bomb-bay doors; and the Hudson Motors Corporation of Detroit, Michigan, for the aft portions of the plane.

Pre-Production Testing — 1951

Martin tested its first British Canberra from April to October 1951,

[7] The Sapphire was a hand-tooled production of the British firm Armstrong-Siddeley for which the Curtiss-Wright Corporation at Wood-Ridge, N. J., had acquired a manufacturing license. Production of the Wright YJ-65, as the Sapphire engine was redesignated, was not expected to begin before September 1951.

The B-57, an American version of the British Canberra, featured wing tip fuel tanks.



accumulating 41 hours of flying time in the process. The second imported plane reached Martin in September, was test flown not more than 4 hours, and disassembled. Appropriate sections of the plane were then shipped to Martin's main subcontractors.[8] USAF pilots began test flying the first Canberra in the fall of 1951. A 21 December accident, in which the plane was completely destroyed, accounted for some of the slippage that plagued the B-57 program from the start.

Mockup Inspection — 20 July 1951

The Mockup Board's inspection of the B-57A was not an overwhelming success. The board approved the location of the eight .50-caliber forward-firing guns (placed in the wings instead of the fuselage nose), but noted numerous shortcomings. It also pointed out that the aircraft would have to be modified to carry special weapons, that a compatible bombing system was required, and that pylons were needed to support external stores. Particularly dissatisfied with the B-57A cockpit, the board insisted that it should be redesigned.

Other Initial Deficiencies — August 1951

The Aircraft Laboratory of the Wright Air Development Center examined Martin's first B-57 specifications in August 1951. The laboratory was well-prepared for its chores. In January, it had thoroughly evaluated the Canberra and indicated that an Americanized production from the British drawings and data would not satisfy USAF requirements. In August, the laboratory's criticism grew. Besides sharing the mockup board's concern, it found fault with the aircraft's landing gear, the brake actuating system, the absence of winterization, and many other items. Moreover, the laboratory concluded that, as currently planned, Martin's tip tank installation, engine mounting, and nose gear swivel angle would be inadequate.

Problems and Controversies — 1952

In January 1952, Wright Air Development Center decided to challenge the B-57's production philosophy. So far, the center noted, the Board of

[8] Eventually reassembled, this Canberra went to the Sampson AFB Museum, Geneva, N.Y., on 2 June 1954. It was scrapped 2 years later.

Senior Officers had approved the correction of only 6 deficiencies. Yet, some of the 35 design faults uncovered by the center's engineers could affect the safety, utility, and maintenance of the future B–57. In fact, the Royal Air Force (RAF) had refused to accept the Canberra from the English Electric Company until many of the very same flaws were eliminated. It therefore appeared inconsistent to carry any of these deficiencies into the American production of the plane. At first, Wright Center's position was not well-received. Air Materiel Command was quick to point out that the center previously had made no attempt to integrate its list of deficiencies into the production schedule of the plane, even though it made no sense to discuss one without the other. Any configuration changes adopted at this late date, AMC emphasized, would cause unacceptable production delays. Moreover, in the command's opinion, several of the corrections suggested by the air development center were superfluous, at least for the B–57A. The Air Materiel Command agreed, however, that the B–57 production guidelines ran counter to the USAF regulations calling for technical excellence. Another month of debate failed to alter the production restrictions of March 1951, but it did bring AMC around to support Wright Air Development Center's position. And, as events soon proved, the center's effort would have significant impact on the program.

Program Changes — 11 August 1952

On 11 August 1952, production of the B–57A's reconnaissance version, ordered earlier in the year, was reduced by one-third. More importantly, and to Wright Air Development Center's great satisfaction, procurement of the B–57A was virtually canceled. Only 8 B–57As would be built. Despite slight alterations, these aircraft would be recognized as direct copies of the Canberra. As actually recommended 2 years before by the Boyd Committee, the B–57A would be used for testing, thereby paving the way for production of a similar but better aircraft.

Production Slippages — 1951–1953

The unexplained Canberra loss of late 1951 and ensuing testing setback undoubtedly accounted for part of Martin's production slippage. But a major initial delay was caused by the government-furnished Sapphire jet engines that were due to power all B–57s. The Sapphire was a hand-tooled production of the British firm Armstrong-Siddeley for which the Curtiss-Wright Aeronautical Division at Wood-Ridge N.J., had acquired a manufacturing license. However, the J65, as the Air Force version of the Sapphire was designated, was perhaps more difficult to adapt to American specifications and manufacturing methods than the British plane. Although the Wright production had been set to begin in September 1951, the J65 prototype engines consistently failed to meet USAF requirements.[9] In June 1952, when the Air Force finally accepted the first 2 YJ65-W-1 engines, neither had yet completed the required 150-hour qualification test. Still, there were other problems of equal consequence. In April of the same year, a technical status report could only state that the B-57 manufacturer and subcontractors had begun the fabrication of "bits and pieces." In June 1952, while the B-57A basic engineering seemed to be completed, projected test flights were postponed to mid-1953 because of continuing engine and cockpit troubles.

First Flight (Production Aircraft) 20 July 1953

The Martin twin-jet B-57A night intruder bomber at long last took to the air on 20 July. Company officials described the 46-minute flight as entirely successful. On 20 August, the plane underwent its official Air Force flight acceptance test at the Martin airfield at Middle River, Maryland. In attendance, among high-ranking Air Force officials, were General Twining, Air Force Chief of Staff since 30 June 1953; Lt. Gen. Edwin W. Rawlings, Commander of Air Materiel Command; and Lt. Gen. Donald L. Putt, Commander of Air Research and Development Command. Newspaper accounts of the B-57A performance were enthusiastic, more so than subsequent USAF appraisals.

Enters Operational Service

Relegated to the testing status, none of the B-57A productions entered operational service. Yet, 1 or 2 eventually participated in a few special projects.

Testing December 1953

The Air Force accepted the first B-57A on 20 August, but lent it

[9] The new engine was also earmarked for the Republic F-84F. Due to the urgent need for improved fighter-bombers since the outbreak of the Korean War, the Air Force in December 1950 selected the Buick Division of the General Motors Corporation as the second source for the Sapphire engine.

immediately to Martin and never took delivery of the plane.[10] Hence, USAF testing did not start until December 1953, when all other B-57As were delivered. Once underway, however, testing was extensive. USAF pilots test flew the second B-57A (Serial No. 52-1419) for no less than 101 hours, reached in 80 flights. While testing would go on for years, by late 1954 the Air Force knew without doubt that the B-57A was somewhat superior to the original Canberra. Yet the overall improvement carried a price. Added equipment and the more powerful J65 engines had increased the aircraft's empty weight by 3,700 pounds, in turn reducing speed, distance, and altitude.

Total B-57As Accepted 8

Acceptance Rates

All B-57As were received in FY 54. The Air Force accepted—but never physically possessed—the first B-57A in August 1953. It took delivery of the remaining 7 in December.

End of Production December 1953

Flyaway Cost Per Production Aircraft $9.3 million

Airframe, $8,937,886; engines (installed), $349,357; electronics, $20,780; ordnance, $7,442; armament and others, $33,704.[11]

Subsequent Model Series B-57B

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[10] This plane (Serial No. 52-1418) remained with the Martin Company from its completion until 19 June 1957, when it was transferred to the National Advisory Committee for Aeronautics. The contractor received the airplane under Bailment Contracts AF 33 (038)-32001 and AF 33 (600)-2407 of 6 August 1953 and 21 February 1956. Martin test pilots flew the plane 292 hours in 284 flights.

[11] The high cost of the B-57A was explained by the fact that only 8 of them were built, and that Martin's initial and one-time manufacturing costs were prorated among those first few aircraft. But for rare exceptions, the higher the production, the lower the cost. Although only 67 RB-57As entered the inventory, the reconnaissance B-57A showed a significant price decrease. And despite important improvements, the unit cost of the subsequent and more numerous B-57B was still cheaper.

Other Configurations RB–57A

Phaseout 1961

Attrition, conversions, and special projects gradually absorbed the few B–57As. By mid-1961, the aircraft no longer appeared in the Air Force inventory.

Other Uses 1957

Early in 1957, the Air Force lent the second B–57A to the Weather Bureau of the Department of Commerce. Following modification, the plane participated in the National Hurricane Project.

RB-57A

Manufacturer's Model 272A

Weapon System 307L

New Features

Cameras, installed aft of the bomb-bay, constituted the main difference between the reconnaissance B-57A and the B-57A test-bomber. The cameras—P-2s, K-17s, K-37s, K-38s, or T-17s—could be interchanged, according to the aircraft's missions, which were many and included day and night, high and low, and visual and photographic reconnaissance besides day combat mapping. Unlike the B-57A, the RB-57A was totally unarmed and painted with a high gloss black paint that minimized detection by searchlights. In common with the B-57A, the plane carried only a 2-man crew—1 pilot and 1 photo-navigator, the latter replacing the B-57A's navigator-bombardier.

Basic Development — October 1951

As in the B-57A's case, the decision to develop a reconnaissance version was prompted by the Korean conflict. Increasingly effective enemy air defenses underscored USAF reconnaissance shortcomings. Hence, in an October meeting, the Air Staff and representatives of AMC and Wright Air Development Center defined the RB-57A configuration. So few changes were outlined that it would only take a minimum of effort to return the future RB-57A to service as a bomber—an occurrence that never came to pass in view of the B-57A's fate.

Program Reduction — 1952

The Air Force at no time seriously considered canceling the B-57, but nearly deleted the reconnaissance counterpart. Early in January 1952, as a result of the past October meeting, AMC prepared to order 99 RB-57As.

Within a few weeks, however, a whole new situation arose. The Air Staff not only spoke of procuring only 87 RB-57As, but also ventured that eliminating the entire order might be best. Assuming the RB-26s could somehow be equipped with night photographic equipment and made to work until the Douglas RB-66 became available, about $30 million could be saved in doing away with the RB-57s. Because delivery of the first RB-66 could not be expected before 1954, and successful modernization of the RB-26s was questionable, the Air Staff finally decided against any drastic change. Nevertheless, after dropping the requirement to 87 planes, the RB-57A procurement underwent a final cut on 11 August 1952, when it was reduced to 67. Despite ensuing RB-57A problems, the decision proved wise. In the midst of the Korean War, the RB-26s steadfastly demonstrated the difficulty and occasional futility of fitting old planes with modern, sometimes unproven, components. Also, consistent with almost traditional production patterns, delivery schedules for the RB-66 slipped significantly.

Production Slippage 1952–1953

On 24 April 1952, the Air Research and Development Command asked Martin to give priority to the RB-57A at the expense of the B-57A program—officially still practically intact at the time. The RB-57A production nonetheless slipped. But the command's directive served its purpose and worked in favor of the B-57B—Martin's first true Canberra bomber. Meanwhile, the contractor's problems kept on growing. Part of Martin's Baltimore plant remained occupied by the Army Signal Corps, and the late delivery of machine tools hampered reactivation of available facilities. To make things worse, in addition to avowed engine difficulties, Kaiser production of wing panels and nacelles had also begun to fall behind.

First Flight (Production Aircraft) October 1953

Flight of the first RB-57A came about 3 months after that of the first B-57A. Both flights were made from the Martin airfield at Middle River, and, ironically, the RB-57A flight occurred close to the date initially set for delivery of the 250th B/RB-57. By that time, the Air Force had reached several perplexing conclusions. First, the B/RB-57As would not meet USAF requirements; therefore, relatively small quantities would be built. On the other hand, regardless of their known shortcomings, the RB-57As remained urgently needed. However, speeding up Martin's new delivery schedules would be extremely costly. The Air Force, after weighing such conflicting factors, adopted what were most likely the best solutions. Testing was cut short, and most RB-57As were produced without benefiting from the usual "debugging" period that normally preceded operational use. But a major effort was made to improve subsequent models in the series—the B-57Bs and the unique RB-57Ds.

Enters Operational Service — July 1954

The RB-57As came into operational use in mid-1954. The Tactical Air Command earmarked the first few for transition training with the 345th Light Bomb Wing, Langley AFB, Virginia, and sent the next 22 to the 363d Tactical Reconnaissance Wing at Shaw AFB, South Carolina. The 363d reached an initial operational capability (IOC) in July.

Operational Problems — 1954–1955

The 363d's initial operational readiness was short-lived. Subsequent RB-57A deliveries were held up because the J65-BW-5 engines started burning oil and filled the cockpit with smoke. This matter taken care of, all 67 RB-57As were accepted by September 1954. However, the entire Canberra fleet was grounded in January 1955, this time for engine compressor failure. And while this problem was being solved, new deficiencies were uncovered. The RB-57A's control system required adjustment, and the wing-fuselage attachment fitting needed reinforcement.

Structural Modifications — 1954–1955

Modifications, referred to as Garden Gate,[12] strengthened the connection of the wings to the fuselage. All RB-57As had received the Garden Gate changes by November 1954, and these modifications later were incorporated into Martin's production line. However, new structural deficiencies came to light as cracks developed around the aircraft's nose cap.[13] Repair of the cracks limited the operation of the aircraft.

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[12] The term came from the "garden gate" shape of the fittings that linked the wings to the fuselage.

[13] Martin had already canceled a Hudson subcontract involving the manufacture of RB-57A nose sections.

Overseas Deployments 1955

The engine malfunctions, structural deficiencies, and many other ills that afflicted the RB-57As were compounded by the lack of equipment and spare parts to support the new planes. Hence, at home or overseas, the aircraft assignments were delayed, and the first 2 USAF wings in West Germany which transitioned from RB-26s to RB-57As did not keep their new planes very long. Both the 10th Tactical Reconnaissance Wing at Spangdahlem AB and the 66th at Sembach AB started converting to more efficient RB-66s in late 1957.

End of Production August 1954

Production ended with the August delivery of the last 5 aircraft.

Total RB-57As Accepted 67

Acceptance Rates

The Air Force accepted 49 RB-57As in FY 54—from December 1953 through June 1954. The last 18 were accepted in FY 55—13 in July 1954 and 5 in August.

Flyaway Cost Per Production Aircraft $1.66 million

Airframe, $1,240,051; engines (installed), $349,357; electronics, $4,096; ordnance, $9,324; special equipment, $58,485.

Average Maintenance Cost Per Flying Hour $191.00

Subsequent Model Series B-57B

Other Configurations RB-57A-1, RB-57A-2, and EB-57A

RB-57A-1s—Ten RB-57As, after elimination of their most serious deficiencies, were converted for high-altitude reconnaissance. The project, known as "Lightweight" and later renamed "Heartthrob," was handled by the Wright Air Development Center and Martin. Under Heartthrob, all equipment and items not absolutely essential for daylight photography were removed from the basic RB-57A. The plane's J65-BW-5s were replaced by higher thrust J65-W-7 engines, and the crew was reduced from 2 to 1. The RB-57A-1 was 5,665 pounds lighter than the RB-57A (43,182 to 48,847), and its altitude was increased by 5,000 feet. The Heartthrob modifications were successfully completed in August 1955. Six RB-57A-1s went to the 7499th Composite Squadron in United States Air Force in Europe; 4 to the 6007th Composite Squadron in Far East Air Forces.

RB-57A-2s—Two RB-57A-1s were modified under Hardtack, a project also referred to as Heartthrob, Jr. The modification removed some equipment from the airplanes to make room for the Convair-developed AN/APS-60 Startrack, a high-altitude radar that had been briefly tested on a B-57B. Martin undertook the project with reluctance, because the non-standard AN/APS-60 was highly sophisticated and its installation promised to be difficult—which in fact it was. The 2 Startack-equipped RB-57A-2s were delivered in September 1957—a 9-month delay.

EB-57As—In the mid-sixties, the Air Force endorsed the modification of 32 RB-57As. The work, done by Martin, essentially consisted of fitting a compartment, full of electronic countermeasures equipment, in the aircraft bomb bay. The first EB-57A (Manufacturer's Model 272R) flew in April 1966 and was immediately accepted by the Air Force. Martin completed the fairly complicated project in less than a year and the Air Defense Command[14] continued to use the EB-57As for electronic countermeasures training until the early seventies.

Phaseout 1970-1971

The original RB-57A received little praise. By 1958 ten RB-57As had already been lost in flying accidents. At the end of 1970 only 2 remained on the active USAF rolls. But the RB-57A, although scarcely satisfactory from the start, did pay its own way. The aircraft's numerous special configurations proved invaluable for many years. Twelve EB-57As were still in the operational forces in late 1971.

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[14] The Air Defense Command became the Aerospace Defense Command on 15 January 1968.

Other Uses

In early 1956 one RB-57A satisfied the special photographic requirements of the United States Air Forces in Europe. Known as the Sharp Cut RB-57A, the aircraft did not materialize as soon as expected. Revisions to the bomb-bay and instrument panels and the installation of special purpose photographic equipment (the F-11 camera in particular), took time. In 1957 the Air Research and Development Command lent an RB-57A to Northrop Aircraft, Inc., to study laminar-flow boundary layer control, a topic of crucial USAF interest. In the spring of 1958 the Air Force prepared a number of RB-57As for atmospheric sampler missions. The modification added special equipment to the aircraft, which were temporarily designated B/20 airplanes.

Other Countries

Two RB-57As, after modification, were turned over to the Republic of China under Project Large Charge.

B-57B

Manufacturer's Model 272

Weapon System 307A

Previous Model Series RB-57A

The RB-57A preceded the B-57B in the USAF inventory, but the B-model was the B-57's first production bomber as well as the major inventory model.

New Features

The most significant change featured by the B-57B was an entirely new design of the cockpit area. The reconfiguration placed the navigator-bombardier behind the pilot under a large bubble canopy similar to that of the T-33.[15] This arrangement improved visibility, afforded more space for the installation of equipment, and conformed to the Air Force-preferred tandem type of seating. Specifically, the B-57B pilot's seat was on the fuselage centerline. The navigator's back seat was slightly offset left of the center line to provide room for the Shoran receiver-indicator and the Swedish-designed M-1 toss-bomb computer unit. The B-57B also introduced a flatplate wind-shield allowing the installation of a gun sight, external wing pylons, improved defrosting, and fuselage dive brakes. The wing pylons mounted high-velocity aircraft rockets or bombs. Beginning with the 91st B-57B production, the eight .50-caliber forward-firing wing guns, first seen on the B-57A test aircraft, were replaced by 4 M-39 20-millimeter guns.

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[15] The Lockheed T-33 Shooting Star was an all-metal, full cantilever low-wing, 2-seat, high-performance aircraft used by the Air Force for the training of flight personnel.

Basic Development 1952

The B-57B development took shape in early 1952, when Air Materiel Command and Air Research and Development Command acknowledged the unacceptable deficiencies of the B-57A configuration. In March, they jointly presented the current problems to Air Force Headquarters. And as early as 17 April, the 2 commands gave the Air Council a list of minimum but mandatory changes for ensuring production of a sound airplane. Although not relinquishing production control, the Board of Senior Officers did endorse most of the proposed modifications.

Production Decision 11 August 1952

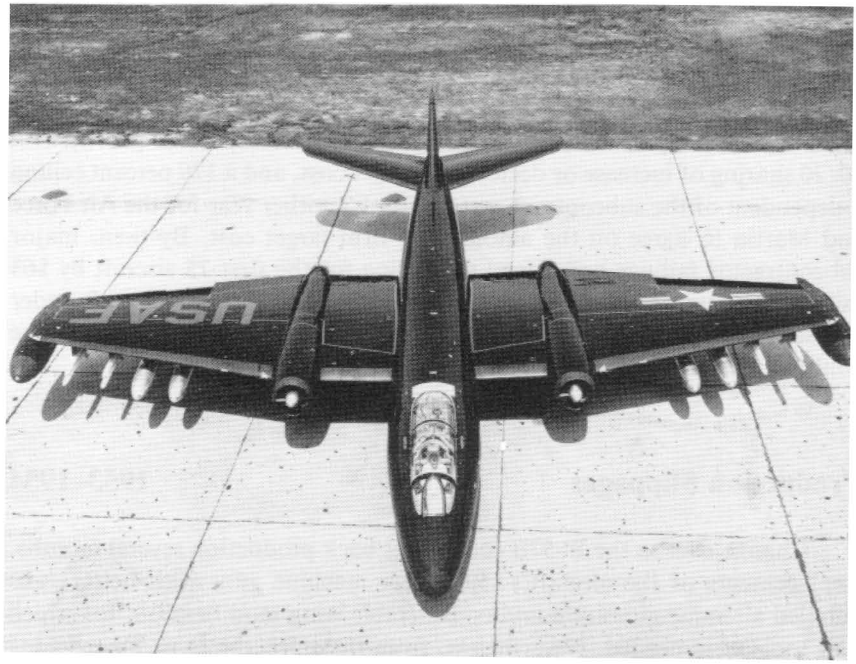
The B-57B production became official on 11 August, concurrent with the B-57A's virtual demise.

Mockup Inspection 2 October 1952

The B-57B mockup was officially inspected on 2 October. Of primary interest was the new cockpit arrangement and the single blister canopy. Deletion of the Shoran equipment, to provide space for a new type of radar, was discussed but not adopted.

Additional Procurement September/December 1952

Letter Contract AF 32(038)-22617 of March 1951 called for the production of 250 B-57s but was amended several times. In August of the same year, the number of B-57s on order stood at 209; in February 1952, at 177. On 11 August 1952, total procurement remained at 177, but 102 B-57Bs were substituted for 70 B-57As and for 32 RB-57As. The first follow-on fiscal year 1953 contract began with Letter Contract AF 33(600)-22208, which was issued 19 September 1952 and covered the additional procurement of 119 B-57Bs. An amendment on 18 December raised the FY 53 B-57B procurement to 191, bringing the cumulative B-57B future production to 293. This total, however, did not materialize. Affected by changes almost from the start, the B-57 program was revamped many times over. In some cases, obsolescence was the governing factor. On other occasions, special or ever-increasing operational requirements were the cause.



An armed B-57B, displaying the reconfigured cockpit which placed the pilot in front of the navigator-bombardier.

Revised Production Schedules 1952

Although frowned upon, the revision of production schedules was seldom avoidable. In August 1952, completion of the 177 B/RB-57s then on order was pushed back to August 1954, a date which proved highly optimistic. Also, Martin's production peak rate was reduced from 50 to 17 airplanes per month. The Air Force thought the B-57B would benefit from a slower production tempo. Still, it did not expect to wait until May 1956 for its full complement of new bombers—almost 3 years past the deadline set by the Board of Senior Officers back in 1951. Such complications, the program changes occurring during the interim years, and the new production schedules generated by such changes all proved costly. In the end, the B-57B's average unit price was double that first negotiated.

First Definitive Contract 1 August 1953

The Air Force finalized Letter Contract AF-33(038)-22617 in August

1953. Changes in quantity, type of airplane, and configuration explained the protracted negotiation period, and the contractor's hard bargaining played a part. Besides higher profits, Martin wanted to be amply protected against subcontractor failure and cost increase. The definitive contract was a fixed price incentive type, with reset. Martin received a 7.5 percent profit, with 80/20 sharing of increase or decrease of target cost, and a 120 percent ceiling independent of the subcontract costs. It took another year for the Air Force and Martin to agree on the amounts of firm target cost. By then, major subcontractor failings had upped the billing for the first 75 aircraft by $63 million. The target cost negotiations for the remainder of the aircraft under the same contract dragged on until April 1955. It was 1958 before the contract was completely closed out.

Production Slippages 1953–1954

Change-over to the B–57B cockpit set back production several months. Replacements of the aircraft's .50-caliber machine guns with better guns entailed airframe alteration and considerable wing modification, for which new tools were needed. Nevertheless, from the start, the most far-reaching production problem was Kaiser's failure to deliver B–57 wings on schedule. Martin asked for permission to cancel the Kaiser contract but was allowed to withdraw only part of it. The Air Force pointed to the exorbitant cost of dropping Kaiser, in money as well as time. In any case, Kaiser's difficulties could be traced to poor management, but the subcontractor still remained well-qualified to do the work. For that matter, Martin also posted a good record manufacturing the special bomb-bay doors pulled back from Kaiser. Yet, later events showed that the Martin engineering capacity could be overtaxed. In the long run, the price increase of the first 90 aircraft was chiefly due to the Kaiser muddle. Still, other alternatives undoubtedly would have been more expensive.

Program Changes 1954

The B–57B program, set at 293 aircraft, was reduced by 91. In early 1954, the Air Force pared the FY 53 B–57B procurement to 158 (a 33-aircraft cutback) and dropped the tentative purchase of 50 more B–57Bs. In the spring, 38 B–57Bs were canceled in favor of producing an equal number of B–57 dual-control trainers. A final change, a few months later, diverted 20 B–57Bs to the B–57D program of 1953. These aircraft were subsequently redesignated RB–57Ds.

First Flight (Production Aircraft) 18 June 1954

Following the B-57B's first flight, a few aircraft were delivered to the flight test center at Edwards AFB.

Enters Operational Service 1954-1955

B-57Bs were assigned to 2 Tactical Air Command light bombardment wings in late 1954 and early 1955. The 3-squadron wings in time received 18 aircraft per squadron—16 B-57Bs and 2 B-57 dual-control trainers. The initial recipient was the 424th Bomb Wing, Light, at Langley AFB. The 461st Wing, Blytheville AFB, Arkansas, acquired its first B-57B on 5 January 1955.

Operational Problems 1954-1955

Like the RB-57As, the B-57Bs prior to delivery suffered from engine malfunctions that filled the cockpit with toxic fumes. Following delivery, new engine problems required the grounding of B/RB-57s. Inspection of the engine compressor (the culprit) and lifting of the grounding order afforded short relief. Difficulties with the aircraft's stabilizer control system triggered another grounding in February 1955. The B-57Bs were released for flight the following month, but were restricted to a maximum speed of 250 knots pending modification of the horizontal stabilizer and the installation of a different stabilizer trim switch—yet to be accomplished by mid-year.

Testing 1954-1955

Fourteen of the first B-57Bs accepted by the Air Force never received the Garden Gate modification that was implemented on the production line. These planes were assigned permanently to testing, a program that started inauspiciously. Already delayed by Martin's production slippages, testing was continuously interrupted because the 14 test-bombers shared the deficiencies, groundings, and flight restrictions of other B-57Bs. Hence, an operational suitability test, conducted by the Air Proving Ground Command, was not completed on schedule. To make things worse, in February 1955 the command's interim test report generally confirmed TAC's expectations. After incomplete investigation, Air Proving Ground Command pointed out that the B-57B appeared in no way to satisfy the night intruder and close support requirements that had generated its production. The command gave several good reasons for its pessimism. The B–57B's target acquisition system was inadequate, the navigational range was too short, and the radio navigation could not recover the aircraft after strikes. The new bomber's armament also was deficient, the gun-bomb-rocket sight, the gun charging systems, and the external stores release being unreliable. Even the long-awaited M–39 guns could not be fired safely because the cartridge links hit the wing undersides. Moreover, the B–57Bs so far received still had no anti-icing and de-icing equipment. Nonetheless, the proving ground command tentatively concluded that the B–57B showed the potential of becoming an effective fighting machine. However, besides correction of the aircraft's present flaws, this would require the addition of proper internal equipment. Another obvious must was to increase range, which had shrunk in proportion to the aircraft's weight increase.[16]

Overseas Deployments — 1955

Once underway, B–57B deliveries were almost uninterrupted. Thus, in 1955 two oversea light bombardment wings were equipped with B–57Bs. The 38th Bomb Wing, Light, at Laon AB, France, was the first, beginning in June. The other, the 3d Bomb Wing, Light, at Johnson AB in Japan, followed late in the year.

Improvement Postponement — 1955

B–57B deployments, whether at home or overseas, did not signify that the Air Force was unaware of or accepted the aircraft's shortcomings underlined in the Air Proving Ground Command's interim operational suitability test report. In fact, these deficiencies were amply confirmed in the spring of 1955, when the AMC's Inspector General rated the new bomber nearly as low as the obsolete B–26 it was to replace. But the B–57B as received was quite flyable. The Air Force knew that, unlike the B–47, the aircraft could go directly to the tactical units and not make an immediate turn-around to a modification center. Moreover, money was scarce. The Air

[16] It would cost too much to modify the B–57 for air refueling, but there were other means to extend range. In principle, this had been taken care of in June 1954, with a purchase order for 54 external fuel tanks of the kind used by the old B–26s. Years later, however, TAC still experienced difficulties in getting enough long-range ferry tanks for the B–57s of its Composite Air Strike Force.

Force wanted to see how the faster B-66 fared, before endorsing a costly B-57 improvement program. Also, new equipment (radar, navigational, and other electronic systems) was either in short supply or still in the development or early production stages. In any event, the B-57's longitudinal control and stabilizer systems would be modified. But this could be postponed temporarily because, should the Air Force decide on other improvements, it would be cheaper to do all the work at once. Meanwhile, enforced (and not so unusual) flight restrictions would continue to ensure the aircraft's safety.

Post-Production Modifications 1955-1957

In September 1955 the Air Force decided to bring the B-57 to tactical standards. To this end, it organized a 3-phase combat readiness program. Phase I installed the low-altitude bombing system (LABS), the AN/APS-54 Radar Search, and the ALE-2 Chaff Dispenser. Phase II added the M-1 Toss Bomb Computer as well as the AN/APG-31 Tie-in-Equipment. This phase also involved so-called Class IV and V modifications to the longitudinal control and stabilizer systems and to the fuel control panels and special weapon bomb-bay doors. Phase III dealt with the AN/APN-59 Radar Beacon and a number of tentative engineering change proposals. Planning its 3-phase program carefully, the Air Force directed that it should be carried out by USAF personnel and contractor teams during the normal inspection and repair of each plane, as necessary. Some of the work was to be done at the Martin plant and some at the Warner Robins Air Materiel Area in Georgia. Like most planning, these arrangements were affected by circumstances. For example, modification schedules were altered by changes in programming and B-57 utilization. On occasion, Phases I and II were lumped together. Sometimes there were delays. The AN/APN-59's Phase III installation did not materialize. A Martin subcontract with the Swedish Airlines Services in Copenhagen, covering the modification of 55 United States Air Forces in Europe (USAFE) B-57s, was amended. The change decreased the number of aircraft involved by 20. Late in 1956, special USAFE requirements prompted TAC to part with 15 reworked B-57Bs. These aircraft, no longer under flying restrictions, remained on loan overseas while an equivalent number of USAFE B-57Bs underwent similar modifications. As for the Pacific Air Forces (PACAF) B-57s, they were modified at the Kawasaki plant at Gifu in Japan. Air Force personnel and teams from Land-Air, Inc. (another Martin subcontractor) handled the modification. The same Land-Air teams also helped in the United States. Even so, a great deal remained to be done in late 1957, as the aircraft's phaseout already appeared on the horizon.

End of Production — May 1956

Delivery of 2 last B-57Bs marked the end of production.

Total B-57Bs Accepted — 202

The Air Force accepted a peak number of 27 B-57s in June 1955—18 B-57Bs and 9 B-57Cs.

Acceptance Rates

The Air Force accepted 123 B-57Bs in FY 55, and 79 in FY 56.

Flyaway Cost Per Production Aircraft — $1.26 million

Airframe, $852,973; engines (installed), $257,529; electronics, $49,032; ordnance, $16,090; armament and others, $88,738.

Average Cost Per Flying Hour — $511.00

Subsequent Model Series — B-57C

Other Configurations — B-57G

Night strike operational problems in Southeast Asia led to a major reconfiguration of the plane that had been ordered many years before for another conflict. The B-57 night intruder, too late for combat in Korea and never totally successful in Southeast Asia, at least demonstrated under fire the basic qualities justifying its original selection. In 1967, after several trial projects involving the special equipping of different planes were delayed or proved unsuccessful,[17] the Air Force looked to the B-57 to begin satisfying

[17] Included in these many projects were the testing of a forward-looking infrared sensor, installed in an old B-26, and of a fairly similar but more sophisticated system, in a Fairchild C-123. These projects carried exotic names. One of them, Tropic Moon I, put low-light-level

increasingly tough requirements. As successively published in the late sixties, Southeast Asia Operational Requirements 35, 64, 77, and 117 called for a self-contained night attack jet aircraft. The plane had to carry every device needed to acquire and attack mobile ground targets and fixed anti-aircraft artillery sites, in any kind of weather and without any ground or airborne assistance.

The Air Force thought General Dynamics F–111D, as ordered in May 1967, would be the ultimate answer. Yet, production of such a high-performance, avionics-loaded weapon system would not be an easy task. For that matter, the less-ambitious reconfiguration of the already-proven B–57 would also be difficult, again because of the components earmarked for it. Pressed for time, the Air Force in March 1967 decided to equip 3 PACAF B–57Bs with an improved version of the Tropic Moon I low-light-level television already fitted in 1 A–1E. Referred to as Tropic Moon II, the new project was not allowed to linger. The Air Force notified all concerned commands on 12 April, and soon thereafter the Westinghouse Electric Corporation received the modification contract for the 3 aircraft that PACAF chose and ferried from Southeast Asia to Baltimore. Once modified, the Tropic Moon II planes were returned to Southeast Asia without delay. They actually reached Phan Rang AB in South Vietnam on 12 December 1967.

Meanwhile, the B–57's final reconfiguration was approved. Initially labeled Night Rider, this project centered on a General Dynamics proposal to equip 15 B–57s with low-light-level television, forward-looking radar, and infrared sensors. The B–57 appeared well suited for the Night Rider role. The aircraft was available, had room for several sensors, and could carry 9,000 pounds of bombs at speeds of 160 to 500 knots. TAC and PACAF supported the Night Rider project, but in May 1967 the Air Staff rejected it as somewhat risky and far too costly. Rising difficulties in Southeast Asia, where enemy night movement of troops and supplies continued unabated, caused the Air Staff to reconsider its disapproval. In mid-year, the Air Force not only decided to endorse the Night Rider concept, but also to speed it up. This gave way to Tropic Moon III, the conversion of B–57s to self-contained night attack configuration. Tropic Moon III received added impetus in August, when the Air Staff told the Air Force Systems Command[18] to skip usual managerial procedures, to develop a B–57G prototype "immediately," and to plan for simultaneous procurement of a full B–57G squadron. The

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television in a McDonnell-Douglas A–1E Skyraider, but the plane was not expected to reach South Vietnam until the end of 1967.

[18] The Air Force Systems Command came into being on 17 March 1961, replacing the Air Research and Development Command that had been established in 1950.

Air Force wanted the Tropic Moon III prototype to be ready for testing by September 1968. It also wanted the 15 B–57Gs "to be deployed as soon as possible" to Southeast Asia.

Notwithstanding Tropic Moon III's urgency, money had to be found before anything could be done about it. By late 1967, the skimpiest Air Force estimates showed that it would take some $50 million to accomplish the project. But in early 1968, the problem seemed to be solved. Funds from lower priority programs had been shifted, $25 million had been added to the overall budget for fleet modification, and the Air Force was ready to inform industry of its requirements. Hence, on 8 March, Air Force Systems Command's Aeronautical Systems Division advertised for bids to modify government-furnished B–57Bs to a new "G" configuration by integrating government- and contractor-furnished equipment. The contractor guidelines, offered by the Aeronautical Systems Division, were quite explicit. Besides the basic airframe, the Air Force would furnish engines, electronic countermeasures equipment, and communications sets. The contractor would provide the weapons delivery and navigation systems as well as modify the airframes. Specific yardsticks were established for the B–57G's avionics. The Tropic Moon III forward-looking radar had to be highly sophisticated, certainly as efficient as the AN/APQ–126 of the Ling-Temco-Vought A–7D (the Air Force's forthcoming version of the Navy A–7 Corsair). The Tropic Moon III weapons delivery computer and navigation system were to be particularly accurate. Additional armor plate and new

Deployed to Southeast Asia, this B–57 Canberra completed a mission against Viet Cong troops in the province of Tay Ninh.

ejection seats had to be provided to increase crew protection. Also, other changes were required in order to enhance safety, including the mounting of self-sealing fuel tanks in the aircraft fuselage.

The Air Force's 1968 financial bliss did not last long. Bids submitted in April by General Dynamics, Ling-Temco-Vought, North American Rockwell, and Westinghouse topped the highest USAF estimate by $30 million or more. In May and June, the extra money actually needed could not be secured. It therefore became clear that the Air Force had only 3 choices, one of which was to forget the whole project, a possibility considered for a while. Less drastic second and third alternatives were to reduce the number of B-57Gs, or to trim some of the weapon system's costly requirements. Well acquainted with the state-of-the-art limits and the pitfalls of new components of the forward-looking radar type, the Aeronautical Systems Division fought for the third solution. The division[19] won its case, as Wright Air Development Center had years before when challenging the wisdom of the B-57A production. Reconfiguration of 16 lower-performance Tropic Moon III B-57Gs (prototype included) was officially approved on 29 June. The selected prime contractor, the Westinghouse Defense and Space Center of Baltimore, agreed on 15 July to do the work for $78.3 million—an amount still higher than hoped for. Two major subcontractors were involved. Westinghouse counted on Martin-Marietta to inspect and repair the elderly B-57Bs picked for reconfiguration. Texas Instruments was made responsible for the forward-looking infrared radar and laser ranger.

When dealing with new technology, the best plans could go astray. The Air Force wanted to put the Tropic Moon III B-57s into combat by April 1969, but this soon was changed to December. And this more realistic deployment date was not met, even though the modification at first proceeded smoothly. There were many reasons for every delay. In early 1969, Westinghouse category I tests fell behind schedule because the Air Force was late with the shipments of necessary ground equipment. To compound the problem, in August Texas Instruments' deliveries of forward-looking infrared sensors began to slip significantly, and the Air Force failed to deliver the electronic countermeasures equipment on time. In late 1969 investigation of recent crash of a B-57G, still being tested by Martin pilots, indicated that the aircraft's minimum speed was too slow for safety. Ensuing flying incidents, in February and May 1970, uncovered mechanical flaws which, although minor, had to be corrected.

Meanwhile, there were other setbacks. In 1968, the Tropic Moon II B-57's performance had proved disappointing, mainly because the low-light-level television system did not live up to expectations and the aircraft's

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[19] Aeronautical Systems Division was established on 1 April 1961, replacing WADC.

navigation system remained unreliable. In mid-1969, Westinghouse announced that the Tropic Moon III project would cost at least an extra $3.5 million. This additional expense was troublesome, but the Air Force was more disturbed by other events. Foremost were difficulties experienced with the weapon system's most crucial components which, besides delaying the program further, affected crew training and testing of new devices and munitions. As a result, the Air Force no longer thought of Tropic Moon III as a partial solution to a most urgent Southeast Asian problem. Rather, it had begun to consider the B-57G and F-111D as evolutionary steps toward the development of a high-speed, fully integrated, self-contained night and all-weather weapon system of the future.

In line with its new Tropic Moon III appraisal, the Air Staff in early 1970 insisted that the latest September deployment date would be met. The B-57G's category III tests, conducted by the Tactical Air Warfare Center between 29 April and 27 July, did not alter the Air Staff's decision. Overall, the results of category III testing indicated that, except for the forward-looking infrared radar, the aircraft's avionics equipment satisfied basic requirements. Concluding that the aircraft performance was nearing that originally specified, Gen. John D. Ryan,[20] Air Force Chief of Staff, ordered the 13th Bombardment Squadron to move to Ubon Air Base, Thailand, on 15 September. Only 11 of the remaining 15 B-57Gs were assigned to the squadron, leaving 3 aircraft at MacDill AFB to train replacement crews. A last B-57G also stayed behind to serve as a "test bed" for future improvements.

The Tropic Moon III B-57Gs were returned to the United States in April 1972. Despite the combined efforts of Texas Instruments and Westinghouse, the forward-looking radar proved deficient. Improved sets updated at a cost of $2 million and first combat tested in September 1971, also never worked completely well. But the B-57G airframe, with its new J65-W-5D engines, measured up to the planning criteria. The aircraft also got involved successfully in such projects as Pave Gat, which showed that sensor-slued guns could function effectively in a jet bomber.

Phaseout 1958–1973

As programmed, TAC phaseout of its B-57B/C aircraft was fast. Started in April 1958, it was completed on 23 June 1959. To some extent, TAC deplored its loss. Despite limited speed, short range, and other

[20] General Ryan replaced Gen. John P. McConnell as Chief of Staff of the United States Air Force on 1 August 1969, and served in that position through 31 July 1973.

deficiencies, the B–57B had become a proven weapon system presenting few maintenance problems. A PACAF request for retention of its own B–57s fared better, and 2 squadrons remained at Johnson AFB, Japan, until 1965. These B–57 units, the 8th and 13th Bomber Squadrons, Tactical, then moved to Clark AB, in the Philippines for possible action in Southeast Asia. Small numbers of the aircraft soon flew missions from Bien Hoa and Da Nang Air Bases in South Vietnam. Combat attrition, accidents, and old age took their toll of the aircraft. Forthcoming Tropic Moon requirements also did not help, forcing PACAF to inactivate its last squadron in 1968. But this did not really spell the B–57B's end. As already noted, TAC reactivated the 13th Bombardment Squadron, Tactical, to fly reconfigured B–57B and B–57C aircraft. Known as B–57Gs, these planes stayed in Southeast Asia until 12 April 1972. Having been stripped of most of their Tropic Moon components, the B–57Gs went to the Air National Guard—like many of TAC's B–57Bs in the late fifties. The Guard flew the B–57Bs, that had been modified for reconnaissance, until 1966. However, its newly acquired B–57s were scheduled for storage at Davis-Monthan AFB in early 1974.

Other Uses 1956–1957

One B–57B was extensively modified for Operation Red Wing, a special weapons test held in the Pacific in 1956. To save time and money, the plane was modified while on the production line. Martin later restored this Red Wing B–57B to its regular configuration.

Six B–57Bs were modified during August and September 1956 to perform sampler roles in the Red Wing tests. In December 1957 four additional B–57Bs were also modified to monitor the type and rate of radioactive fallout in the upper atmosphere after a nuclear blast. Following completion of the Red Wing tests, these planes were all allocated to the Air Force Special Weapons Center at Kirtland AFB, New Mexico.

In late 1957, ten B–57Bs were modified under Project Stardust. This modification removed all armament equipment from the aircraft, but put in the latest flying instruments. These modified B–57Bs were used by high-ranking officers for proficiency flying and transportation.

Other Countries 1960

More than 50 B–57Bs, re-fitted with less-sophisticated components, were delivered to Pakistan under the auspices of the Military Assistance Program.

B-57C

Manufacturer's Model 272

Weapon System 307A

Previous Model Series B-57B

New Features

Rear cockpit flight controls and instruments were the only new features of the B-57C.

Basic Development 1953-1954

Development of a dual-control B-57B was spurred by an Air Training Command request in February 1953. In the ensuing months, TAC also insisted that a new trainer was needed to replace the T-33. Even the most seasoned pilots, TAC argued, needed to learn how to handle multi-engine jet bombers skillfully.

Go-Ahead Decision April 1954

Reduction of the B-57B program in favor of production of a dual-control version of the aircraft was officially approved in April 1954. At first, 34 B-57Bs on the fiscal year 1953 program were to be modified on the production line, but this number was almost immediately raised to 38. The modification, consisting mostly of installing government-furnished equipment in the aircraft's rear cockpit, was expected to cost less than $50,000 per aircraft. Although low cost was a factor, the Air Staff's decision stemmed primarily from Martin's assurance that the B-57B could be brought to the dual-control configuration without compromising its combat performance. In other words, no extra B-57Bs would be needed to replace those converted into trainers since the latter could still be used as bombers.

Additional Procurement — August 1954

Purchase of an additional 26 dual-control B–57s was included in the fiscal year 1955 program, in connection with the production of another B–57 type. In August 1954, however, the 26-aircraft order was canceled and the dual-control planes, formerly known as TB–57Bs, were redesignated B–57Cs.

Prototype Inspection — November 1954

The November inspection of the first B–57B modified for dual-control revealed no discrepancies.

First Flight — 30 December 1954

The B–57C made its first flight on 30 December 1954 and its second one on 3 January 1955. The Martin pilots who flight tested the plane were impressed by its performance and pointed out that they encountered no handling difficulties.

Enters Operational Service — 1955

Four B–57Cs, purchased to take care of attrition, were initially allocated to Air Training Command to support the B–57B transition training program. All other B–57Cs immediately went to tactical units. In fact, in the United States or overseas, 2 out of every 18 aircraft in a B/RB–57 squadron were B–57Cs.

Problems and Modifications — 1955–1957

Being practically identical, the B–57Bs and B–57Cs shared the same operational problems. Hence, most B–57B modifications were applied to the B–57Cs.

End of Production — May 1956

Delivery of 1 last B–57C in May 1956 marked the end of the dual-control production line modification.

Total B-57Cs Accepted **38**

Acceptance Rates

The Air Force accepted 18 B-57Cs in FY 55, and 20 in FY 56.

Flyaway Cost Per Production Aircraft **$1.21 million**

Airframe, $916,279; engines (installed), $144,523; electronics, $46,128; ordnance, $20,340; armament and others, $84,685.

Subsequent Model Series **RB-57D**

Other Configurations **None**

Phaseout **1958-1959**

Phaseout of the small B-57C contingent followed the B-57B's pattern. Like the B-57Bs of the Tactical Air Command, most B-57Cs were brought up to the reconnaissance configuration in 1958, when they began reaching the Air National Guard. Three RB-57Cs were still listed on the Guard inventory in mid-1973.

RB–57D

Manufacturer's Model 294

Weapon System 307L

Previous Model Series B–57C

New Features

The single-seat RB–57D featured a substantially altered B–57B fuselage, new wings, more powerful engines, and components that varied, according to the aircraft's many specialized roles. Specifically, the fuselage bomb-bay was permanently closed off, the fuselage fuel tanks were removed, and 4 camera windows were installed forward of the nose wheel well. The RB–57D's large nose and tail radomes further lengthened the fuselage. The aircraft empennage incorporated a power-driven rudder and yaw damper. Fuel cells were integral with the RB–57D wing, which was of honeycomb construction—the first time that such a structural feature had been used in a piloted aircraft. The new wings, with their 105-foot span and their 1,500 square-foot area (replacing the 64-foot span and 960 square-foot area of the regular B–57), completely changed the appearance of the airplane. Two 1,000-pound thrust J57–P–9 engines (that took the place of the 7,200-pound static thrust J65s) had anti-icing equipment and could be used at altitudes over 70,000 feet. To increase range, all but the first 6 RB–57Ds were equipped for air refueling.

Basic Development 1952–1953

Martin's Model 294, which ultimately became the RB–57D, developed from a study concluded in December 1952 by the Wright Air Development Center. This study showed that it should be possible to develop "in a relatively short time period" a turbojet-powered special reconnaissance aircraft, with a radius of 2,000 nautical miles at altitudes of 65,000 feet. Anticipating a formal requirement for such an aircraft, the center established design Project MX-2147, which also specified that subsonic speed would be acceptable and that no defense armament would be required.

Requests for Proposals — April 1953

The advertisement of Project MX-2147 in April 1953 was followed by the award of 3 design contracts—to Bell, Fairchild, and Martin. The Martin study contract was initiated by a 29 June letter contract, amounting to $31,406. This document, as revised in October, bound Martin to submit reports on its design study by 11 December 1953 and allowed a $2,784 cost increase.

Production Decision — 21 June 1954

The Air Force decided in June that 6 of the B-57Bs currently on order would be built in the configuration of Model 294. The decision was based on several factors. Martin's high altitude design offered "relatively good performance, an operational date 12 to 18 months earlier, and lower costs" than Bell's X-16.[21] Martin's new planes, designated B-57Ds in August 1954, became RB-57Ds in April 1955—after the Air Force made it known that the airplanes would be used exclusively for strategic reconnaissance.

Additional Procurement — 3 January 1955

The Air Force increased the specialized reconnaissance B-57D program to 20 airplanes—the final total—and attached an overriding priority to the whole project. The forthcoming RB-57Ds, all destined for the Strategic Air Command, were ordered in 3 versions. The original 6, plus 6 of the additional 14, would be 1-man RB-57Ds carrying among other components 2 K-38 and 2 KC-1 split vertical cameras. One RB-57D, singled out as the RB-57D-1, would be equipped with the AN/APG-56 high-resolution, side-looking radar for day or night radar mapping reconnaissance. The RB-57D-1 would also carry a crew of 1. The remaining 6 RB-57Ds,

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[21] This did not mean the end of the X-16 Bald Eagle. The Bell design had actually been judged the best proposal and the Air Force endorsed the aircraft development concurrent with production of the Martin model. Just the same, the X-16 never reached the fabrication stage. Even though a significant number of Bald Eagles were ordered, the project was canceled in mid-1955 after Lockheed flew a U-2 which had been designed and built with company funds.

identified as RB-57D-2s, would be fitted with ferret electronic countermeasures equipment and would have a crew of 2—pilot and electronic countermeasures operator. All but the first 6 airplanes would be equipped for in-flight refueling by KC-97 tankers. Air-refueling would be done via a boom slipway door, aft of the canopy. The 20 RB-57Ds would have an autopilot and the D-1 and D-2s would feature the AN/APN-59 navigational equipment.

Contractual Arrangements 1954-1955

The Air Force intended to carry Martin's high-altitude B-57 on Contract AF 33(600)-22208, which followed the first definitive contract—AF 33(038)-22617—initiated by the letter contract of March 1951. However, negotiations for this second contract, like those of its predecessor, were complicated by the many changes that kept on afflicting the whole B-57 program. After discovering that less than 20 percent of the new aircraft's parts matched those of the B-57B, the Air Force had to alter its plans. The programmed quantity of B-57Bs was reduced by 20, and the 20 airframes (completed to the extent components were common to both B and D airplanes) were booked against contract AF 33(600)-25825, even though this document had been designed to cover nothing more than a pure development study. The stripped-down airplanes, transferred on paper as government-furnished equipment, were valued at $6 million. This sum, like subsequent costs for the D airplanes, was charged to the AF 33(600)-25825 development contract. This cost-plus-fixed fee agreement was allowed a high fixed fee rate of 7 percent, because of the program's urgency and the many imponderables faced by Martin in undertaking such a project. In early 1958 the total estimated cost of the entire D program was about $60 million—$1 million short of the final amount.

First Flight 3 November 1955

The high-altitude, daylight photo-reconnaissance RB-57D was first flown on 3 November. The flight lasted 50 minutes and the results were satisfactory.

Testing 1955-1956

Because of the urgency of the program for which the RB-57Ds were built, flight testing had to be limited and all tests ended in 1956. To begin with, Category II testing (a joint contractor-USAF effort) was not allowed to linger. Started on 29 November 1955, these tests were completed on 7 December. Just the same, RB-57D deliveries slipped to the spring of 1956.

Enters Operational Service 1956

It took until May 1956 for Strategic Air Command (SAC) to get its first RB-57Ds, even though the aircraft had been scheduled for delivery in late 1955. Strikes at Lear, Incorporated, which supplied the radars, caused delays in equipping the aircraft. Westinghouse, another main subcontractor, also had labor problems that created a shortage of autopilots. But the overall situation improved. By the end of September, SAC's inventory counted 11 RB-57Ds. Four B-57C trainers, brought up to the reconnaissance configuration, accompanied the new aircraft.

Operational Problems 1957-1958

Materiel deficiencies accounted for 20 of 22 unsatisfactory sorties, flown during June 1957 by the specialized RB-57Ds of the 4025th Strategic Reconnaissance Squadron. The Pratt and Whitney J57-P-9 engines, Westinghouse autopilots, and some of the more complicated electronic countermeasures systems did not function properly. In addition, it was difficult to obtain parts for the new electronic countermeasures components. The greatly enlarged wing also kept causing problems. First, the main wing spar had to be strengthened as did sections of the wing panels. Then, the Martin-developed "honey-comb" wing surfaces were subject to water seepage and wing stress. These shortcomings taken care of, the RB-57Ds served SAC's purposes well for several years.

End of Production December 1956

The RB-57D production ended in December 1956, but the Air Force did not take delivery of the last plane before March 1957.

Total RB-57Ds Accepted 20

Acceptance Rates

The Air Force accepted 12 RB-57Ds in FY 56 and 8 in FY 57.

Flyaway Cost Per Production Aircraft — $3.05 million

Airframe, $2,531,437; engines (installed), $313,974; electronics, $171,271; others, $39,750.

Subsequent Model Series — B–57E

Other Configurations — RB–57F and WB–57F

RB–57F—Most RB–57Fs were modified RB–57Ds even though a few B–57Bs were brought up to the same configuration. The modification, endorsed in the early sixties, was accomplished by the General Dynamics Corporation in Fort Worth, Texas. The first RB–57F flew in April 1964 and was accepted by the Air Force 2 months later. Still, it took until March 1967 to complete the last aircraft—a 2-year delay. The 16-aircraft project also proved to be much more expensive than expected. Each modified plane carried a price tag of $9 million—airframe, $5,958,530; engines (installed), $562,500; electronics, 1,573,750 others, $925,000. Moreover, some RB–57Fs, equipped for long-range oblique photography, cost an additional $1.5 million—for a unit cost close to $10.6 million. But the RB–57F, funded under a very special project, turned out to be an exceptional plane. Equipped with 2 Pratt & Whitney TF33–P–11A engines and 2 auxiliary J60–P–9s, the 2-seat (pilot, plus navigator or special equipment operator) RB–57F had a service ceiling of 68,500 feet, a cruising range of 3,690 nautical miles, a cruise endurance of 9.7 hours, and a cruising speed of 420 knots. Yet, the RB–57F's average cost per flying hour was only $886; the average maintenance cost, $407. Two RB–57Fs were allocated to the United States Air Forces in Europe and 2 others went to the Pacific Air Forces. The remaining 12 RB–57Fs were at Kirtland AFB, New Mexico, where they served with the 58th Weather Reconnaissance Squadron of the Military Air Transport Service.[22] These RB–57Fs were used to support Atomic Energy Commission and the Air Force Technical Applications Center's requirements until they were redesignated as WB–57Fs.

WB–57F—General Dynamics modified a few additional B–57Bs to give Military Airlift Command's Air Weather Service its 17 WB–57F contingent.

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[22] The Military Air Transport Service, responsible for furnishing rapid airlift for the armed forces of the United States and its allies throughout the world since June 1948, was renamed the Military Airlift Command on 1 January 1966.

The WB-57Fs, former RB-57Fs as well as newly reconfigured B-57Bs, retained the RB-57F's price—$9 million each. The redesignated aircraft stayed at Kirtland AFB, with the same squadron, for very similar purposes. Among other duties, the 58th Squadron for years continued to fly high-altitude radiation sampling missions to furnish data to the Defense Atomic Support Agency. In mid-1973, however, both the aircraft and the squadron neared their end. The Air Force planned to inactivate the 58th and to put all WB-57Fs out of the active inventory in mid-1974. Two of the aircraft were scheduled to go to the National Aeronautics and Space Administration, where they were expected to support further high-altitude sampling projects and the development of satellite systems.

Phaseout 1959–1960

SAC did not retain its RB-57Ds and few RB-57Cs very long. Only 6 of the aircraft remained with the command by December 1959. On 22 April 1960 SAC disposed of the last one, an RB-57C (Serial No. 53-3838) assigned to the 4080th Strategic Wing, Laughlin AFB, Texas. Four years before, the 4080th, then located at Turner AFB, Georgia, had received the command's first RB-57C (Serial No. 53-3842).

B–57E

Manufacturer's Model 272E

Previous Model Series — RB–57D

New Features

The 2-man (pilot and tow-target operator) B–57E featured a hydraulic power-boosted rudder (to improve directional stability) and target launching equipment. The B–57E differed externally from the dual-control B–57C in that it carried 2 target canisters (located on the lower rear fuselage), a modified tail cone, 2 rotating beacons, and a larger tail skid. The E-model had no armament and no bombing equipment, but either could be added without difficulty. The tow-target B–57E could easily be brought to the configuration of the B–57B bomber, because its target containers, internal cable reels and fittings, as well as cockpit towing controls were removable.

Initial Requirement — 16 March 1954

The Air Force asked the AMC to issue requirements for a modified B–57 that would be capable of acting as a tow-target aircraft and, like its predecessors, be suitable for rapid conversion to an operational bomber. The dual-control tow-target B–57 was expected to carry 4 tow reels and 4 banner targets per mission.

Go-Ahead Decision — January 1955

Although the Air Force was eager to replace its tow-target versions of the B–26 and B–45 airplanes, a firm decision on the B–57E program was not reached until January 1955. A number of factors accounted for the delay. Martin was slow in submitting specifications for the new configuration, and protracted program decisions as to quantities and types of airplanes did not help.

Contractual Arrangements February–December 1955

The last major B-57 contract—AF 33(600)-29645—was initiated under the fiscal year 1955 procurement program by a letter contract, signed on 21 February 1955. Contract negotiations started with a requirement for 68 B-57Es and 26 B-57Cs, but this order was subsequently canceled. This prompted a new round of negotiations and postponed signature of the definitive contract to 8 December—half-way through fiscal year 1956. To avoid a costly break in production scheduling (estimated at $16 million), previous programs were stretched. This raised the cost of the fiscal year 1955 program by $1.5 million (a comparatively low-cost alternative) and lowered Kaiser's workload, giving the wing subcontractor a chance to finally catch up.

First Flight (Production Aircraft) 16 May 1956

Martin first flew successfully a production B-57E with tow targets on 16 May—the first aircraft built for the Air Force specifically for this type of duty. The target launchers of 2 modified dual-control B-57Cs, used by Martin as B-57E prototypes, failed to work during earlier flights in April of the same year. But eventually, these problems were solved, and the 2 aircraft joined the B-57E fleet.

Program Change 10 July 1956

The Air Force canceled Strategic Air Command's requirement for conversion of 7 B-57E aircraft to the TRB-57E configuration. The Air Staff decided that, as planned, all but 4 of the 68 B-57Es would go to the Air Defense Command. The 4 exceptions, B-57Es without tow-target equipment, were allocated to the Air Force Flight Test School.

Enters Operational Service August 1956

A few B-57Es began reaching Air Defense Command in August and 18 more were delivered in September. However, Air Force Flight Test School did not receive its first aircraft until 24 October, and additional deliveries lagged behind schedule.

Program Slippage — March 1957

Because it started late, the B–57E program was accompanied by short deadlines and hurried production orders, all of which could spell trouble. But the program actually benefited from an odd combination of events. Already engrossed in the RB–57D program in February 1955, when the B–57E letter contract started, Martin found itself short of 600 engineers and of necessity subcontracted a good bit of the B–57E engineering. This turned out well. Hudson Motors was made responsible for the tow-target installation; Kaiser received an extension of its subcontract for the E wings; and excess parts, built by Martin for the high priority RB–57Ds, were transferred to the B–57E program. Nonetheless, there were a few setbacks. Late deliveries of government-furnished equipment, difficulties in getting the tow reel system to work with the B–57E without excessive airframe modifications, and other equipment problems held up the program for a time. Yet, much of the backlog was eliminated by the end of 1956. In the long run, the B–57E program's overall slippage did not exceed 1 month—a most rewarding accomplishment.

End of Production — 1957

Production ended in early 1957, and the last B–57E was delivered in March.

Total B–57Es Accepted — 68

Acceptance Rates

The Air Force accepted 2 B–57Es in FY 56—both in May 1956. All others were accepted in FY 57—beginning in August 1956 and ending in March 1957.

Flyaway Cost Per Production Aircraft — $1.01 million

Airframe, $847,534; engines (installed), $125,756; electronics, $22,377; others, $21,433.

Subsequent Model Series — None

Additional Procurement — None

Rather than buying more B-57Es, the Air Force converted B-57Bs to the tow-target configuration. Some of these B-57Bs (such as those allocated in 1958 to TAC's lst Tow Target Squadron) came from USAFE, where they had received so-called "hard usage" modifications. Before undertaking their towing missions, these aircraft needed much more than modification. Fortunately, Warner Robins Air Materiel Area was able to do most of this work. The lst Tow Target Squadron flew its newly acquired aircraft for several years, transferring the last 14 to Air Defense Command on 1 July 1962. This marked the end of the B-57 weapon system in the TAC inventory.

Modernization — 1965

In the mid-sixties, all B-57Es (converted B-57Bs included) were equipped with the external AF/A372-1 tow-target system.

Other Configurations — EB-57E, RB-57E, and TB-57E

B-57E productions as well as B-57Bs converted to the E configuration underwent changes throughout the years. The Air Force at times used a few of these aircraft for training—modifying, adding equipment, and referring to the planes as TB-57Es. Many B-57Es, regardless of their origin, became RB-57Es after modification and the addition of reconnaissance equipment. Some of these planes still served in Southeast Asia in mid-1966, even though they were beginning to show signs of fatigue. The most gratifying change (from the economical standpoint) put electronic countermeasures equipment in the planes, which were redesignated EB-57Es. The sophisticated but relatively inexpensive EB-57Es, with a unit price of $2.02 million (electronic countermeasures equipment and modification costs included), provided electronic countermeasures targets to ground and airborne radar systems. In mid-1973, the Air Force active inventory counted an almost equal number of reconnaissance or electronic countermeasures-equipped B-57Es (19 RB-57Es and 23 EB-57Es), but the EB-57Es were expected to outlast every B-57 version.

Operational Status — Mid-1973

Air Force rolls only listed 9 B-57Es by the end of June 1973, but various configurations of the versatile airplane continued to play significant roles, with no immediate phaseout in sight.

Program Recap

The Air Force accepted a grand total of 403 B-57s, all of which were produced in Baltimore, Maryland, by the Glenn L. Martin Co. Specifically, the B-57 program comprised 8 B-57As, 202 B-57Bs, 38 B-57Cs, 68 B-57Es, 67 RB-57As, and 20 RB-57Ds. Other B-57s, such as the B-57Gs, RB-57Fs and WB-57Fs, were the result of extensive post-production modifications. Production ended in early 1957, but at the close of the year USAF records showed that 47 of the 403 aircraft had been destroyed in major accidents. This came as no great surprise. Overall, the B-57 was not easy to fly. Moreover, prior to modification of its longitudinal control and stabilizer systems, the B-57 was uncontrollable if 1 of its 2 engines failed during takeoff or landing. In 1958, after completion of all possible modifications, the Air Force ascertained that 50 percent of the major accidents resulted from pilot errors, with 38 percent of the accidents occurring upon landing. Yet, while the number of B-57 accidents was high—129 major and minor accidents as of 1958, the rate compared favorably with that of the B-47 and some other aircraft.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

B/RB-57 AIRCRAFT

Manufacturer (Airframe) The Glenn L. Martin Co., Baltimore, Md.

(Engines) Wright Aeronautical Division of The Curtiss-Wright Corporation, Wood-Ridge, N.J., and Buick Division of The General Motors Corp.

Nomenclature Light Tactical Bomber, Trainer, Target Tug, and Reconnaissance Aircraft.

Popular Name Canberra

	B-57B	B-57C	B-57E	RB-57A	RB-57F
Length/Span (ft)	65.5/64	65.5/64	65.5/64	65.5/64	68.3/122.5
Wing Area (sq ft)	960	960	960	960	2,000
Weights (lb)					
Empty	28,793	28,793	34,789	26,380	37,020
Combat	38,689	38,689	37,300	32,448	49,500
Takeoff	56,965[a]	56,965[a]	54,072	57,000	61,500[b]
Engine: Number, Rated Power per Engine, & Designation	(2) 7,220-lb st (max) J65-W-5 or (2) 7,220 lb st (max) J65-BW-5	(2) 7,220-lb st (max) J65-W-5 or (2) 7,220-lb st (max) J65-BW-5	(2) 7,220-lb st (max) J65-W-5 or (2) 7,220-lb st (max) J65-BW-5	(2) 7,220-lb st (max) J65-W-5 or (2) 7,220-lb st (max) J65-BW-5	(2) 16,000-lb st (mil) TF33-P-11A & (2) 2,900-lb st (mil) J60-P-9
Takeoff Ground Run (ft)					
at Sea Level	5,000	5,000	5,050	3,400	2,600
Over 50-ft Obstacle	6,200	6,200	6,250	4,300	2,800
Rate of Climb (fpm)					
at Sea Level	4,320	4,320	3,825	4,800	2,725
Combat Rate of Climb (fpm) at Sea Level	6,180	6,180	370 (with target deployed)	7,100	7,600

Service Ceiling (100 fpm Rate of Climb to Altitude)	40,100	40,100	28,600 (with target deployed)	44,500	60,800
Combat Ceiling (ft) (500 fpm Rate of Climb to Altitude)	45,100	45,100	36,950 (with target deployed) at final towing weight	49,000	60,650
Average Cruise Speed (kn)	414	414	342 (initial towing speed)	355	411
Max Speed at Optimum Altitude (kn/ft)	520/2,500	520/2,500	403/25,000 (limited by banner shredding)	499/9,000	420/63,500
Combat Radius (nm)	824	824	2.50 hr (towing time)	250	1,280
Total Mission Time (hr)	4.13	4.13	2.68	3.12	6.12
Armament	4 20-mm M39[c]	4 20-mm M39[c]	Not Applicable	None	None
Crew	2	2	2	2	2
Max Bombload (lb)	6,000[d]	6,000[d]	N.A.	None[e]	None[f]

Abbreviations

fpm = feet per minute
kn = knots
max = maximum
mil = military
nm = nautical miles
st = static thrust

[a] Limited by space.
[b] Limited by wheel loading.
[c] Plus 16 underwing rockets.
[d] Bombloads could be made of various combinations—M117s MK82s, MK81s, CBU/SUU-30s, M14A frag clusters, fire bombs, flares, and the like.
[e] Several cameras (P-2s, K-37s, T-11s, K-17s, K-38s), plus flash bombs and photo flash cartridges.
[f] High-altitude weather photo reconnaissance equipment and special components for atmosphere sampling operations.

