

An hourglass-shaped graphic with a globe inside. The top bulb is dark blue, and the bottom bulb is light blue. The globe is a darker shade of blue. The hourglass is centered on the page.

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*THE U.S. DEFENSE INDUSTRIAL BASE: TRENDS AND
CURRENT ISSUES*

Daniel H. Else, Foreign Affairs, Defense, and Trade Division

Updated October 27, 2000

Abstract. This report describes the U.S. defense industrial base, its structure and evolution, and examines challenges and potential issues for Congress to consider. Issue areas include competition in defense contracting, the role of commercial technologies, and foreign participation in U.S. defense programs, and the ability of U.S. defense firms to recruit and retain sufficient numbers of technical workers.

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The U.S. Defense Industrial Base: Trends and Current Issues

October 27, 2000

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The U.S. Defense Industrial Base: Trends and Current Issues

Summary

The end of the Cold War precipitated one of the greatest reductions in U.S. defense spending since the final months of World War II. The Department of Defense (DOD) and U.S. defense industry have struggled coming to terms with smaller defense budgets and ill-defined threats to U.S. security. Cold War's end also transformed the defense business environment, marking the rapid worldwide globalization of economics and trade and changes in DOD policy toward the industry itself. Technological change, especially visible in the information processing and telecommunications industries, has forced convergence between civilian and military research and applications. Shrinking defense budgets worldwide have forced producers into heightened competition.

These factors compelled DOD to reassess its half-century relationship with the U.S. defense industrial base. As a result, DOD policy has changed in two major ways. First, because the lead in some state-of-the-art product lines had passed from defense to the commercial sector of the economy, DOD reformed the way it buys equipment. Second, DOD sought to reform structural aspects of the defense industrial base itself. Instead of continuing to support excess production capacity across the board, DOD focused on preserving "defense-unique" manufacturing capabilities, allowing other U.S. defense firms to more freely respond to conventional market forces.

Congress has traditionally protected economically vulnerable parts of the defense industry that are critical to U.S. national security, but global changes in the economic and defense environments pose new issues. First, continued mergers and acquisitions in the U.S. defense industry raise questions about maintaining competition. Some maintain that surviving firms have emerged healthier and more competitive, but others worry about the potential loss of technological innovation and price competition from fewer companies. Second, defense acquisition reform has encouraged military use of commercial products in military systems. Proponents of this cite the advantages of rapid access to new technologies for DOD and the adoption of efficient business practices, while others question the inappropriateness of some products to military applications, and the ability of DOD to cope with the speed of obsolescence for commercial products. Third, globalization has increased cross-border flows of information and the availability of technology that could be used for military purposes.

The result has been pressure for the United States to ease defense-related technology transfer restrictions which could increase exports of U.S. systems, and help the U.S. defense supplier base. Critics of this logic, however, worry about the extra vigilance needed to prevent the unauthorized transfer of U.S. defense technology, potentially increasing U.S. vulnerabilities. And fourth, some U.S. defense firms find it difficult to recruit and retain qualified designers and technical managers, presaging potential problems. Some analysts note a downturn in the number of recent U.S. science and engineering graduates and see strong competition for their talents from commercial high-technology firms as ominous. But others observe that perceived shortfalls seem concentrated in only some specialties, such as armored vehicle design, while other specialty requirements, such as computer systems design, appear able to fill their requirements.

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The U.S. Defense Industrial Base: Trends and Current Issues

Introduction

During most of the 1990s, U.S. defense companies faced unprecedented challenges – a shrunken domestic market for their specialized military products, reduced defense budgets among U.S. allies in Europe and Asia, and increased competition in export sales from overseas firms. The resulting U.S. defense industrial base was smaller, in some ways more economically more vulnerable, and more dependent on commercial technologies. New challenges have evolved which will have to be addressed as Congress and the executive branch ponder future U.S. defense policy decisions, such as developing new U.S. military capabilities.

This report briefly describes the U.S. defense industrial base, its structure and evolution, and examines challenges and potential issues for Congress to consider. Issue areas include competition in defense contracting, the role of commercial technologies, and foreign participation in U.S. defense programs, and the ability of U.S. defense firms to recruit and retain sufficient numbers of technical workers.

This report focuses primarily on the private-sector U.S. firms that design and produce weapons, equipment, and other items for the Department of Defense (DOD). It does not cover other elements of the nation's defense technological and industrial infrastructure, such as government-operated laboratories and repair depots, and university-affiliated research and development organizations.

