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ABOUT THE AUTHOR

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ABOUT THE AUTHOR

Dr. Howard Olrik DeVore is a specialist on Asian security and technology issues and innovation-based economic development. He is currently a special consultant for Jane's Information Group, and is the author of a recent series of Jane's Special Reports on Asia that include *China's Intelligence and Internal Security Forces*, *China's Aerospace Industry* (extensively referenced in the 1999 US Cox Report on Chinese espionage activities), *Japan's Defence Industry* and *Technology, Trade and Investment - China*.

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Industry Directory

Academia Sinica Institute of Systems Science

Zhongguancun, Beijing 100080

Tel: +86 (10) 255-3063

Fax: +86 (10) 256-8364

Aerospace Knowledge Magazine

Hongkong Zhishi

37 Xueyuan Lu, Haidian Qu

Beijing 100083

Air Survey Remote Sensing Centre of Nuclear Industry

PO Box 183, May Seventh Road, Shijiazhuang

Hebei 050002

Tel: +86 (311) 639-705, 639-046

Fax: +86 (311) 639-760

ASRSC specialises in nuclear industry related aerial surveys (eg. finding uranium deposits), remote sensing application techniques, computers, and mapping and demarcation with radioactive instruments. Its staff complement of 660 includes 100 senior engineers and over 300 multidisciplinary engineers and technicians. It has China's largest air survey team, the top level remote sensing application centre and radioactive survey measuring stations at the state level. Special departments include: Air Gamma Energy spectrum Survey and Air Magnetic Force Survey Speciality; Space Remote Sensing Technology Application Speciality for computer processing, optical and chemical processing, geophysical spectrum testing, aerial mapping and space-based surveying; Radioactive Survey and Measuring Station; and Mapping and Printing. Remote sensing applications are used for industries such as petroleum, forestry, gold mining, chemical industry and environmental protection. Technical exchanges have been undertaken with the United States, Canada, Japan and Russia.

Aircraft Design Institute of China National Guizhou Aviation Industry Group

PO Box 44

Anshun, Guizhou 561000

Tel: +86 (851) 385-4500

Fax: +86 (851) 385-4800

Founded in 1968, this aircraft design institute has 600 employees, and has specialised in the R&D of training aircraft such as the JT-7P ands JT-7.

Aircraft Strength Research Institute

PO Box 86

Xi'an, Shaanxi 710065

Tel: +86 (29) 821-3623

Fax: +86 (29) 821-4765

Founded in 1965, this AVIC institute is the only Chinese R&D establishment dedicated to aircraft and aerospace vehicle strength research. It has a 450,000 square metre facility and fixed assets of 250 million Rmb yuan, and employees that include 200 technical specialists. Specialised facilities include a large structural test building with load-bearing floor and ceiling, integrated test, measuring and control systems, shimmy test rigs, drop test rigs, thermal test rigs, and integrated environment test rigs, etc. It is headquartered in the High-Tech Development District of Xi'an, with test bases at Yao County and Chang'an County. Specialised R&D is conducted on static and fatigue strength, vibration, dynamic strength, thermal strength, aeronautical acoustics, computational mechanics, software engineering, etc.

Airforce Four Station

Yinchuan Automobile Repair Factory

Yongning Wangyuan EDZ

Yinchuan, Ningxia 750101

Tel: +86 (951) 802-9096

ANDA Forging Plant

PO Box 22

Anshun, Guizhou 561005

Tel: +86 (851) 385-1713, 385-4510

Fax: +86 (851) 385-2155

This AVIC affiliate was founded in 1966 and produces free and die forging for airframes and aeroengines, including turbine discs, compressor disc, ring forgings, landing gear, etc., and specialised forgings for the armament industry. It occupies over 400,000 square metres, has 2,200 employees including over 700 engineers and technicians, and has fixed assets of 280 million Rmb yuan. Forgings (free, die, ring isothermal, etc.) can be undertaken with various metals including carbon steel, alloy structural steel, stainless steel, high-temperature alloys, titanium alloys, aluminium alloys, magnesium alloy, copper, etc. Equipment includes leading-edge forging, mould and die systems and NC tools. The firm is a supplier of large ring forgings for Pratt and Whitney, and has been ISO9002 certified since 1996.

Anhui Shipbuilding Industry Company

Dadongmen, Anhui 230011

Tel: +86 (551) 267-5809, 267-8021

Trade Dept. 265-1856, 267-8125

Anji Foundry

PO Box 16

Anshun, Guizhou 561003

Tel: +86 (851) 385-1430, 322-3465

Fax: +86 (851) 385-4223

Founded in the 1960s, this AVIC affiliate has a construction area of 130,000 square metres, has 2,000 employees including 400 engineers and technicians, and total assets of 144 million Rmb yuan. It is ISO9002 quality certified, and has sub-factories for aluminium casting, magnesium casting, precision-investment cast steel, precision titanium casting, and precision aluminium casting, and various advanced manufacturing support systems. Main products include castings for aircraft, aeroengines and auxiliary equipment. It has also provided precision weapons castings for Ordnance Industries of China.

Anqing Marine Diesel Engine Plant

PO Box 107

12 Dujiang Road, Anqing

Anhui 246003

Tel: +86 (556) 542-814, 542-813

Fax: +86 (556) 516-944

A subsidiary of the China State Shipbuilding Corporation, this plant has 1,200 workers, including 150 engineers and technicians, occupies an area of 170,000 square metres, and has over 400 sets of major equipment. Diesel engines used mostly in ships and power plants. In 1981 imported diesel engine production technology from the Japanese Daihatsu Diesel Manufacturing Company Ltd.

Anzhong Machinery Factory

PO Box 21

Hanzhong, Shaanxi

723000

Tel: +86 (29) 212-853

Manufactures hydraulic presses, bending machines, titanium alloy superplastic forming devices, seam welders and heat treatment furnaces.

APT Satellite Company Ltd.

1 Pacific Place, 88 Queensway

Hong Kong

Tel: (852) 526-2281

Fax: (852) 522-0419

Manages the regional Apstar satellite telecommunications system, that includes direct broadcasting services to the mainland.

Asia Satellite Telecommunications Company Ltd.

23/F East Exchange Tower, 38 Leighton Road

Causeway Bay, Hong Kong

Tel: (852) 2805-6666, 2805-6657

Fax: (852) 2504-3875

Website: http://www.asiasat.com.hk

Operates the AsiaSat regional satellite telecommunications system.

Asian Star Development, Inc.

Hong Kong

Tel: Investor Relations: 1-415-566-2503, 1-800-488-7151, or visit

Stephen Chow, President, 011-852-2721-0936

http://www.asianstardev.com

e-mail: info@asianstardev.com

International commercial agent for CAST

Aviation Industries Corporation of China (AVIC)

67 Nandajie Jiaodaokou

PO Box 33

Beijing 100712

Tel: +86 (10) 6401-3322, 6401-3645

Fax: +86 (10) 6401-3648, 6401-9360, 6410-1632

Overall holding company for China's aviation industry. Aircraft, aeroengines, sub-systems, avionics, and aviation parts and components are primary activity areas. Organisation includes 43 "export bases" and 27 firms that have provided self-managing trade rights. AVIC is responsible for the management and allocation of state assets, new technology development, export promotion, contracting state projects, and aligning the planning of the aviation sector with the priorities of the State Council and Central Military Commission. Overall, over 50 foreign joint ventures established with aviation-related enterprises.

AVIC II

Aviation Industries of China Number Two Group

Department of International Co-operation and Trade

67 Jiaonan Street

Beijing, 10072

Tel: +86 (10) 6409-4352

Fax: +86) (10) 6403-2109

New conglomerate resulting from the 1998-99 reorganisation of the AVIC mega-conglomerate.

AVIC Chengdu, 611 Institute of Science and Technology

PO Box 394-25

Chengdu, Sichuan 610041

Tel: +86 (28) 776-3611 ext. 2496

Fax: +86 (28) 776-7382

Aviation Spaceflight Industry Bureau

Wuhan Instrument Factory

Wujiawan, Wuchang

Wuhan, Hubei 430074

Tel: +86 (27) 780-1382, 780-1161

Fax: +86 (27) 780-1207

Defence instrumentation products.

Baiyun Household Electrical Appliances Factory

PO Box 101 Chenxi

Hunan 419503

Tel: +86 (7402) 233-288

Fax: +86 (7402) 233-288

A subsidiary of NORINCO, this factory has over 10,700 workers, including 1,400 engineers and technicians, and occupies a total area of 8 million square metres, including building floor space of 500,000 square metres. Fixed assets total 200 million Rmb yuan, including over 2000 pieces of testing equipment.

Baocheng General Electronic Corporation

PO Box 38, Baoji

Shaanxi 721006

Tel: +86 (0917) 312-901

Fax: +86 (0917) 313-903, 313-601

Under the AVIC this firm produces directional attitude systems, general compass systems, gyro magnetic compass systems, flight guide systems, assorted magnetic compasses, altazimuthes, sensors, precision inertial elements such as flexible accelerometers, servo motors, various liquid switches and microtransmission facilities. Gyro technology has resulted in gyro dynamometric systems, gyro pachimetric systems, gyro altazimuthes, radiographs, and directional guide systems for armoured vehicles. Future R&D centres on the 'Jielian altitude system'. A total of 5,600 employees includes some 1500 engineers and technicians. Facilities include 332,000 square metres of floor space, 77,500 metres of workshops and 1000 machines and 1,940 instruments. Equipment includes hot and cold processing centres, and tool, die set, fixture and testing instruments manufacturing centres, imported 3-D surveyors, random vibration beds, high-precision jig grinders, optical grinders, four-axle and double-axle boring mills, and other testing and precision measuring facilities.

Baoding Propeller Plant

PO Box 818, Boading

Hebei 072152

Tel: +86 (312) 705-2454

Fax: +86 (312) 705-1454, 705-1442

Under the AVIC, the plant is China's specialist producer of aircraft propellers and was founded in 1960. It covers a total area of 650,000 square metres, with building floor space totalling 200,000 square metres, with the plant having over 1,900 specialised machines, and 4,000 employees, including 1,100 engineers, technicians, and managers. Conducting both R&D and production, BPP has forging, casting, heat and surface treatment, tools manufacturing, equipment maintenance, composite components, anti-electrostatic floor (used by the Xichang Satellite Launching Centre), general assembly testing and power workshops, designing, cold processing, hot processing, physico-chemical testing, fatigue testing, metering and quality control capabilities. By the 1990s, the plant had developed aircraft propellers, speed governors, feathering pumps, helicopter rotor heads and tail rotors for dozens of aircraft types (eg. Z-9 helicopters) for equipping thousands of military and civilian aircraft over the past three decades. Recent R&D and production areas have been in the areas of aircraft propellers, wind tunnel rotors, advanced composite materials, and advanced manufacturing and processing techniques.

Baoji Non-ferrous Metal Processing Plant

PO Box 71

Baoji, Shaanxi 721002

Tel: +86 (29) 382-222, 382-239

Fax: +86 (29) 382-000

Baoshan Machine Factory

PO Box 19

Xinxiang, Henan 453009

Tel: +86 (373) 331-218

Fax: +86 (373) 332-258

A division of the Xinxiang Aeronautical Machinery Corporation, this firm produces industrial woven wire cloth, Dutch weaves, test sieve cloth woven with brass, phosphorbronze, stainless steel, other alloy materials, and steel wired inserts.

Bashan Instrument Factory

83 Shixin Road

Shiqiaopu, Shapingba District

Chongqing, Sichuan 630039

Tel: +86 (811) 810-344

Produces astronomical telemetering and data acquisition and recording equipment.

Behai Shipyard

Gaode Lu, Behai

Guangxi 536000

Tel: +86 (771) 303-0002

Beijing Aeronautical Manufacturing Technology Research Institute

PO Box 863

Ba Li Chiao, Chao Yang District

Beijing 100024

Tel: +86 (10) 6575-6876

Fax: +86 (10) 6576-2306

E-mail: bamtri@public3.bta.net.cn

Established in July 1957, this AVIC comprehensive research institute of 1,700 employees developing advanced aircraft manufacturing technologies. It has some 1,000 senior research personnel, and structures totalling some 60,000 square metres of floor area, and 300 sets of machining equipment, over 400 sets of power and testing equipment, and over 2,900 sets of measuring equipment. Its assets are worth over 180 million Rmb yuan. It was the first R&D centre in China to develop advanced composite structures, and advanced manufacturing technology developments have included: high-performance resin systems and preparation techniques; advanced composite forming technology; Nomex honeycomb and sandwich structure manufacturing technology; advanced composite structure joining and machining technology; non-destructive testing technology; CAD/CAM application technology; AL flame coating technology for anti-static electricity and thunderstorm protection. It has 14 research departments, as well as a COSTIND Key Laboratory for High-Energy Density Beam Processing Technology (lasers, electron beams, plasmas), the Beijing Flexible Manufacturing System (FMS) Experimental Centre, a Sub-Institute for High New Tech Development, and a Sub-Institute for Aeronautical Manufacturing Technology. It has developed the MPCS multi-processor control system parallel bus-oriented computer system for milling machines and centres of up to five axes, and various other computerised NC systems.

Beijing Aerospace Digital Control Group Company

PO Box 142-86

Beijing 100854

Beijing Aerospace Measurement and Control

Technology Development Company

8 Fucheng Lu

Beijing 100830

Tel: +86 (10) 837-1693, 837-1699

Fax: +86 (10) 837-1578

Beijing Aerospace Numerical Control

Group Corporation

51 Yongding Lu

Beijing 100854

Tel: +86 (10) 838-6769, 838-5054

Fax: +86 (10) 838-5746

Defence electronic equipment and components.

Beijing Aircraft Brakes Corporation

45 Dongsi Liutiao

Beijing 100007

Tel: +86 (10) 403-3234

Fax: +86 (10) 401-4828

As a joint venture, this firm has produced torque tubes for Messier-Bugattia as part of the offset package for Airbus transport aircraft sales to China.

Beijing Aircraft Materials Institute

(Beijing Institute of Aeronautical Materials)

PO Box 71, Sub-Box Number 81

Number 36 Haidian, Xidajie

Beijing 100080

Tel: +86 (10) 6245-6622, 6245-8158, 6245-6923

Fax: +86 (10) 6245-6925

E-mail: biam@pubilic3.bta.net.cn info@biam.com

Website: http://www.biam.com

Under the AVIC, the BAMI was originally founded in 1956 and is a comprehensive applied research institute on aerospace materials with 22 research offices (including 86 specialities), two experimental factories, an advanced composite materials lab, six pilot production lines, and various advanced equipment and instrument facilities. Its advanced carbon-reinforced and honeycomb composite materials capability is considered a key national defence asset, and it has specialised capabilities in thermal processing and the small-batch production of high-performance materials (eg. titanium and high-temperature alloys) and unique components. It likely undertakes stealth and anti-stealth related research. It has over 2,700 employees, including 1,400 scientists and engineers, with facilities covering over 1.2 million square metres, and containing 4,400 pieces of equipment and instruments, and fixed assets of over 150 million Rmb yuan. Specific aerospace products include components for aeroengines, brakes, centrifugal impellers, turbine blades, and aircraft wheels and brake skates; brakes meet CAAC and FAA standards). Has undertaken about a dozen foreign funded and joint ventures, provided various aerospace components for Trident of U.K., Boeing (707, 737, 747, 767), McDonnell Douglas (MD-82), Anotov (An-24), and Tupolev (Tu-154). Publishes monthly periodical *Aeronautical Material*. It has a US subsidiary called General Titanium Inc., El Monte, California.

Material R&D activities include:

· stealth, microwave absorbing, and transparent materials;

· precision casting and press shaping of high-temperature, special purpose alloys, structural steel, stainless steel, and ferrous metals;

· cast superalloy directional solidification and single crystal turbo-blades;

· precision casting alloys of copper, aluminium, magnesium, titanium, and non-ferrous metals and alloys;

· platinum, rhodium, palladium, iridium, and gold and silver based precious metals;

· materials, flux and solder for metal-based composites, and high-temperature and abrasion resistant coatings;

· neodymium-iron-boron permanent magnetic materials, biomedical engineering materials, structural adhesive and rubber adhesive materials, various sealing materials, various lubricants and abrasion reducing materials, special purpose paints and coatings, non-asbestos brake materials;

· silicon rubber, fluorine rubber, acrylonitrile-butadiene rubber and special purpose rubbers;

· technologies for high-temperature alloy precision casting, directional and monocrystal solidification setting, vacuum precision casting of hollow blades and the casting of complicated structural parts;

· titanium alloy investment precision casting technology;

· metal-based composites shaping technology;

· metal parts cloudburst and hole pressing technology

· metal isothermal forging and superplastic shaping technology; and

· shaping technology for glass fibre reinforced plastic, carbon fibre composite, honeycombs (paper, glasscloth, and aluminum), non-asbestos brake materials, and rubber materials.