Basic Mission Note

All basic mission's performance data based on maximum power, except as otherwise indicated.

Combat Radius Formula:

B-57B and B-57C—Warmed up, took off, and climbed on course at maximum power. Cruised out at long-range speeds, increasing altitude with decreasing weight (external tanks being dropped when empty). Over target, descended to sea level and dropped bombs; external stores also, if carried. Remained in combat area for 5 minutes and climbed on course to cruise ceiling at maximum power. Cruised back to home base at long-range speeds, increased altitude with decreasing weight. Range-free allowances included 5-minute normal-power fuel consumption for starting engine and take-off; 5-minute sea level fuel consumption at power required for maximum structural limit speed; 20 minutes of maximum-endurance fuel consumption at sea level, plus 5 percent of initial fuel load for landing reserve.

Formula: Radius Mission II (High Speed)

Same profile and fuel reserve as for basic mission (Mission I), except all cruising was at normal-rated power.

Formula: Range Mission V (Ferry Range)

Warmed up, took off and climbed on course to cruise ceiling at maximum power. Cruised out at long-range speeds, increasing altitude with decreasing weight (external tanks being retained when empty). Range-free allowances included 5 minutes of normal-power fuel consumption for starting engines and take-off, 30 minutes of maximum-endurance fuel consumption at sea level plus 5 percent of initial fuel load for landing reserve.

B-57E—Formula: Towing Mission I

Took off and climbed on course at military power to normal-power service ceiling for banner extended configuration. Extended banner and cruise-climbed at speeds for maximum mile per pound in a race track pattern until only fuel for landing reserve remained. Cut banner and landed. Time-free allowances included 5-minute normal-power fuel consumption for starting engine and take-off, and 30 minutes of maximum-endurance fuel consumption at sea level plus 5 percent of initial fuel load for landing reserve.

B-57E—Formula: Towing Mission II

Same as Mission I, except towing was conducted at a constant altitude of 30,000 feet.

B-57E—Formula: Range Mission III

Took off and climbed on course to optimum cruise altitude at military power. Cruised out at maximum-range speeds, increasing altitude with decreasing weight, until all useable fuel (less reserve fuel) was consumed. Range-free allowances similar to time-free allowances of Mission I.

RB-57A—Formula: Radius Mission I

From sea level, took off and climbed on course to 24,000 feet with military thrust. Cruised at 24,000 feet at recommended cruise speed. Made an on-course normal descent to 5,000 feet. Flew at 5,000 feet, at 300 knots true airspeed, with no distance credit. Climbed on return course to 24,000 feet with military thrust. Cruise back at 24,000 feet at recommended cruise speed. Made normal descent to sea level on return course. Mission reserve fuel was 2,500 pounds.

RB-57F—Formula: Radius Mission

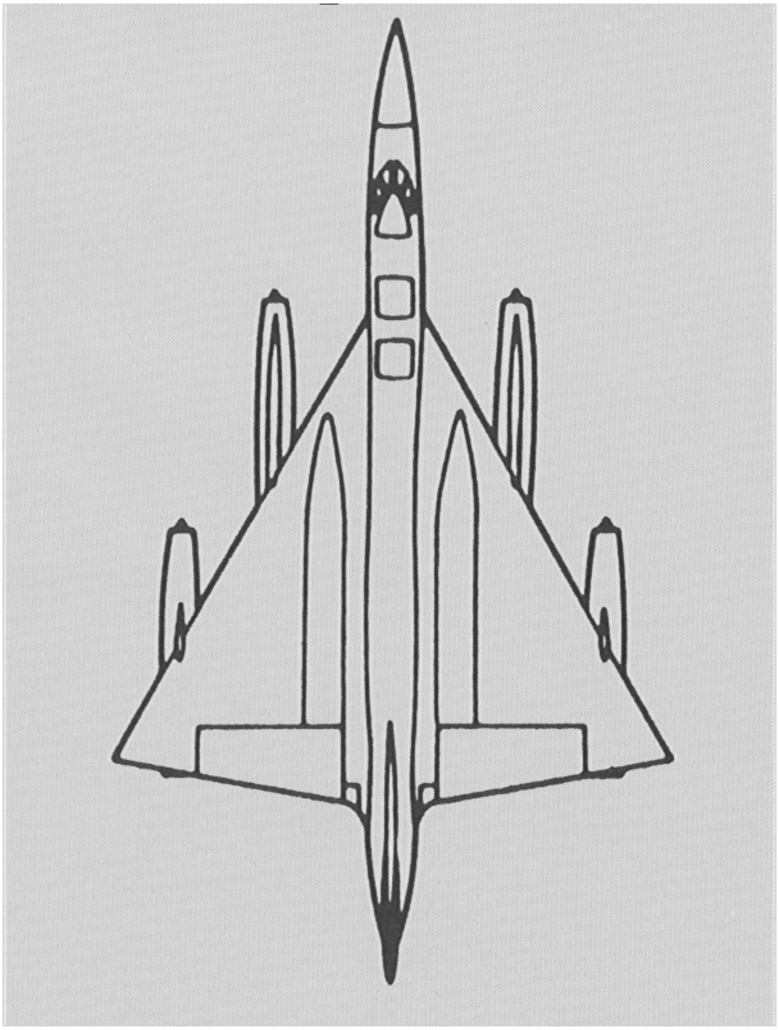
Took off and climbed on course at maximum allowable power to initial altitude of 60,000 feet. Cruised out at long-range speeds and at maximum altitudes to target at 63,200 feet. Returned to base at long-range speeds and maximum altitudes. Range-free allowances were fuel for 5 minutes at take-off power (70 percent of military-rated power) and 20 minutes at maximum-endurance speeds at sea level, plus 5 percent of initial fuel for landing reserve.

RB-57F—Formula: Ferry Range Mission

Took off and climbed on course at maximum allowable power to optimum cruise altitude. Cruised out at long-range speeds at optimum altitudes. Range-free allowances were fuel for 5 minutes at take-off power (70 percent of military-rated power) and 20 minutes at maximum-endurance speeds at sea level, plus 5 percent of initial fuel for landing reserve.

B-58 Hustler

Convair Division of General Dynamics Corporation



B–58 Hustler
General Dynamics

Manufacturer's Model 4

Weapon System 102A

Overview

Future aircraft "will move with speeds far beyond the velocity of sound," said renowned Hungarian-born aerodynamicist Theodore von Karman in 1945. Highly regarded by Henry "Hap" Arnold, Commanding General of the Army Air Forces (AAF), and by Maj. Gen. Curtis LeMay, the first Deputy Chief of Staff for Research and Development, von Karman, as the AAF's chief scientific advisor, most likely influenced LeMay's vigorous and diverse research and development program. Part of the program prompted the impressive 14 October 1947 test flight of the Bell X–1 rocket airplane, a flight which shattered both the sound barrier and the speculation that aerodynamic forces became infinite at Mach 1.

Development in the late 1940s of the single-place, air-launched X–1 was a major achievement. Nevertheless, as time would show, production of a 3-seater aircraft, capable of sustained speeds approaching the muzzle velocity of a 30-caliber bullet and of functioning effectively as a strategic bomber, would be a challenge of monumental proportions. The controversial B–58 program that ensued was to illustrate the dangers of untried technology versus the necessity of pioneering state-of-the-art developments. Where to draw the line between the two would remain open to question long after the costly B–58 ceased to exist.

A 1946 study by Consolidated Vultee Aircraft Corporation (Convair), a contractor noted for interest in the delta-wing configuration, marked the beginning of the B–58. The project was so complex, however, that a new study was requested and a second contractor, Boeing, became involved. Proposed in 1951, the initial Convair design, as recommended by Dr.

Alexander M. Lippisch, an eminent German scientist, foretold a delta-configured, 100,000-pound bomber; the Boeing design, a conventional, 200,000-pounder. Suggestive of the future B–58's tumultuous history, the 2 contractors followed totally different development approaches, and drastically opposed concepts emerged within the newly independent Air Force. USAF engineers kept asking for realistic military requirements, but the Air Staff decided that instead of accepting technology as the determining factor against which a mission could be fitted, mission objectives would come first and technology would be developed to satisfy them.

In late 1952, believing it promised the best means of achieving supersonic speeds with a weapon system of minimum size, the Convair design, already altered several times, was selected over that of Boeing. The choice was not unexpected. In a recent study, the Rand Corporation had clearly stated that by minimizing size, one reduced the radar reflectivity of a vehicle and, therefore, the probabilities of interception by surface-to-air missiles. Also, the Air Force's latest development directive had reemphasized the importance of minimum size, of high-speed and high-altitude performances and, finally, of the weapon system development technique, an objective with which Convair was familiar.

General LeMay, who by the fall of 1952 had been heading the Strategic Air Command (SAC) for 4 years, and who would remain in that position until promoted to Vice Chief of Staff in mid-1957, did not like the Air Staff's selection. Among other arguments, he pointed out that instead of fostering economy and reliability, combining unconventional design and operational techniques made "it entirely possible that the system might prove operationally unsuitable." General LeMay's objections did not prevail, which was unusual. Rejection of the more conventional, longer-range, supersonic bomber, proposed by Boeing and preferred by General LeMay, also was ironic, since it was LeMay who, back in early 1948, ensured that a new strategic jet bomber would be developed on the heels of the B–52.

Throughout the years, money had a great deal to do with the B–58's retention. By 1954, for example, after an investment of some $200 million, the B–58 project could show no tangible achievements. Cancellation at this stage, the Air Staff reasoned, would mean an unacceptable financial loss. Hence, despite production slippages, soaring costs, and General LeMay's continued opposition, the B–58 survived. Yet, the program that finally emerged was emaciated, in terms of numbers as well as military capabilities.

The Air Force bought 116 B–58s, less than half of the minimum initially planned. At long last operational in 1961, the B–58 still harbored deficiencies of varying importance. Its bombing and navigation system was unreliable, and the aircraft was unable to carry several kinds of new weapons. Although expensive, necessary modifications were accomplished between 1962 and 1964. However, significant problems remained. In the early 1960s, technological advances had radically altered the antiair defenses that the B–58 was expected to challenge. Defensive nuclear-tipped air-to-air and surface-to-air missiles appeared to preclude penetration of enemy airspace at high altitude. Since the B–58 structure incurred significant fatigue damage when flying at low level, and since the new bomber had no terrain-following radar, extensive modifications would be needed to permit effective low-level penetration. Such modifications did not materialize because of their prohibitive cost, and all B–58s were phased out of the Air Force inventory by early 1970, less than 8 years after the last ones rolled off the assembly line.

While the $3 billion price tag of the B–58 program did not help the manned bomber's cause, the aircraft did represent an important technological achievement. In its day the B–58 broke 12 world speed records and won almost every major aviation award in existence. The aircraft marked the first major departure from the monocoque riveted metal construction techniques of the 1930s and prompted the investigation of non-metallic composite structural methods. It brought about major technical advances, entailing technical uncertainties which remained until such an aircraft was flown. The Air Force took the risk, and the results may not have been cost-effective. Nonetheless, similar developmental risks again would have to be taken to assure progress in aerospace technology.

Basic Development — October 1946

Development of a long-range supersonic bombardment aircraft was officially initiated by a generalized bomber study (GEBO),[1] begun in October 1946 by Convair.[2] In requesting GEBO, the AAF called for determination of which design trends would be necessary to achieve unspecified, yet ambitious supersonic performances. Of necessity, the scope of the study was very broad, but "investigation of low aspect wings in general and Delta Wings in particular" was emphasized. Although already acquainted with the delta wing and, therefore, well suited for the work, Convair had to investigate countless configurations to determine the effects of wing area, aspect ratio, thickness and sweep, as well as the impacts of type (turbojet and turboprop), size, and number of engines on airplane speed, range, and gross weight. The GEBO findings were described in 3 reports,

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[1] Identified as GEBO I in June 1949, after the Air Force issued a contract for a second GEBO.

[2] The corporation subsequently became a division of the General Dynamics Corp. For details, see B–36, p 5.

which were completed in June 1948. Yet, this was only a beginning. Indicative of the magnitude of the project, in late 1948 the Air Materiel Command (AMC) Engineering Division of the now independent Air Force asked for a continuation of the GEBO study. The USAF engineers presented many valid reasons for their request, but their most telling arguments were that the findings so far obtained be used to show the "feasibility of military characteristics," and to assist in establishing "balanced characteristics and desirable design compromises." Meanwhile, pre-GEBO studies, conducted by Convair, had formed the basis of the winning interceptor design submitted by the company in 1946. Forerunner of the F-102, the ensuing rocket-propelled, XF-92 interceptor was extremely costly and highly impractical. Though the aircraft failed to earn a production contract, it proved to be an important step in the development of the delta wing, one of the future B-58's most striking features.

The delta wing itself, like many other aerodynamic innovations, had its inception in the German wind tunnels of World War II.[3] Although the National Advisory Committee on Aeronautics, independent of the German research, by 1945 had explained many of the delta configuration's theoretical advantages, the delta wing concept remained credited to Dr. Alexander M. Lippisch, leader of the German program.[4] In postwar years, U.S. governmental agencies and many of the American aircraft corporations studied extensively Dr. Lippisch's captured reports, with data on his never-flown, rocket-powered DM-1 glider and his spectacular, if not very successful, Messerchmitt-built Me-163B (the first operational liquid rocket-

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[3] While the word "delta" is inextricably linked to the work of Alexander Lippisch, a brillant aeronautical scientist, his work followed a path first taken by John Dunne, who developed such aircraft in Great Britain prior to the First World War. Actually, Dr. Lippisch's efforts paralleled those of G. T. R. Hill and the Westland company in Great Britain and that of John K. Northrop in the United States. For details, see Richard P. Hallion, *Lippisch, Gluhareff, and Jones: The Emergence of the Delta Planform and the Origins of the Sweptwing in the United States, Aerospace Historian,* Volume 26, No. 1 Spring, March 1979. Dr. Hallion, a former curator of science and technology at the National Air and Space Museum, joined the Air Force History Program in January 1982, becoming Chief of the Office of History of the Air Force Systems Command's Flight Test Center at Edwards AFB, Calif. He is currently an historian at Headquarters Air Force System Command, Andrews AFB, Md.

[4] Reportedly, Dr. Lippisch's scientific curiosity was first stimulated by observing Orville Wright's flight at Templehof Airfield in 1909. Eventually, Lippisch became assistant aerodynamicist with Zeppelin-Werke, which later became the Dornier organization. His interest in gliders, which had its roots in the Rhone Mountain glider movement of 1920, brought him in 1927 to the Forschungs Institut der Rhone-Rossitten Gesellschaft, an institute for the study of gliders, where he became technical director of the design section. Although he designed the "Fafnir," a high-performance glider, as well as numerous others, his primary interest lay in proving his assumption that aircraft could have the appearance of a "flying wing" and still be practical—a delta-wing aircraft from which came the modern delta supersonic design.

propelled interceptor), introduced by the Germans in August 1944. Yet, while Dr. Lippisch was not the inspiration that caused Convair to continue working on the 60-degree delta, his comments reinforced and encouraged Convair engineers to believe that the delta wing could solve most of the problems of supersonic flight.[5]

Initial Requirements 1947

The initial requirements for a new bomber were emphasized in 1947 by Maj. Gen. Curtis E. LeMay, Deputy Chief of Air Staff for Research and Development.[6] In May, General LeMay wrote directly to Lt. Gen. Nathan F. Twining, AMC Commander, to urge that studies be undertaken of a new jet bomber that could become operational in the late 1950s. This airplane, General LeMay stated, should have a combat radius of 2,500 miles, a cruising speed of at least 500 miles per hour, and a gross weight of about 170,000 pounds. No amount of modification to the B-50 or B-36 would bring these airplanes within the desired characteristics, General LeMay added. A completely new medium bomber was needed, and development and procurement of such an airplane could well follow the B-52's development. That the B-58, generated by the post-World War II enthusiasm for the unconventional delta-wing configuration, evolved from requirements advocated by General LeMay was to prove ironic. Meanwhile, General LeMay's insistence prompted the Air Staff to solicit ideas about a new bomber from the Boeing Airplane Company of Seattle, Washington. Yet, several years would pass and many changes would occur before any specific projects started taking shape.

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[5] Nature, Dr. Lippisch wrote, had designed the flying wing thousands of years before man even thought of flight. The flying wing was the Zanonia seed, a seed from a large vine of the cucumber family. It grew in the dense, moist jungles of Indonesia and adapted its reproductive processes to a region in which there was no wind to distribute the seeds. The vine climbed 150-foot trees, and from the top, the seed—a kidney-shaped platform—began its glide, rising on thermals from the jungle heat, and finally landing at considerable distance from its point of departure. The aerodynamic qualities of the seed attracted attention. Two Austrian engineers, Etrich and Wels, analysed its stability. Etrich eventually combined the Zanonia wing with a conventional monoplane configuration, known as the Etrich "Dove." The Dove became famous in the days before World War I, as the first German military aircraft. Its demise followed the onset of war, when it was abandoned in favor of the more maneuverable Fokker-designed aircraft.

[6] In spite of the declining post-war budget, General LeMay directed improvements in research and development. He also asked for more money. Appearing often before congressional committees, he pointed out on one occasion that the entire annual budget of the propeller division at Wright Field, "wouldn't buy one set of B-29 propellers."

Research Intensification 1949

As suggested by AMC, Headquarters USAF asked Convair to begin a second generalized bomber study for the development of future long-range supersonic bombers. This study, GEBO II, was formalized on 6 June 1949 by contract AF33(038)-2664 and, like GEBO I, ended covering a myriad of configurations. There were many justifications, besides AMC insistence, for the Air Staff's continued interest in the Convair research. To begin with, the shortage of funds forced the Air Force to make difficult decisions. Boeing's XB-55, a design initiated as an immediate result of General LeMay's 1947 request,[7] had been canceled in January 1949 for lack of money, as well as the following reasons. First, there no longer seemed to be an immediate need to originate a design to meet the medium bomber requirements, in view of the currently projected B-47 growth. Also, since the XB-55's development promised to take longer than anticipated, the Air Force thought its design should have been predicated on greater aerodynamic achievements and an improved propulsion system. Finally, and most importantly, continued testing of the delta wing XF-92, first flown in June 1948, was starting to attract wide attention. Even though the Board of Senior Officers in early 1949 had rejected an unconventional strategic bomber proposed by the Fairchild Aircraft Corporation, it was obvious by mid-year that the Senior Officers, with Secretary of the Air Force Symington's full support, were searching for new and imaginative solutions to the strategic bombing problem.

Conventional Alternatives 1949–1950

While looking for novel ideas, the Air Force remained cautious and did not lose sight of Boeing's extensive experience in bomber design.[8] As already noted, the contractor had been encouraged to investigate the development of higher-performance aircraft, long before its XB-55 was canceled. Boeing, therefore, had worked on a series of new turbojet designs in order to compare them with its original turboprop studies and with the XB-55 in particular. Aware of these facts, the Air Force issued termination orders for the XB-55 in such a way as to allow maximum benefit from the studies which Boeing had in progress. Mockup and detailed engineering on the XB-55 were stopped, but the study reports and tunnel tests then underway

[7] Requirements for a new medium bomber, submitted to industry in October 1947, proved Boeing the undisputed winner of the ensuing competition.

[8] The experimental B-47 earned a first development contract in December 1945; the XB-52, in July 1948.

were to be completed. Moreover, the Air Force soon increased the scope of the Boeing tunnel tests and asked for firm study results.

Competitive Proposals — February 1951

On 26 January 1951, following completion of GEBO II, Convair offered to develop and manufacture a long-range supersonic reconnaissance bomber.[9] The proposal, named Project MX-1626 by AMC, was accepted promptly by the Air Force. However, this did not spell the end of Boeing's related work. In fact, the Air Force endorsed in February the Phase I development of 2 reconnaissance bombers through wind tunnel testing, engineering design, and mockup. The Boeing project was designated MX-1712 and was initiated on 26 February by Letter Contract AF33(038)-21388. A similar document, Letter Contract AF33(038)-21250, had been signed by Convair on the 17th. It called for a 107,000-pound reconnaissance bomber, with a delta configuration and 2-stage system (release and retrieval) based on the parasite principle, using the B-36 as the carrier. The MX-1626's basic difference from the other Convair configurations studied in GEBO II lay in the use of 3 engines, 2 in wing nacelles and the third in a droppable bomb pod. In contrast, the Boeing MX-1712 project proposed a conventional, 200,000-pound medium-range reconnaissance bomber, capable of supersonic flight over a limited portion of its mission. The Boeing design objective involved a 2,000-nautical mile radius, 200 miles of which would be flown at Mach 1.3 or more, and the balance at Mach 0.9. For shorter missions, the supersonic radius would increase, while range extension devices such as refueling or extended wing tips would lengthen the range for longer missions. Power was to come from 4 J67-type engines with afterburners, and the aircraft as projected was to be capable of delivering atomic or conventional bombs from altitudes of 45,000 to 50,000 feet. Sea-level missions were another possibility being considered.

Radical Change — December 1951

The parasite-carrier combination, proposed by Convair in early 1951, did not last long. As conceived, Project MX-1626's primary appeal

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[9] Reconnaissance had not been mentioned before. Most likely, the Heavy Bomber Committee's year-old decision that the heavy bomber program be expanded to include reconnaissance, accounted for the Convair suggestion. As far as Boeing was concerned, reconnaissance, as an adjunct to bombing, was almost routine, the RB-47B being already on the drawing board in March 1951.

stemmed largely from the stringent fiscal restrictions of the post-World War II period.[10] Since money was lacking, the parasite-carrier concept appeared to be the most economical method for tackling the unconventional approach to the long-range, strategic bombing problem. During 1951, however, the Air Force started to view MX-1626 from a different angle. Both the B-36 carrier and parasite aircraft (officially designated B-58 in December 1952) would require complete navigation equipment; the 2 might not locate one another on the return course of the mission; and once rejoined, the composite aircraft would be more vulnerable to attack. Finally, the 2-aircraft attack system would be far more expensive to build and maintain than would a single bomber. Hence, in December 1951, the MX-1626 configuration was altered drastically. The parasite mode of range extension was dropped in favor of air refueling; the third and expendable engine in the bomb pod of the original configuration was eliminated, while afterburners were added to the aircraft's remaining 2 engines. Moreover, a landing gear was provided to allow take-off at a gross weight of about 126,000 pounds, and the number of crewmen was increased from 2 to 3 (1 pilot, 1 navigator-bombardier, and 1 defense-systems operator).

General Operational Requirements — 1 February 1952

Concurrent with the elimination of flaws from the initial MX-1626 configuration, the Air Force further defined what would be generally expected of the future Supersonic Aircraft Bomber (SAB). USAF planning culminated on 1 February 1952 with the publication of General Operational Requirement (GOR) SAB-51.[11] This highly ambitious document called for a versatile, multi-mission strategic reconnaissance bomber capable of carrying 10,000 pounds of bombs, and of operating in daylight or darkness under "all-weather" conditions. Production should take place within 5 years. There were many other sophisticated requirements. The aircraft had to be able to cover almost 5,000 miles (4,000 nautical miles) both ways, with a single outbound inflight refueling; about half that distance without refueling. It also needed supersonic speed at altitudes of 50,000 feet or more, and high subsonic speeds when flying at low levels. It was to be easy to fly, highly reliable, and should require few personnel for operation and maintenance. Although due to feature the best electronic countermeasures systems,

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[10] Like the Glenn L. Martin Company, Convair at one point was also working on a Navy proposal for a money-saving carrier-based medium-range bomber.

[11] This actually was GOR No. 8 (SAB-51). It added reconnaissance to the requirements embodied in a December 1951 GOR, which only called for a strategic bombardment system.

"economy from the standpoint of cost to our national resources" was a must. The GOR also emphasized that the future aircraft should be small, a specification apparently suggested in a recent Rand Corporation study which stressed that by minimizing size, one reduced the radar reflectivity of the vehicle and the probabilities of interception by surface-to-air missiles. As it turned out, this "small size" requirement was to influence greatly subsequent decisions.

Revised Requirements — 26 February 1952

As customary, the GOR of February 1952 led to a development directive. Also, detailed military characteristics were issued for the benefit of interested contractors. There was a significant change, however. The directive (No. 34, published on 26 February 1952) created a precedent in that it sharply curtailed the general requirements formulated earlier in the month. The revision, formalized on 1 September 1952 by GOR No. 1 (SAB-52-1), stood to reason. As pointed out by Gen. Donald N. Yates, Director of Research and Development, Office of the Deputy Chief of Staff for Development, it was unrealistic to expect the rapid development of a high-altitude, long-range, supersonic reconnaissance bomber that could also be used for low-level missions requiring high subsonic speeds. Some aeronautical engineers argued this could be done with the proper technological efforts and plenty of money, but many in the Air Staff were not convinced. Following discussions with members of the Air Council and representatives of Air Research and Development Command (ARDC), SAC, the Rand Corporation, and the Scientific Advisory Board, the Air Force endorsed General Yates' recommendation. Directive No. 34, as finally worded, only called for the development of a high-altitude, long-range supersonic strategic reconnaissance bomber. However, a low-altitude strategic bomber was still needed. Even though this would be costly, the Air Force issued a separate directive for development of such an aircraft,[12] insisting in both cases that the 2 airplanes should be available by 1957.

Early Problems — 1952

If refining and slimming down requirements were not an easy matter,

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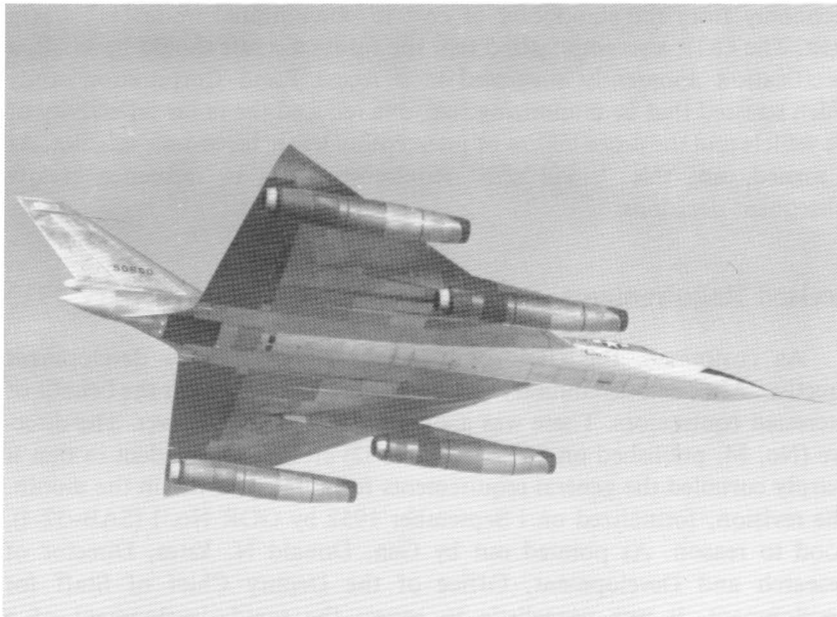
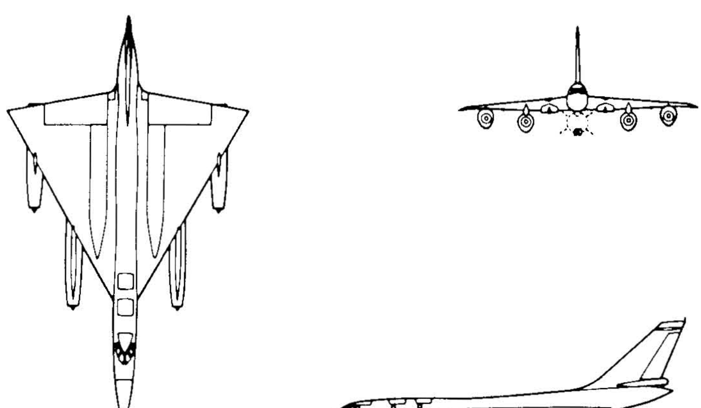
[12] The Martin Company won the competition that ensued with a design featuring a delta-wing planform, but the Air Force canceled the project in 1957. SAC's confidence that the B-47 was rugged enough for low-level bombing accounted in part for the cancellation. Another factor was the Air Force's anticipation that modified B-52s would eventually fulfill the requirements wanted in a low-altitude bomber.



The delta-wing B–58 Hustler was powered by 4 General Electric J79 turbojet engines.



financing the Phase I development of 2 parallel projects was even more difficult during a period of austerity. Boeing's MX-1712 benefited to some extent from the XB-55 cancellation and did not seem to face a serious money problem, but the financial support of Convair's MX-1626 was another story. To begin with, although the 2 letter contracts of February 1951 were fairly similar, Convair's document failed to provide sufficient funds to carry the MX-1626 through the mockup stage. Complicating the situation further, confusing events began to emerge in early 1952. In January, the Air Staff asked Convair to prepare package program costs for specific numbers of airplanes (25, 50, and 100). Estimates were to cover all development and production costs, except for the engines which were to be furnished by the government. Tentative delivery schedules also were required. In late February, however, the MX-1626 project was nearly canceled. The emergency transfer of $100,000 provided some relief, but the MX-1626 status remained precarious until 15 May, when a supplemental agreement to the deficient letter contract assured the MX-1626's General Phase I Development Program of $2,800,000. Meanwhile, the Air Force faced another dilemma. Back in 1951, although reasonably sure that Convair and Boeing offered the best hopes to secure quickly the urgently needed supersonic bomber, AMC had requested informal proposals from other aircraft producers including Douglas, Lockheed, Martin, and North American. The field narrowed, when only 2 of the last 4 contractors submitted proposals. Moreover, the problem was resolving itself since these last proposals did not arouse any special interest. Nevertheless, now that the requirements were changed, the Air Force considered whether the entire aeronautical industry should again be queried.

Preliminary Conclusions 1952

Early in 1952, the Air Force agreed with Brig. Gen. John W. Sessums, ARDC Deputy for Development, that it would be better to forego additional competition along traditional lines. Time and money would be saved in selecting contractors on the basis of experience, facilities, and the intrinsic value of the proposals already submitted. Shortly thereafter, the Wright Air Development Center was given permission to eliminate or reorient current projects. In short, Boeing and Convair were instructed to stop their present investigations and to begin new Phase I designs of their respective projects (MX-1712 and MX-1626), as dictated by Directive 34. Maj. Gen. Donald L. Putt, the newly appointed Wright Air Development Center Commander, also informed the 2 contractors that contracts would be issued in the fall of 1952 for the detailed design and mockup of each supersonic bomber. Evaluation and selection of the winning design would follow in February or

March 1953, which clearly indicated that obtaining production aircraft by 1957 would never be feasible.[13]

Meanwhile, events were determining the shape of the program. To begin with, Development Directive 34 strongly reemphasized the Supersonic Aircraft Bomber design priorities of minimum size and high performance (altitude and speed), already specified by the GOR of February 1952. Secondly, both GOR and the directive called for the application of the weapon system concept, an objective with which Convair was familiar.[14] This concept, in essence, acknowledged that the increasing complexity of weapons no longer permitted the isolated and compartmented development of equipment and components which, when put together in a structural shell, formed an aircraft or a missile. It integrated the design of the entire weapon system, making each component compatible with the others, and put heavy responsibilities on the prime contractor. The weapon system concept coincided with a significant deviation from previous practices. Instead of accepting technology as the determining factor against which a mission could be fitted, the Air Force had decided that mission objectives now should come first and technology could be made to satisfy them. In any case, other events occurred in mid-1952, which also seemed to favor the delta-wing configuration. By that time, the 2 contractors had made considerable progress in their efforts to conform with the requirements set forth in Directive 34. In the process, Convair's former MX-1626 had become project MX-1964, while Boeing's MX-1712 was now known as the MX-1965. Wright Air Development Center's analysis of both designs in the summer of 1952 yielded no startling discoveries. The center tentatively concluded that the 2 designs appeared to meet performance and size requirements, but that extensive development work would be needed to give either configuration the necessary engines and the required integrated electronic system. Soon afterwards, the center's Weapons Systems Division proposed that recent plans be changed. The division's officials felt that selecting 1 of the 2 contractors before design and mockup completion would be advantageous to the Air Force. It would eliminate the many problems created by simultaneous development programs, as well as the need to develop costly electronic and control systems for 2 aircraft. Moreover, an earlier selection would save additional time and money, thereby allowing a more extensive

[13] Assuming all went well, Wright Air Development Center officials speculated, a prototype might perhaps fly in 1957.

[14] The so-called "1954 Interceptor," an upshot of the Convair XF-92, soon symbolized the difficulties involved. It marked the first attempt to apply the weapon system concept, and the concept's practical defeat. Yet, it eventually led to Convair's production of the F-102 and F-106, 2 most-effective and long-lasting fighter-interceptors.

development of the selected system. Since Project MX-1965 was lagging slightly behind the Convair MX-1964, such recommendations could hardly be expected to help Boeing's prospects.

Contractor Selection 18 November 1952

In September final evaluation of the competing designs by the Wright Air Development Center left little doubt about the forthcoming decision. The center thought that the Boeing MX-1965 design would produce either an aircraft of small size with mediocre supersonic speeds or one so large as to almost preclude any supersonic capability.[15] On the other hand, the MX-1964 design, already nicknamed the "Hustler" by Convair, provided the more promising means of achieving supersonic speeds with a weapon system of minimum size. In addition, the center felt that the Convair approach best satisfied the "spirit" of the Development Planning Objective for Strategic Air Operations during the period 1956-1960. This objective, issued by the Air Force on 29 May 1952, favored a small bomber and underlined that future strategic aerial warfare could be most economically and effectively accomplished by a "combination system that incorporates a tanker cargo airplane for refueling in flight the combat zone airplane." The small bomber concept, embodied by the Development Planning Objective of May 1952, reflected the opinion of Col. Bernard A. Schriever, the USAF Assistant for Development Planning in the Office of the Deputy Chief of Staff for Development,[16] and had been endorsed by the Air Force Council and Gen. Hoyt S. Vandenberg, Chief of Staff of the Air Force. But this Development Planning Objective of May 1952 also ran counter to many established principles. SAC officials and particularly General LeMay, who by 1952 had been heading the command for several years, generally favored large bombers, capable of greater ranges. "Even though the best intercontinental bomber available requires some refueling," SAC insisted, "it does not follow necessarily that the optimum system requires a bomber which has no intercontinental capability without refueling." The command argued that "high performance alone" could "never insure mission success"

[15] The Boeing supersonic bomber design was conventional. It featured wings swept at 35 degrees, an internal bomb bay, a fore and aft bicycle landing gear which, like that of the B-52, retracted into the fuselage. It called for 4 engines, similar to those proposed for the Convair bomber, but integral with the wing, 2 on each side, tucked inboard against the fuselage. It projected a supersonic speed of Mach 1.8 at 55,000, but promised plenty of room for its 3-man crew. Maximum take-off weight was about 156,000 pounds.

[16] Colonel Schriever was promoted to lieutenant general in 1959 and to full general on 1 July 1961, when he headed the newly organized Air Force Systems Command.

against targets defended by modern interceptors and surface-to-air missiles, and pointed out that the small supersonic bomber's lack of range would prevent it from operating without refueling from most forward operating bases. Also, crew members would be very confined in such a small bomber. Finally, instead of fostering economy and reliability, combining unconventional design and operational techniques made "it entirely possible that the system might prove operationally unsuitable." SAC's arguments notwithstanding, a decision was near. In an unusual step, the decision makers would totally disregard SAC's concern. In late October, following ARDC's thorough review of the Wright Air Development Center's conclusions, Lt. Gen. Earle E. Partridge, the ARDC Commander, recommended to Headquarters USAF that the competition between Boeing and Convair be stopped immediately. General Partridge noted that the MX-1964 supersonic drag and gross weight figures appeared optimistic, and if true, this would further limit the aircraft's range. Also, costs had not been considered properly, and the forecast operational date would inevitably slip, perhaps to 1959. Nevertheless, the ARDC Commander endorsed prompt selection of the Convair project and asked that accelerated development of General Electric's J53 engine (from which the J79 derived) be authorized without delay. This was approved by the Weapons Board, the Air Force Council, and by General Vandenberg on 18 November 1952. Soon informed that the design competition was ended, Boeing reportedly took the bad news well.

Design Refinement — 1952–1953

The Air Force selection of Convair over Boeing was not a blanket endorsement of the MX-1964 design. It took several months and many consultations between Convair, National Advisory Committee on Aeronautics, AMC, ARDC, and Wright Air Development Center personnel to settle on a definite configuration which, as it turned out, was subjected to many later revisions. These initial delays were not unfounded. Development problems with the Convair F-102 interceptor were confirming the Air Force's suspicion that the contractor had failed to make proper allowance for the aerodynamic drag of a delta-wing aircraft, be it a fighter or a bomber. Moreover, the area-rule concept of aircraft design,[17] discovered by National Advisory Committee on Aeronautics researcher Richard T. Whitcomb, had been verified during December 1952 in the agency's new transonic wind tunnels. This concept held that interference drag at transonic

[17] A prescribed method of design for obtaining minimum zero-lift drag for a given aerodynamic configuration, such as a wing-body configuration, at a given speed.

speed depended almost entirely on the distribution of the aircraft's total cross sectional area along the direction of flight. The solution was to indent the fuselage over the wing to equalize the cross section areas (and thus the volume) at all stations, thereby producing the so-called "coke bottle" or "wasp waist" configuration. Yet, as in the F-102's case, Convair did not accept the Whitcomb findings until its own engineers had confirmed their validity. Another delaying factor was the absence of military characteristics, which were deferred until the fall of 1953.

Specific Planning 1952–1953

Although the MX-1964 design was yet to be finalized, the Air Force proceeded with specific plans. In December 1952, the Deputy Chief of Staff for Development endorsed a production schedule developed by the Wright Center. This schedule was based on the 4-year procurement of 244 B/RB-58s (more than twice the final total). Thirty of these aircraft, with the first one due for delivery in January 1956, would be used for testing, while preparations would be made for full scale production of a version incorporating all test-dictated changes. The 30 initial planes would then be reworked on the production line into the approved configuration. This plan, drawn from the "Cook-Craigie production policy," was expected to eliminate the faults in a basic design before many aircraft had been built and to speed the acquisition of operationally effective weapon systems.[18] Recent experiences seemed to justify such an approach. Building aircraft prototypes before selecting one of them, as occasionally done, had proved costly and time consuming. Moreover, the selected prototype, once produced, has often still been found to have design flaws that needed correction. In any case, the Cook-Craigie philosophy, if not an integral part of the weapon system concept, fitted it perfectly. The weapon system concept itself promoted significant changes and therefore more planning.

In early 1953, General Putt, ARDC's new Vice Commander, announced the Air Force's revised management tasks. The B-58 weapon system would require a minimum of government-furnished equipment since the prime contractor would be responsible for system design and engineering

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[18] The Cook-Craigie production plan was actually a mere concept, developed in the late forties by USAF Major Generals Laurence C. Craigie, Deputy Chief of Staff for Development, and Orval R. Cook, Deputy Chief of Staff for Materiel. They both knew this concept could be expensive and thought "it was only applicable where you had a high degree of confidence that you were going to go into production." The F-102, a by-product of the "1954 Interceptor," bared some of the pitfalls of the Cook-Craigie plan for early tooling. In October 1953, when testing established unequivocally that important changes had to be made in the F-102's design, 20,000 of the 30,000 tools already purchased by Convair had to be discarded.

and would deal directly with subcontractors to acquire major components. The Wright Air Development Center, now headed by Maj. Gen. Albert Boyd, would contract for major components "only when limitations of industry, operations, or logistic considerations force the USAF to control source and/or methodology." Even then, such components would have to be designed, built, and tested to Convair's specifications. In short, the Air Force's role was to monitor the prime contractor's plans and progress; to approve specifications as well as subcontractors, and to supply the money. It also retained the right to veto any developments that could cause operational or logistical problems. The Air Force management of the B-58 weapon system would be exercised at the Wright Air Development Center by a 20-man joint project office, made up of ARDC and AMC representatives.

Contractual Arrangements 1953

Contracting proved to be a difficult endeavor, far more complex than usual. Limited experience with the weapon system concept prolonged negotiations, as the Air Force and Convair worked out specific provisions to define each party's prerogatives and responsibilities. These clauses became part of Convair's letter contract on 12 February 1953, when a supplemental agreement was signed.[19] This was an important turning point, indicating the B/RB-58 program was getting under way, with the B-58 mockup scheduled for the end of the summer, while that of the reconnaissance version would follow in the fall of 1953. The amendment also gave Convair $22 million to cover pre-production planning costs and the acquisition of long-lead time tools and equipment. Yet, it failed to resolve immediately a few basic problems. As single manager, Convair believed that compensation for its additional managerial efforts should be incorporated in the program's direct cost. The Air Materiel Command disagreed, contending that such payments should be added to the overhead administrative costs of present and future contracts, on a yearly pro-rated basis. AMC also postponed total approval of the funds requested by Convair to expand its Fort Worth facilities, causing the contractor to spend $500,000 of its own to secure extra office space.

Design Approval 20 March 1953

The Air Force selected a firm configuration for the B/RB-58 and

[19] This was the fifth and so far most significant amendment to Letter Contract AF33(038)-21250. The contract itself was not finalized until the end of 1955, even though the letter contract dated back to February 1951.

authorized Convair to begin work on each full-scale mockup version. The approved design incorporated the changes dictated by the National Advisory Committee for Aeronautics's transonic area rule. Specifically, the airplane cross-sectional area was redistributed longitudinally to minimize the compressibility drag rise encountered at transonic speeds. This had been accomplished by fuselage redesign, housing the engines in 4 staggered nacelles, and adding a 10-degree trailing edge angle to the wing, which also increased the wing area to 1,542 square feet. In addition, the wing's leading edge had been cambered and twisted to reduce drag at lift.

Immediate Problems — May 1953

Approval of Convair's new design did not ease the Air Force's concern about the engine of the future aircraft. As summed up by General Partridge, every effort had to be made to safeguard the successful development of the J79 upon which the "vitally important B-58 and other projects will be so heavily dependent."[20] Equally concerned, General Putt informed the General Electric Company that the J79 project controlled "to a very major degree, this country's ability to defend itself during the 1958-1965 period." "This responsibility," General Putt wrote, "should not be treated lightly." The fact remained that the development histories of American and British turbojets showed that 4 to 5 years were needed from the beginning of design to completion of the 150-hour engine test. This was confirmed by the General Electric engineers, who insisted that delivery of the J79 engine could not be scheduled until July 1957. Based on experience, the Air Force thought this schedule might still be unrealistic. The solution therefore was to equip early B-58s with a version of the already-tested Pratt and Whitney J57, but this temporary expedient also would pose problems.

Development Engineering Inspection — 17-18 August 1953

This first development engineering inspection replaced the formal mockup inspection which, obviously, had been scheduled to occur too soon for major subsystems to be available.[21] Nevertheless, except for the missing

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[20] The J79 turbojet became the world's first production Mach 2 engine. In addition to the B-58, it eventually powered the Lockheed F-104, the McDonnell F-4, and the North American Aviation A-5.

[21] A second development engineering inspection took place on 29 September 1953. It covered portions of the RB-58 that differed from the B-58. Also held in Fort Worth, the inspection did not cover major subsystems, most of them still remaining a long way off.

components (for which space was provided), the B-58 mockup was complete. Air Force inspectors, including representatives from SAC, were able to get a good idea of the new weapon system, by then known as Configuration II. The inspection group, and General LeMay in particular, asked for many changes, but none appeared vital. Just the same, as the inspection neared its end, General Boyd most likely expressed everyone's opinion in stating: "It is a radical design, and we must be careful in following through with these technical developments." He added, however, that Convair seemed to have done a very good job.

Military Characteristics II — September 1953

Military characteristics (No. 345) for the B-58 high-altitude bombardment system, at long last issued in September 1953, did not bring any great surprises. The requirements fairly matched the specifications proposed by Convair in August 1952, and the lesser USAF demands embodied in the September GOR of the same year. Yet the new characteristics required the carrying of payloads in addition to the warheads originally specified. While this requirement had been anticipated, it implied that greater performance standards would have to be achieved in order to preserve the aircraft's range, which was unchanged.[22] There were a few other changes, most of which stemmed from SAC's criticism. For instance, the side-by-side seating that General LeMay preferred to the tandem seating arrangement of most Air Force planes was not provided, but the B-58 would at least contain a jump seat[23] for one of the crew members to sit alongside of the pilot during take-off and landing. The new characteristics also included some concessions. Maximum dash speeds at altitudes of 55,000 feet were reduced slightly, and the B-58's operational date was postponed from 1957 to 1958 or later.

Increasing Difficulties — 1953

Much to the disappointment of ARDC, and despite application of the area rule, on-going wind tunnel tests of Configuration II continued to

[22] The B-58 would carry 20,000 pounds of munitions, a 13,000-pound increase. This could be expected to entail a reduction of the aircraft's fuel load and, therefore, a significant loss of range.

[23] Subsequently omitted, for lack of space.

produce high-speed drag figures. Stability test results also caused concern. The elevons and rudder were not inherently balanced and depended on the rigidity of their actuating systems to prevent flutter. The engine positions and the anticipated Mach 2.1 speed similarly produced some qualms. In addition, as first identified by the development engineering inspection of August 1953, it had become obvious that the compartmented pod, housing the bomb and fuel, needed to be entirely redesigned.[24] Finally, other changes had to be made to satisfy the anticipated new requirements of the September military characteristics. Meanwhile, other problems loomed ahead. Subsystem development, never considered to be easy, promised to be especially difficult in the B–58's case.[25]

The future aircraft had already been acknowledged as a most complex, highly integrated, and mutually interdependent weapon system. The Air Force, consequently, kept a close watch on every component's progress. In December 1953, it asked for studies to determine if the Arma Company's A–3A Fire Control System could serve as a back-up for the Emerson Company's Active Defense System earmarked for the B–58. The Air Force also wanted to know if a modified M–2 Bombing System, built by the International Business Machine Corporation, could possibly substitute for the sophisticated Navigation-Bombing and Missile Guidance System, being developed by the Sperry Gyroscope Company. Aware of the state-of-the-art's current and foreseeable limits, the Air Force attached great importance to the B–58's forthcoming bombing and navigation system. How a B–58 would find and hit its targets, given its speed and altitude design characteristics, was a difficult question to answer.[26] The problem was serious enough to justify organizing a special committee to monitor the development of B–58 bombing and navigation procedures.[27]

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[24] This was confirmed in October 1953, when the Air Force authorized Convair to shorten the B–58 pod and to sling it on a pylon under the fuselage.

[25] As early as 1951, the Air Material Command stressed that it took much more time to design, develop, and produce new equipment such as guns, engines, and fire-control systems than it did to produce new airframes.

[26] Worrisome comparisons came to mind. For example, in order to obtain a 3-minute bomb run for a B–17 operating at 25,000 feet, the bombardier would have to get on his target about ll miles away; in the same vein, with a B–58 operating at 40,000 feet at an airspeed of 450 knots, the bombardier would have to spot and track his target from at least 25 miles away. But to have a 3-minute bomb run at the B–58's designed speed of Mach 2 and at an altitude higher than 50,000 feet, the bombardier would have to be on target some 66 to 70 miles away.

[27] This committee consisted of representatives from the Air Staff, ARDC, SAC, Air Training Command, and the contractors. In early 1954, the B–58 Joint Project Office considered the adoption of the monitoring committee idea for other component systems as well.

New Setbacks 1953–1954

Configuration III, as devised by Convair, did not fare as well as expected. The reconfigured B/RB-58 featured a new bomb and fuel pod that had been shortened from 89 feet to 30 feet, and was now detached from the fuselage and suspended on a pylon. To compensate for the smaller amount of fuel carried by the pod, external fuel tanks had been added to the wing tips. The search radar had also been removed from the pod and placed into the fuselage nose. There were other alterations and deletions. The droppable nose gear was eliminated, and the positions of the bombardier-navigator and the defensive systems operator were reversed. For lack of space, Configuration III omitted a jump seat, a new requirement of the military characteristics. In any case, the Air Force did not share Convair's confidence that the reconfigured B/RB-58 would achieve better performance. Early 1954 tests in the tunnels of the Wright Air Development Center and National Advisory Committee on Aeronautics soon confirmed that the contractor's estimates once again were wrong. In addition, a problem thought to be solved had reappeared. In 1953, the contractor and the Air Force had decided to abandon the previously endorsed split nacelle engine arrangement in favor of 2 strut-mounted Siamese nacelles. The change would save weight, ease engine maintenance, and facilitate retrofit of J57-powered aircraft with new J79s.[28] Recent tests, however, indicated that Siamese nacelles induced extra drag on the composite (pod- or missile-carrying) B-58, although the airframe itself was affected almost equally by either type of nacelles. In practical terms, this meant a return to split nacelles, more testing, more delays, and postponement of the Configuration III's mockup inspection from the initially scheduled May date to September 1954.

Program Reorientation 30 April 1954

Based on a preliminary review of the B/RB-58's third configuration, the Wright Air Development Center finally agreed on 4 December 1953 that Convair could begin the construction of airframe components. Yet, subsequent testing of Configuration III qualified this hopeful decision. In March, the B-58 program underwent a drastic change; research and development came to the fore at the expense of production, and the number of B-58s originally contemplated was reduced from 244 to 30, with the latter quota

[28] Unknown to all at the time, this last advantage would have been of no value since the B-58 schedule slipped and production of the J79 engine caught up with the Convair program.

emphatically referred to as "test vehicles." Moreover, long lead time items such as ground training devices and maintenance and test equipment were canceled. Secretary of the Air Force Harold E. Talbott approved the redirected program on 30 April 1954, and authorized release of the procurement funds necessary to support it.[29] Yet, as illustrated by the June procurement directive that followed, the Air Force again qualified its authorization. The directive freed about $190 million of fiscal year 1955 money for 13 test aircraft, but no procurement of any kind could be initiated prior to determining a firm configuration. As it happened, these 13 aircraft were the only B–58s covered by the first definitive contract, at long last signed in December 1955.[30]

Fourth Configuration — September 1954

Crucial events preceded Convair's achievement of its fourth B/RB–58 configuration. A development engineering inspection of Configuration III, held in mid-May, was a near fiasco. Not only did it endorse the poor results of past and concurrent wind tunnel tests, but SAC representatives insisted that the width of the configuration be altered to allow side-by-side seating of the pilot and the navigator-bombardier, a change considered totally impossible. But as the future of the B–58 appeared at its gloomiest, important research progressed. National Advisory Committee on Aeronautics aerodynamicist R. T. Jones at first had been mystified by the problems of airframes designed to the transonic area rule and tested at supersonic speeds. However, by the summer of 1954, he had ascertained that the position and the extent of the fuselage indentation was indicated by the aircraft's designed speed. This time, the Convair engineers did not question Jones' discovery. In August, Configuration III's fuselage was aligned to the modified transonic area rule for supersonic speeds.[31]

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[29] Secretary Talbott succeeded Thomas K. Finletter as Secretary of the Air Force on 4 February 1953. Mr. Finletter had replaced Mr. Symington, the first Secretary of the Air Force, on 24 April 1950.

[30] The remaining 17 test vehicles were carried on another procurement contract, finally initiated by a mid-1956 letter contract. Indicative of the uncertainties that surrounded the costly B–58 program, it took 5 definitive contracts to get less than half of the number of B–58s first ordered. Furthermore, most letter contracts ended with an unusually large number of supplements and amendments. The whole procedure eventually resulted in substantial amounts of termination costs.

[31] For a transonic body, the area rule is applied by subtracting from or adding to its cross-sectional area distribution normal to the airstream at various stations so as to make its cross-sectional area distribution approach that of an ideal body of minimum drag; for a

Officially referred to as the B/RB-58A configuration, the new design featured other innovations. External wing fuel tanks were eliminated, the tail area was extended to 160 square feet, and the 4 engines were suspended by separate pylons, 2 under each wing. Convair was sure that the new B/RB-58A configuration would satisfy the performance requirements of the military characteristics of September 1953, but conceded that minor refinements might still be needed. The contractor also asserted that its new configuration was "the best design supportable by the current state-of-the-art." However, delivery of the first test aircraft, already delayed by the program reorientation, would slip further if production was not authorized soon. Still in a quandary, the Air Force doubted that the new configuration would meet Convair's expectations, and refused to approve the model specifications. Even so, the Air Force in November asked ARDC to develop 2 important back-up systems, one for the Sperry bombing and navigation system, the other for the Emerson tail defense armament. That same month, after learning that Convair was about to reduce its labor force, the Air Force finally authorized limited fabrication of the new airframe.

Near-Cancellation 1954–1955

After seeming to improve, the B/RB-58A's future once again appeared on the brink of disaster. A chief factor in the new crisis was SAC's dislike of the proposed aircraft. True to character, General LeMay had not changed his mind.[32] In fact, based on the command's arguments of November 1952, a mid-1954 staff study, prepared by Maj. Gen. John P. McConnell, SAC's Director of Plans,[33] had excluded the B-58 from the 51-wing bomber force proposed for the period 1958-1965. At first unimpressed by the SAC

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supersonic body, the sectional areas are frontal projections of areas intercepted by planes inclined at the Mach angle.

[32] At the urging of General LeMay, the Air Force in July 1954 instructed ARDC to initiate the research and development of an intercontinental bomber to succeed the B-52. This eventually promoted North American's ill-fated B-70, a bomber which had its origin in May 1953. Boeing was the recipient of the May 1953 study contract for a nuclear- or chemical-powered weapon system of intercontinental range. In 1955, the Air Force Council agreed that development of a nuclear-powered aircraft would not negate the requirement for a bomber using conventional fuel, and weapon systems 125 (nuclear-powered aircraft) and 110A (B-70) assumed their individual identities. Reminiscent of the B-58's case, North American in 1957 won the B-70 design competition over Boeing.

[33] Promoted to four-star rank in 1962, General McConnell served as Chief of Staff of the United States Air Force from 1 February 1965 through 31 July 1969.

omission, the Air Staff in late 1954 was having second thoughts. In early 1955, after General LeMay had directly confirmed to Gen. Nathan F. Twining (Air Force Chief of Staff since 30 June 1953), that SAC wanted no B-58 aircraft for its operational inventory, the Air Force endorsed a thorough review of the program. A B-58 review board was appointed in February and chaired by Maj. Gen. Clarence S. Irvine, AMC Deputy for Production. The board faced the difficult task of recommending whether the B-58 program should be continued, modified, or canceled. General Boyd, one of the board's members, admitted that Convair's latest configuration might again not meet all requirements of the military characteristics, but still believed, that the B-58 should be built, even if the Air Force could not use it as originally intended. The B-58, the Wright Air Development Center Commander argued, represented major technical advances and, therefore, entailed technical uncertainties and the risk of high costs. These uncertainties would remain until "we have flown such an aircraft," and "we must accept such a risk sooner or later."

The board studied anew other valued opinions that had been discussed in previous months. As already stated by Lt. Gen. Thomas S. Power, in charge of ARDC since April 1954,[34] the B-58 was the first attempt to build a supersonic bomber (making in retrospect the production of supersonic fighters look relatively simple), and this task demanded extensive knowledge of aircraft materials and aerodynamic heating. The board's chairman agreed that from this standpoint the program was probably worth the money it had already consumed. Nevertheless, after an investment of 2 years and almost $200 million, no tangible achievements could be claimed. If the B-58 should now be canceled, the money would actually be lost, whereas another $300 million might suffice to build the 13 test-aircraft included in the reoriented program of April 1954. There were other pro-B-58 arguments. In his testimony before the review board, Convair's chief engineer maintained that, if allowed, the B-58 effort would produce the earliest and most inexpensive integrated weapon system, as well as a very outstanding bomber. At worst, he added, the B-58 would be superior to the existing B-47 medium bomber, a contention fully supported by General Power, who also noted that the aircraft might fulfill Tactical Air Command's requirements for a short-range attack bomber.

On 10 March 1955, the review board submitted its recommendations to the Air Force Council and to the Secretary of the Air Force. Aware that whatever suggestion was adopted could have far-reaching effects for years to

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[34] Deputy Commander of SAC between 1948 and 1954, General Power left ARDC after 3 years. He acquired his fourth star in mid-1957 and returned to SAC, this time as General LeMay's successor.

come, the board took no chances. First, it emphatically recommended that the reoriented program be continued on a modified basis. Only 13 test-vehicles would be ordered; they would be equipped from the start with J79 engines; and all back-up subsystems would be eliminated in order to reduce costs. The board observed that Convair could be asked to submit several new design proposals, one for a B-58 tactical bomber, one for special reconnaissance aircraft, and one for a long range B-58 interceptor. Finally, to complete developments vital to the design and operation of future strategic bomber weapon systems, the board did not exclude another possibility. Instead of limiting the program to 13 test-vehicles, it might be wise to buy also a number of B-58s for the operational inventory.

Development Reendorsement — June 1955

Development of 13 B-58 test aircraft, and nothing more, was approved by Secretary Talbott on 2 June 1955. The Secretary's approval carried stern, if not unexpected conditions. The Air Force wanted the program's costs to be reduced, and it wanted the aircraft to begin flying before November 1956. Furthermore, ARDC was to plan the aircraft's utilization in light of the Air Force's new objectives. In short, there no longer was any question of producing a high-altitude, manned strategic bomber and reconnaissance weapon system out of the B-58 test-aircraft. The program's only purpose was to promote research and development.[35] The Air Force needed to learn more about the aerodynamic problems of sustained supersonic flights at high altitudes, and it needed to test subsystems and components for future weapon systems. There were no delays in satisfying most of Secretary Talbott's demands. AMC had been studying the aircraft's cost problem for several months. An April estimate showed that $554 million would cover 13 B-58s, 31 pods, all engines, other government-furnished equipment and support, as well as Convair's fee. With the aircraft now strictly earmarked for research and development, various items could be deleted. This would save about $50 million and bring total costs close to the Air Force's tentative maximum. Convair seemed unabashed by the cut of its program, believing time would work in its favor. Hence, it went all out to match AMC's cost reductions, while projecting costs for the production of up to 500 aircraft. In mid-June, AMC authorized Convair to resume work on development engineering, tool fabrication, airframe parts, and the like. At month's end, the contractor felt confident it could fly a B-58 by November 1956, which

[35] SAC was pleased with the decision, but thought a 13-aircraft research and development program was larger than necessary.

it did. Meanwhile, personnel of the B-58 project office coordinated with representatives of various offices to identify non-essential B-58 subsystems and components, while preserving the development of any B-58 hardware that could benefit other projects.[36]

Decision Reversal 22 August 1955

Scheduled for production in December 1952, an object of indecision in April 1954, practically canceled 10 months later, and relegated to research and development in June 1955, the B-58 project was yet to undergo another major change. Abruptly, on 22 August 1955, the B-58 weapon system once again emerged as a production candidate. The decision, approved personally by General Twining, climaxed weeks of debates.[37] General Putt, now Deputy Chief of Staff for Development, had helped to initiate the program and still professed the B-58 could be "a useful SAC tool." General Irvine, the new Deputy Chief of Staff for Materiel, and others on the Air Force Council shared General Putt's opinion. However, attempts to sway General LeMay failed. This failure most probably accounted for the production directive's unusual wording. The directive of 22 August 1955, calling for a wing of B-58s by mid-1960, was most specific in stressing the need for economy but made no mention of the wing's recipient or of SAC in particular.

Contractual Arrangements 1955-1956

Convair's Letter Contract AF33(038)-21250 of February 1951 was superseded in December 1955 by a definitive contract of the cost-plus-incentive-fee type. This gave Convair an additional $340 million for 13 aircraft, 31 pods, and all contractor-furnished equipment, bringing the contract's total value to about $540 million. The incentive fees depended on technical performance, weight control, and contractor adherence to cost and to delivery schedule. A second letter contract, AF33(600)-32841, issued on 25 May 1956, provided another $13.6 million to buy long-lead items and to maintain B-58 production at a minimum sustaining rate through October

[36] Included in such projects were the B-70, the nuclear-powered aircraft, and a tactical bomber logged as Weapon System 302A.

[37] Secretary Talbott did not participate in the debates. He resigned his position on 1 August 1955 and was succeeded two weeks later by Donald A. Quarles, who served as Secretary of the Air Force until 30 April 1957.

1956. The Air Force planned to decide in the fall of 1956,[38] if it should buy 17 more upper components (B-58 airframes), 17 powered bomb pods, 12 free fall bomb pods, 3 photo pods, and 3 electromagnetic data (ferret) pods. If it did, an extra $14.9 million of pre-production funds would be needed.

First Flight — 11 November 1956

The initial B/RB-58 made its first flight on 11 November 1956, taking off from the Convair Fort Worth facilities at Carswell AFB, Texas. A second flight on 14 November lasted one hour and was also described as successful. On both occasions, the maximum altitude reached was 30,000 feet, while the maximum speed did not exceed Mach 0.9. Supersonic speeds of Mach 1.6 and Mach 1.35, at altitudes of 35,000 feet, were first reached in a third flight on 4 December. The 3 flights were made by the same plane which, like several subsequent ones, was temporarily identified as a prototype (YB-58). In another departure from the usual, a characteristic that typified the B-58 program from the start, the YB-58 flights of late 1956 and early 1957 proved extremely important. Although testing had just begun, they undoubtedly influenced the Air Force's ensuing decisions.

Initial Testing — November 1956

By virtue of the weapon system concept adopted for the highly complex B/RB-58, the core of the testing program was altered. Also, the Air Force's insistence in 1952 that technological developments fit requirements inevitably affected testing.[39] As a result of such innovations, the flight testing program, an always thorough undertaking, acquired a new, time-consuming, and occasionally frustrating dimension.[40] The Category I tests, begun by the

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[38] This planning was in line with the August 1955 decision to buy a wing of B-58s. As all along understood, this could only be done if there was sufficient evidence that the project was viable.

[39] The Air Force decision of 1952 was one of the many difficulties and momentary contradictions that plagued the B-58. A few years before, when the GEBO study was initiated, USAF engineers asked for more realistic military characteristics and advocated state-of-the-art design compromises.

[40] By chance, this coincided with the end of the 8-phase concept of testing, under which a new aircraft was designed, built, and tested first by the contractor, then at various ARDC centers, and finally transferred to a major Air Force command for operational utilization. The new testing program, although counting only 3 categories, did not degrade in any way the former program's scope (see B-52, p 225).

contractor in November 1956, accounted for almost 3,000 hours of flight tests by March 1962, and the destruction of 1 aircraft (the fifth YB-58, Serial No. 55-664) in November 1959. Furthermore, pod drops, aerial refueling, and a few other special tests, properly part of Category I, were completed under the Category II program, which did not officially start before March 1959.