Background

Structure of the Defense Industrial Base

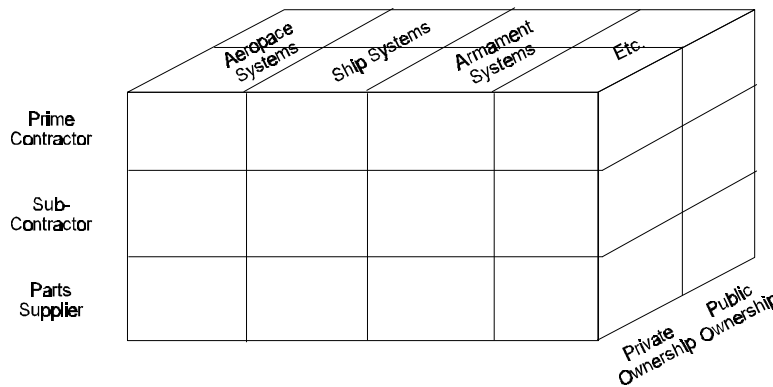
Today's defense industry is a multifaceted and complex sector of the national economy, employing more than 2.3 million workers in hundreds of firms of all sizes. Elements of the U.S. defense industry exist in every state and include many joint ventures with foreign defense companies, especially those based in allied countries.

The structure of the U.S. defense industrial base can be imagined as a collection of firms placed in a matrix of three dimensions: *function*, *product*, and *ownership*, as depicted in **Figure 1**.

In the first dimension, *function*, enterprises are categorized as prime contractors, subcontractors, and suppliers. *Prime contractors* (also known as “primes”) deal directly with DOD and hold primary responsibility for product fabrication and overall

management in programs where more than one company is involved. *Sub-contractors*, under obligation to the primes, create some portion of the final product, such as an electronics suite for a ship, or the engines for an aircraft. *Suppliers* provide lower-tier parts or processed materials to sub- and prime contractors. Traditionally, this lowest layer of business was referred to as the “dual-use sector” because much of its product line could be used for both defense and non-defense purposes. In recent years, though, a significant number of the components provided by sub-contractors for use in military products has been made to “commercial, off-the-shelf”(COTS) specifications. These are also considered “dual-use.”

The Structure of the Defense Industry



Adapted from Jacques S. Gansler, *The Defense Industry*, Cambridge: MIT Press, 1980, p. 3

Figure 1

The second dimension, *product*, indicates the separate industrial sectors (aerospace, ships, armaments, etc.) within which firms operate. Any individual enterprise may conduct business in several sectors, but each sector retains its own very specific characteristics. For example, aircraft and ships are built individually but uniforms and rifles are assembled by mass production processes, while electronics manufacturers fund more research and development than do boot and shoe makers.

The third dimension, *ownership*, shows production facilities in private hands, in the public domain, or in some mixture of the two. Arsenals used for the final assembly of munitions are publicly owned and operated by government employees. A significant portion of the facilities and production equipment used to manufacture military aircraft are government-owned but staffed by private corporations. All U.S. new-construction shipyards used for building warships are privately owned and operated.

DOD funding of the industrial base is concentrated in three of the defense budget’s **appropriations titles**. These are **Operation and Maintenance** (O&M: fuel, ship operations, training, equipment maintenance and overhauls, etc.), **Procurement** (acquisition of weapons and components, communications equipment, munitions, modernizations, and upgrade kits), and **Research, Development, Test, and Evaluation** (RDT&E: development and testing of equipment, prototypes, technology demonstration devices, and basic research for potential military applications). In 1999, outlays for O&M, procurement, and RDT&E were \$62.4,

\$48.6, and \$38.0 billion (in constant FY2001 dollars), respectively.¹ For the top two U.S. defense firms in 1999, Lockheed Martin Corp. and Boeing Co., DOD contracts resulted in \$17.8 and \$16.3 billion in revenue, or 69.8% and 28.0% of their annual totals.²

Factors Shaping the Defense Industrial Base

Until the end of the Korean War, the United States had no distinct, identifiable defense industrial base. Industry organized itself around civilian needs, mobilized to meet war or crisis, and demobilized afterward, reconverting to the manufacture of civilian products.

The onset of the Cold War changed this. With the Soviet Union and its satellites presenting a constant threat to the United States and its allies, U.S. defense spending remained at a considerably higher level than in previous times of peace, and a portion of the U.S. industry consequently found itself permanently organized around meeting DOD needs. As a result, many firms gravitated toward DOD as their principal, or even sole, customer, and an identifiable U.S. defense industrial base began to emerge.