Beijing Astronautics Mechanical and Electrical Company

240 Xisi Bei Dajie

Beijing 100034

Tel: +86 (10) 607-1772, 601-1104

Fax: +86 (10) 421-3714

Dual-use electronic equipment and components.

Beijing Aviation Simulator Company

M63 Shangdi Information Base

Haidian District

Beijing 10086

Tel: +86 (10) 257-7089

Manufactures aviation and space simulators and related subsystems.

Beijing Aviation Development Technology Company Ltd.

Bldg. 1, Nine Flowers Mountain Villa

A1 Banbijie Nan Lu, Haidianqu

Beijing 100081

Tel: +86 (10) 841-9621, 842-5602

Fax: +86 (10) 841-9622

Chinese Academy of Sciences

Beijing

Tel: +86 (10) 255-9145

Chang'an Machinery Plant (Chan'gan Automobile Co. Ltd.)

260 Jianxin Donglu, Jiangbeiqu

Chongqing, Sichuan 630023

Tel: +86 (811) 785-1921

Fax: +86 (811) 352-902

Under NORINCO this plant occupies an area of 2.8 million square metres, with buildings totalling 600,000 square metres in floor space. It has 4,000 sets of equipment and 12,000 workers, including 1,100 engineers and technicians. Military R&D and production include armaments.

Changcheng Institute of Metrology and Measurement

PO Box 1066

Beijing 100095

Tel: +86 (10) 6254-1394

Fax: +86 (10) 6255-2895

Founded during the early 1950s, this institute undertakes research on advanced metrology and measurement techniques and standards for the aerospace-defence sector, and also has the role of COSTIND Number One Metrology and Measurement Centre, the Metrology Technology Centre of the Aviation Industry, the centralised administrative centre for national metrology calibration procedures, and the quality verification unit for import-export of measuring equipment and instruments. It has over 800 employees, including 200 engineers, 70 senior engineers, and 6 research fellows. It undertakes R&D on dynamic temperature calibration, piezo-resistance vibration transducers, laser and grating techniques, sensors, etc. Equipment includes a large precision centrifuger and photoelectric spot image measuring devices.

Changchun (Aviation) Airborne Equipment Company

PO Box 1017

Changchun, Jilin 130062

Tel: +86 (431) 293-9070

Fax: +86 (431) 293-7135

Founded in 1958, this firm produces airborne fuel regulators, electromagnetic control systems, pumps, hydraulic solenoid and pneumatic valves, and is now under AVIC.

Changchun Great Wall Uniform Company

80 Chang Tong Ave.

Changchun, Jilin 130042

Tel: +86 (431) 897-2036

Fax: +86 (431) 295-4082

Produces military uniforms.

Changfeng Machinery Plant

Jiangjin, Chongqing

Sichuan 632264

Tel: +86 (811) 521-167

Fax: +86 (811) 811-582

Affiliated with NORINCO, this plant has 3,000 staff, including 600 engineers and technicians. It engages in forging, casting, stamping, welding, heat treatment, physio-chemical testing and mechanical processes.

Changfeng Machinery Factory

Changfeng Measuring and Cutting Tool Plant

PO Box 5

59 Dongbeijie

Suzhou, Jiangsu 215001

Tel: +86 (512) 753-4621, 753-3266

Fax: +86 (512) 753-3266

This AVIC affiliate firm manufactures avionics and aeronautical instruments, NC wire-cut EDMs, thermoplastic injection moulding machines, thermostats, marine propellers, and measuring and cutting tools. The facility is some 200,000 square metres in size, has over 3,000 employees including 300 engineers and technicians, and some 1,000 major pieces of equipment. Sub-units include a Military Product Research Institute, and a Military Product Business Department.

Changhe Aircraft Industry Corporation

(Changhe Aircraft Factory)

PO Box 109

Jingdezhen

Nanchang, Jiangxi 333002

Tel: +86 (798) 844-2019

Fax: +86 (798) 844-1460

This is a key AVIC helicopter R&D and production centre built on a 578 acre site and with 2.5 square million of production area and 5,000 pieces of major manufacturing and testing equipment, and having some 6,800 workers, including 2,000 engineers and technician. A member of the China Helicopter Industry Corporation, it has developed Z-8 and Z-11 light and medium helicopter series, and is also a major automobile producer. Advanced manufacturing capabilities include areas of composite materials, titanium, and honeycomb composites. Helicopter production is currently reportedly in small batches, but it would apparently have a large surge capacity. It has some 7,100 employees and total assets of over 1.9 billion Rmb yuan.

Changkong Precision Machine Building Corporation

PO Box 76

Hanzhong, Shaanxi 723102

Tel: +86 (29) 212-974, 212-171

This firm had produced ejection rocket shells for J-6 and J-7 fighters, aero instrument gears and assemblies, and aeroengine gear boxes.

Changling (Group) Company Ltd.

75 Qingjiang Road

PO Box 43, Baoji

Shaanxi 721006

Tel: +86 (917) 314-433

Fax: +86 (917) 312-331, 312-934

Main products include electronics, navigation radars, satellite receivers and communications systems.

Changqing Machinery Plant

PO Box 631

Huancheng Nanlu, Yichun

Jiangxi 336000

Tel: +86 (795) 241-906, 241-907

Director Yuan Yunsheng

Emphasises electrical control and mechanical processing products. It has 2,200 staff, including 200 engineers and technicians. The plant occupies an area of 800 hectares, with building floor space totalling 100,000 square metres, has over 1000 pieces of equipment, with a fixed asset value of over 50 million Rmb yuan. During the mid-1990s invested 22.5 million Rmb for technical transformation. Total annual industrial output value of some 55 million Rmb yuan, with profits and taxes of some six million Rmb yuan.

Changzhou Aircraft Factory

PO Box 16

Jichang Lu, Xijiao, Changzhou

Jiangsu 213016

Tel: +86 (519) 327-0421, 327-0439

Fax: +86 (519) 327-0437

This firm is a division of the Shanghai Aviation Industrial Group of China, manufactures RPVs, light Z-6 helicopters, airborne high-pressure gas bottles and cryogenic tanks, and nuclear power components. Likely co-operates with the Unmanned Aircraft Research Institute of the Nanjing Aeronautical Institute, which has developed at least four types of RPVs. It has over 1,200 employees, including 400 technical staff, and a production area of some 1 million square metres. The Jiangnan General Aviation Company is an affiliated firm that undertakes remote sensing operations.

Changzhou Lanxiang Machinery Works

PO Box 37

10 Changding Road, Changzhou

Jiangsu 213022

Tel: +86 (519) 510-5142, 510-5143

Fax: +86 (519) 510-5064

A key AVIC enterprise located in a special economic zone, the plant specialises in manufacturing aeroengines, in addition to other military products such as patrol boat engines. Specific products have included the WZ6/A turboshaft aeroengine and the WZ6G and WZ6O industrial gas-turbine engines. It employs 4,100 workers, including 1,100 engineers and technicians, and covers an area of 220,000 square metres with 120,000 square metres of building space. The factory is equipped with 1,300 mechanical, forging and metal cutting machines. It has 11 specialised factories and 5 associated research institutes. Specialised production and R&D facilities exist for casting, stamping, welding, gears, blades, rubber processing, heat treatment moulds, engines, glass fibre reinforced materials, and various product and technology research institutes, technique design institute, and a measuring and chemical laboratory. It also produces Hongling brand fibre reinforced plastic military patrol boats.

Chengdu Aeroinstrument Company

PO Box 229

Chengdu, Sichuan 610091

Tel: +86 (28) 740-0412

Fax: +86 (28) 776-7404

This enterprise develops avionics and sensors such as high-precision vibrating cylinder sensors, industrial programmable controllers, standard pressure instruments, high-precision resonant sensors, capsule pressure sensors, and annunciators.

Chengdu Aircraft Design Institute

PO Box 394

Chengdu, Sichuan 610041

Tel: +86 (28) 550-9211

Fax: +86 (28) 776-0545

This R&D institute was founded in 1970 for advanced fighter aircraft design and research. It has some 2,000 employees including 1,400 engineers and technicians, and 47 research fellows. Areas of research include fluid dynamics, engineering mechanics, mechanical structures, strength, vibration, electronics, electrical systems, instrumentation, radar, lasers, vacuums, automatic controls, environmental controls, advanced materials, computer and software development (eg. CAD/CAM), etc. It conducts some of China's leading-edge R&D in advanced aircraft configuration layout, design system optimisation for multi-constrained structures, wing flutter active control, static aeroelasticity calculation, air inlet/outlet design, aircraft structure damage limitation design, etc. It facilities include extensive static, dynamic, temperature, fatigue strength and simulator systems, as well as high and low speed wind tunnels. It has an advanced experimental production plant. It is closely involved with the development of the J-10 next generation fighter aircraft.

Chengdu Aircraft Industrial Corporation

(formerly Chengdu Aircraft Company)

PO Box 95

800 Huang Tian Ba, Chengdu

Sichuan 610092

Tel: +86 (28) 740-1033

Fax: +86 (28) 740-4984

Established in 1958 and now affiliated with AVIC, CAIC is a primary fighter plane R&D, design and production establishment for China. It also has representative offices in Beijing, Shenzhen, Kunshan and other coastal areas. The Chengdu plant has over 19,000 employees, including 4,400 engineers and technicians. The facility covers an area of over 4 million square metres, with 13,000 machines, power and electronic facilities including large computers, micro-computers, computer aided design/manufacturing (CAD/CAM) systems, numerically controlled machines, measuring machines, and large hydraulic machine tools. The firm has integrated design and manufacturing through CAD/CAM and computer-aided-management systems. In 1989 it was designated an enterprise to pilot computer integrated manufacturing systems (CIMS) and as a base to study China's Manufacturing Resources Programme (MRP-II), and has maintained a high standing in this area, CAD/CAM, NC and quality ISO9000 certification. Capabilities include advanced composite materials manufacturing, electrolytic machining, superplastic forming, high-pressure hydraulic cutting, and laser and electromagnetic interference systems. CAIC has an engineering development centre, four branches, 12 specialised plants and a test flight centre. Past products have included ten aircraft types such as the J-5, JJ-5, J-7M fighters; over 2,000 fighter aircraft thought to have been built by the plant. It has recently played a key role in the development of the advanced J-10 fighter-bomber, and the FC-1 and J-7MG light fighters. The J-10 is thought to be based upon significant Israeli Lavi aircraft technology (originally obtained from US), and will likely employ Russian radar and aeroengine systems. CAIC produces foreign commercial aircraft components such as the MD-80/82/90 series aircraft nose sections, entrance doors and air stairs assemblies, Boeing 757 components, A320/340 components, etc. The firm has participated with the development of trunk airliner concepts. The Chengdu aircraft manufacturing plant has recently benefited from MOST's "863" R&D support programme through the development of a sponsored CIMS that applies NC technologies for integrated airframe manufacturing.

Chengdu Engine Company

PO Box 77

Shuangqiaozi, Chenghua District

Chengdu, Sichuan

610067

Tel: +86 (28) 444-3628, 444-1103

Fax: +86 (28) 444-2470, 444-1103

This firm is an AVIC enterprise and founded in 1958.It has 15 specialised factories, 4 research institutes, 15 subsidiaries, and various joint-ventures throughout China. The Chengdu Aerotech Manufacturing Company Ltd. is a joint venture with Pratt and Whitney. The firm occupies an area of over 1.3 million square metres, has over 16,000 employees including 5,300 professionals and 7,000 senior skilled workers, and over 8,000 major pieces of equipment in 900 types. It has manufactured over 10,000 aeroengines of seven models, including the WP6 and WP13 military turbojet aeroengines, and developed the FT8 industrial/marine gas-turbine engine derived from the Pratt and Whitney JT8D aeroengine during the late 1980s. Parts also produced for the Pratt and Whitney JT8D, JT9D, PWA2037 and PWA4000 aeroengines, that included flame gas tube, gas collector, compressor case, stator shroud, turbine exhaust case.

China Academy of Engineering Physics

Believed by some to be the core R&D centre of China's nuclear weapons complex.

China Academy of Launch Vehicle Technology (CALT)

China Carrier Rocket Technology Research Institute

PO Box 9200-28

Beijing 100076

Tel: +86 (10) 838-1383, 838-1386, 838-1381, 838-1701,

838-1703

Fax: +86 (10) 838-1705

Established in 1957 and affiliated with the CAIC's Missiles and Carrier Rocket Division (supported by "First Academy" design bureau) for surface-to-surface and launch vehicle rockets; controls 13 to 20 research institutes and 6 factories. CALT is China's largest launch vehicle research base. Products include liquid fuel strategic rockets and Long March launch vehicles. It has 27,000 employees, including 12,000 engineers, technicians and research scientists. It occupies an area of 5.4 million square metres, has over 27,000 pieces of equipment and instruments, with fixed assets of more than 500 million Rmb yuan. Co-operates with China Great Wall Industries Corporation for marketing international launch vehicle services. Products include launchers, spacecraft satellite communications systems manufacture (dual-use), precision measuring and testing instrumentation, applied computer technology, automatic control technology, etc. Has provided launch vehicle services for AsiaSat communications satellites, experimental satellite for Pakistan, science satellite for Sweden, communications satellite for Australia, Intelsat communications satellites, etc.

China Aerodynamic Technology Development Centre

PO Box 211, Mianyang

Sichuan 621000

Tel: +86 (816) 22-490

Fax: +86 (816) 22-490

This centre has over 1,700 scientists, engineers, technicians and workers, and undertakes R&D in: aerodynamics and hydrodynamics, and applications to aerospacecraft and wind power projects; high-speed, high-pressure, high-vacuum wind tunnels; various kinds of transducers, data collection and processing devices, and other complete sets of data systems and measuring and control systems; instrumentation; computer software systems; regional and long-distance telecommunications networks; and electronic control devices for machinery.

China Aero-Information Centre

PO Box 9816

14 Xiaoguan Dongli, Anwai

Hepingli, Beijing 100029

Tel: +86 (10) 6492-2211, 6491-8182

Fax: +86 (10) 6491-8420

This is an AVIC collection, analysis, distribution and exchange centre on international aerospace information, with related centres (below). Founded in 1956, it now has some 650 personnel. Includes printed materials, films, videos and software development. Publishes *China Aero-Information*, a monthly English language periodical on the Chinese aviation industry, as well as *International Aviation*, *Aviation Production Engineering*, and *Aviation News Weekly*. It also organises technical and information exchanges, and agent searches for foreign aerospace businesses. A foreign subsidiary, Sino-American Seven Stars International Ltd., Los Angeles, undertakes information and consulting services. Related organisations include:

· Beijing Audio and Video Press

· China Aeronautical Documentation and Information Centre - has collected some 800,000 books and documents, and developed and English-Chinese 'Aeronautical Bibliographic Data-base' with some 1 million entries. Publications include the *China Aviation Science and Technology Report*, the month *Aerospace Abstracts*, the quarterly *China Aeronautical Abstracts* (in English), and a CD-ROM database of the *China Aerospace Documentation Database*.

· China Aero-Technology Exchange Service Centre - engages in domestic and foreign information and technology exchanges.

· China Aero-Technology Translation Corporation - provides technical and commercial interpretation, translation, editing, publishing, information consultation for aerospace, electronics and other technology sectors. Will also provide a liaison service between Chinese and foreign firms, and organise seminars.

· Information Analysis Department - some 70 expert technical consultants undertaking studies for government and industry customers.

· Computer Centre - equipped with the Alpha 2100 4/275 network server and SUN work station; developing the 'Network Operation Centre of Golden Aviation Information Engineering Project', 'Aviation Industry Network Sun-Centre of the Electronic Project of National Defence Scientific and Technological Information'; publishes *Aviation News, Aeronautical Documentation, Aviation Enterprises and Products*, etc.

China Aeronautical Project and Design Institute

Fourth Design and Research Department

12 Deshengmenwai Dajie

Beijing 100011

Tel: +86 (10) 6201-6633

Fax: +86 (10) 6201-1613

Established in 1951, this is a multi-disciplinary R&D organisation with some 1,200 personnel. The institute undertakes engineering feasibility studies, planning, project design, and construction of aeronautical related facilities. It has had ISO9001 quality certification since 1996.