New Controversy 1957

While the production decision of 22 August 1955 failed to indicate which command would use the new aircraft, it soon again became obvious that the B-58 lay in SAC's future.[41] As technological difficulties increasingly impaired the B-70 development, the command became more involved with the B-58. Willing to believe in the B-58's potential for improvement, SAC in late 1956 was actually preparing to participate in the aircraft's forthcoming test program. In the spring of 1957, imminent budget decisions affecting SAC aircraft nearly shattered the command's fragile cooperation. By that time, the B-58 had established itself as the world's fastest jet bomber. The Mach 2 speed success of the B-58, cited as one of the reasons for decreasing the B-52 production rate, did not satisfy General LeMay. He quickly reasserted his early 1955 position that no B-58s were needed. New studies, General LeMay explained, showed that the B-52G with its programmed penetration aids would be superior to the production-improved B-58 and to any "better" B-58, such as the new B-58B configuration proposed by Convair. This was particularly true from the standpoints of cost effectiveness and availability. As for the B-70, General LeMay added, there was no doubt that it would provide substantial improvements over the B-52G. Therefore, "the B-58 should be limited to a test program. Funding for procurement or model improvement testing should not be provided." The Air Staff bluntly disagreed with General LeMay, stating that it was "most desirable" that SAC get a supersonic bomber at an early date and that the decision had been made to buy a limited quantity of B-58s for the SAC inventory. In a mollifying gesture, the Air Staff underlined that the United States had to protect its technological lead over the Soviets as well as the

[41] General LeMay's lack of enthusiasm for the B-58 put the aircraft within the reach of the Tactical Air Command. It was a fact, however, that the Convair project had been geared from the start to meet SAC's performance criteria, that the recently flown YB-58 basically remained a SAC-configured aircraft, one that would require the time-consuming incorporation of many costly changes if it were to fulfill the Tactical Air Command mission. In early 1957, Gen. Otto P. Weyland, who headed the command, wanted a minimum of 2 B-58 wings, but the Air Staff disagreed.

money already invested in the B-58 program. Also, the B-58 would improve through normal growth, and the program's funding requirements would not affect the B-70's prospects.[42]

Critical Shortcomings 1957

Flight testing of the first 3 YB-58s, while accounting for some spectacular achievements,[43] brought to light several problems. The J79-GE-1 prototype engines, installed on the YB-58s pending certification of the J79-GE-5s,[44] had a number of flaws. Malfunctions in the fuel system sloshed the fuel around when the YB-58 accelerated or slowed down, impairing the aircraft's stability. Afterburner problems caused intermittent yawing at supersonic speeds. Of greater concern were already noted acoustical and sonic fatigue problems as well as excess vibration in the YJ79-GE-1 engines. The acoustical and sonic fatigue difficulties affected the aft area of the fuselage and would cause testing restrictions unless promptly solved. Fatigue created cracks along the rivet lines in the forward section of the fuselage. Since the cracks appeared after less than 50 hours of flight, replacing the YJ79-1 engine by the J79-5 would worsen the problem because the more powerful J79-5 would increase the sound level 10 decibels above the level induced by the YJ79-1. The engine vibrations also might affect components of the electronic equipment, installed in the fuselage's aft section and in the aft portion of the various droppable pods that were programmed for the aircraft. There were other difficulties of varying importance. The brake system was not satisfactory. Because of inadequate heat dissipation after braking, tire failures were frequent following landing at high gross weights and high-speed taxi runs. The upward-type of ejection seat put in the aircraft was unsafe at high speed, due to insufficient thrust. Convair tests of a more powerful, rocket-type catapult seat identified problems of another kind. Other sorts of ejection seats were being consid-

[42] Indeed, the proposed B-70 fell under a different time period. Nevertheless, by focusing attention on cost, the enormously expensive B-58 program did not help the cause of future high-performance manned bombers.

[43] By the end of 1957, the YB-58s had attained a maximum speed of Mach 2.11 at altitudes over 50,000 feet; made 2 successful pod drops from 42,000 feet at Mach 2 speeds; maintained a speed of more than Mach 1.15 during 91 minutes, and zoomed without pod from a speed of Mach 2 at 50,000 feet to a speed of Mach 1.13 at 68,000 feet.

[44] Even though General Electric's progress had negated the temporary use of Pratt & Whitney J57s, the J79-5's 150-hour preliminary flight rating test was not expected before year's end.

ered, with misgivings. The Air Force and the B-58 contractor greatly favored a capsule-type escape system, under development by both the Martin Company and the Goodyear Tire and Rubber Company, but time was of the essence. Finally, slippage in the bombing-navigation subsystem development program portended a serious delay in the delivery of the initial equipment. This would retard the B-58 flight-test program, as would shortages of spares for both the YJ79-1 and -5 engines.

Another Near-Cancellation 1958

In 1958, the B-58 program came under renewed scrutiny. The YB-58 could fly fast and high, but its range remained poor. With 1 refueling, the aircraft had a radius of 3,800 nautical miles; without refueling, the distance dropped by almost 40 percent. In addition, limited testing had already uncovered far too many problems. Configuration changes worked out between Convair and an 85-man team from ARDC, AMC, and SAC, would probably help a lot. Yet, changes were always costly. In August 1958, General Power, who had been heading SAC for over a year,[45] told the Air Staff that the B-58's deficiencies were exaggerated, a common occurrence, he remarked, when a program was expensive and it became difficult to obtain financial support. Believing that a mixed force of B-52s and B-58s was the best way to replace the B-47s,[46] General Power pointed out that the B-58's bombing and navigation system, already late, might become available sooner than expected since performance of the system's doppler radar was getting better. Agreeing with General Power that the B-58's early difficulties had been taken out of perspective, General White nevertheless cautioned that, should the program survive, the quantity of aircraft to be purchased in fiscal year 1959 would have to be reduced. The money thereby saved would pay for the most important changes and inevitable cost increases. By the end of December, photo reconnaissance, one of the B-58 program's initial requirements, was deleted. ME-1 pods and ground photo

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[45] General Power acquired his fourth star and succeeded General LeMay as SAC's Commander-in-Chief in July 1957. General LeMay moved to Headquarters USAF as Vice Chief of Staff, under Gen. Thomas D. White, becoming Chief of Staff of the Air Force on 1 July 1961, when General White retired.

[46] General LeMay, although acknowledging in November 1957 that the mixed force concept was apparently in the offing, continued to question the wisdom of the proposed combination. The cost, from the standpoint of refueling operations alone, did not favor the B-58. It would take 1 tanker to refuel 1 of the new bombers, while 2 tankers could take care of 3 B-52s. Among the members of the Air Force Council, General LeMay stood alone in his opinion.

processing equipment, under contracts but yet to be delivered, were canceled, as were 45 ALD-4 ferret pods. On the positive side, the MB-1 free fall bomb pod was exchanged for a 2-component bomb and fuel pod.[47] Other approved changes included improved communications equipment (single-side band/high frequency and emergency ultra-high frequency radios), encapsulated crew ejection seats (another new development), tactical air navigation (TACAN) electronics, and various minor improvements. However, as indicated by General White, one-third of the fiscal year 1959 B-58 procurement was canceled.[48]

Category II Testing — March 1959-30 June 1960

Officially initiated in March 1959, but actually started on 15 February 1958, the Category II tests first assumed some of the flight testing normally conducted under Category I. This variance was primarily due to the November 1957 decision to consolidate the B-58 flight test program under the direction of the weapon system office. While the ARDC testing role was not changed significantly, the proposed using command (SAC, as already confirmed) was to participate in all testing, which was unusual. In another departure from past procedures, testing would be carried out as close as possible to the contractor facilities, which made Carswell AFB the obvious location. The Air Force believed that, among other advantages, this arrangement should reduce costs for logistical training and for support of the Convair technicians. As to the consolidated testing program, it should help to discover and solve development problems quicker. SAC's 3958th Operational Employment Testing and Evaluation Squadron was activated on 1 March 1958, too late to monitor the beginning of the Category I tests. Nevertheless, the 3958th, its ARDC counterpart (the 6592d Test Squadron), and representatives from AMC and Convair soon were in place, constituting the test force that took care effectively of the Air Force Category II and III tests.[49] The Category II tests were completed on 30 June 1960, after

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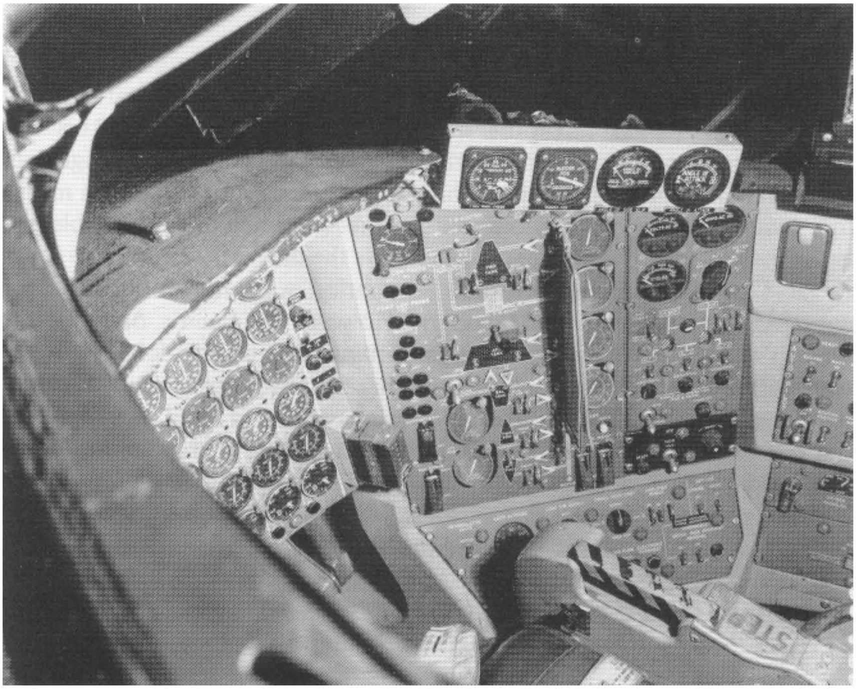
[47] The new 2-component bomb and fuel pod had special merits. After the fuel had been used, the bomb and integral tankage would be dropped on a target, making the aircraft lighter for its return flight.

[48] Letter Contract AF33(600)-36700, issued on 1 November 1957, called for 47 B-58s, bringing forecast procurement to a total of 77—30 so-called prototypes and 47 aircraft for the operational inventory. But the letter contract of November 1957 remained to be finalized, and its 47 aircraft were reduced to 33 on 26 September 1958.

[49] The bulk of the responsibility for the Category I tests did remain with the contractor; Category II proved the airplane's subsystems and was carried out mainly by ARDC's 6592d



A control panel in the B-58.

accumulating 1,216 flight hours that were reached in 256 sorties. Except for a few authorized deviations and some unexpected delays, the Category II testing progressed as planned. Two YB-58As, undergoing stability and control evaluation, were flight tested from Edwards AFB, California, and from Convair's Fort Worth airfield. Another test-aircraft, earmarked for climatic hangar evaluation, went directly from Fort Worth to Eglin AFB, Florida. Finally, the accelerated service test of the J79-GE-5 engine, after 330 flight hours under Category II, was completed under Category III, when SAC crews accumulated 170 additional hours of flight. From the practical standpoint, the Category II tests proved invaluable. Yet, they probably accounted in part for the program's last near-cancellation and final reduction. Seven test-aircraft were lost between December 1958 and June 1960, including 1 which disintegrated in flight on 7 November 1959.

Squadron; the Category III operational tests (always accomplished by the using command) were conducted by the 43d Bomb Wing with the technical assistance of the Test Force.

Program Finalization 1959–1960

While testing was going on, the B–58's fate once again appeared uncertain. A Rand Corporation study, requested by the Air Staff, proved disappointing. Rand thought that the B–52 was superior to the B–58 because the Boeing aircraft could carry heavier payloads and had a longer range than the B–58. Of course, the corporation agreed that air refueling was a means to extend range, but pointed out that such recourse could be unreliable and expensive. Instead, the cheapest way to solve the dilemma would be to equip the B–47s with improved engines. Penetration was another factor to be considered in assessing the bombers. However, in Rand's opinion, the aircraft's penetrative ability was unimportant since enemy defenses of the near future would be so sophisticated that bomber losses would be high, regardless of speed. While these observations appeared valid, the Air Force did not want to alleviate its financial difficulties through retention of an improved but still obsolescing B–47 fleet. The Air Staff, therefore, asked Rand to review its original conclusions. This second round of deliberations served no purpose. Rand returned its study unaltered and without any further solution.

Meanwhile, dissatisfaction with the B–58 program grew. The correction of obvious combat deficiencies was slow, and it seemed almost certain that early inventory aircraft would be short of components and would have no high frequency radio or identification equipment. Some SAC officials were beginning to think that 2 wings of B–58s would be plenty since the aircraft would require greater tanker support than the B–52s. Also, the B–58s would not be able to fly at low level without extensive and costly modifications. Others at SAC wanted more B–58s, having faith in the follow-on B–58B that could be expected to materialize after production of the first 105 B–58As (test-aircraft included).

In May 1959, after reendorsing continued production of the B–52s, as well as support of the B–70 and of the nuclear aircraft program, General White refused to discuss the B–58's future. Just the same, the Air Force on 11 June 1959 began to plan the production and delivery schedules of 185 B–58Bs which, counting the B–58As, would increase the total to 290 aircraft, or enough to equip 5 wings. While at SAC, General LeMay had not liked the B–58A, and as Vice Chief of Staff, he did not change his opinion. The new model would be too expensive, its automatic equipment for low-level flight too complex.[50]

On 7 July, the Air Staff eliminated the B–58B from the program and the

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[50] The B–58B was also due to provide increased range, speed, altitude, and external stores such as multiple free fall bomb pods, fuel tanks, and air-to-surface missiles.

B-58A itself again appeared to be in serious jeopardy. The 60 B-58As, under Letter Contract AF33(600)-38975 and due to be funded in fiscal year 1960, were first reduced to 32, then to 20. General Power tried to justify retaining the 290-aircraft program, but the Air Staff retorted that budgetary considerations were sometimes overriding and Secretary of the Air Force James H. Douglas confirmed that the B-58B was a dead issue.[51] The B-58A came very close to following the B-58B's path. A saving factor again proved to be the money already invested in its development. Also, as noted by Secretary of Defense Thomas S. Gates, a redeeming virtue of the B-58A was its availability in the near term. Yet, even the latter justification was weakening. Time had been catching up with the B-58 weapon system, originally designed to perform against enemy targets of the 1958-1965 period. It was now obvious that the B-58A would not be available in quantity before 1962. Once at the top of the Air Force's priority list, the B-58A program had lost its urgency. In July 1960 (FY 61), Letter Contract AF33(600)-41891 was initiated, but the 30 aircraft and 96 BLU-2/B pods covered by the document were subject to cancellation. The Air Force reached a final decision in December 1960. The fiscal year 1961 purchase was retained, but the fiscal year 1962 procurement was deleted. SAC would receive 2 wings of B-58As and no more.

Category III Testing — August 1960-July 1961

Category II test results and several accidents postponed Category III testing to August 1960, a 6-month slippage. SAC did not want to start the Category III tests before correction of certain B-58 deficiencies. Electrical malfunctions, tire failures, difficulties with the flight control system, and possible structural weaknesses appeared responsible for a rash of recent crashes. Accident findings did not indicate any consistency in the causes, but the B-58 remained under flight restrictions and SAC would not accept the aircraft pending further investigation.[52] Also, modifications required by SAC had to be made to improve safety. By mid-1960, some structural improvements were completed. The aircraft tail had been strengthened, critical side panels had been reinforced, and an ARDC ad hoc committee report was given to SAC. The report emphasized that there were no design deficiencies in either the aircraft or the flight control system, and that when

[51] Secretary Douglas succeeded Secretary of the Air Force Donald A. Quarles on 1 May 1957.

[52] Supersonic speed restrictions were raised to Mach 1.5 in March 1960, but only for the aircraft equipped with modified flight controls.

all functioned, the systems met the specifications. The report also noted that SAC pilots had verified the B-58's good handling characteristics, but pilot training and high proficiency were necessary. In addition, maintenance and control personnel should be highly skilled since those areas could greatly affect B-58 operations.

Obviously satisfied with the committee's report, SAC on 1 August 1960 assumed executive management of the B-58, a function previously vested in ARDC. This marked the beginning of Category III testing, which was accompanied by a number of changes. For example, ARDC's 6592d Test Squadron was inactivated, and the squadron's aircraft and personnel were transferred to the 65th Bombardment Squadron (Medium) of SAC's 43d Bomb Wing. The B-58 Test Force was formally dissolved, although a small nucleus of ARDC people stayed at Carswell AFB to assist the 43d Wing through completion of the Category III tests.

SAC's 3958th Operational Employment Testing and Evaluation Squadron had been a most important member of the now extinct test force. The 3958th was responsible for the proper development of a combat crew training program. It had to select and educate B-58 maintenance personnel and to create a cadre of flight crews that would serve as instructors in forthcoming combat crew training classes. In addition, the 3958th put together standard operating procedures for the future B-58 wings. When it took over, SAC's 65th Bombardment Squadron (Medium) found no fault in the 3958th's performance. Formal 3-month classes for combat air crews, started in mid-1960, encountered no personnel difficulties. Selected students, former B-47 pilots and regular officers for the most part, were highly qualified, with a minimum 1,000 hours of jet flying experience. Student navigators, with 500 hours of flying time on multi-jet aircraft, and defense system operators, with a minimum of 200 hours, were also excellent candidates. The 65th Combat Crew Training Squadron used Convair 2-place TF-102As to start training B-58 pilots and welcomed the August 1960 delivery of the first TB-58A trainer. As a rule, 3 TB-58 flights were made before a pilot could solo in a B-58A.

Even though nearly 1,879 combat crew training hours were flown as part of the Category III tests, the program had little to do with the 43d Bomb Wing's combat crew training. The Category III task was to evaluate the overall operational performance of the B-58A. Since the aircraft was a highly integrated, complex weapon system, the scope of the Category III tests was unusually broad. The tests covered all aircraft systems, passive defense, electronics, communications and the like, but also aerospace ground equipment and supply, for all these factors played a part. Still, because of its critical importance, a great portion of the Category III tests was devoted to the ASQ-42V Bombing-Navigation Electronic System. Ended on 31 July 1961, after the loss of 1 more B-58, Category III testing was credited with some 5,265 hours of flying time, of which about 945 hours were used strictly for testing. The rest was accumulated in various ways. A subtotal of 1,878 hours was flown to meet various Category III combat crew training objectives. The remaining hours, approximately 2,439 of them, encompassed maintenance test flights, the acceptance and delivery flights of new and retrofitted B-58As, airshows and record-breaking flights, and the hours flown for ferry missions.

Enters Operational Service 1961

B-58As, a first lot of 12, began reaching the 43d Bomb Wing at Carswell AFB in August 1960, but the 43d did not gain an initial operational capability until 1961, and waited until May of that year to get its full complement of 36 B-58s.[53] An unreliable bombing and navigation system, maintenance difficulties, shortages of ground equipment, and continuous involvement in the Category III tests combined to delay the 43d Bomb Wing's combat readiness. A second SAC wing, the 305th[54] at Bunker Hill AFB, Indiana,[55] received its first new bombers in May 1961 to start converting from subsonic B-47s to supersonic B-58s. SAC expected that the 305th would have its full allocation of B-58s by May 1962. Twenty KC-135 tankers were already in place at Bunker Hill.[56]

Initial Shortcomings 1960-1961

The first 47 B-58As did not have tactical air navigation (TACAN) electronics. The system, developed by the Hoffman Laboratories, was provided

[53] In later years, this number was increased to 45, a total which included 4 of SAC's 8 TB-58As. The other 4 trainers went to SAC's second wing of B-58s.

[54] SAC had earmarked the 305th as the first B-58 recipient. Initially, this was changed as a result of the new testing arrangement. Later, the 43d Bomb Wing's proximity to Fort Worth remained an important factor in view of the B-58's early operational problems.

[55] Bunker Hill was renamed as Grissom AFB on 12 May 1968, in honor of Lt. Col. Virgil Ivan ("Gus") Grissom (1926-1967). Colonel Grissom, one of the original 7 United States astronauts, made the second Project Mercury flight and a Project Gemini flight in July 1961. He died on 27 January 1967 in a fire aboard an Apollo spacecraft under test at the Kennedy Space Center, Fla.

[56] Aerial tests, completed in October 1959, showed that Boeing KC-135 tankers could refuel the B-58s. However, air refueling training and operations were limited at first because the B-58 search radar was not compatible with the refueling rendezvous equipment installed in the KC-135.

as government-furnished equipment and due to be retrofitted in most of these early planes. Also, the B-58As could not fly at low levels. Design changes to give the aircraft this added performance were being worked out. Prompt results could not be expected since the changes had only been authorized in mid-1959, when Convair's subsequent model series, the improved, low-level flying B-58B, was canceled. There were many other deficiencies of varying importance. The aircraft's ejection seats were still unsatisfactory. Development of a capsule-type of escape system for a single crewman, now handled by the Stanley Aviation Corporation, was progressing well. However, the capsule's stability remained marginal after ejection, thereby preventing Convair from incorporating the capsule during production. This meant that all B-58s would have to be retrofitted, a task started in late 1962.[57] Meanwhile, another retrofit project was taking place. B-58As were re-equipped with sturdier wheels and new tires, marking the end of at least one long-standing problem.[58] But this was just a beginning. In mid-1961, following completion of a 6-month study, the Air Staff decided that much more would have to be done to enhance the B-58A's performance. It also approved modification of existing B-58s (about 70 of them) to allow the aircraft to carry a greater variety of weapons, 4 of which would be transported externally. Subsequent B-58As would be so equipped on the production line.

Post-Production Modifications 1962–1964

Significant modifications were initiated in November 1962, under the code name of Hustle Up, a 2-phase project accomplished in Fort Worth by the prime contractor, and in San Antonio, Texas, by technicians of one of the Air Force Logistics Command's air materiel areas. The first phase of Hustle Up covered 59 B-58As; the second phase, only 36. However, Phase II also modified 76 pods of various configurations. Modification kits, including aircraft kits, pod kits, training kits and kit spares, were acquired through special contract at a cost of $6.1 million and used by both the Convair people and personnel of the San Antonio Air Materiel Area. Retrofitting the escape capsules and installing

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[57] The B-58 was the first aircraft with individual escape capsules for emergency use at any speeds. This escape system could rocket the crew to safety from anywhere between ground level at 120 knots and 70,000 feet at Mach 2.2. The capsule, fitted with clam-shell doors, was pressurized. Once sealed and ejected, it stabilized itself and descended by parachute. It was equipped with a flotation system that deployed automatically in the event of a landing on water. The capsule was not large, restricting the size of the crew. Even so, the capsule consumed space and made the B-58's small crew compartments more cramped.

[58] The loss of a B-58A on 16 September 1959 (totally destroyed by fire after an aborted take-off from Carswell) was directly attributed to tire failure, followed by disintegration of the wheel.

multiple weapons proved to be the most extensive modifications covered by Hustle Up, which was completed in May 1964. Meanwhile, contrary to SAC's hope that the development program would yield a trouble-free aircraft, the B-58A weapon system was again encountering more than its share of difficulties. Two fatal accidents and 30 in-flight "incidents" between March and September 1962 imposed new flight restrictions and generated another major modification program. This program, centering essentially on the aircraft's flight control system, was also conducted in several phases. Phase I put a gang bar on yaw damper switches, but provided minimal improvements. Phase II (redesignated Phase I, following the May 1963 completion of the program's initial phase) modified the mach altitude repeater and improved the unreliable amplifier computer assembly circuitry, thereby allowing the B-58As to fly again at speeds up to Mach 1.65. Started in April 1964, the new Phase I closed before year's end, as scheduled, with 13 B-58s of the 305th Bomb Wing being so improved while undergoing the last part of the Hustle Up modification program. The next phase (Phase III, now known as Phase II) did not fare as well. It was due to further improve the flight control system, which in turn would allow the B-58A to use its desired Mach 2 speed. Many costly changes were involved, totaling $30 million. Furthermore, this phase was not intended to take place before the fall of 1966.

Crewmen dash for their B-58 during alert training at Carswell AFB, Texas, July 1961.

Unrelenting Problem 1965

Besides its obvious shortcomings, the B-58A was plagued from the start by a very serious problem. Its bombing and navigation system (the AN/ASQ-42) was far less reliable than that of the B-52 and the B-47. The problem, confirmed during Category III testing, did not lend itself to easy solutions. The AN/ASQ-42 was extremely complex. Its electronic signal loops were generated and circulated within several interconnected electronic "black boxes." Thus, malfunctions were hard to track down, since it was difficult to identify which black box was primarily responsible for the failure. By 1965, the AN/ASQ-42 had become an old problem, with no remedy in sight. Occasionally, malfunction causes were identified, but more often, they were merely suspected or totally undetermined. That the AN/ASQ-42 system had to be made to work well was obvious. To begin with, it was SAC's most sophisticated bombing system. Also, once fully operational, the AN/ASQ-42 would allow the B-58A to find and bomb any target, be it at high-altitude/supersonic or low-altitude/subsonic speeds. Yet, improvement proposals, submitted by various contractors in September 1965, were found unacceptable. They did not meet requirements, carried no guarantees, and fluctuated around $70 million, twice the anticipated cost. In any case, circumstances beyond SAC's control raised doubts about the AN/ASQ-42's potential performance.

Phaseout Decision 1965

In December 1965, Secretary of Defense Robert S. McNamara directed phaseout of the entire B-58 force by the end of June 1970.[59] Secretary McNamara also publicly announced that the FB-111A would be built.[60] The new bombers, along with improvement of the Minuteman and Polaris missiles and modernization of the B-52, would enhance strategic deterrence and make longer retention of the B-58s superfluous. In addition, Defense officials deemed necessary budget cuts another valid factor. Appalled by the decision, SAC pointed out that the B-58A, after coming off production with

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[59] The decision followed completion of a study of the comparative costs and performance of a proposed bomber (the FB-111A) and existing B-52 and B-58 strategic aircraft.

[60] The FB-111A medium-range strategic bomber, like the B-58, was built in Fort Worth by the Convair Aerospace Division of the General Dynamics Corporation. The FB-111A, a modified version of the F-111A tactical fighter, was part of an interrelated and highly controversial program. As such, the FB-111A coverage was included in Marcelle S. Knaack, *Encyclopedia of U.S. Air Force Aircraft and Missile Systems, Vol 1: Post-World War II Fighters, 1945-1973* (Washington: Office of Air Force History, 1978).

many weaknesses, was well on its way to becoming a sound, effective weapon system. Stressing the declining number of manned bombers, SAC in the ensuing 2 years kept pressing for retention of the B-58s, at least until June 1974. But the decision of 1965 was to prove unshakable.[61] And while it did not spell the end of the modifications programmed at the time, the overall B-58 improvement program was immediately affected.

Reduced Improvements 1965-1969

Modifying the B-58A for low-level flying would be a meager improvement if the aircraft were not properly equipped. SAC insisted from the start that the B-58A, to be truly effective at low levels, needed a terrain-following radar to penetrate increasingly fierce enemy defenses. Prototype development of the radar, approved with misgiving in view of the entire venture's cost and technical hazards, was the first casualty of the B-58's early phaseout. It was canceled in late 1965, when SAC settled for a reliable radio altimeter and a forward-looking visual sensor (day/night television) system. This much less expensive project, installation and modification included, was completed in early 1969. Another modernization project had an even more disappointing fate. The B-58A's electronics countermeasures systems, never updated since the aircraft's production, were nearly obsolete. Should the high-altitude B-58A be committed to combat, it would be extremely vulnerable to surface-to-air missiles, such as the SA-2s. Several contemplated modifications had been held in abeyance pending the development of better techniques. One of them, modification 1180, had been approved in mid-1966 and would give the B-58A a new version of the ALQ-16 trackbreaker. However, when flight tested in 1968, this component did not work. As to other penetration aid improvements, they had not even reached the testing stage. Ongoing talks that the B-58s might, after all, be retained through 1974 kept the electronic countermeasures improvement projects alive until the end of 1969. When the B-58's longer retention did not materialize, all penetration aid modifications were canceled.

Retained Modifications 1965-1969

Retirement of the B-58 by mid-1970 meant that modifications, even if approved, would be deleted if not funded by mid-1968. Aware that several

[61] On 21 February 1968, General McConnell, Air Force Chief of Staff since 1 February 1965, reaffirmed before the Senate Armed Services Committee that the entire B-58 fleet would be phased out before June 1970.

B-58 problems would take a long time to solve, SAC asked for a waiver of the so-called 2-year utilization rule, but the request was denied. Nevertheless, many of the modifications, pursued all along by SAC, came to fruition. After numerous setbacks, a solution was found for the B-58A's erratic flight control by adding a redundant yaw damper to the system. Retrofit kits were purchased in 1967, and the installation undertaken in May 1968 progressed smoothly. During the same period, an improved version of the AN/ASQ-42, flight tested in mid-1967, proved successful. Production of the improved system, approved on 27 September 1967 and funded within prescribed time limits, foretold no problem. Technical data and the delivery of spare parts had been included in the necessary contract. Moreover, installation of the system, as started in May 1968, was not expected to disrupt significantly SAC's operational plans. Another modification had also been sought by SAC, almost since the aircraft had become operational. The command wanted the B-58A crew to be capable of starting their engines without having to depend on pneumatic ground starting carts. Equipping the aircraft with a cartridge self-starter would allow it in an emergency to take off from dispersal, post-strike, and other remote bases. Yet the project had been handicapped from the start. It was approved, canceled, reapproved, modified, and constantly hampered by technical difficulties. SAC, nonetheless, won its case and the B-58 was equipped with a cartridge self-starter. The installation began on 7 May 1968, approximately 6 months after all B-58s had exchanged their J79-5B engines for improved J79-5Cs.

Inspections and Repairs 1966-1969

In mid-1965, the San Antonio Air Materiel Area recommended a program of inspect and repair as necessary (IRAN) for a scheduled, comprehensive depot-level inspection of the B-58. So far, San Antonio and SAC had taken care of the aircraft's difficulties as they arose. However, increasingly serious problems were being uncovered. The plumbing and wiring of the B-58As and TB-58As were deteriorating, and the aircraft were also showing signs of structural fatigue and corrosion. SAC had no objections to the IRAN program proposed for the B-58, a routine procedure for most aircraft. Nor did it object to the 36-month cycle favored by the materiel area. However, the command qualified its approval. Since fuel leaks indicated that corrosion was further along than estimated, corrective action could not await the January 1966 implementation of the IRAN program. Also, B-58s of the 43d Bomb Wing should be treated first, which they were. Initially conducted from Convair's Fort Worth facilities, the IRAN program was moved in mid-1967 to James Connally AFB, near Waco, Texas. There were no other changes. The B-58 modification/IRAN program was thorough. Major tasks included removal of all releasable panels; inspection and repair of the aircraft's primary and secondary structures; and inspection and repair of all wire bundles and cables, hydraulic lines and fittings, and air conditioning and pressurization duct components. The program also included bench testing and calibration of all electronic units, removal and overhaul of landing gear assemblies, and repair and treatment of corroded areas. This work consumed 16,000 manhours. In 1967, the cost per aircraft totaled $181,000; $201,000 in 1968.

End of Production — 1962

Production ended in the fall of 1962, with the last 3 B-58s being delivered on 26 October, 1 month ahead of schedule.

Total B-58s Accepted — 116

All B-58s were built at the contractor's Fort Worth plant.

Acceptance Rates

The Air Force accepted 3 B-58s in FY 57; 8 in FY 58; 16 in FY 59; 11 in FY 60; 30 in FY 61; 33 in FY 62; 15 in FY 63 (the last 3 in October 1962).

Research, Development, Test, and Evaluation — $1.4 billion

The Air Force estimated the B-58 weapon system program's research, development, test, and evaluation at $1,408.6 million.[62]

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[62] Air Force records reflecting appropriations for fiscal years 1954 through 1961 showed that a total of $3,174.4 million was approved for the B-58 program. This was reduced to $3,026.2 million in fiscal year 1962, after total procurement was set at 116. Prorated, this brought the cost of every B-58 weapon system to $26.9 million. However, additional costs were later incurred. In 1967 SAC estimated that each B-58 cost about $30 million.

Flyaway Cost Per Production Aircraft **$12.44 million**

Airframe, $6,447,702; engines (installed), $1,117,120; electronics, $1,294,791; ordnance, $26,674; armament (and others), $3,555,573.[63]

Average Cost Per Flying Hour **$2,139.00**

Average Maintenance Cost Per Flying Hour **$1,440.00**

Subsequent Model Series **None**

Other Configurations **B-58C, RB-58A, and TB-58A**

B-58C—This model of the B-58, designated B-J/58 by Convair, but known unofficially by the Air Force as the B-58C, incorporated significant airframe modifications, including a new wing leading edge, more tail area, a 5-foot fuselage extension, and 4 Pratt & Whitney J58 engines without afterburners. In 1960 Convair estimated that its all-supersonic, Mach 2.4 B-58C would be as efficient and much cheaper than the B-70. The Air Force did not test these propositions for several reasons. Even if the proposed airplane approached the B-70's anticipated performance, it had neither the payload nor the growth potential of the latter. The B-70 was the beginning of a design, the B-58C would be the ultimate product of an old configuration. Further study of the Convair proposal practically closed the case. In April, ARDC reported that the contractor's estimate of a 5,200-nautical-mile unrefueled range was probably 25 percent too optimistic. Also, extensive use of aluminum in the B-58C could create problems since the effects of this metal's exposure to high temperatures (aerodynamic heat) was not known. Lack of funds prompted the final decision. Greatly concerned with the B-70, recently confined to development status,[64] the Air Staff as well as SAC did not want to risk the financial interference of a new project.

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[63] Excluding prorated research, development, test, and evaluation costs and the expenses of modifications and engineering changes, added on after approval of a basic contract.

[64] In early 1961, the Kennedy Administration asked the Congress to cancel production of the "unnecessary and economically unjustifiable" B-70 Valkyrie. Thereupon, the B-70 funds were reduced and the program was limited to 3 experimental planes.

In late April, Convair was informed that the Air Force had no interest in the B-58C.

RB-58A—The early photo reconnaissance pod program, due to transform the B-58 into a high-altitude and speedy reconnaissance weapon system had been canceled, reinstated, and again canceled by December 1958. One pod, delivered in June 1958, was lost as the plane it equipped crashed in June 1960. The electromagnetic reconnaissance program followed the same pattern, being canceled in October 1957, then reendorsed, and finally abandoned in May 1958, after delivery of two pods. In 1963, another change took place. As a result of the October 1962 Cuban Crisis, SAC decided the B-58A could be used to great advantage for low-level, high-speed photographic reconnaissance. This was based on the assumption that the extra task could be carried out without making a reconnaissance aircraft out of the few available B-58As. After rejection of several unsatisfactory proposals, a solution was found. It simply involved the incorporation of a KA-56 panoramic camera into the nose fairing of the MB-l pod. Approved by the Air Staff in mid-1963, the modification was successfully flight tested on 30 October and 10 cameras and associated equipment were purchased. Known as Project Mainline, the modification of 44 B-58As and 10 MB-1 pods was completed on 6 December at a cost of approximately $1 million.

TB-58A—The flight characteristics peculiar to delta-wing planforms and the B-58's unmatched high speed called for a trainer version of the new bomber. The Air Force first authorized the conversion of 4 early test B-58As to the training configuration on 25 February 1959. The modification, done under production contract AF33(600)-36200, provided side-by-side seating for pilot training, with the instructor placed aft and 10 degrees right of the student. The Air Force took delivery of the first TB-58A in August 1960, and subsequently ordered the conversion of 4 additional test B-58As to a similar configuration. This last lot was modified under special contract, but the costs were lumped together for a total of almost $16 million.

Phaseout 1969-1970

Phaseout of the entire B-58 force by the end of fiscal year 1971 (June 1970) was directed in December 1965. This schedule was a change from Secretary McNamara's earlier plans and gave the aircraft an extra year of operational life. However, once underway, the B-58 retirement program moved fast, actually ending 6 months ahead of time. It was completed on 16 January 1970, when the 305th Bomb Wing's last 2 B-58s (Serial Numbers 55-662 and 61-0278) were flown to Davis-Monthan AFB, Arizona. The planes joined 82 other B-58As, including the 8 converted trainers, retired since 3 November 1969. Two B-58As, responsible for record-breaking flights in 1962 and 1963, escaped retirement at Davis-Monthan and were placed in museums.

Record Flights 1961–1963

If the B–58 established itself at home as one of the most expensive and controversial weapon systems, it also attracted the world's attention as one of the most extraordinary airplanes. Actually, the B–58 broke a great many speed records (some still standing 10 years later) and won almost every major aviation award.

The aircraft's historical achievements commenced on 12 January 1961, when a B–58 of the 43d Bomb Wing set 6 international speed and payload records on a single flight, in the process breaking 5 previous records held by the Soviet Union. Two days later, another B–58 of the 43d Bomb Wing broke 3 of the records set on 12 January. The plane flew over a 620-mile closed course with similar payloads of 4,409.2 or 2,208.6 pounds and no payload at all, at an average speed of 1,284.73 miles per hour—an increase of 222.9 miles per hour. On 28 February, the crew was awarded the Thompson Trophy for 1961. This was the first time in 31 years that the trophy was awarded to a medium bomber. On 10 May, a new record for sustained speed was set by a B–58, flying 669.4 miles in 30 minutes and 45 seconds at an average speed of 1,302 miles per hour. This earned the aircraft's pilot, Maj. Elmer E. Murphy, the Aero Club of France's Bleriot Cup, a trophy named for Louis Bleriot, famous for his pre-World War I flight across the British Channel.[65] The B–58 continued its record-setting pace on 26 May when it flew the 4,612 miles from New York to Paris in 3 hours, 19 minutes and 41 seconds. The time was almost one-tenth that taken by Charles Lindbergh in his famous solo flight of 1927. The flight of 26 May 1961 earned the B–58's 3-man crew the Mackay Trophy, a trophy first won on 9 October 1912 by Gen. "Hap" Arnold, then a young lieutenant flying a reconnaissance mission with an early version of the Wright biplane.

The B–58 had another notable year in 1962. On 5 March, a 43d Bomb Wing B–58 broke 3 speed records in a round-trip flight between New York and Los Angeles. The B–58 made the entire trip in 4 hours, 41 minutes and 14.98 seconds while averaging 1,044.46 miles per hour. Three in-flight refuelings by KC–135s were required. The entire flight earned the crew the

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[65] One of the first warplanes employed by the allies during World War I bore the name of France's aviation pioneer, Louis Bleriot. The Bleriot Cup, established in 1931, was badly damaged during World War II, while in Italy's possession. Subsequently remade by the Italians, the 1,600-pound trophy had been awarded before, but only provisionally. Not until the required speed and duration marks were reached by the B–58 could the trophy be won permanently.

Mackay Trophy. A part of the same flight was particularly impressive. The B–58 flew from Los Angeles to New York in 2 hours and 58.71 seconds, for an average speed of 1,214.65 miles per hour. For this the crew received the Bendix Trophy, first awarded in 1931 to Jimmy Doolittle for his 9-hour and 10-minute flight from Los Angeles to Cleveland. The B–58 closed 1962 with 2 altitude records, acquired on 18 September and worthy of the Harmon Trophy.

The B–58 set its last 5 records in 1963, all of them on 16 October. On that date, a B–58 of the 305th Bomb Wing set an official world speed record by flying 8,028 miles from Tokyo to London in 8 hours, 35 minutes and 20.4 seconds, averaging about 938 miles per hours.[66] Another B–58 established speed records, flying from Tokyo to Anchorage, Alaska, and from Anchorage to London.

[66] At retirement, this B–58 (Serial Number 61–2059) went to the SAC Aerospace Museum, Offutt AFB, Neb. The B–58 (Serial Number 59–2458) which set the speed and altitude records of March 1962 went to the Air Force Museum, Wright-Patterson AFB, Ohio.

Program Recap

The Air Force bought 116 B-58As, including 30 early planes identified as prototypes or test-aircraft. In 1959, the Air Force decided that 15 of the first YB-58As would be brought up to the production configuration's latest standards. Eight TB-58As, acquired through production modifications, were also part of the total contingent. The B-58 program proved costly, reaching over $3 billion, and its acquisition process was complex. It took 5 contracts (AF33(038)-21250, and AF33(600)-32841, -36200, -38975, -418911), all of the cost-plus-incentive-fee type, to acquire the aircraft, and each contract carried an unusual number of amendments and supplements. The Air Force also entered in almost a dozen miscellaneous contracts to secure B-58 modification kits, multiple weapon kits, mobile training units, flight simulators, and various items of lesser importance.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

B-58A AIRCRAFT

Manufacturer (Airframe)	Convair Division of General Dynamics Corporation, Fort Worth, Tex.
(Engines)	General Electric Company, Evandale, Ohio.
Nomenclature	Strategic Medium Bomber
Popular Name	Hustler

Length/Span (ft)	96.8/56.8
Wing Area (sq ft)	1,542.5
Engine: Number, Rated Power per Engine, & Designation	(4) 15,000 lb st J79-GE-5B (with afterburner)
Armament	1 M-61 Gatling gun
Crew	3
Basic, High-Altitude, Refueled Mission[a]	
Weights (lb)	
Empty	55,560
Combat	82,595
Takeoff	163,000
Takeoff Ground Run (ft)	
At Sea Level	7,850
Over 50-ft Obstacle	13,700
Rate of Climb (fpm) at Sea Level[b] (Takeoff Weight/Maximum Power)	
With MB-1C Pod	17,830
With MB-1C Pod & 2 small weapons	16,805
Service Ceiling at Combat Weight (100 fpm Rate of Climb to Altitude)	63,500
Combat Ceiling with Max Power (500 fpm Rate of Climb to Altitude)	
With MB-1C Pod	63,080
With MB-1C Pod & 2 small weapons	62,900
Average Cruise Speed Outside Combat Zone (kn)	503
Max Speed at Combat Service Ceiling (kn/ft)[b]	
With MB-1C Pod	1,147/63,500
With MB-1C Pod & 2 small weapons[c]	1,147/62,500
Initial Cruise Altitude with MB-1C Pod (ft)	22,500
Target Altitude with MB-1C Pod (ft)	55,650
Final Cruise Altitude with MB-1C Pod (ft)	46,880
Combat Distance with MB-1C Pod (nm)	4,275
Combat Zone Distance with MB-1C Pod at Combat Zone Speed (nm/kn)[d]	500/1,147
Total Mission Time With MB-1C Pod (hr)	11

Basic, High-Altitude, None-Refueled Mission[d]

Weights (lb)	
Empty	55,560
Combat	81,345
Takeoff	163,000
Takeoff Ground Run (ft)	
At Sea Level	7,850
Over 50-ft Obstacle	13,700
Rate of Climb (fpm) at Sea Level[d] (Takeoff Weight/Max Power)	17,830
Service Ceiling at Combat Weight (ft) (100 fpm Rate of Climb to Altitude)	63,850
Combat Ceiling with Max Power (ft) (500 fpm Rate of Climb to Altitude)	63,400
Average Cruise Speed Outside Combat Zone (kn)	531
Max Speed at Combat Service Ceiling (kn/ft)[d]	1,147/63,400
Initial Cruise Altitude (ft)	28,200
Target Altitude (ft)	55,900
Final Cruise Altitude (ft)	46,900
Combat Radius (nm)	1,400
Combat Zone Distance at Combat Zone Speed (nm/kn)[d]	500/1,147
Total Mission Time (hr)	5.09

Abbreviations

fpm = feet per minute
kn = knots
max = maximum
nm = nautical miles

[a] Under so-called "Post-Strike" conditions, which actually meant that all performance data were based on the assumption that the plane would have to fly 1,500 nm from the target to a recovery base.

[b] High speed restricted by engine and airframe structural limits.

[c] Altitude limited by physical load limits.

[d] All data based on airplane carrying MB-1C pod and no small weapons.

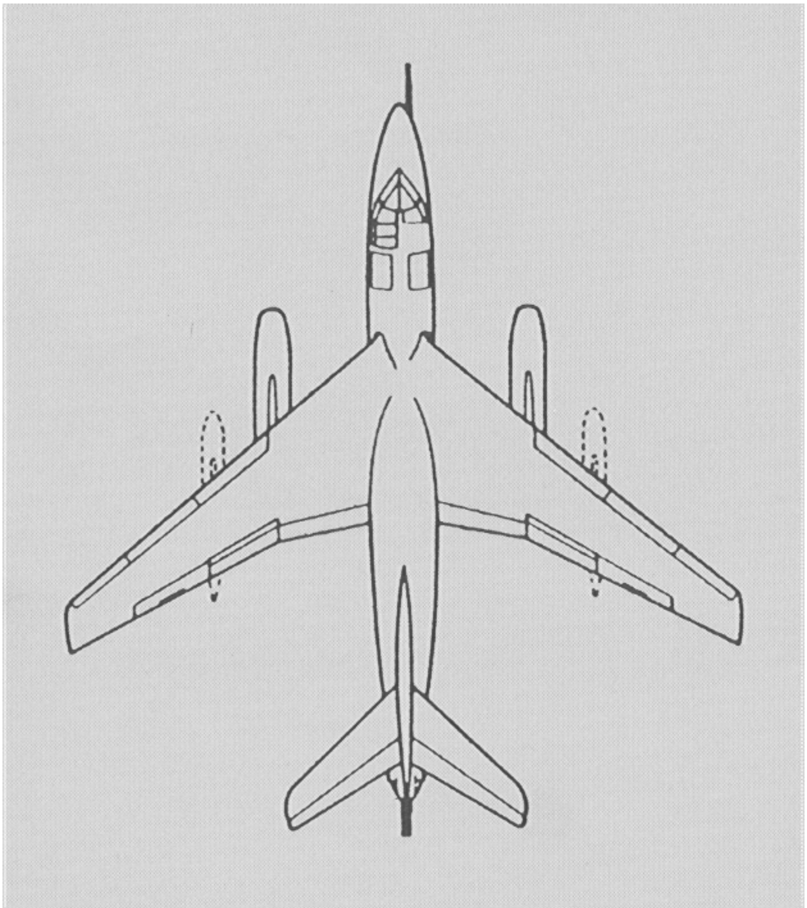
Basic Mission Note

Refueled mission's range data were based on refueling the B-58 with a Boeing KC-135 tanker having a 1,000-nautical mile post-refuel stage. The B-58 took off, climbed on course with military power,* then buddy-cruised with the tanker at Mach 0.8 to point of hookup for refueling. Range-free allowances included: 10 minutes for rendezvous after climb-out, additional fuel equal to 5 percent of fuel burned prior to hookup, and service tolerances amounting to an additional 5 percent increase in fuel consumption for both pre-refuel and post-refuel stages. Refueling was conducted at an altitude of 25,000 feet, at a Mach number of 0.8, and with the high-speed boom.

Formula: Basic Mission's Post-Strike Stage
After refueling, accelerated with military power to the speed for maximum range, cruised at maximum-range speeds and altitudes until initiating the maximum-power acceleration and climb to supersonic zones. The supersonic zone distance was 500 nautical miles and consisted of flying in at Mach 2.0 and dropping the MB-1C pod. After dropping the pod, cruised 1,500 nautical miles to complete mission at Mach number and altitudes for maximum range. Range-free allowances included: 5 minutes of normal-power and 1 minute of maximum-power fuel consumption for warm-up and take-off, 10-minute fuel consumption to cruise on Mach 0.8 flight path for buddy-refueling, 5 percent of fuel burned prior to refueling, and service tolerances amounting to an additional 5 percent increase in fuel consumption for the pre-refuel and post-refuel stages. A reserve fuel allowance sufficient to fly 8 percent of the creditable mission range after refuel, plus the amount of fuel required for 1 ground-controlled approach (GCA) go-around, was also included.

B/RB-66 Destroyer

Douglas
Aircraft Company



B/RB-66 Destroyer
Douglas

Navy Equivalent: A3D-1

Overview

As in the B-57's case, the Air Force bought the B/RB-66 for lack of any better choice. The analogy did not stop there. Like the stopgap B-57, which it was due to replace, the B/RB-66 was to be an interim weapon, primarily earmarked for tactical reconnaissance, until the subsequently canceled B-68 came into being. Similar misjudgments occurred: the difficulty of Americanizing a British aircraft was underestimated and, while not overlooked, the complexity of turning a Navy plane into an efficient land-based system was improperly assessed. On both occasions, the Air Force requirements proved too ambitious, too hasty, and the 2 programs fell behind schedule. Finally, it took years, and particularly the conflict in Southeast Asia, to justify the costs involved, a conclusion actually far more applicable to the B/RB-66 than to the B-57.

Based on a year-old proposal by Douglas, the Air Force in 1952 bought the Navy's yet-to-be-flown A3D-1 Sky Warrior. Hurriedly, and in keeping with the mood of the time, exacting requirements were levied which, in view of the program's urgency, proved totally unrealistic. The future B/RB-66 Destroyers, as the Air Force versions of the Navy aircraft were designated, had to be fast, highly maneuverable, and able to perform in all types of weather, at very high or low altitudes, and from makeshift or short runways. The B/RB-66s also had to have a 1,000-nautical mile radius and be large enough to accommodate a 10,000-pound payload of either atomic, conventional, or photographic flash bombs. The bomber and reconnaissance versions were to be kept closely alike. Finally, and of great importance, all versions were to be fitted with sophisticated electronic countermeasures components to deal with enemy radars.

As a necessary start, Douglas deleted the folding wings, catapult capability, and arresting gear from the Navy A3D configuration. In keeping with Air Force instructions, adaptations were kept to a minimum in order to expedite matters. The next major steps, therefore, were addition of upward ejection seats, a must when flying low at high speeds, and reinforcement of the aircraft structure to compensate for the greater stresses of low-altitude, high-speed operation. To the Air Force's dismay, once these changes were made, new requirements emerged, as did design and layout deficiencies. Hence, larger tires were provided, as were emergency air brakes, wing spoilers, and improved lateral controls. The wing's angle of incidence was altered to minimize dutch roll, the cockpit pressurization was improved, and a number of other development modifications took place. Just the same, problems remained. A more serious handicap was the need for better jet engines, still at a premium.

The RB-66's first flight in June 1954, 6 months behind the Air Force's deadline, was not a success. The aircraft did not handle well, it pitched up unexpectedly, the wings vibrated excessively, the vision from the canopy was poor, and the landing gear doors did not function properly. Ensuing efforts were hardly rewarding. In 1955, reminiscent of yet another aircraft, the B-58, the Air Staff pondered whether the B/RB-66 should be canceled, for a cold loss of perhaps up to $600 million. No substitute aircraft were available, and this fact also had to be considered. The dilemma was solved in familiar fashion; the program was retained, but reduced.

Improved RB-66s entered operational service in 1956, permitting the long overdue replacement of the obsolete RB-26s, and allowing phaseout in early 1957 of the problem-ridden RB-57As. While the bulk of the small contingent of B/RB-66s, 294 instead of the 342 aircraft initially programmed, was earmarked for the Tactical Air Command (TAC), some of the badly needed reconnaissance models promptly joined the Pacific Air Forces in the fall of 1956. Others went to the United States Air Forces in Europe in late 1957. Whether at home or overseas, every version of the aircraft remained troublesome. Their successive engines, Allison J71-A-9s and J71-A-11s were better, but not good enough, and the subsequent retrofit of more powerful J71-A-13s caused other problems.

In the long run, the B/RB-66s were made to work, and the aircraft became a main asset of the Air Force intelligence gathering and electronic warfare forces. Even though lack of money precluded numerous special modifications and most modernization projects, many changes were effected as the aircraft's specialized roles accrued. Because of the United States involvement in Southeast Asia, the aircraft's life-span was extended far beyond expectation. Some B-66Bs were phased out in 1963, only to be reactivated within a few years. After refurbishing, the aircraft, now known as the EB-66, headed for the war theater. Other B/RB-66s, although earmarked for retirement, were kept active, re-equipped, redesignated, and committed to combat as early as 1965.

In 1966, press accounts began to give the EB-66s credit for neutralizing surface-to-air missile radars as well as much of the enemy's radar-controlled but conventional anti-aircraft weaponry. As the war escalated and enemy defenses grew, the old aircraft, with their upgraded electronic devices and despite their worn-out engines, became invaluable and so remained until the end of the conflict. Thus, a difficult decision, made nearly 20 years before by a greatly concerned and cautious Air Staff, proved correct.

Basic Development — 1951

The B/RB-66 Destroyer grew out of the Douglas Aircraft Company's XA3D-1, a high-altitude, light bombardment airplane developed for the U.S. Navy. The A3D-1 Skywarrior, the production version of the experimental carrier-based bomber, was first flown on 16 September 1953.

Initial Requirements — 14 June 1951

The beginning of the Korean conflict caught the Air Force with a tactical inventory of light bombers and reconnaissance aircraft consisting essentially of World War II B/RB-26s. This was supplemented by a few B-45s, acquired between 1948 and 1950. However, 50 of the B-45 Tornadoes had been modified to carry atomic weapons, and another 60 were unable to meet the projected need for tactical bombers designed to carry conventional munitions. This predicament accounted for the March 1951 production order for the B-57 light bomber (too small to carry current atomic weapons). Yet the Air Force harbored no great illusions. Although it thought erroneously that the B-57 Canberra would be available between 1952 and 1953, it never overestimated the new aircraft's potential. The Air Force also knew that, realistically, the ideal weapon system for tactical bombing and reconnaissance—Weapon System 302A—remained a long way off.[1] The solution, therefore, was to seek a more satisfactory interim airplane that

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[1] Design studies for Weapon System 302A were submitted by the Glenn L. Martin Co. and Douglas Aircraft Co. in 1952 and again in 1954, along with an entry from North American Aviation, Inc. A proposal by Boeing Airplane Co., presented after the competition deadline, was automatically rejected, and Martin ended being the winner. Unfortunately, the proposed B-68's inertial guidance bombing and navigation system ran into serious difficulties. This meant that production quantities of the B-68, should they be approved, would be postponed to at least 1963. This problem soon became immaterial. In early 1957, citing stringent budget limitations and the higher priorities of other weapon systems, Air Force Headquarters canceled the B-68 program.

would become operational around 1954. While the Air Force's June 1951 objective centered on a reconnaissance vehicle, this requirement was extended in August to include tactical bombing.[2]

Potential Candidates — Fall 1951

Defining a requirement was usually easy; finding the best aircraft for the task was always difficult. An improved B–45 might satisfy the Tactical Air Command's demands of the mid-fifties. However, the Tornado's relatively slow speed and inferior defense armament were not encouraging. The Air Research and Development Command (ARDC) believed the B–47 would be a preferable choice, even though the Boeing medium bomber was a Strategic Air Command airplane and rather costly. It also called for more maintenance than practical for tactical theatre operation. In any case, ARDC was the first to recognize that the B–47 would not be the absolute answer. TAC could put the aircraft to good use for high-altitude bombing, but the command's close air support missions would probably be better served by the Martin B–51. The latter, still in the experimental stage, was a 3-engine all-weather airplane designed primarily for low-level bombing. On the other hand, the XB–51 was far from perfect. First flown in October 1949, it had a short radius of action and could not carry more than 4,000 pounds of bombs. A fourth candidate, the Navy's Douglas XA3D–1, was the most promising on paper; however, as the plane was not expected to fly before another year, there was no knowledge of this plane's stability and control characteristics.[3] Finally, to make matters worse, whatever plane was chosen would suffer at first from a probable shortage of engines and a lack of reconnaissance equipment.

Tentative Selection — 29 November 1951

Based on a Douglas proposal of 29 August, the USAF Aircraft and Weapons Board opted in November for an Air Force version of the future A3D–1. Inasmuch as the adaptation suggested by Douglas would require such major changes as deletion of naval aircraft carrier provisions; addition

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[2] Tactical bombing is the bombing conducted, usually by tactical air units, in support of surface forces. Bombing to achieve air superiority or to carry out interdiction is a part of tactical bombing, although the term tends to be restricted to battle area operations.

[3] The XA3D–1 flew for the first time on 28 October 1952.

of ejection seats, of a larger search antenna, and an increase of the aircraft's load capacity, the board wanted to start with a few service test aircraft. The board also recommended procurement of modified RB-57s to fill the gap until Air Force A3Ds could be purchased in significant quantities, planning centering at the time on a fleet of about 350 interim aircraft. The Air Materiel Command (AMC) took exception, and actually did prevail, after arguing that such an arrangement would be wasteful, since the new aircraft most likely would be available only 8 months later than the additional RB-57s proposed by the board.

Definite Endorsement — 12 January 1952

On 12 January 1952, AMC was informed by USAF Headquarters that the USAF Aircraft and Weapons Board selection had been fully endorsed, because the adapted A3D came closest to fulfilling the interim tactical requirements than other candidates, and that the Air Force version of the Navy aircraft would be designated B-66. Although brief, the Air Staff message carried specific instructions. Reconnaissance would have priority, the RB-66 would be immediately equipped for night photography, and electronic reconnaissance equipment, as well as electronic countermeasures components, would be added at the earliest possible date. AMC notified Douglas of the Air Force production decision on 15 January.

General Operational Requirements — 1952

The Air Force issued the general operational requirement (GOR) for the future RB-66A, RB-66B, and RB-66C on 21 January 1952. A second GOR, strictly concerned with the B-66B, was published in April. In essence, these documents were basically alike. They asked for a fast, highly maneuverable tactical reconnaissance bomber that could perform in all types of weather, at very high or low altitudes. Nevertheless, the requirements were quite explicit. A 1,000-nautical mile radius was needed, and the planes had to be capable of carrying large amounts of equipment (radio, radar, electronics) without affecting their normal performance. The B/RB-66s had to be large enough to accommodate a 10,000 pound payload of either atomic, conventional, or photographic flash bombs. They had to be fitted with defensive armament, and would require sophisticated electronic countermeasures components to deal with enemy radars. Finally, the Air Force wanted every model of the new aircraft to be able to use makeshift or short runways. It also insisted that the B/RB-66's maintenance and logistic support be fairly simple.

Contractual Arrangements 1952

On 12 February 1952 letter contract AF 33(600)-9646 initiated the procurement of a test quantity of 5 RB-66As. The purchase of 2 Navy A3Ds, also directed by the Air Staff, was canceled after AMC pointed out that the testing value of the 2 would be negligible in view of the anticipated differences in the Air Force version. The February letter contract gave way to a definitive contract, which was signed on 4 December 1952. In spite of the configuration changes that were to be expected, the Air Force originally thought that the urgently needed RB-66As would be more or less off-the-shelf copies of the A3D. Hence, there would be no experimental or prototype B/RB-66s. Moreover, the December contract already called for production tooling for a peak rate of 12 airplanes per month by March 1955, and for a total of 342 airplanes. The Air Materiel Command warned, however,that since no A3Ds had been produced it could not properly assess the cost of changes necessary to satisfy USAF requirements. This precluded the usual fixed-price-firm (FPF) type of agreement then favored by the Air Force. Instead, the December contract covered cost, plus a guaranteed profit of 6 percent. In the meantime, Letter Contract AF 33(600)-16314 had been signed on 24 April 1952. This contract, providing for the fiscal year 1953 procurement of 127 RB-66As, also did not follow the standard procurement pattern. It was first negotiated as a FPF contract with a renegotiable clause, but reverted to the terms of the preceding letter contract in August of the same year, when the FY 53 procurement of the B/RB-66s was significantly altered.

Basic Configuration May 1952

While the Air Force seemed to believe—or perhaps, hope—that the eagerly awaited B/RB-66 would partly replicate the A3D, the new aircraft's basic configuration was being worked out. Not yet incorporated were a few major changes proposed by Douglas back in August 1951, and subsequently approved by the Aircraft and Weapons Board. The difficulty of these basic alterations could be disputed. What was termed "major" appeared almost routine. The first step was to delete from the Navy A3D the various inherent features of a carrier-based aircraft, such as folding wings, catapult capability, and arresting gear. Satisfying the stated Air Force requirements came next, keeping in mind that only a minimum of adaptations could be tolerated in view of the program's urgency. Essentially, this meant that upward crew ejection seats had to be installed, since one of the aircraft's many roles would be to fly at low altitudes and at fairly high speeds. In the same vein, the airframe structure had to be strengthened to compensate for the greater stresses of low-altitude, high-speed operation. Finally, a 45-inch search radar antenna needed to be substituted for the 30-inch antenna of the A3D. These changes were the salient points of the basic configuration approved by the Air Force in May 1952. While they brought the airplane closer to the Air Force's tactical requirement, they reduced range from 1,325 to 1,070 nautical miles.

Additional Alterations 1952

That the May approval of the B/RB-66's basic configuration proved to be a mere beginning came as a surprise. The Air Force from the start had planned to define further the actual configuration of the new aircraft's bomber version.[4] And, while going along with the so-called major changes of the approved configuration, it had been busy identifying necessary minor improvements. Under this category fell the exchange of Navy- for Air Force-designed equipment, a substitution which would simplify the airplane's logistic support. An unexpected jolt, however, was the snowball effect of the changes introduced in the approved basic configuration.

Also, new requirements kept showing up, as did design or layout deficiencies. By mid-1952, the quasi A3D that the Air Force hoped to rush into production had acquired a long list of innovations. To decrease footprint pressures[5] and permit landing on runways designed for fighter aircraft, the B/RB-66 required larger tires. It also needed new emergency air brakes, wing spoilers, improved lateral controls, changes to the wing's angle of incidence to minimize dutch roll,[6] better cockpit pressurization, and a number of other improvements. The Air Force did not like the A3D's hydraulic system and wanted the system to be completely revised. It wanted the aircraft's fuel system to be redesigned and insisted that the B/RB-66 should carry a fuel purge system, a feature missing from the A3D. Finally, all B/RB-66s were to be fitted for in-flight refueling, the photo/navigator station had to be relocated, and better engines were needed.

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[4] The Air Force nevertheless wanted the aircraft to be interchangeable, and every effort was to be made to keep the bomber and reconnaissance versions closely alike.

[5] Footprint pressure is the pressure of an aircraft's wheels (with tires inflated) upon the unyielding contact surface of a runway, expressed in terms of pounds per square inch, as determined by a ratio of static gross takeoff weight to the contact area.

[6] Dutch roll is the colloquial expression used to describe the combined yawing and rolling motion of an airplane. Dutch roll is usually caused by rough air, but it can occur even in still air.

Engine Problems 1952

As anticipated in late 1951, engine difficulties materialized. Development of the Westinghouse J40-WE-5, due to equip the Navy A3D, was not progressing well. This confirmed the Air Force's suspicion that such an engine would be unable to give the B/RB-66s the radius of action and overall performance required of the airplanes. An engine competition, initiated by AMC on 17 May, yielded several possibilities. Westinghouse offered a new version of the J40, which was turned down because of excessive fuel consumption and because the engine's 7,250-pound thrust was minimal, when compared to the 9,750 pounds of the J71 engine proposed by Allison, a division of the General Motors Corporation. The General Electric J73 failed because of its cost and the fact that its development lagged behind the J71. In addition, and perhaps of greater significance, General Electric at the time was fully occupied with the J47 engine program. Douglas Aircraft favored the Pratt and Whitney J57, but because it was earmarked for several weapon systems of higher priority than the B/RB-66, the Air Force, did not feel the manufacturer could produce enough J57s to satisfy all demands.[7] This left Allison's J71 as the undisputed winner of the competition. Yet, even though Allison had guaranteed the development status of its engine, problems in getting the J71-A-9 engine through its 50-hour test held back the Air Force production order until 5 August 1952, 2 months later than required in order to maintain the aircraft's schedule lead time. In fact, AMC authorized the engine's production before completion of the 50-hour test, a risk frowned upon by the Wright Air Development Center.

Mockup Inspection June-July 1952

The RB-66A's official mockup inspection was held at the Douglas Long Beach Plant, California, from 27 June through 2 July. Sixty-three of 83 changes requested by the board members were approved. Most of the endorsed alterations were minor, a main exception concerning the aircraft's landing gear. The Mockup Board determined that the landing apparatus of the RB-66A, now stressed to the 70,000 pounds of the configuration first sought by the Air Force, would be altered in order to accept the 83,000-pound limit of the B-66. The decision confirmed the Air Force's intent to keep reconnaissance and bomber versions as similar as possible. Obviously, it also promised to simplify production.