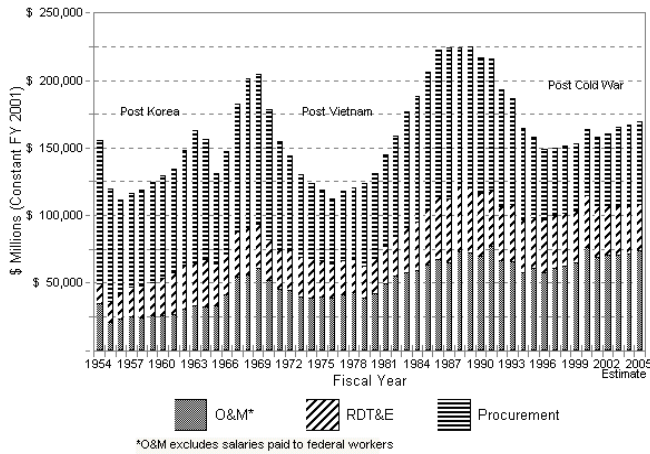
The end of the Cold War in 1991 led to a significant reduction in defense spending as a whole, and an even more significant reduction in the procurement portion of DOD's budget. These developments – together with reductions in defense budgets among allies in Europe and Asia, increased competition in export sales from overseas firms, and other economic and technological changes – have prompted changes in the U.S. defense industrial base in several areas, including the following: consolidation, diversification, commercialization, teaming arrangements, globalization, and the availability of skilled technical workers. Each of these is discussed below.

Declining Defense Spending Levels. Defense spending during the Cold War, though high, was inconsistent (see **Figure 2**). Of the budget titles considered here, expenditures on defense research and development (RTD&E) and in support of operations and maintenance (O&M) generally rose in real terms each year, peaking late in the Reagan Administration. Procurement spending (weapon purchases, communications gear, munitions, spare parts, etc.) fluctuated widely, hitting highs and lows at irregular intervals. Market prospects for U.S. weapons manufacturers mirrored these changes, rising in the early 1960s and again during the Vietnam War. Even after the post-Vietnam fall in procurement spending, continuing superpower rivalry offered the potential for a turnaround that was realized in 1976 and which continued through the late 1980s.

¹Economic data, unless otherwise noted, are extracted from the Office of the Under Secretary of Defense (Comptroller) *National Defense Budget Estimates for FY2001*. O&M figures used in this report exclude salaries to federal workers in order to more accurately reflect funds paid to private enterprises.

²*Defense News*, August 14, 2000, p. 17.

Military O&M, RDT&E, and Procurement
Fiscal Years 1954-2005



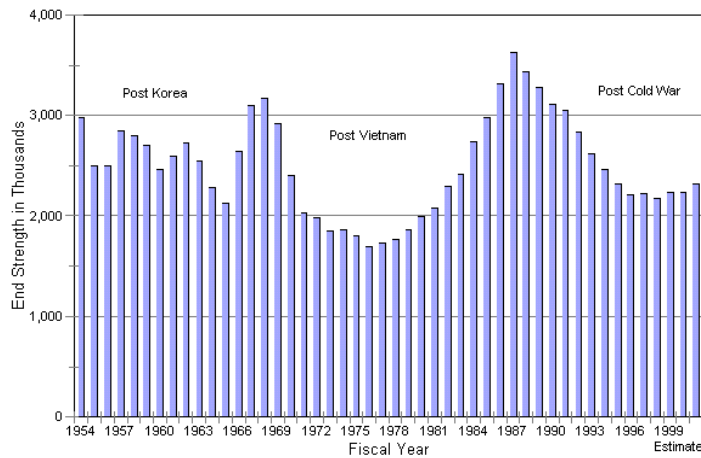
Source: OSD, *National Defense Budget Estimates for FY2001*

Figure 2

The disappearance of the Soviet Union broke this cyclic spending pattern. After peaking in real (i.e., inflation-adjusted) terms in FY1987, defense outlays as a whole decreased 31.8% in real terms, with the procurement portion decreasing 55.3%, by FY1998. Defense-related civilian industrial employment shrank by 28% (see **Figure 3**). Most significantly, with no immediate external threat, any expectation of a spending upswing vanished. Procurement expenditures appeared to enter an indefinite period of decline.

Defense Related Industry Employment

Fiscal Years 1954-2001



Source: OSD, *National Defense Budget Estimates for FY2001*

Figure 3

Changing DOD Policy. During 1993, then-Deputy Defense Secretary William Perry addressed a gathering of business executives at what has become known as “The Last Supper.” He told them that the defense budget could no longer support unused production capacity, and that DOD would not hamper, but would monitor, any corporate mergers or acquisitions they felt it advantageous to make. However, he went on to say, and later outlined with greater clarity, that DOD would protect (and the Department continues to protect) domestic facilities possessing what he termed “defense-unique” industrial capabilities, such as the construction of nuclear submarines or the production of heavy armored vehicles.³

A rapid vertical (buyout of parts suppliers and sub-contractors by primes) and horizontal (mergers between primes) consolidation began among U.S. firms. Some of the most prominent names in the defense business soon disappeared. By 1995, for example, Ford Aerospace, the defense division of Unisys, and the Fort Worth division of General Dynamics (builders of the F-16 fighter) had been absorbed by Loral. Two years later, Loral became part of Lockheed Martin, which itself was the product of a four-year series of 17 individual corporate mergers. Boeing acquired fellow defense giants Rockwell in 1996 and McDonnell Douglas in 1997. In 1998, Litton Industries capped its own series of acquisitions by buying rival shipbuilder Avondale Industries. **Table 1** indicates some results of the major consolidations of the 1990s.