China Aeronautics Computing Technique Research Institute

PO Box 90

Xi'an, Shaanxi 710068

Tel: +86 (29) 526-1011, 526-1370

Fax: +86 (29) 526-5739, 526-2137

Founded in 1958, this R&D centre evolved from the Northwest Computing Technique Research Institute of the CAS, and is China's foremost developer of airborne computers and aeronautical software. It has over 1,000 employees, including 17 research fellows and 115 senior engineers, and has advanced facilities such as a production line for multilayer military PCBs, electronic packaging modules and computers, and a software development centre (CAD/CAM, MIS, CASE). It is capable of the small-batch production of sophisticated systems. It undertakes R&D in high-performance and parallel computer system architectures, computational fluid dynamics and finite element analysis, fault-tolerant computers with high reliability, miniaturised and low-power consumption airborne computers, computer system software, computer support environment, computer power supplies, aeronautical system software, militarised PCBs, and computer chassis.

China Aerospace Civil Products Corporation

PO Box 33

35 Qin Lao Street

Beijing 100712

China Aerospace Corporation

Information and Communication Centre

Fucheng Lu, Beijing 100830

Tel: +86 (10) 837-0114

China Aerospace Corporation

Shenyang Xinie Precision Machinery Company

1 Leshan Lu, Santaizi

Huangguqu

Shenyang, Liaoning 110031

Tel: +86 (24) 680-1119, 680-0561

Fax: +86 (24) 680-1369

Defence-related instruments and measuring devices.

China Aerospace News

9 Yangfang Hutong

Dennei Street

Beijing 100009

Tel: +86 (10) 601-3331

Fax: +86 (10) 602-5311

China Aerospace Tooling Association

PO Box 1665

Beijing 100028

Tel: +86 (10) 6462-1970, 6466-3322 ext. 2261/2561

Fax: +86 (10) 6462-1970

Since 1990, this has been a professional association for the Chinese aviation and space tool manufacturing sector. It has 230 member firms involved in the production of aircraft, missiles, rockets, satellites, aeroengines, airborne equipment, and related research institutes, universities and colleges. It provides a professional and promotional service to both AVIC and the CAIC through consultancy and information activities. It conducts foreign technology transfers, organises professional training, compiles relevant standards and norms, publishes related information, etc.

China Aero Polytechnical Establishment

PO 1665

Beijing 100028

Tel: +86 (10) 6466-3322

Fax: +86 (10) 6465-2320

This AVIC R&D institute was founded in 1970 to conduct research on aero-industrial standards and specifications, quality assurance and management, reliability and airworthiness, and the transfer of advanced and new technology to industry such as new software and CNC systems. It provides representation to the International Standards Organisation (ISO). It has 500 employees, including 12 research fellows, 87 senior engineers, and 200 engineers, and 1,000 pieces of equipment for testing and measuring, and over 200,000 standards in its CD-ROM reference library. It maintains an advanced climatic and mechanical environment simulation and reliability testing lab for the evaluation and certification of new aerospace products.

China Association for Peaceful Use of

Military Industrial Technology (CAPUMIT)

Number 8 Che Dao Gou

Haidian District

Beijing 1000081

Tel: +86 (10) 847- 4980

Fax: +86 (10) 847- 4980

China Aviation Industry Civil Products Corporation

1 Huanggufen, Anzhenqiao Bei

Andingmenwai, Beijing 100029

Tel: +86 (10) 6426-3171, 6426-1741

Fax: +86 (10) 6426-1728

China Aviation Construction Development Corporation

Number 12, Dewai Dajie, Xicheng Qu

Beijing 100011

Tel: +86 (10) 6201-1612, 6201-8728

Fax: +86 (10) 6201-1612

China Aviation Industry Design Institute Number Three

4 Xi'angzhang Lu

PO Box 18

Changsha, Hunan 410004

Tel: +86 (731) 558-3809

Fax: +86 (731) 558-5823

China Aviation Industry General Corporation

Tianjin Aviation Electro-Mechanical Corporation

3 Xizhan Qianjie

Tianjin 300123

Tel: +86 (22) 735-1285, 735-7348

Tel: +86 (22) 735-1285

China Aviation Industry Supply

and Marketing Corporation

PO Box 4710

10A Dongzhimen Nan Dajie

Dongchengqu, Beijing 100027

Tel: +86 (10) 6416-8495, 6415-7788

Fax: +86 (10) 6416-8494, 6415-4701

CAISAMC has responsibilities for foreign procurement of commercial and military aircraft, aeroengines, avionics, spares, airport systems, communications and navigation systems. Affiliated with AVIC, its headquarters is in Beijing, with branches in major cities including Shanghai, Shenyang, Harbin, Dalian, Wuhan, Nanjing, Xi'an, Chengdu, Nanchang, Changsha, Hanzhong, Anshun, Shenzhen and Haikou. It employs 3,200 people, including 650 senior professionals. With assets of over 1.6 billion Rmb yuan and annual revenues of some 1.8 billion Rmb yuan, CAISAMC is also responsible for supplying various materials for the R&D and production of China's aerospace industry and is the core of the industry's aviation materials group.

China Aviation Industry Supply

and Marketing Sichuan Company

196 Renmin Bei Lu Erduan

Chengdu, Sichuan 610081

Tel: +86 (28) 334-2944, 333-1508

Fax: +86 (28) 334-1749

China Aviation Supplies Corporation (CASC)

PO Box 612

11 Jian Hua Nan Lu Road

Jianwai, Beijing 100022

Tel: +86 (10) 515-8470, 515-8822, 515-8469

Fax: +86 (10) 515-8465, 515-8482

China Broadcasting System

Fu Xing Men Wai Jie 2

Beijing

Tel: +86 (10) 686-8581

Direct broadcast satellite system development.

China Carrie Enterprises Ltd.

(aka: Kaili Corporation)

12 Xinjian Lane, Xichengqu

Beijing 100031

Tel: +86 (10) 603-3388, 601-8094

Fax: +86 (10) 601-3619

and

Qingdao Kaili Industry and Trade United Company

6A Yancheng Lu

Qingdao, Shandong 266071

Tel: +86 (532) 387-2597

A trading company that has traditionally reported to the PLA General Political Department, specialising in communications equipment and publications products.

China Chamber of Commerce for Machinery and Electronic Products Import and Export

Aerospace Products Branch Chamber

PO Box 33-2

67 Jiao Nan Street

Beijing 100712

Tel: +86 (10) 401-3322 (Ext. 3507)

Fax: +86 (10) 403-1480, 401-1632

China Communications Satellite Corporation

31 Baishiqiao Lu

Beijing

China Electronics Corporation

Research Centre for Computer and Microelectronics Industrial Development

27 Wanshuo Road

Beijing 100846

or 1 Jinggouhe Road, Haidian

Beijing 100039

Tel: +86 (10) 821-8370, 821-8372, 821-2233, 821-8528

Fax: +86 (10) 821-8370, 822-1835, 821-3745

China Electronics Systems Engineering General Corporation

8 Xiaotun Lu, Fentaiqu

Beijing 100039

Tel: +86 (10) 821-9619, 821-8863

Fax: +86 (10) 821-7516

China Electronics Systems Engineering Company

PO Box 101 Beijing 100840

Tel: +86 (10) 821-9614

Reporting to the Communications Department of the PLA General Staff, and specialising in communications and electronics technology and equipment.

China Everbright Holding Company Ltd.

Everbright Bank of China

Everbright Building

No. 6 Fuxingmenwai Dajie

Beijing 100045

Tel: +86 (10) 6857-1302

Fax: +86 (10) 6857-1301

China Flight Test Establishment (Flight Test Research Institute)

PO Box 73

Xi'an, Shaanxi 710089

Tel: +86 (29) 683-9651, 683-7347

Fax: +86 (29) 721-4586

Founded in 1959, this is China's only establishment for the flight test certification of new military and civilian aircraft, aeroengines and related equipment, and test pilot flight training on civilian and military aircraft. It has over 2,000 personnel, including '50 famous scientific and technical specialists and flight test pilots'. It has evaluated over 25 aircraft designs, 18 aeroengine designs and over 300 types of airborne equipment. Areas of R&D include flight mechanics, strength, flying qualities, flutter, powerplants, airborne equipment, electronics, fire control systems, high-altitude protection and survival, simulation, measurement and testing, automatic controls, identification techniques, etc. Facilities include two all-weather navigation runways of 3,400 metres, in-flight test platforms for aeroengines, ejection seat experimental aircraft, variable stability systems, simulation rigs, antenna test site, laser radar station, and a vehicle with a real-time data processing system. It has developed a third generation data recording and processing system, and as of 1998 was developing a fourth generation magnetic system.

China General Aviation Corporation Handan

Helicopter Branch

Handan Airport

Handan, Hebei 056001

Tel: +86 (311) 301-0946

China General Aviation Corporation

Tianjin Branch

Zhangguizhuang Airport

Tianjin 300300

Tel: +86 (22) 439-4104, 439-4106

Fax: +86 (22) 439-4107

China Great Wall Industry Corporation

22 Fucheng Lu, Haidianqu

PO Box 129

Beijing 100036

Tel: +86 (10) 6837-2363

Fax: +86 (10) 6842-9112

Reporting to the CAIC, CGWIC specialises in military research and development and the manufacture of specialised precision machinery, missiles and the Long March launch vehicle series, launch vehicle services, Cupertino and services in satellite and space technologies. Import and export business for special equipment, precision machinery, instrumentation and electronics products, engineering and labour services, etc. Dual-use products in such areas as the launch of commercial communications satellites, precision machinery, electronics, instruments and metres, special vehicles, medical systems, broadcast and communications systems, general machinery and tools, magnetic materials, electric appliances, measuring tools and chemicals. CGWIC has exclusive government authorisation to provide commercial launch services for foreign customers and develop international space technology Cupertino and joint ventures in such areas as production and technology transfer. Accepts orders for processing with supplied materials, designs and samples, organises foreign investment and development in China, storage and transportation, international exhibitions, tourism, and other trading activities. Subsidiaries include:

China Great Wall Industry Chongqing Corporation

207 Shixiao Lu

Chongqing, Sichuan

630039

Tel: +86 (811) 881-0798

Fax: +86 (811) 881-2852

China Great Wall Industry Dalian Corporation

173 Youhao Lu, Zhongshanqu

Dalian, Liaoning 116001

Tel: +86 (411) 263-5648, 263-7570

Import/Export Dept. 280-4386

Fax: +86 (411) 263-6278

China Great Wall Industry Guangzhou Company

51-53 Guangyuan Xi Lu

Guangzhou, Guangdong 510010

Tel: +86 (20) 651-8288, 651-7159, 651-7001, 651-7621

Fax: +86 (20) 651-7663

China Great Wall Industry Shandong Corporation

Bldg. 5, Shunhe Shangye Jie

Jinan, Shandong 250001

Tel: +86 (531) 691-3836, 692-7885

Fax: +86 (531) 691-3837

China Helicopter Industry Corporation

67 Jiaonan Dajie

Beijing 100004

Tel: +86 (10) 513-7766, 401-2233

Fax: +86 (10) 500-8081, 401-9757

AVIC subsidiary that co-ordinates and oversees military and commercial helicopter development and production in China.

China Institute for Radiation Protection

PO Box 120, Taiyuan, Shanxi, 030006

Tel: +86 (351) 704-0266

Fax: +86 (351) 704-0407

Defence-related activities include the irradiation curing of composite materials. CIRP undertakes R&D in radiation physics and dosimeter, environmental medicine, irradiation biology, radiation medicine, occupational disease and labour hygiene, isotope applications (eg. modification of plastics by irradiation), environmental protection and waste disposal, electronics (nuclear electronic techniques, instruments and metres) and computer applications. Staff number 1,160, including 856 scientists and technicians. Responsible for monitoring environmental quality of CNNC subsidiaries, radiation dosages data-bases, nuclear industry occupational disease registry centre, support centre for major nuclear emergencies, nuclear safety and irradiation protection centre, and operation of COSTIND metrological station. In the past decade CIRP has established relations with more than 40 nations, regions and international organisations for international radiation protection technology R&D.

China Institute of Atomic Energy

Xinzhen, Fangshanqu

PO Box 275 (sub-box 5)

Beijing 102413

Tel: +86 (10) 935-7829, 935-7487, 935-7346

Fax: +86 (10) 935-7008

CIAE is located in the "China Nuclear Town" in the Southwestern suburb of Beijing, and has a total of 4,500 workers including 900 research scientists, 1000 engineers and 1000 assistant engineers. It has eight research institute, more than 50 research offices, and specialised facilities such as pilot plants under its direct control. Facilities amount to an area of some 135 hectares and over 520,000 square metres of facility space. R&D facilities include three nuclear reactors, four zero power reactors, ten accelerators, two isotope electromagnetic separators, numerous computers and PC networks, a strong heat liberation chamber, nuclear reactor engineering systems, instrumentation and facilities for radioactive chemicals and isotopes. R&D project areas include experimental and theoretical nuclear physics, medium and heavy ion nuclear reaction, conglomerated nuclear physics, strong current particle beam laser nuclear fusion, free electron lasers, quasi-molecular lasers and chemicals, nuclear reactor engineering, fast reactor engineering, low energy accelerators, nuclear electronics, detectors and special instrument systems, the development and application of isotopes, radiation processing, nuclear instrumentation, radioactive chemicals, radioactive waste disposal, materials analysis, radiation protection and measurement, nuclear security, computer and software data-base systems. Various foreign academic and commercial exchanges are undertaken.

China Institute of Atomic Energy

Electronic Equipment Factory

PO Box 275-71

Fangshan, Beijing 102413

Tel: +86 (10) 935-7763, 935-7393, 935-7215

China International Trust and Investment Corporation (CITIC)

CITIC Industrial Bank

Capital Mansion, 6 Xinyuan Nanlu

Beijing, 100027

Tel: +86 (10) 6466-0344

Fax: +86 (10) 6466-1059

· **302nd Research Institute (General Institute of Military Products)**

· **Jiangnan Electromechanical Design Institute**

· **38th Research Institute**

· **303rd Research Institute**

· **Wujiang Machinery Factory**

· **Nanfeng Factory**

· **Xinfeng Instrument Manufacturing Corporation - tracking and control systems**

· **Qunjian Machinery Factory**

· **Chaohui Electromechanical Factory**

· **Meiling Factory**

· **Honggang Electromechanical Factory**

· **Guizhou Gaoyuan Machinery Factory - SAM launchers.**

China Jingan Import-Export Corporation

25 Xitangzi Lane

Wangfujing Bei Dajie

Beijing 100006

Tel: +86 (10) 513-5558, 525-1560

Fax: +86 (10) 512-1365

Provides riot, security, firefighting and small arms equipment for the People's Armed Police (PAP).

China Leihua Electronic Technology Research Institute

PO Box 3

Neijiang, Sichuan 641003

Tel: +86 (832) 202-3823

Fax: +86 (832) 202-4822

and

R&D Headquarters

Number 108, Liangxi Lu

Wuxi, Jiangsu 214063

Tel: +86 (510) 551-1607

Fax: +86 (510) 551-1387

Founded in 1970, this was the first Chinese R&D establishment specialising in airborne radars, including airborne multifunction fire control radars, continuous wave radars for missile guidance, Pulse Doppler radar, SAR, colour weather radar (eg. JYL-6 series), airborne phased-array radar, etc. It also conducts research on antennas, microwaves, signal and data processing, electronic circuits, satellite ground receiving systems, etc.

China Light Duty Gas-Turbine Development Centre

67 Jiaonan Dajie

Beijing 100721

Tel: +86 (10) 401-3322, 401-3342

Fax: +86 (10) 501-6248

This centre has the responsibility for co-ordinating China's light gas turbine R&D, production and training across industry and research institutions. Gas-turbine technologies have been applied to power generation for various industries. Co-operative relationships have been with Pratt and Whitney, General Electric, Allison, Avco, Rolls-Royce, etc. The FT8 gas-turbine engine is a joint venture product.

China Munitions Industry General Company

44 Sanlihe Lu

Beijing 100037

Tel: +86 (10) 859-4420

Develops defence ordnance, machine tools and machinery

China Munitions Industry General Company

Guangdong Weiguo Machinery Factory

26 Huizhou Dadaonan

Guangdong 516001

Tel: +86 (756) 280-3249

China National Aeroengine Corporation

67 Jiaonan Dajie

Beijing 100712

Tel: +86 (10) 401-3322 ext. 219

This AVIC affiliate firm conducts aeroengine and related product R&D, production, and independent international trade.