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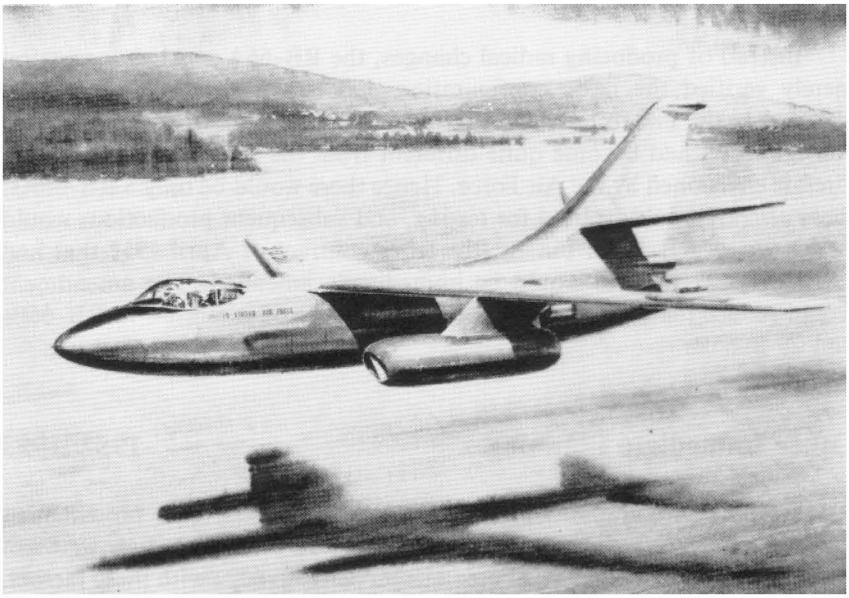
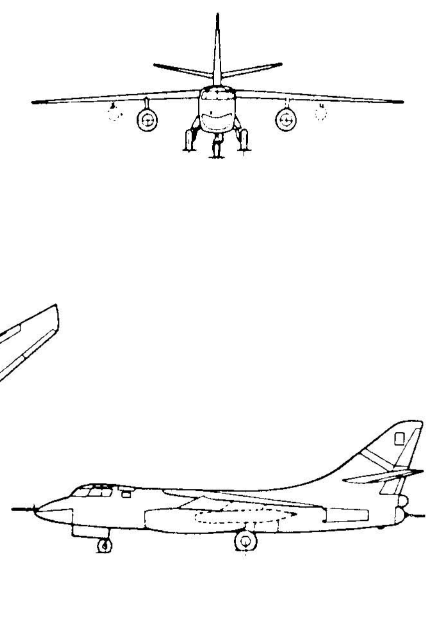
[7] The J75 was subsequently selected by the Navy to replace the A3D's J40s.



A drawing of the Douglas B–66 in flight.



Program Revision — August 1952

Instead of producing radical changes, the RB-66A mockup inspection merely verified the basic configuration that had evolved since February 1952, when the first technical inspection of the aircraft had taken place. This configuration had become quite different from the slightly modified A3D aircraft envisioned by the Air Force. Hence there would be only 5 RB-66As; these aircraft would be used for testing, and subsequent productions would be known as RB-66Bs. Finally, the letter contract of April 1952 that had called for 127 RB-66s would be immediately amended. The amendment would reduce the fiscal year 1953 procurement to 99 aircraft—73 RB-66Bs and 26 B-66Bs.

Other Immediate Planning — 1952-1953

If the configuration changes, program revisions, and procurement amendments deriving from such changes seemed confusing, they were not particularly unusual. The Air Force was prepared to cope with these factors, its task greatly eased because selection of the basic A3D design had been unanimous, a rather extraordinary occurrence. Actually, the Air Force's essential concern was to ensure that no configuration changes would preclude the urgently needed program from proceeding as scheduled. To that effect, a conference held in August paved the way for prompt approval of the B-66B configuration. In the same month, the Air Force directed a review of available and forthcoming electronic countermeasures components that could possibly be installed in the entire B/RB-66 fleet. Early in 1953, the Air Force ordered procurement of the RB-66C, the RB-66's ferret version,[8] and decided that the future B-66B would carry only atomic or modern conventional bombs, and not the bulkier high explosives from World War II. Late in the year, as the Allison J71 successfully completed its 50-hour test, AMC ended its search for an alternate engine, which until then had been considered an unavoidable form of insurance.

First Flight (RB-66A) — 28 June 1954

The RB-66A's initial flight on 28 June 1954 was 6 months behind schedule and could hardly be called a success. Engineering flaws appeared

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[8] The term "ferret" denotes an aircraft specifically equipped to detect, locate, record, and analyze electromagnetic radiation.

that required immediate attention. The aircraft did not handle well, the landing gear doors did not function properly, and vision from the canopy was poor. Although the Air Force officially accepted the initial RB-66A (Serial No. 52-2828) in June, it did not take possession of the plane, leaving it with Douglas for correction of the most obvious defects, prior to the beginning of the usual contractor flight tests. Douglas pilots flew the plane thoroughly, accumulating by mid-1956 300 hours of flying time in 192 flights.[9]

Increasing Difficulties 1954–1955

Flight of the first RB-66A was promptly followed by delivery of the 4 other RB-66As ordered from Douglas. The Air Force accepted these planes between August and December 1954, gaining nothing but problems in the process. Speed and load restrictions placed in effect in August hampered testing, actually preventing the early detection of many additional deficiencies. Yet, the restrictions could not be avoided. As suspected, even before the RB-66A's initial flight, the aircraft's flight control system was unreliable, and flying the plane using emergency manual control had proven hazardous. Besides, the RB-66A was unstable because its wings vibrated excessively, and the aircraft had the dangerous habit of pitching-up unexpectedly.

Near-Cancellation 1954–1955

The Air Force knew that an improved cockpit, giving the pilot better visibility, might not appear on the B/RB-66s before production of the 100th aircraft, but it did not anticipate the many aerodynamic shortcomings that came to light as soon as the RB-66As were flown. AMC's San Bernardino Air Materiel Area, responsible for the new weapon system, faced a difficult situation in the fall of 1954. TAC thought the first aircraft would be forthcoming in February 1955; Douglas admitted this could not be done, but insisted that deliveries could start no later than July—which was still unrealistic. The contractor, naturally enough, contended that the B/RB-66 was a good aircraft, which could be improved in several stages. Yet, Douglas

[9] Completion of the contractor's Phase I and Phase III tests in June 1956 marked the beginning of additional special modifications. When these changes were completed in October 1957, the plane was loaned to the Hughes Aircraft Company to participate in various experimental programs. However, Hughes pilots did not fly the plane, and it was returned to the Air Force in March 1958.

was unable to estimate the impact of the future modification work, since not enough was then known to define the number and types of changes needed. To the contractor's credit, Douglas at the time was also asking for an accelerated and intensified flight-test program. Meanwhile, the Air Force plant representative had reported that the contractor, to prevent further slippage of its original production schedule, was excessively resorting to expensive overtime. In late December, as recommended by the Air Materiel Command, Headquarters USAF cut off all overtime at the Douglas Plant and asked AMC to consider stopping or at least limiting production. In early 1955, the Air Staff began to investigate which aircraft could be substituted for the B/RB-66s, should this program be canceled. No rash decision had to be made, but the Air Staff wanted AMC and Air Research and Development Command to complete as soon as practicable their on-going evaluation of the new aircraft's many problems.

Final Decision 17 May 1955

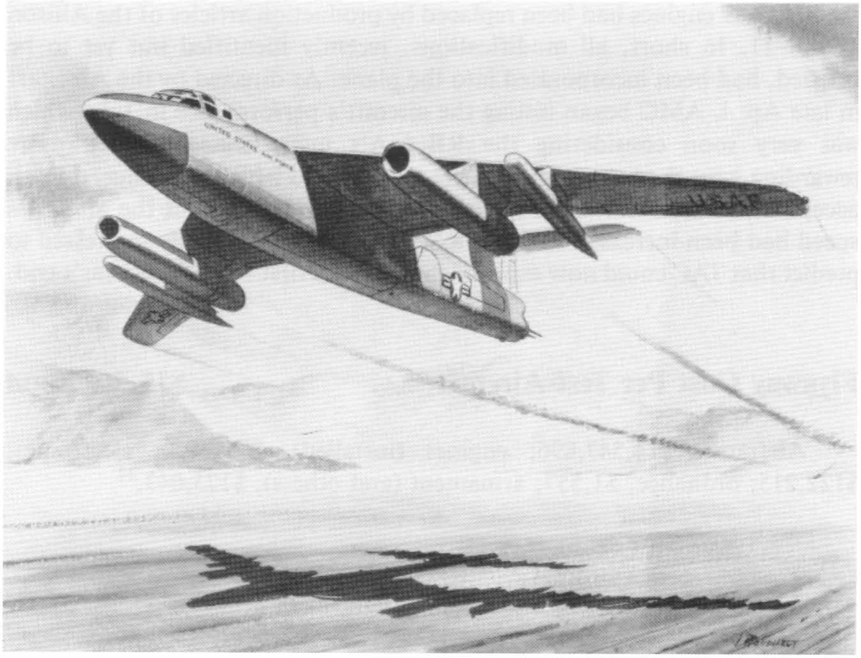
Even though AMC and ARDC gave the Air Staff their appraisal of the Douglas program in February 1955, the B/RB-66's fate was not immediately determined. There were valid reasons for the delay. Phase II flight-test results were an essential part of the combined review. However, because of the flying restrictions still imposed on the RB-66As, the Air Force tests, like those conducted by the contractor, were not totally conclusive. For example, the airplane's high-speed limitations were still unknown. A great deal remained to be done. The static test program was incomplete, and the majority of the aircraft's equipment and subsystems had yet to be tested. Finally, the modifications needed to correct most of the aircraft's problems had been identified, but not verified. In essence, the 2-command evaluation of February 1955 pointed out that immediate termination of the program would cost the Air Force $300 million, a total that would double by mid-May. If the potential loss of $600 million influenced the Air Force to retain the program, the lack of suitable replacement aircraft undoubtedly was an equally important factor. At a meeting held in Washington on 17 May, General Nathan F. Twining, Air Force Chief of Staff, Lt. Gen. Clarence S. Irvine, Deputy Chief of Staff for Materiel, Lt. Gen. Frank F. Everest, Deputy Chief of Staff for Operations, and Mr. Roger Lewis, Assistant Secretary of the Air Force for Materiel, all agreed to stay with the program. However, this was not a blanket endorsement of the B/RB-66 aircraft, and several conditions, listed by the Air Materiel Command, qualified the decision, which in the long run would prove to be sound. As so often the case with many of the Air Force's new aircraft, the B/RB-66s had a shaky beginning, underwent many changes, but ended paying dividends.

Program Reduction 1955

Retention of the B/RB-66 was accompanied by a significant reduction of the program. Yet, it took several months to study the cost and logistic aspects of various possible changes. The Air Staff's goal, as related to AMC in late May, was to "reduce the B-66 program by the most economical and feasible method and still retain an RB-66B/C capabilty." By mid-August, a revised program, developed by AMC and Douglas, was approved by Headquarters USAF. The revision reflected an overall decrease of 48 aircraft from the total once approved for procurement. As directed, the brunt of the decrease fell on the B-66Bs.

Other Changes 1955

Engineering changes, as worked out between the Air Force and the prime contractor, were many. Forty-seven of them had been approved by the end of March, and additional ones most likely would be necessary in time. As a start, the Air Force wanted the B/RB-66 aircraft to be equipped with



An artist's conception of the B-66A taking off.

a parachute brake and an anti-skid device; it also desired immediate revision of the cockpit enclosure and relocation of the cockpit instruments. In addition, the aircraft's 2 J71-A-9 engines had to be replaced by more efficient J71-A-11s. Of course, these changes did not exempt Douglas from correcting the many problems already uncovered during the aircraft's flight tests. Moreover, none of the aircraft thus far produced by Douglas would be accepted by the Air Force before completion of so-called "turnaround" modifications.[10] Set on preventing further costly mistakes, the Air Force by June 1955 had also imposed various administrative adjustments on the contractor. To begin with, production would not exceed 7 aircraft per month until the fall of the year. All fiscal year 1955 subcontracts, not related to the RB-66C, had to be canceled. Finally, Douglas had to stabilize its labor force at the June 1955 level and keep overtime at or below 7 percent of the total labor effort.

Engineering Improvements — Mid-1955

By mid-1955, Douglas had significantly modified 1 RB-66A. The reworked plane featured an improved control system, a reconfigured tail turret, and heavier wing tips. Better engine pylons had been installed, and the J71-A-9 engines had been replaced by production articles of the Allison J71-A-11. In short, all modifications, recently identified but yet to be verified, had been incorporated into the plane. As directed by the Air Staff in late April, AMC began testing the aircraft's performance in July, which was very soon considering the RB-66A's many changes. Even more rewarding were the test results. Buffet appeared to have been reduced to an acceptable level, the control system worked fairly well, and the aircraft's speed had been increased to 550 knots. AMC was sufficiently impressed to predict that TAC could now expect delivery of its first RB-66s by year's end.

Flyaway Cost Per Test Aircraft — $15.5 million

Airframe, $14,547,896; engines (installed), $719,500; electronics, $122,215; ordnance, $1,557; armament (and others), $125,043.[11]

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[10] The "turnaround" modifications brought such aircraft to the level of the reworked RB-66A of mid-1955.

[11] Only 5 RB-66As came into being. As in the case of the B-57A and other aircraft, this limited production resulted in a high cost per aircraft.

Subsequent Model Series

RB-66B

Ultimate Use

None of the 5 RB-66As ever joined the Air Force's combat forces. Use of the aircraft exclusively for testing led to improved B/RB-66s and acquisition of considerable technical knowledge.

RB-66B

Manufacturer's Model 1329

Weapon System 308

New Features

The RB-66B at first closely resembled the improved RB-66A. Differences emerged over the years, as the B-model received better cameras and electronic countermeasures equipment. Some changes were made on the production lines; others, long after completion of the entire program. The J71-A-13 engine, an important feature of the aircraft, appeared on the last 17 RB-66Bs, earlier productions acquiring the higher-thrust engines through retrofit.

Special Testing 1955

Even though the improved RB-66A had been thoroughly tested, the Air Force Flight Test Center conducted extensive qualifying flight tests on one of the initial RB-66Bs. In contrast to the reworked RB-66A, which had been refitted with J71-A-11s,[12] this plane and 19 other early RB-66Bs carried the less powerful -9 engines. Nevertheless, the flight center's tests and subsequent RB-66B acceptance flights were generally successful. Electronic interference disturbed the image on the aircraft's AN/ARC-21 radar receiver, but Air Research and Development Command engineers soon found out that the ionization of particles in the jet engine exhaust caused the problem. This helped the contractor to swiftly devise an effective production modification.

First Flight (Production Aircraft) 29 October 1955

The first truly official flight of the RB-66B occurred on 29 October,

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[12] This model powered most of the aircraft until the -13 engine became available.

after 8 of the aircraft had already been accepted by the Air Force. The flight, which was considered satisfactory, confirmed earlier test-flight results.

Enters Operational Service — January 1956

The first RB-66Bs joined the 9th Tactical Reconnaissance Squadron of the 363d Tactical Reconnaissance Wing (TRW), at Shaw AFB, South Carolina. Although the aircraft's initial all-weather capability was limited, arrival of the RB-66Bs permitted the long overdue replacement of the obsolescent RB-26s, and speeded phaseout in early 1957 of the problem-ridden RB-57As. The RB-66B program was a year behind schedule, but by the end of 1956 two-thirds of the RB-66Bs on order had been delivered, allowing activation of 2 other squadrons within the 363d TRW, the 41st and 43d, both located at Shaw AFB. The RB-66B in time became the primary night photographic weapon system of the Tactical Air Command.

Development Engineering Inspection — 26–29 June 1956

A special development engineering inspection verified the proper installation of active defense electronic countermeasures equipment in forthcoming RB-66Bs. Several new devices were involved, most of which were intended to jam hostile radars. The 2-day development engineering inspection also covered retrofit of the 46 RB-66Bs, already accepted from Douglas. Even though attendees submitted 32 requests for alteration, the inspection board only approved 22 of them. The endorsed changes represented no extra expenses for the Air Force, since they all fell under the purview of Douglas's contract.

Overseas Deployments — 1956–1957

While the bulk of the B/RB-66 contingent was earmarked for TAC, the Air Force originally wanted some of the delivered aircraft to be deployed overseas immediately. Slippage of the program changed this planning. Still, the 12th Tactical Reconnaissance Squadron, at Itami, Japan, a unit of the Pacific Air Forces (PACAF), received its RB-66Bs in late 1956, at about the same time that TAC activated 2 additional RB-66B squadrons. The United States Air Forces in Europe (USAFE), however, did not get any of the new aircraft until the fall of 1957. The 2 RB-66B squadrons, first assigned to the USAFE's 66th Wing, were later transferred to the 10th Tactical Reconnaissance Wing, another USAFE unit.

Operational Difficulties 1956–1957

The fact that the RB-66Bs were operational, at home and overseas, did not mean that all was well with the aircraft. To begin with, the program's near-cancellation and subsequent indefinite slippage, combined with overall financial restrictions, had created troublesome setbacks. TAC's 363d TRW was ill-prepared to support its first aircraft. The wing did not have enough MA-3 all-purpose servicing units and had too few of the MA-1 air conditioners that were necessary to preflight the RB-66s. There were also serious shortages of personal equipment, helmets in particular. The RB-66Bs themselves were encountering some of the problems often experienced during the early operational life of a new aircraft. Cautious, the Air Force grounded all RB-66Bs in mid-1956 after an incident at Shaw in which an aircraft suffered engine failure because bolts or screws either worked loose or sheared from the alternator. The grounding did not last, but similar restrictions were imposed in September, following the discovery of cracks on the horizontal stabilizer of a B-66B. The grounding this time affected both the B-66Bs and the RB-66Bs and remained in effect until all aircraft had been inspected and repaired, as necessary.

Engine Problems 1956–1957

Slow acceleration, flameout, stall, and surge were malfunctions that characterized the performance of the J71-A-9 engines that originally equipped 20 RB-66Bs and 17 B-66Bs. Allison improved the engine's bleed air system (reduced from the 16th to the 8th stage), and this with other minor changes led to the production of the J71-A-11. The new engine reached the Douglas plants promptly, equipping most B/RB-66s from the start. But the J71-A-14, despite its 9,700 pounds of thrust, proved disappointing. To begin with, the engine was still underpowered. In addition, like its predecessor, the J71-A-11 often stalled under high acceleration because of sticking compressor bleed valves and poorly designed electrical relays. Even though the most serious stall problems were solved without delay, TAC kept on insisting that better engines were needed. The command had in mind still another version of the Allison J71, namely, the 10,200-pound thrust J71-A-13, which could be injected with a mixture of water and alcohol. TAC believed, rightly as it turned out, that the higher-thrust engines would decrease takeoff roll by nearly 40 percent, would ensure a range increase of 10 percent, and would guarantee a 5-percent improvement of the aircraft's maximum speed. The Air Staff, in the fall of 1956, finally endorsed TAC's request. This meant that nearly 200 aircraft had to be retrofitted with J71-A-13s, while the B/RB-66s that had yet to clear the Douglas production lines would receive the new engines directly. Unforeseen by all parties—the Air Force, Douglas, as well as Allison— were the many difficulties that the new engines would soon create.

Significant Achievements — Mid-1957

Operational difficulties and forthcoming engine changes notwithstanding, the RB-66B by mid-1957 seemed to have shed most of its developmental flaws, and for all practical purposes the incorporation of production fixes had ceased. The aircraft, in addition, contributed to the successful development of a rain removal system that would serve the entire program, and other Air Force jet bombers. This system used a stream of engine bleed air, which was blown over the aircraft's windshield. Tested by the Wright Air Development Center under both artificial and natural conditions, the new development appeared to be the most effective and reliable means thus far devised to control a visibility problem of long standing. Indicative of the system's importance, the Air Force by mid-1957 had already initiated the procurement of retrofit kits for installing the new rain removal system on all B/RB-66s. The kits were geared to the J71-A-13s, since these engines were now due to appear on every B/RB-66 aircraft.

Unexpected Setbacks — 1957-1958

Unforeseen problems were caused by the J71-A-13s, whether production installed or retrofitted on the B/RB-66s, because the new engines' higher thrust was accompanied by greater noise. Evidences of acoustically induced sonic fatigue were immediately noted, as skin cracks and stress breaks increasingly appeared in the ailerons, flaps, dive brakes, elevators, stabilizers, and rudders of the J71-A-13-equipped aircraft. Remedial procedures, undertaken without delay, consisted of pouring a powdered substance, known as Sta-Foam, into the aircraft's control surfaces that were subject to stresses. The powdered Sta-Foam, subsequently combined with chemicals causing it to foam up and solidify, promised to be a counteracting stress agent in the aircraft's most vulnerable surfaces.[13] TAC was greatly concerned by the stress problems besetting its new aircraft, particularly because the Sta-Foaming program, as initiated in 1957, would be lengthy. In effect, the most exacting work was assigned to Douglas, while tactical units

[13] The B/RB-66s predated metallic honeycombing, an industrial technique used to absorb the higher acoustical disturbances caused by the higher thrusts of later engines.

would accomplish the simpler tasks. Yet TAC insisted that whether the B/RB-66s were flown to the manufacturer for rework, or whether Douglas shipped Sta-Foamed surfaces to the tactical units, its new aircraft would be kept out of operation for an excessive period. In mid-1957, TAC again protested the program's pace, and suggested to save time that its RB-66s be flown to the San Bernardino Air Materiel Area where reworked surfaces would be exchanged for damaged and unmodified surfaces. Once flight tested, the modified planes would fly back to their bases. The Air Staff endorsed the TAC proposal, but new problems arose within a month. In August 1957, the command was informed that the B/RB-66 overall modernization program had to be curtailed for lack of money. The cut would be drastic, up to 80 percent if possible, and the entire inspect-and-repair-as-necessary (IRAN) program was eliminated. However, neither the aircraft conversion to J71-A-13 engines, nor the Sta-Foaming of fixed and movable surfaces were affected. The irony of the latter exemption came to light in February 1958, when the Sta-Foaming program was stopped. To some degree, 98 percent of the TAC B/RB-66s carried Sta-Foamed surfaces. Unfortunately, there was now clear evidence that the Sta-Foaming technique was a failure. The compound promoted corrosion and could eventually absorb up to 180 percent of its own weight in moisture, thus affecting aircraft balance. Although Douglas estimated that it would take some 8 months to fabricate new B/RB-66 control surfaces, the Air Force stated categorically that the work had to be done in little more than half that time.

Post-Production Improvements 1957–1958

Not only was the so-called all-weather RB-66B incapable of performing under adverse weather conditions, but it could not take photographs at night from high altitudes. Obvious from the start, the lack of proper tactical reconnaissance equipment was an increasingly crucial problem. To remedy the deficiency, Headquarters USAF in mid-1957 approved a TAC request for replacement of the aircraft's 12-inch cone K-37 camera by two 24-inch K-47s. However, the funding restrictions of the new fiscal year (FY 1958) postponed procurement of the more efficient cameras until mid-1958—fiscal year 1959. This would be in time to prevent Fairchild from shutting down its K-47 production lines, thereby saving the expense of re-establishing production, a financial burden that Air Force would have had to bear. Just the same, while this timing was a plus, the postponed camera procurement presented TAC with another delay, since the installation of K-47 cameras on all RB-66Bs would require nearly 1 year. Meanwhile, the acquisition of a high-resolution radar, to give the aircraft the capability to navigate in all types of weather, was almost at standstill. In late 1957, various radars were being considered and some testing was being done, but no solution was in sight.

Modernization 1958–1960

The B/RB-66 overall modernization program, postponed because of the FY 58 funding restrictions, finally got under way in May 1958. Tagged as "Little Barney," the $29 million project encompassed a myriad of technical order compliances, which had been delayed for lack of money. It covered the installation of J71-A-13 engines in the aircraft still equipped with J71-A-11s and the improvement of all PACAF and USAFE B/RB-66s which, in contrast to the TAC aircraft, had never benefitted from any type of modification. Of necessity, Little Barney also had to deal with the metal fatigue and corrosion problems encountered in all varieties of the B/RB-66s. Although Douglas provided sufficient newly designed control surfaces to allow all needed substitutions, Little Barney was not completed until August 1959, a slippage of several months. The delay was caused by a contractor-labor dispute, which prevented Douglas from sending field teams to the Air Force as soon as expected. Still, the project's results were satisfactory, and "Big Tom," which succeeded Little Barney at the Mobile Air Materiel Area in Alabama, also proved successful.[14] The 2 projects were closely related, since both centered on the yearly IRAN program of the weapon system. TAC delivered 5 percent of its RB-66s to Mobile each month and, as a rule, received its aircraft back within 30 days. The arrangement, while it lasted, worked well. Meanwhile, there were other problems, and frustrating incertitudes would soon follow.

Flaws and Frustrations 1959–1961

TAC grounded all its RB-66s in February 1959, after discovering cracks in the aircraft's nose gear attaching lugs. The repair of this flaw as well as other design deficiencies was guaranteed to be corrected by the contractor. The Air Force returned all available spares to Douglas for rework, and modifications to strengthen the nose gear strut assemblies were done at field and depot levels. Three Douglas teams arrived at Shaw, where they worked on 24-hour schedules so that all aircraft resumed flying before March. But another vexatious problem arose in mid-year, putting a new burden on the

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[14] The managerial logistics support of the B/RB-66 program was transferred from the San Bernardino to the Mobile Air Materiel Area on 31 July 1959.

Big Tom project. The fuel tanks of all B/RB-66s had to be inspected, and most of them resealed, to prevent fuel leaks attributed to deterioration of the original sealant. When another sealant was applied, a different problem developed. Various areas of the resealed tanks started leaking under pressurization, which tended to indicate that the tanks were nearing the end of their useful lives.

In 1960, the long-awaited installation of K-47 cameras, having been canceled for lack of money, was reinstated.[15] However, the RB-66B's new K-47 camera system again became a cause of concern in early 1961. Camera magazines did not function properly. They could be fixed for $178,000 or replaced for $268,000, two expensive propositions considering the Air Force's continuing penury. In addition, while efficient for night photography, the cameras still needed to be upgraded for daytime operation, a modification finally approved in October.

Unrelenting Problems 1961-1963

Since its introduction into the TAC inventory, the RB-66B had failed to achieve the desired level of operational readiness, often due to maintenance and supply shortcomings. In fact, the same failings were experienced Air Force-wide by every version of the plane and persistent funding limitations did not help. While unwelcome by any command, support deficiencies made the Tactical Air Command's many tasks especially onerous. In the last months of 1961, TAC possessed an average of 20 RB-66s for combat crew training, but only 12 of them were flyable. Similar conditions compounded the difficulty of training replacement aircrews for all USAF RB-66 units, another responsibility of the command. Furthermore, B/RB-66 support problems might restrict TAC's ability to reinforce other major command units during contingencies. Although great improvements were realized in early 1962, the general support outlook was not optimistic. Subsystems of the RB-66 aircraft were past their normal life expectancy and were almost certain to cause further unexpected maintenance.

Planning changes, again intricately related to tight budgets, aggravated the overall situation. Previous phaseout schedules had spurred the end of the aircraft's IRAN program, but retention of the RB-66s was now programmed to extend through fiscal year 1965, because there was no replace-

[15] On the other hand, Headquarters USAF in 1960 also recommended that TAC drop its requirement for putting a high resolution radar on the RB-66Bs. The cost involved, about $100,000 per aircraft, seemed no longer justifiable in view of the RB-66B's near phaseout, then programmed to take place in fiscal year 1964.

ment. In 1962, this meant bringing back some kind of IRAN program, on a one-time basis, in view of the aircraft's forthcoming retirement. As approved by the Air Force, this $7.1 million project (About Time) covered 145 RB-66s, 32 of them belonging to TAC. The project was at once affected by fund shortages. To make sure that as many aircraft as possible would be repaired, without reducing the scope of the work to be performed, TAC agreed to a sizable commitment of its own resources.

In January 1963, a corrosion-induced failure of one aircraft's nose struts engendered a complete retrofit of the fleet by the Mobile Air Materiel Area. During the same period, overhaul of the RB-66's J71-A13 engines began. Done under contract at the Naval Air Station at Quonset Point, Rhode Island, this crucial task proved time-consuming, prompting TAC to wonder if some kind of arrangement enabling engine repair at Shaw AFB would not be more effective. On the other hand, Shaw had retained its full share of problems. Despite every effort, the overall maintenance of the RB-66s remained difficult. Parts shortages did not abate throughout the year, contributing to high cannibalization rates within the 363d Wing and 4411th Combat Crew Training Group of the Tactical Air Command.

Planning Changes 1964-1965

As of 30 June 1964, only 100 RB-66Bs remained in the Air Force inventory and within 12 months, this total had dipped to 79. Still, phaseout of the entire B/RB-66 fleet was becoming less likely. The Air Force's increasing involvement in Southeast Asia affected all planning. The primary question no longer seemed to be how long a given model's retirement would be postponed, but rather to assess how retained aircraft would cope with their extended commitments. Obviously, some modifications would be needed. Yet, experience showed that the best modifications would not necessarily work from the start. For example, 3 RB-66Bs had been equipped in 1963 with infrared sensors, electronic strobes, and side-looking radars, but the performance of the strobes and infrared sensors, as demonstrated during a 1964 exercise, did not satisfy TAC. In any case, retention of the RB-66s, however probable, could not be taken for granted. This posed another dilemma by preventing reinstatment of a formal IRAN program. Wanting to be ready for an early IRAN program, should the Department of Defense approve the aircraft's retention, Headquarters USAF in April 1965 directed a "minimum prudent work package for IRAN of RB-66 aircraft during FY 66." Developed by TAC and endorsed by Air Force Logistics Command, this program made allowances for the fact that previous work on the RB-66 consisted of a series of short-term actions, none intended to keep the plane in service for more than 2 additional years.

End of Production 1957

The October 1957 delivery of the last RB-66B reflected the end of the aircraft's production.

Total RB-66Bs Accepted 145

Acceptance Rates

The Air Force accepted 4 RB-66Bs in FY 55, 46 in FY 56, 87 in FY 57, and 8 in FY 58.

Flyaway Cost Per Production Aircraft $2.55 million

Airframe, $1,563,671; engines (installed), $696,034; electronics, $155,000; ordnance, $10,081; armament (and others), $166,137.[16]

Average Cost Per Flying Hour $715.00

Average Maintenance Cost Per Flying Hour $323.00

Subsequent Model Series B-66B

Other Configurations EB-66B and EB-66E

The EB-66Bs and EB-66Es came into being in the spring of 1966, when the prefix E was assigned to all versions of the B/RB-66s intended for electronic warfare.[17] However, neither of the 2 models was new. The Air

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[16] Including the costs of research and development and in-production engineering changes, but excluding the expenses of all-post production modifications.

[17] The prefix E symbolized a modified mission. It was given to all aircraft equipped with special electronic devices for employment in 1 or more of the following roles: electronic countermeasures; airborne early warning radar; airborne command and control, including

Force contingent of EB-66Bs comprised both modernized and re-equipped B-66Bs and RB-66Bs, with no distinction made between the 2 types. In both cases, original electronic countermeasures gear (electronic devices and chaff dispensers) had been upgraded, and sophisticated pieces of equipment added. Similarly, EB-66Es, the first of which did not reach Southeast Asia before August 1967, could be converted B-66Bs or RB-66Bs.[18] The EB-66E did, however, represent an improvement over the EB-66B. Although the "E" carried fewer jamming devices, its new tuneable transmitters enabled the electronic warfare operator to change frequencies during flight in order to jam several kinds of radar.

Southeast Asian Deployment — April 1965

First committed to the war in April 1965, long before the Department of Defense decided to postpone the entire program's phaseout, the RB-66Bs quickly demonstrated the limitations of their equipment which, in view of existing retirement plans, had never been modernized. There was an exception, however. Three of the early RB-66Bs, deployed to Southeast Asia, had been equipped with infrared sensors, an important asset to meet growing night reconnaissance requirements. Nevertheless, the 3 planes were old and were replaced in 1966 by modern infrared-equipped RF-4Cs. Meanwhile, a great many RB-66Bs were being modified to update nearly obsolete electronic countermeasures (ECM) equipment. Improved support also was being worked out, in order to raise the aircraft's safety and efficiency. In 1966, most active RB-66Bs became EB-66s,[19] but this did not spell the end of the aircraft modernization.

Modernization Efforts — 1966–1969

In mid-1966, the Air Staff directed that 26 RB-66Bs be fitted with

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communications relay; and tactical data communications link for all non-autonomous modes of flight.

[18] This lack of specific identification was actually logical, since all B/RB-66s were basically alike. Initial differences had reflected the aircraft's individual roles. In practical terms, the Air Force intended all along that the aircraft's makeup and load be adjustable to mission requirements.

[19] Throughout the years, small numbers of RB-66s remained or were brought back in the active inventory. In 1968, for instance, the war's demands and the redistribution of electronic warfare assets caused TAC to use 20 RB-66s for training worldwide replacement crews.

passive and active ECM systems. The first of the 26 modified aircraft (EB-66Es) reached the war theater on 30 August 1967, but did not perform as well as expected, forcing PACAF to defer plans to make similar improvements to another 13 EB-66Bs. When money became available, 6 additional RB-66Bs, withdrawn from storage, were brought to an upgraded EB-66E configuration. At the same time, the problems of the first 26 EB-66Es were corrected. In 1968, confronted by increasingly sophisticated enemy defenses, the Air Force began using all EB-66s in the jamming role. This pinpointed the need for further improvements, such as steerable antennas and modification of the aircraft's new communication jammer. The wisdom of spending extra money on such an aged aircraft was debatable. TAC's new Commander, Gen. William M. Momyer, arriving from Southeast Asia in mid-1968, also had strong reservations about the modernized EB-66's effectiveness as a standoff jammer. Because no sound alternative could then be worked out,[20] General Momyer concurred in the extended modernization of the EB-66s, even though the entire project was fraught with difficulties since no single electronic-countermeasures configuration would meet the specific goals of all contingencies.[21] Continued EB-66 improvement reinforced TAC's argument that the aircraft's engines had to be replaced, a change sought by the command since 1966. TAC's belief, fully shared by PACAF and USAFE, was not unfounded.[22] The J71-A-13 engine was limited in power and had become extremely expensive to operate because of the short time between overhauls. Air Staff support notwithstanding, the Department of Defense had disapproved TAC's first request on the ground that the limited number of EB-66s remaining in the inventory did not warrant the purchase of better engines. Although TAC subsequently underlined that additional electronic systems could not be fitted in the EB-66s because the J71s and the associated generator banks could not supply enough electrical power, the Department of Defense did not alter its decision.

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[20] In the fall of 1968, the Air Force Systems Command suggested that all EB-66 modernization programs be revalidated and that selection of an electronic warfare vehicle other than the EB-66 be reconsidered.

[21] The Air Staff had already told PACAF, TAC, and USAFE to review current planning and to develop alternate electronic countermeasures configurations to satisfy their individual requirements.

[22] The improved B/RB-66s (EB-66s) with their many new components had grown from some 70,000 to about 81,000 pounds. But the thrust of their engines had not changed. Obviously, the overworked J71 engines of the EB-66s soon began to consume fuel at a disturbing rate.

Modernization Reversal 1969

In May 1969, Gen. John P. McConnell, Chief of Staff of the Air Force, stopped the EB-66 modernization. Three of the primary factors accounting for the decision were cost, time involved, and Defense Department's denial of a new engine. The Air Staff made it known that remaining EB-66s would have to be maintained through normal processes for perhaps 5 more years.

Support Problems 1969–1972

Fatigue cracks in the compressor of the J71 engine became a problem of major importance. Since flight safety was at stake, most of the available funds went for engine repair, and little was left to invest in airframes and electronics. In these circumstances, maintenance of the EB-66s proved increasingly difficult. Reduction of the EB-66 inventory in late 1969 brought relief by allowing a realignment of the modification programs to match available funds. Nonetheless, critically needed alterations often could not be done.

Operational Status Mid-1973

By mid-1973, the EB-66 had truly become an old, underpowered aircraft that had been extended repeatedly beyond its programmed life span. Because of the small fleet's approaching phaseout, no IRAN program supported the aircraft, and a contract team performed substitute inspections of the EB-66s. TAC had planned all along to get rid of its EB-66s as soon as the aircraft's Southeast Asian commitments were over. Yet, no other electronic countermeasures aircraft was available. In mid-1972, the Air Staff had recommended that the EB-66s be replaced by ECM-equipped F-111s, a solution actively pursued by TAC. But the Department of Defense had yet to reach a decision in mid-1973, and TAC had to retain a minimum number of EB-66s, as did PACAF and USAFE.[23]

Perilous Incident 10 March 1964

One year before the first RB-66Bs were sent to Southeast Asia, one of the aircraft was involved in a potentially very dangerous situation. On 10

[23] The EB-66s left the Air Force inventory the following year.

March 1964, an RB-66B of the 10th Tactical Reconnaissance Wing, a unit of USAFE's Third Air Force, took off from Toul-Rosieres Air Base, France, on a flight scheduled to carry it into West Germany. Malfunction of the RB-66B's compass and the crew's failure to recognize the problem brought the aircraft over East Germany, where it was shot down. After seeing the enemy interceptors, the crew ejected, landed, and was taken prisoner. No one was seriously injured, and the 3 crewmen were released before the end of March. The RB-66B loss, however, because it closely followed a far more tragic incident,[24] took on added importance. Hence, on 10 March, within hours of the airplane's crash, Gen. Gabriel P. Disosway, USAFE Commander-in-Chief, informed his staff of the President's deep concern and of the crucial necessity of preventing such incidents in the future. On 14 March, General Disosway imposed a buffer zone which extended and widened the existing Air Defense Identification Zone in central Europe. Special permanent procedures, known as Wind Drift, were established for positive control of every type of aircraft in the buffer zone. General Disosway also demanded that crew responsibilities and air discipline be "hammered home" to all aircrews during pre-flight briefings. The Wind Drift rules became even more stringent in 1965, when Gen. Bruce K. Holloway assumed command of USAFE.

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[24] On 28 January, a T-39 straying over East Germany had been shot down, resulting in the death of the 3 crew members.

B-66B

Manufacturer's Model 1327

Previous Model Series RB-66B

New Features

Increased design gross weight and the Western Electric K-5 bombing system were the most significant new features of the conventional swept-back wing, all-metal B-66B. Like the RB-66B, the B-66B carried a 3-man crew.

Basic Development August 1952

The bomber configuration, endorsed by the Air Staff in August 1952, occasioned further changes to the initial Air Force version of the experimental A3D. The airplane's design gross weight was raised to 78,000 pounds (8,000 pounds more than the RB-66B's), the bomb bay was lengthened 17.5 inches, the capacity of the aft fuselage fuel tanks was increased, and pylons were provided to support extra 500-gallon fuel tanks. The approved B-66B configuration also involved the installation of a bombing system and of bomb dropping devices. Finally, a detachable probe-drogue in-flight refueling system was added, and a further revision of the XA3D's hydraulic system was directed. Of necessity, since every effort was to be made to keep the bomber and reconnaissance versions as close to each other as possible, most B-66B requirements were incorporated into the RB-66As. Ensuing problems, resulting modifications, and reduction of the B-66B procurement did not alter the program's policy on interchangeability.

Contractual Arrangements 1952–1956

The B-66B procurement was initiated in August 1952, when Letter Contract AF 33(600)-16341 was amended to cover the purchase of 26 B-66Bs. The amendment in addition changed the terms of the letter contract of April 1952, which reverted to the cost-plus-fixed-fee type of agreement endorsed for the RB-66As. The amended contract of August 1952, like the initial RB-66A document, assured Douglas of a profit amounting to 6 percent of the aggregate contract cost. A similar contract, AF 33(600)-25669, started by an October 1953 letter contract, called for 75 B-66Bs, but was amended many times as a result of a program reduction in mid-1955. For the same reason, contract AF 33(600)-28368, the fourth and last procurement order signed on 24 September 1954 also underwent many changes.[25] By the end of 1955, only 55 B-66Bs were to be bought, but General Twining agreed in early 1956 that the single authorized wing of B-66Bs should acquire more planes to take care of normal attrition. The Air Force held the B/RB-66 program on a tight financial rein. The program's ceiling had been settled once and for all. Hence, the approved extra 17 B-66Bs were diverted from the RB-66B total. The Air Force also specified that any cost increases generated by the directed substitution would have to be absorbed by deleting additional RB-66Bs.

First Flight (Production Aircraft) — 4 January 1955

The first official B-66B flight was accomplished on 4 January 1955, 7 other B-66Bs being accepted by the Air Force before the new tactical bomber was cleared for operational assignment. Besides participating in the usual testing program, the early B-66Bs were involved from the start in the crucial development of their future sophisticated components. For instance, flight testing of a prototype K-5 bombing system, tailored for the B-66B, was pursued actively during the early part of 1955.[26] These tests entered a new phase in March 1955, when high-altitude and high-speed trials began.

[25] Contract AF 33(600)-25569 and AF 33(600)-28368 were renegotiated during 1956, the Air Force being convinced that the cost-plus-fixed-fee type of agreements, dictated by circumstances, had worked even more poorly than expected. Nothing could be done to revamp the early B/RB-66 procurement, since deliveries on the first 2 contracts were nearly complete. The Air Force nevertheless intended to straighten out the 2 remaining orders. The service believed that frequent and onerous cost overruns in any given program could be avoided, or at least minimized, if all parties were affected by the program's financial outcome. This was reflected in the 2 supplemental agreements signed in March 1957 by Douglas and the Air Force. Douglas exchanged its fixed fee for a target fee of about 5 percent (the incentive was plus or minus 10 percent on sums falling within 115 and 85 percent of each contract's target cost).

[26] The K-5 was greatly altered for its use with the B-66, but it was not a weapon system development. The system had to be fitted into the already established airframe configuration, not developed parallel with it. The equipment was procured by the contractor rather than furnished by the government. Douglas spent about $100 million in subcontracts with Western Electric, manufacturer of the K-5, and with Bell Telephone Laboratories, which took care of the developmental engineering.

The functional testing of a production model of the bombing system soon followed. As fully expected by the Air Research and Development Command's Armament Laboratory in mid-1955, the K–5 promised to give the Air Force ". . . an all-weather tactical bombing capabilty compatible with the mission requirements of the B–66."

Enters Operational Service — March 1956

The B–66Bs began reaching the Tactical Air Command in March 1956, about 1 year later than originally scheduled. However, once under way, deliveries were reasonably steady, 64 of the 72 B–66Bs on order being accepted by mid-1957. The Ninth Air Force's 17th Light Bombardment Wing, at Hurlburt Field,[27] Florida, remained sole recipient of the B–66Bs until September 1957, when TAC began to transfer its total contingent to the United States Air Forces in Europe.

Development Engineering Inspections — Fall 1956

Despite the importance of the electronic countermeasures program, nothing could be done about it when the B/RB–66 configuration started taking shape. Electronic countermeasures components were in early developmental stages, and technological incertitudes prevented the establishment of firm operational requirements. Nevertheless, after many tentative plans, the Air Force in October 1954 decided the process should be accelerated to acquire at least an interim electronic countermeasures capability. Hence, a multi-phase interim ECM program was set up early in 1955. Briefly stated, the program called for installation (during the aircraft production) of available parts of the APS–54 radar warning receiver and ALE–2 chaff dispensers. Three interchangeable types of jamming equipment were ordered, and interchangeable ECM tail cones were to be fashioned to carry some of the chaff equipment and antennas. Finally, provisions for ECM cradles were to be made in the bomb bay of the B–66B. Yet, even though some B–66Bs had already begun to reach TAC, configuration changes were still under consideration in the fall of 1956. Procurement of the B–66B had been reduced in mid-1955, but the aircraft had not been exempted from the ambitious electronic countermeasures program planned for the entire B/RB–66B fleet. During the second half of 1956, 2 development engineering inspections were held a few weeks apart. The first, in late September, covered

[27] An auxiliary field of Eglin AFB.

The B-66B featured the new K-5 bombing system and increased fuel capacity.

all-chaff and half-chaff electronic countermeasures cradle configurations of the B-66B. The second, held in early October, was concerned with the B-66B's entire electronic countermeasures installation. The 2 development engineering inspections were successful, the Air Force being satisfied by the apparent completeness and flexibility of the selected arrangements. However, the whole project was soon to encounter problems.

ECM Program Changes 1956-1957

Soon after the development engineering inspections of September and October 1956, the electronic countermeasures program ran into trouble. Major alterations would be needed to fit the required pieces of ECM equipment into the B/RB-66 airframes. Even if the Douglas production lines expedited the necessary modifications, full transfer of the B-66Bs to Europe and deployment of the several RB-66Bs destined for the Far East would have to be postponed. By the end of the year, it became clear that more unexpected changes would be needed, all of which affected tail cones and cradles. Included were substitution of various components, addition of some kind of apparatus to permit selective switching among jammers (a requirement previously overlooked), more powerful jamming signals, and new tail cone antennas.[28] Moreover, just the interim ECM program pro-

[28] The antenna changes eventually delayed the beginning of tail cone deliveries to March 1958, a slippage of about 1 year.

posed in March 1955 would be extremely costly—$40 million for a partial installation. In July 1957, Headquarters USAF decided that no B/RB-66Bs would be ECM-equipped during production. The Air Staff also cut down the procurement of cradles by one-third, to a total of 12, and reduced the tail cone purchase to 113, a decrease of 25. At the same time, the Air Force indicated that a modernization/IRAN program would catch the B/RB-66Bs that had not been modified to accommodate needed ECM equipment. In late 1957, 13 B-66Bs and 31 RB-66Bs were scheduled for such preparation.

Flight Testing 1955-1957

For all practical purposes, flight testing of the B-66B ended in January 1957, for the few tests yet to be completed were of minor importance. Overall test results were satisfactory, and the engineering improvements prompted by the testing program either had been or were being incorporated into the aircraft. The B-66B nearly met the Air Force procurement specifications. Noted performance decreases (10 percent in altitude, 12 percent in range, and 7 percent in low-altitude speed) might not be correctable, but the aircraft's flying characteristics were good. Thorough testing had demonstrated that the B-66B was especially well-adapted to low-level flight, could handle a variety of special weapons, and could be aerially refueled to 96,000 pounds.

Operational Problems 1956-1958

The positive qualities of the B-66B, flown by the 17th Bombardment Wing, were not in doubt, testing having ascertained the aircraft's basic soundness. Nevertheless, being practically identical to the RB-66B, the new tactical bomber shared the engine problems, Sta-Foam vicissitudes, and other early difficulties of the reconnaissance aircraft. The B-66B in addition had a few flaws of its own, which also remained uncorrected prior to the aircraft's overseas deployment.

Overseas Deployment 1958

Early in 1958, after a period of training, the squadrons of TAC's 17th Bombardment Wing were transferred to the 47th Bomb Wing (Tactical), a unit of USAFE's Third Air Force, with stations at Sculthorpe and Alconbury in the United Kingdom. While the 47th Wing's conversion from the obsolescent B-45[29] was a major operational gain, the B-66B's arrival was accompanied by serious maintenance difficulties. The flow of spare parts from the United States remained inadequate until August 1958, and shortages of electronic equipment and of such critical items as hydraulic pumps and oxygen regulators persisted throughout much of the year. In addition, the bomb shackles initially installed on the B-66B did not have a lock secure enough to prevent inadvertent bomb releases. This problem, though addressed from the start by TAC, was not being solved as fast as the Air Force would have liked. To save time, personnel of the 47th Wing installed the first new shackles developed by Douglas. Other B-66Bs were due to receive the improved shackles during the B/RB-66 overall modernization program. However, even the simplest plans could be affected by circumstances beyond USAF control. Although started as scheduled on 1 May 1958, the "Little Barney" overseas program taking place at the AMC's Air Depot at Chateauroux, France, was hindered significantly by French labor unrest. The B-66Bs shipped to Chateauroux for modernization (elimination of Sta-Foaming damages, engine retrofits, and the like) were often held for 52 days, almost twice the work time authorized for every aircraft. To speed up the B-66B's operational readiness, the Air Force decided to ship new shackles directly to the 47th Bomb Wing, which would enable the unit to install them promptly on the modified aircraft, finally back from Chateauroux.

End of Production 1957

The October 1957 delivery of the last B-66B marked the end of production.

Total B-66Bs Accepted 72

The 72 B-66Bs accepted by the Air Force reflected a reduction of nearly 50 percent from the maximum procurement once considered.

Acceptance Rates

The Air Force accepted 1 B-66B in FY 55, 27 in FY 56, 36 in FY 57, and

[29] The B-45s were taken out of the combat inventory and transferred to USAFE bases in Europe and North Africa, where they were used for fire fighting training.

the last 8 in FY 58 (3 in July 1957, 1 in August, 3 in September, and 1 in October).

Flyaway Cost Per Production Aircraft — $3.68 million

Airframe, $2,515,511; engines (installed), $664,034; electronics, $400,000; ordnance, $10,625; armament (and others), $95,300.[30]

Average Maintenance Cost Per Flying Hour — $280.00

Subsequent Model Series — RB-66C

Other Configurations — EB-66B and EB-66E

The EB-66Bs and EB-66Es were reconfigured B-66Bs, identical to modified and similarly redesignated RB-66Bs. Like the former RB-66Bs, converted B-66Bs began to acquire "E" prefixes early in 1966.

Initial Phaseout — Mid-1963

The Air Staff finally agreed to let USAFE retain its B-66Bs beyond the FY 61 inactivation date that had been established originally. Still, except for 13 specially equipped B-66Bs, the entire contingent was out of the operational inventory by mid-1963.

Special Modifications — 1964-1965

From the start of the B/RB-66 program, the Air Force thought the B-66 light tactical bomber would also be used for ECM jamming. Hence, a pallet (or cradle), carrying jammers, chaff dispensers and other necessary gear, could be fitted in the aircraft's bomb bay, once the latter was stripped

[30] Including the costs of research and development and in-production engineering changes, but excluding the expenses of modifications added on after approval of a basic contract.

of its bombload and shackles.[31] Nevertheless, retention of 13 ECM-equipped B-66Bs would entail some work since the aircraft were not new. In April 1964, the Air Force Logistics Command began to develop a working agreement between USAFE's 42d Tactical Reconnaissance Squadron, the Mobile Air Materiel Area, and a Lear-Siegler contract team. The project, as settled, covered the IRAN program for each aircraft, including removal and inspection of all fuel cells and updating of the electronic countermeasures system of the aircraft, referred to as Brown Cradle. The Air Force estimated that to do the overall task properly would require some 3,400 manhours for each of the 13 Brown Cradle B-66Bs. Since USAFE did not want to part with more than 2 of the aircraft at one time, the B-66B's renovation and Brown Cradle modification extended well into 1965.

Southeast Asian Deployment — 1965–1966

USAFE retention of its updated Brown Cradle aircraft was short.[32] In late 1965, 5 of the modernized B-66Bs were deployed to Southeast Asia. In May 1966, the 42d Tactical Reconnaissance Squadron's remaining 8 Brown Cradle aircraft also departed for the war theater.

Reactivation — 1967

Eleven B-66Bs were reactivated early in 1967 and, after modification, were sent to Southeast Asia. Meanwhile, on-going testing to determine the aircraft's life expectancy proved satisfactory enough. Even though the B-66B shared the engine problems of the entire RB-66 fleet, additional B-66Bs were soon withdrawn from storage and modified for war service.

Operational Status — Mid-1973

Reactivated and modernized B-66Bs followed the operational pattern

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[31] Similarly, the RB-66's bomb bay, minus cameras and related equipment, could accommodate a cradle. In fact, by mid-1959 ECM tail cones had been authorized for USAFE's entire B/RB-66 contingent and for all of the PACAF RB-66Bs.

[32] The B-66Bs had no electronic intelligence capability, when configured as ECM aircraft. The USAFE Brown Cradle aircraft's intended role was to support the strike force by actively jamming enemy radars. The command recognized that its ECM B-66Bs might be vulnerable to enemy interceptors, but bitterly deplored deployment of the 13 aircraft to Southeast Asia.

of the RB-66Bs. Also known as EB-66s since early 1966, a few of the aircraft still lingered in the active inventory in mid-1973.

Milestones 1956–1957

On 12 August 1956, one of the Air Force's new subsonic B-66 jet bombers flew from Hawaii to California in 4 hours and 27 minutes, covering a distance of 2,690 miles at an average speed of more than 600 miles per hour.

In the fall of 1957, only 17 hours after being alerted in the United States, several B-66Bs, after crossing the Pacific as elements of a Composite Air Strike Force, were flying simulated bombing missions over the Philippines.

RB-66C

Manufacturer's Model 1328

Previous Model Series — B-66B

New Features

The RB-66C featured a reconfigured bomb bay, which housed electronic components and provided space for 4 additional crew members (electronic countermeasures operators or observers). The aircraft's design weight was 75,000 pounds (5,000 more than the RB-66B's and 3,000 pounds less than the B-66B's). Wingtip radar pods and a radome containing antennas for the various radars were the other significant new features of the RB-66C. As in the case of every B/RB-66 version, the basic 3-man crew of the RB-66C (pilot, navigator, and gunner) used upward ejection seats, the 4 additional ECM operators, downward ones.

Basic Development — 1953

Development of the RB-66's electronic intelligence version, although anticipated as early as 1952, did not begin until 1953. The aircraft's overall configuration was submitted to USAF Headquarters in early March and approved the following month. A more specific design was initiated in June, but the Air Force knew that the equipment required by the future aircraft's electronic reconnaissance role was not readily available. Production schedules, therefore, forecast an operational date of late 1956. Thus, despite the many problems that soon beset the entire program, the RB-66C practically escaped the production slippages of other and less sophisticated B/RB-66s.

Production Go-Ahead — 15 April 1953

On record, the Air Force endorsed production of the ferret RB-66C in mid-April. In actuality, the production decision was only firmed up several months later. And like preceding models, the RB-66C was nearly canceled in 1955, when the whole B/RB-66 program came under review. The RB-66C's initial procurement document was a purely developmental letter contract calling for "necessary implementation planning and design for the electronic reconnaissance version of the RB-66." This document, AF 33(600)-25669, was issued on 12 June 1953, but it took until August, when the fiscal year 1954 airplane program was released, for the Air Force to indicate a first requirement for 65 RB-66Cs.

Mockup Inspection — 14 January 1954

Inspection of the RB-66C mockup generated 31 change requests. The 14 January mockup inspection, held at Douglas's plant in Tulsa, Oklahoma, reflected a change of plan. Originally, all B/RB-66s (RB-66Cs, included) were to be produced in Long Beach, a sensible decision since 60 percent of the airframe parts were expected to be alike, and a similar commonality percentage would apply to tooling. However, the Douglas Long Beach plant was already manufacturing C-124s. Despite its 3,320,000 square feet of space, the plant was not large enough, nor did it have the engineering capability to accommodate the whole B/RB-66 program. By necessity, Tulsa was selected in 1953 to build all RB-66Cs, but this decision, like most long-range plans, was revised. The Tulsa plant ended manufacturing a great many wings for other B/RB-66 models, while Douglas eventually found it more economical and convenient to produce certain portions of the RB-66Cs in Long Beach.[33]

Program Change — July 1955

In mid-1955, the Air Force confirmed a heretofore tentative decision to reduce the RB-66C program of 72 aircraft by half. The 36 deleted RB-66Cs would be produced in the synoptic weather configuration.

First Flight (Production Aircraft) — 29 October 1955

The RB-66C's first official flight took place on 29 October 1955, TAC getting one of the new aircraft soon afterwards.

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[33] The Long Beach plant had been built during World War II to manufacture such airplanes as the A-20, A-26, C-47, C-74, and B-17. The United States government only owned 52 percent of the plant. In contrast, the Tulsa plant was totally owned by the government. It was also not as large as the Long Beach plant and was expected to stop manufacturing and modifying B-47s sometime in 1955.

Contractual Arrangements 1955–1956

Procurement of the RB-66C mirrored the turbulent history of the entire program. An October 1953 amendment to the letter contract of June 1953 became the prelude to several unusual arrangements. Again, because Douglas could not possibly come up with realistic fixed-price estimates, the contract, finalized in December 1953, covered Douglas's costs, plus a fixed fee of 6 percent. In another departure from preferred procurement methods, contract AF 33(600)-25669 covered 3 different models of the B/RB-66s. The rationale for this procedure was that 1 contract would be cheaper than 3, because it would permit co-mingling of common parts and the use of common tooling. In any case, as a result of the mid-1955 program reduction, the contract was altered in August 1956. The changes, however, did not specifically affect the RB-66Cs. Meanwhile, another RB-66C order had been processed in fiscal year 1955, when the fourth and last B/RB-66 contract was negotiated.[34] This contract, AF (33(600)-28386, was signed on 24 September 1954. It was another cost-plus-fixed-fee contract, carrying the same fee of 6 percent, as well as several types of B/RB-66s. This contract also underwent changes. In January 1956, the contract's total was reduced; in August, the procurement of some models was altered in favor of others, and the 36 RB-66Cs canceled in mid-1955 were formally deleted in December. Finally, as already noted, the terms of both contracts (the last 2 of a total of 4) were renegotiated, 2 new supplemental agreements being signed in early 1957.

Enters Operational Service 1956

TAC's initial RB-66C, received at Shaw AFB on February 1956, was assigned to the 9th Tactical Reconnaissance Squadron. Only a few more of the aircraft were delivered before mid-year, but by the end of December, more than half of the RB-66C contingent had reached the Air Force. The ferret RB-66C was the first weapon system of its kind. Its assignment also proved unique, as TAC from the start planned to equip certain squadrons with a mixture of RB-66Cs and of forthcoming and equally novel WB-66Ds.

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[34] At the time, only 1 RB-66A had been delivered, only 1 B-66B was partially shop-completed, and no work had been done on the RB-66C. Therefore, as far as prices were concerned, Douglas knew little more than it had the previous year. And obviously, the forthcoming production correction of airframe deficiencies was bound to complicate all cost estimates.

Engine Deficiencies 1956

As in the case of most B/RB-66s, some RB-66Cs were equipped originally with J71-A-11 engines. Hence, they too were hindered by engine malfunctions and demonstrated disappointing operational performance until retrofitted with more powerful J71-13s.

Grounding June 1956

The Air Force grounded on 14 June the 6 RB-66Cs it had already accepted from Douglas. The grounding was necessary because the aircraft's center of gravity was affected by the fuel level. The retrofit installation of a boost pump in the aircraft's forward tank solved the problem, but it took until mid-August to flight test the modification. The change was incorporated during the production of subsequent RB-66Cs.

Engineering Problem July 1956

An engineering difficulty, peculiar to the RB-66C, received special attention. The instability demonstrated by the first RB-66A had been corrected, but the wingtip radar pods featured by the RB-66C had created a new buffeting problem. In July, the Air Force Flight Test Center checked the effectiveness of a Douglas-devised modification, which attached a vane to the wingtip pod. The Air Force determined that the new device was fairly effective. Yet, it wanted a "buffet free airplane," not one so fitted as to bring buffeting to an "acceptable level." In late July, representatives from Air Research and Development Command, AMC, and the Wright Air Development Center met with Douglas and decided that the contractor's modification would do for a while, but that the root of the problem had to be eliminated. In short, better shaped pods had to be designed and tested. Following selection and production of a reconfigured pod, all 36 RB-66Cs would be retrofitted, which they were.

Overseas Deployments 1956-1957

The RB-66Cs arrived overseas shortly after TAC received its first aircraft. USAFE got most of its RB-66C quota in 1956. The 12 aircraft, one-third of the total procurement, went to the newly activated 42d Tactical Reconnaissance Squadron at Spangdahlem Air Base, West Germany.

PACAF in 1957 received 12 RB-66C electronic intelligence (ELINT) aircraft, which it assigned to the 67th Tactical Reconnaissance Wing's 11th Tactical Reconnaissance Squadron at Yokota Air Base, Japan. To various extents and regardless of location, the delivered RB-66Cs were to participate in the Little Barney and other modification programs, still to be applied to the preceding RB-66Bs and B-66Bs.

Special Testing 1957

Testing of the electronic reconnaissance RB-66C was completed in November 1957. The employment and suitability tests, conducted by the Air Proving Ground Command, showed that the aircraft was capable of performing "peripheral reconnaissance during peacetime" without equipment modifications. However, major engineering changes would be needed, should the RB-66C be used in a combat environment.

End of Production 1957

Delivery of 2 last RB-66Cs in June 1957 marked the end of the aircraft's production.

Total RB-66Cs Accepted 36

Acceptance Rates

The Air Force accepted 6 RB-66Cs in FY 56, and 30 more in FY 57.

Flyaway Cost Per Production Aircraft $3.06 million

Airframe, $2,138,445; engines (installed), $664,034; electronics, $155,000; ordnance, $13,722; armament (and others), $95,300.[35]

Subsequent Model Series WB-66D

[35] The cost formula of previous B/RB-66s applied to the RB-66C and subsequent WB-66D.

Other Configurations EB-66C

The EB-66C, so designated in 1966, when all B/RB-66 aircraft engaged in electronic warfare acquired the E prefix, was a modernized RB-66C. Even though the former RB-66C at the time was the only tactical electronic warfare vehicle in the Air Force, further improvement of the EB-66C was stopped in 1969. In short, all models redesignated as EB-66s underwent special modifications to improve their electronic warfare capabilities, but they needed additional changes which were not approved.

Canceled Modifications 1959-1961

While the RB-66C participated, as needed, in the B/RB-66 program's overall improvement, proposals for special modifications were often denied. As equipped in 1959, the RB-66C could not provide a rapid count and location of enemy radars. The addition of a Baird Remote Control Sextant[36] would help, but TAC's request was turned down by the Modification Review Board of the Mobile Air Materiel Area, because of fund shortages. Also, the expensive equipment was not readily available. If approved, it would have reached the aircraft too late to justify its cost, since the RB-66C was expected to begin leaving the inventory about mid-1963. In 1961, TAC again pointed out that the airborne system of the RB-66C had never been modernized,[37] and that manually operated equipment produced data which required hours of processing.

Cuban Crisis October 1962

Operational deficiencies, observed during the Cuban missile crisis of 1962, vindicated TAC. In the next years, continuing reconnaissance operations around Cuba further demonstrated the validity of the modifications that had been sought by the command. Meanwhile, during the first months of the crisis, TAC's RB-66s (a mixture of RB-66Bs and RB-66Cs) flew many extra hours, and soon began to participate in numerous exercises.[38]

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[36] An instrument that would provide a look-down altitude capability.

[37] TAC's deep concern led it to suggest that perhaps a single USAF organization, properly equipped, should provide electronic intelligence for the entire Air Force.

[38] The Tactical Air Command had been engaged in RB-66 electronic warfare since 1956, but emphasis had been on electronic reconnaissance. It took until 1960 for TAC to begin sending RB-66 crews to Europe to gain experience in electronic warfare operations.

New facts came to light. The RB-66C required more maintenance. Electronic countermeasures were most important during contingency operations, and the reconnaissance wing did not have enough trained personnel to maintain the system and to take care of the problem-ridden APD-4 antenna. TAC believed a pure training program was not required; instead technical support was needed to better indoctrinate a minimum of personnel on corrosion, interference, and other problems with the RB-66C's antenna. Activities prompted by the October crisis also served the useful purpose of testing a special RB-66B. The aircraft's recently installed infrared and KA-18 components were expected to provide reconnaissance information on troop and heavy equipment in forested areas.

Planning Changes 1963–1964

The Air Force's decision to retain its electronic intelligence gathering force, pending availability of ELINT RF-4Cs,[39] caused a first postponement of the RB-66C phaseout. The recent Cuban Crisis and its on-going impact, the growing threat in Southeast Asia, and the confirmed RB-66C shortcomings induced other changes. To begin with, TAC organized the USAF Tactical Air Reconnaissance Center (TARC). Located at Shaw AFB and due to serve as a worldwide focal point for tactical reconnaissance programs, TARC swiftly proved its worth. Although partially manned, TARC, in 1963 alone, tested an in-flight film processing magazine; the RS-7 infrared sensor; the KA-18A Sonne or continuous strip camera, and the KA-52A panoramic camera. The new center also ascertained how quickly electronic intelligence signals could be located and fixed. Finally, it tested a special navigation system for the Army; a portable film processor, and a TACAN antenna for the RF-101.[40] During the same period, minimum but significant modifications of the RB-66C were being devised.

Urgent Modifications October 1964

Several RB-66Cs were modified, beginning in October 1964. The

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[39] Slippage of a sensor being tested by the Navy was a primary problem. TAC attached great importance to the new ELINT sensor, which the RF-4C was expected to carry in a pod.