Table 1. Consolidation in U.S. Defense Firms, 1993-2000

Corporation/Division (1993)	Corporation (2000)
Boeing McDonnell Douglas Rockwell	Boeing
Litton Industries Avondale Industries	Litton Industries
Lockheed Martin Marietta Loral Ford Aerospace General Dynamics (Fort Worth)	Lockheed Martin
Northrop Grumman LTV (Aircraft) Westinghouse (Electronic Defense) General Dynamics (Space)	Northrop Grumman
Raytheon General Dynamics (Missiles) Hughes Electronics Texas Instruments (Electronics)	Raytheon

Source: *Aviation Week and Space Technology*, May 8, 2000, p. 23.

³See Anthony L. Velocci, Jr., “Perry Forges New Shape for Industry.” *Aviation Week and Space Technology*, November 15, 1993, pp. 52-54; and Jeff Cole, “Defense Industry Regroups,” *Wall Street Journal (European edition)*, December 9, 1996, p. 1. For detail on the development of defense consolidation during the 1990s, see CRS Issue Brief IB92122, *Defense Industry in Transition: Issues and Options for Congress*, by Gary J. Pagliano.

Corporate consolidations, both vertical and horizontal, are expected to continue.⁴ Although their effects are always difficult to assess, further reduction of the number of producers in the defense base raises questions about the continued viability of technological innovation and price competition. U.S. military forces are the world's most technologically advanced, and future force structures assume a continual integration of rapidly evolving weapon and command and control system technology. As a move to expand the pool of potential bidders on defense projects, reduce costs, and gain access to the latest technologies, DOD began to reform its acquisition practices during the mid-1990s. Central to this reform have been the adoption of commercial (rather than military) specifications in some product designs, the adoption of some commercial-like acquisition practices, and the reduction of regulatory barriers to commercial firms attempting to enter the defense market.⁵

Even with acquisition reform, there are some sectors within the industrial base where a lowest acceptable limit on numbers of firms competing may have been reached, and DOD appears to be rethinking its policy of encouragement to mergers and acquisitions. For example, the Department cited competition concerns in 1997 when it did not permit Lockheed Martin to complete a proposed \$11.2 billion buyout of Northrop Grumman, and for the same reason it is currently reviewing the proposed purchase of Lockheed Martin's Aerospace Electronics Division by BAE Systems North America.⁶

Effects of Economic Globalization

An additional post-Cold War phenomenon affecting U.S. defense is economic globalization--the integration of national and regional economies that were previously separated by political, economic, or cultural boundaries.⁷ Globalization has been accelerated in the 1990s by advances in computers, the advent of the Internet, and other developments in information and telecommunication technologies. Central to this is the "information revolution," which has helped to precipitate and sustain the post-Cold War reduction of physical and political obstacles between communities.

The effect of globalization on the U.S. defense industrial base has been two-fold. First, faced with a reduced level of defense spending, many defense firms have

⁴For examples of statements of corporate intentions, see Anthony L. Velocci, Jr., "Northrop Grumman Chief Renews Aggressive Acquisition Strategy," *Aviation Week and Space Technology*, August 7, 2000, p. 53, and Robert Wall, "Lockheed Martin Ends No-Acquisition Mode," *Aviation Week and Space Technology*, August 14, 2000, p. 47.

⁵For a detailed discussion of background and recent actions taken by DOD and Congress, see Valerie Bailey Grasso, *Defense Acquisition Reform: Status and Current Issues* (IB 96022), Washington: Congressional Research Service.

⁶See Reed Landberg, "Defence Industry Fights for Its Future," *The Independent*, July 6, 1997, p. 2; and Bryan Bender, "Special Watch by U.S. DOD on BAE-Lockheed Deal," *Jane's Defence Weekly*, August 9, 2000, p. 2.

⁷Office of the Under Secretary of Defense for Acquisition and Technology, *Final Report of the Defense Science Board Task Force on Globalization and Security*, Washington: Department of Defense, 1999, p. 1.

broadened their focus to include a more commercial orientation. Those companies which have remained within the traditional defense sector have begun to bring commercially-developed technologies into military applications, have expanded the number of joint ventures and strategic partnerships in which they have engaged with their European counterparts, and have increased their reliance on commercial sector business and defense exports. Second, the revolution in information technology (IT) has resulted in an increased emphasis on “capability-amplifying” information integration products such as telecommunications and computer-based systems.