China National Aero-Industry Supply and Sales Corporation

East China Company

518-1 Zhongshan Dong Lu

Nanjing, Jiangsu 210002

Tel: +86 (25) 664-4258

Fax: +86 (25) 441-8349

China National Aero-Industry Supply and Marketing

Jiangxi Co.

294 Beijing Xi Lu

Nanchang, Jiangxi 330046

Tel: +86 (791) 833-3466, 833-3767

China National Aerotechnology Import and Export Corporation (CATIC)

CATIC Plaza, 18 Beicheng Dong Lu

Chaoyangqu, Beijing 100101

Tel: +86 (10) 6494-2255, 6494-0370, 6494-1090

Fax: +86 (10) 6494-0658, 6494-1088

Website: http://www.catic.co.cn

Founded in 1979, and reporting to the AVIC with import and export activities managed by the Xinshidai Group, military products include airborne equipment, aeroengines, aircraft and remotely piloted vehicles. Authorised agent for the export of military aircraft including fighters, attack aircraft, bombers, primary and advanced trainers, transport aircraft, helicopters, and aircraft engines, airframes and components, and missiles. Claims to have established various economic, scientific and technical Cupertino links with more than fifty "countries and regions", and is a key technology transfer and joint venture promoter for the aviation manufacturing sector. In 1996, CATIC obtained a total volume of US$1.39 billion.

The CATIC Group was established in 1993, with over 130 subsidiaries, enterprises and overseas representative offices. CATIC has a number of direct subsidiary corporations (see details below), and links with a number of manufacturing firms including the Chengdu Aircraft Corporation, Shanghai Aviation Industrial Corporation, Changhe Aircraft Factory, Guizhou Aviation Industry Corporation, Guangzhou Orlando Helicopters Ltd., Harbin Aircraft Manufacturing Company, Shaanxi Aircraft Company, Shenyang Aircraft Company, Shijiazhuang Aircraft Plant, and the Xi'an Aircraft Manufacturing Company. Subsidiary branches include:

China National Aerotechnology Import and Export Corporation

Beijing Company

9 and 19 Floors, CATIC Plaza

18 Beichen Dong Lu

Chaoyangqu, Beijing 100101

Tel: +86 (10) 6491-1145, 6493-4059, 6491-1123

Fax: +86 (10) 6491-1149, 6493-4031

CATIC Dalian Company

125 Zhongnan Road, Zhongshan District

Dalian, Liaoning 116015

Tel: +86 (411) 289-7650, 289-7649

Fax: +86 (411) 289-7647

China National Aerotechnology Import and Export Corporation

Fujian Company

123 Dong Jie

Fuzhou, Fujian 350001

Tel: +86 (591) 783-7622, 781-2170

Fax: +86 (591) 783-7511, 784-7974

China National Aerotechnology Import and Export Guangzhou Corporation (CATIC GZ)

39-1 Zhusigang Er Ma Lu

Dongshan, Guangzhou

Guangdong 510080

Tel: +86 (20) 8766-9279

Fax: +86 (20) 8776-5619

Dual-use activities in such areas as international technology acquisition and transfer. Established by CATIC in 1979, CATIC GZ is amongst China's top foreign trade enterprises.

CATIC Hangzhou Company

257 Tiyuchang Lu

Hangzhou, Zhejiang 310003

Tel: +86 (571) 516-3718, 516-3716

Fax: +86 (571) 517-2053

E-mail: catichz@pub.zjpta.net.ca

China National Aerotechnology Import and Export

Harbin Company

10/F, Heping Bldg., 2 Heping Lu

Dongliqu, Harbin

Heilongjiang 150040

Tel: +86 (451) 211-8454, 211-8437, 211-8434

Fax: +86 (451) 211-8504

China National Aerotechnology Import and Export Corporation

Shanghai Company

Bldg. 3, Aijian Bldg.

583 Lingling Lu

Shanghai 200030

Tel: +86 (21) 6439-2800

Fax: +86 (21) 6439-0166, 6439-0354

E-mail: caticsh@public.sta.net.cn

China National Aerotechnology Import and Export Corporation

Shenzhen Co.

Aviation Plaza, CATIC Zone,

Shennan Zhong Lu

Shenzhen, Guangdong

518041

Tel: +86 (755) 336-6427, 336-3698

Fax: +86 (755) 336-6732

China National Aerotechnology Import and Export Corporation

Xiamen Corporation

9/F, Hong Xi'ang Bldg.

258 Hubin Nan Lu

Xiamen, Fujian 361004

Tel: +86 (592) 515-0899

Fax: +86 (592) 515-0939

CATIC Zhuhai Company

CATIC Building, Jiuzhou Blvd.

Zhuhai, Guangdong 519015

Tel: +86 (756) 333-2808

Fax: +86 (756) 333-2785

CATIC International Engineering Company

3/F, CATIC Plaza

18 Beichen Dong Street, Chaoyang District

Beijing 100101

Tel: +86 (10) 6494-0328, 6494-0329

Fax: +86 (10) 6494-0338, 6494-0337

This firm is the sole certified exporter of Chinese aviation services, and has representative offices around the world.

CATIC Supply Company

18 Beichen Dong Street, Chaoyang District

Beijing 100101

Tel: +86 (10) 6493-3358, 6493-3304

Fax: +86 (10) 6493-3355

Formerly CATIC's Equipment's and Materials Division, this is now a subsidiary firm of the CATIC Group. In 1996, CATIC Supply achieved a total trade of over US$160 million, and has representative offices around the world.

China National Airborne Equipment Corporation (CNAEC)

Chinese Aeronautics and Astronautics Establishment (CAAE)

14 Xiaoguan Dongli

Andingmenwai, Chaoyang Qu

Beijing 100029

Tel: +86 (10) 6491-8403

Fax: +86 (10) 6492-3024

Affiliated with AVIC, CNAEC is a corporation group engaged in R&D, production, sales and services dealing with airborne equipment and related products. Specific aeroengine activity areas include propellers, fuel governors, speed governors, and gearboxes. Active in international Cupertino, technology exchanges/transfer, import and export activities, etc., it also has joint ventures located across China.

China National Automotive Industry Corporation

27B Liuyin Jie, Xicheng District, Beijing 100009

Tel: +86 (10) 6326-3870

Fax: +86 (10) 6326-3602

China National Aviation Company

Building 8

23 Qian Men Dong Street

Beijing 100006

Tel: +86 (10) 512-4774, 513-3062

Fax: +86 (10) 513-3060

China National Aviation Industry Corporation

Qingdao Qianshao Precision Machinery Company

11 Luoyang Lu

Qingdao, Shandong 266045

Tel: +86 (532) 485-2028, 485-5619, 485-6190

Fax: +86 (532) 485-5181

This AVIC firm produces aerospace-defence machine-tools and machinery, and has some 1,300 employees, and is equipped with various advanced equipment such as 3-coordinate measuring machines, NC tools, CAD/CAM systems, etc. A joint venture has been established with a partner from the Netherlands.

China National Aviation Industry Gas Turbine Power (Group) Corporation

China National Light-Weight Gas Turbine Development Centre

16 Dong Huangchenggen Beijie, Doncheng Qu

Beijing 100717

Tel: +86 (10) 6401-8833 ext. 230, 6406-2843, 6405-2578, 6405-4595

Fax: +86 (10) 6403-6107

This is a national centre for the R&D, design, construction, commissioning, installation and service of gas-turbine systems, as well as the import and export of related products and technologies in the fields of aero-derivative, industrial, marine, and mechanical drive applications. The FT8 gas-turbine system transferred from Pratt and Whitney is a major product. This AVIC centre has had the responsibility for co-ordinating China's light gas-turbine R&D, production and training across industry and research institutions. Since 1984 it has developed and produced some 10 types gas-turbine engines, and digital electronic aeroengine control systems. Has also developed co-operative relationships with General Electric, Allison, Avco, Rolls-Royce, etc. R&D is all conducted on wind power generation. All of the major aviation aeroengine manufacturers and R&D centres are members of this group: the Shenyang Liming Engine Manufacturing Corporation; Chengdu Engine Company; Xi'an Aero-Engine Corporation; Guizhou Liyang Aero Engine Corporation; Harbin Dongan Engine Manufacturing Company; China National South Aeroengine Company; Baoding Propeller Factory; Shenyang Aeroengine Research Institute; Zhuzhou Aviation Powerplant Research Institute; Wuxi Aeroengine Research Institute; China National Gas Turbine Research Institute; and the China Aeronautical Project and Design Institute.

China National Aviation Industry Marketing

General Company, Beijing Qinghang Trading Company

257 Dongsi Bei Dajie

Dongchengqu, Beijing 100007

Tel: +86 (10) 404-4878

Fax: +86 (10) 403-3928

China National Electronics Import and Export Corporation

PO Box 140

Electronics Building, 23A Fuxing Lu

Beijing 100036

Tel: +86 (10) 821-9550, 821-9532, 821-7346, 822-3915

Fax: +86 (10) 821-2352, 822-3916

Subsidiaries also located at Beijing, Heilongjiang, Anhui, Chongqing, Fujian, Gansu, Hubei, Hunan, Jiangsu, Jiangxi, Jilin, Liaoning, Neimenggu, Ningbo, Shaanxi, Shanghai, Shenzhen, Chengdu, and Zhuhai. Manufacturing plants include Beijing Semiconductor Devices Factories Numbers One, Two, Three, Four, Five, Nine and Tweleve, and Shanghai Radio Factories One, Two, Four, Six, Eight, Nine, Ten, Twelve, Fourteen, Seventeen, Eighteen (Branches One and Two), Twenty, Twenty-One, Twenty-Six, Twenty-Seven, Twenty-Eight, Thirty-Two, and Thirty-Five.

Controlled by the Ministry of Information Industry and ultimately managed by the Xinshidai Group, CEIEC is China's primary authorised organisation responsible of the export of military electronics systems. Products include air, naval and army radios and radars, air defence systems, navigation systems, optical systems, cryptographic equipment, mine detection equipment, fibre and laser optics, command, control and communications systems, electronic warfare systems, simulators, and Western and former-Eastern bloc components and spare parts. Services include the modification, overhaul and upgrading of older radar systems, military communications systems, fire control systems and air defence networks; operates a comprehensive spare parts service. Has developed various electronics systems such as air traffic control and telecommunications systems have dual-use applications. Foreign joint ventures are sought as a means to further advanced technology transfer to lessen China's import dependency for advanced semiconductors.

China National Instruments Import and Export Corporation

Import Bldg.

Erligou, Xijiao

Beijing 100044

PO Box 1818

Tel: +86 (10) 258-8543, 258-8544, 849-5123

Fax: +86 (10) 258-8547, 831-8380

Bureaus for Science and Technology; Space Systems Engineering; Military Aircraft Systems Engineering; Civil Aircraft Systems Engineering; and Quality Assurance. Import and export of computer equipment, satellites, ground stations, radar, telecommunications equipment, broadcasting equipment, remote sensing equipment, navigation, air surveillance and optical equipment, material testing machines, electronics, and related testing equipment.

China National Machine Tool Corporation

19 Fang Jia Xiaoxiang

An Nei Jie

Beijing 100007

Tel: +86 (10) 403-2224, 401-7830

Fax: +86 (10) 406-4952, 401-5657

Dual-use systems supplied for the machine building industry, and the import and export of all aspects of machine tools and tool products, components and equipment.

China National Machinery Import and Export Corporation

Erligou, Xijiao, PO Box 49

Beijing 100044

Tel: +86 (10) 849-4812/4

Dongfang Trading Company 831-5591

Qianjing Import and Export Company 832-0620

Fax: +86 (10) 831-7962

Imports and exports aircraft, ships, machine tools, diesel engines.

China National Machinery and Equipment Import and Export Corporation

6 Xisanhuan Nan Lu

Liuliqiao

Beijing 100073

Tel: +86 (10) 326-8694, 326-8157, 327-1391

Fax: +86 (10) 326-1865, 326-8203

Branches are also located at Fuzhou, Quanzhou, Xiamen, Guiyang, Harbin, Wuhan, Nantong, and Wulumuqi. Import and export of AFVs, trucks and special use vehicles.

China National Nuclear Corporation (CNNC)

1A Yuetan Biejie, Dongkou

Beijing CN-100037

Tel: +86 (10) 851-2211, 831-0319

Fax: +86 (10) 851-2393

Formerly the Ministry of Nuclear Industry, the CNNC's export and import activities have been co-ordinated through the Xinshidai Group. Export and import activities include all dual-use aspects of nuclear energy and related equipment and systems. It has established trading relationships with over one hundred companies in some forty nations. CNNC has a large number of subordinate or affiliated organisations, including the Atomic Research Centre, Tarim Pendi, Xinjiang Province, and the State Committee for Nuclear Safety, Beijing.

China National Nuclear Corporation

Wuhan Guangming Instrument Factory

9 Yejin Dadao, Qingshanqu

Wuhan, Hubei 430080

Tel: +86 (27) 686-3971

Fax: +86 (27) 686-5616

China National Nuclear Corporation

State-Owned Factory Number 523

2 Haibei Lu, Ganjingziqu

PO Box 21

Dalian, Liaoning 116032

Tel: +86 (411) 667-2412

Import/Export Corporation 667-2279

High Science and Technology Company 667-2541

Fax: +86 (411) 667-1898

China National Nuclear Industry General Corporation

1 Nan Sanxiang

Sanlihe, Beijing 100044

Tel: +86 (10) 851-2211

China National Nuclear Industry Corporation

Suzhou Valve Factory

679 Renmin Lu

Suzhou, Jiangsu 215001

Tel: +86 (512) 727-3655, 727-2587, 727-4877, 727-2707

Fax: +86 (512) 727-2587, 727-2707

CNNC Factory 720

PO Box 901, Xijian, Nanchang, Jiangxi 330101

CNNC Nuclear Fuel Complex Lanzou

CNNC Plant 404, (Atomic Complex)

38A PO Box 08, Lanzhou, Gansu

Lanzhou 730061

CNNC Plant 202 (Nuclear Materials) Baotou

PO Box 456, CN-014035

Baotou City, Inner Mongolia

CNNC Plant 276, Xileng

Xifeng County, Guizhou 551107

CNNC Ybin Nuclear Fuel Element Plant (Plant 812)

PO Box 273, Ybin City, Sichuan

China National Shipbuilding Equipment and Materials Corporation

5 Yuetan Beijie

Beijing 100861

Tel: +86 (10) 857-2999

Fax: +86 (10) 857-2999, 858-1558

China National South Aeroengine and Machinery Group

China National South Aeroengine Company

PO Box 211

Dongjiaduan, Zhuzhou

Changsha, Hunan 412002

Tel: +86 (733) 855-1330, 855-1331

Tel: +86 (733) 822-4220, 858-2220

Established in 1951, CNSAMG employs some 15,000 workers, including over 4,000 engineers and technicians for aeroengine R&D and production for medium and small sized aircraft. Facilities cover an area of 6 square kilometres with fixed assets of nearly 2.2 billion Rmb yuan. It has over 4,000 major pieces of manufacturing and testing equipment, including over 100 NC systems some of which are 4-axis by 5-axis NC milling machines, and various CAD/CAM systems. Testing equipments includes electron scanning microscopes. Currently a subsidiary of AVIC, it has developed and produced industrial gas-turbine, turbo-prop aeroengines, and small to medium aeroengines (5 series and 26 types) for military and civilian applications, including the WJ6 and WJ9 aeroengines, WZ8 turboshaft, WS11 and HS6K piston aeroengines, and the WJ6G1A, WJ6G2A, WJ6G4A, and WJ6G4B gas-turbines for industrial and marine applications. China's first aeroengines were developed at this facility over four decades ago. Formerly the Zhuzhou Aeroengine Company, it has also absorbed the Zhuzhou Aeroengine Design and Research Institute. It has representative offices in Shenzhen and Beijing, a factory in Changsha and ten enterprises in Shenzhen and other coastal areas. Aeroengine manufacturing technology for export includes piston prop, turboprop, and turboshaft systems. Combustion turbines used to power hovermarine landing barges of the PLAN, and further R&D is planned for this application area. Future R&D/technology transfer emphasis on advanced optical, electronic and mechanical products such as energy-efficient technologies, medical apparatus, industrial metres and instruments, automatic monitoring systems, etc. Particular electronics R&D for the development of multiple (16 layer and up) flexible printed circuit boards. Intends to undertake foreign technology transfer to revamp mechanical hands on current generation machine tools into intelligent manipulators and, ultimately, complete robots to match China's anticipated requirements. Has co-operated with 20 other Chinese enterprises and institutions to create the China National South Aeroengine and Machinery Group with an expanded product manufacturing and R&D base. Has produced aeroengine components and parts for Allison, Lycoming, and Garrett companies of the US, and Turbomeca of France.