[40] The RF-101 was due to remain the principal intelligence gathering weapon system until replaced by the RF-4C, another McDonnell production. The RF-101 went through several modernization programs between 1962 and 1967, while the RB-66C asserted itself as the only USAF electronic warfare vehicle.

changes attempted to upgrade the aircraft's electronic countermeasures equipment, so it could cope with various types of enemy missiles. A subsequent but related modification, tested under Project Sea Fast, seemed to work fairly well, which meant that the RB-66Cs were at least prepared to enter the war.

Southeast Asian Deployment 1965

Like the RB-66Bs, TAC's RB-66Cs first went to Southeast Asia in April 1965. Soon the command's entire meager RB-66C contingent was committed to the war effort, leaving the command no other immediate alternative than to request 5 RB-66Bs for training aircrews. Of necessity, TAC's temporary duty RB-66C personnel carried out most electronic warfare operations in Southeast Asia during the whole of 1965.[41]

Other Modifications 1965–1968

As the Vietnam War escalated and enemy defenses grew, more modifications, the improvement of old and new components, and additional EB-66Cs (so redesignated in 1966) were needed. Big Sail, a priority modification started in 1965, hoped to reduce fighter losses by raising the EB-66C's efficiency against increasingly sophisticated enemy radars. Soon all USAFE EB-66Cs were included as backup for additional so-called Big Sail types of commitments. But the war demands did not abate. Although the Big Sail modification did work, TAC and USAFE asked the Air Staff that the EB-66C fleet be further updated for electronic warfare. Other modifications were made as unexpected problems arose. For instance, electromagnetic interferences with other aircraft systems demonstrated before long that the EB-66C needed a different jammer. TARC tested the new modification as part of the tactical electronic warfare system improvement.

Towards the end of 1966, the Center again got involved in a crucial task. The EB-66Cs in Southeast Asia often had to mask electronically the strike aircraft entering and leaving areas defended by deadly SA-2 surface-to-air missiles. Two jamming techniques could be used by the EB-66Cs, too few in number and increasingly vulnerable. Borrowing a B-52 from the Strategic Air Command, TARC helped determine which of the 2 B-66C techniques

[41] Electronic warfare officer training was started at Shaw AFB in March 1966.

was the safer and more efficient. In mid-1967, Secretary of Defense Robert S. McNamara explained to members of the 90th Congress that the RB/EB-66s, although not new, could satisfy adequately the Air Force's interim electronic countermeasures requirements. Mr. McNamara admitted that significant modifications would be needed to update the aircraft currently operational, as well as those being reactivated. While all of the Secretary's tentative plans did not materialize, the EB-66Cs were further improved. Among many important aircraft modifications, most noteworthy was the installation of steerable antennas in the EB-66Cs.[42] This change, begun in the spring of 1968, enabled electronic warfare officers to focus a plane's jamming energy against a specific radar transmitter.

Additional Commitments 1968-1969

Seizure of the USS *Pueblo* by North Korea prompted the immediate deployment of USAF forces. As part of the buildup, TAC had to send 6 EB-66s (4 EB-66Es and 2 EB-66Cs) to provide standoff ECM support to the strike units in the event of hostilities. The EB-66s departed the United States on 29 January 1968 and reached Kunsan, South Korea, on the 31st. However, before the end of February, priority requirements in Southeast Asia dictated relocation of the Kunsan EB-66s to Itazuke Air Base, a development TAC did not like. The command, during the previous year, had already pointed out to the Air Staff that any plan to replace Southeast Asian EB-66C losses with assets from the Shaw training pool would seriously affect the training of electronic warfare officer replacements. Nonetheless, TAC's predicament was to get worse. Early in 1968, crew training began to falter, as did the testing of ECM equipment and concepts, and TAC asked that all RB-66s be retrieved from storage and modified. In July, when most ECM modification programs neared completion, Secretary McNamara designated all EB-66s for dual-basing,[43] but TAC's reactivation request again proved futile. Meanwhile, since the total requirement for EB-66s far exceeded the number of aircraft available, other major air commands had problems. Because PACAF desperately needed a continuous flow of crew replacements, this command was the first to recommend in March 1968 that

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[42] The EB-66E never carried this device, probably because the modification would have required the further installation of direction-finding equipment to tell the operators where to aim the new antenna.

[43] Dual-basing basically meant that a tactical combat unit, at a tenant location separated from its area of responsibilty and parent command, would deploy to a predesignated base within its area of responsibility, prior to or during hostilities.

8 EB-66s, programmed for Southeast Asia, be temporarily diverted to TAC. As for USAFE, after losing all its EB-66 resources to the Vietnam War, it flew inferior EB-57s pending activation of the 39th Tactical Electronic Warfare Squadron at Spangdahlem Air Base, West Germany. This interim arrangement lasted until April 1969, when 16 EB-66s finally became available to equip the new squadron.

Program Extension 1970–1974

Scheduled to phase out around 1970, the EB-66C's operational life was again extended. Still, like other EB-66s, the aircraft would no longer be modernized and would have to be maintained through normal processes. In 1969, decreased air activities in Southeast Asia promised relief and TAC expected the return of some of its resources. Meanwhile, the command found it difficult to support the new Spangdahlem squadron of EB-66s. During the same period, preliminary results of on-going structural tests showed that the B/RB-66 or EB-66 airframe could accumulate safely perhaps as many as 13,000 hours of flying time.[44] Hence, TAC once more asked that additional aircraft be removed from storage. Since its request again was turned down, the command reiterated that contingency support commitments would have to be scaled down. In mid-1971, the overall EB-66 program called for TAC to reduce combat crew training and to end it 1 year later. In the meantime, PACAF would handle the training of EB-66C crews until TAC received the EB-66s, due to leave Spangdahlem. Then, TAC would resume training of EB-66C and EB-66E personnel, while continuing to take care of all contingency operations. Clearly, both the Air Staff and TAC trusted that additional EB-66s would not have to be sent to Southeast Asia. However, B-52 support needs in November 1971, and problems with some of the war theater aircraft required the commitment of 2 TAC EB-66Cs. Moreover, a new contingent of EB-66s had to be deployed in mid-1972, when the enemy drive intensified and Strategic Air Command B-52Gs entered the war. Nevertheless, the B/RB-66 saga of nearly 2 decades was coming to an end.

Operational Status Mid-1973

In mid-1973, few EB-66Cs remained in the inventory. As foreseen by

[44] The flight loads and analytical study phases of the aircraft's fatigue life program were practically completed in May 1969, when testing of the aircraft's components began. The thrust-deficient and worn-out J71 engine obviously was excluded from the testing program.

TAC, without enough money for proper support, many EB-66s had been lost to attrition. Deactivation of Shaw AFB's 39th Tactical Electronic Warfare Training Squadron, the last Air Force unit to use any type of the old B/RB-66 aircraft, would take place in early 1974. While in Southeast Asia, the 39th had received the Outstanding Unit Award for its contributions during the Linebacker II operations of December 1972.[45]

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[45] See B-52, p 278.

WB-66D

Manufacturer's Model 1365

Previous Model Series RB-66C

New Features

The WB-66D was identical to the RB-66C, except that the bomb bay housed electronic weather equipment in lieu of ECM components. The pressurized crew compartments also were alike, but the WB-66D only required a crew of 5—pilot, navigator, gunner, and 2 weather observers. In contrast to other B/RB-66s, all WB-66Ds were equipped from the start with J71-A-13 engines.

Production Decision 1 August 1955

Production of the WB-66D was made official on 1 August 1955, soon after the procurement deletion of 36 RB-66Cs had been confirmed. Contract AF 33(600)-28368, the fourth and last B/RB-66 contract, was amended accordingly on 12 December 1956.

Mockup Inspection 21 June 1956

The inspection team was actually confronted by a dual task, because Douglas displayed 2 configurations of the WB-66D synoptic weather reconnaissance aircraft. The first of the 2, referred to as the interim WB-66D, contained the weather equipment of the time; the second configuration, or best model, provided for and described the more sophisticated equipment expected for use within 2 or 3 years. The inspection prompted 47 change requests, 27 of which were considered of priority importance. Yet the AMC mockup board did not seem excessively concerned. Confirming this optimistic appraisal, the Air Force announced in November that both the interim and ultimate WB-66Ds would be purchased, with the understanding that the interim aircraft would be retrofitted with more modern weather equipment as soon as feasible.

Testing 1957

Douglas testing of the WB-66D ended with satisfactory results in late September 1957. Ensuing functional testing by the Air Force failed to uncover any significant problems and was practically completed before the end of the year.

Enters Operational Service 16 June 1957

The spring delivery of 3 interim WB-66Ds to Shaw AFB's 9th Tactical Reconnaissance Squadron was an important milestone for the Tactical Air Command. The synoptic weather mission, which covered a large geographical area simultaneously, was a relatively new development within the command. Theoretically, a few modified T-33 trainers (produced by Lockheed and commonly known as T-Birds) constituted TAC's weather reconnaissance fleet. In reality, these planes awaited delayed equipment kits. Because of the obsolescence of the WB-26s, TAC flew the partially equipped T-33s to gather high-altitude weather information, relying essentially on the data observed by the aircraft's back-seat weatherman. Although the early WB-66Ds did not meet all of TAC's needs, their arrival did signify a long overdue operational improvement.

Overseas Deployments 1957–1958

Except for 4 aircraft delivered in FY 1957, all WB-66Ds were accepted by the Air Force during FY-58. While the first deliveries went to the Tactical Air Command, WB-66D deployments to PACAF and USAFE closely followed. PACAF's 12 WB-66Ds were assigned to the 67th Tactical Reconnaissance Wing; USAFE's equal lot, to the 66th.

Program Shortcomings 1957–on

The WB-66Ds received by 3 of the Air Force's major air commands fell short of meeting the requirements set up for either the interim or ultimate version of the aircraft. Little more than a year had elapsed since the

WB-66D mockup inspection, but many events had taken place. Unexpected developmental setbacks, the procurement slippage of weather components much simpler than those under preliminary development, fiscal restrictions, and the high cost of on-going B/RB-66 modifications, all had caused the Air Force to lessen its weather reconnaissance objectives. In March 1957, while realizing that the ideal weather airplane would not materialize in the foreseeable future, the Air Force still hoped that the so-called interim WB-66D could gain, through post-production modifications, a few of the ultimate features that had been planned for the aircraft. In August 1957, even this more modest planning became uncertain, as deliveries of the proposed components could no longer be assured before 1960, or later. As feared, the Air Force on 30 October 1957, had to cancel the purchase of 5 future components. In their place, the Air Materiel Command would attempt to expedite the procurement of radiosonde sets,[46] MG-3 data computers, and AMQ-7 temperature and humidity devices. As time would show, this still remained a tall order.

Operational Deficiencies 1958–1959

TAC quickly took advantage of the eagerly awaited WB-66Ds. First received in late June 1957, the aircraft began flying regularly scheduled weather reconnaissance tracks on 1 September. Despite equipment problems, the superiority of the WB-66D over reciprocating engine aircraft or the T-33s was immediately apparent. To some extent, the WB-66D could determine weather conditions regardless of surroundings, and it soon started probing vast areas of hitherto unsampled overwater skies. This meant that weather briefings became more accurate, and that overseas deployments would face fewer weather hazards. Nevertheless, the WB-66D was still unable to transmit meteorological data automatically by radio. In mid-1959, the retrofit of key components kept slipping. For example, testing of the dropsonde receptors and dispensers was unsatisfactory. Ensuing live tests, conducted at Shaw AFB, only confirmed that the WB-60D's radiosonde system needed further improvement. In several drops, the dropsonde struck the aircraft on ejection and failed to transmit.

End of Production 1958

The Air Force took delivery of the last 2 WB-66Ds in January 1958, marking the end of the aircraft's production.

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[46] Radiosonde sets are airborne meteorographs, with associated components, that automatically transmit meteorological data by radio.

Total WB-66Ds Accepted 36

Acceptance Rates

The Air Force accepted 4 WB-66Ds in FY 57, and all others in FY 58 (5 each month from July 1957 through December 1957, and 2 in January 1958).

Flyaway Cost Per Production Aircraft $1.91 million

Airframe, $1,313,373; engines (installed), $270,000; electronics, $138,784; ordnance, $15,160; armament (and others), $174,983.

Average Maintenance Cost Per Flying Hour $448.00

Subsequent Model Series None

Other Configurations X-21A and EB-66C

X-21A. In the late fifties, the Air Force gave Northrop a contract to convert 2 WB-66Ds. The purpose of the conversion was to test a new laminar flow control system developed by Northrop. Design of the conversion was started in August 1960, and modification of the Douglas-built aircraft began in 1961. Designated X-21A, the first modified WB-66D flew in April 1963, and testing of the laminar flow control system over sections of the wings was underway by 20 May 1963. Conversion of the second WB-66D was completed in August of the same year.

EB-66C. A number of WB-66Ds, withdrawn from storage after 1966, were brought up to the EB-66C configuration.

Phaseout 1960–1964

The WB-66D phaseout started in 1960, when USAFE and PACAF got rid of their weather reconnaissance aircraft. At the time, the Air Staff endorsed TAC's request to retain its small WB-66D contingent for a few more years. Nonetheless, by July 1965, all WB-66Ds were out of the Air Force's active inventory.

Reactivation 1966

In October 1966, press accounts began to give the EB-66s credit for neutralizing surface-to-air missile radars as well as much of the enemy's radar-controlled but conventional anti-aircraft weaponry. Less publicized throughout the years were the Air Force's difficulties in satisfying recurring or unforeseen demands with too few aircraft. Late in 1966, Secretary McNamara at long last approved the reactivation of 9 WB-66Ds and the modification of each aircraft to the EB-66C configuration. Even though some of the reactivated and modernized planes acquired slightly different components, all EB-66Cs remained basically alike and all played important roles. For that matter, the entire fleet of EB-66Bs, EB-66Es, and EB-66Cs, as well as their heroic crews, were highly praised for their combat contributions.[47]

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[47] Like most other aspects of the electronic warfare effort, the EB-66's effectiveness could not be evaluated in terms of missions flown and fighter-bombers lost. There were no valid supporting statistics, but the aircraft became quickly known for its outstanding usefulness. Despite unrelenting engine problems, its performance was also well rated.

Program Recap

The Air Force accepted a grand total of 294 B/RB-66s—5 RB-66As, 145 RB-66Bs, 72 B-66Bs, 36 RB-66Cs, and 36 WB-66Ds. Early production difficulties, and deficiencies identified late in 1954, accounted for the program's reduction—48 aircraft less than initially ordered. The same reasons delayed deliveries to the using commands by about 1 year, and TAC did not receive its first RB-66B until January 1956. Still only 4 years elapsed between the production go-ahead and the aircraft's service introduction. And once in the inventory, the often-modified aircraft earned their keep far longer than anticipated.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

B/RB-66 AIRCRAFT

Manufacturer (Airframe)	Douglas Aircraft Company, Long Beach, Calif., and Tulsa, Okla.
Manufacturer (Engines)	Allison Division of The General Motors Corporation, Detroit, Mich.
Nomenclature	All-weather Night Photographic Aircraft; Light Tactical Bomber; Electronic Reconnaissance Aircraft.
Popular Name	Destroyer

	RB-66B	B-66B	RB-66C
Length/Span (ft)	75.2/72.5	75.2/72.5	75.2/72.5
Wing Area (sq ft)	780	780	780
Weights (lb)			
Empty	43,476	42,549	44,771
Combat	49,440	57,800	65,360
Takeoff[a]	83,000	83,000	83,000
Engine: Number, Rated Power per Engine, & Designation	(2) 10,200-lb st J71-A-13	(2) 10,200-lb st J71-A-13	(2) 10,200-lb st J71-A-13
Takeoff Ground Run (ft)			
At Sea Level[b]	6,750	6,750	6,750
Over 50-ft Obstacle[b]	9,350	9,350	9,350
Rate of Climb (fpm)	3,260	3,260	3,180
Combat Rate of Climb (fpm) at Sea Level	4,840	5,000	4,320
Service Ceiling (ft) at Combat Weight (100 fpm Rate of Climb to Altitude)	40,900	41,500	37,700
Combat Ceiling (ft) (500 fpm Rate of Climb to Altitude)	38,900	39,400	35,500
Average Cruise Speed (kn)	456	456	436
Maximum Speed at Optimum Altitude (kn/ft)	548/6,000	548/6,000	533/8,000
Basic Speed at Altitude (kn/ft)	496/36,089	498/36,089	477/35,000
Combat Radius (nm)	805	794	947
Total Mission Time (hr)	3.57	3.49	4.38
Armament	2 20-mm M-24A-1	2 20-mm M-24A-1	2 20-mm M-24A-1
Crew	3[c]	3[d]	7[e]
Maximum Bombload (lb)	4,084 (photoflash bombs & photoflash cartridges)	15,000 (E-53s, T-36s T-54E2s T-55E5 bombs)	Not Applicable

Abbreviations		
fpm	=	feet per minute
kn	=	knots
nm	=	nautical miles
st	=	static thrust

[a] Limited by gear strength.
[b] Using maximum takeoff power.
[c] Pilot, photo-navigator, and gunner.
[d] Pilot, bombardier-navigator, and gunner.
[e] Pilot, navigator, gunner, and 4 electronic countermeasures operators

Basic Mission Note

All basic mission's performance data based on military-rated power, except as otherwise indicated.

Combat Formula: Radius and Electronic Countermeasures Basic Missions
RB-66B and B-66B—Warmed up, took off and climbed on course to optimum cruise altitude at military power. Cruised out at maximum-range speeds increasing altitude with decreasing airplane weight to a point 15 minutes from target. Dropped external fuel tanks when empty. Ran-in to target at normal power, dropped bombload, conducted 2-minute evasive action and 8-minute escape to normal power. Climb to cruise altitude was conducted during the 8-minute escape operation. Cruised back to base at maximum-range speeds, increasing altitude with decreasing airplane weight. Range-free allowances included 5-minute normal-power fuel consumption for starting engines and take-off, 2-minute normal-power fuel consumption at combat altitude for evasive action, and 30 minutes of maximum-endurance fuel consumption at sea level plus 5 percent of initial fuel load for landing reserve

Formula: Ferry Mission
RB-66B and B-66B—Warmed up, took off and climbed on course to optimum cruise altitude at maximum power (military power in the B-66's case). Cruised out at maximum-range speeds increasing altitude with decreasing airplane weight until all usable fuel was consumed. External tanks were dropped when empty. Range-free allowances included 5-minute normal-power fuel consumption for starting engines and take-off and 30 minutes of maximum-endurance fuel consumption at sea level, plus 5 percent of initial fuel load for landing reserve.

Combat Formula: Radius and Electronic Countermeasures Basic Missions
RB-66C—Warmed up, took off, and climbed on course to optimum cruise altitude at military power. Cruised out to turn-around and cruised back at maximum-range speeds, increasing cruise altitude as airplane weight decreased. Dropped external tanks when empty. Range-free allowances included 5-minute normal-power fuel consumption for starting engines and take-off, and 30 minutes of maximum-fuel consumption at sea level, plus 5 percent of initial fuel load for holding and landing reserve.

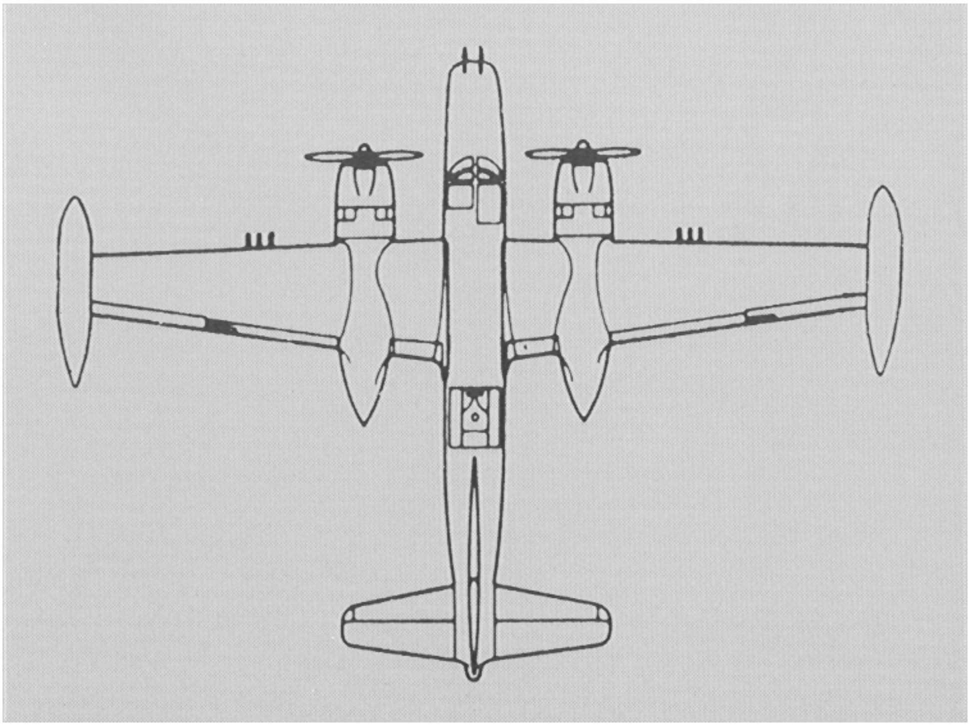
Formula: Range Mission

Warmed up, took off, and climbed on course to optimum cruise altitude at military power. Cruised at maximum-range speeds, increasing cruise altitude as airplane weight decreased, until all usable fuel less reserve was consumed. Dropped external tanks when empty. Range-free allowances included 5-minute normal-power fuel consumption for starting engines and take-off, and 30 minutes of maximum-endurance fuel consumption at sea level plus 5 percent of initial fuel load for holding and landing reserve.

Appendices

Appendix I

World War II Bombers in the Postwar Period



Appendix I
World War II Bombers in the Postwar Period

In 1945, the Army Air Forces had a fair selection of bombers in its operational inventory. But after World War II came to a close, only a few types were retained. Included were the Boeing B–17 Flying Fortress, the Consolidated B–24 Liberator, the Douglas A–24 dive bomber, the North American B–25 light bomber, the Douglas A–26 Invader, and the Superfortress—Boeing's new B–29.

Retention, however, did not necessarily entail significant post-war activity, be it in an aircraft's original configuration or any other mode. The handful of famed B–17s flown by the Strategic Air Command, when it was formed in 1946, were only used for reconnaissance, and no longer appeared on the command's rolls after 1949. The few B–24s, converted to train B–29 gunners, saw little service after the end of the war. Some of the Douglas A–24 dive bombers, redesignated F–24s in 1948 when the attack designation was officially dropped, remained active until 1950. Yet, their sole purpose was to test dive-bombing tactics for fighter-bombers. Similarly, after 1945 hundreds of B–25s served merely as trainers or staff transports, most of them having left the Air Force inventory by late 1959. The Douglas A–26 (redesignated as the B–26 in 1948) and Boeing B–29 fell in a different category. Both returned to combat. The B–29, in addition, briefly served as an instrument of deterrence—a post–World War II role of major importance.

B-26 Invader
Douglas Airplane Company

Navy Equivalent: JD-1

Basic Development — November 1940

Development of the B-26 Invader, initially known as the A-26, originated in November 1940, when the Army Air Corps's Experimental Engineering Section at Wright Field, Ohio, gave first priority to the Douglas Airplane Company for designing and developing a new plane. But, as evidenced by official requirements, the so-called new design drew a great deal from the A-20 Havoc.[1] The A-20 was a Douglas production, developed in 1937 from Model A-7: a 1936 original design for a high-performance attack bomber.

Initial Requirements — 1940

Official Army requirements, as spelled out by the Air Corps, called for a new plane that would be faster and structurally stronger than the A-20. Additional defensive armament over the A-20 and shorter takeoff and landing distances, were also part of the requirements. The Air Corps wanted the new plane eventually to replace the A-20, the Martin B-26 Marauder, and the North American B-25 Mitchell.

Contractor Proposal — 1941

In early 1941, Douglas proposed to manufacture 2 XA-26s, one a night-fighter adaptation of the other, and to schedule such a thorough series

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[1] The A-20 was put into production for foreign air forces in 1938 and became the most-produced of all the "attack" aircraft procured by the United States Army Air Corps. The A-20 was the first type of aircraft flown by American crews in the European theater during World War II.

of wind tunnel tests of the experimental planes that mass production could follow almost immediately. Mockup inspections would take place during the spring.

Contractual Arrangement 1941

The Chief of the Army's Materiel Division did not endorse the developmental contract, submitted in March 1941, because overall costs seemed unreasonable. At Douglas's request, the contract was rewritten to cover costs, plus a fixed fee. Finally signed on 2 June 1941, the revised contract (W535 ac-17946) covered 1 XA-26 and 1 XA-26A (the XA-26's night fighter version) at an estimated price of $2.08 million. Excluded from this sum was Douglas's fixed fee, which was set at $125,000. Soon afterwards, a change order provided for an additional experimental plane. Designated the XA-26B, this third configuration would incorporate a 75-millimeter cannon.

Mockup Inspections April 1941

As planned by Douglas, inspections of the XA-26 mockups were held in April 1941. Representatives of the Wright Field Production Engineering Section were particularly impressed by the apparent versatility of the future plane.

Production Decision 31 October 1941

The decision to go ahead with mass production of the A-26 became official on 31 October 1941, when Contract V535 ac-21393 was approved. Even though none of the experimental planes had been flown, the production contract covered 500 A-26s for a total cost of $78.2 million.

First Flight (XA-26) 10 July 1942

The first of the 3 XA-26s, ordered in the summer of 1941, was not initially flown until 10 July 1942. The other 2 experimental planes were flown on the heels of the first one.

Program Refinement — August 1942

Testing of the 3 XA-26s, as well as the experience already gained from combat in Europe and the Pacific area, prompted the Army Air Forces to decide that the 500 aircraft, covered by the production contract of June 1941, would be patterned on the third experimental plane: the XB-26B ground attack configuration that featured a 75-mm cannon nose, primarily intended to destroy tanks. In short, a heretofore uncertain Army Air Forces gave priority to ground attack over the multi-purpose light bomber requirements of 1940. Yet, the aircraft's versatility was not overlooked. Two hundred additional noses, each with six .50-caliber guns, would also be procured. Each of the latter noses could be installed in about 24 hours by field personnel.

Production Delay — 1943

Delay of the XA-26's first flight clearly indicated that, at best, mass production would not begin before July 1943, a significant slippage from the original time estimate. Lack of tooling was a primary factor, but shortages of engineers were equally damaging. Hence, the Wright Field Production Division directed Douglas to transfer at least two-thirds of the personnel listed on the C-74[2] project to the A-26. Also, no engineers were to be utilized for the improvement of crew comfort, or any other endeavors, unless specifically authorized by Wright Field. Finally, no other armament studies were to be made until the A-26 production's stage was more advanced. In January 1943, despite these stringent directives, Douglas informed the Army Air Forces that the new production schedule would not be met. The contractor indicated that October appeared to be a more likely date for production to begin.

Additional Procurement — 17 March 1943

A second production contract, W535 ac-34433, covering the procurement of 500 additional A-26s was approved on 17 March 1943. Total cost was $109.1 million. Included in this total was the purchase of 167 bombardier-observer nose sections that could also be quickly substituted for

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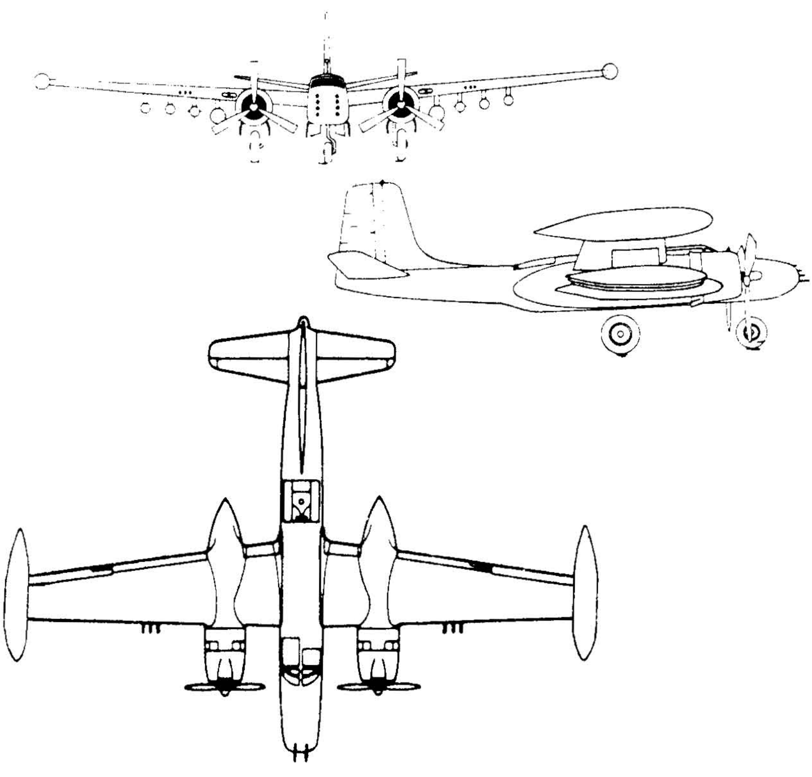
[2] The Army Air Forces recognized that it needed a long-range heavy transport aircraft during the early days of World War II. However, the first C-74 (Model 415A, a development of the Douglas DC-4) was not delivered before October 1945. Hence, 36 of the 50 C-74s on order were canceled.

The B-26, originally developed as an attack bomber during World War II, served in both the Korean War and the Southeast Asian conflict.



the A-26's 75-millimeter cannon nose. While the first 500 A-26Bs would come from the Douglas Long Beach plant in California, the new order was to be manufactured in Tulsa, Oklahoma. Obviously, time was important.

New Production Slippages 1943–1944

Although the Army Air Forces took delivery of a few A-26Bs in the fall of 1943, production again slipped. In early 1944, production was practically at a standstill, a situation which did not satisfy Gen. Henry H. Arnold, Commanding General of the Army Air Forces. Various excuses were offered, such as the shortage of machinery for making wing spars. Another valid reason was the number of modification requests, which was clearly excessive.

In March 1944, when only 21 A-26s had been delivered, General Arnold bluntly expressed his increasing dissatisfaction. "One thing is sure," said General Arnold, "I want the A-26s for use in this war and not the next war." Maj. Gen. Oliver P. Echols, Assistant Chief of Air Staff for Materiel, Maintenance, and Distribution, blamed the continuing delays on Douglas's apparent lack of interest or "little desire to manufacture the plane," and explained that the Materiel Command all along had urged the contractor to place orders for tools and to find qualified subcontractors. In defense of Douglas, the Western Procurement District, Los Angeles, California, stressed that the A-26 wing was entirely different from that of any other airplane; that delivery schedules were set before design and tooling problems were solved; and that there had been on occasions as many as 35 change orders a day on the A-26.

The divergence of opinion did not deter General Arnold. He insisted that something drastic had to be done to ensure that, as initially intended, B-25s, B-26s, and A-20s would be replaced by A-26s. As a first step, he placed additional A-26 orders.

New Production Orders 29 March 1944

Existing production problems were not allowed to affect the programmed procurement of additional A-26s. On 29 March 1944, the Under Secretary of War approved 2 supplemental agreements to the production contracts already in force. The extra A-26s, 2,700 of them, were expected to cost about $300 million.

Special Features

The A-26 had a 70-foot wing span, compared to the 61-foot span of the

30-percent-lighter A-20. Greater care had been applied to simplify the manufacturing and maintenance of the A-26 structure. Moreover, the fuselage of the all-metal, semi-monocoque A-26 allowed the 3 crewmen to exchange positions, an advantage the A-20 did not offer.

A most unusual feature of the A-26 was the aluminum alloy monocoque engine mount, which was a combination of structure and cowling, thereby reducing weight and easing engine installation. Another special feature was the Douglas-devised slotted wing flap, which had a lower pitching movement for a given lift coefficient than the Fowler flap. Finally, the engines were cooled with a new type of high entrance velocity cowling.[3] This cowl induced less aerodynamic resistance and lowered the temperatures of the engines.

Unexpected Setback — May 1944

Improvement of the A-26 production flow, recently achieved, did not last long. New complications arose in May 1944, when the A-26 wing failed during the static tests of one of the aircraft. Douglas was told to redesign the wing, if necessary, and was required to increase its strength by 10 percent.

Combat Testing — 1944

The A-26 entered combat testing in mid-1944, when 4 of the aircraft assigned to the Fifth Air Force began operating in the Southwest Pacific. Lt. Gen. George C. Kenney, Commanding General of the Far East Air Forces, grounded the planes after less than 175 hours of total flying time and stated shortly afterwards, "We do not want the A-26 under any circumstances as a replacement for anything." Ironically, about 4 years before, as a colonel in charge of the Wright Field Production Division and a strong proponent of attack aviation, Kenney had strongly urged the aircraft's development. General Kenney's statement and his mid-1944 decision to ground the planes appeared justified. A-26 production had slipped badly; the B-25s and A-20s that the A-26s would replace had proven satisfactory; and the canopy of available A-26s was poorly designed. A new canopy was needed to improve visibility. Without it, pilots could not safely fly the formations required for low-level tactics. While the Wright Field Production Division agreed that the A-26 could not replace current types of light and medium

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[3] The new cowl had been developed by the National Advisory Committee for Aeronautics and the Douglas Airplane Company.

bombers, Maj. Gen. Hoyt S. Vandenberg, Commanding General of the Ninth Air Force, was much less critical than General Kenney. The few A-26s introduced in the European theater towards the end of the summer were performing well. Undoubtedly, the aircraft's marginal visibility needed attention. But new productions were seldom free of problems, and General Vandenberg thought the A-26 was a satisfactory replacement for the B-26s and A-20s in Europe.

Final Procurement 1944–1945

Regardless of the mixed reports generated by the performance of the early A-26 (A-26As or A-26Bs), the Army Air Forces' plans to re-equip all B-25, B-26, and A-20 units with A-26s were reaffirmed in November 1944. In December, 2 more contracts were approved, and in April 1945 both of the new agreements were supplemented, bringing to 4,000 the total of new A-26s ordered since mid-1944. However, the German surrender on 8 May 1945 prompted a re-evaluation of military requirements. Production which had been scheduled to increase to 400 A-26s per month was cut to 150. The procurement orders of 1944 and 1945 were canceled.

Modifications and Appraisals 1944–1945

Douglas adopted several long-standing suggestions by General Arnold: engineering personnel at Long Beach established closer liaison with the Tulsa plant; extra well-qualified personnel were placed in the 2 plants; and the number of stations in the production lines was raised. These production changes facilitated modifications of the aircraft, which were designed to improve its effectiveness. An all-purpose gun nose was devised and the faulty nose landing gear redesigned. A-26s (redesignated as A-26Cs) that came off the production lines after January 1945 featured an enlarged, raised canopy which provided increased visibility.

The Ninth Bombardment Division was first in pointing out that once pilots were familiar with the A-26, they liked it better than any other plane they had flown. Even General Kenney eventually agreed that improved A-26s—particularly the A-26 with the 8-gun nose—were proving to be highly satisfactory replacements for the A-20s and B-25s. Deficiencies such as canopy frosting, faulty brakes, and the like were still being corrected. However, substantial progress was achieved swiftly.

End of Production 1945

The A-26 production was completed in 1945, but the last aircraft was delivered in early 1946.

Total A-26s Accepted 2,451

The Army Air Forces accepted a grand total of 2,451 A-26s. More than 4,000 A-26s, ordered before the end of World War II, were canceled. The first 9 of the 2,451 produced by Douglas were built in El Segundo, California. The remainder, consisting of A-26Bs and A-26Cs, was manufactured in Long Beach and Tulsa. The Tulsa plant produced 1,086 of the 1,091 A-26Cs.

Flyaway Cost Per Production Aircraft $242,595

Airframe, $143,747; engines (installed), $47,302; propeller, $14,583; electronics, $11,045; ordnance, $4,740; armament (and others), $21,178.[4]

Subsequent Model Series None

The A-26C turned out to be the last A-26 model and was practically identical to the A-26B, except for its Plexiglass "bombardier" nose, which permitted more accurate bombing from medium levels. Initially delivered in 1945, the A-26C joined the A-26B in combat service during the last stages of the war in the Pacific.

The A-26D, a development of the A-26B, was designed with more engine power and more guns. But the 350 A-26Ds, ordered in April 1945, were included in the mass cancellation that followed the end of hostilities in the European theater.

Redesignation June 1948

In June 1948, after the Martin B-26 Marauder was withdrawn from service, the Douglas A-26 dropped its prefix ("A" for attack) and became the B-26, a designation more representative of its actual role as a standard light bomber for the new United States Air Force and the Tactical Air Command in particular.[5]

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[4] All modification costs included. No cost breakdown was available. The figure applied to the A-, B-, and C-models alike, being most likely an average of the total cost and the overall number of aircraft.

[5] The Air Force gained its independence in September 1947; the Tactical Air Command had been created in March 1946 from the wartime Ninth and Twelfth Air Forces.

New War Commitments 1950–1953

The outbreak of the Korean conflict on 25 June 1950 catapulted the Douglas B-26 back into combat. Initial targets, selected to prevent reinforcement of the enemy forces, included North Korean troop concentrations, tanks, guns, supply elements, railway yards and bridges south of the 38th parallel. Immediate results were disappointing because bad weather and darkness curtailed the B-26's effectiveness. Engine failures and various mechanical deficiencies were additional handicaps. Moreover, as the war continued, other problems became obvious.

The World War II B-26 was limited in radius of fire and its speed could no longer cope with the air and ground fire of the enemy's modern equipment. The B-26 had no electronic countermeasures capability and could not carry many types of new armament and control and guidance systems.

Almost from the very beginning of hostilities, the Far East Air Forces gained air superiority against an enemy offering little or no daylight air opposition to strategic or tactical operations. But the night hours presented a different situation. Commanders were forced to utilize a part of their available day force for night operations, and the 3d Bombardment Wing's B-26s, more readily usable for night duty, acquired new importance.

Refurbished B-26s sustained significant losses during the war as their tasks increased. Yet, despite their limitations, the obsolete B-26s compiled a distinguished combat record. The first combat strike into North Korea was flown in 1950 by a B-26 crew. On the evening of 26 July 1953, 1 day before the Korean armistice agreement was signed, a B-26 dropped the last Air Force bombs of the Korean conflict in a ground-radar-directed close support mission.

Special Modifications 1952–1954

The B-26's ineffectiveness in Korea, especially during night attacks directed by radar, prompted special modifications. In 1952, the Air Staff decided that several B-26s of the Tactical Air Command would be fitted with more sophisticated electronic equipment. In 1953, some B-26s, already brought up to the reconnaissance configuration, were given additional components to perform electronic reconnaissance and weather reconnaissance missions. Nevertheless, the usefulness of the outmoded B-26 was declining. Too many configurations—16 different ones in the United States, and about 14 in the Far East and Europe—had created supply and maintenance problems of terrific proportions. In mid-1953 the Air Staff approved a last modification to attempt standardizing most B-26s into a few basic configurations.

Phaseout 1954-1958

With the advent of the Martin B-57, B-26s began leaving the Air Force's active inventory in late 1954. The last of the B-26s were withdrawn from service in Air Force Reserve and Air National Guard units in 1958.

Reactivation 1961

President John F. Kennedy's policy that the major task of U.S. advisors in Southeast Asia was to prepare the Republic of Vietnam Armed Forces for combat raised the tempo of training and resulted in the delivery of additional equipment to the South Vietnamese. Fixed-wing aircraft were in short supply, so B-26s were taken out of storage and modified for special combat missions in Southeast Asia.

Return to Combat 1961-1969

Reactivated B-26s began reaching South Vietnam in the fall of 1961. Once in the theater, they accomplished a variety of tasks ranging from standard bombing operations and close air support attacks to visual and photo reconnaissance missions. In mid-1962, the B-26's role in the conflict was further expanded. Several of the aircraft, already equipped for reconnaissance, received additional modifications in order to perform night photo operations and some intelligence gathering duties.

Specially modified for service in Vietnam, the B-26K featured permanent wing tip fuel tanks and various bomb and rocket pods.

Keeping the weary B/RB-26s flying was a challenge. Despite changes and improvements, the aircraft actually belonged to a type that had been declared obsolete during the Korean War, 10 years earlier. The combination of old age, hard usage, and the operating conditions of Southeast Asia made maintenance of the B-26 force increasingly difficult. The aircraft were becoming more vulnerable to enemy ground fire, and most B/RB-26s were subject to flight restrictions to avoid undue wing stress. Just the same, losses occurred that were directly attributable to structural fatigue. In August 1963, a B-26 crashed after 1 of its wings broke off. Then, a B-26 wing failed during a combat flight in February 1964. All B/RB-26s were immediately grounded and withdrawn from Southeast Asia soon afterwards. Yet, this action did not end the aircraft's war involvement.

Forty B-26s returned to the war zone in mid-1966 as B-26Ks. The modifications for the K-model, accomplished by the On-Mark Engineering Company, Van Nuys, California, were extensive. The $16 million On-Mark contract, initiated in 1962, involved much more than a facelifting of the old aircraft—nearly a complete transformation. The B-26K differed from the basic aircraft in that both turrets had been removed; R-2800-52W engines replaced the B-26's R-2800-79s; the wings had been reinforced by the addition of steel straps both on the top and bottom of the spars; the propellers, wheels, brakes, and rudder had been changed; permanent wing tip tanks had been added; instrument panel and electronics were new; 8 wing pylons had been included; and a myriad of minor changes incorporated.

In short, the B-26K was a tactical bomber for special environments, mounted with rocket pods, guns pods, or bomblet dispensers, and capable of being readily fitted with photographic reconnaissance components and other sensors. The B-26K was redesignated A-26A soon after it reached the war theater.[6] The rejuvenated aircraft promptly proved to be an effective hunter and destroyer of trucks and other vehicles, its loitering capability enabling it to locate and attack an enemy often concealed by jungle or weather. Most A-26As stayed in Southeast Asia for nearly 3 years, the last combat mission being flown in November 1969.

Final Phaseout 1970-1972

In 1970, regardless of designations, none of the old B-26s remained in the Air Force's active inventory; and none remained with the Air National Guard after 1972.

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[6] The attack category, dropped some 20 years earlier, was re-endorsed in the early sixties, when some aircraft were specifically earmarked for the attack role during limited war and counterinsurgency operations.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

B-26 AIRCRAFT

Manufacturer (Airframe)	Douglas Aircraft Co., El Segundo, Long Beach, Calif., and Tulsa, Okla.
Manufacturer (Engines)	The Pratt and Whitney Aircraft Div. of United Aircraft Corp., East Hartford, Conn.
Nomenclature	Light Bomber
Popular Name	Invader

	B-26B	B-26C	B-26K[a]
Length/Span (ft)	50.8/70.0	51.3/70.0	52.1/71.5
Wing Area (sq ft)	540	540	540
Weights (lb)			
Empty	22,362 (actual)	22,690 (estimate)	25,130 (actual)
Combat	31,775	29,920	30,809
Takeoff	41,811	39,416	37,000
Engine: Number, Rated Power per Engine, & Designation	(2) 2,000-hp R-2800-79	(2) 2,000-hp R-2800-79	2 2,500-hp R-2800-52W
Takeoff Ground Run (ft)			
At Sea Level	3,900	3,390	4,075
Over 50-ft Obstacle	4,820	4,180	4,800
Rate of Climb at Sea Level	1,060	1,220	1,380
Combat Rate of Climb (fpm) at Sea Level	2,515	2,745	2,050
Service Ceiling at Combat Weight (100 fpm Rate of Climb to Altitude)	19,200	20,450	28,600
Combat Ceiling (500 fpm Rate of Climb to Altitude)	21,800	23,100	24,400
Average Cruise Speed (kn)	200	196	147
Max Speed at Optimum Altitude (kn/ft)	322/10,000	323/10,000	281/15,000
Combat Radius (nm)	839	775	606
Combat Target Altitude (ft)	Sea Level	Sea Level	Sea Level
Total Mission Time (hr)	8:8	8:23	8:48
Crew	3[b]	3[c]	[d]
Armament	16 .50-cal guns & 14 5-in HVAR	12 .50-cal guns & 14 5-in HVAR	8[e] .50-cal M3 guns & 18 rockets (LAU-3A, -32A/A, -59A)
Maximum Bombload (lb)	6,000	6,000	6,000 (various types, M1A2, MK-82, BLU-10A/B, -27B, CBU-14A, -22A, -25A, etc.)

Abbreviations		
fpm	=	feet per minute
hp	=	horsepower

[a] The B-26K, a modified B-26B or B-26C, was redesignated A-26A in 1968. The aircraft was used primarily for special air warfare and reconnaissance. In the latter role, the B-26K/A-26A carried the F-492 camera, including a split-vertical F-477, a panoramic KA-56, and a K-38A reconnaissance camera.

[b] Pilot-radio-operator, gun-loader-navigator, and gunner.

[c] Pilot-radio-operator, bombardier-navigator, and gunner.

[d] The normal crew included pilot and navigator or flight mechanic. For reconnaissance, the aircraft carried a pilot, navigator, and photo systems operator.

[e] Some of the aircraft had 14 guns: 8 in the nose and 6 in the wing leading edge.

B-29 Superfortress
Boeing Airplane Company

Manufacturer's Model 345

Basic Development 1937

The B-29's development stemmed from the Boeing XB-15, a long-range bomber first flown on 15 October 1937,[7] and from a March 1938 design study of a pressurized version of the B-17 with a tricycle undercarriage. Since the Army had little money to purchase the existing B-17, Boeing developed the new pressurized model on its own. This was Model 334A, the B-29's direct ancestor. A mockup of Model 334A, also built at Boeing's expense, was completed in December 1939.

Initial Requirements 1938-1939

By September 1938, Nazi Germany had incorporated Austria into the Third Reich and seized part of Czechoslovakia. President Franklin D. Roosevelt therefore ordered a survey of the manufacturing capacity of the United States aircraft industry. According to Maj. Gen. Henry H. Arnold, then acting head of the Army Air Corps, the President believed that an air force was "the only thing that Hitler understands" and was determined to build up America's air power so it could defend the nation and the Western Hemisphere against any aggressors. On 4 January 1939 (still prior to the outbreak of World War II), President Roosevelt asked the Congress for $300 million to buy several types of military aircraft. On 3 April, Congress authorized the Army to purchase 3,000 new aircraft and raised the Air Corps authorized ceiling to 5,500. The Air Corps used some of the appropriated funds to finance subsequent work on the B-29. Later in the year, it specified that the future B-29 would need a range of 4,000 miles.

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[7] Plans for the 5,000-mile range bomber were drawn up at Wright Field, Ohio, in 1933. In 1943, following modification, the single XB-15 was briefly used as an experimental transport.

Revised Requirements — February 1940

Boeing first thought it could satisfy the Army Air Corps's slightly altered requirements with design 341, an 85,000-pound bomber with the specified 4,000-mile range. But events had been moving swiftly. Although the United States would not enter World War II before 11 December 1941, the war in Europe was already raging, bringing to light new requirements. According to the revised requirements of February 1940, the new bomber visualized by the Army Air Corps would need armor plate, fuel tank sealing, and greater fire power than anticipated. Boeing consequently altered its plans. Competing with other contractors,[8] it answered the Army's revised requirements on 11 May 1940, with design 345, a still larger bomber with a gross weight between 100,000 and 120,000 pounds. Approved by a board of officers headed by Col. Oliver P. Echols, Chief of the Army Air Corps's Materiel Division, Model 345 became the experimental B-29—so designated on 24 August.

Initial Procurement — 1940

Procurement of the XB-29 started in June 1940, when some of the aviation money that had been appropriated by the Congress was used to pay for further study and wind tunnel tests of Model 345. Satisfactory results quickly assured the experimental project of more than $3.6 million to cover the construction of 2 XB-29s and 1 static test article. The development contract (W535 ac-15429) that necessarily ensued was signed on 6 September and amended on 14 December. The amendment provided extra funds to increase the number of flyable XB-29s to 3.

Production Decision — 1941

Although the experimental B-29 was yet to be flown, the Army in May 1941 notified Boeing of a forthcoming order for 14 service test B-29 prototypes and 250 B-29s that would be built in new government-owned facilities at the Boeing Wichita plant. Robert A. Lovett, Assistant Secretary of War for Air, confirmed the May decision in September, when the production contract was signed. In February 1942, the Army informed Boeing that the urgently needed B-29s would also be built in several new

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[8] See B-50, pp 162-163.

plants by other manufacturers, namely the Bell Aircraft Corporation and the Glenn L. Martin Company. By September, 1,000 additional B–29s were under contract, and total production nearly reached 4,000.[9] The end of the war, in August 1945, prompted the cancellation of over 5,000 extra B–29s, still on order in September of the same year.

First Flight (XB–29) 21 September 1942

The first experimental B–29 (Serial No. 41–002) made its initial flight on 21 September 1942; the second XB–29 (Serial No. 41–003), on 30 December.

Testing 1942–1948

Boeing pilots test flew the first XB–29 for a total of more than 559 hours, accumulated in 417 flights. Army Air Forces (AAF) pilots completed more than 16 hours, but the number of flights they made was not recorded. On 18 December 1942, upon completion of its 19th flight, the first XB–29 encountered some difficulties. Two tires blew during landing, causing slight damage to the landing gear doors and to some wing flaps. A more significant incident ensued. On 28 December the Boeing test crew had to stop an altitude performance flight as soon as the plane reached 6,000 feet. Failure of the number 1 engine's reduction gear proved to be the problem. To correct this condition, Boeing replaced the nose section of all engines with noses having floating bushings which had passed 150-hour tests.

No accidents marred the first XB–29's operational life. The plane was sent to the 58th Bombardment Group, Wichita, Kansas, for accelerated testing and was loaned to Boeing in November 1943 to undergo the various flight tests required by the basic development contract. Testing ended in the spring of 1948, the first XB–29 being returned on 11 May.

The second XB–29 did not fare well, having flown only 7 hours in 10 flights when it was entirely destroyed on 18 February 1943. The plane was descending for an emergency landing at Boeing Field, Seattle, Washington,

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[9] Development, plant exchanges, and the many problems inherent to the production of a revolutionary bomber in the midst of a world war have been well documented. Informative accounts may be found in Peter M. Bowers, *Boeing Aircraft Since 1916* (Fallbrook, Calif., 1966), pp 275–293; Gordon Swanborough and Peter M. Bowers, *United States Aircraft Since 1908*, rev ed (London, 1971), pp 97–108; and *Wings* 3 (Oct 73), 10–39. For a more comprehensive treatment of the new bomber, see Carl Berger, *B–29: The Superfortress* (New York and Toronto, Canada, 1970). Mr. Berger was a former Senior Historian of the Office of Air Force History.

but crashed into the Frye Meat Packing Plant, located 3 miles from the end of the Boeing Field runway, killing the 11-man crew,[10] 19 employees of the packing plant, and a Seattle fireman, and seriously injuring 12 persons. The accident, caused by fire which spread throughout the plane, was not attributed to any mechanical failure. Leakage of gasoline and a backfire were the likely factors.

Special Features 1944

Construction of the B-29 was thoroughly conventional. As standardized by Boeing and the aircraft industry during the pre-World War II decade, the new bomber had an all-metal fuselage with fabric-covered control surfaces. On the other hand, and in spite of being a further development of the B-17, the B-29 was a radically different airplane, featuring significant aerodynamic innovations. Included were a high-aspect ratio wing mid-mounted on the circular-section fuselage; huge Fowler flaps that increased the wing area by 19 percent when extended,[11] and also raised the lift coeficient; a dual wheel retractable tricycle landing gear; flush riveting and butt jointing to reduce drag (the landing gear lowered contributed 50 percent of the resistance); and pressurized compartments for the usual crew of 10.

For defensive armament, the B-29 was equipped with non-retractable turrets mounting ten .50-caliber machine guns and one 20-millimeter cannon (which was dropped from later models). All turrets were remotely operated by a General Electric central fire-control system. The B-29 also had an extensive radio and radar equipment that included a liaison set, radio compass, marker beacon, glide path receiver, localizer receiver, IFF (identification friend or foe) transformer, emergency rescue transmitter, blind bombing radar (on many aircraft), radio countermeasures, and static dischargers.

Another special—and for a while greatly troublesome—feature of the B-29 was the brand new, but fire-prone, 18-cylinder Wright R-3350-23 engine. The 4 engines were mounted by 4-bladed Hamilton constant-speed, full-feathering propellers, 16 feet, 7 inches in diameter. In addition, instead of the traditional single unit, each engine made use of 2 turbo-superchargers.

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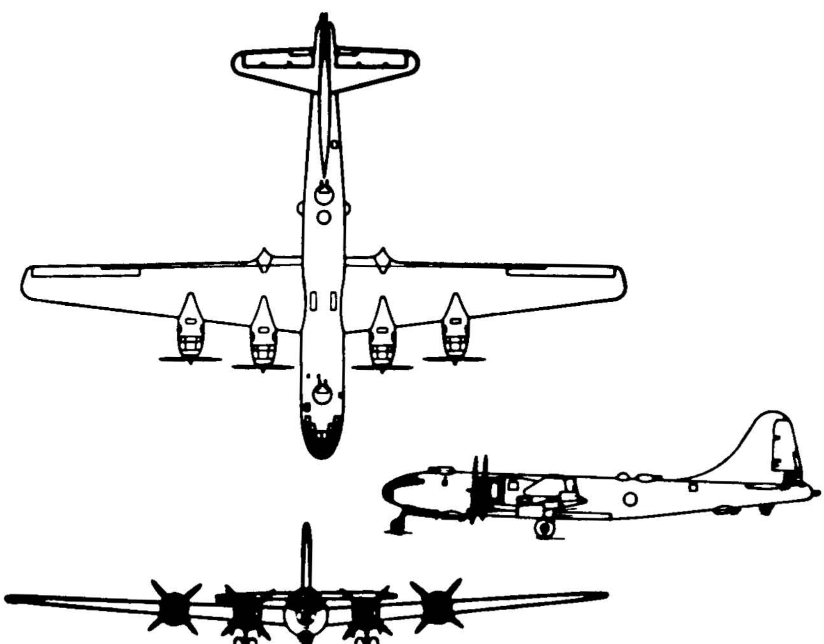
[10] Included in the crew casualties was Eddie Allen, America's most distinguished test pilot at the time.

[11] This arrangement reduced takeoff and landing distances to correspond to those of the B-17 and B-24 bombers. Nevertheless, the heavy B-29 generated extensive construction, as existing landing strips could not be used unless reinforced.

A Boeing B-29, equipped with 4 Wright engines.



Production Problems 1942–1944

The cumulative effect of the B-29's many new features caused more than the normal quota of "bugs" attendant to the production of a new plane. This was compounded by several factors. First, the B-29 was urgently needed. Secondly, troubles with the R-3350 engine hampered testing to the point that all flight operations were suspended until September 1943,[12] even though production models of the already greatly modified B-29 kept on rolling off the line. Also, the many subcontracts for equipment and sub-assemblies, generated by the rushed B-29 procurement, could not keep pace with the aircraft production. Many components, as they became available, did not fit the aircraft coming off the production line without having been modified to accommodate them.

Such a multitude of difficulties called for drastic action. The AAF's solution was to set up centers where the B-29s would be fitted with their indispensable components. But the AAF's lack of experience with the new bomber, as well as the shortage of ground equipment and tools, defeated the centers' initial efforts. The AAF then requested the assistance of Boeing and other contractors. Production personnel, mostly Boeing technicians from Wichita and Seattle, were brought to the centers to reorganize the AAF's modification programs and to help with the work. A first lot of 150 B-29s was successfully modified between 10 March and 15 April 1944, in a record period of time later referred to as the "Battle of Kansas."

War Commitments 1944–1945

B-29s of the Twentieth Air Force entered the war in June 1944 (less than 3 years after the experimental plane's first flight) with a "shakedown" raid on Bangkok, Thailand. The real air offensive against the Japanese Empire started in the same month, when 60 B-29s bombed steel mills and shipping facilities at Yowata in Japan proper. In the months that followed, XX Bomber Command B-29s from bases in China and India struck some of the enemy's most important targets in such major industrial cities as Nagasaki, Palembang, Singapore, Rangoon, Bangkok, and Tokyo. By November 1944, Tokyo was being raided regularly by the XXI Bomber Command, based at Isley Field, Saipan.

Early B-29 raids were hardly effective, their intensity being held down by inclement weather, logistical problems, and technical difficulties—espe-

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[12] By mid-1943, 2,000 engineering changes had been made to the R-3350 engine, first tested in early 1937. Approximately 500 of these changes required tooling modifications.

cially engine troubles. Despite the progress in resolving these problems, overall results of the high-altitude precision attacks conducted by the new B–29s throughout 1944 were disappointing.[13] Aircraft losses, due to enemy defenses, high fuel consumption, or engine failures, remained excessive.

In January 1945, replacing Maj. Gen. Haywood S. Hansell, Jr., Maj. Gen. Curtis E. LeMay was put in charge of the XXI Bomber Command. The new Commanding General, under pressure from General Arnold and Brig. Gen. Lauris Norstad, Chief of Staff of the Twentieth, became convinced within a few months that low-altitude incendiary bombing was feasible and would be more productive, since the B–29s at low altitude would not have to carry so much fuel and, therefore, would be able to carry more bombs. Ensuing events demonstrated the validity of the low-level bombing tactics initiated by General LeMay. In a single raid on 9–10 March 1945, B–29s loaded with incendiary bombs destroyed one-fourth of Tokyo. By June, Japan's 6 most important industrial cities were in ruins, paving the way for a forthcoming planned invasion of the enemy territory—an endeavor which, even under the best circumstances, would cause a great many U.S. casualties. But the costly invasion of Japan proved unnecessary.

On 6 August 1945, the Enola Gay, a B–29 that had been secretly modified to carry a weapon also developed with the utmost secrecy, dropped the world's first atomic bomb on Hiroshima. Bock's Car, another modified B–29, dropped a second bomb on Nagasaki 3 days later. Being, at the time, the most terrifying weapon ever devised, the atomic bomb made its point. The use of only 2, Little Boy and Fat Man, as the bombs were named, in addition perhaps to the Soviet entry into the war, compelled the Japanese Emperor to accept the Postdam requirement for unconditional surrender, which was signed on 2 September 1945.

End of Production — 10 June 1946

The end of World War II prompted the cancellation of over 5,000 B–29s, still on order in September 1945. However, several B–29s well along in production were completed. For all practical purposes, production did not end before June 1946, the last B–29 being delivered on the 10th.

Total B–29s Accepted — 3,960

The AAF accepted a grand total of 3,960 B–29s: 3,943 B–29s, 3 XB–29s

[13] High winds over Japan adversely affected bombing; occasionally, operational activities were reduced to only a few days during an entire month.

(including the experimental plane which crashed before delivery), and 14 B-29 prototypes.[14] Actually, B-29s, B-29As, and B-29Bs made up the production total. The B-29 and B-29A were alike and barely differed from the B-29B. The B-model was about 2,000 pounds lighter than the A, had an extra 150 feet in service ceiling, and a slightly longer range.

Flyaway Cost per Production Aircraft — $639,188

Airframe, $399,541; engines (installed), $98,657; propellers, $10,537; electronics, $34,738; ordnance, $3,977; armament (and others), $91,738.[15]

Subsequent Model Series — None

The B-29C designation was intended for a later model, due to use improved R-3350 engines, but the project was canceled. Featuring many improvements, including new Pratt & Whitney R-4360 engines, the B-29D was redesignated before procurement.[16]

New Planning — 1945-1946

The end of the war did not diminish the importance of the atomic-capable B-29. The 509th Composite Group, activated in December 1944 and to which Enola Gay and Bock's Car belonged, was brought back intact to the United States. The group was then assigned to the 58th Wing of the Fourth Air Force of the Continental Air Forces, which became the Strategic Air Command (SAC) in March 1946.[17] Just the same, immediate post-World War II efforts to create a full-scale atomic program were entangled in the confusion of demobilization, the transition from a 2- to a 3-service

[14] The post-World War II records of the Army Air Forces and those of the prime contractor did not match, Boeing reporting that 3,974 B-29s were delivered: a discrepancy of 14 aircraft.

[15] Available records failed to reveal if the cost of modifying some B-29s to carry and deliver the first atomic bombs was prorated in the final figure.

[16] See B-50.

[17] Actually, the Headquarters, Continental Air Forces, was redesignated Headquarters, SAC. Some of the air forces under Continental Air Forces went to the Tactical Air Command and to the Air Defense Command.

military system, the question of atomic custody, and the belief that atomic bombs would not be extensively used in the future.

Despite the generally conservative attitude toward the atomic bomb in late 1945 and much of 1946, the AAF remained aware of the need to keep delivery capability up to date. A first step in that direction was the creation of a 3-squadron atomic striking force as part of the 58th Bombardment Wing. Other early plans were affected by various opinions. Shortly after the Nagasaki raid, Gen. Carl Spaatz, Commanding General of the U.S. Strategic Air Forces in the Pacific, pointed out that the atomic bomb had such a wide range of destruction that its use should primarily be intended against industrial areas. Smaller areas could be handled better, and at a much cheaper cost, by the normal type of bomb. In short, General Spaatz believed that wasting atomic bombs on small targets would be "like using an elephant gun on a rabbit." The words of General Spaatz, who was to become in September, 1947, the first Chief of Staff of the new United States Air Force, were not to be forgotten. In the meantime, however, they brought to mind another troublesome factor.

As early as 1945, it was obvious that any major war in the forseeable future would be against Russia. Using the atomic bomb as a weapon of psychological terror was one thing; the atomic strategic doctrine advocated by General Spaatz was another. Since the Soviet Union's industry was scattered in the Soviet Union's heartland, the general's strategy called for bombers capable of covering immense distances. Even from bases in Europe, the range would be very great. To further this strategy,[18] the AAF decided in January 1946 that atomic-capable B-29s would be equipped with new Pratt & Whitney R-435-57 engines. This change should improve reliability, while increasing range and speed.

Special Modifications 1946–1947

Modification of the original lot of B-29s, earmarked to carry the first atomic bombs, had been a slow and difficult task, even though most of the work centered on the aircraft bomb bay. At first, several of the designated aircraft were modified by hand. Changes in specifications were frequent, since scientists continued to improve their own designs for the new atomic bombs; the modification process grew more complex as new technological developments swiftly accrued.

Early in 1946, 22 of the 509th Composite Group's B-29s were at the Oklahoma City Air Materiel Depot for installation of the MX-344 radar

[18] See B-36, pp 11-14.

computer, more easily removable engine cowlings, and other miscellaneous items, which would further improve the performance of the newly, or soon to be, re-engined planes. By April 1947, 46 atomic-capable B-29s had received the latest special modifications, and work had begun on 19 others. However, only 24 of the 46 modified planes were operational, 20 being flown by the 509th and 4 by the testing section. Four of the other remodified B-29s had been destroyed, 1 was used as a mockup for further standardization of past modifications, and the remainder were being stripped of the equipment previously added to allow the aircraft to carry the original bombs.

Because of the advent of the B-50 (an improved B-29 known as the B-29D until December 1945), no additional modifications were programmed after May 1947. Yet, the atomic-capable B-29s would not immediately become obsolete. They were capable of carrying some of the latest atomic bombs and could be used for combat in an emergency. They undoubtedly could ferry atomic weapons from the United States to forward bases, as called for by the latest plans. In any case, obsolete or not, as growing international tensions were aggravated by the Korean conflict and the production of new atomic-capable aircraft slipped, 180 of the thousands of B-29s left from World War II had to be reactivated and modified for the atomic task.[19]

Overseas Deployments 1946-1952

While a handful of B-29s were earmarked for the atomic role, and various kinds of reconfigured B-29s became directly involved in the support of these special aircraft, a great many B-29s, left over from the war, remained the mainstay of the medium bombardment force until 1952.[20] There were good reasons for the aircraft's retention. The postwar period witnessed drastic budgetary restrictions; developing and producing any aircraft was a time-consuming task, and the impact of new technology was bound to lengthen this task.[21]

In 1946, SAC's only bomber was the B-29—148 of them. Despite the shortage, B-29 rotational tours of duty in Europe and the Far East were

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[19] See B-50, pp 173-174.

[20] The heavy B-29 was reclassified as a medium bomber on 17 September 1947. For details, see B-36, p. 21.