The worldwide proliferation of computers and the ease with which data can pass between them has greatly expanded the quantity and the types of information available to virtually anyone equipped with a modem and a mouse. Much unclassified government information and almost any commercial product (such as reasonably detailed satellite imagery) is readily obtainable from any Internet-connected computer. Indeed, the kind of technology upon which DOD is building its future “information-centric” warfare cannot be kept from potential adversaries precisely because it is largely commercial in nature and accessible from anywhere on the globe. A recent Defense Science Board task force report stated that:

From a long-term strategic standpoint, globalization’s most significant manifestation is the irresistible leveling effect it is having on the international military technological environment in which DOD must compete. ... The technology DOD [anticipates being able to leverage most] to maintain military dominance is that which the United States is *least* capable of denying its potential competitors. Access to commercial technology is virtually universal, and its exploitation for both civil and military ends is largely unconstrained. ... Indeed, owing to the proliferation of military technology, the commercialization of former military-specific technology, and the increasing reliance of militaries worldwide on commercially-developed technology, and the general diffusion of technology and know-how, *the majority of militarily useful technology is or eventually will be available commercially and/or from non-U.S. defense companies.*⁸ [emphasis in the original]

Congressional Action in Recent Years

Congress in recent years has enacted legislation in response to some of the previously mentioned developments affecting the U.S. defense industrial base. These actions have included steps--such as annual decisions to keep certain defense manufacturing lines “warm”--intended in large part to protect defense sectors or firms that were deemed economically vulnerable. The discussion below provides a few examples of some of these actions during the 104th, 105th, and 106th Congresses.

104th Congress. During the 104th Congress, the House Committee on National Security (HNSC)⁹ pressed DOD to request increased authorization on a range of projects “to stabilize the modernization accounts and key elements of the defense

⁸*Ibid.*, pp. v-vi.

⁹In the 106th Congress, this body was renamed the House Committee on Armed Services.

industrial base.”¹⁰ Congress funded procurement above levels proposed by the Clinton Administration for tactical aircraft, ships, small arms, and precision guided munitions. The Senate Committee on Armed Services (SASC) expressed strong interest in forcing the Army to utilize multiyear contracts for the purchase of tracked combat vehicles, and in maintaining competition through the judicious allocation of funds for submarine and warship construction.¹¹ Defense authorization acts crafted during both sessions included language designed to ensure that “technology and industrial base considerations [continue to be] given appropriate consideration in the programming and budgeting process in the Department of Defense.”¹²

105th Congress. Legislation passed during the 105th Congress funded purchases above those requested by DOD in order to, as the SASC put it, “support the industrial base until end-state requirements can be identified after the [1997] Quadrennial Defense Review process is complete”¹³ and to guide the preservation of production capacity in specific programs (such as the B-2 *Spirit* heavy bomber). HNSC urged “the Secretary of the Army to identify and evaluate processes and economical practices that would enable [federal] arsenals to remain viable and critical components of the defense industrial base,” and in the matter of ship overhaul and repair, directed “the Secretary of the Navy to apply no less than 50% of any additional funding above the budget request to the private sector.”¹⁴ SASC indicated its dissatisfaction with several aspects of the various services’ procurement plans and devoted considerable attention to the continued domestic manufacture of small arms ammunition, to increasing the production of Army helicopters, and to the rapidity of corporate mergers within the defense sector.¹⁵

106th Congress. The 106th Congress took steps to secure continued competition in the procurement of small arms ammunition, aircraft engines and aircraft ejection seat development, and created a new office within the Office of the Secretary of Defense having specific responsibility for monitoring and reporting on the health of and competition within the defense industrial base.¹⁶ Congress debated

¹⁰H.Rept. 104-131, June 1, 1995.

¹¹S.Rept. 104-112, July 12, 1995.

¹²S.Rept. 104-267, May 13, 1996.

¹³S.Rept. 105-29, June 17, 1997. The Quadrennial Defense Review (QDR) is a comprehensive analysis of the nation’s national security requirements undertaken every four years by the Department of Defense. The next QDR is scheduled for release in early 2001.

¹⁴H.Rept. 105-532, May 12, 1998.

¹⁵S.Rept. 105-29, June 17, 1997.