China National Space Administration and the

China Aerospace Industry Corporation (CAIC) (former Ministry of Aerospace Industry)

PO Box 848

8 Fucheng Road

Beijing 100830

Tel: +86 (10) 6837-0811

Fax: +86 (10) 6837-0849

Production and R&D of dual-use space systems, and the provision of space policy and international liaison and Cupertino; reports to the Ministry of Science and Technology and COSTIND. Manages national civil space programme. Total number of employees in subsidiary firms and research organisations is over 200,000. Related organisations include:

· CALT First Academy, adjacent to PLAAF Nanyuan Airfield, Beijing:

-1st Planning Department, Beijing Institute of Astronautical Systems Engineering (Liquid Systems)

- 4th Planning Department, Beijing Institute of Electro-mechanical Systems Engineering (Solid systems engineering)

- 11th Research Institute, Beijing Institute of Liquid Rocket Engines (Beijing

Fengyuan Machinery Company)

- 12th Research Institute, Beijing Institute of Automatic Control - engaged in

R&D of missile related guidance technology including GPS

- 13th Research Institute, Beijing Institute of Control Devices - R&D of

inertial instrument technology such as gyros and accelerometers

- 14th Research Institute, Beijing Special Electromechanical Institute - warhead development in close co-ordination with the CNNC's CAEP

- 15th Research Institute, Beijing Institute of Special Engineering Machinery

- ground equipment for missile launch control

- 702nd Research Institute, Beijing Institute of Structure and Environmental

Engineering

- 703rd Research Institute, Beijing Research Institute of Materials and Technology

- 704th Research Institute, Beijing Research Institute of Telemetry - GPS development since 1991

- 200 Factory, Guanghua Radio Factory - Control system electronic components.

- 210 Factory, Beijing Jianhua Electronic - instrument factory for inertial components; closely associated with the 13th Research Institute, Nanyuan

- 211 Factory, Capital Space Machinery Corporation, General Assembly Plant,

Nanyuan - liquid systems

- 230 Factory, Beijing Xinghua Machinery

- 7107 Factory, Baoji - inertial devices (associated with 230 Factory)

- Beijing Experimental Factory, Muxidi - electronic hydrolic servo

systems

- Beijing Wanyuan Sealing Factory

· 2nd Academy Changfeng Electromechanical Technology Design Academy, Beijing - R&D and production of air and missile defence, ASAT, and associated radar systems:

- 2nd Planning Department, Beijing Institute of Electronic Systems Engineering - air/missile defence and ASAT systems engineering

- 17th Research Institute, Beijing Institute of Control and Electronic Technology

- 23rd Research Institute, Beijing Institute of Radio Measurement - R&D of radar systems

- 25th Research Institute, Beijing Institute of Remote Sensing Equipment -

radar and optical terminal guidance systems

- 203rd Research Institute, Beijing Institute of Radio Metrology and Measurement

- 204th Research Institute, Beijing Institute of Computer Applications and Simulation Technology - computer software and simulation technology

- 206th Research Institute, Beijing Institute of Mechanical Equipment - launchers and ground equipment

- 207th Research Institute, Beijing Institute of Environmental Features - target characteristics; microwave, optical, and laser environmental engineering; special facilities include a microwave anechoic chamber and laser laboratory

- 208th Research Institute, Information Center - publisher of the Second Academy's journal "Systems Engineering and Electronics Technology"

- 210th Research Institute, Xian Changfeng Electromechanical Institute - electromechanical systems engineering R&D on telemetry, dynamic strength and heat/cold testing

- 706th Research Institute - computer development

- 112 Factory, Xinfeng Machinery Factory - SAM production

- 123 Factory - air defence missile warheads

- 283 Factory - ground control systems

- 284 Factory, Xinjian Power Machinery Plant - control systems manufacturing.

- 786 Factory - radar and guidance systems

· 3rd Academy, Haiying Academy of Eletromechanical Technology: R&D and production of anti-ship and land attack cruise missiles and associated systems; established in 1961:

- 3rd Design Department, Beijing Institute of Electromechanical Engineering - anti-ship/land attack cruise missile design and systems engineering

- 31st Research Institute, Power Machinery Research Institute - cruise missile

propulsion systems; established in 1957

- 33rd Research Institute, Beijing Institute of Automated Control Equipment -

cruise missile autopilot and inertial naval systems

- 35th Research Institute, Huahang Institute of Radio Measurement, Beijing

- 310th Research Institute - data collection, analysis, and dissemination on foreign cruise missile systems

- 8357th Research Institute, Jinhang Institute of Computing Technology, Tianjin - control systems and on-board computer systems

- 8358th Research Institute, Jinhang Institute of Technical Guidance, Tianjin - publishes journal "Infrared and Laser Engineering"

- 8359th Research Institute, Beijing Special Machinery (Tezhong Jixie) Institute - cruise missile launch equipment and Russian technology transfer

- 119 Factory - autopilot systems

- 159 Factory, Xinghang Electromechanical Factory, Yungang.

- 239 Factory, Beijing Hangxing Machine Building Factory - cruise missile assembly

- 558 Factory - autopilot and altimeter production

- 781 Factory - terminal guidance system plant

- 786 Factory - fround tracking radar factory

- 5013 Factory - warhead Plant

· CALT 4th Academy: R&D and production of solid fuelled motors for ballistic missiles and satellite kick motors; founded in 1965, it also has the corporate name of the Hexi Chemical Machinery Company:

- 41st Research Institute, Shaanxi Institute of Power Machinery - solid rocket motor design

- 42nd Research Institute, Red Star Chemical Institute of Hubei

- 43rd Research Institute, Shaanxi Institute of Non-Metallic Materials and Technology - filament winding machines

- 44th Research Institute, Shaanxi Institute of Electronics

- 46th Research Institute, Hexi

- 47th Research Xiangyang, Chemical Machinery Corporation

- 7414 Factory, Shaanxi Hongchuan Machinery Factory

- 7416 Factory, Shaanxi Changhong Chemical Plant -manufacturing

- 7422 Factory, Xi'an Space Lanling Factory

- 7424 Factory

- Shaanxi Xianfeng Institute of Machinery

- Hexi Corporation:

* Synthetic Chemical Engineering Institute

* Inner Mongolia Hongguang Machinery Plant

* Inner Mongolia Hongxia Chemical Plant

* Inner Mongolia Power Machinery Plant.

· 5th Academy Chinese Academy of Space technology (CAST): R&D and production of communications, space-based ISR systems, and weather satellites. Laying groundwork for future navigation satellites; data relay satellites; space shuttle and space station concepts; current capability to produce 4-6 satellites per year:

- 501st Research Institute, Beijing Institute of Spacecraft Systems Engineering - satellite systems engineering

- 502nd Research Institute, Beijing Institute of Control Engineering - R&D of attitude control systems

- 503rd Research Institute, Beijing Institute of Satellite Information Engineering - R&D of satellite applications and communications technology, ground segments of FY-2 weather satellite, GPS receivers, indigenous effort to develop satellite navigation systems

- 504th Research Institute, Xi'an Institute of Space Radio Engineering - R&D of space communications, remote sensing, spacecraft TT&C, space electronic systems (eg. TWTs, CCD cameras, microwave data-links, antennas)

- 508th Research Institute, Beijing Institute of Space Machinery and Electronic Engineering - R&D of remotesensing and recoverable vehicle technology

- 510th Research Institute, Lanzhou Institute of Physics - optical cryogenics, microgravity, and radiation effects

- 511th Research Institute, Beijing Institute of Environmental Test Engineering

- 513rd Research Institute, Yantai Telemetry Technology Institute

- 529 Factory, Beijing Orient Scientific Instrument Factory - final

assembly of satellite systems

· 8th Academy Shanghai Academy of Space Technology: created in 1961, employs 30,000 personnel in 17 institutes and 11 factories. SAST supplies the first two stages of the LM-2, LM-3, and LM-4 launchers and Fengyun Fy-1 and FY-2 meteorological satellites:

- Shanghai Institute of Electromechanical Engineering (8th Design Department)

- Shanghai Institute of Satellite Engineering (509th Research Institute) - major satellite systems engineering and environmental testing centre that produces FY series of satellites

- Shanghai Precision Machinery Research Institute

- Shanghai Institute of Power Machinery

- Shanghai Institute of Radio Equipment (802nd Institute) - SAM guidance and fuzes

- Shanghai Institute of Precision Instruments, Xinyue Institute - guidance systems

- Shanghai Institute of Electronic Communications Equipment Engineering

- Shanghai Institute of Electromechanical Equipment

- Shanghai Xinfeng Chemical Engineering Institute - propellant technology

- Shanghai Institute of S&T Information for Electromechanical Engineering

- Shanghai Institute of Precision Metrology and Test Engineering

- Shanghai Xinwei Electronic Equipment Research Institute (809th Institute) - launch vehicle and tactical weapons computer automation launch control systems design and satellite control computers

- Shanghai Xinli Institute of Power Equipment - engines and motors

- Shanghai Institute of Space Power Sources

- Shanghai Spaceflight Automatic Control Equipment Research Institute

- Shanghai Institute of Spaceflight Telemetry, Control, and Telecommunications

Engineering

- Shanghai Institute of Video and Telecommunications Equipment Engineering

- Shanghai Spaceflight Architecture Design Institute

- Shanghai Xinzhonghua Machinery Factory

- Shanghai Xinjiang Machinery Factory

- Shanghai Xinxin Machinery Factory

- Shanghai Xinhua Radio Factory

- Shanghai Xinya Radio Factory

- Shanghai Xinguang Telecommunications Factory

- Shanghai Xinyu Power Supply Factory

- Shanghai Xinli Machinery Factory

- Shanghai Broadcast Equipment Factory

- Shanghai Instrument Factory

- Shanghai Wire Communication Factory

· 9th Academy China Academy of Space Electronics Technology: development of specialised computers, integrated circuits, and other microelectronic devices in support of CASC projects:

- 771st Research Institute, Lishan Microelectronics Institute - missile and

satellite-related computers and integrated circuits.

China North Industries (NORINCO) Group

44 Sanlihe Lu

Beijing 100823

Tel: +86 (10) 859-4210, 859-4230

Fax: +86 (10) 859-4232

China North Industries Corporation (NORINCO)

7A Yuetan Nanjie

Beijing 100045

Tel: +86 (10) 851-2244, 853-3695

Fax: +86 (10) 853-3236

Formed in the early 1980s, the NORINCO Group is China's largest defence industry manufacturer and exporter, and is subordinate to the State Council. It controls 157 large and medium sized factories, over 30 research institutes, over 200 sales companies and branches, and over 60 subsidiaries abroad, and has a total workforce of some 800,000 personnel, including 160,000 engineers, scientists and technicians. It specifically develops and produces an array of defence products that include MBTs, APVs, self-propelled artillery systems, 155 mm gun/howitzer, multi-tube rocket launchers, anti-tank missiles, mortars, anti-aircraft systems, assorted small arms and ammunition, fire control systems, sighting and aiming devices, high-powered engines, military engineering vehicles, and a full range of nuclear, biological and chemical warfare equipment. NORINCO multiple rocket systems are produced in diameters from 107mm to 350mm, with ranges from 10 to 100 kilometres. Products are produced to both NATO and ex-Warsaw Pact standards. NORINCO is reportedly willing to research and market innovative weapons that do not have international approval such as laser weapons designed to blind individuals. Subsidiaries include:

China North Industries Dalian Corporation

54 Renmin Lu

Dalian, Liaoning

116001

Tel: +86 (411) 263-6690, 263-8649, 263-4082, 263-4914

Fax: +86 (411) 280-8520

China North Industries Guangzhou Corporation

NORINCO Bldg.

376 Huanshi Dong Lu

Guangzhou, Guangdong

510060

Tel: +86 (20) 386-2888

Fax: +86 (20) 384-2173, 384-2393

China North Industries Hainan Corporation

North Bldg.

31 Haixiu Dadao

Haikou, Hainan 570206

Tel: +86 (898) 677-2239, 677-3430

Fax: +86 (898) 677-2427

China North Industries Shanghai Corporation

Rm. 2104, Beifang Bldg.

999 Zhongshan Nan Yi Lu

Shanghai 200023

Tel: +86 (21) 6472-9006, 6472-5581

Fax: +86 (21) 6472-0164

China North Industries Shenzhen Corporation

North Bldg.

Shennan Zhong Lu

Shenzhen, Guangdong

518033

Tel: +86 (755) 336-5432, 336-4220

Import/Export Dept. No. 1 336-4221

Storage and Transport Dept. 336-4223

Fax: +86 (755) 336-5429/4

China North Industries Zhanjiang Corporation

6 Haibin Er Lu, Xiashan

Zhanjiang, Guangdong

524005

Tel: +86 (759) 226-0999

Fax: +86 (759) 226-0989, 226-0979

China North Industry Tianjin Corporation

67 Zijinshan Lu, Hexiqu

Tianjin, 300061

Tel: +86 (22) 835-9885, 835-9623

Fax: +86 (22) 835-9796

China North Industrial Xiamen Corporation

North Bldg., 6 Lianhua Nan Lu

Xiamen, Fujian 361009

Tel: +86 (592) 513-3800

Fax: +86 (592) 513-3804

China North Vehicles Research Institute

4 Huaishulin, Fengtai

Beijing 100072

Tel: +86 (10) 381-8433, 381-8140

Fax: +86 (10) 381-9450

This military industry research institute undertakes the R&D of special purpose vehicles, and specialises in the design, testing, inspection, structural analysis and strength testing of wheeled and tracked AFV vehicles. Particular areas of research include dynamic force, gear-drive equipment, electric control, liquid control electricity and computer software. It has 1,700 staff, including over 400 engineers and researchers. Organisations includes 40 labs with 2,000 sets of equipment, instruments and meters. Foreign technology recently acquired for test data collecting systems, field testing systems, CAD systems, high-power driving testing platforms, road simulated testing platforms, 3-D fire control testing platforms, thermal cable shrinking cable protection line, electric control equipment and machine tools. Interested in R&D on special vehicles, gas-oil hangers, and compact heat exchangers and intercoolers. It has sponsored seminars on tanks and AFVs attended by experts from 10 nations, and staged a new heavy weaponry show that was attended by 340 experts from over 100 nations and regions.

China Nuclear Energy Industry Corporation

PO Box 822, A1 Yuetanbeijie

Beijing 100037

Tel: +86 (10) 833-7827, 835-0384

Fax: +86 (10) 851-2393

China Nuclear Energy Industry Guangzhou Company

Room 803/804

Qiaotong Tower, Guanghua Bldg.

82 Tianhe Bei Lu

Guangzhou, Guangdong 510620

or

Number 3 Yongfu Road

Guangzhou, Guangdong 510070

Tel: +86 (20) 753-0586, 753-0880, 776-6697

Fax: +86 (20) 757-3647, 775-5106

China Nuclear Energy Industry Shenzhen Company

Room 604, Nuclear Electricity Building

Shennan Road, Shenzen

Guangdong 518031

Tel: +86 (755) 332-6675

Fax: +86 (755) 336-4795

Established on February 25, 1980, the CNEIC exports uranium, nuclear power systems and equipment and instrumentation, isotopes, radiation detection systems, nuclear medical equipment, and nuclear radioimmunity apparatus. It imports systems and technology for nuclear power plant systems and nuclear R&D. It is responsible for developing international nuclear joint-ventures and the transportation of nuclear fuel abroad.

China Nuclear Equipment and Materials Corporation

12 Chegongzhuang Street, Western District

Beijing 100037

Tel: +86 (10) 832-3344

Fax: +86 (10) 835-5172

This corporation has 14 subsidiaries in Beijing, Shanghai, Guangzhou, Shenzhen, Zhengzhou, Wuhan, Chengdu, Xi'an, Shenyang, Tianjin, and Harbin. It trades in a full range of nuclear engineering and power products and equipment, and provides technical consultation and information services.