[21] As aircraft systems became increasingly more complex, their production time rose by several orders of magnitude. Thus, while it took 200,000 manhours to assemble the B-17, the B-29 and B-36 required approximately 3 million manhours each. With the advent of the jet-powered B-52, production time again rose dramatically, to more than 7 million manhours.

started in that year. By 1948, the SAC B–29 fleet had been increased to 486 aircraft, and the oversea rotation of B–29 units had been intensified. In late June, when the Berlin Blockade began, extra B–29s were immediately deployed to England and Germany. The rest of the SAC force was put on 24-hour alert.

New War Commitments 1950–1953

On 25 June 1950, when the North Korean armies crossed the 38th parallel, the 19th Bombardment Group, the only Far East bombardment unit available for the air counter-offensive was immediately moved from Guam to the more strategically favorable location of Okinawa. Reinforcement, obviously needed, was provided swiftly. On 3 July, Gen. Hoyt S. Vandenberg, USAF Chief of Staff, ordered the 22d and 92d Bomb Groups to deploy their B–29s to the Far East to carry out conventional bombing operations north of the 38th parallel. Once in the Far East, SAC's 22d and 92d Bomb Groups joined the 19th Bomb Group of the Far East Air Forces (FEAF) to form the FEAF Bomber Command (Provisional), which was organized on 8 July. The bomber command's first strike took place on 13 July, when 50 B–29s hit Wonsan, an important North Korean port. But additional B–29s were still needed, and SAC again quickly managed to comply.

By late September 1950, the strategic bombardment offensive was finished. The FEAF Bomber Command had destroyed all significant strategic targets and enemy airfields in North Korea, establishing in the process that the Strategic Air Command's mobility concept was valid and practicable. This was an important lesson of the Korean War. Another, of a controversial nature, was demonstration of the strategic bomber's versatility. Because the early ground situation was desperate, many B–29s were initially diverted from the strategic mission to direct support of the ground forces. Despite adverse weather conditions, the B–29s blasted successfully such tactical targets as trucks, tanks, troop bivouacs, supply dumps, and the like.

The Air Force met the immediate demand for additional bombers in Korea in large part by withdrawing B–29s from storage. While commercial contractors removed the planes and made them combat ready, Air Materiel Command depots overhauled engines and accessories. The command also set up a production line at the Sacramento Air Depot, California, to recondition B–29s returned from the Far East for necessary repairs.

Late in 1950, 2 bomb groups were allowed to return to the United States. Other SAC B–29s, plus 1 squadron of B–29s that had been converted for the reconnaissance role, remained in the Far East, under the operational control of the FEAF Bomber Command, until the fighting ended on 27 July

1953. Except for FEAF's own B-29s, which had been raised to wing level, the FEAF Bomber Command was composed entirely of SAC units and was commanded by SAC personnel. Of course, combat losses occurred.[22] Yet, they were relatively low when compared to the bomber command's achievements. Through the 3-year conflict, B-29s flew 21,328 effective combat sorties, including 1,995 reconnaissance sorties and 797 psychological warfare sorties. The B-29s dropped 167,000 tons of bombs on various targets, ranging from front-line enemy troop emplacements to airfields on the banks of the Yalu River. The 98th and 307th Bomb Wings, also elevated from group level, and the 91st Strategic Reconnaissance Squadron were included in the South Korean Presidential Unit Citation that was bestowed upon the FEAF Bomber Command (Provisional).

Immediate Phaseout — 1954

The increasing availability of B-36s, B-47s, and B-50s, spelled the B-29's end. On 4 November 1954, SAC's last B-29 bomber, an A-model, which had been assigned to the 307th Bomb Wing, Kadena Air Base, Okinawa, was retired to the Air Force aircraft storage facility at Davis-Monthan AFB, Arizona.

Other Configurations — KB-29M, KB-29P, RB-29, TB-29, VB-29, and WB-29[23]

KB-29M: In 1948, 92 B-29s were sent to the newly reopened Boeing Wichita Plant for conversion to hose-type tankers, subsequently known as KB-29Ms. This project was urgent, being directly associated with the build-up of the atomic forces. The bomber's serious range limitations had called for special arrangements. There was an extensive forward base network, encompassing airfields in Alaska, Canada, England, West Germany, Spain, North Africa, Okinawa, and Guam. But the use of overseas staging bases was a troublesome expedient.[24] A better solution was to

[22] The B-29 was exceptionally vulnerable to the MiG-15, even at night.

[23] Other designations were applied or allocated to reconfigured or due to be reconfigured B-29s, but such designations were dropped, as the reconfigured aircraft (usually a single model) fulfilled their special purposes, or were not used because the projects for which they had been designed were canceled.

[24] See B-50, p 11 and p 15.

develop inflight refueling systems that would give to the SAC bombers the intercontinental striking range they still lacked.

The first such system was featured by the K-29M, which was fitted with British-developed hose refueling equipment. The British system involved trailing a hose from the tanker to the receiver and transferring fuel practically by means of gravity. The receiver aircraft (listed as B-29MR, in the B-29's case) also required modifications, but they were relatively minor. In contrast, the tanker modifications were extensive. Each bomb bay was fitted with a separate jettisonable tank holding approximately 2,300 gallons of fuel. These tanks were connected to the aircraft's normal fuel system so that fuel from it could also be transferred to the receiver bomber. The KB-29M's inflight refueling system required that the tanker and receiver fly in formation, with the tanker above and ahead trailing a cable referred to as the hauling line. The receiver trailed a line of its own from its refueling receptacle. Called the contact line, this line was so equipped that it could hook the tanker's trailing line and lock the two lines together. The receiver operator then caught the lines, separated them, secured them, pulled the tanker's refueling hose and put it into the receptacle of his bomber. The

The forward compartment of the B-29 housed the bombardier (front), pilot (left), and co-pilot (right).

whole procedure, obviously, was perilous from the start, and the KB-29Ms, after reaching the inventory in late 1948, were replaced within a few years.

KB-29P: The hose refueling system had many disadvantages, especially in the lengthy time required to make contact, the slow rate of fuel transfer, and the very limited airspeed imposed by the hoses. Boeing therefore soon developed on its own an aerodynamically controlled swivelling and telescoping arm, known as the "Flying Boom." Essentially, this system consisted of a telescopic pipe, which was lowered from the tanker, and connected to a socket in the receiver aircraft. The system was entirely controlled by an operator in the tanker, and the fuel transfer was made with the aid of a pump. B-29s so equipped were designated KB-29Ps. The first of 116 KB-29Ps reached SAC's 97th Air Refueling Squadron on 1 September 1950, the total contingent being delivered by the end of 1951. In spite of the increasing availability of the much faster KC-97,[25] SAC retained many of its KB-29Ps until 1957. The Tactical Air Command gave up its last KB-29s in the middle of that year.[26]

RB-29: Nearly 120 B-29s were converted to the reconnaissance configuration and redesignated as RB-29s. Some of these aircraft, known as F-13s during World War II, were first fitted with fairly primitive photographic equipment: 3 K-17Bs, 2 K-22s, and 1 K-18 camera. After 1948, when the RB-29 designation came into being, the converted bombers began acquiring more sophisticated components. The RB-29s were assigned to the 91st Strategic Reconnaissance Squadron, which like other SAC units played a crucial role during the Korean conflict. The RB-29s followed the phaseout pattern of the bombers from which they derived. The same reasons prompted their retirement.

TB-29: Some B-29s, fitted with additional trainee or instructor stations, recording equipment, and related types of apparatus, were used for training and identified as TB-29s.

VB-29: A few B-29s, after being internally refurbished, were used for the transportation of key personnel.

WB-29: Some B-29s were modified to carry meteorological equipment

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[25] Outfitted with an improved version of the flying boom and additional air-refuelable tanks, the 4-engine, propeller-driven KC-97 could fly fast enough to match the B-47's minimum speed. Manufactured by Boeing, the KC-97s began reaching SAC in July 1951.

[26] The urgent conversion of B-29s to the tanker configuration had been dictated by the initial deficiencies of the growing atomic forces. When more efficient, atomic-capable bombers and better tankers became available, the KB-29P's flying boom system was adapted to fighters and other bombers, which had their receptacle fitted in a variety of positions. This allowed other forces to make use of the KB-29Ps, when the allocation of improved tankers was still at a premium.

and used on weather-reconnaissance flights. Designated as WB-29s in1948, these aircraft were the last B-29s to phase out of the regular Air Force.

Final Phaseout 1959

Regardless of configuration, no B-29s appeared on any Air Force roll after 1959.

Milestones 1951

On 6 July 1951, despite its rudimentary equipment, a KB-29M refueled 4 RF-80 aircraft flying a reconnaissance mission over North Korea. On 14 July, a KB-29P, outfitted with the boom-type system, refueled 1 RB-45C on a combat mission over North Korea. These were the first air refueling operations conducted over enemy territory under combat conditions.

Items of Special Interest Mid-1944

Early engine problems delayed the B-29's entrance into World War II. The much-needed and initially few bombers were piloted by some of the WASPs (Women's Air Force Service Pilots),[27] themselves a new phenomenon of the war and restricted to non-combat operations.

The technological importance of the American-made B-29 was quickly confirmed. One of the bombers, after crash-landing in Soviet territory during World War II, was not returned, even though Russian authorities promptly returned the unharmed crew. The reason soon became obvious, as Russia developed her own version of the B-29, known as the TU-4. In 1951, foreign observers in Russia saw a derivative version of the TU-4 with turboprop engines.

[27] The title WASP was the designation for the women pilots of the Army Air Forces.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

B-29 AIRCRAFT

Manufacturer (Airframe)	Boeing Airplane Co., Seattle and Renton, Wash., plus Wichita, Kans.
Manufacturer (Engines)	The Wright Aeronautical Corp. (a division of the Curtiss-Wright Corp.), Wood-Ridge, N.J.
Nomenclature	Medium Bomber
Popular Name	Superfortress

	B-29
Length/Span (ft)	99.0/141.2
Wing Area (sq ft)	1,736
Weights (lb)	
Empty	71,500 (actual)
Combat	101,082
Takeoff	140,000
Engine: Number,	
Rated Power per Engine	(4) 2,200-hp
& Designation	R-3350-57 or -57A
Takeoff Ground Run (ft)	
At Sea Level	5,230
Over 50-ft Obstacle	7,825
Rate at Climb (fpm) at Sea Level	500
Combat Rate of Climb (fpm) at Sea Level	1,630
Service Ceiling at Combat Weight (100 fpm Rate of Climb to Altitude)	39,650
Combat Ceiling (500 fpm Rate of Climb to Altitude)	36,250
Average Cruise Speed (kn)	220
Max Speed at Optimum Altitude (kn/ft)	347/30,000
Combat Radius (nm)	1,717 (with max bombload)
Combat Target Altitude (ft)	30,000
Total Mission Time (hr)	15:35
Crew	11[a]
Armament	5 turrets (mounting 12 .50-cal guns)
Maximum Bombload (lb)	20,000

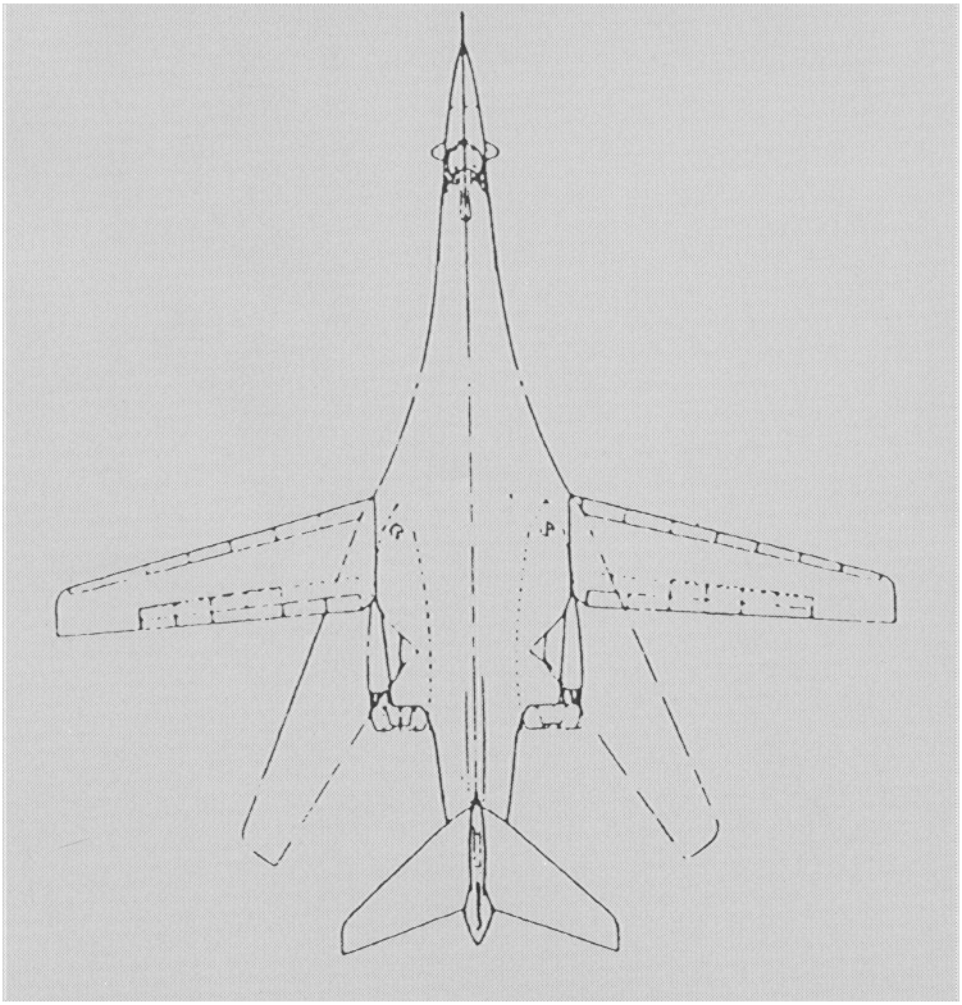
Abbreviations

cal	= caliber	kn	= knots
fpm	= feet per minute	max	= maximum
hp	= horsepower	nm	= nautical miles

[a]The crew of 11 were in 3 pressurized compartments linked by crawl-spaces. The standard crew had 5 officers: a pilot, co-pilot, flight engineer, bombardier, and navigator. These, plus the radio operator, normally worked in the forward compartment, while the one aft housed gunner-mechanics, and a radar operator. The tail gunner was alone in the smallest compartment.

Appendix II

Post-World War II Experimental and Prototype Bombers



XB-35
Northrop
Aircraft, Incorporated

Manufacturer's Model N-9M

Basic Development 1923

The origin of the B-35 may be traced as far back as 1923, when John K. Northrop, then an engineer with the Douglas Aircraft Company, became interested in the possibilities of a "flying wing" design. However, more than a decade would pass before the young engineer's efforts showed tangible results. In August 1939, John Northrop became President and Chief Engineer of Northrop Aircraft, Incorporated, a totally independent concern primarily interested in the manufacture of military aircraft. Less than a year later, the N-1M, as Northrop called his initial "flying wing," took to the air.[1] It was the world's first pure all-wing airplane, and high-ranking officials of the Army Air Corps were soon impressed by the flight characteristics of the spectacular research vehicle. The Army Air Forces (established in June 1941) applied the designation XB-35 to the N-1M's military variant, which was subsequently ordered.

Military Characteristics 1941

On 27 May 1941, the Army Air Forces (AAF) asked Northrop to provide studies of the flying wing as it related to requirements for a bomber with a range of 8,000 miles, a minimum cruising speed of 250 miles per

[1] The N-1M's first flight occurred on 3 July 1940. In 1945, following completion of its test program, Northrop sent the airplane to the Army Air Forces for display in the Wright-Patterson Museum, Dayton, Ohio. The Air Force eventually transferred the N-1M to the Smithsonian Institution, which stored it at Silver Hill, Maryland.

hour, a service ceiling of 40,000 feet, and a bombload of 10,000 pounds. Such characteristics were far less demanding than the preliminary ones of April 1941, which led to production of the Convair B-36.[2] The revised characteristics of August 1941, slightly more ambitious than the May characteristics, were again submitted to Northrop and other potential manufacturers of conventional, long-range bombers. Contrary to expectations, by year's end only 2 models were contemplated for production before the Boeing B-29: the Northrop XB-35 and the Convair XB-36. The first was extremely unconventional, aerodynamically; the second was unconventional, but strictly from the weight, propulsion, and size standpoint. Although the AAF deplored the lack of choice offered by its experimental heavy bombardment program, several years would go by before comparable bombers would appear on the drawing boards.[3]

Initial Procurement — 1941

The Northrop proposal submitted to the AAF in September 1941 was immediately followed by contractual negotiations. In a departure from standard practices, the initial procurement of the flying wing was preceded by a purchase order for engineering data, model tests, and evaluation of reports on the N-1M that had been flight-tested since June 1940. Also included was the purchase of the first N-9M, a 1/3-scale flying mockup of the future B-35. The entire order, approved by Secretary of War Henry L. Stimson on 3 October 1941, was covered by Contract W535 ac-21341 which was signed on the 30th.[4]

Procurement of the first full-scale flying wing, endorsed by Maj. Gen. Henry H. Arnold, Chief of the AAF, on 9 September 1941, came under Contract W535 ac-21920 on 22 November. At the contractor's request, the contract, estimated at $2.9 million, was of the cost-plus-fixed-fee type because, as pointed out by Northrop Incorporated, development of the XB-35 was a large project, involving funds in excess of those available to the company for experimental purposes. In addition, Northrop anticipated that materiel and labor costs would rise significantly before November 1943, when the XB-35 was scheduled for delivery. Besides providing for the first XB-35, Contract W535 ac-21920 included 1 XB-35 mockup, engineering

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2 See B-36, pp 5-7.

3 See B-52, pp 205-211.

4 Available records did not reveal the cost of Contract W535 ac-21341, an oversight which by the end of the costly flying wing program proved immaterial.

data, plus an option clause covering the purchase of 1 additional XB-35. This option was exercised on 2 January 1942. Northrop quoted a delivery date of April 1944 for the second XB-35, also known as the back-up article. Estimated extra costs were set at $1.5 million.

Additional Procurement 1942

Another cost-plus-fixed-fee contract (W535 ac-33920) was approved on 17 December 1942. It called for the construction and testing of 13 service test models of the XB-35, designated YB-35s. Counting spare parts and the contractor's fee, the contract's cost was expected to reach $22.7 million. The AAF's approval of this YB-35 prototype contract followed by a few months the purchase of 2 additional N-9Ms, a fourth and last N-9M being ordered in mid-1943.[5]

Special Features 1942

The huge XB-35's most noticeable features were its size and shape. Otherwise, the 4-engine aircraft was not so unusual. Its cantilever wings of aluminum-alloy were constructed in 1 piece, straight-tapered, and swept back. On the other hand, the XB-35 also featured some distinctive internal characteristics. It offered 8 spacious bomb bays, and the crew compartment and various systems bays were fully pressurized. In addition, the future B-35 would provide 6 beds and a small galley to allow 6 of the aircraft's 15 crewmen to rest during long missions.

First Flight (N-9M) 27 December 1942

As a military variant of the N-1M, the N-9M was similarly built and consisted primarily of a welded steel tube center section and an external covering of wood. As a research model of the XB-35, the 60-foot wing-span N-9M closely resembled the future full-size "flying wing." Two Menasco C654 engines aboard the N-9M, instead of the 4 Pratt & Whitney R-4360s earmarked for the XB-35, were the main difference between the 7,100-pound scaled-down model and the experimental bomber, originally planned. Actually, the N-9M was expected to allow Northrop to more accurately

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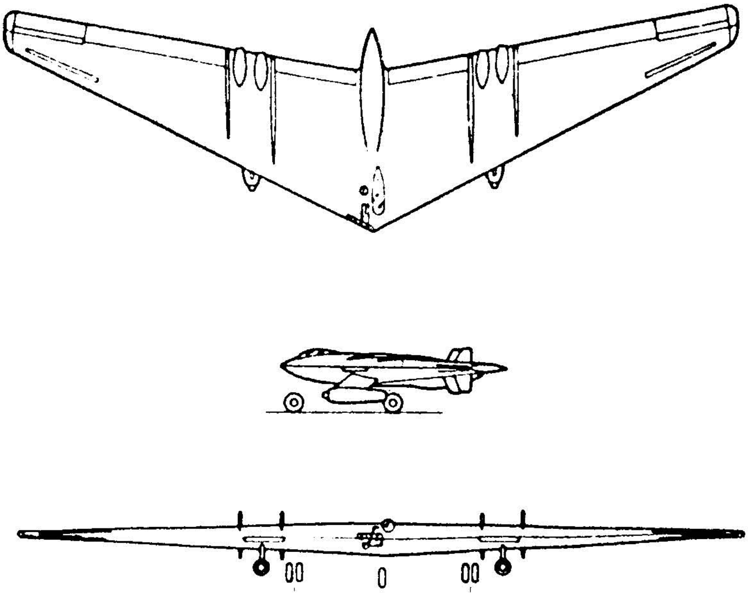
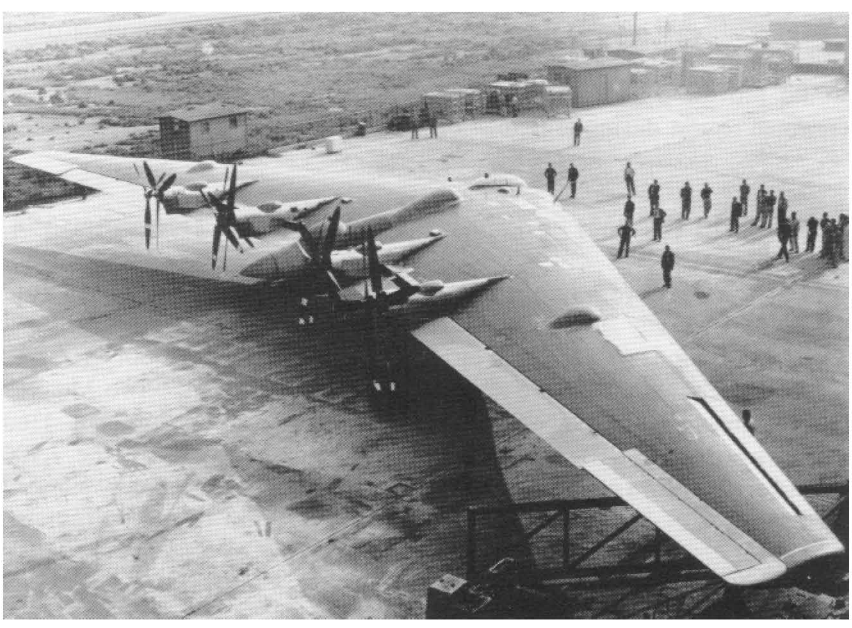
[5] Retained records did not itemize the costs of the additional N-9Ms. However, such costs were included in the XB-35 program's total amount.





The Northrop XB–35, with its 4 engines at the rear.

predict the flight characteristics of the upcoming XB-35, a purpose which presumably would also save money and time. Nevertheless, the N-9M's first flight on 27 December 1942 was about 3 months behind schedule. Nearly all of the N-9M's ensuing flight tests were shortened by mechanical failures of one kind or another, most of them involving the Menasco engines that also equipped the next 2 N-9s.

The initial N-9M crashed on its 45th flight, killing its Northrop test pilot. The crash on 19 May 1943, after the model had only accumulated some 22 hours of flying time, was closely followed by the second N-9M's first flight. During the maiden flight of the second model, on 24 June 1943, the small aircraft's cockpit canopy was lost shortly after takeoff, but a successful landing was made.[6] Meanwhile, other difficulties had begun to compound the AAF's many problems.

Preliminary Difficulties 1942–1943

The multitude of requirements generated by World War II complicated from the start the Army Air Forces' many tasks. While all sorts of weapons were urgently needed, shortages of material and manpower resources could not be immediately resolved. National priorities, regardless of their careful selection, hampered the timely progression of some aircraft programs and nearly stopped the development of crucial experimental projects. Two cases in point were the Convair B-36 and the Northrop B-35, the latter presenting the AAF with a peculiar situation. Northrop, located in Hawthorne, California, while sharing the industry's shortage of engineers, also lacked adequate production facilities. The Materiel Command's efforts to borrow engineers from other West Coast manufacturers to assist the young corporation had been totally unsuccessful, and the possibility of enlarging the Hawthorne plant was non-existent.

By the end of 1942, it seemed that Northrop's problem was solved as negotiations, instigated by the AAF, were being concluded between Northrop, Incorporated, and the Glenn L. Martin Company. In short, Northrop had indicated that it would be satisfied to fabricate only the experimental and prototype B-35s. The Martin production contract for 400

[6] Slightly different N-9M's were still being tested late in 1945, even though a total of 150 flights had been accomplished. Flights of the remaining models averaged considerably less than 1 hour each. This time limit was shared by the N-9MB, the fourth N-9, bought to replace the lost N-9M and powered by 2 Franklin 0-540-5 air-cooled engines.

B-33s had been canceled on 25 November,[7] and this actually meant that the B-35 could be produced, in lieu of the deficient B-33, at Martin's spacious Baltimore plant in Maryland. This change would also allow Northrop and the AAF to benefit from Martin's engineering talent and experience in the design of large, long-range transport airplanes. But this optimistic outlook was to prove deceptive.

Other Problems 1943–1944

Hampered by mechanical failings, the N-9 flight test program prevented the acquisition of reliable flight data through 21 September 1943, when the N-9MB, last of the N-9s, initially flew. Engines excepted, the N-9MB included all latest design features of the XB-35, but the model's flight testing did not help the XB-35's cause. By the end of November, test results indicated that the XB-35's range would most likely be 1,600 miles shorter than anticipated and that the bomber's highest speed would be at least 24 miles per hour below previous estimates. Such disappointing prognostics were not overlooked. General Arnold[8] himself began to question the merits of the extensive B-35 production plans.

Production of 200 B-35s, as planned in November 1942, was formalized on 30 June 1943 by Contract W535 ac-24555, which called for delivery of the first "flying wing" by June 1945. But Martin had already begun to lose personnel to the draft before the contract was signed. In mid-1943, projected delivery rates were reduced by 50 percent, and Martin pointed out that changes requested by Northrop amplified the many risks shrouding the aircraft's manufacture. In August, Martin reiterated its concern for the shortage of engineers and the project's uncertainties, adding that perhaps further production expenditures should be postponed. By March 1944, the Baltimore plant still lacked tooling, and Martin had rescheduled delivery of the first B-35 to 1947. Not surprisingly, the AAF's headquarters canceled the Martin production contract on 24 May 1944. The decision, however, did not spell the end of the "flying wing." In November, the Air Technical Service Command's Engineering Division reported that the XB-35 project seemed worthwhile "even if the B-35 never becomes operational."

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[7] By that time, Martin knew that a production contract for 200 B-35s was forthcoming. Furthermore, the company had many other commitments. In fact, it had to refuse to make a study of the long-range, heavy bombardment airplane, as suggested by the AAF in October 1942.

[8] General Arnold had received his fourth star in March 1944.

Program Changes 1944–1945

In December 1944, some 6 months after the Martin production contract was nullified, modification requests began to alter the B-35 development contract. The AAF decided that Northrop would build the first 6 B-35 prototypes (YB-35s) on the XB-35's pattern, with certain exceptions affecting individual aircraft. Soon afterward, Northrop was authorized to build 2 of those 6 prototypes as all-jet models, a change so important that it actually marked the beginning of a new program.[9] In 1945, after 2 YB-35s had been added to the first YB-35 lot to replace the 2 earmarked for jet-conversion, the AAF told Northrop to manufacture the remaining 5 airplanes to more advanced specifications, a directive that automatically entailed the aircraft's redesignation as YB-35A.

In the meantime, Northrop, like Martin, had its share of problems. The poor showing of the N-9 and the impact of the war had not helped the experimental program. In 1941, Northrop believed the first XB-35 could be delivered in November 1943. But by May 1944, the best estimate for the XB-35's first flight was August 1945, another optimistic prediction that would not materialize.

First Flight (XB-35) 25 June 1946

The initial flight of the first XB-35, from Hawthorne to Muroc Army Airfield, California, took place at long last on 25 June 1946 and lasted 45 minutes. Two AAF test pilots, after maneuvering the first XB-35 during its initial and second flights, termed the experimental flying wing "satisfactory, trouble-free." Yet, once again, this encouraging appraisal was to prove wrong.

Grounding 1946–1948

Gear box malfunctions and propeller control difficulties prompted the XB-35's grounding on 11 September 1946, less than 3 months after the aircraft's first flight. Flying was not resumed until February 1948, after many modifications had taken place that affected the aircraft's engineering as well as the entire experimental program.

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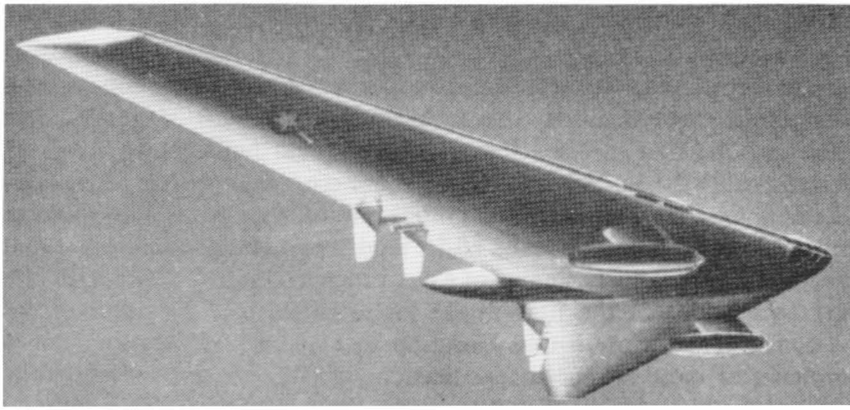
[9] See YB-49, this appendix, p 536.



The all-jet prototype YB-35A.

Testing 1946–1948

The first XB–35 underwent only about 24 hours of testing, all of which were accumulated in 19 contractor flights. The second XB–35, also covered by Contract W–535–ac–21920 of November 1941, fared even worse. First flown on 26 June 1947 (a slippage of 3 years), the plane was tested for approximately 12 hours. As in the first XB–35's case, Northrop pilots did the testing. Only 8 flights were accomplished.

Modifications 1947–1948

Since most of the serious troubles encountered during testing were attributed to the XB–35's dual-rotation propellers and gear boxes, significant modifications were undertaken. In February 1948, flights of the first XB–35 were resumed, this time with single-rotation propellers and simpler gear boxes installed. The new installation began to operate without exhibiting any particular mechanical difficulties, but test pilots immediately reported considerable vibration and reduced performance. Moreover, the modified XB–35's landing gear doors still failed to close after gear retraction, a malfunction that had plagued the 1947 tests.

Cost Overruns 1947–1948

The cost of the first XB–35 had initially leaped from an estimated $2.9 million to a substantial $14 million, and other financial setbacks were on the way. In February 1947, Northrop reported that the 2 all-jet prototypes

(YB-49s) and the first 6 YB-35s (built to XB-35 specifications) were either complete or nearing completion. However, the originally allocated $23 million would cover construction of only 3 or 4 of these aircraft. An additional $8 million would probably finance completion of these 8 planes, and $16 million would make it possible to complete all 13 (counting the 5 YB-35As included in the program changes of 1945). On 28 May 1947, $12 million was approved for cost overruns—$4 million below Northrop's estimate. At the end of January 1948, Northrop again reported that an additional $4.4 million would be required to complete all 13 aircraft.

Program Review — June 1948

By mid-1948, the XB/RB-35 program had started to show definite signs of an approaching demise. To begin with, a propeller-driven bomber could not match the performance of jet bombers already in development and nearing the production stage. In addition, the "flying wing" in its mid-1948 configuration was less stable than a conventional wing-fuselage aircraft, and thus made an inferior bombing or camera platform. The factor that kept the program alive was the multi-million dollar investment in the aircraft's development, with no tangible gain for the operational forces. Such failing most likely accounted for the Air Force's decision to get a reconnaissance version of the jet-equipped YB-35s, first ordered in 1945. The decision, as formalized in June 1948, called for the production of 30 aircraft, due to be known as RB-49As.[10] As it turned out, the RB-49 project, like other "flying wing" ventures, proved unsuccessful. In the meantime, and again because of the money involved, the Air Force continued to attempt rescuing the original XB-35 program. For example, a study was underway in mid-1948 to determine the feasibility of producing the B-35 for the air-refueling role.

Other Proposals — July-December 1948

Proposals for conversions and modifications of the experimental B-35s increased during the second half of 1948. Both contractor and Air Force still hoped that a tactical or strategic mission could be found for the aircraft. Yet, the odds were not encouraging. In August, Northrop indicated that existing experimental contracts could be completed with the funds already allotted if no further changes were made, but Air Materiel Command promptly

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[10] See this appendix, pp 541-542.

pointed out that such a procedure would be self-defeating. Changes were necessary, the command insisted, to solve the vibration problems created by the single-rotation propellers. Also, the XB-35's intricate exhaust system caused tremendous maintenance difficulties, and the cooling fans of the R-4360 engines were beginning to fail due to metal fatigue. The only solution, the Air Materiel Command believed, was to convert every B-35 prototype to a 6-jet configuration.

By the end of 1948, modification plans had evolved further. Five YB-35s and 4 YB-35As were to be equipped with Allison J35-A-17 jet engines (6 per aircraft), fitted with cameras, redesignated RB-35Bs, and used for reconnaissance. In addition, 1 YB-35A was earmarked for static tests, a second YB-35B, after being re-engined with 6 Allison jets, was to serve as a reconnaissance prototype for the B-49 program, and a third jet-converted YB-35A would be fitted to serve as a test bed for the T-37 turboprop engine being developed by the Turbodyne Corporation, a Northrop subsidiary. Referred to as the EB-35B, the test-bed aircraft (last of the 13 prototypes included in the B-35 experimental program) would be capable of carrying 2 T-37 engines, although only 1 would be initially installed. Finally, a flexible-mount gear box would be fitted in the second XB-35 to try stopping the vibrations caused by the aircraft's single-rotation propellers. All this, the Air Materiel Command calculated, could probably be done with an additional $13 million.

Total Development Costs — $66 million

By the end of fiscal year 1948, development costs of the experimental B-35 had reached $66,050,506.[11] More than one-third of this amount had been spent on the first contract (535-ac-21920). This cost-plus-fixed-fee contract, as amended in January 1942, gave the Air Force 2 XB-35s for a final sum of $25,632,859, some $21 million more than originally estimated by the AAF. The remaining $40,417,647 covered the second and last cost-plus-fixed fee contract (535-ac-33930) which, as supplemented by Change Order No. 11, totalled $24,417,647, excluding cost overruns of $12 and $4 million, approved respectively in April 1947 and April 1948.

Program Cancellation — November 1949

Faced with a $13 million modification proposal at a time when money

[11] Including $1,644,603, which paid for conversion of 2 YB-35s to 6-jet-equipped B-49 prototypes.

was especially scarce, Air Force enthusiasm for the B-35 conversion program fell sharply. In August 1949, the 2 XB-35s and the first 2 YB-35s were scrapped. And while the decision did not signify the official end of the program, its fate was determined soon afterward. In November, the Air Staff canceled plans to convert remaining YB-35s and YB-35As, pointing out that no requirements existed that a "flying wing" could fulfill as efficiently as more conventional aircraft.

Total XB/YB-35s Accepted 15

Two XB-35s and 13 YB-35s were paid for and also accepted, in theory. In actuality, the Air Force hardly took possession of the B-35 lot. Some of the aircraft were diverted to the B-49 program, and most others, although finally completed, were immediately scrapped.

Final Disposition 1950

Scrapping of the remaining YB-35 types started in December 1949 and ended in March 1950, when the disassembling of the EB-35B test-bed began.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

YB-35B AIRCRAFT[a]

Manufacturer (Airframe)	Northrop Aircraft, Inc., Hawthrone, Calif.
Manufacturer (Engines)	Designed by the General Electric Co.; built by the Allison Div. of the General Motors Corp.
Nomenclature	Long-Range Bomber
Popular Name	Flying Wing

Length/Span (ft)	53.1/172
Wing Area (sq ft)	4,000
Weights (lb)	
Empty	82,807
Combat	125,715
Takeoff	175,000 (limited by structural strength)
Engine: Number, Rated Powers per Engine, & Designation	(6) 4,900-lb st J35-A-19
Takeoff Ground Run (ft)	
At Sea Level	4,280
Over 50-ft Obstacle	5,380
Rate of Climb (fpm) At Sea Level	1,500 (at takeoff weight, with max power)
Combat Rate of Climb (fpm) at Sea Level	3,050 (with max power)
Service Ceiling (100 fpm Rate of Climb to Altitude)	30,200 (takeoff weight/normal power)
Combat Ceiling (500 fpm Rate of Climb to Altitude)	36,200 (with max power)
Max Speed at Optimum Altitude (kn/ft)	381/35,322 (max power)
Combat Radius (nm)	1,300 with no payload, at 337 kn
Total Mission Time (hr)	7:9
Crew	4
Armament (provisions for)	(20) .50-cal guns
Max Bombload (lb)	40,000

Abbreviations

cal	=	caliber
fpm	=	feet per minute
kn	=	knots
max	=	maximum
nm	=	nautical miles
st	=	static thrust

[a]Estimates only.

XB-42 and XB-42A Mixmaster
Douglas
Airplane Company, Incorporated

Basic Development 1943

Studies made by Douglas in early 1943 marked the start of the official development of the XB-42, first known as the XA-42.[12] The radically new design was another example of the evolutionary process, although it incorporated features of the slightly smaller A-20 and A-26 airplanes, also manufactured by Douglas.

Requirements 1943

Requirements for the XA-42 (formally redesignated as the XB-42 on 25 November) stemmed from the Army Air Forces's recurring need during the war years for smaller, more efficient, more economical, speedier, and longer-range tactical bombardment aircraft. Acquisition of the XA-42 was related to that of the B-29. The Army Air Forces (AAF) wanted modern light bombers to avoid using costly strategic bombers in strictly tactical applications.[13]

Initial Procurement 25 June 1943

The design proposal, submitted by Douglas in April 1943, impressed

[12] In 1939, the "attack aviation" category was replaced by a "light bombardment" one, even though the "A" designation was kept throughout the war. One reason for the change came from Gen. H. H. Arnold's belief that it was more efficient and safer to fight the enemy with light bombers, and their carefully selected bombloads, than to rely on the machine guns of the attack-type aircraft.

[13] A few B-29s were flyable in June 1943, but the aircraft would not be ready for combat before 1944. Moreover, even though production was stopped in late 1945, the average unit cost of the B-29 reached over $600,000 (a high price in 1940-1945 dollars).

the AAF favorably, and Letter Contract W535-ac-40188 was approved on 25 June. This document, calling for 2 experimental models and a static test article, was logged by the Materiel Command[14] under Project MX-392 as a purely experimental endeavor. And, as it turned out, plans for manufacturing production models of the airplane did not go beyond the discussion stage.

Additional Requirements — September 1943

In September 1943, just a few months after approval of the XB-42 project, the AAF asked if jet engines could be added to 1 of the experimental aircraft covered by the contract of June 25th. In October, the Materiel Command recommended that jet engines be installed in the XB-42 static test article, if the contractor thought that a satisfactory all-jet airplane would result. Douglas quickly pointed out that development of a practically new aircraft would take time and that modifying 1 of the XB-42s would be much faster. But the AAF's interest in jet propulsion was increasing, and the development and production of new jet bombers were strongly favored. Hence, the XB-42 modification devised by Douglas, although approved by the AAF in December 1943, would not get underway before 1945, 1 year after the aircraft's first flight.

Special Features — 1944

Clean aeronautical lines and the novel engine-propeller arrangement were the most striking features of the all-metal, cantilever, mid-wing XB-42 monoplane. The 2 Allison liquid-cooled, reciprocating engines were mounted inside the fuselage in order to eliminate the drag of large nacelles. Pusher-type propellers were located in the empennage to do away with thrust disturbances. Twin shafts, similar to those in the Bell P-39 fighter, connected the propellers to the forward-located engines.

First Flight (XB-42) — 6 May 1944

Designed and constructed in the record time of less than a year, the XB-42 was first flown by Douglas on 6 May 1944. As a safety measure, the

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[14] Soon to be discontinued, as AAF Air Technical Service Command came into being.

aircraft's initial flight originated from and was conducted over Palm Springs Army Air Base, California. Even though the XB-42 was the first AAF bomber during World War II to substitute pusher for the conventional tractor-propulsion, a change requiring the development of radically different propellers,[15] the 22-minute flight proved uneventful.

Contract Changes 1944-1945

In routine fashion, the letter contract of June 1943 was replaced on 11 February 1944 by a definitive contract carrying the same identification (W535 ac-40188). The definitive contract, however, included a new provision covering the development of an all-jet version of the XB-42, later identified as the XB-43.[16] On the other hand, no official mention was made of the approved XB-42 modification until 23 April 1945, when a contract change notification authorized conversion of the first XB-42 to the XB-42A configuration.

Testing 1945-1947

Flight testing of the first XB-42 proved, on the whole, disappointing. In test flights, conducted between May 1944 and March 1946, stability of the airplane was satisfactory, but controls were inadequate. During development, the XB-42 had taken on considerable extra weight over that foreseen in the design proposal and, as a result, did not meet the Douglas guarantees either for maximum speed at altitude, or for range. Even more frustrating was the excessive vibration from the engines and propellers and from the bomb-bay doors when open.

Testing of the second XB-42, first flown on 1 August 1944, was another disappointment, mainly because its combat capability was no better than that of the first model. The plane did have slightly improved speed and range, however, as demonstrated in a coast-to-coast flight in November 1945 in which it covered 2,295 miles in 5 hours and 17 minutes. In any case, testing ended abruptly. The second XB-42 was completely destroyed on 16

[15] Built by Curtiss-Wright, the 13-foot propellers needed perfecting. However, further development was stopped when it became obvious that production of the XB-42 was out of the question.

[16] See this appendix, p 516.

December 1945, in an accident near Bolling Field, D.C. Failure of the landing gear and fuel starvation were the accident's major causes.

The XB-42 flight testing program was extensive, but the second aircraft's premature loss prevented completion of a number of special tests. Douglas tested the first XB-42 for some 129 hours, accumulated in 154 flights. The contractor test-flew the second, short-lived aircraft for more than 65 hours, accrued in 57 flights. The Air Force put in 14 hours of flight tests on the first XB-42, and 51 hours on the second one. The modified XB-42 (XB-42A) was flight tested by Douglas for approximately 17 hours that were reached in 22 flights. The Air Force test-flew the XB-42A only once, for 1 hour. The flight met the contractual acceptance requirements.

Modifications 1946-1948

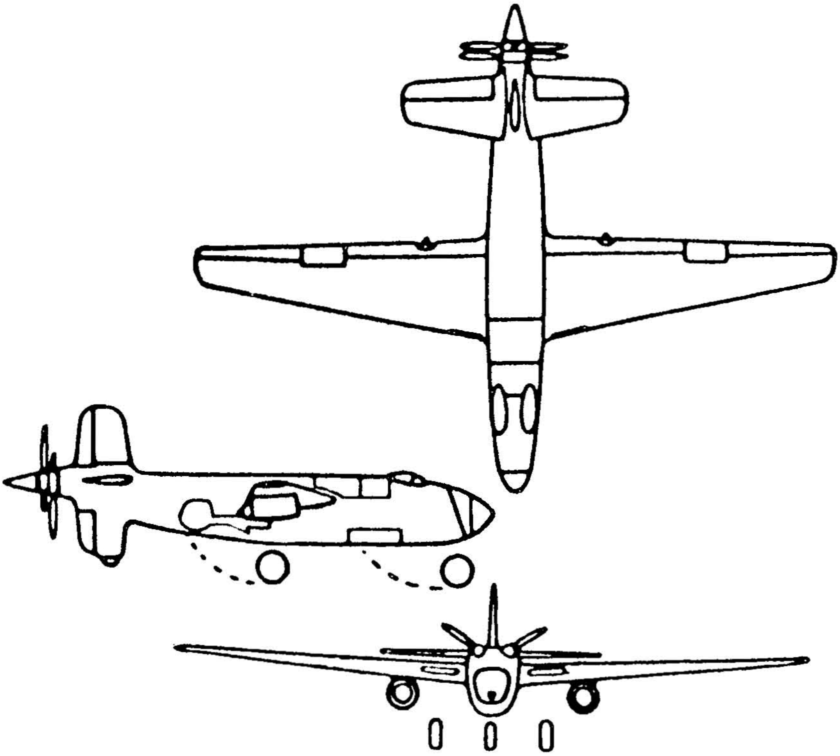
Douglas was authorized to begin work on the XB-42 conversion in April 1945, but the modifications were immediately postponed because the Bureau of Aeronautics could not speed delivery of the Westinghouse 19XB-2A Navy-type jets due to be fitted on the aircraft (1 unit under each wing). Testing therefore went on until March 1946, when the aircraft's left engine failed in flight. The XB-42 was then returned to the Douglas plant in Santa Monica, California, where a new landing gear, plus internal and external fuel tanks were to be installed in addition to the auxiliary turbojet engines.

During the latter part of 1946 and early in 1947, after the forging problems of the Westinghouse turbojets were solved, Douglas advanced the factory completion date of the programmed modifications several times, consequently delaying the important vibration tests.

The first flight of the XB-42A on 27 May 1947, from Santa Monica to Muroc Army Airfield, California, was marred by the obvious drag of the XB-42A's new turbojets. In ensuing flight tests at Muroc, both the Allison engines and added jets proved unsatisfactory. To make matters worse, the vibration tests, only started in mid-1947, were stopped on 15 August, when the XB-42A made a hard landing in the tail-low position, damaging the lower vertical stabilizer and lower rudder. The contractor wanted to resume testing as soon as possible, but the Air Materiel Command[17] decided that the new jet nacelles also needed modifications, and the aircraft was flown back to Santa Monica late in 1947. In the ensuing months, although it appeared that the Air Force still wanted a perfected XB-42A, Douglas

[17] The Air Materiel Command replaced the Air Technical Service Command on 9 March 1946. For details, see B-36, p 13.

The XB-42 featured a novel engine-propeller arrangement.



became increasingly convinced that further studies and engineering to reduce weight, eliminate vibration, and bring the modified plane up to guaranteed performance would not be economical.

Program Cancellation August 1948

Convinced by the Douglas argument, the Air Force in August 1948 decided to cancel the remainder of the XB-42A modification program, and to accept the aircraft "as is." The decision also marked the end of the entire B-42 experimental project.

Total XB-42s Accepted 2

The first XB-42, after being conditionally accepted on 24 September 1946, became the XB-42A which was finally accepted on 19 August 1948. The second, ill-fated XB-42 was accepted and delivered on 8 December 1945.

Total Development Cost

Both the XB-42 and XB-43 (also developed by Douglas) were procured under the same contract (W535 ac-40188) at a total cost of $13,682,095, including the contractor's fixed fee of $227,775. The $13.7 million settlement figure, recorded by the Air Force Contract Audit Office on 30 November 1947, did not provide a breakdown of the amount expended on each project. A portion of the XB-42A modifications was the object of another contract (W33-038-ac-14525), signed on 31 March 1947. The contract's relatively small amount (about $300,000) was most likely covered by the audit of November 1947.

Final Disposition November 1948

The Air Force thought the modified XB-42A, with its clean aeronautical lines and other novel features, was a true museum piece and kept it at the National Air Museum Storage Activity in Park Ridge, Illinois, pending completion of additional space at the Smithsonian Institution in Washington, D.C. In April 1959, the fuselage of the XB-42A was moved to the Smithsonian's Suitland Annex, in Silver Hill, Maryland.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

XB-42 AND XB-42A AIRCRAFT[a]

Manufacturer (Airframe)	The Douglas Aircraft Company, Inc., Santa Monica, Calif.
Manufacturer (Engines)	Allison Division of General Motors Corp. (V-1710-129); Westinghouse Electric and Manufacturing Co. (XJ-30).
Nomenclature	Light Bombers
Popular Name	Mixmaster

	XB-42	XB-42A
Length/Span (ft)	53.6/70.6	53.6/70.6
Wing Area (sq ft)	555	555
Weights (lb)		
Empty	20,888	Not Available
Combat	Not Available	33,000
Takeoff	35,702	35,000
Engine: Number, Rated Power per Engine, & Designation	(2) 1,460-lb st V-1710-129	(2) 1,460/lb st V-1710-137 & (2) 1,600-lb st XJ-30
Takeoff Ground Run (ft) Over 50-ft Obstacle	6,415	3,540
Rate of Climb (fpm) at Sea Level	1,050 (mil power)	Not Available
Service Ceiling (ft)	29,400 (takeoff weight/normal power)	35,500 (takeoff weight/normal power)
Maximum Speed	386 mph	385 knots (estimate)
Combat Range	1,800 miles	Not Available
Combat Cruising Radius (nm)	Not Available	495
Crew	3	5
Armament	6 .50-cal guns	None
Maximum Bombload (lb)	8,000	4,000[b]
Maximum Bomb Size (lb)	2,000	4,000

Abbreviations

cal = caliber
fpm = feet per minute
mil = military
mph = miles per hour
st = static thrust

[a]From Flight Test Reports only.
[b]Space and structural provisions for 8,000 lb.

XB-43
Douglas
Aircraft Company,
Incorporated

Basic Development — September 1943

The XB-43 was essentially a jet version of the unconventional XB-42, officially developed by Douglas in early 1943. The XB-43 did not reach the drawing board before 1944, but the project's development started in September 1943.

Requirements — 1943-1944

General requirements for a jet bomber of the XB-43 type arose during World War II, as a result of the development of German jet fighters. Also, the Air Corps needed an aircraft that could destroy military targets on land and sea in support of air, ground, or naval forces. Specific requirements were defined in 1944. The Army Air Forces (AAF) wanted the XB-43 to have a gross weight of 40,000 pounds; a maximum speed of 420 miles per hour at an altitude of 40,700 feet; and a range of 1,445 miles, at the same high altitude, with an 8,000-pound bombload.

Initial Procurement — 1944

A letter supplement to the XB-42 contract (W535 ac-40188) authorized on 14 January 1944 the initial procurement of 2 XB-43s. A formal supplemental agreement, approved on 31 March, set the estimated cost of the 2 experimental planes at $2.7 million and the contractor's fixed fee at about $107,000. The reason for such hurried transactions was to introduce tactical jet bombers swiftly into the operational inventory. As early as December 1944, the AAF seriously considered placing the XB-43 in production. Accordingly, the Air Technical Service Command asked Douglas on 30 December to submit a production proposal without delay.

Special Features 1944–1945

The XB-43 was the first American bombardment airplane to be powered exclusively by jet engines: TG-180 turbojets (later J35s), designed by the General Electric Company. Otherwise, except for the absence of the dual-rotating propeller at the rear of the empannage, the XB-43 had retained the XB-42's appearance and structural design.

Development Slippage 1944–1945

Early engineering problems with the pioneer J35 power plant hampered the XB-43's development. To begin with, General Electric only shipped the first J35 engine to Douglas in December 1944. Then, numerous changes in piping, wiring, and sheet metal work were necessary to make the engine suitable for flight. By March 1945, and in spite of the assistance of General Electric technicians, Douglas had spent more than 3,000 manhours to solve problems connected with the first engine. Moreover, subsequent engine deliveries, due since October 1944, were delayed until July 1945.

Program Change 1945

While the B-43 experimental program was assured from the start, the production program, which once appeared very promising, did not materialize. The Air Technical Service Command recommended in March 1945 the immediate procurement of 50 B-43s, but the Douglas production schedule for a preliminary lot of 13 test service airplanes proved unsatisfactory. Contrary to expectation, the planes would not be available for testing ahead of the B-45 and B-46 prototypes.[18] In addition, and probably of greater import, the proposed B-43 test aircraft would not meet the performance requirements that had been previously established. The AAF therefore opted to cancel all B-43 production plans. Air Technical Service Command notified Douglas of the AAF decision on 18 August 1945, specifying that the projected procurement of the 13 test aircraft was also nullified.

First Flight 17 May 1946

The XB-43 made its first flight on 17 May 1946. As in the XB-42's

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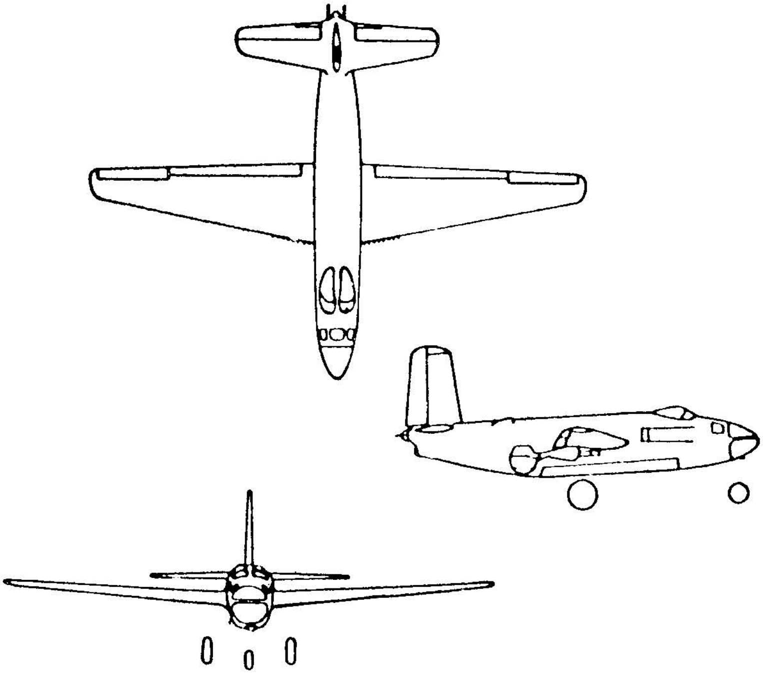
[18] As it turned out the XB-43 flew almost 1 year before the XB-45. In any case, the small XB-43 could hardly be compared to the much heavier B-45 and B-46 experimental aircraft, except for the fact that all such projects centered on jet propulsion.



A Douglas XB–43, the first American jet-propelled bomber.

case, because of the experimental status of the aircraft, the 8-minute flight was made from a military installation. The XB-43 had been dismantled at the contractor's plant in Santa Monica, California, and moved to Muroc Army Airfield, where it was reassembled. The AAF had invoked the War Powers Act to override the state's objections to having the disassembled airplane trucked over the public highway.

The first official flight of the second XB-43, on 15 May 1947, lasted 20 minutes and took place between Hughes Field in Culver City, California, and Muroc. After being fitted with special instruments, the second XB-43 had been trucked to Hughes Field where Douglas tested its ground handling and flight characteristics. To control costs, the AAF had informed Douglas that the second XB-43's flight test time was not to exceed 5 hours, without special authorization.

Continuing Problems 1946–1947

General Electric's labor difficulties and similar problems at the General Motors Corporation's Chevrolet Division, where most J35 engines were being built, continued to slow Douglas's progress. For example, in January 1946, no one knew with any certainty when the J35s earmarked for the second XB-43 would be available.

However, Douglas's engineering setbacks were not confined to the XB-43's power plant. One early problem, stemming from the difficulty encountered in obtaining positive nose wheel door operation, involved the pressurization of the entire nose section and nose wheel well. This problem was solved, but only by default. In January 1946 Douglas requested, and the AAF granted, permission to eliminate this pressurized area because the original requirement which called for the installation of a nose cone had been deleted. A second serious engineering problem was the tendency of the XB-43's plexiglass nose to crack under temperature extremes. The substitution of costly metal units, $5,000 each, was first considered. In November 1947, however, the Air Force decided that the difficulty could be corrected by installing wooden noses, much cheaper and adequate for a plane earmarked for testing, but no longer due to reach production.

Testing 1946–1948

While both XB-43s were used extensively for testing purposes, flight testing of each aircraft was relatively short. Douglas test-flew the first XB-43 for over 9 hours, accumulated in 28 flights; the AAF only test-flew it for about 4 hours, reached in 3 flights. Testing of the second XB-43 was even shorter. Douglas flew it for less than 8 hours, gained in 17 flights; the Air Force test-flew it once, for 1 hour.

Total XB-43s Accepted 2

The first XB-43 was accepted on 27 February 1947; the second, on 27 April 1948.

Total Development Costs

The Air Force Contract Audit Office on 30 November 1947 recorded the cost of the XB-42, XB-42A, and XB-43 programs at $13.7 million, and did not provide a breakdown of the amount spent on each program.[19] However, retained data on the XB-43 project set the program's tentative cost at $6.5 million. Although estimated, the figure appeared creditable.

Final Disposition 1951-1953

ARDC used the first XB-43 for a variety of tests until February 1951, when an accident ended the aircraft's testing career, which by then had reached almost 400 hours in flight. The second XB-43, after being assigned to the Air Materiel Command's Power Plant Laboratory, went to Muroc where it served as a test-bed for the General Electric J47 (TG-190) engine. Supported by the spare parts retrieved from the first XB-43, the second model also paid back its investment, totaling more than 300 hours of flight time before leaving the Air Force inventory in December 1953. The second XB-43 then went to the National Air Museum of the Smithsonian Institution.

[19] See XB-42, this appendix, p 514.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

XB-43 AIRCRAFT

Manufacturer (Airframe)	The Douglas Aircraft Company, Inc., Santa Monica, Calif.
Manufacturer (Engines)	Designed by the General Electric Co.; built by Chevrolet Div. of General Motors Corporation
Nomenclature	Light Bomber
Popular Name	None

Length/Span (ft)	51.4/71.2
Wing Area (sq ft)	563
Weights (lb)	
Empty	22,600
Combat	35,900
Takeoff	40,000
Engine: Number, Rated Power per Engine, & Designation	(2) 3,820-lb st J35
Takeoff Ground Run (ft) Over 50-ft Obstacle	7,080 (contractor's guarantee)
Rate of Climb (fpm) at Sea Level (mil power)	2,470 (contractor's est)
Service Ceiling (ft)	41,800 (combat weight/mil power)
Average Cruise Speed	365 kn
Maximum Speed (mil power)	437 kn (contractor's est)
Combat Cruising Radius	470 nm
Crew	3
Armament	None
Maximum Bombload (lb)	8,000[a]
Maximum Bomb Size (lb)	4,000[a]

Abbreviations

cal = caliber
fpm = feet per minute
kn = knots
max = maximum
nm = nautical miles
st = static thrust

[a]Space and structural provisions only.

XB-46
Consolidated Vultee Aircraft (Convair) Corporation

Manufacturer's Model 109

Basic Development 1944

The XB-46's development originated in 1944, when the War Department called for bids and proposals on an entire family of jet bombers, with gross weight ranging from 80,000 to more than 200,000 pounds.[20] Consolidated Vultee Aircraft (Convair) Corporation answered the War Department's requirements with the design study of a 90,000-pound, jet-propelled bomber. The design, submitted and accepted in November 1944, was labeled by the Army Air Forces (AAF) as the XB-46.

Initial Procurement 17 January 1945

The AAF initiated the XB-46's procurement with Letter Contract W33-038 ac-7674, which was approved on 17 January 1945. This first document covered preliminary engineering, wind tunnel, model, tests, mockup, and data that were to be based on the contractor's proposal of November 1944.

Definitive Development Contract 12 February 1945

The letter contract of January was supplemented on 12 February by a definitive contract of the standard cost-plus-fixed-fee type. This contract followed by 1 week completion of the XB-46's first mockup inspection. As was usually the case, the contract satisfied the inspection board's essential

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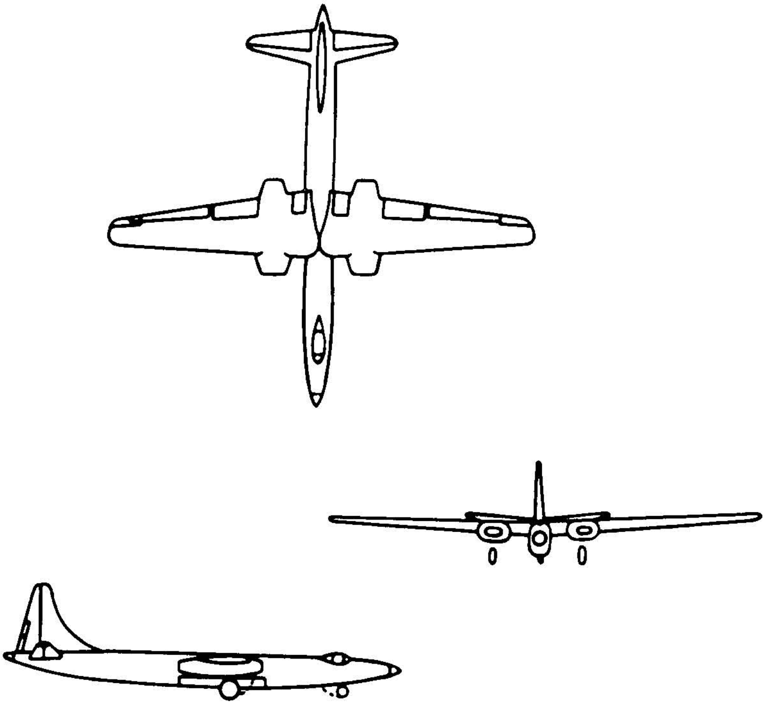
[20] See B-45, pp 62-65, and B-47, pp 101-102.

Long, thin wings and a teadrop canopy were special design characteristics of the XB-46.



recommendations. In short, 3 experimental B–46s were ordered and required to incorporate the necessary changes identified by the board. A supplemental agreement on 3 March provided for data and spare parts for the 3 XB–46s. Because of fiscal restrictions, the AAF also altered the terms of the basic contract, changing it to the fixed-price type.

Near-Cancellation — November 1945

By the fall of 1945, the AAF had become particularly interested in a Convair jet attack design, identified as the XA–44. The AAF actually considered canceling the XB–46 in favor of the XA–44, since there was not enough money for both projects. The contractor, however, firmly believed a better solution would be to complete 1 XB–46 in a stripped but flyable condition and to develop 2 XA–44s in lieu of the 2 other XB–46s remaining under contract. Although the AAF ratified the suggested substitution in June 1946, the XA–44 program did not materialize.[21] Similarly, the special testing of a TG–180 engine, due to be installed in a B–24J airplane as an added requirement related to the XB–46 development, was also subsequently abandoned.

Special Features — 1947

A distinguishing feature of the XB–46 was the tail turret, designed by the Emerson Electric Company Also, the pilot rode in a fighter-style cockpit with a teardrop canopy.[22] In other respects, despite its extremely thin wings and long, oval fuselage, the graceful airplane did display a few conventional features. Its wings were straight, and it was powered by 4 J35 axial flow engines, which were paired in low-slung nacelles, 1 on each side of the fuselage, a typical arrangement.

First Flight — 2 April 1947

The XB–46's first flight on 2 April 1947, from San Diego, California,

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[21] AAF support of the XA–44 did not last long. The program was ended in December 1946, when the design was converted to a light bomber design and redesignated the XB–53. The XB–53 project was given up soon afterwards. The XA–44 program was reinstated in February 1949, but only for a short while.

[22] The XB–46's cockpit design was selected for study by other aircraft manufacturers.

to Muroc Army Airfield lasted over 1 hour and a half. The contractor's test pilot praised the functioning and handling of the airplane which, as completed, contained only the equipment considered necessary to prove its air-worthiness and handling characteristics.

Testing 1947

The basic flight tests (Phases I and II) of the single XB-46 (Serial No. 45-59582) were concluded in September 1947, within 5 months of the aircraft's first flight. Convair test pilots accumulated more than 26 hours of testing in 16 flights; the AAF's pilots, about 101 hours in 46 flights. Although stability and control were for the most part excellent, engineering problems included engine troubles as well as difficulties with the spoiler clutch installation and with the lateral control surfaces when the aircraft flew at high speeds. All in all, the XB-46 appeared to meet the contractor's only guarantee—that it would be safe for experimental test purposes.

Total XB-46s Accepted 1

The Air Force accepted the sole XB-46 on 7 November 1947 and took delivery of the aircraft on the 12th.