¹⁶Congress created the position of Under Secretary of Defense for Acquisition, Technology, and Logistics in order to bring an experienced private sector manager into defense acquisition. That individual is to supervise defense procurement and set policy for the management of the defense industrial base while reporting to the Congress on those actions necessary to promote long-term research and technological development (H.Rept. 106-162, May 24, 1999). Congress also considered establishing a separate Defense Technology Security Agency under a Deputy Under Secretary of Defense, responsible for advising the Secretary on industrial

(continued...)

the establishment of a loan guarantee program for the steel industry, “a critical element of the U.S. defense industrial base ... necessary to the defense readiness of the United States.”¹⁷ Finally, though its heated discussions of funding requested by DOD for initial production of the F-22 *Raptor* and continued development of the multiservice, multinational Joint Strike Fighter aircraft program, Congress appeared to enter into more direct management of DOD procurement programs.¹⁸

Potential Issues For Congress

Congress continues to face a variety of issues regarding the defense industrial base. The remainder of this report will touch upon four which are of potential congressional concern: continued corporate consolidation; commercialization of defense technology; globalization of the defense industry; and a perceived technical manpower shortage.

Industry Consolidation

Horizontal consolidation among well-known and economically important prime contractors has been perhaps the most visible post-Cold War industry development. Mergers and acquisitions have yielded fewer and larger companies to which DOD can turn for the equipment it needs. For example, today there are but five U.S. companies able to construct Navy surface warships, three military airframe manufacturers, and two builders of tracked combat vehicles where eight, eight, and three companies, respectively, existed in 1990.¹⁹

Vertical consolidation between the primes and their subcontractors and suppliers has been less evident, and its impact is more difficult to assess.²⁰ Nevertheless, the decrease in the number of companies, combined with the recent practice of “bundling” numerous defense contracts into fewer, larger offerings, has generated concerns about the health of the lower tier of the defense industry.²¹

¹⁶(...continued)

base, competitiveness, foreign acquisition, and munitions export policy (H.Rept. 106-166, May 27, 1999), and wrote into the Export Administration Act of 2000 the creation of an Office of Technology Evaluation within the Department of Commerce, tasking it with writing technical studies of those U.S. industrial sectors critical to the defense industrial base (S.Rept. 106-180, October 8, 1999).

¹⁷S.Rept. 106-8, March 4, 1999.

¹⁸Harvey M. Sapolsky and Eugene Gholz, “The Defense Monopoly,” *Regulation* 22/3, 1999, pp. 39-43.

¹⁹David E. Cooper, *Defense Industry Consolidation and Options for Preserving Competition* (GAO/NSIAD-98-141), Washington: General Accounting Office, 1998.

²⁰David E. Cooper, *Defense Industry Consolidation: Competitive Effects of Mergers and Acquisitions* (GAO/NSIAD-98-112), Washington: General Accounting Office, 1998.

²¹“Oliver Launching Study of Contract Bundling’s Small-Business Impact,” *Inside the Pentagon*, November 7, 1999, pp. 7-8; also Peter Behr, “Contract Woes for Small Firms:

(continued...)

Although proponents of continued consolidation maintain that the surviving firms will emerge healthier and more competitive against each other and foreign defense firms, critics focus their concerns on issues of technological innovation and price competition.

Some analysts view continued corporate acquisitions as economically inevitable,²² and have suggested several methods by which both innovation and competition might be preserved in an environment where few companies, or even a single source, remain.²³ Among suggestions offered are: requiring that prime contractors compete contracts to their sub-tier suppliers and use open-system (non-proprietary) architectures to permit wider competition; taking measures to encourage commercial firms to enter the defense market; promoting the use of alternative (i.e., soft-kill, information-based, etc.) technologies; competing missions rather than platforms (i.e., using unmanned vehicles instead of manned); or opening competition to foreign suppliers.

Commercialization of Defense Technology

Commercialization of the defense industrial base reflects a convergence of military and civilian technologies in research and in application. In some fields, most visibly in information systems and telecommunications, the cutting edge of technological advancement lies in the commercial sector.

The federal share of the total U.S. investment in research and development has shrunk steadily over the last several decades. This is in part due to a steep rise in funding from private sources and a concurrent decline in federal dollars (see **Figure 4**). With the most advanced technology in many fields now residing in the commercial sector, DOD has become more willing to rely on non-defense industry to supply its needs.

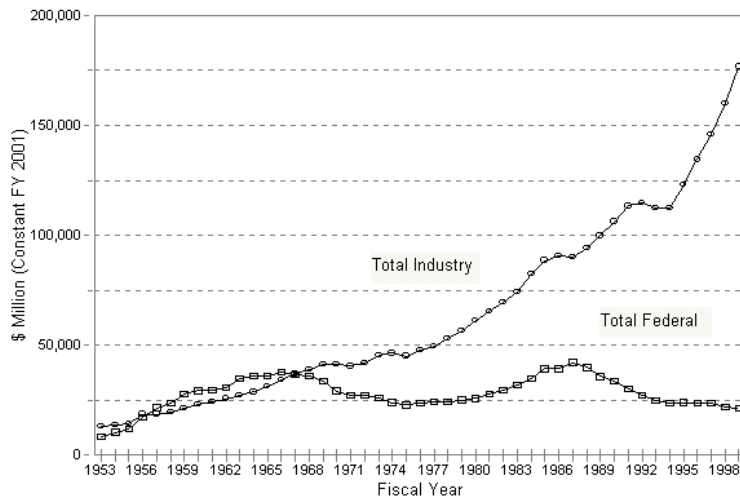
²¹(...continued)