China Nuclear Industry Number 5 Installation Company

Longshenglu, Shihua,

Shanghai CN-200450

China Nuclear Industry 24th Construction Company

PO Box 554, Chengdu, Sichuan 610003

China Nuclear Industry 25th Construction Company

PO Box 8, Hengyang, Hunan 421001

China Nuclear Instrumentation and Equipment Corporation

Bldg. 18, Hepingli Qiqu

Dongchengqu, Beijing 100013

Tel: +86 (10) 421-1718

Factories Management Department 421-2645

Development Management Department 421-0920

Fax: +86 (10) 421-1718

With over 2,000 technical personnel, this corporation is involved with various aspects of nuclear technology R&D in such areas as nuclear physics, fire control systems, nuclear power, nuclear medicine, and instrumentation. Affiliated organisations include the Xi'an Nuclear Instrument Factory and the Suzhou Optical Instrument Factory.

China Nuclear Power Research Institute

PO Box 291, Chengdu, Sichuan

China Ordnance Materials Corporation

SW Company

3 Xiejiawan Zhengjie

Chongqing, Sichuan 630050

Tel: +86 (811) 881-0441, 881-7565

Fax: +86 (811) 881-8246

China Ping He Import and Export Corporation

5A Taipinghu Dongli

Xichengqu, Beijing 100031

Tel: +86 (10) 601-3344

Fax: +86 (10) 601-5687

Provides military electronics technology for the PLA General Staff's General Equipment Division.

China PLA Factory 3522

49 Sanwei Lu, Nankaiqu

Tianjin 300100

Tel: +86 (22) 731-7234, 731-3522

Fax: +86 (22) 730-1477

Produces defence metal products and plastics.

China PLA Factory 7322

Baiyao Chang, Jiuyanqiaowai

Chengdu, Sichuan 610061

Tel: +86 (28) 555-1553, 555-2629

Produces defence metal products.

China PLA Factory 7438, Branch Number One

289 Hongshan Lu

Wulumuqi, Xinjiang 830002

Tel: +86 (991) 282-5340, 282-5497

Produces defence transportation equipment.

China PLA General Logistics Department

Military Supplies Technical Institute

PO Box 326

Beijing CN-100000

Tel: +86 (10) 525-2531 ext. 28

China Precision Engineering Institute for Aircraft Industry

Fourth Department

PO Box 2559-8

5 Nanyuan Dong Lu

Beijing 100076

Tel: +86 (10) 838-3390, 838-3385, 838-0521

Fax: +86 (10) 838-3387

CPEI, as a member of the AVIC, is responsible for the R&D and production of airborne equipment, precision processing machines, precision measuring machines, and automated production lines. It employs 1,200 staff, of which 120 are professors and senior engineers. Organisation is comprised of seven R&D labs, three workshops, and five development and production sites. The "Key Laboratory of National Defence Science and Technology on Ultra-Precision Machining" is located at CPEI. R&D areas include co-ordinate measuring machines, inertial navigation tests and simulation, and digital metrology instruments and precision components. CPEI houses a Service Station for Microtecnica of Italy and has co-operated with firms from Russia, US, etc. Has developed CAD/CAM systems for aerospace applications.

China Precision Machinery Import and Export Corporation (CPMIEC)

22 Fucheng Lu

PO Box 129

Beijing 100036

Tel: +86 (10) 842-9126, 837-1961

Fax: +86 (10) 842-9117, 842-9112

Established in 1980 and reporting to the CAIC and associated with the Xinshidai Group, CPMIEC's product areas include missile systems (surface-to-surface, surface-to-air, air-to-ship, ship-to-ship, and shore-to-ship), rocket propellants, systems engineering, space hardware, satellite techniques and products, precision machinery, automatic control, electronics and electrical apparatus, optics, radars, antennas, instrumentation, vehicles, broadcasting and communication equipment, magnetic materials, chemicals, and computer software development. CPMIEC has reportedly negotiated for the CAIC for all military export systems except ballistic missiles. CPMIEC accepts orders for processing to customer specifications, engages in joint R&D, co-production, technology transfer, contracts for the design and construction of industrial and civil products, etc. CPMIEC and its sister corporation, CGWIC, have been the past targets of US government trade sanctions resulting from their perceived violations of the MTCR. Associated manufacturing plants include:

· Shanghai Bureau of Space Xinjiang Machine Plant

· Shanghai Bureau of Space New China Machine Plant

· Ministry of Aerospace Industry First, Second and Third Departments.

China Precision Machinery Import and Export

Fuzhou Corporation

3/F, 242 Bayiqi Bei Lu

Fuzhou, Fujian 350001

Tel: +86 (591) 325-0162, 753-3003

China Precision Machinery Import and Export

Shenzhen Corporation

18/F, International Trading Building

Shenzhen, Guangdong 518014

Tel: +86 (755) 225-1659, 222-1391

Fax: +86 (755) 222-1387, 225-1270

China Rainbow International (Development) Corporation

PO Box 4517

Building Number B2

Yuetan Xijie

Beijing 100045

Tel: +86 (10) 853-7254, 851-2373, 853-7927, 851-2211

Fax: +86 (10) 857-0257

Under the authority of the CNNC and the Ministry of Foreign Trade and Economic Co-operation, China Rainbow has branches in the Middle East and other regions. Activity areas include dual-use nuclear power applications, R&D and a nuclear export project management and contractor role. Defence activities include nuclear weapons and propulsion applications and R&D, as well as civilian nuclear power development. It retains 'strong customer references with the Air Force Institute and the Military Foundation'.

China Research Institute of Aero-Accessories

(Subsidiary of China National Airborne Equipment Corporation)

PO Box 219

2 Long Zhong Road

Xiangfan, Hubei 441052

Tel: +86 (710) 356-4029, 356-0172

Fax: +86 (710) 356-4882

Founded in 1961, this institute develops airborne equipment such as aircraft wheel brakes, electronics, control and hydraulic systems, fuel systems, etc. It employs some 1,900 personnel and has over 1,500 sets of major equipment.

China Shipbuilding Industry Corporation, Wuhan State

Shipbuilding Special Equipment Factory

23 Zhong Bei Lu, Wuchang

Wuhan, Hubei 430071

Tel: +86 (27) 782-2364, 782-9757, 782-9759

Fax: +86 (27) 782-2364

China Shipbuilding Trading Company Limited

10 Yuetan Bei Xiaojie

Beijing 100861

Tel: Shipping Dept. +86 (10) 831-2562

Technical Introduction 831-7623

Technical Services 832-8194

Foreign Affairs Office 831-7618

Fax: +86 (10) 831-3380

A subsidiary of China State Shipbuilding Corporation that undertakes the export of naval ships and craft and marine equipment, the construction and control of all shipyards, shipbuilding and related marine equipment facilities, and the import of naval materials and expertise. Import and export activities controlled by the Xinshidai Group. Products include submarines, guided missile destroyers and frigates, anti-submarine vessels, guided missile boats, landing craft, pontoon bridges, rapid-fire naval guns, torpedoes, mines, anti-ship missiles and electronic systems.

China Ship Research and Development Academy

2a Shuangquanbao, Deshengmenwai

Beijing 100085

Tel: +86 (10) 201-6644

Fax: +86 (10) 201-6789

Has R&D organisations in Beijing, Shanghai, Tianjin, Dalian, Qingdao, Lianyungang, Hangzhou, Xiamen, Foshan, Shenzhen, Haikou, Nanjing, Wuhan, Zhengzhou, Harbin, Chongqing, Luoyang, Jiujiang, Nanchang and Handan. This academy has over 10,000 technical and engineering personnel and has extensive national R&D facilities related to all aspects of shipbuilding and ocean engineering. Conducts R&D and product development in the areas of special crafts (air-cushion vehicles, hydrofoils, ground-effect machines, small waterline plane craft), submarines and submersibles, diving robots, diving apparatus, surface warships, power generating installations (nuclear, internal combustion, steam turbines, boilers, gas turbines, generators, and various combined systems), new and special materials for shipbuilding, high-precision gyros and stable platforms, computer systems, wire and wireless communications and navigation systems, analogue simulation systems, noise reduction engineering, fibre optics and hydro-acoustics engineering, CAD/CAM, etc. Civilian/dual-use activity areas include oceanic construction, offshore oil platforms, energy production engineering (thermal, hydraulic, wind, tidal, solar and nuclear), photoelectric machinery, fish shoal detection systems, etc.

China Ship Sciences Research Centre

PO Box 116, Wuxi

Jiangsu 214082

Tel: +86 (510) 668-012, 602-131

Under the China State Shipbuilding Corporation, this centre has over 900 technical personnel and 400 workers, occupies an area of 56 hectares and has 18 large and medium sized R&D installations such as water pools, wind and water ducts for fluid dynamics experiments. R&D areas include fluid dynamics, structural dynamics, vibration, noise, impact, anti-explosion, instrumentation, and computational mathematics. Has developed atmospheric diving suits, energy efficient device for retrieving energy from propeller wakes, Dongfang series of high-speed boats, cavitation propeller systems, double duct propellers, ship's propellers software, Z-type counter-rotation propulsion device, intelligent sensors, hydrofoils, and submersible devices and structures.

China Southwest Electronic Equipment Research Institute

Xicha Dianzi

Chengdu, Sichuan 610036

Tel: +86 (28) 784-233, 784-259

Fax: +86 (28) 784-610

Offices and branches located in Beijing, Shenzhen and Xiamen. An affiliate of the China Electronics Corporation, this institute has 1,700 staff, including 920 engineers and technicians. CSEERI occupies an area of 220,000 square meters, with building floor space totalling 130,000 square meters, and with total assets of over 100 million Rmb yuan. It operates twelve research offices, four trial production workshops, one machine repair workshop, and has over 1000 pieces of mechanical processing equipment, over 70 computer workstations, and over 1,200 testing instruments and meters. Product and R&D emphasis is on airborne, marine and ground electronic systems and components, wide microwave devices, wide band antennas, receiving equipment, transmitting equipment, information processing and terminal display equipment, computer software, low/medium/high voltage power sources, satellite ground receiving systems, and telecommunications systems.

China Southwest Institute of Applied Magnetics

PO Box 105, Mianyang

Sichuan 621000

Tel: +86 (816) 22-194, 22-196

Fax: +86 (816) 24-936

Institute staff includes over 600 researchers and other personnel. Primary R&D areas are microwave ferrite materials, microwave ferrite single crystal and multiple crystal devices, rare earth permanent magnets and applications, magnetic recording and soft magnetic ferrite materials and devices, and relate special equipment and products. Areas of R&D and foreign technology transfer interest include special magnetic devices such as multifunctional permanent magnetic measuring meters, microcomputer temperature controllers, fast magnetic charge and de-magnetic machines.

China Space Technology Research Institute

31 Baishiqiao Road

Beijing 100081

Tel: +86 (10) 837-8356, 837-8379

Fax: +86 (10) 837-9449, 837-8237

As a space technology R&D centre this institute has developed and launched over 30 satellites over the past two decades. It main R&D areas are national space programme policy development, spacecraft, and satellite ground systems. It has developed telecommunications, meteorological, and remote sensing satellites, and satellite ground systems such as measuring systems, tracing systems, data collection and transmission systems, satellite earth stations, satellite TV stations, weather information receiving systems, and software for processing and correcting land survey satellite retrieval films. Other products include power frequency modulating receivers, special antennas, non-interrupted power sources, precision controlled power sources for motors, composite materials processing technology, magnetic environment testing technology, laser holograms and anti-riot bullets. It has 14 sub-institutes and factories in Beijing, Shanghai, Xi'an, Lanzhou, Shandong, Shanxi and Guangdong.

China State Bureau of Quality and Technical Supervision

Beijing

Website: http://www.csbts.cn.net/english/index.htm

China State Shipbuilding Corporation

5 Yuetan Beijie

Beijing 100861

Tel: +86 (10) 831-8833, 832-3245

Under COSTIND, this is a national industrial complex, operating some 27 large and medium sized shipyards, 67 manufacturers of maritime equipment, some 40 R&D and technical training organisations, and has a total workforce of 300,000 people, including 80,000 engineers and technicians. Newer designs include the "BeiXing" all aluminium and alloy hydrofoil that operates between Hong Kong and Macao. A new high-speed hydrofoil craft being developed at Huangpu Shipyard is a priority project. Major shipyards located at Jiangnan, Hudong, Guangzhou, Xinggang, Dalian, Shanghai, Behai and Zhonghua. Currently, CSSC claims that 80 percent of its product output value is civilian, and 50 percent of its tonnage is exported. Ships up to 150,000 tons constructed (Chinese designed cargo ship built at Dalian Shipyard). Technical Cupertino agreements have been signed with Japanese shipbuilding organisations on ship design, shipbuilding technology, production organisation, management, technical innovation, new product development, etc. CSSC has, over the past decade, organised over 2,000 persons to go abroad for technical training and investigations, and some 1,000 foreign experts to provide lectures in China. CSSC has cumulative foreign investments of over US$200 million, and some 150 direct foreign investment projects. Over one-third of CSSC affiliated enterprises have initiated foreign joint-ventures with firms from Hong Kong, US, Singapore, Thailand, Belgium, United Arab Emirates, etc. Total of over 68 foreign joint enterprises by early 1990s.

China State Shipbuilding Corporation

Qingdao Beihai Shipyard

Yanerdao, Nanqu

Qingdao, Shandong 266071

Tel: +86 (532) 386-2255, 581-4263

Fax: +86 (532) 581-4466

China State Shipbuilding Corporation

Qiuxin Shipyard

132 Jichang Lu

Shanghai 200011

Tel: +86 (21) 6326-1551, 6377-5305

Business Department 6328-9830

Fax: +86 (21) 6377-2100

China Telecommunications Broadcast

Satellite Corporation

2 Xitucheng Lu

Haidianqu, Beijing 100088

Tel: +86 (10) 202-6997

Fax: +86 (10) 202-9505, 202-6997

China Xiaofeng Technology and Equipment Corporation

8 Gongjian Lane, Dianmen Xidajie

Xichengqu, Beijing 100009

Tel: +86 (10) 401-6668

Fax: +86 (10) 401-5088

Subordinate to COSTIND, with an advanced technology specialisation in computers, testing equipment and robotics. Similar import and export co-ordinating role to that of the Xinshidai Group.

China Xingping Aircraft Wheel Corporation

PO Box 48

Xingping, Shaanxi 71306

Tel: +86 (9201) 22-701

Fax: +86 (9201) 22-745

This firm is a manufacturer of aircraft wheels, brakes, and hydraulic and pneumatic braking components.

China Xinshidai (New Era) Corporation (Group)

40 Xie Zuo Hu Tong

Dongcheng Qu

Beijing 100007

Tel: +86 (10) 401-7383

Fax: +86 (10) 401-5088

Subordinate to COSTIND, Xinshidai has a generalised advanced technology export co-ordination role, with the provision of support activities such as international scientific Co-operation, exchanges and exhibitions. It specialises in tactical missile export sales for systems such as the M-9 ballistic missile, and co-ordinates and manages the import and export activities of the so-called "Xinshidai Group" (China National Aerotechnology Import and Export Corporation, China National Electronics Imports and Exports Corporation, NORINCO, CNNC, CPMIEC, and the China State Shipbuilding Corporation).

China Xinxing Corporation (Group)

Wanshouluxijie, Beijing

Tel: +86 (10) 851-6688

Fax: +86 (10) 801-4669

Provides PLA logistical requirements for food, clothing, construction materials, fuels, vehicles, boats. Traditionally has reported to the PLA General Logistics Department, but recent reports indicate it may have been privatised.

China Xinxing Corporation

Tianjin Branch

40 Youyi Lu, Hexiqu

Tianjin 300241

Tel: +86 (22) 835-8742

Import/Export Dept. 835-9022

Enterprises Dept. 835-9074

Fax: +86 (22) 835-8742

China Xinxing Dalian Import and Export Company

Zhongshan Hotel, 9 Wuwu Lu

Zhongshanqu

Dalian, Liaoning 116001

Tel: +86 (411) 263-0590

Fax: +86 (411) 280-3231

China Xinxing Guangzhou Import and Export Company

3/F, Xinxing Hotel

1115 Jiefang Bei Lu

Guangzhou, Guangdong 510400

Tel: +86 (20) 668-3288

Fax: +86 (20) 666-2406

China Xinxing Hainan Import and Export Company

Xinxing Bldg., Jichang Xi Lu

Haikou, Hainan 570006

Tel: +86 (898) 679-1949, 679-5845

Fax: +86 (898) 679-4050

China Xinxing Harbin Import and Export Company

Bldg. 102, Dideli Xiaoqu

Daoliqu, Harbin

Heilongjiang 150016

Tel: +86 (451) 451-3172

Fax: +86 (451) 451-3172

China Xinxing Qingdao Import and Export Company

7 Zhengyangguan Lu

Qingdao, Shandong 266002

Tel: +86 (532) 286-2259

Fax: +86 (532) 287-9623

China Xinxing Shanghai Import and Export Corporation

15 Dong Jiangwan Lu

Shanghai 200081

Tel: +86 (21) 6540-5208

Fax: +86 (21) 6324-8964

China Xinxing Xiamen Import and Export Company

11/F, Zhenxing Bldg.