Program Cancellation August 1947

The B-46 program was officially canceled in August 1947, several months before the experimental aircraft was formally accepted and exactly 1 year after the AAF had endorsed the immediate production of the North American XB-45. Still, only a small quantity of B-45s would be bought because, in the final analysis, the performance characteristics of the XB-47, being developed by the Boeing Airplane Company, were sure to exceed those of the future B-45 and of the unfortunate B-46. The AAF selected the XB-45 over the XB-46 for a number of reasons. Weight was one of them. Being at the time slightly heavier than the XB-45, the XB-46 could not be expected to match the future B-45's performance. Another factor against the XB-46 was the size of the necessary radar equipment. Most likely, the installation of such equipment would have required an extensive modification of the aircraft's thin fuselage.

Total Development Costs **$4.9 million**

As agreed upon in mid-1946, completion of only 1 stripped version of the XB–46 was intended to provide "a very realistic approach to the problem of development with relatively low cost." Just the same, when completed 1 year later, the experimental program nearly reached the $5 million mark.

Final Disposition **February 1952**

Like most strictly experimental airplanes, once accepted by the Air Force, the XB–46 participated in a variety of extra tests such as noise measurements, tail vibration investigations, and the like. Additional stability and control tests were also conducted at West Palm Beach AFB, Florida, between August 1948 and August 1949. However, after 44 hours of flight, these tests were stopped because "maintenance difficulties, aggravated by lack of spare parts, required a prohibitive number of manhours to keep the aircraft in flying condition." Actually, no additional testing was done on the airplane for almost a year. The XB–46 was flown to nearby Eglin AFB in July 1950, where its pneumatic system was tested at low temperatures in the base's climatic hangar. Completion of the climatic tests in November 1950 marked the bomber's end, since the Air Force had no more use for it. Except for its nose section, which was sent to the Air Force Museum at Wright-Patterson AFB, Ohio, on 13 January 1951, the XB–46 was scrapped on 28 February 1952.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

XB-46 AIRCRAFT

Manufacturer (Airframe)	Consolidated Vultee Aircraft Corp., Fort Worth, Tex.
Manufacturer (Engines)	Designed by the General Electric Co.; built by the Chevrolet Div. of the General Motors Corp.
Nomenclature	Medium Bomber
Popular Name	None

Length/Span (ft)	105.8/113
Wing Area (sq ft)	1,285
Weights (lb)	
Empty	48,000
Combat	75,200
Takeoff	94,400
Engine: Number, Rated Powers per Engine, & Designation	(4) 3,820-lb st J35-C3 (axial flow-11 stage)
Takeoff Ground Run (ft)	
At Sea Level	2,000[a]
Over 50-ft Obstacle	4,000[a]
Rate of Climb (fpm) at Sea Level	2,400 (at design takeoff of 91,000 lb)[a]
Combat Rate of Climb (fpm) at Sea Level	3,000 (at target weight of 75,200 lb)[a]
Service Ceiling (ft)	40,000 (guaranteed by contractor)
Combat Ceiling (ft)	36,500[a]
Average Cruise Speed (kn)	381
Max Speed at Optimum Altitude (kn/ft)	425/40,000[a]
Combat Radius (nm)	603
Total Mission Time (hr)	Not Available
Crew	3 (pilot, co-pilot, & bombardier-navigator)
Armament	2 .50-cal machine guns (space and structural provisions for APG-27 remote control with optics & radar sighting)
Maximum Bombload (lb)	22,000 (in various loads)
Maximum Bomb Size (lb)	22,000

Abbreviations

cal	= caliber
fpm	= feet per minute
kn	= knots
nm	= nautical miles
st	= static thrust

[a]Contractor's estimates only.

XB-48
Glenn L. Martin Company

Manufacturer's Model 223

Basic Development 1944

The XB-48, like the more fortunate XB-45, originated in 1944, when the War Department concluded that jet propulsion was promising enough to warrant extension of the program, thus far centered on fighters and light bombers, to heavier aircraft with gross weights ranging from 80,000 to more than 200,000 pounds.[23] Realizing that such an ambitious project could be fraught with difficulties, Army Air Forces (AAF) headquarters informed the Materiel Command and Air Services Command on 10 August[24] that in the beginning contracts for jet bombers of the medium and heavy categories would have to be let on a phased basis so that they could be readily terminated upon completion of any one stage of development. This cautious procedure was formalized on 15 August.

Military Characteristics 1944–1945

On 17 November 1944, the AAF issued military characteristics calling for a bomber with a range of 3,000 miles (minimum acceptable, 2,500); a service ceiling of 45,000 feet and a tactical operating altitude of 40,000 feet (minimums acceptable, 40,000 and 35,000 feet, respectively); and an average speed of 450 miles per hour with a high speed of 550. These characteristics were amended on 29 January 1945 to reemphasize that such aircraft needed

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[23] See B-45, pp 353-363.

[24] About 2 weeks later the 2 commands merged to form the AAF Technical Service Command, which was redesignated Air Technical Service Command on 1 July 1945. This organization became the Air Materiel Command on 9 March 1946.

to carry specific types of bombs, including the conventional M-121, a 10,000-pound "dam-buster" developed during World War II.[25]

Initial Procurement 1944–1945

In accordance with the AAF's endorsement of "phase" contracts and based on the military characteristics of November 1944, a Martin proposal, submitted to the Air Technical Service Command on 9 December 1944, led to Letter Contract W33-038 ac-7675. Approved on 29 December, this initial document covered certain engineering services and completion by 1 May 1945 of 1 mockup of Martin's Model 223, designated XB-48 by the Air Technical Service Command. Tentative costs were set at $574,826. The letter contract of December 1944 was replaced on 27 March 1945 by a definitive contract, which reduced estimated costs to $569,252, including Martin's fixed-fee of $16,500.

Final Procurement 13 December 1946

Procurement of the XB-48 overcame many vicissitudes. In June 1945, 2 months after inspection of the XB-48 mockup, Martin submitted a proposal for 1 stripped and 1, 2, or 3 complete XB-48s. Accompanying cost figures, however, were immediately questioned. To Air Technical Service Command's surprise, it was soon ascertained that the estimated cost of $80.09 per pound for the XB-48 compared favorably to the $105.68 for the XB-45, but the AAF remained dissatisfied because the XB-48's engineering lagged behind the XB-45 and XB-46. Despite these concerns, the XB-48 project survived, and the initial contract was supplemented many times while negotiations went on. In March 1946, the contractor introduced a new proposal and offered to furnish 1 stripped and 1 complete XB-48 for about $10 million. This proposal was made on a fixed-price rather than a cost-plus-fixed-fee basis in order to conform to the policy set forth by the Air Technical Service Command in December 1945 on the procurement of

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[25] The M-121, sometimes called the "Earthquake" bomb, was more often referred to as the "Grand Slam" bomb, a totally misleading nickname. Actually "Grand Slam" was the code name of a highly classified modification project strictly concerned with atomic matters. The "Grand Slam" modifications would allow the Convair B-36 to carry atomic bombs, which the Air Force believed might weigh more than 40,000 pounds. Since the 10,000-pound M-121, when properly dropped, could inflict the damage of a 40,000-pound bomb, curiosity and rumors most likely explained the ensuing confusion. As a matter of fact, the "Grand Slam" designation was also loosely applied to other conventional bombs of the M-121 category.

experimental airplanes. Just the same, the Martin proposal of March 1946 had to be revised, and negotiations were not consummated until the end of the year. The final contract (W33-038 ac-13492), approved on 13 December 1946, superseded Contract W33-038 ac-7675 which, as amended, had reached an estimated future cost of $10.9 million.[26] For the same amount, the new contract promised 2 XB-48s, spare parts, and a bomb-bay mockup. Also, the first XB-48 was to be flight tested and delivered by 30 September 1947; the second one, by 30 June 1948. Finally, all wind tunnel tests were to be completed by 1 January 1947.

Program Slippage 1947-1948

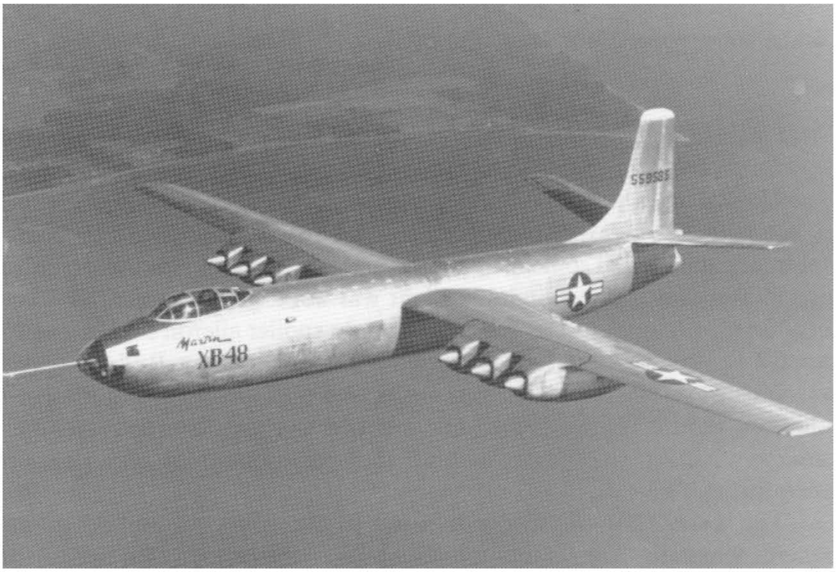
Development and testing of the 2 XB-48s were delayed by engine difficulties. General Electric turbojet engines were installed, the first XB-48 being powered by 6 J35-GE-7 (TG-180-B1) engines; the second, by 6 J35-GE-9s (TG-180-C1s). Since the engines were in an even more experimental stage than the airplanes, it took time to get them to operate properly. Also, like every new engine, the J35s were in short supply. Still, the first XB-48 would go through 14 engines during its first 44 flights.

Special Features 1947-1948

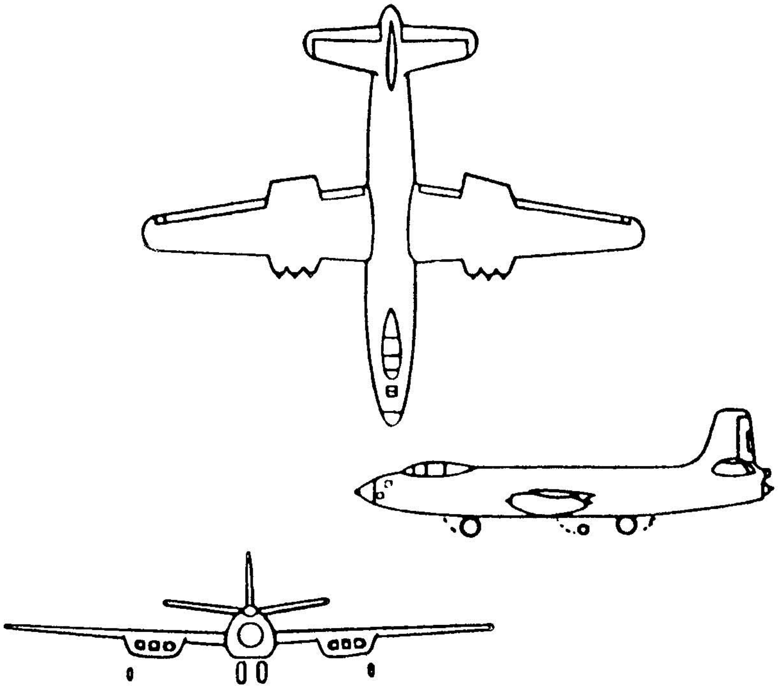
The sleek, all-metal, high-wing XB-48 presented many special features, the most outstanding one being the tandem bicycle landing gear necessitated by the airplane's wings, too thin to house conventional landing gear with bulky retracting mechanisms.[27] Other novel features were the number of engines, 6 as compared to 4 on the other proposed medium bombers; the turbojet engine's installation, encased in pods (3 under each wing) in a lift section with air ducts between the pods; and also adjustable tail pipes on the engines. The 3-crew arrangement was also unusual. The pilot and co-pilot were seated in tandem under a canopy-type inclosure, similar to that found in high-speed fighter planes, while the bombardier-navigator was seated in the aircraft's nose. The XB-48 had retractable bomb-bay doors, a feature that sprang from the fact that all new medium and heavy bombers had to be

[26] Only some $500,000, covered by the initial letter contract, were unaffected.

[27] Martin had experimented with a 4-wheel bicycle landing gear on an XB-26H and concluded that such an arrrangement was feasible. Bicycle-type landing gears were later used by other jet bombers, including the B-47.



The XB-48, developed by Glenn L. Martin Company.



capable of carrying the so-called "Grand Slam" bombs, as well as the cumbersome atomic bombs of the period.

First Flight — 22 June 1947

The XB–48, the first U.S. 6-jet bomber to fly, made its initial flight on 22 June 1947. The experimental plane took off from Martin's airfield at Baltimore and landed some 80 miles away at the Patuxent Naval Air Station, also in Maryland. The 38-minute flight was not a great success. At 10,000 feet, the Martin pilot discovered that the right spoiler aileron snapped up too rapidly. On landing, the XB–48 drifted across the runway. Rudder steering was attempted, but the rudder was ineffective with the full use of brakes. In addition, the brakes overheated and stopped working. The aircraft finally came to a halt off the runway with no damage, even though both tires were worn through.

The second XB–48 did not fly until 16 October 1948, some 3 months behind schedule. The 30-minute flight was satisfactory, but of relative unimportance since the future of the experimental program had already been decided.[28]

Testing — 1947–1949

Martin pilots tested the first XB–48 52 times, for a total of 41 hours; the Air Force, 50 times for a total of 64 hours. The second XB–48 was also thoroughly tested. The contractor put in 14 hours, accumulated in 15 flights; the Air Force, 49 hours, reached in 25 flights. Results of the first XB–48's flight test program revealed that the aircraft did not meet the Martin guarantees. The XB–48 was 14,000 pounds overweight; the nose wheel was too sensitive; turbulence occurred in the bomb bay when the doors were open; and metal chips, deposited by disintegrated test stand hydraulic pumps, shattered the hydraulic system.[29]

Program Cancellation — 1948

The experimental B–48 program agreed upon in December 1946 was not

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[28] See B–45, pp 64–65, and B–47A, p 107.

[29] The Air Force gave the contractor the option to eliminate all flaws or to pay a lump-sum penalty of $25,000. In January 1950, Martin agreed to pay the penalty.

curtailed. Yet, in spite of the contractor's efforts, no production program followed. Although no firm commitment would be made before many months, planning for the procurement of B-47 production models began in December 1947, right after the XB-47's first flight—a poor omen for the B-48, initially flown in June of the same year.

In the spring of 1948, after early experimental flight information had been obtained for both the XB-47 and the XB-48, the Air Force conducted an evaluation to determine which of the 2 planes could best satisfy the urgent need for a high-speed, high-altitude medium bomber. The evaluation confirmed that the performance of the XB-47 was appreciably better than that of the XB-48. It was also apparent that the XB-47 design provided possibilities for growth which surpassed those of the XB-48. The XB-47's swept-back wing would enable it to attain higher speeds, and its simpler pod-nacelle arrangement minimized the problem of incorporating newer and more efficient jet engines as they became available.[30]

Early in 1949 Martin attempted to rescue the B-48 production program and proposed to modify the second XB-48 by removing the J35 engines and nacelles and installing 4 XT-40A propeller turbines in new and repositioned nacelles, at an estimated cost of $1.5 million. Actually, the reconfigured XB-48 would become a prototype of the Martin Model 247-1, an airplane, the contractor insisted, capable of competing with the B-47, B-50, and B-54. On paper, Model 247-1's performance looked good, but the Air Force did not believe the proposed reconfiguration could be accomplished for the amount of money estimated by the contractor. In addition, since the XT-40A turboprop was a Navy-developed engine, it was doubtful that Martin could obtain enough engines to complete the reconfiguration on schedule. Finally, and of overriding importance, senior Air Force officials believed that turbojet aircraft "currently offered greater promise than turboprop installations." Thus, on 31 March 1949, Martin was formally told that the Model 247-1, like the original XB-48, was a dead issue.

Total XB-48s Accepted 2

The Air Force accepted the first XB-48 on 26 October 1948, but only conditionally. The acceptance became final in 1950, when Martin paid the $25,000 penalty assessed by the Air Force because of the aircraft's several defects. The second XB-48, also conditionally accepted on 26 October 1948,

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[30] The end of the B-48 production program became official in September 1948, when the Air Force ordered the first lot of 10 B-47s.

was finally accepted on 23 February 1949, after the contractor completed various modifications.

Total Development Costs $11.5 million

The total cost of the XB-48 development program reached $11.5 million. Of this amount, less than $500,000 pertained to the letter contract of December 1944. The rest covered the final contract of December 1946 and represented an increase of about $100,000, justified by various changes ordered by the Air Force.

Final Disposition 1949–1951

In the fall of 1949, the first XB-48 was cannibalized to provide parts for the second XB-48. The latter aircraft was scheduled for many tests, including tests on the F-1 autopilot, jet engine cooling system, and a hydraulic system for jet engines. The proposed tests, however, were canceled. The Air Force decided to use the second XB-48 as a test-bed for "bad-weather" flight items, including a badly needed deicing system. Completion of the thermal anti-icing survey test program in mid-1951 paved the way for the second XB-48's end. In September, the aircraft was flown to Phillips Field, Aberdeen Proving Ground, Maryland, where the strength of the XB-48 structure was tested until the aircraft was totally destroyed.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

XB-48 AIRCRAFT

Manufacturer (Airframe)	The Glenn L. Martin Co., Baltimore, Md.
Manufacturer (Engines)	Developed by General Electric; built by the Allison Div. of General Motors Corp., Kansas City, Mo.
Nomenclature	Medium Bomber
Popular Name	None

Length/Span (ft)	85.8/108.3
Wing Area (sq ft)	1,330
Weights (lb) Empty Combat	58,500 92,600 (max) 102,600 (4,968 gal of fuel, included)
Engine: Number, Rated Power per Engine, & Designation	(6) 3,820-lb st J35-B-1 (1st XB-48)[a] (6) 3,820-lb st J35-D-1 (2d XB-48)[a]
Takeoff Ground Run (ft) At Sea Level Over 50-ft Obstacle	 7,900 (at 102,600-lb takeoff)[b] 5,200 (at 102,600-lb takeoff)[b]
Rate of Climb (fpm) at Sea Level	3,250 at design takeoff of 102,000 lb)[b]
Combat Rate of Climb (fpm) at Sea Level	4,200 (at combat takeoff of 86,000 lb)[b]
Service Ceiling (ft) (100 fpm Rate of Climb to Altitude)	39,400[b]
Combat Ceiling (ft) (500 fpm Rate of Climb to Altitude)	43,000[b]
Average Cruise Speed (kn)	360[b]
Max Speed at Optimum Altitude (kn/ft)	454/35,000[b]
Combat Radius (nm)	433 (with max bombload)[b]
Cruising Radius (nm)	783[b]
Total Mission Time	Not Available
Crew	3 (pilot, co-pilot, & bombardier-navigator)
Armament	None (provided for 2 .50-cal machine guns to be controlled by AN/APG-27 Radar)
Maximum Bombload (lb)	22,000 (in various loads)
Maximum Bombload (lb)	22,000

Abbreviations

cal	= caliber	max	= maximum
fpm	= feet per minute	nm	= nautical miles
kn	= knots	st	= static thrust

[a]First known as Allison TG-180s, the initial J35s were axial flow gas-turbine engines, grouped in threes under each wing. The J35-B-1s were later replaced by J35-GE-7s; the J35-D-1s, by J35-GE-9s.

[b]Contractor's estimates only.

YB-49 and YRB-49A
Northrop Aircraft, Incorporated

Basic Development — 1944

The YB-49 evolved from the unconventional XB-35 "flying wing,"[31] its development being prompted by a 1944 study of the possibilities of converting the propeller-driven XB-35 to turbojet engines. Actually, the YB-49 project and its reconnaissance counterpart represented the continuing effort of the Army Air Forces (AAF) and Northrop to establish a tactical use for the original "flying wing," yet to be flown but already plagued by virtually insurmountable problems.

Initial Procurement — 1 June 1945

On 1 June 1945, Change Order 11 to Contract W535 ac-33920, a December 1942 document calling for 13 B-35 prototypes, confirmed earlier verbal decisions and authorized Northrop to convert 2 future YB-35s to the YB-49 configuration.

Conversion Slippage — 1947

Conversion of the YB-35 to the YB-49 configuration, due to be completed by June 1946, slipped more than a year. The delay was caused by unforeseen problems, encountered in adding fins to the wings to provide the stabilizing effect that the propellers and propeller shaft housings gave to the basic XB-35.

Special Features — 1947

The YB-49 featured eight 4,000-pound-thrust J35 engines, 2 more than

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[31] See this appendix, pp 497-516.

planned; 4 small trailing edge fins, to replace the XB-35's yaw dampening prop shaft housings; 4 large wing fences; and a reconfigured leading edge ahead of and between each pair of fences that provided a low drag intake slot for each of the 2 sets of jet engines. In most other respects, since the all-metal XB-35 airframe was used for the conversion, the YB-49 was identical to the YB-35.

First Flight — 21 October 1947

The initial flight of the first YB-49 occurred on 21 October 1947, from the contractor's plant in Hawthorne to Muroc Army Airfield, both in California. The new prototype's first flight lasted 34 minutes without incident. The second YB-49 was first flown on 13 January 1948, from and to the same places and also without special difficulties.

Testing — 1947-1950

Testing of the first YB-49 was extensive. Northrop test-flew it for almost 200 hours, accumulated in some 120 flights; the Air Force completed about 70 hours, totaled in some 20 flights.[32] Early in 1948, Northrop began test-flying the second YB-49. Some 24 flights were made by the contractor's pilots for a near-total of 50 hours. The Air Force test-flew the second YB-49 5 times, for perhaps 13 hours. In the YB-49's case, early test results acquired special significance. Tragically, just after being officially accepted by the Air Force, the second YB-49 crashed, killing its entire 5-man crew.[33]

Investigations of the second YB-49's crash could assign no specific cause for the accident, but determined that a major structural failure had taken place in flight. An eyewitness described the plane as tumbling uncontrollably about its lateral axis just before hitting the ground. Project officers later verified that under certain conditions a "flying wing" would indeed "somersault" through the air. The loss of the aircraft and further wind tunnel work perpetuated doubts concerning the flying wing's aerodynamic stability and revealed the need for additional flight testing.

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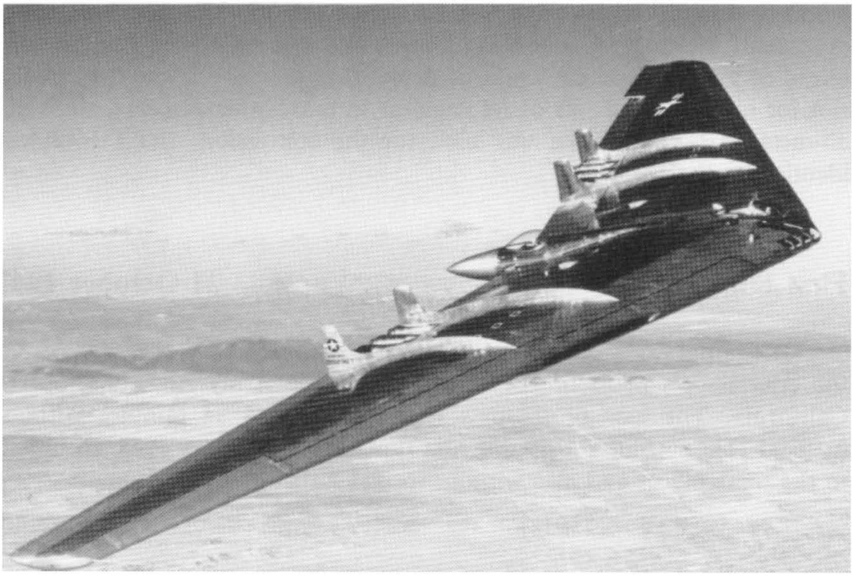
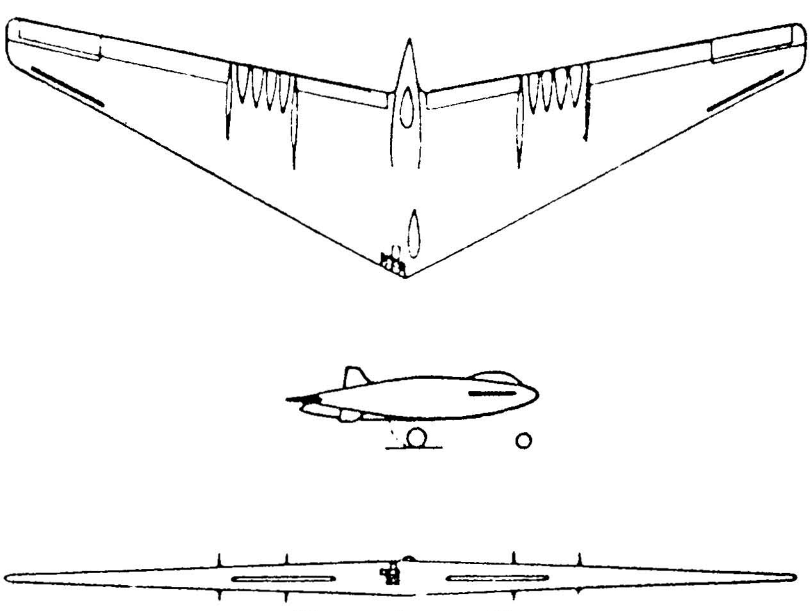
[32] Conflicting information did not allow the computation of absolute figures. However, extensive research by various Air Force historians confirmed the stated estimates.

[33] Capt. Glen Edwards, from the Air Materiel Command Flight Test Division, was co-pilot on this fatal trip. Muroc Army Air Base, after becoming Muroc AFB on 12 February 1948, was renamed Edwards AFB on 5 December 1949, in honor of Captain Edwards.



The Northrop YB-49 was a converted YB-35, with jet engines instead of propellers.



Program Re-Appraisal 1948–1949

By 1948, progress in range-extension had relegated the YB–49 to the status of a medium bomber. Actually, the YB–49 was the largest of the medium bombers under consideration, but it faced stiff competition from the B–45 (already in production), and from the XB–46, XB–47, and XB–48 (all in flight test). Soon afterward, and although the project would not be firmed up for another year or so, the Aircraft and Weapons Board decided to use flight test results to evaluate the B–47 and B–49 as possible "special piloted atomic" carriers.[34] The YB–49 program also profited from the Air Materiel Command's decision to de-emphasize turboprop propulsion and push turbojet development. Yet, other aspects of the program were not so favorable.

The first YB–49 made a significant flight on 26 April 1948, a test of the aircraft's range which proved quite successful. The aircraft was aloft 9 hours, of which 6 hours were flown at an altitude of 40,000 feet. Both accomplishments were believed to set records for that period. Only 1 engine and 1 auxiliary power unit failure marred the otherwise excellent performance. But the second YB–49's fatal crash in June prompted the contractor and the Air Force to decide that the remaining prototype would be flight tested an extra 125 hours, and the testing that ensued gave mixed results.

Meanwhile, Lt. Gen. Benjamin W. Chidlaw, Deputy Commander of the Air Materiel Command, had ordered that determination of the YB–49's stability as a bombing platform be given first priority. Evaluated against a B–29 on comparable mission tests, the YB–49 (without an autopilot) performed poorly. Pilots concluded that the jet-equipped "flying wing" was "extremely unstable" and found it "impossible to hold a steady course or a constant airspeed and altitude." The YB–49's circular average error and range error were twice those of the B–29. Finally, the B–29 invariably acquired bomb-run stability in under 45 seconds, while the YB–49's best time was over 4 minutes. Clearly, the B–49 program was doomed unless sweeping improvements were made to correct the performance defects demonstrated by the prototype.

Total YB–49s Accepted 2

The first YB–49 was not accepted by the Air Force until 15 March 1950

[34] See B–47, pp 125–126.

(after being extensively tested by the contractor). The second, ill-fated B–49 prototype was transferred to the Air Force on 28 May 1948. Northrop considered the airplane officially accepted on 5 June, when it crashed.

Subsequent Model Series — YRB–49

Program Cancellation — 15 March 1950

The October 1948 conclusion of the primary evaluation tests comparing the YB–49 and the B–29, and the YB–49's poor showing most likely determined the outcome of the B–49 program. Just the same, the YB–49 testing was extended, and even though remote, the possibility remained that the program might survive its initial calamities. This did not prove to be the case. Between May 1948 and the spring of 1949, the B–49 prototype was involved in 5 incidents, most of them due or related to engine problems. On 26 April 1949, a fire occurred in 1 of the aircraft's engine bays, necessitating $19,000 worth of repairs. Cancellation of the B–49 program became official on 15 March 1950—the day the sole XB–49 crashed and testing came to an abrupt end. There were no fatalities, but crewmen were injured and the airplane was completely destroyed. Failure of the nose gear was the accident's basic cause. Contributing factors were excessive shimmy of the nose wheel and final collapse of the gear, resulting from the unsatisfactory center of gravity.

Total Development Costs

After 1948, the additions and withdrawals of funds made a separate appraisal of any one aircraft's cost impractical, especially since the Air Force found it difficult to secure anything but an overall "flying wing" program cost estimate from Northrop.[35]

Final Disposition — 1948–1950

The second YB–49 was totally destroyed on 5 June 1948; the first, on 15 March 1950.

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[35] See XB–35, this appendix, p 506.

YRB-49A

Basic Development March 1948

Like the canceled B-49, the RB-49 grew out of the unconventional XB-35, under development by Northrop since 1941. However, the aircraft's basic development did not take shape until March 1948 when the contractor, after canvassing possible uses for the "flying wing," submitted to the Air Force proposals for a photographic reconnaissance version of the aircraft. Referred to as the RB-49A and the FB-49A, the proposed aircraft would be essentially a YB-49, stripped of items required only for bombardment missions and incorporating necessary photographic apparatus. The formal nomenclature of the prototype became YRB-49A.

Early Planning April 1948

In April 1948, the Air Staff and high-ranking officers of the Air Materiel Command, after comparing reconnaissance versions of the F-12,[36] B-35, B-47, and B-50, concluded that perhaps the eventual RB-49A could "realistically" perform a portion of the strategic reconnaissance mission. Undoubtedly, this optimistic appraisal stemmed from the testing already accomplished on the Northrop aircraft, as well as from the aircraft's range, speed, altitude, and growth potential with combinations of turbojet and turboprop engines. Therefore, 3 versions of an ever-improving RB-49A were planned—an initial aircraft with 8 TB-190A (General Electric J47) turbojets, an interim model powered by 6 Westinghouse J40 engines (when they became available), and an ultimate configuration, which would achieve greater range and economy with 2 Turbodyne T-37 turboprops and 2 TG-190A engines. The ultimate model was not an immediate possibility, since the T-37 engines would not be available until October 1951 or later.

Initial Procurement 12 June 1948

Believing that the planned RB-49A configuration truly had merits, and

[36] The F-12 was developed by the Republic Aviation Corporation. Only 2 prototypes came into being.

still eager to salvage its costly investment in the unfortunate XB-35 program, the Air Force promptly decided to endorse the YRB-49A development. Following notice of the decision in May 1948, Northrop received a letter contract on 12 June for preliminary engineering work looking toward an eventual production contract for 30 reconnaissance aircraft, at a cost of $86,800,420,—this total to include aircraft, engineering data, and flight testing.

Production Contract 12 August 1948

Signed on 12 August 1948, Contract W33-038-ac-21721 covered the production of 30 RB-49As and a static test shell. One of the aircraft was to be built by Northrop, the remaining 29 by Consolidated Vultee, at the latter's government-leased plant in Fort Worth, Texas. The agreement had been preceded by difficult negotiations, the 2 contractors being unwilling from the start to accept the Air Force's contention that the nation would benefit from a pooling of Northrop's engineering skill and Consolidated's experience in quantity production of large aircraft.

Program Re-Appraisal Fall 1948

Support of the RB-49A production program was short lived. Less than 2 months after the contract's signature, several Air Materiel Command officials concluded that the program's initial 8-jet version would only be "satisfactory as an interim installation." In late September, the Air Force also began to encounter difficulties in pinning down the 2 contractors' future delivery dates for the 30 RB-49As. Just as disturbing was the continuing indecision over which prototype Northrop would use to develop the YRB-49A. At first, the remaining YB-49 was chosen. Then, various versions of the 13 YB-35s ordered in 1942 were reviewed, before settling on modification of the third B-35 prototype—a YB-35A featuring specific reconfiguration changes dictated early in 1945.

Against this clouded background, a board representing numerous Air Staff offices met in November to review the requirements for reconnaissance aircraft. All 3 versions of the future RB-49As came under fire. The 8-jet RB-49A, it appeared, would not be available until January 1950 and would have an inadequate operating radius; the 6-jet model, planned for 1951, would be much slower than the B-47; finally, Northrop could not promise the ultimate turboprop-turbojet version until 1953, at which time that particular RB-49A would be in competition with (and outclassed by) the

B-52. The Air Staff Board, therefore, recommended elimination of the RB-49A.

Program Cancellation 1948-1949

The RB-49A production program was irrevocably canceled in late December 1948, as the new USAF Board of Senior Officers[37] supported the Air Staff Board's recommendation, deciding also soon afterward to substitute the procurement of additional B-36s for the deleted RB-49As.[38] The RB-49 cancellation became official in mid-January 1949, when the Air Materiel Command directed Northrop to stop work on all phases of the reconnaissance version except for completion and test of the 1 YRB-49A.

First Flight 4 May 1950

Conversion of the third YB-35A was "shop completed" by February 1950, shortly after the Northrop project was totally cut back to the level of a low-budget, state-of-the-art research and development endeavor. Yet, despite the contractor's continuing attempts to revive its program, the April delivery deadline set by the Air Force was not met. The YRB-49A's first flight occurred on 4 May, a 1-month slippage due to the time consumed in installing additional instrumentation. Like the YB-49, the reconnaissance prototype's first flight was from Hawthorne to Edwards AFB, California.

Special Features 1950

The YRB-49A differed significantly from the third YB-35A by featuring 6 engines instead of 8. Four of the YRB-49's 6 J35s were internally-mounted; 2 were outside of the airframe. The removal of 2 engines and the relocation of an additional 2, allowed the YRB-49A to carry much more fuel, a configuration change designed to extend the aircraft's range.

Testing 1950-1952

The YRB-49A's test program was quickly marred by a potentially fatal

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[37] See B-52, p 216.

[38] See B-36, p 26.

accident. On 10 August 1950, during its tenth test flight, the reconnaissance prototype was in a climb at approximately 35,000 feet, at a speed of about 225 miles per hour, when the canopy failed and blew off, tearing away the pilot's oxygen mask and injuring him slightly. Only because the alert flight engineer supplied emergency oxygen was the pilot able to land the aircraft without further incident. The test program was resumed after a replacement canopy was provided and various aircraft modifications were made. No test flights were recorded after 10 September 1950, even though the aircraft was probably still test-flown on and off. In any case, on 6 May 1952, the Air Materiel Command indicated that there was "no future flying time scheduled" for the YRB-49A.

Final Disposition 1953

The YRB-49A, the last of the "flying wings," was flown to Northrop's Ontario International Airport facility, and it most likely remained in storage for 18 months. The Air Force reclaimed and scrapped the aircraft in November 1953.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

YB-49 AIRCRAFT[a]

Manufacturer (Airframe)	Northrop Aircraft, Inc., Hawthorne, Calif.
Manufacturer (Engines)	Designed by the General Electric Co.; built by the Allison Div. of the General Motors Corp.
Nomenclature	High-Altitude, Long-Range Bomber
Popular Name	Flying Wing

Length/Span (ft)	53.1/172
Wing Area (sq ft)	4,000
Weights (lb)	
Empty	88,442
Combat	133,569
Takeoff	193,938
Engine: Number, Rated Power per Engine, & Designation	(8) 3,750-lb st J35-A-15
Takeoff Ground Run (ft)	
at Sea Level	4,850
over 50-ft Obstacle	5,850
Rate of Climb (fpm) at Sea Level	1,780
Combat Rate of Climb (fpm) at Sea Level	3,785
Service Ceiling (ft) (100 fpm Rate of Climb to Altitude)	35,400
Combat Ceiling (ft) (500 fpm Rate of Climb to Altitude)	40,700
Max Speed with max power at Altitudes (kn/ft)	403/35,000—428/20,800
Combat Radius (nm)	1,403 with 10,000-lb payload at 365 knots in 8:27 hours
Armament	None
Crew	6
Max Bombload (lb)	16,000

Abbreviations		
fpm	=	feet per minute
kn	=	knots
nm	=	nautical miles

[a]Based on manufacturer's flight test and wind tunnel data.

XB-51
Glenn L. Martin Company

Manufacturer's Model 234

Basic Development 1945

Development of the XB-51 was initiated in 1945, when the Army Air Forces (AAF) issued military characteristics for a light bomber aircraft. The AAF's requirements led to a design competition, held in February 1946. The Glenn L. Martin Company won the competition with a design for an airplane containing a composite power plant and promising a maximum speed of 505 miles per hour (438 knots), a cruise speed of 325 miles per hour (282 knots), and an 800-mile combat radius. The Martin design, then labeled the XA-45, also provided for a 6-man crew, all-around armament, and high-altitude bombing equipment.

Revised Characteristics Spring 1946

The AAF military characteristics of 1945 were revised in the spring of 1946. The new requirements called for an aircraft with better performance for all-weather, close support bombing. In line with Gen. H. H. Arnold's deletion of the requirement for "attack" aircraft,[39] the revised characteristics also called for a redesignation of the Martin design, subsequently known as the XB-51.

Initial Procurement 23 May 1946

Procurement of the experimental B-51 was initiated by a fixed-price letter contract, issued on 23 May 1946. This agreement gave Martin $9.5

[39] See this appendix, p 509.

million to produce 2 XB-51s, to be preceded by the usual wind-tunnel models and mockups. Special tools, spare parts, drawings, technical data, armament reports, and the like were also required.

Additional Revisions 1947

The military characteristics of 1945 and 1946 were revised again in 1947 to satisfy officials of AAF Headquarters, who doubted that the XB-51, as then envisioned, would become a satisfactory light bomber. The possibility of seeking 1 or 2 new production sources was considered but given up after the Air Materiel Command pointed out that to stay with the XB-51 and use funds already obligated for this purpose was probably the surest way to acquire a light bomber that would not be obsolete before reaching the inventory.

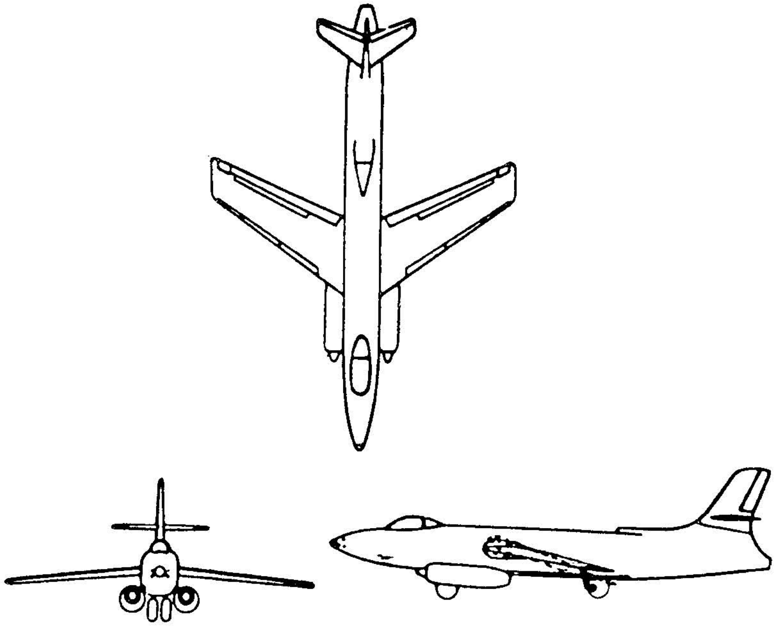
Concurrent studies by Martin resulted in the design of an XB-51 aircraft with a top speed of 620 knots, a cruise speed of 463 knots, and a 378-mile radius of action. The revamped XB-51 was to be equipped with eight 20-millimeter cannon, be capable of carrying a 4,000-pound bomb load, and would require a 2-man crew, 4 men less than originally planned. Further design studies, conducted by Martin at the request of the Air Materiel Command, brought additional changes. More realistically, the revised XB-51's top speed was set at 521 knots and its cruising speed at 434. Since the XB-51 was intended essentially as a low-altitude weapon, the radius requirement was decreased, bearing in mind that the Shoran (*sho*rt-*ra*nge *n*avigation) system earmarked for the plane was limited to less than 200 nautical miles. These final characteristics were approved by AAF Headquarters in early 1947. Shortly thereafter, the aircraft's development, in limbo for over a year, was re-instated.

Special Features 1949

Martin decided that a turbojet version of the basic XB-51 was the best configuration to satisfy the military characteristics that had been finally approved. Hence, the all-metal, mid-wing monoplane was fitted with 3 J47 engines. Two of the engines were in nacelles mounted on pylons on the lower forward sides of the fuselage, while the third engine was carried internally in the rear fuselage, with a top air inlet and a jet exit in the aircraft's tail.

First Flight 28 October 1949

The experimental XB-51 made its first flight on 28 October 1949. It was



Two of the XB-51's turbojets were mounted on the fuselage. The third was inside the rear fuselage.

the Air Force's first high-speed, jet-propelled, ground support bomber, and was one of the first post-war airplanes designed to destroy surface targets in close cooperation with Army ground forces.

Definitive Development Contract — 1 November 1949

Martin's letter contract of May 1946 was superseded on 1 November 1949 by a formal contract of the cost-plus-fixed-fee type. This contract (W33-038 ac-14806), carrying the same number as the 3-year-old letter contract, increased the amount initially obligated by $500,000 to cover the contractor's fixed fee.

Subsequently, change orders were to raise the cost of the ill-fated, $10.2 million development contract. Meanwhile, the procurement requirements of 1946 remained unaltered. Martin was required to provide mockups, spare parts, technical data, and 2 XB-51s.

Testing — 1949-1952

Testing of the first XB-51 was extensive. The Phase I tests, which lasted until the end of March 1951, indicated that relatively few modifications were needed and attested to the serviceability and excellent functional design of the experimental aircraft. Results of the Phase II tests, that had been conducted from 4 April to 10 November 1950, corroborated these findings. Martin pilots flew the first XB-51 (Serial No. 46-685) for 211 hours, accumulated in 233 flights. Air Force pilots totaled 221 hours on the same aircraft. The number of Air Force test flights was not accurately recorded, but did exceed 200. Flight testing of the second XB-51 (Serial No. 46-686), first flown on 17 April 1950, although thorough, was relatively brief. Martin test pilots flew the aircraft 125 hours, accumulated in 168 flights; the Air Force put in 26 hours, presumably reached in 25 flights. The second XB-51 was destroyed on 9 May 1952, during low-level aerobatics over Edwards AFB, California. The pilot was killed as the aircraft exploded and burned upon striking the ground.

Total XB-51s Accepted — 2

The Air Force accepted the 2 XB-51s built by Martin. The first one was accepted and delivered on 22 January 1952;[40] the other during the previous month, on 8 December 1951.

Program Cancellation — November 1951

The Air Force canceled production of the B-51 before the 2 experimental aircraft were formally accepted. Air Force records offered various reasons for the decision. For example, the XB-51 had received a second-best rating in comparison with other aircraft designed to fulfill similar mission roles. Yet, these records failed to identify the aircraft which were compared and the factors that established the XB-51's disappointing rating. Considering the time invested in the XB-51's development (about 5 years), the Air Research and Development Command offered a more specific explanation. The command stated that termination of the XB-51 contract in November 1951 was due to the fact that the plane, in its existing configuration, did not meet the requirements, particularly the range requirement, of the Tactical Air Command.

Total Development Costs — $12.6 million

Although Martin was informed in November 1951 that the XB-51 program was ended, the light-bomber contract was not closed out until 7 October 1953, when a last change order was issued. This document had several important purposes. It instructed the contractor to repair the first of the 2 experimental aircraft which, though significantly damaged in February 1952, was the only remaining XB-51. The Air Force also instructed Martin to prepare the plane for bomb-dropping tests and to send 2 field service representatives to participate in a 3-month bomb-dropping program to be conducted at Edwards AFB. The final change order, in addition, determined the last sums owed to Martin. Included were $381,439 for the aircraft's repair, some $90,000 for the required special work and the field representatives' services, plus 2 fixed-fees. Added to the expenses previously incurred for minor repairs and unexpected modifications, this brought the total cost of the experimental program to $12.6 million, a $2.4 million increase in about 4 years.

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[40] Delivery of the first XB-51 was delayed because of the extensive testing conducted by the contractor—a routine procedure.

Final Disposition 24 March 1956

The Air Force did not determine the final disposition of the repaired and much improved XB-51. The aircraft was totally destroyed on 25 March 1956 in a crash at Biggs Field, Texas. In the meantime, however, a great deal was learned from the experimental program. The work performed by the 2 XB-51s in the high-speed bomb-release program contributed much to advancing the state-of-the-art in that field. Also, the tail configuration, variable incidence wing, and bicycle-type landing gear of the XB-51 provided useful design data.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

XB-51 AIRCRAFT

Manufacturer (Airframe)	The Glenn L. Martin Co., Baltimore, Md.
Manufacturer (Engines)	The General Electric Co.; Schenectady, N.Y.
Nomenclature	Light Bomber
Popular Name	None

Length/Span (ft)	85.1/53.1
Wing Area (sq ft)	548
Weights (lb)	
Empty	29,584
Combat	41,547
Takeoff	55,923[a]
Engine: Number, Rated Power per Engine, & Designation	(3) 5,200-lb st J47-GE-13
Takeoff Ground Run (ft)	
At Sea Level	4,340[a] (no assist)
Over 50-ft Obstacle	5,590[a]
Rate of Climb (fpm) at Sea Level	3,720 (normal power)
Combat Rate of Climb (fpm) at Sea Level	6,980 (max power)
Service Ceiling (ft) (500 fpm Rate of Climb to Altitude)	32,400 (takeoff weight/normal power)
Combat Ceiling (ft) (500 fpm Rate of Climb to Altitude)	38,900 (combat weight/max power)
Average Cruise Speed (kn)	434
Max Speed at Optimum Altitude (kn/ft)	500/35,000 (combat/max power)
Combat Radius (nm)	378 with 4,000-lb payload at 463 kn average in 1.82 hr
Total Mission Time (hr)	2.07
Crew	2 (pilot and Shoran operator)
Armament	8 20-mm guns with total ammunition of 1280 rounds
Maximum Bombload (lb)	4 internal bombs (1,600 lb ea) or 2 external bombs (2,000 lb ea)
Maximum Bomb Size (lb)	4,000
Rockets	Provisions only for (8) 6-in HVAR[b]

Abbreviations

cal	= caliber	max	= maximum
fpm	= feet per minute	nm	= nautical miles
kn	= knots	st	= static thrust

[a]Including 1,275 lb water/alcohol.
[b]High-Velocity Aircraft Rockets.

YB-60

Consolidated Vultee Aircraft (Convair) Corporation

Basic Development — 25 August 1950

The YB-60 originated in August 1950, when the Consolidated Vultee Aircraft (Convair) Corporation offered to develop the B-36G, a swept-wing, all-jet version of the B-36F—fourth model of the basic B-36, initiated in 1941. The design, covered by the contractor's formal proposal, could eventually be converted into a turboprop bomber. Moreover, existing B-36s could later be brought up to the new configuration's standards.

Military Characteristics — November 1945

The first in a series of post-World War II military characteristics for heavy bombardment aircraft was issued on 23 November 1945. These characteristics were revised many times, but by 1950 the experimental aircraft thus far favored still fell short of satisfying the overall performance and long-range requirements expected of an atomic-capable, strategic bomber, due to be operational around 1955.[41]

Initial Procurement — 15 March 1951

A letter, rather than a formal agreement, supplemented the basic B-36 contract and authorized Convair to convert 2 B-36Fs into prototype B-36Gs, entirely equipped with turbojets but capable of accepting turbo-prop engines. The first YB-36G was to be ready for flight testing in December 1951; the second, in February 1952.

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[41] See B-52, pp 207-218.

Redesignation — Mid-1951

The proposed B–36G had little in common with the B–36F. The Air Force therefore determined that the B–60 designation would be assigned to the plane, because of the striking change in physical appearance and improvement in performance over that of the conventional B–36 airplane.

Program Change — August 1951

A misunderstanding concerning the configuration of the B–60 prototypes compelled Convair to recommend in August 1951 that at first only 2 stripped aircraft be developed. Accepting responsibility for the error, the contractor also proposed that the second YB–60 later be completed as a full tactical model. The Convair solution meant that separate specifications would have to be developed for each prototype. The Air Force agreed, after a 2-day conference during which the basic tactical configuration was set.

Special Features — 1951–1952

The B–60 prototype differed significantly from the B–36 by featuring swept-back wings and swept-back tail surfaces, a new needle-nose radome, a new type of auxiliary power system, and 8 Pratt & Whitney J57–P–3 jet engines, installed in pairs inside "pods" suspended below and forward of the leading edge of the wings. Another special feature of the YB–60 was its extended tail, which enabled the aircraft to remain in a level position for a considerable period of time during takeoff and to become airborne, with a gross weight of 280,000 pounds, after only 4,000 feet of ground roll.

Engine Shortages — 1951–1952

The J57–P–3, earmarked for the YB–60, was primarily scheduled for the B–52. Thus, while Convair would be able to use the Boeing-designed nacelles and engine pods, which seemed to be a distinct advantage, engine shortages were to be expected. This was particularly true, since the J57 engine was itself the product of an intensive effort to develop a high-thrust turbojet with a low fuel consumption. By the beginning of 1951, engine prototypes had accrued only 550 hours of full-scale testing. In 1952, even though production was already started, the engines were likely to remain in very short supply for quite a while.

First Flight 18 April 1952

The YB-60 flew for the first time on 18 April 1952—only 12 days after the prototype's eighth J57-P-3 engine finally arrived at the Convair's Fort Worth plant. The 66-minute flight was hampered by bad weather, but 2 subsequent flights in the same month were entirely successful, the YB-60 actually displaying excellent handling charateristics. This encouraging trend, however, did not prevail.

Flight Testing 1952–1953

Flight testing of the YB-60 officially ended on 20 January 1953, when the Air Force canceled the second phase of the test program. Convair test-flew the first YB-60 for 66 hours, accumulated in 20 flights; the Air Force, some 15 hours, in 4 flights. The second YB-60, although 93 percent complete, was not flown at all. By and large, test results were worrisome, because the stripped YB-60 displayed a number of deficiencies. Among them were engine surge, control system buffet, rudder flutter, and problems with the electrical engine-control system.

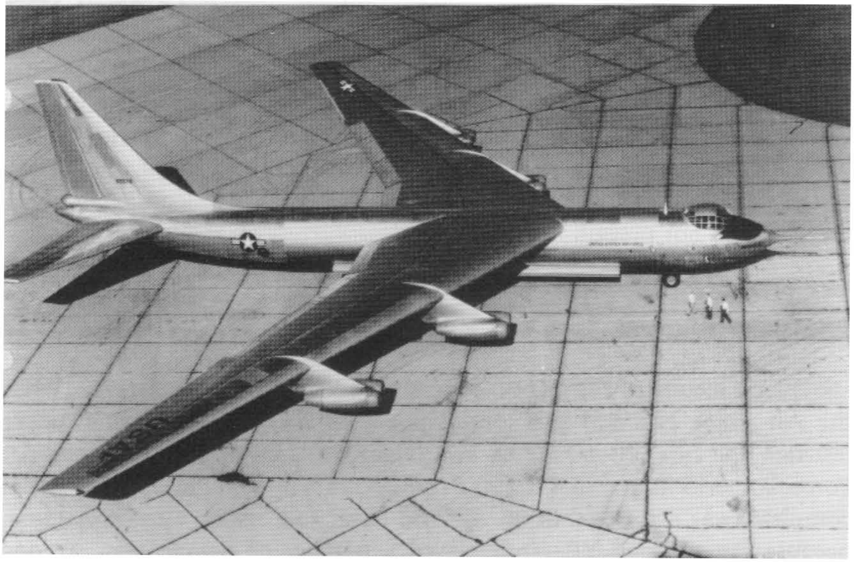
Program Cancellation 14 August 1952

The Air Force canceled the B-60 program several months before the prototype testing was officially terminated. The decision was inevitable. From the start, the project's sole purpose had been to help the Air Force in its quest for a B-36 successor. In this capacity, the B-60 competed all along with the B-52. There was no official competition, but test results were irrefutable. The YB-52 demonstrated better performance and greater improvement potential than the YB-60.[42] The latter was handicapped by the speed limitation imposed by structural considerations at low altitude and buffet at high altitudes. Also, the Convair prototype's stability was unsatisfactory because of the high aerodynamic forces acting upon the control surfaces and the low aileron effectiveness of the plane.

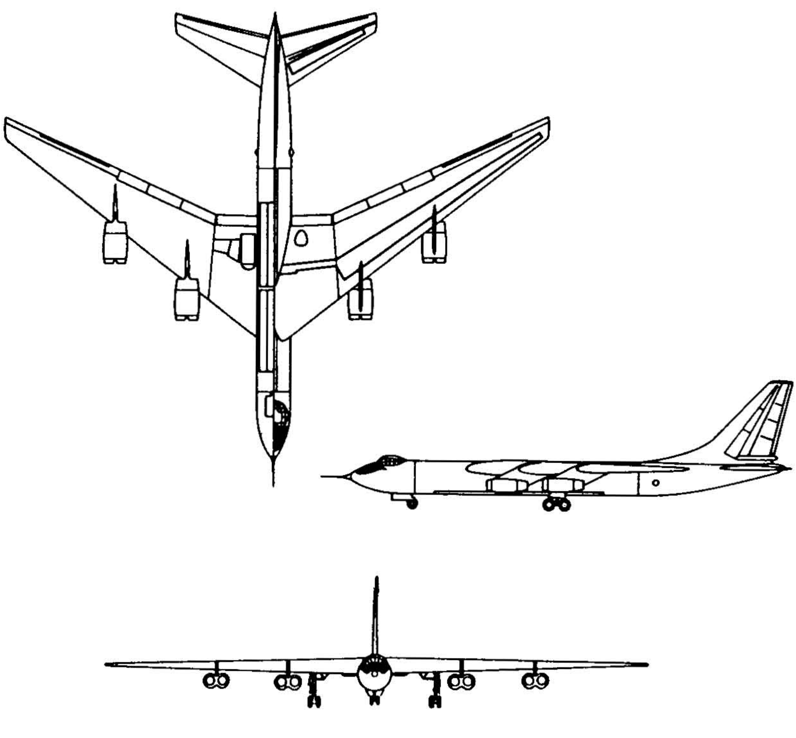
Total YB-60s Accepted 2

The B-60 program was canceled in the summer of 1952, and testing of

[42] The YB-52's first flight on 15 April 1952—3 days ahead of the YB-60's—was an impressive success and generated great enthusiasm for the Boeing airplane.



The prototype YB-60, a reconfigured B-36 with jet engines and swept-back wings.



the stripped prototype ended in January 1953. Even so, the Air Force did not accept the 2 YB-60s before 24 June 1954. There were valid reasons for the delay. Convair truly believed, and tried to convince the Air Force, that the YB-60s should be used as experimental test-beds for turbopropeller engines. Shortage of money and the YB-60's several unsafe characteristics accounted for the Air Force's decision to turn down Convair's tempting proposal.

Total Development Costs — $14.3 million

The final cost of the 2 B-60 prototypes was set at $14,366,022. This figure, agreed upon by both the Air Force and the contractor on 13 October 1954, included Convair's fee, the contract termination cost, and the amount spent on the necessary minimum of spare parts.

Final Disposition — June 1954

The Air Force scrapped the 2 YB-60s before the end of June 1954.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

YB-60 AIRCRAFT[a]

Manufacturer (Airframe)	Consolidated Vultee Aircraft (Convair) Corporation, Fort Worth, Tex.
Manufacturer (Engines)	The Pratt & Whitney Aircraft Division of United Aircraft Corporation
Nomenclature	Strategic Heavy Bomber
Popular Name	None

Length/Span[b] (ft)	171/206
Wing Area (sq ft)	Not Available
Weights (lb)	
Empty	150,000
Takeoff	410,000 (contractor design)
Engine: Number, Rated Power per Engine, & Designation	(8) 9,000-lb st J57-P-3
Service Ceiling (ft)	45,000
Maximum Speed (kn)	451
Combat Speed (kn)	440
Range (nm)	8,000
Combat Radius (nm)	2,910 with 10,000-lb payload at average speed of 400 kn
Crew	10

Abbreviations		
kn	=	knots
nm	=	nautical miles
st	=	static thrust

[a]Based on contractor's estimates and flight-test results.

[b]The new swept wing reduced the overall span to 206 ft as compared with 230 ft for the B-36.

XB-70A
North American Aviation, Incorporated

Manufacturer's Model NA-278

Weapon System 110A

Basic Development 1954

The XB-70A had its genesis in Boeing Aircraft Corporation's Project MX-2145, in which the contractor conducted studies relating to the type of weapon system required to deliver high-yield special weapons. The contractor, along with the Rand Corporation, considered various types of weapon system carriers. Among them were manned intercontinental bombers, delivering both gravity bombs and pilotless parasite bombers; manned bombers, air-refueled by tankers to extend their ranges and cover round-trip intercontinental distances; manned aircraft and drone bomber combinations; and unmanned bombers. During these studies Air Force Headquarters requested enlargement of the study program to include possible trade-off information; for example, the potential results of trading weight for speed, weight for range, or speed for range.

Boeing presented the requested information on 22 January 1954, pointing out the possibilities of a bomber aircraft powered by chemically augmented nuclear powerplants. For the first time, it appeared feasible to develop a weapon system of a reasonable size possessing the unlimited range characteristics of nuclear propulsion,[43] plus a high-altitude, supersonic dash capability. In March 1954, Boeing presented promising data on a chemically augmented, nuclear-powered aircraft. At the same time, both the Convair

[43] The development of nuclear propulsion for aircraft or missiles originated in 1945. In May 1946, the Army Air Forces signed a "letter of intent" with the Fairchild Engine and Airplane Corporation, thereby conferring on the highly classified NEPA (Nuclear Energy for the Propulsion of Aircraft) program a legal right to exist. While favoring the program, General LeMay, then Deputy Chief of Air Staff for Research and Development, said the work to be performed under NEPA would be somewhat speculative.

Corporation and Lockheed Aircraft Corporation, under contracts with the Office of Aircraft Nuclear Propulsion, submitted similar data.

Developmental Changes — Fall of 1954

In the fall of 1954, the Air Force Council endorsed 2 independent but simultaneous development programs, one for a nuclear bomber capable of short bursts of supersonic speed;[44] the other, for a subsonic, chemically powered, conventional bomber. The Air Force Council's announcement closely followed the October publication of General Operational Requirement No. 38. The document was brief. It simply called for an intercontinental bombardment weapon (a piloted bomber) that would replace the B-52 and stay in service during the decade beginning in 1965.

General Operational Requirement — 1955

The Air Force, on 22 March 1955, put out a second general operational requirement, No. 82, which superseded No. 38. Like its predecessor, the new general operational requirement was short. It called for a piloted strategic intercontinental bombardment weapon system that would be capable of carrying a 20,000-pound load of high-yield nuclear weapons, a requirement increased to 25,000 pounds by a September amendment. But the task of defining the Air Force's new project fell to the Air Research and Development Command. The command, therefore, had issued a study requirement, designated No. 22, which identified the Air Force's future new bomber as "Weapon System 110A" and established 1963 as the target date for the first wing of 30 operational vehicles.

Study Requirement 22's performance objectives were mach .9 for cruise speed and "maximum possible" speed during a 1,000-nautical mile penetration. Still, high speed was of less importance than the penetration altitude and radius. A revision of Study Requirement 22 on 15 April stipulated that the new weapon system's cruise speed should not be less than mach .9, unless a lower speed would result in a significant range increase. There were other important changes. Instead of the subsonic requirement covered by General Operational Requirement 38, maximum possible "supersonic"

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[44] General Operational Requirement No. 81, issued in March 1955, specifically called for the development of a nuclear-powered weapon system that would be capable of performing a strategic mission of 11,000 nautical miles in radius, of which 1,000 miles were to be traveled at speeds in excess of mach 2, at an altitude of more than 60,000 feet.

speed within the combat zone was desired. On 11 October, Air Research and Development Command amended the revised Study Requirement 22. The amendment set July 1964 as the target date for the first operational wing of B-70s—so designated in February 1958. The purpose of the delay was to avoid financial and overall weapon system risks, if at all possible.[45]

Other Requirements — 1955-1956

In early 1955, the Air Force released another general operational requirement (No. 96) for an intercontinental reconnaissance system having similar objectives as the previously established bombardment system, known as Weapon System 110A. In July, the Air Research and Development Command issued a study requirement of General Operational Requirement 96 that validated a reconnaissance version of the B-70. The reconnaissance system was identified as Weapon System 110L. The 2 systems were combined soon afterward, becoming in the process Weapon System 110A/L.

Program Implementation — June 1955

In June 1955, the Air Staff directed that development of Weapon System 110A/L be initiated as soon as possible with a multiple, competitive "Phase I" program.[46] Although 6 eligible contractors were contacted, only the Boeing Airplane Company and North American Aviation, Incorporated chose to submit proposals.

Contractual Arrangements — 1955-1956

On 8 November 1955, the Air Force awarded letter contracts to both Boeing and North American for the Phase I development of Weapon System 110A/L. Boeing's letter contract amounted to $2.6 million; that of North

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[45] In 1955, the Air Research and Development Command estimated the weapon system's costs through fiscal year 1962 at $2.5 billion. The estimate covered development, test aircraft, and 30 operational bombers, but assumed that a nuclear bomber would also be developed, that a new engine for the chemically powered bomber would be created, and that the price of certain subsystems, earmarked for the B-70, would be borne by the nuclear aircraft program.

[46] The use of "phase" contracts was not new, having been approved as early as 1944 by the Army Air Forces to facilitate the termination of contracts dealing with highly experimental and, therefore, very uncertain programs.

American, to $1.8 million. Each contractor had to furnish a design for the required weapon system; provide models, drawings, specifications, reports, and other data; conduct studies and wind tunnel tests, and construct a mockup. The mockup was to be completed and ready for Air Force inspection within 2 years of the date on which the contractor accepted the contract. Contractor fees could not exceed $450,000.

The 2 letter contracts became definitive in 1956. The Boeing contract, AF33(600)-31802, signed on 15 March, specified a total estimated cost of $19.9 million; the North American contract, AF33(600)-31801, signed on 16 April, $9.9 million, subject to renegotiation. The Air Force, in its definitive contracts, allotted originally $4.5 million to Boeing and $1.8 million to North American.

Military Characteristics 1956

Concurrent with the letter contracts of 1955, the Air Force established specific requirements that were included in the final documents signed in 1956. To begin with, each contract emphasized that the purpose of the entire program was to develop, test, and produce for wing strength by 1963 (much sooner than decided in October 1955) a chemically powered weapon system which, in conjunction with the nuclear-powered bomber, would replace the B/RB-52 as a "first line operational weapon."

With regard to operational characteristics, the new weapon system was to rely primarily on nuclear weapons to accomplish its mission, and the origin and termination of its operations were to be within the limits of the North American continent. The Air Force specified that weapon system 110A/L would have to be capable of performing during the day, at night, and in any kind of weather. A minimum unrefueled radius of 4,000 nautical miles, and a desirable extended radius of 5,500 nautical miles were required, with aerial refueling allowed in the latter case. Finally, the minimum target altitude was to be 60,000 feet, and the contracts reiterated that cruise speed could not be less than mach .9, with maximum supersonic dash speed in the combat zone.

These were exacting characteristics. Studies of conventional aircraft had shown that no such performance could be obtained with proven design techniques. The Air Force acknowledged that the ability to satisfy its demands, particularly the radius-of-action and speed requirements, would depend on the use of high-energy fuels, new engines, new design techniques, and some other break-through in the state-of-the-art by the operational date of 1963. The Air Force also made sure that the contractors knew that while range and speed trade-offs would be acceptable in order to assure maximum supersonic dash at a "practical" gross weight, every reduction would have to be minimal. Finally, the new weapon system's configuration would have to allow for the easy addition of state-of-the-art improved subsystems and components, not initially incorporated.