‘Bundling’ Found to Undermine Minority-Owned Businesses,” *The Washington Post*, July 20, 2000, p. A23, “SBA Final Rule on ‘Contract Bundling’ Gives Small Firms Strong Protection,” *M2 Presswire*, July 28, 2000, and Peter Behr, “Air Force Bidding Worries Small Firms,” *The Washington Post*, September 22, 2000, p. E2.

²²See Anthony L. Velocci, Jr., “Further Consolidation Looms Over Industry,” *Aviation Week and Space Technology*, May 8, 2000, p. 22; also Robert Wall, “Lockheed Martin Ends No-Acquisition Mode.” *Aviation Week and Space Technology*, August 14, 2000, p. 47.

²³ See William E. Kovacic, “Competition Policy in the Postconsolidation Defense Industry,” *Antitrust Bulletin* 44/2 (Summer, 1999), pp. 421-487.

Total U.S. and Federal R&D Spending
FY 1953-2001



Source: National Science Foundation, *National Patterns of R&D Resources: 1999 Data Update*

Figure 4

Proponents of using more commercial products emphasize the rapid access to current technology, the exposure of the defense community to modern business practices, and the ability of DOD to purchase new products in significantly reduced time. The Defense Science Board has indicated that there are probable benefits to DOD in cost and capability which are available in at least six product areas, including information systems, communications, air and sea lift, logistics, space-based surveillance, and high-efficiency ground transportation.²⁴

Some critics of the move to commercialize more of the defense acquisition process cite examples of high modification costs and delivery delays when DOD program managers have failed to appreciate gaps between military requirements and COTS equipment capabilities. They also point out that commercial products are not appropriate to all military applications, and that it is possible that forcing commercial products into military niches can be inappropriate, expensive, and may result in modification of the military requirement rather than improvement to the commercial equipment itself.²⁵

Others see a systematic aversion on the part of some DOD acquisition managers and prime contractors to the use of commercial components. This is due in part to a perception that machines built to civilian specifications may fail under extreme test or operational conditions, increasing cost and potentially placing larger programs at

²⁴Office of the Under Secretary of Defense for Acquisition and Technology, *Final Report of the Defense Science Board Task Force on Globalization and Security*, Washington: Office of the Secretary of Defense, 1999, p. 14.

²⁵ See Office of the Secretary of Defense, *Commercial Item Acquisition: Considerations and Lessons Learned*, Washington: Department of Defense, June 26, 2000.

risk.²⁶ Once purchased and placed in service, commercial products can rapidly become obsolete. The civilian market moves rapidly, especially in the information technology and telecommunications fields. Some critics fear that vital equipment could go out of production and may not be available in quantity when needed.²⁷ Moreover, new versions of commercial products and components may not be “backward compatible” and able to operate with existing equipment.

Globalization

The globalization of industry translates into the lowering of barriers to trade, financial movement, and access to information. Companies with a global outlook seek opportunity for acquisitions and markets with little regard for national boundaries. In the defense industry, this trend can raise concerns regarding the transfer of sensitive technology and of foreign corporate control.

Those who support a more globalized defense industry, particularly in transatlantic relationships, point out that the reduction of controls on the transfer of defense-related technology can help increase exports of U.S. products to friends and allies. Such a relaxation can increase the number of individual units sold (offsetting to some degree the post-Cold War shrinkage in domestic defense procurement), make the equipment used by different national military establishments interoperable (enhancing the ability of U.S. forces to operate in conjunction with foreign units), increase the scope of work in which U.S. industry engages, and effectively counter competitive sales of equivalent foreign technology. In addition, globalized industries foster cross-border collaboration on projects, can spread the financial risk of new system development and production, and can assist in gaining U.S. access to foreign technology.

Those who criticize the easing of technology export restrictions cite the need to prevent unauthorized transfer of U.S. defense technology.²⁸ Critics also maintain that any reliance on globalized production carries with it the danger of being unable to maintain adequate supply of materiel and components during times of crisis or heightened need. Defense companies are acutely aware of government sensitivity to the sharing of militarily-useful technology across national borders. Statements by industry executives in both the United States and Europe, where the European Aeronautic Defense and Space Co. (EADS) was recently created by the merger of German, French, and Spanish defense firms, indicate a strong desire to pursue

²⁶Bryan Bender, “DOD in Search for COTS Despite Mixed Results,” *Jane’s Defence Week*, August 9, 2000, pp. 20-21.

²⁷There is a discussion of the challenge posed by obsolete and out-of-production parts in the F-22 program in David A. Fulghum, “USAF Maps Solution to Rapidly Aging Parts,” *Aviation Week and Space Technology*, June 12, 2000, pp. 51-53.

²⁸Michael A. Taverna, “Thomson Cautious On U.S. Defense Links.” *Aviation Week and Space Technology*, July 31, 2000, p. 54. For a fuller discussion of a specific technology export control issue, see CRS Report RL30273, *Encryption Export Controls*, by Jeanne J. Grimmer.

transnational joint ventures and business alliances while satisfying governments that critical information is not being compromised.²⁹

Shortage of Technical Personnel

Finally, some defense companies appear to be facing current and projected shortages of junior and middle-level scientists and engineers within the more sophisticated and complex programs.³⁰ Several causes seem to contribute to the shortfall. In the military aircraft industry, for example, there are relatively few aerospace engineers in the 40-49 year age bracket, reflecting the industry's downturn during the 1970s. Likewise, an insufficient number of recent engineering and science graduates aged 25-30 are employed in defense, reflecting both the drawdown in defense budgets during the ten years prior to 1998 and the intense compensation competition for skilled personnel coming from computer and Internet companies. This shortfall is felt to be especially acute in the electrical, software, and systems engineering disciplines, where competition with commercial firms is the most severe. An additional challenge for defense companies is the fact that many advanced students (master and doctoral candidates) in U.S. engineering schools are foreign nationals who are less likely than U.S. citizens to be able to work in fields requiring access to classified information.

According to top-level managers, a critical factor in the recruitment and retention of high-quality personnel is the industry's ability to maintain vitality and vibrancy in technically challenging programs. During the 1940s, 1950s, and 1960s, jet aircraft, ships, and advanced ground vehicles were at the forefront of technology, and young engineers saw rewarding futures in their design and construction. Today, relatively few defense-related programs are focused on building "platforms;" the greater emphasis lies in electronics and systems integration. The bulk of industry complaints about personnel shortfalls seem concentrated in the platform industries, particularly airframe manufacturers, while programs stressing information technology appear to be better able to recruit new talent. For example, Raytheon, a defense company with a heavy focus on electronics and IT, has hired 3,000 engineers during the last 18 months, with 70% of those offered positions accepting them.³¹ Northrop Grumman, a defense firm which is shifting its efforts away from aircraft manufacture and into

²⁹John D. Morrocco, "EADS, Northrop Grumman Broaden Cooperative Links," *Aviation Week and Space Technology*, June 12, 2000, p. 35-36.

³⁰William B. Scott, "Industry's Loss of Expertise Spurs Counterattack," *Aviation Week and Space Technology*, March 13, 2000, pp. 160-161; Anthony L. Velocci, "Loss of Intellectual Capital Challenges Company Ingenuity," *Aviation Week and Space Technology*, April 24, 2000, p. 26; Robert Wall and Anthony L. Velocci, "Pentagon Board Urges Fix for Defense Industrial Base," *Aviation Week and Space Technology*, April 24, 2000, p. 28; and Anthony Velocci, "Industry Prognosis Flags Ominous Trends," *Aviation Week and Space Technology*, July 17, 2000, pp. 28-30. See also Kimberly Ann Harokopus, "Reforming Defense Procurement: The Politics and Practices of Weapons Acquisition," Ph.D. dissertation, Boston College, 1999.

³¹See Robert Holzer, "One-on-One: Louise Francesconi, Raytheon Co. Vice President and Raytheon Guided Missile Systems General Manager," *Defense News*, October 23, 2000, p. 94.

electronics and IT, appears to face recruiting and retention challenges in product lines tied to platforms, but not in those areas where “young people ... see a future.”³²

For those firms that are having difficulty, staffing problems among middle- and senior-level engineers and program managers pose challenges different in quality but similar in effect. In the aerospace industry, for example, some of the larger defense corporations will soon face the retirement of a large number of technical managers who entered their careers during the late 1950s and the 1960s. One major Pentagon program managed by a large defense contractor is noted by an observer as expecting more than 80% of its engineering staff to retire before the end of September of 2002.³³ The scarcity of mid-career engineers already noted means that an insufficient number of experienced managers is available to fill the ranks of the retiring. Analysts note that of those who are available for promotion into program management, few have worked on enough major systems development projects to develop the same breadth of experience as those they will replace.

³²Unattributed, “One-on-One: Kent Kresta, Chairman, CEO, Northrop Grumman Corp.,” *Defense News*, October 16, 2000, p. 30.

³³Anthony L. Velocci, “Brain Drain Threatens Aerospace Vitality,” *Aviation Week and Space Technology*, April 24, 2000, p. 24.