Design Proposals — Mid-1956

Naturally enough, the preliminary design proposals submitted in mid-1956 by Boeing and North American were quite different. Boeing utilized a conventional swept-wing configuration; North American, a canard-type, resembling a scaled-up Navaho missile.[47] Still, in order to attempt meeting the payload requirements and ranges stipulated in the spring of the year, the contractors had incorporated similar features in their respective designs. The aircraft envisioned by both would weigh some 750,000 pounds and require the use of cumbersome floating wing panels. These panels would carry fuel for the outgoing trip and be jettisoned when empty. Maximum speed might then exceed mach 2 by a significant margin.

The Boeing and North American preliminary designs had another common factor: both were unsatisfactory. The gross weights were excessive. The proposed fuel devices, whether fuel panels or straight floating wing tips, while promising to extend the aircraft's subsonic range, seemed impractical. To begin with, the enormous expendable panels (or non-folding floating wing tips) would create logistical problems and runway difficulties because of the total width of any airplane so equipped. In September, a disappointed Air Staff recommended that both contractors "return to the drawing board." And money being short, a more drastic decision followed that nearly spelled the program's cancellation. On 18 October, the Air Force discontinued the weapon system's Phase I development. Boeing and North American were allowed to resume their studies, but solely on a reduced research and development basis.

Concerned that the contractors might construe their contract's reorientation as resulting from lack of funds—an interpretation not far from the truth—and would merely mark time while refining their current designs, the Air Force promptly minimized the impact of its October decision. First, new work statements were issued, underscoring the necessity of achieving acceptable, but less exacting, performance characteristics. Then on 20 December, the Air Force sent identical letters to the presidents of Boeing and

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[47] The North American SM-64A Navaho (System 104A) was a vertically launched, air-breathing, intercontinental surface-to-surface, delta-wing missile, with a length of 87 feet and a diameter of 6½ feet. Production was canceled in July 1957 because of budgetary and technical problems. The Navaho development cost over $600 million, but the work expended on the canceled program was not a loss and benefited other projects significantly.

North American, asking that every possible means be explored to improve the aircraft's range "through complete redesign if necessary."

Contractor Selection 23 December 1957

After the delay induced by the rejected proposals, events moved swiftly. By March 1957, it seemed almost certain that the new weapon system could be an all-supersonic cruise air vehicle as opposed to a "split-mission" (subsonic cruise-supersonic dash) aircraft.[48] In other words, aircraft designers had discovered that, if the entire design (especially engines, air induction system, and airframe) was geared for a single flight condition such as mach 3, the range of the supersonic system would compare favorably with that of a subsonic vehicle. Both contractors, independently, had also concluded that, as suggested by the Air Force, high-energy fuel would be needed and that its use should be extended to the engine afterburner.

In mid-1957, believing their re-oriented contractual commitments had been fulfilled, Boeing and North American asked for an early competitive selection of 1 contractor over the other. Dual contracting and dual funding made extra work and was costly. Moreover, the Air Research and Development Command was convinced that state-of-the-art advances had been fully exploited by both contractors. Further study of the project would mean more delay and be self-defeating. Hence, the tempo of activities quickened. On 30 August, the Air Force directed a 45-day competitive design period, ending with the onsite inspection of each contractor's facilities. On 18 September, the Air Force gave Boeing and North American the new system characteristics established for the competition. These characteristics called for a speed of mach 3 to mach 3.2, a target altitude of 70,000 to 75,000 feet, a range of 6,100 to 10,500 miles, and a gross weight between 475,000 and 490,000 pounds.

Meanwhile, a source selection evaluation group had been organized. It comprised 3 teams: representatives from the Air Research and Development Command, the Air Materiel Command, and, for the first time, a using command—the Strategic Air Command, in this case. The evaluation group, numbering about 60 members, reviewed the North American proposal during the last week of October; that of Boeing, during the first week of November.[49] The 3-team evaluations were presented to the Air Force Council

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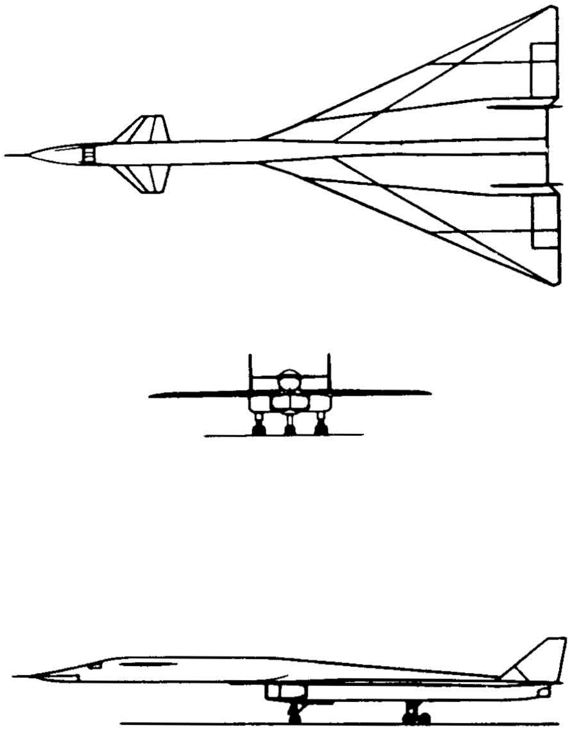
[48] Theoretical research on the "supersonic wedge principle," conducted by the National Advisory Committee for Aerononautics in 1956, actually had much to do with the "graduation" to an all-supersonic flight pattern.

[49] Due to the success of the 3-team evaluation group, the Air Force changed its source selection procedures, the using command becoming an integral part of the selecting process.



The striking XB–70A was "rolled out" at the contractor's plant.

on 15 December. The North American proposal was found unaminously to be substantially superior to that of Boeing. The Air Force formally announced North American's selection on 23 December.

New Planning 1958

As winner of the 1957 competition, North American on 24 January 1958 signed contract AF33(600)-36599. Strictly speaking, this document again covered only the new weapon system's Phase I development. Just the same, availability of the first operational wing (30 planes and 15 test vehicles) was already planned for late 1965. In February 1958, believing that by late 1965 or thereabouts, when the RB-70 would become operational, other systems could better satisfy the reconnaissance requirements, the Air Force canceled the development of Weapon System 110L (part of WS 110A since 1956).

While the reconnaissance requirement was being deleted, an 18-month acceleration of the B-70 program was planned. This change, endorsed by the Air Research and Development Command and Air Materiel Command, scheduled the aircraft's first flight for December 1961 and formation of the first operational wing for August 1964. No performance decrease would result, and the increase in costs would not exceed $165 million. The Air Staff approved the accelerated plan in principle on 19 March 1958. In the same month, a revised general operational requirement was issued, updating such matters as the speed specification. In April, a preliminary operational concept was published.

In the fall of 1958, the Air Force's apparent optimism had a severe jolt. Gen. Thomas D. White, Air Force Chief of Staff since August 1957, announced that the B-70 program's planned acceleration was no longer viable because of funding limitations. A first flight, therefore, should not be expected before January 1962; an operational wing, in August 1965, at the earliest. This reversal damaged the program, particularly the weapon system's components. General White wanted more judicious use of currently available equipment and flight test inventory. He further wished to reduce the overall complexity of the bombing-navigation and missile guidance subsystems. Of greater import, and a harbinger that worse might yet come, General White also told his staff that the Eisenhower Administration believed that no large sums of money should be committed to the program before the B-70 prototype had proven itself. General White's words reflected the Administration's determination to hold military expenditures for radically new or unproven weapon systems to a minimum, while taking advantage of technological advances. Deployment of the free world's first long-range ballistic missiles, and accelerating the operational readiness of additional weapons systems of this type, which appeared more cost-effective and less speculative, fell under the purview of such a philosophy.

Mockup Inspection — 30 March 1959

A development engineering inspection and mockup review were conducted at North American's Inglewood plant on 2 and 30 March 1959, respectively. The mockup review differed from the inspection in that it was styled to present the operational characteristics and suitability of the weapon system's configuration, rather than to introduce detailed system analysis and theory. On both occasions, the Air Force requested a great many changes, some of which were considered of primary importance. Nevertheless, almost 95 percent of the work generated by the requested alterations was accomplished before the end of the year.

New Setbacks — 1959

Decisions made in the second half of 1959 hampered Air Force aircraft development efforts, placing additional pressure on the B-70 program.[50] On 11 August, the Department of Defense canceled the high-energy fuel program. The use of this fuel had been counted on to extend the B-70's range substantially over its required radius. As it turned out, the high-energy fuel program cancellation had a lesser impact than anticipated because other jet fuels, JP-6 especially, were greatly improved. Just the same, as planning stood in mid-1959, elimination of the high-energy fuel program required additional configuration changes and, more specifically, a new engine for the B-70.

Termination on 24 September of the North American F-108 Rapier, a never-flown long-range interceptor under letter contract since 1957, was another blow. The B-70 program was directly affected. It would now be compelled to finance, at least partially, such development items as engines, escape capsules, and fuel systems that had been common to both aircraft systems and previously covered by F-108 funds. The loss was expected to boost B-70 program costs by at least $180 million.

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[50] The nuclear-powered bomber, after overshadowing the chemically powered aircraft for years, began to suffer from financial malnutrition in 1956. By mid-1959, decisions at the highest executive level had put the program into almost total eclipse. The project's downfall was bound to impede the B-70 program since the cost of several B-70 subsystems were to be borne by the nuclear-powered bomber—officially canceled by the Kennedy Administration in March 1961.

Near-Cancellation 1959

General White's words of caution notwithstanding, more than 15 major subcontracts were let during the early part of 1959. In the ensuing months, after the high-energy fuel program and F-108 project were given up, money became increasingly scarce, and most B-70 activities were slowed down. But the program's new predicament was only a beginning.

In November 1959, during a meeting concerning the military programs of the coming year, President Eisenhower told the Air Force Chief of Staff that the "B-70 left him cold in terms of making military sense." General White conceded there were important questions involved and that the aircraft was very different from anything previously developed. He said the B-70 must overcome the terrific heat generated by high speed and high altitude and that the shape of the aircraft's wings and fuselage must be studied. However, to eliminate such unconventional aircraft would be going too fast and too far. Hardly impressed with the many pro-B-70 arguments put forth, the President stressed that the B-70, if allowed to reach production, would not be available for 8 or 10 years, when the major strategic retaliatory weapon would be the missile. The President finally agreed to take another look at the B-70 proposition, but in the same breath pointed out that speaking of bombers in the missile age was like talking about bows and arrows in the era of gunpowder.

The Air Force announced on 29 December that the B-70 program was reoriented to produce a prototype vehicle only and that the development of most sub-systems was canceled. The program's near demise was generally attributed to the Administration's budget.

Program Reendorsement 1960

The politics of the 1960 presidential campaign kindled the interest of both parties in the B-70. Thus, with the approval of the Defense Department, the Air Force in August 1960 directed that the XB-70 prototype program once again be changed to a development and test program. Twelve B-70 prototypes were added, and the program was designed to demonstrate the bomber's combat capability. This directive, coupled with a congressional appropriation of $265 million for fiscal year 1961, restored the B-70 to the status of a weapon system headed for production.

In September, North American was instructed to proceed with the design, development, fabrication, and testing of a number of YB-70s. Also, development of the major systems for an operational mach 3 bomber had to be ensured, which meant that many of the recently canceled subcontracts (let by the prime contractors early in 1959) had to be reopened. This exercise might be time-consuming as well as difficult, since some of the subcontractors might now be involved in other work. Even so, by mid-October the defensive subsystem contract with Westinghouse Electric Corporation had been reinstated. In November, North American reactivated the contract with Motorola, Incorporated for the mission and traffic control system of the B-70. In the same month, development of the B-70's bombing and navigation system, under the auspices of the International Business Machines Corporation and significantly reduced since the summer of 1959, regained the impetus normally afforded a system intended for production. Still, the B-70 program's recaptured importance was to be short lived.

Definite Cancellation 1961-1962

Once in office, it did not take long for President John F. Kennedy to take a critical look at the B-70 program. Like his predecessor, President Kennedy obviously doubted the aircraft's reason for being from the standpoint of future operations. On 28 March 1961, he recommended that the program be continued in order to explore the problems of flying at 3 times the speed of sound with an aircraft "potentially" useful as a bomber.[51] This, President Kennedy underscored, should only require the development of a small number of YB-70s and bombing and navigation systems. No more than $220 million should be needed in fiscal year 1963, and the program's total cost should not exceed $1.3 billion.

President Kennedy's words gave the Air Force no choice but to redirect the B-70 program from full weapon system status to that of a mere prototype aircraft development. Since the aircraft's eventual production appeared now most unlikely, the Air Force immediately began to consider various alternatives to the defunct B-70. In May 1961, there was talk of an improved B-58, armed with both bombs and air-launched missiles; of a specially designed, long-endurance, missile-launching aircraft; of transport planes modified to launch ballistic missiles; of the nuclear-powered aircraft, and again of a reconnaissance B-70, which would also be capable of striking the enemy.[52] In August, the U.S. Senate attempted once more to rescue the

[51] President Kennedy's recommendations were part of his special message on the Defense budget, as submitted to the Congress on 28 March. The President emphasized the importance of accelerating long-range missile programs and of increasing the armed forces' capability to handle limited wars.

[52] The Air Force's persistent search for a new manned bomber seemed unrealistic. On 25 May 1961, in an address to a joint session of the Congress, the President proposed to reinforce further the military establishment's capabilities in limited warfare and to expand substantially the Defense programs related to the newly accelerated national space effort. These specific

B–70 and asked that a production program be outlined for the purpose of introducing the aircraft into the operational inventory at the earliest possible date. Undaunted, Secretary of Defense Robert S. McNamara expressed his thorough dissatisfaction with North American Aviation's handling of the B–70 development.

The year 1962 did not resolve the B–70 predicament. The President insisted that only $171 million of FY 63 funds ($49 million less than proposed in 1961) be spent on the prototype program, instead of the $491 million requested by the Air Force and previously approved by Congress. In March, Congress indicated that the Air Force should use the $491 million for planning and procurement of a reconnaissance and strike B–70 (RSB–70), but later in the month reduced the amount to $362.6 million. In April, a group headed by Gen. Bernard A. Schriever, Commander of the Air Force Systems Command, developed several approaches to the proposed RSB–70 system. The development plan preferred by the group would cost $1.6 billion and it programmed the RSB–70's first flight within little more than 2 years. In June, this plan and others were disapproved by the Department of Defense. Nevertheless, on 23 November the President authorized the addition of $50 million to the currently approved $1.3 billion B–70 development program. The extra money was intended for the development of highly experimental sensor components, a requirement if the RSB–70 (as unlikely as it was) or any similar new weapons system should be considered later.

Technical Problems 1962

As explained to members of the Congress in January 1960 by Thomas S. Gates, Secretary of Defense during the last 2 years of the Eisenhower Administration, the B–70 program was hampered from the start by technical problems stemming from the "use of metal and components . . . still in the research stage." By 1962, although much progress had been made, severe problems remained. North American was still working on an automatic air induction control system for regulating the flow of air to the J93–3 jet engines, originally designed to power the canceled F–108 and, following the end of the high-energy fuel program, immediately earmarked for the B–70.

The secondary power generating subsystem, due to provide current to the pump that maintained hydraulic pressure, also was unsatisfactory.

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goals clearly indicated that production of a costly new aircraft was excluded from President Kennedy's foreseeable planning.

Excessive vibration caused failures in the generator gear boxes, and the hydraulic pumps frequently broke down. Braces were added to steady the gear boxes, but the pumps had to be rebuilt with metals capable of withstanding the intense heat of supersonic operations as well as the extreme pressure generated within the hydraulic lines.

At the close of 1962, other serious problems still prevented completion of the first air vehicle, accounting for North American's continual revision of the XB-70's delivery schedule. Defective stainless steel honeycomb panels necessitated an unanticipated number of repairs. The panels of the air ducting system bay and the fuel tank areas had numerous examples of such defects. A nickel-plating process was sufficient to eliminate most imperfections, but repairs on the fuel tank areas had to be air-tight to prevent the escape of nitrogen gas. In December, North American was considering giving up the use of polyimide varnish in favor of vitron sealant. Another significant problem was that the wings did not fit properly to the wing stubs. Special adapters had been developed and were being manufactured, but again this took time and money.

Other Difficulties 1963-1964

In 1963 and 1964 frustrations with the B-70 increased. Almost 40 of the $50 million approved for the development of sensor components was diverted to the experimental bomber to allow continuation of the 3-plane program. In June 1963, the Air Force converted the XB-70 contract from the cost-plus-fixed-fee to the cost-plus-incentive-fee type. But no spectacular progress ensued. In September, North American suggested further delivery revisions. The first aircraft, North American said, would be completed in April 1964—4 months past the latest deadline assigned by the Air Force. In October, continued technical problems and rising expenses prompted the Air Force to request that the cost of a 2-vehicle program be defined. On 7 January 1964, Gen. Curtis E. LeMay, Air Force Chief of Staff since 30 June 1961, although a strong supporter of the B-70, endorsed the Air Force Council's recommendation favoring the 1-vehicle reduction. The decision was dictated by the compelling need to avoid exceeding the program's approved total cost of $1.5 billion. The decision also practically closed the case of the two-XB-70 program and definitely prevented the start of RSB-70 development.

First Flight 21 September 1964

The first flight of the XB-70A Valkyrie[53] occurred on 21 September 1964, nearly 4 years later than the date scheduled in 1958 (right after North American had won the contract). The experimental bomber flew for approximately 1 hour in the northeast-southwest corridor between Palmdale, California, and the Rogers Dry Lake at Edwards AFB, also in California. The 2-member crew—Alvin White, North American Chief Test Pilot, and Col. Joseph F. Cotton, USAF B-70 Chief Test Pilot—landed successfully at Edwards AFB. Nevertheless, the plane had to undergo additional ground tests before entering an extensive flight testing program at Edwards.

Special Features 1964

The striking features of the experimental B-70 centered on the configuration and composition of its airframe, with its semi-monocoque fuselage of steel and titanium. Also, the bomber's external skin was composed of brazed stainless steel honeycomb sandwich, wide use having been made of titanium alloys. The XB-70's flying controls comprised elevons on the trailing edges of the cantilever delta wings and twin vertical fins and rudders. The large canard foreplane was adjustable to achieve "trim" (balance in flight or landing, etc.). Its trailing edge flaps enabled it to droop the elevons to act as flaps, making it possible for the XB-70 to take off from and land on existing B-52 airstrips.

Unrelenting Problems 1965-1966

Continued technical difficulties delayed the XB-70's testing program. For the same reasons, completion of the second experimental B-70 took longer than expected, and the bomber did not fly before July 1965. Less than a year later, on 19 May 1966, the second XB-70A flew for 32 minutes at the sustained speed of mach 3. Unfortunately, tragedy closely followed this remarkable achievement. On 8 June, the plane was lost in a mid-air collision with a Lockheed F-104 fighter. The loss, occurring at approximately 25,000 feet, near Barstow, California, 43 miles east of Edwards AFB, reduced the XB-70A program to a single vehicle.

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[53] The name Valkyrie resulted from a "name the B-70" contest, sponsored by the Strategic Air Command in the spring of 1958.

Total XB-70As Accepted **2**

Total Development Costs **$1.5 billion**

Final Disposition **1967**

In March 1967, the Air Force transferred the remaining XB-70A to the National Aeronautics and Space Administration, where the plane took part in an expanded flight research program. The program's main objective was to verify data applicable to a supersonic transport. The space agency's retention of the XB-70 was of short duration. Before the end of the year, the Valkyrie reached its final destination and was put on display at the Air Force Museum, Wright-Patterson AFB, Ohio.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

XB-70A AIRCRAFT[a]

Manufacturer (Airframe)	North American Aviation, Inc., Los Angeles, Calif.
Manufacturer (Engines)	General Electric Co., Flight Propulsion Division, Evendale, Ohio
Nomenclature	Supersonic Bomber
Popular Name	Valkyrie

Length/Span (ft)	185.8/105
Wing Area (sq ft)	6,297
Weights (lb)	
Empty	231,215
Combat	341,096
Takeoff	521,056 (273,063 lb of fuel, included[b])
Engine: Number, Rated Power per Engine, & Designation	(6) 28,000-lb st (max) YJ93-3 (axial turbojet)
Takeoff Ground Run (ft)	
At Sea Level	7,400 (with max power)
Over 50-ft Obstacle	10,550 (with max power)
Rate of Climb (fpm) at Sea Level	7,170 (with military power)
Combat Max Rate of Climb (fpm) at Sea Level	27,450 (with max power)
Service Ceiling (100 fpm Rate of Climb to Altitude)	28,100 ft (with military power)
Combat Service Ceiling (100 fpm Rate of Climb to Altitude)	75,500 ft (with max power)
Combat Ceiling (500 fpm Rate of Climb to Altitude)	75,250 ft (with max power)
Basic Speed at 35,000 ft (kn)	1,089 (with max power)
Average Cruise Speed (kn)	1,721
Max Speed at Optimum Altitude (kn/ft)	1,721/75,550 (with max power)
Combat Range (nm)	2,969
Total Mission Time (hr)	1.87
Crew	2 (pilot and co-pilot)
Armament	None
Maximum Bombload (lb)	65,000 (space provisions, only)
Maximum Bomb Size (lb)	25,000

Abbreviations

fpm	= feet per minute
kn	= knots
max	= maximum
nm	= nautical miles
st	= static thrust

[a]Derived from flight-test results.
[b]Specifically, 43,646 gal of JP-6 fuel.

B-1A
Rockwell International Corporation

Manufacturer's Model W/S 139A

Basic Development 1963

Known as the Advanced Manned Strategic Aircraft (AMSA) until April 1969, the B-1 had its beginning in July 1963, when a USAF program change proposal called for an extra $25 million in fiscal year 1965. The Air Force wanted to use this money to develop 1 or more of the various advanced strategic manned systems then under study in mid-1963. Unofficially, the B-1 dated back to 1961, when the Air Force began considering alternatives to the canceled B-70.

Developmental Planning 1961-1963

Budgetary restrictions and the Eisenhower and Kennedy Administrations' clear belief that missile systems[54] like the Minuteman[55] were the strategic weapons of the future generally explained why the XB-70 did not go to production. Gen. Thomas S. Power, Commander-in-Chief of the Strategic Air Command since 1 July 1957, offered another reason: the B-70 was really "killed" because it was designed for flight at very high altitudes —an advantage when the aircraft was first conceived, which lost most of its attraction when the Soviets developed effective, high-altitude antiaircraft missiles. Whatever the cause, several studies were undertaken to circumvent the B-70's deficiencies, while enhancing the manned bomber concept. The Air Force insisted that bombers would continue as a necessary dimension to the United States' strategic deterrent capability.

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[54] See this appendix, p 569.

[55] The first Minuteman squadron was activated in late 1961, but the new intercontinental ballistic missile did not become operational until 11 December 1962.

The first of the bomber studies accomplished in the early sixties was finished in 1961. Known as SLAB (for *S*ubsonic *L*ow *A*ltitiude *B*omber), the study demonstrated that a fixed-wing aircraft of 500,000 pounds, with a payload of 12,000 pounds and an 11,000-nautical mile range, including 4,300 nautical miles at low altitude, was needed to replace the B-52. Next came ERSA (for *E*xtended *R*ange *S*trike *A*ircraft), a study which maintained that a 600,000-pound plane of variable swept wing with a payload of 10,000 pounds and a total range of 8,750 nautical miles (with 2,500 nautical miles at 500 feet) would suffice. Then in August 1963, a third study, LAMP (for *L*ow *A*ltitude *M*anned *P*enetrator), was completed. It recommended a 350,000-pound aircraft with a 6,200-nautical mile range (and 2,000 nautical miles at low altitude), carrying a 20,000-pound payload. As anticipated by the Air Force, these studies were not conclusive, and other planning was already in motion.

By mid-1963, a Manned Aircraft Studies Steering Group, headed by Lt. Gen. James Ferguson, Deputy Chief of Staff, Research and Development, examined various possibilities. Included were a long-endurance aircraft, a supersonic reconnaissance craft and, eventually, LAMP, which the steering group later recognized as most promising. In the meantime, another major Air Force effort to calculate its future needs had been making progress. Initiated in 1963 and known as "Forecast," the project was directed by Gen. Bernard A. Schriever, Commander of the Air Force Systems Command and an advocate of acquiring an advanced manned system.

In October 1963, Generals Schriever and Ferguson, accompanied by Lt. Gen. William H. Blanchard, Deputy Chief of Staff, Programs and Requirements since August 1963, met with other members of Project Forecast and the Manned Aircraft Studies Steering Group. The 2 organizations, after arguing over such factors as size and payload, eventually reached conclusions that were to provide the foundation for a new bomber, now termed the Advanced Manned Precision Strike System (AMPSS).

Requests for Proposals — November 1963

In November 1963, the Air Force gave 3 contractors—the Boeing Company, General Dynamics Corporation, and North American Rockwell Corporation[56]—requests for proposals for the AMPSS. However, as in the B-70's case, Secretary of Defense Robert S. McNamara had a tight hold on

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[56] The North American Rockwell Corporation was formed on 22 September 1967, when North American Aviation, Incorporated, and Rockwell Standard Corporation merged, the 1967 designation being applied ahead of time for clarity's sake.

any money earmarked for a sophisticated new bomber. In addition, Mr. McNamara questioned the validity of the assumptions used by the Air Force to justify the AMPSS. Because of the Secretary's doubts, only $5 million became available, and the released requests for proposals were limited to the mere study of the bomber concept. Moreover, some of the tentative requirements outlined by the Air Force were promptly discredited by all contractors. One of the suggested USAF designs would have involved prohibitive costs; another, including a vertical and short takeoff and landing capability, was not feasible when dealing with the heavy gross weights envisioned by the Air Force. In any case, the industry's negative comments proved academic. By mid-1964, when the results of every study had been received, the requirements outlined in the requests for proposals of November 1963 had been substantially altered.

New Requirements — Mid-1964

By mid-1964 the bomber concept, illustrated by the proposed AMPSS, remained basically unchanged, but some of the tentative requirements previously identified had been redefined and the aircraft, expected to satisfy the new criteria, had been retitled as the Advanced Manned Strategic Aircraft (AMSA). Briefly stated, the AMSA system, while retaining the required takeoff and low altitude characteristics of the AMPSS, would also be capable of maintaining supersonic speeds at high altitudes. As a basis for further study, the Air Force in July 1964 gave the renamed, and now supersonic system, a projected gross weight of 375,000 pounds, and a range of 6,300 nautical miles, 2,000 of which would be flown at very low altitudes.

Project Slippage — 1964–1968

Against odds which at first appeared highly favorable, the AMSA project was to remain unsettled for years to come. Gen. Curtis E. LeMay, Air Force Chief of Staff, after briefing President Lyndon B. Johnson in December 1963 on the program's importance, secured in 1964 the Joint Chiefs of Staff's approval of the USAF plans. In that year, as well as others, Congress approved all the AMSA money the Air Force wanted, be it for project definition,[57] or for the advanced development of engines and of an

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[57] Project definition would produce data on probable costs, time needed for development, and technical risks. If the results were satisfactory, the Air Force would be in a position to contract for further work.

avionics system. Yet, Secretary McNamara again refused to commit any Department of Defense funds unless he was given a better justification for developing the new manned system and a clearer picture of what the projected AMSA could do.

Attempts to change Secretary McNamara's opinion of AMSA were futile. The Secretary thought surface-launched ballistic missiles could perform the "assured destruction" strategic mission better than manned bombers, and insisted that development of an expensive new system of the AMPSS/AMSA class was most unlikely. On the other hand, he believed the technological effort of avionics and propulsion research and development should go on to produce advances in the state-of-the-art applicable to future or existing manned systems. Thus, while only small sums would be released for preliminary AMSA studies, significant amounts would be allocated for research work on subsystems and components.

In late 1964, Boeing, General Dynamics, and North American Rockwell submitted initial reports on their study of AMSA. Concurrently, propulsion reports were received from Curtiss-Wright, General Electric, and Pratt & Whitney, while International Business Machines (IBM) and Hughes Aircraft sent in their avionics recommendations. In 1965, as the airframe contractors continued to study the AMSA system, General Electric and Pratt & Whitney were selected to construct 2 demonstrator engines that would meet the requirements of the AMSA mission. While this seemed encouraging, the uncertainty of the AMSA project would soon increase.

In December 1965, the Defense Department selected an elongated version of the General Dynamics F-111, known as the FB-111,[58] to replace the Strategic Air Command's B-58s, B-52Cs, and B-52Fs by fiscal year 1972. The Air Force had not requested the development of a bomber version of the controversial F-111, and opinion varied widely on its likely value. Still, the acquisition of a low-cost, interim bomber had merits. The Air Force endorsed production of the plane so long as it did not jeopardize AMSA development. As General Ferguson stated in 1966, the FB-111 was and would remain a "stopgap airplane," an assessment shared by the Strategic Air Command and the entire Air Staff even though Secretary McNamara continued to think otherwise.

By 1968, an advanced development program for avionics had been assigned to 2 contractors, IBM and the Autonetics Division of North American Rockwell. They were to determine if advanced avionics concepts were achievable and compatible to operational development. Ten sub-

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[58] Development and production of the FB-111 proved to be closely interlaced with the whole F-111 program. The bomber's coverage was therefore included in the F-111 chapter of *Post-World War II Fighters*, Vol. 1 of the *Encyclopedia of U.S. Air Force Aircraft and Missile Systems*.

contractors, selected by the 2 firms, worked on various components, studied a wide range of components, including forward-looking radar, doppler radar, and infrared surveillance. Early in that same year, the Joint Chiefs of Staff recommended the immediate development of AMSA, and Secretary McNamara once more vetoed the proposal. He preferred instead to develop several subsystems and components for upgrading the performance of the FB-111s and the remaining B-52s with new technology that might be applied to AMSA.

Planning Changes — March 1969

The election of Richard M. Nixon in 1968 brought about a fundamental transition in strategic thinking, particularly with regard to the continued usefulness of the strategic bomber. In March 1969, Melvin R. Laird, the new Secretary of Defense, announced that the Defense Department's bomber plans were being changed. To begin with, the programmed acquisition of 253 FB-111s would be reduced to 76, because the FB-111 lacked the range and payload for strategic operations. Secretary Laird also directed the acceleration of the AMSA design studies, noting that despite the numerous and costly improvements earmarked for the last B-52 models (B-52Gs and B-52Hs), a new strategic bomber was "a more appropriate solution for a longer term bomber program."

New Designation — April 1969

In April 1969, Secretary of the Air Force Robert C. Seamans, Jr.,[59] redesignated the AMSA as the B-1A.[60]

New Requests for Proposals — 3 November 1969

New requests for proposals were not issued before November 1969, even

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[59] Secretary Seamans succeeded Harold Brown on 14 February 1969. Dr. Brown had replaced Eugene M. Zuckert as Secretary of the Air Force on 1 October 1965—a position held by Secretary Zuckert since 23 January 1961. Mr. Zuckert began serving the Air Force in 1947, when he was Assistant Secretary for Management and worked closely with W. Stuart Symington, the Air Force's first Secretary. Mr. Zuckert proved to be an earnest supporter of the AMPSS/AMSA bomber. Dr. Brown for a while became an advocate of the manned strategic aircraft, although not necessarily of AMSA.

[60] The B-1A designation was temporarily changed to B-1. Still, most of the time, the system continued to be referred to as B-1A.

though a competitive aircraft system design, coupled with an initial engine development program, had been approved in November 1968. The delay, oddly enough, was intended to speed up matters, which it did.

From the start, it had been clear that the design characteristics of the manned strategic bomber system would change as full-scale development proceeded. Because of the system's complexity, trade-offs that would affect performance were not only expected—they were considered as a future integral part of development. The Air Force was convinced that a continuation of the design competition would be fruitless and that, as agreed by Secretary Seamans, further studies would only add to the vast amount of paperwork already produced. Defense Secretary Laird's decision in March 1969 to revise the program in order to begin the B-1A's engineering development sooner confirmed the Air Force's conclusions that additional competitive designs would be time consuming and raise the program's cost without a commensurate return that could be measured by any tangible improvement of the system.

Thus, requests for proposals were issued in November 1969 that reflected an unequivocal departure from the temporizing motions of the past. The new requests were based on Defense Department approval of the USAF engineering plan and were meant to promote the prompt award of major contracts. The same airframe manufacturers, plus the Lockheed Aircraft Corporation, were in fact asked how they proposed to fabricate the B-1A airframe and to satisfy the integration requirements of the total system. In the same month, engine proposals were requested from the General Electric Company, and the Pratt & Whitney Corporation. Proposals for avionics design were again solicited, this time from 15 avionics companies. Only 5 of them chose to submit proposals to the B-1A program office.[61]

Contractor Selection 1969-1970

The avionics proposals received in December 1969 were swiftly disposed of, those of the Autonetics Division of North American Rockwell and the Federal Systems Division of IBM being selected on the 19th. In another positive departure from past procedures, the contracts awarded to the 2 companies no longer centered on feasibility but on advanced development studies. Yet, the overall avionics program was soon to experience serious setbacks.

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[61] Established within the Aeronautical Systems Division as the AMSA program office on 13 March 1964 and redesignated in the spring of 1969.

Selection of the airframe and engine contractors started poorly, as Congress cut back on B-1A money for fiscal years 1970 and 1971. Such a decision was bound to increase development time which, in turn, would raise costs. Still, the Air Force had no recourse. Contractors had to revise airframe and engine proposals (received in January and February 1970) to fit under the program's immediate funding ceiling. The revision delay was short, but no effort could completely eradicate the impact of present and future financial restraints.

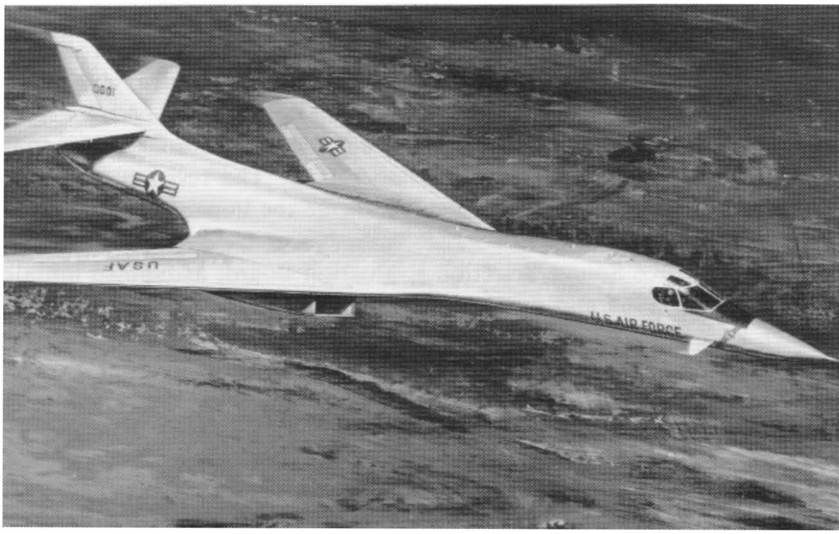
The Air Force Source Selection Evaluation Board, assembled initially on 8 December 1969 and numbering about 600 personnel at one time or another, began evaluating and scoring the revised proposals in the spring of 1970. On 5 June, following a presentation to the Defense Systems Acquisition Review Council, Deputy Secretary of Defense David Packard endorsed the Air Force's contractor selection. On the same date, Air Force Secretary Seamans announced that North American Rockwell and General Electric had been selected as the respective B-1A airframe and propulsion contractors. Secretary Seamans's announcement, wholly supported by the Air Force Chief of Staff and all the general officers in charge of the various Air Force commands concerned with the program, rested on 2 basic factors: superior technical proposals, as well as lower cost estimates.

Contractual Arrangements — 5 June 1970

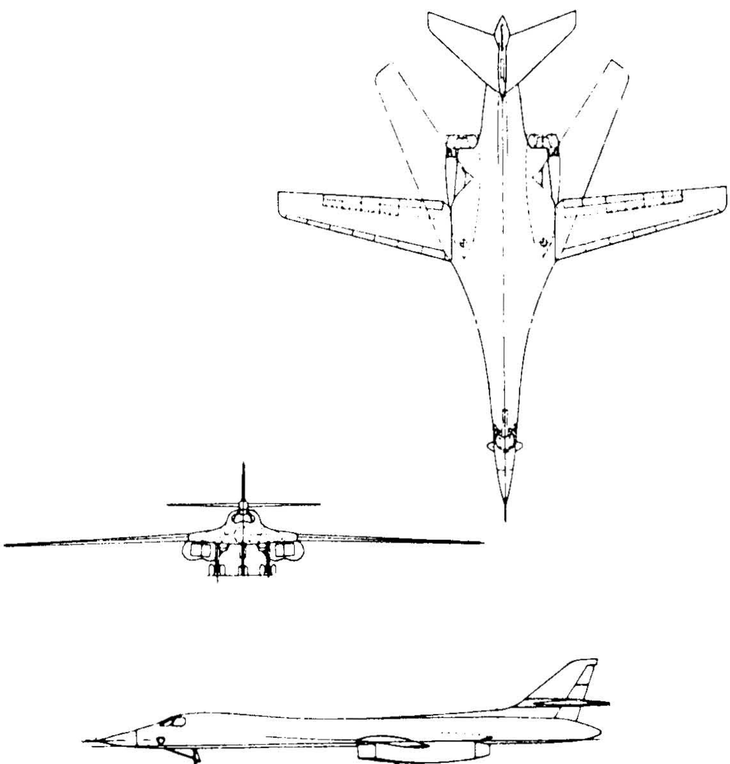
The Air Force negotiated 2 cost-plus-incentive-fee contracts for the B-1A development—a type of contract providing great incentive for technical innovations. Both contracts were awarded on 5 June 1970. The North American Rockwell contract (F33657-70-C-0800), with its 90/10 sharing basis,[62] had a target price of $1.3508 billion. If performance, cost, and time estimates were met, the contractor's incentive fee would amount to $115.75 million. The contract called for the development and delivery of 5 test aircraft, plus 2 structural test articles. It also covered system integration, which encompassed Total System Performance Responsibility, meaning that North American Rockwell would not be simply responsible for the B-1A airframe, but for the full-fledged weapon system.

The General Electric Company cost-plus-incentive contract (F33657-70-C-0801) had a sharing basis of 80/20 and a target price of

[62] The contract's sharing arrangement meant that 10 percent of any amount over the target ceiling of $1,350.8 million would be deducted from the contractor's incentive fee. But if the contractor fulfilled his commitments for less than targeted, 10 percent of the difference would be added to the incentive fee.



An artist's conception of the B-1 in flight.



$406.7 million.[63] It covered the design, fabrication, and qualification testing of 40 engines, as well as a potential incentive fee of $30.2 million.

Immediate Setback 1970

As already noted, the Air Force knew that unexpected funding restrictions would cloud the beginning of the B-1 development. A possible palliative was to minimize management costs and to promote economy in the acquisition of the aircraft without affecting its future performance. To this aim, a special study—Project Focus—came into being. Sponsored by the B-1 project office and actively supported by the 2 major contractors, Focus did satisfy some of the Air Force's money-saving requirements. However, the Focus managerial achievements were not enough to prevent the entire project, as well as related studies, from infringing on other facets of the B-1A development program.

Most Focus recommendations were approved by Secretary Seamans before the end of 1970. One of them dealt with the assignment of a minimum of program office personnel in close proximity to the plants of principal contractors and subcontractors. The arrangement, not new but significantly extended, would reduce the voluminous, periodic paper reports that routinely plagued important development programs. It would also foster the detection and solution of many problems before they could affect cost, schedule, or performance. The Air Force believed a savings of about $60 million might ensue. Many other Focus recommendations were endorsed. Some of them, particularly those with long-range impact, were open to question.

The B-1A program was not an experimental or a prototype venture. Yet, without definitive financial support from the Congress, the Air Force did not know how many aircraft the ultimate B-1 force would include. A figure of 241 production aircraft was used for planning purposes, but this planning was doubly tentative in view of Deputy Secretary of Defense Packard's new concept of systems acquisition. "Fly-before-buy," as the concept was known, emphasized hardware demonstrations, at predetermined dates, prior to making such major program decisions as full-scale development and production. In addition, approval of the Department of Defense Systems Acquisition Review Council would be needed before the B-1A development program could enter a new phase.

All Project Focus decisions had been reached under the purview of

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[63] The cost-sharing basis of the General Electric contract followed the formula used for North American Rockwell, except that percentages and amounts were different.

Deputy Secretary Packard's new acquisition concept. Among the most salient ones was the determination that efforts not directly contributing to a logical production decision would be deleted or deferred until such a decision had been made. Also, B-1A flight test hours would be reduced by combining the development, test, and evaluation phase (DT&E) with the initial operational test and evaluation phase (IOT&E). This was a fairly drastic departure from the established USAF testing cycle, in which the contractor took care of all initial tests (Category I) and the Air Force's participation began with the so-called Category II.[64] But the new procedure of having Air Force and contractor personnel fly together in test aircraft was expected to eliminate duplication that usually occurred during the categories I and II flights of the regular test program. In any case, the program's thoroughness was not to be undermined. The initial development flight test program was scheduled for 1,060 hours, 100 of which (later increased to 200) were to be completed prior to a production decision.

Project Focus did not overlook wind tunnel testing. Such testing would not be diminished, but the USAF facilities at the Arnold Engineering Development Center in Tennessee would be used to the maximum extent possible. Air Force program officials, after meeting with Arnold personnel, had estimated that the air vehicle would require over 18,000 hours of wind-tunnel testing; the engine, some 12,000. Other noteworthy recommendations, due to decrease costs by almost $180 million, were to be reflected in a forthcoming program reduction.

Program Reduction — 18 January 1971

The B-1A development program, initiated under the procurement arrangement of June 1970, did not last long. As anticipated, Congress in the summer of 1970 had further restricted the B-1 funding to levels below $500 million for several fiscal years to come. And while Focus and additional B-1 innovation studies helped to save money, they could not totally prevent some undesirable changes. On 18 January 1971, Secretary Seamans approved a reduced program which cut the number of flight test aircraft from 5 to 3, decreased the airframe's amount of costly titanium, and slightly lowered some performance requirements. In addition, the procurement of engines was slashed from 40 to 27; selected major structural items would be tested to design-limit load levels to eliminate, if at all possible, the purchase of a static test aircraft; and the development program's pace would be slowed down.

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[64] Until the late fifties, phases—instead of categories—delineated specific facets of the testing program. However, the program's streamlining and new terminology barely affected the test cycles and objectives. For details, see B-52, p 225.

In effect, as rescheduled, the B–1A's first flight would slide from March to April 1974, and a production go-ahead would not be considered before April 1975—a 1-year lapse between first flight and production decision, instead of the 6 months originally agreed upon. Finally, the initial operational capability (IOC) date was moved to December 1979, when the Strategic Air Command would receive its 65th B–1A. This was a long delay. Back in 1970, the Air Force had planned that the command would receive the 68th production aircraft by December 1977 and would reach IOC by that date.

Other Changes — Mid-1971

Early in 1970, IBM and North American Rockwell had participated in avionics studies, referred to as Junior Crown. This project analyzed the pros and cons of various avionics packages, taking into consideration size, performance, and cost. Junior Crown, in addition, identified equipment and development phases associated with the progression from the initial avionics subsystems to the standardized ones. But the period's budgetary limitations had also induced B–1 program officials to single out alternate design configurations. Five of those alternate combinations were based on the initial subsystems; 4, on the avionics equipment featured by several F–111 models.

In mid-1971, Secretary Seamans informed Gen. John D. Ryan, Air Force Chief of Staff since 1 August 1969, that because the B–1A production go-ahead had been postponed and only limited avionics would be needed for quite a while, earlier avionics plans could be shelved. All told, selection of an avionics subcontractor was no longer urgent; as required to accomplish the Category I tests, research and development, test and evaluation (RDT&E) B–1As would be fitted with FB–111A components and other off-the-shelf avionics; such equipment would be installed by North American Rockwell; and industry was being notified that the choosing of an avionics integrating contractor was deferred.

Secretary Seamans's decision did not negate the built-in growth factor approach that had been part of the Air Force's B–1A requirements from the start. This approach meant that technological advances could be incorporated into the aircraft design throughout the development period. In fact, while early B–1As would be equipped with available avionics, space would be provided to allow for the later installation of a more advanced network.

Unexpected Shift — September 1971

After stating in mid-1971 that selection of an avionics integrating contractor could wait, the Air Force changed its mind. On 29 September, requests for proposals that separated the avionics subsystems into offensive and defensive functions, were issued to 27 companies. Only 5 companies chose to submit proposals, but all were received before the end of November. Still, the evaluation of proposals was a time-consuming task, a factor that probably explained the Air Force's unexpected about-face. In any case, it would take until 13 April 1972 for the Boeing Company to receive the $62.4 million contract that was involved. This agreement, covering the development of offensive avionics and integration of avionics subsystems, like those of the 2 main contractors, was of the cost-plus-incentive-fee type. The contract's terms were different, however. It had a 90/10 sharing percentage arrangement, and a zero to 14 percent profit range, with a $1 million award fee provision.

In November 1971, requests for proposals for the B-1A's future defensive avionics also were issued to 23 companies. Only 2, Airborne Instrument Laboratory, a division of the Cutler-Hammer Corporation, and the Raytheon Company, responded. Evaluation of the 2 proposals was completed in February 1972, but no contract resulted because the Air Force decided that new requests for proposals were needed. The decision was prompted by the system's complexity. The Air Force believed that development of the advanced defensive avionics wanted for the B-1A could very well involve great technological risks. Therefore, it would be more sensible to divide the project into 2 phases. The first would be a 10-month attempt by 2 competing contractors, working under fixed-price contracts for a maximum combined price of $5 million. The second phase would cover engineering development, but only 1 cost-plus-fixed-fee contract would be finally awarded.

The revised requests for proposals were received by 23 firms on 17 May 1972. One year later, the same 2 contractors (Airborne Instrument Laboratory and Raytheon Company) were nearing completion of their Phase I contract—the 10-month risk reduction demonstration. Phase II, due to begin in mid-1973, was scheduled to run through December 1976. It would commence with proposal instructions for development of the radio frequency surveillance and electronic countermeasures subsystem. In the event that contractor proposals proved unacceptable, the Air Force planned to evaluate one of its own conventional subsystems.

Mockup Review — October 1971

The B-1A mockup review occurred at the North American Rockwell's Los Angeles Division in late October 1971, 2 months after the arrival of a full-scale mockup of the General Electric F101 engine. The review's primary objective was to determine if the USAF specifications were being met by the prime contractors, but some 200 Air Force representatives also examined the location of equipment in the mockup, ease of maintenance and operation being of great importance. The mockup review board and the contractors ended developing and processing 297 requests for alteration. Over 90 of those concerned the maintenance of the future aircraft; nearly 60 dealt chiefly with safety; and 10 with the aircraft's logistical support. The rest fell in the operational category. In addition, there were 21 requests for alterations to the engine, the most noteworthy one involving a change in the piping to make the engine handling mount more accessible.

Special Features 1971–1973

The future B-1A's most notable features were its variable swept wings, which could be fully retracted or totally extended in flight. The aircraft's body shape also was most unusual in that it tended to blend smoothly into the wing to enhance lift and reduce drag.[65] Finally, particularly in view of their length, the location of the 4 F101 supersonic turbofan engines, each in the 30,000-pound thrust class, was another very special feature. The engines (2 per pod) were mounted beneath the inboard wing, close to the aircraft's center of gravity, in order to improve stability when flying through the heavy turbulence often experienced at low altitudes.

The B-1A's special features promised to pay high dividends and put the new weapon system in a unique category. It differed radically from existing bombers,[66] particularly the B-52, the Air Force's highly praised but aging mainstay. Specifically, the B-1A's variable-geometry (swing) wing and high thrust-to-weight ratio would enable it to use short runways, a characteristic due to provide additional opportunities for aircraft dispersal throughout the United States. The new bomber would have a low turn-around and maintenance repair rate because of new methods for rapidly checking out and verifying subsystems. Although only two-thirds the size of the B-52, with aerial refueling the B-1A would be able to carry twice the weapons load over the same intercontinental distances. The future aircraft's supersonic fly-out speed would get it airborne faster, a vital asset in case of an alert warning. And with regard to a nuclear attack, hardening techniques would

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[65] In accordance with the so-called blended-wing body concept.

[66] The relatively small FB-111A, the production of which ended in July 1971, basically was little more than a modified fighter. Its take-off weight was under 110,000 pounds and this interim bomber, as the Air Force regarded it, could not even be remotely compared to the future aircraft.

enable the B-1 bomber to withstand greater over-pressures and thermal radiation from nuclear weapons.

An automatic terrain-following radar and a near-sonic speed capability at low altitudes would permit the new weapon system to penetrate the sophisticated defenses expected to be used into the 21st century. The B-1A's low-altitude performance also would be a defensive advantage against enemy interceptor aircraft since the high aerodynamic stresses of low altitudes would nullify the interceptors' effectiveness. Moreover, the new bomber's small radar cross section would minimize its detection by enemy radars.

Development Problems 1971-1972

Development of any weapon system routinely entailed problems, and the Air Force did not expect the B-1A to deviate from this pattern. Yet, by the end of 1971, except for some weight increase, not an unusual occurrence, and difficulties with the crew escape system, problems were minor. For example, the aircraft's windshield, which included a thin polycarbon inner layer, had poor optical qualities and tended to shatter upon impact. However, 2 new windshields, incorporating different inner layers of stretched acrylic, were soon to be tested, and 1 of the 2 most likely would be satisfactory. The integrated semi-conductor of the Central Integrated Test System AP-2 computer also was deficient, but the technical problems of this major component were solvable.

The crew escape system was a different story. As developed (and eventually installed on the first 3 RDT&E B-1As), it resembled the F-111's crew module which ranked as a major advancement in aircraft design.[67] But when it came to the 4-crew B-1A, the new module's research and development costs could reach about $125 million; nearly half of that amount had already been spent, and test results thus far had been disappointing. Another alternative might be the development of standard, but greatly improved ejection seats—not the Air Force's preferred solution, but an option of last resort. Consequently, the B-1A program office in early 1972 planned to study once again the various options to the basic module system, knowing full well, however, that no clear answer was in sight. The B-1A's

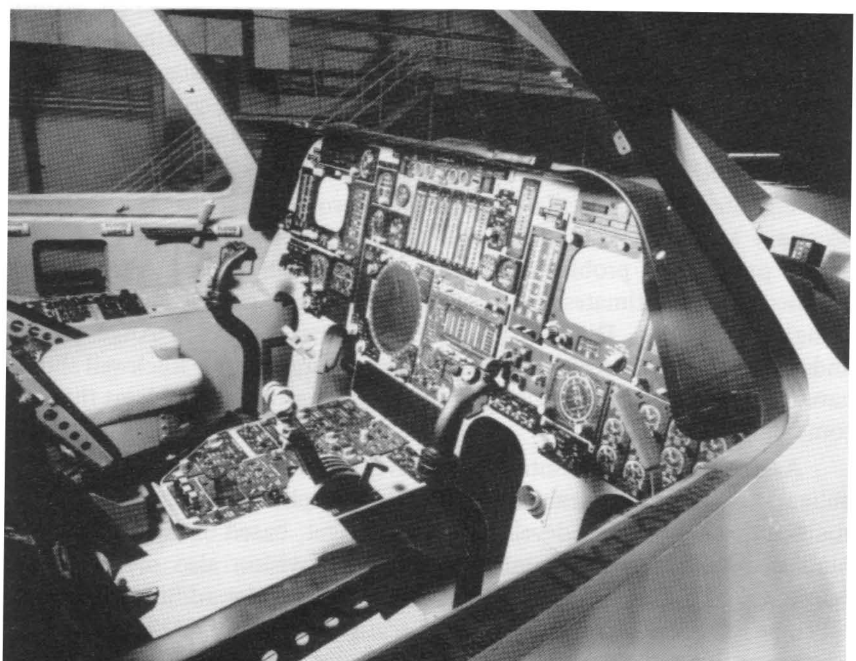
[67] Developed by the McDonnell Aircraft Corporation and initially tested in 1966, the crew module of the General Dynamics F-111 was fully automated. When forced to abandon his aircraft, the pilot only had to press, squeeze, or pull 1 lever. This caused an explosive cutting cord to shear the module from the fuselage; a rocket motor ejected the module upward and it parachuted to the ground or sea. There, like the Mercury and Gemini capsules of the U.S. early space programs, the capsule could serve as a survival shelter for the F-111's 2 crewmen.

prototype F101 engines also were experiencing some of the problems common to all development programs in their early stages. Such difficulties centered on turbine blade failures, high speed compressor stalls, excessive oil consumption, and related deficiencies. But all problems were being taken care of or soon would be. And the propulsion outlook seemed even more rewarding, when USAF engineers commented in mid-1972 that the General Electric F101 had the potential to be the most durable high-performance engine the Air Force had yet procured.

Second Slippage 1973

An April 1972 review of the B–1A program at the Los Angeles Division of the Rockwell International Corporation[68] yielded encouraging results, leading the Air Force to conclude that the B–1A's first flight would occur,

[68] So designated on 16 February 1973, following merger of the North American Rockwell Corporation with the Rockwell Manufacturing Company.



Interior view of the cockpit in a B–1 full-scale mockup.

as scheduled, in April 1974. But the optimism of the spring of 1972 did not necessarily prevail 1 year later.

In July 1973, Secretary of the Air Force John L. McLucas, who had replaced Secretary Seamans in May, notified Senator John C. Stennis, Chairman of the Senate Armed Services Committee, that fabrication of the first RDT&E B-1A had fallen behind schedule. The start of the second one also had been delayed, because the effort involved in manufacturing and assembling the aircraft had been underestimated. The Air Force had become aware of such problems in early 1973 and had turned down the contractor's request for overtime work, since this expedient might increase the program's technical risks and would definitely raise costs. Slowing down the development program seemed to be safer. As now planned, the initial flight of the first B-1A would take place in mid-1974; fabrication, assembly, and flight testing of the second and third B-1As would be slightly delayed, and the production decision would be postponed from July 1975 to May 1976. The new schedule would increase the estimated total development cost from \$2.71 billion to \$2.79 billion—an \$80 million solution, cheaper than attempting to adhere to the original timetable through the expensive use of overtime.

As a direct response to Secretary McLucas' news, the Senate Armed Services Committee's Research and Development Subcommittee held on 27 July a special hearing concerning the B-1A program. Senator Thomas J. McIntyre, Chairman of the subcommittee, expressed his concern about the state of the program. Senator Barry Goldwater commented on the Air Force's inability to adhere to schedule and cost estimates for the program and requested assurance that the Air Force would meet the new schedule. Secretary McLucas pointed out that the Air Force did not anticipate any major production problems. Except for increases caused by inflation, production cost estimates were not expected to rise excessively. Maj. Gen. Douglas T. Nelson, Director of the B-1 program since 13 August 1970, underlined the Air Force's own dissatisfaction, stating that Rockwell should have been better prepared either to prevent or to solve the problems that had come up.

Asked about the contractual provision which limited government obligation each fiscal year, General Nelson explained that this provision enabled the Air Force to develop a stable budget, based on the contractor's funding request for the coming year. The provision also precluded the possibility of a subsequent request by the contractor for additional funds to continue working. The obligation for fiscal year 1974 was \$312 million. The contractor would have exceeded this amount by \$134.8 million if the development program had not been restructured and if the original schedule had been allowed to continue.

Another Reduction — Mid-1973

Restructure of the B–1A development required the amendment of the program's 2 major contracts, since both included very specific provisions. By supplemental agreement, signed before 15 July 1973, the first flight of the Rockwell International B–1A was moved from April to June 1974, and the initial flights of the second and third articles were scheduled for January 1976 and September 1975, respectively.[69] Selected static tests were to be completed by February 1976, while procurement of a full-scaled fatigue test B–1A was definitely deleted.

The General Electric contract, modified in the summer of 1973 like that of Rockwell International, involved more drastic changes. To save money, the number of experimental F101 engines was reduced from 3 to 2, the quantity of prototype F101s was cut from 27 to 23, and the option for 6 F101 qualification test engines was canceled. The modified contract provided for 4 F101 qualification test engines, and for an extended YF101 flight test program of 1,105 hours, due to end in September 1978. As in the airframe's case, engine deliveries were paced down.

The development program's entire funding also was spelled out in no uncertain terms. The total allotment for fiscal year 1970 through fiscal year 1974 was limited to $1.0238 billion, and the allotment for fiscal year 1975 was not to exceed $200 million. The allotment for subsequent years was established at $153.2 million per year, without restriction. Funds for the offensive avionics were included in such figures. The multi-year total for both offensive and defensive avionics was set at $71.8 million, but the money could be disbursed in a more flexible fashion. In other words, not more than $30 million could be spent in any given year through fiscal year 1974, but if only $11.8 million had been paid out by then, the remaining $60 million could be later disbursed in one lump sum.

The avionics funding flexibility was important in view of the fact that amendment of the B–1A weapon system's 2 major contracts dictated another significant change. Specifically, the Boeing offensive avionics integration contract, a $62.4 million deal, had to be revised to match Rockwell's new delivery schedules. Simply put, Boeing would have to postpone for 8 months the installation, check-out, and flight testing of the offensive avionics which, from the start, had been earmarked to be first integrated in the second B–1A.

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[69] This apparently odd sequence made sense; since the second B–1A was to be fitted with the first set of offensive avionics, a trying as well as time-consuming task.

Total B-1A's Accepted **None**

Total Development Costs **$1.1338 billion**

As of mid-1973, cumulative development costs reached over $1.13 billion. This total included the amount spent since 1963 on AMPSS/AMSA studies and other related projects. In 1970, when the program's first reduction occurred, Air Force budget analysts estimated that total development costs would reach $2.6283 billion; production costs (for the planned 241 B-1s), $8.4943 billion. Hence, the Air Force anticipated the entire program's cost would top $11 billion.

Program Status **1973**

As 1973 came to a close, the future of the Air Force's new bomber, be it known as the AMSA or the B-1A, remained uncertain. In August, the Air Force Secretary asked Dr. Raymond L. Bisplinghoff, Deputy Director of the National Science Foundation, to conduct an independent review of the B-1A's status. Secretary McLucas' concern centered primarily on the restructured program's management and the adequacy of efforts to develop and produce the aircraft. The Secretary's request led to the formation of a review committee of 25, staffed with people from industry, the Air Force Scientific Advisory Board, other government agencies, and retired military and civilian federal employees. Members of the Bisplinghoff Committee, as it became known, worked quickly. On 4 October, Dr. Bisplinghoff and 3 committee members gave Secretary McLucas their findings.

Briefly stated, the committee did not foresee any technical problems that would prevent successful development or production, although the B-1 weapon system's complexity could not be overlooked. In this regard, except for wind tunnel testing and engine development,[70] the development program's new schedule was still unrealistic, and the program was insufficiently funded. There was no money to cope with possible problems. Moreover, 3 test aircraft were not enough in view of the redesign work that probably would be necessary prior to production. This was particularly crucial, since each test aircraft had a specific purpose. Should 1 of the 3 aircraft be destroyed during testing, the program's risks would be greatly increased.

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[70] The propulsion system, the committee members confirmed, was the program's brightest spot; chances were good that cost, schedule, and most technical goals would be realized.

Dr. Bisplinghoff in his conclusion described the B–1A's structure as airworthy, but heavy and costly. The Bisplinghoff Committee questioned the accuracy of the USAF estimates of the aircraft's empty weight, range, take-off distance, and refueling altitude. Therefore, the program's cancellation should be seriously considered, in the event of a further funding reduction for an already "marginal" program. As time would show, lack of funds, technical difficulties, and other problems were to plague the B–1A program. Governmental policy changes obviously had the greatest impact. But while the B–1A was to become a dead issue under one administration, a subsequent one would champion an improved version of the aircraft, later known as the B–1B.

TECHNICAL AND BASIC MISSION PERFORMANCE DATA

B-1A AIRCRAFT[a]

Manufacturer (Airframe)	Rockwell International Corp., Los Angeles Div., Los Angeles, Calif.
Manufacturer (Engines)	General Electric Co., Evendale Plant, Evendale, Ohio
Nomenclature	Strategic Bomber
Popular Name	None

Length/Span (ft)	145.3/136.7
Wing Area (sq ft)	1,946
Weights (lb)	
Empty	143,000 (est)
Combat	200,102 (est)
Takeoff	360,000 (est)—limited by landing gear strength
Engine: Number, Rated Power per Engine, & Designation	(4) 29,850-lb st F101-GE-100 (max with afterburners) (axial turbofan)
Takeoff Ground Run (ft)	
At Sea Level	4,440 (with max afterburner thrust)
Over 50-ft Obstacle	6,135 (with max afterburner thrust)
Rate of Climb (fpm) at Sea Level	2,820 (intermediate thrust)
Combat Max Rate of Climb (fpm) at Sea Level	30,930 (with max afterburner thrust)
Service Ceiling (100 fpm Rate of Climb to Altitude)	27,000 (intermediate thrust)
Combat Service Ceiling (100 fpm Rate of Climb to Altitude)	39,300 (intermediate thrust)
Combat Ceiling (500 fpm Rate of Climb to Altitude)	58,800 (with max afterburner thrust)
Basic Speed at 35,000 ft (kn)	1,092 (with max afterburner thrust)
Average Cruise Speed (kn) Outside Penetration Zone	420
Max Speed at Optimum/ Altitude (kn/ft)	1,262/59,000 (with max afterburner thrust)
Combat Range (nm)	6,103
Total Mission Time (hr)	14.0
Crew	4 (pilot, co-pilot, & 2 sub-systems operators)
Armament	
Internal	24 AGM-69A SRAMs[b]
External	8 AGM-69A SRAMs
Maximum Bombload (lb)	75,000

Abbreviations

cal	=	caliber	max	=	maximum
fpm	=	feet per minute	nm	=	nautical miles
kn	=	knots	st	=	static thrust

[a]January 1972 estimates.

[b]Short Range Attack Missile (SRAM), produced by the Boeing Airplane Company.

Glossary

AAF	Army Air Forces
AFB	Air Force Base
AMC	Air Materiel Command
AMPSS	Advanced Manned Precision Strike System
AMSA	Advanced Manned Strategic Aircraft
ARDC	Air Research and Development Command
Convair	Consolidated Vultee Aircraft Corporation
DT&E	development, test, and evaluation
ECM	electronic countermeasures
ECP	engineering change proposal
ELINT	electronic intelligence
ERSA	Extended Range Strike Aircraft
FEAF	Far East Air Forces
FPF	fixed-price-firm (contract)
FPI	fixed-price-incentive (contract)
FPIR	fixed-price-incentive renegotiable
FY	fiscal year
GAM	guided air missile
GEBO	generalized bomber study
GOR	general operational requirement
IBM	International Business Machines, Inc.
IFF	identification friend or foe
IOC	initial operational capability
IOT&E	initial operational test and evaluation phase
IRAN	inspect and repair as necessary
LAMP	Low Altitude Manned Penetrator
LAMS	Load Alleviation and Mode Stabilization
MADREC	Malfunction Detection and Recording
NASA	National Aeronautics and Space Administration
PACAF	Pacific Air Forces
QRC	quick reaction capability
RAF	Royal Air Force
Rand	The Rand Corporation, Santa Monica, Calif.
RDT&E	research and development, test and evaluation phase

SAB	Supersonic Aircraft Bomber
SAC	Strategic Air Command
SHORAN	short-range navigation technology
SLAB	Subsonic Low Altitude Bomber
SRAM	short-range attack missile
TAC	Tactical Air Command
TARC	Tactical Air Reconnaissance Center
TRW	tactical reconnaissance wing
USAF	United States Air Force
USAFE	United States Air Forces in Europe
VDT	variable discharge turbine
WIBAC	Wichita Boeing Aircraft Company (Project)

Selected Bibliography

This volume, covering over 30 years of aviation technology in bomber aircraft, is a compilation of Air Force data from countless official documents. Secondary sources (commercial publications, newspapers, etc.) were used only to confirm data of minor importance. The most important source materials were the major command histories and the special studies of the Air Force Logistics Command, the Aerospace Defense Command, and the Strategic Air Command. Air Staff semiannual reports, technical summaries, and records of wing and squadron histories also provided valuable information. These documents are in the archives of the USAF Historical Research Center, Maxwell AFB, Alabama. Those of special interest are listed below.

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