Hubin Bei Lu

Xiamen, Fujian 361012

Tel: +86 (592) 505-2126, 505-2128

Fax: +86 (592) 505-2127

China Zhihua Corporation Ltd.

Beijing

Reporting to the Communications Department of the PLA General Staff, and specialising in communications, computer, image processing and navigation equipment.

China Zhongyuan Engineering Corporation

China Nuclear Industry Materials and Equipment Huadong Corporation

444 Beijing donglu

CN-200450 Shanghai

China Zhongyuan Foreign Construction Company

43 Fucheng Lu

Haidianqu, Beijing 100037

Tel: +86 (10) 841-6615

Chinese Academy of Sciences

Microelectronics Research and Development Centre

Qujiahuozi, Deshengmenwai

Beijing 100029

Tel: +86 (10) 202-1601, 202-1133

Fax: +86 (10) 202-1601

Chinese Academy of Sciences

Computer Centre

PO Box 2719

Zhongguancun, Beijing 100080

Tel: +86 (10) 256-0928

Business Dept. 255-4023

Technology Development 254-2294

Fax: +86 (10) 254-2285

Chinese Academy of Space Sciences

Haidianqu, Beijing

Chinese Academy of Space Technology (CAST)

PO Box 2417

31 Bai Shi Qiao Lu

Haidian, Beijing 100081

Tel: +86 (10) 6837-9439

Fax: +86 (10) 6837-8237

Reporting to the CAIC, CAST co-ordinates national space technology research and development and other related activities. Design, development and manufacture of spacecraft and test equipment. Primary R&D centre with 14 research institutes and factories, and over 10,000 staff. Designs and manufactures various spacecraft and ground equipment in such areas as structural systems and sub-systems, thermal control, attitude control, orbit control, onboard electronics and telecommunications, remote sensing, sounding rockets, satellite recovery, computers, simulators, spacecraft tests, etc. Has developed advanced ground control, telemetry and communications systems and satellite ground stations. All Chinese geosynchronous orbit communications satellites have been developed by CAST. Has developed recoverable satellites used for microgravity and other experiments, with Long March 2 as the launcher. Developed first Chinese polar orbit meteorological satellite successfully launched on September 7, 1988. Future R&D focusing on related advanced space applications.

Chinese Aeronautics and Astronautics Establishment

China Institute of Aeronautic Systems Engineering

PO Box 761-3

2 Beiyuan, Andingmenwai

Chaoyang District

Beijing 100012

Tel: +86 (10) 6423-2625

Fax: +86 (10) 6423-2693

Founded in 1982, the CAA is one of the most advanced aeronautics R&D establishments in China, with a staff of 10,000 (including 2,000 senior researchers), and fixed assets of over 555 million Rmb yuan. Primary R&D areas include aerodynamics, aircraft structure, propulsion, aerospace materials and manufacturing, flight techniques, aerial computers/avionics and software, air traffic control, inertial navigation, etc. Some 20 affiliated institutes and branches are located across China. Various co-operative activities have been conducted with NASA, FFA, ONERA, DPVLR, etc. Has developed the "Beijing Air Science and Technology Economic Development Zone" (research park) for foreign investors/researchers interested in computer hardware and software, precision casting and forging, man-made titanium-cobalt joints, numerically controlled machines, etc. The affiliated China Institute of Aeronautic Systems Engineering has 130 specialist employees, and has undertaken research on an economic development strategy for the aerospace sector in China, aerospace market research, planning aero-weapons series, future project study concepts (eg. 'Countermeasure to New Technology Revolution', 'Computer Simulation Technology'), etc., for the PLA, AVIC and CAAC. It has also developed software for such areas as CAM and real-time production processing.

Chinese Helicopter Research and Development Institute

PO Box 825

Jingdezhen, Jiangxi 333001

Tel: +86 (798) 844-1841

Fax: +86 (798) 844-3202

This AVIC affiliated R&D centre was founded in 1969 to undertake helicopter design, research and test, and is the largest and most advanced facility of this kind in China. It has over 2,200 employees, including 1,300 engineers and technicians, and has 1,500 major pieces of equipment in a facility of 110,000 square metres. Specific R&D activities include helicopter general configuration aerodynamics, structural design, dynamic and static strength, hydraulics, electronics, airborne systems, software development, etc. The institute has a mainframe computer, RISC work station, vehicle test tower, and various simulators for static, dynamic, fatigue and system tests. It has established research ties with organisations in the US, UK, Germany, Russia, France, Italy etc.

Chinese Mechanical Engineering Society

Sanline Road, Beijing 100823

Nuclear R&D.

Chinese Nuclear Society

PO Box 2125

Beijing 100822

Tel: +86 (10) 801-2211, 801-4343

Chinese Society of Aeronautics and Astronautics

9 Xiaoguan Dong Jie

Chaoyangqu Beijing 100029

Tel: +86 (10) 491-6328

Fax: +86 (10) 491-4643

Professional society that co-ordinates national aerospace research through such activities as seminars.

Chinese Society of Astronautics

PO Box 838

2 Yuetan Bei Xiaojie

Beijing 100830

Tel: +86 (10) 689-4602

Fax: +86 (10) 6837-0849

Organises national/international Co-operation and exchanges in aerospace-related technical and academic areas, and the organisation of annual symposia, technical conferences, and workshops across China through local branches. Its professional committees include the areas of tactical missile system engineering, quality and reliability, robotics, computer applications, space medicine, materials technology, structural strength and environmental engineering, measurement and tests, launch engineering and ground equipment, recovery and re-entry, telemetry, solid rocket propulsion, liquid rocket propulsion, space electronics, space power, space remote sensing, space control technology, aerodynamics and flight mechanics, spacecraft manufacturing technology, spacecraft inertial devices, spacecraft measurement and controls, spacecraft systems engineering, and launch vehicle systems.

Chinese Society of Space Research

Beijing, 100080

Founded in September 1980, this non-governmental society has a membership of over 2,000 and is attached to the Chinese Association for Science and Technology, and its activities are closely related to those of CAS establishments. It promotes international scientific exchanges, provides technical advice to Chinese government organisations, presents awards for scientific excellence, publishes technical journal, and encourages the popularisation of space science amongst the general public. Technical committees include the areas of space astronomy (Purple Mountain Observatory), space physics (Centre for Space Science and Research), space chemistry and geology (Guyang Institute of Geology and Chemistry), space life sciences (Institute of Space Medical Engineering), space materials sciences (Shanghai Institute of Ceramics), space mechanical technology (Changchun Institute of Optics Mechanics), space exploration (Centre for Space Science and Applied Research and the Beijing Institute of Space Machine and Electricity), space remote-sensing (Shanghai Institute of Technical Physics), and the National Society of Microgravity Science and Application (Institute of Mechanics).

Chongqing Huachuan Machinery Plant

Shiling, Longquanyi

Chengdu, Sichuan 610106

Tel: +86 (28) 447-022

A subsidiary of NORINCO, this plant employs 3,100 people, occupies an area of 408,260 square meters, with building floor space totalling 165,270 square meters, has 3,540 pieces of equipment (75 foreign systems, 44 microprocessor-based systems, and 22 pieces of precision equipment), net fixed value assets of 37.71 million yuan, and working capital of 30.47 million yuan. It specialises in the production of magnetic motors and auto-electrical appliances. Products include magnetic motors for motorcycles (largest production capacity in China), chemicals, micro starting motors, igniting coils, fan motors, etc.

Chongqing Shipbuilding Industry Corporation

21 Jianxin Dong Lu

Chongqing, Sichuan 630020

Tel: +86 (811) 785-0441, 785-2584

Fax: +86 (811) 785-0208, 785-3148

Chongqing Space Industry Corporation

207 Shixiao Lu

Chongqing, Sichuan 630039

Tel: +86 (811) 881-2440, 881-3911

Fax: +86 (811) 881-2454

Chuanjiang Instrument Plant

PO Box 8, Guanghan

Sichuan 618300

Tel: +86 (8233) 220-091

R&D and production of aeroengine tachometers, direction indicators, synchronizers, permanent magnet materials and elements, micromotors, etc.

Chuanxi Machinery Plant

18 Kangzang Road, Ya'an

Sichuan 625000

Tel: +86 (835) 2970

Fax: +86 (835) 3207

and

Sichuang Shuhang Isostatic Pressing Technology

and Equipment Development Company

15 Bldg., Guangrong Xiaoqu, Jinniu

Chengdu, Sichuan 610031

Tel: +86 (28) 763-727

Under AVIC, these two interrelated plants are manufacturers of aviation ground checkout gear and related specialised technology. Plant area totals 145,000 square meters, including 95,000 square meters for production. It has fixed assets worth over 25 million Rmb yuan, and some 2,210 employees, of which over 27 percent are engineers and technicians. Products include various isostatic presses, hydraulic gears, ultrahigh pressure valves and parts, and neodymium-iron-boron rare-earth magnets. Materials worked with include refractory materials, hard alloys, moly-B, electric ceramics, and graphite carbon.

Civil Aviation Administration of China (CAAC)

155 Dongsi Street West

Beijing 100710

Tel: +86 (10) 401-2233x8333

Fax: +86 (10) 401-6918

CAAC is the central government civil aviation regulatory body that has overall responsibility for airline safety, airworthiness, certification, control of segments of the ATC systems, new route approvals, airline expansions, key personnel decisions, etc. It also operates the China Aviation Supplies Corporation (CASC). Subsidiaries include:

Civil Aviation Administration of China

Flying College (Flight Institute)

Shuangliu Airport

Chengshuang Gong Lu

Guanghan, Sichuan 618307

The CAAC Flying College, located near a small town 25 miles north of Chengdu in southwestern China, provides pilot and air traffic controller training for Chinese civil airports and regional and international airlines. Established in 1955, the college has a fleet of 90 aircraft including 30 Socata TB-20 Trinidads, 20 Aerospatiale TB-200 trainers, 5 Piper Cheyenne 3A advanced trainers, 3 Y-7-100 transports, 5 Bell JetRanger 206B3 helicopters, 3 Boeing 737-200s, and thirty Y-5 biplanes (Soviet Antonov An-2 derivatives). The eight million square meter campus features a 3,000 meter runway, and extensive aircraft simulator (CAE Electronics Boeing 737-300, CAE Cheyenne 3A full flight simulators) and language training facilities are also present. Branch offices are located in central China at Xin Jin, Sui Ning, Luoyang, and Mian Yang. Some 95 percent of China's airline pilots are graduates of this programme. By mid-1990s had trained some 10,000 pilots, mechanics, air traffic controllers, and dispatchers with a staff of 2,700 including 300 classroom teachers and 200 flight instructors.

Civil Aviation Institute of China

Tianjin

Provides CAAC sponsored college-level training for airline managers, plus ATC and maintenance, engineering and technician training.

CAAC Number One Research Institute

A31, Guangximenbeili

Chaoyang District

Beijing 100028

Tel: +86 (10) 422-2220

Fax: +86 (10) 427-6962

CAAC Number Two Research Institute

Number 27, 4th Section of South Renmin Road

Chengdu, Sichuan 610041

Tel: +86 (28) 555-1923

Fax: +86 (28) 555-4583

Chuanxi Machinery Plant

18 Kangzang Road, Ya'an

Sichuan 625000

Tel: +86 (835) 2970

Fax: +86 (835) 3207

and

Sichuang Shuhang Isostatic Pressing Technology

and Equipment Development Company

15 Bldg., Guangrong Xiaoqu, Jinniu

Chengdu, Sichuan 610031

Tel: +86 (28) 763-727

Under the AVIC, these two interrelated plants are manufacturers of aviation ground checkout gear and related specialised technology. Plant area totals 145,000 square meters, including 95,000 square meters for production. It has fixed assets worth 25.3 million Rmb yuan, and 2,210 employees, of which over 27 percent are engineers and technicians. Products include various isostatic presses, hydraulic gears, ultrahigh pressure valves and parts, and neodymium-iron-boron rare-earth magnets. Materials worked with include refractory materials, hard alloys, moly-B, electric ceramics, and graphite carbon.

Commission of Science, Technology and Industry for National Defence (COSTIND)

PO Box 1092

1 Aimin Jie, Xicheng Qu

Beijing 100034

Tel: +86 (10) 673-8080

or Dongguanfang, di'anmenxidajie

Beijing

00034

Tel: +86 (10) 6605-8958

Fax: +86 (10) 6667-38111

Direct subsidiaries include:

· China Satellite Launch and Telemetry, Tracking and Control General Company

· Base 21 Lop Nor Nuclear Site

· Base 20 Jiuquan Satellite Launch Centre

· Base 25 Taiyuan Satellite Launch Centre

· Base 27 Xichang Satellite Launch Centre

· Base 26 Xi'an Satellite Monitor and Control Centre (located at Weinan, 60 km. north of Xi'an)

· Base 31 Baicheng Conventional Weapons Testing Centre

COSTIND has operational control of China's space launch and ground control infrastructure and strategic and conventional weapons test sites, in addition to the broad defence technology R&D and commercialisation role discussed in the report text.

Businesses recently operated by the PLA, and now likely spun-off to the commercial sector due to the recent reforms organised by COSTIND, include:

· *1201 Haidian, Beijing - printing*

· *1202 Dongcheng, Beijing - printing*

· *2207 Xicheng, Beijing - printing*

· *2230 Xicheng, Beijing - Printing*

· *2672 Wu'an, Hebei - iron-steel*

· *3301 Shenyang, Liaoning - instrumentation for vehicles*

· *3302 Shijazhuang, Hebi - machinery*

· *3303 Wuchang, Hubei - electronics*

· *3305 Dunhua, Jilin - chemical/metals*

· *3326 Guiding, Guizhou - opto-electronics*

· *3401 Xuanwu, Beijing - vehicles*

· *3403 Jiulongpo, Chongquing - vehicle parts*

· *3501 Chaoyang, Beijing - textiles*

· *3503 Nanjing, Jiangsu - textiles/dyes*

· 3506 Wuhan, Hubei - textiles

· 3507 Xi'an, Shaanxi - software

· 3508 Chengdu, Sichuan - textiles

· 3509 Hanchuan, Hubei - textiles

· 3511 Xi'an, Shaanxi - textiles

· 3512 Lanzhou, Ganshu - textiles/leather

· 3513 Xi'an, Shaanxi - textiles/dies

· 3515 Lilohe, Henan - leather

· 3516 Hongkou, Shanghai - leather

· 3517 Yueyang, Hunan - chemicals

· 3522 Nankai, Tianjin - plastics

· 3529 Hebei, Tianjin - rubber

· 3530 Kianyang, Shaanxi - textiles

· 3531 Wenxi, Shanxi - leather

· 3533 Jiangjin, Sichuan - textiles

· 3534 Wenxi, Shanxi - personal equipment

· 3535 Guiding, Guizhou - textiles

· 3536 Mianyang, Sichuan - textiles

· 3538 Xi'an, Shaanxi - leather

· 3543 Jiangxian, Shanxi - textiles

· 3546 Xi'an, Shaanxi - textiles

· 3602 Danjiangkou, Hubei - metal products

· 3608 Fangshan, Beijing - vehicles

· 37712 (Troop), Shanghai - electrical equipment

· 4306 Shanghai - optical machinery

· 4309 Dalian, Liaoning - instruments

· 4810 Dalian, Liaoning - machinery

· 4820 Zhijiang, Hubei - transport equipment

· 5311 Nanjin, Jiangsu - instruments

· 5701 Chengdu, Sichuan - electrical equipment

· 5706 Ganjinzi, Dalian, Liaoning - transport equipment

· 5707 Zunyi, Guizhou - electrical equipment

· 5708 Guiyang, Guizhou - chemicals/metal

· 5712 Changsa, Hunan - chemicals

· 5715 Luoyang, Henan - instruments

· 5716 Jincheng, Shanxi - electrical equipment

· 5719 Pengxian, Sichuan - electrical equipment

· 5720 Wuhu, Anhui - laboratory equipment

· 6107 Sipinglu, Shanghai - electrical equipment

· 6411 Shijiazhuang, Hebei - machinery

· 6443 Hebei, Tianjin - energy plant

· 6444 Xinglong, Hebei - transport equipment

· 6465 Nanyang, Henan - metallurgy

· 6901 Chaoyang, Beijing - transport equipment

· 6902 Nanjing, Jiangsu - electrical equipment

· 6904 Taiyuan, Shanxi - computers/equipment

· 6905 Chongquing, Sicuhan - electrical equipment

· 6906 Yueyang, Hunan - light metalwork

· 6913 Tianchui, Gansu - instrumentation

· 6914 Dujuiyan, Sichuan - telecommunications equipment

· 7007 Tangshan, Hebei - cement

· 7019 Xingcheng, Liaoning - pipes/tubes

· 7219 Lanzhou, Ganshu - printing

· 7312 Shijinshan, Beijing - petroleum

· 7315 Longhualu, Shanghai - cables/wires

· 7318 Nanping, Fujian - medical equipment

· 7319 Lenghuitan, Hunan - rubber

· 7321 Kunming, Yunan - electronics/machinery

· 7322 Chengdu, Sichuan - metalwork

· 7407 Tiexe, Shenyang - transport equipment

· *7410 Chaohu, Anhui - mechanical engineering*

· *7418 Dalian, Liaoning - transport equipment*

· *7420 Shijiazhuang, Hebei - transport equipment*

· *7421 Fengtai, Beijing - mechanical engineering*

· *7426 Quijang, Shanghai - ceramics*

· *7427 Minhou, Fujian - transport equipment*

· *7428 Fuzhou, Fujian - metalwork*

· *7429 Chenzhou, Hunan - transport equipment*

· *7435 Wuhan, Hubei - transport equipment*

· *7437 Wuwei, Gansu - light engineering*

· *7438 Urumqi, Xinjiang - transport equipment*

· *7449 Shehong, Sichuan - transport equipment*

· *7451 Chenzhou, Hunan - mechanical engineering*

· *7452 Tianshui, Gansu - transport equipment*

· *7454 Urumqi, Xinjiang - food products*

· *7814 Dalian, Liaoning - mechanical engineering*

· *7815 Ningbo, Zhejiang - mechanical engineering*

· *9074 Xuchang, Henan - chemicals*

· *9078 Xinxiang, Hunan - chemicals*

· *9510 Yunmeng, Hubei - chemicals*

· *9719 Dalian, Liaoning - chemicals*

· *9733 Penglai, Shandong - chemicals*

· *9734 Lianyungang, Jiangsu - paper/cellulose*

· *9735 Kaifeng, Henan - chemicals*

· *9746 Putian, Fujian - papers*

· *9846 Dachang,Shanghai - chemicals*

Dalian Haiyang Chemical Technology Company

Dalian, Liaoning

Produces solid propellants for missiles and space launchers.

Dalian Marine Propeller Plant

PO Box 9, Dalian

Liaoning 116021

Tel: +86 (411) 331-697

Fax: +86 (411) 322-204

Under the China State Shipbuilding Corporation, this specialist propeller and bronze alloy casting plant has 264 staff and 64 technical personnel, and occupies an area of 44,000 square meters, including 17,800 square meters of building floor space. Produces propellers for up to 150,000 dwt ships. R&D areas include nickel-free high manganese aluminium bronze materials, low-voltage and marginless low-voltage casting technology for large propellers, CAD/CAM applications, etc. Developed China's first "VCCC" marine propeller, in addition to side skew propellers, adjustable pitch propellers, and side propellers. Imported propeller casting technology from NPC of Japan in 1985.

Dalian Shipbuilding Industry Corporation (Group)

16 Zhuqing Jie

Dalian, Liaoning 116001

Tel: +86 (411) 263-3247, 263-9633

Fax: +86 (411) 280-4594

Dalian Shipyard

1 Yanhai Street, Xigang

Dalian, Liaoning 116002

Tel: +86 (411) 263-9811, 263-4054

Fax: +86 (411) 263-3461

Under the China State Shipbuilding Corporation, this shipyard has over 10,400 workers, including 2,228 technical personnel, occupies an area of some 420,000 square metres, has three shipbuilding slipways for ships of up to 80,000 tons, two slipways for 15,000 dwt ships, a bulk goods dock of 1,475 metres, 22 cranes, one 100 ton revolving floating crane, large hydraulic presses and rollers, and widespread computer-controlled systems, including management information systems and NC machines, etc. Organisation includes a shipbuilding technology research institute, and an explosives processing research institute. Has built China's first ocean-going supply ships for dry and liquid supplies, and has build shuttle oil tankers up to 118,000 tons. R&D from the explosive processing research unit has been applied to projects in the shipbuilding, nuclear, space, electronics and other sectors.

Dalian Xingguang Lifting Magnet Works of

Air Army PLA China

Xinghai Station Number One

Shahekouqu

Dalian, Liaoning 116023

Tel: +86 (411) 469-1760, 464-7011

Fax: +86 (411) 467-2549

Department of Radioisotope

PO Box 275 Ext. 12

Beijing 102413

Tel: +86 (10) 935-7312, 935-7743

Fax: +86 (10) 935-7195

This Institute and its agencies conducts R&D in the field of nuclear physics, radiochemistry, nuclear chemical engineering, reactor engineering, accelerator engineering, nuclear instrumentation, preparation of isotopes, environmental and radiation protection, radiometrology and military applications.

Dingyuan Motor Vehicle Proving Ground

Dingyuan, Anhui 233210

Tel: +86 (552) 249-838

Fax: +86 (552) 249-839

Under the PLA General Logistics Department, this facility includes testing and proving grounds and roads, such as reliability, cross country and high-speed testing roads, that total some 33.8 kilometres in length. Designated a national motor vehicles testing and proving unit by the China National Automotive Industry Corporation.

Dongfang Instrument Factory

PO Box 57

Nanzheng, Shaanxi 723100

Tel: +86 (916) 512-471

Fax: +86 (916) 512-471

Manufactures flight altitude instruments, sensors, autopilots, turn indicators, precision inertial devices, accelerometers, servomotors, and torque meters.

Donghai Shipyard

2601 Yixian Road

Shanghai 200940

Tel: +86 (21) 667-1008

Fax: +86 (21) 667-2153

A subsidiary of the China State Shipbuilding Corporation, this shipyard has 2,500 workers and 600 technical personnel, occupies 320,000 square meters, owns a 2,000 ton vertical ship lifting machine, a 1,000 ton class dock, four 25 ton overhead cranes, 570 meters of docks, and various other equipment systems. Has repaired up to 220,000 ton oil tankers. Products include dredgers, firefighting ships, light container ships, marine machinery, hydraulic motors and steering wheels. Has established a service centre with a Japanese firm.

East China Research Institute

of Electronic Engineering

PO Box 9023, Hefei

Anhui 230031

Tel: +86 (551) 564-433, 564-063

Fax: +86 (551) 562-998

Institute focussed on the R&D and production of technologies related to anti-air-raid information radars, air traffic control radars, and meteorological radars. It employs 1,700 personnel, of which 880 are engineers and technicians. It covers 190,000 square meters, with building floor space totalling 98,000 square meters. It is equipped with some 1,380 pieces of testing instruments and meters and over 730 pieces of metal cutting and special processing equipment. The institute has ten research departments, one general electronics sub-institute (operating three research departments on ATC, machinery numerical control, and high-energy and nuclear physics), and four trial production and processing departments. It is a national leader for the production of 3-D radar (JY-14 medium to long range system), low coverage radar (JY-9 low altitude search radar), meteorological radar, digital signal processors, data processors, ship navigation systems, millimetre-wave communications systems, and ASIC design and application. Since the late 1970s has developed the JY series of radars for export (JY-8 3-D radar, JY-9 low coverage radar, JY-10 radar information processing station, JY-14 medium/long-range 3-D radar, and the JY-16 meteorological radar). Produces integrated automatic air defence systems and air defence information radars. Produced equipment for the Beijing synchronised accelerator and Electron-Positron Collider. Other R&D interests include fibre optics telecommunications systems, signal processing, data processing, high-resolution monitors, high-power equipment and special elements in high-energy and nuclear physics, electronic sea charts and electronic maps, machinery numerical control systems, and special capacitors and pulse formation networks.

Economic Research Centre of AVIC

Number 67 Jiaodaokou Nandajie

Beijing 100712

Tel: +86 (10) 6401-3647

Fax: +86 (10) 6401-3647

This is an AVIC economic think tank founded in 1983.

Eighth Research Institute of Nuclear Industry

PO Box 800-218

Shanghai 210800

Tel: +86 (21) 953-0856, 952-9484

Fax: +86 (21) 952-8755

ERINT is an institute for special materials under the Nuclear Fuels Bureau of CNNC, and is located in the eastern side of Chengqiao Bridge outside of the east gate of Jiading County of Shanghai. It has an occupied area of 77,000 square metres with a floor space of 25,000 square metres, and fixed assets of 13.19 million Rmb yuan. It has more than 1,100 pieces of specialised equipment including a Dupont thermal analytical system of the CR-G type, a microcontrol glass fibre winding machine of the WBC-60 type, porosimetres of the Carlo Erba200 series, laser dust counters of type 236, and filtering efficiency analysers. It has some 528 staff including 207 scientists and engineers. Key facilities include an engineering technical centre for purification filters, and research offices for magnetic materials, powder products, metal dust, electronic pastes and compounded materials. Products include thin diamond blades and a thin cube boron carbide blade used for notch cutting on metal membranes and metallic oxidised resistors. ERINT is prepared to set up joint factories to produce filter equipment, filter membrane materials, melt spun NdFeB powder and NdFeB bonded magnets, etc.

Fenyang Hydraulic General Factory

PO Box 180

Guiyang, Guizhou 550009

Tel: +86 (851) 383-3315, 383-3316, 383-4622

Fax: +86 (851) 383-4633

Founded in 1967, this is a specialised AVIC plant engaged in the development and manufacture of aircraft hydraulic, pneumatic and electromagnetic accessories such as fuel solenoid valves and switches for various aeroengines.. It covers an area of 252,000 square metres, has over 2,000 employees of which some 538 are engineers and technicians, and has fixed assets of over 138 million Rmb yuan. I has GB/T19001-ISO9000 quality certification. It production capabilities include advanced domestic and foreign manufacturing and test equipment such as NC and CAD/CAM systems.

First Research Institute of the

Ministry of Public Security

1 Capital Gym Nan Lu

Beijing 100044

Tel: +86 (10) 841-8807

Fax: +86 (10) 841-8801

Flight Automatic Control Research Institute

PO Box 41

Xi'an, Shaanxi 710065

Tel: +86 (29) 821-8600

Fax: +86 (29) 822-4543

This AVIC institute was established in 1960, and conducts R&D on flight control and inertial navigation, aerospace vehicle control, guidance and simulation, as well as small-batch production of such systems and the related training of technical professionals. It has undertaken recent research breakthroughs in 4-redundancy fly-by-wire systems, inertial/GPS combined navigation systems, and 4-redundancy combined servo actuators.

Free Electron Laser Lab

Institute of High Energy Physics

Beijing

Tel: +86 (10) 255-4583, 256-3339, 256-4240

Fujian Shipbuilding Industry Corporation

Gaoqiao Bldg.

Wuyi Zhong Lu

Fuzhou, Fujian 350005

Tel: +86 (591) 755-0055

Manager's Office 753-4198

Fax: +86 (591) 753-3210

Fujiang Machinery Factory

PO Box 203, Mian Yang

Sichuan 621000

Tel: +86 (816) 22-612 ext. 360

Under the Ministry of Information Industry, this plant undertakes the R&D and production of radar components and satellite receiving systems.

Gansu Huayuan Enterprise Corporation

A1 Lanzhou, Gansu

Tel: +86 (931) 417-584, Lanzhou 567 special line, ext. 4622

Fax: +86 (931) 417-584

Branch offices are located in Shanghai, Shijiazhuang, Shanhaiguan, Beijing and Shenzhen. Dual-use activities conducted under CNNC, while "GHEC has actively opened up the market of civilian products at the same time as it ensures the fulfilment of the task of military production and scientific research". The GHEC site in the Hexi Corridor of west China occupies an area totalling some 1,225 square kilometres, with nearly 10,000 workers, a quarter of which are technicians. R&D emphasises nuclear power development and the transfer of military technologies to civilian products. Products have included the Pu-238 Xelminator, cigarette detoxicant card, tritium products, versed radioactive sources, intelligent automatic fire alarms, multi-functional ray absorbers, nuclear lamps, uranium reagent serial products, and nuclear radiation application techniques.

Ganzhou Tungsten and Molybdenum Materials Plant

88 Xijiao Lu, Ganzhou

Nanchang, Jiangxi 341000

Tel: +86 (791) 224-177, 225-177

Fax: +86 (791) 223-850

Gas Turbine Establishment of China

PO Box 305

Jiangyou, Sichuan 621703

Tel: +86 (816) 322-2512, 322-2567

Fax: +86 (816) 322-2804

For the past two decades, this AVIC affiliated R&D establishment has focused on new gas-turbine aeroengine development, and is the nation's major centre for the R&D, testing, design and production support for such propulsion systems in China. It has over 1,000 professional staff, some ten R&D departments and workshops, and some 10,000 major pieces of equipment. A high-altitude simulation test bed was developed in 1995.

General Establishment of Space Sciences and Application (GESSA) Chinese Academy of Sciences

PO Box 8701, Zhong Guan Cun

Beijing 100080

Tel: +86 (10) 255-9794

Fax: +86 (10) 254-2551

Space science and applications, space utilisations.

Guangdong Lingnan Industrial Corporation

Shenzhen Company

Bldg. 3, 18 Hongling Road

Shenzhen, Guangdong 518028

Tel: +86 (755) 226-9365, 226-5603

Under the Guangdong Provincial National Defence Science and Technology Office, this firm has a total of 30,000 square meters of facilities, and fixed assets worth over 30 million reminbi Rmb yuan.

Guangdong Nuclear Power General Service Company

15-16F, Nuclear Power Bldg.

Shennan Zhong Lu

Shenzhen, Guangdong 518047

Tel: +86 (755) 334-4769, 336-6566

Fax: +86 (755) 335-5206

Guangdong Shipbuilding Industry

Import and Export Corporation

60 Guang Da Lu

Guangzhou, Guangdong 510030

Tel: +86 (20) 336-8218, 334-1796

General Manager's Office 334-1607

Import/Export Dept. 334-1951

Fax: +86 (20) 333-3480

Guangzhou Communications Research Institute

Number 381 Xingan Road

Guangzhou, Guangdong 510310

Tel: +86 (20) 445-1773

Fax: +86 (20) 445-1053

Directly subordinated to the Ministry of Information Industry, this institute is engaged in the R&D of mobile communications systems and networks, including digital multi-path radio relay systems, "telemelring, telecontrol and telecomms (T3) systems", communications terminals, power supplies, antennas, security systems, piezoelectric devices, electronics ceramics and crystals.

Guangzhou Institute of Laser Technology Applications

79 Taipingsha, Beijing Nan Lu

Guangzhou, Guangdong 510115

Tel: +86 (20) 339-5738, 332-8184

Guangzhou Military Medical University Number One

Affiliated Nanfang Hospital Huiqiao Bldg.

Tonghe, Guangzhou, Guangdong 510515

Tel: +86 (20) 770-5656

Guangzhou Shipbuilding Company Ltd.

67 Panfu Lu

Guangzhou, Guangdong 510180

Tel: +86 (20) 334-8988, 333-4745, 331-7641, 332-6639

Fax: +86 (20) 335-0517

Guangzhou Shipyard International Company Ltd.

2 Fangcun Dadao, Baihedong

Guangzhou, Guangdong 510382

Tel: +86 (20) 889-1712

Fax: +86 (20) 889-1575, 889-6341

Machine Engineering Division

126 Gexin Lu 510250

Tel: +86 (20) 431-8160, 444-1743

Fax: +86 (20) 442-7454

The largest modern shipbuilder in South China, this shipyard has over 8,000 workers, including 1,600 technical personnel, occupies an area of 700,000 square meters and 1,600 meters of coastline, has three shipbuilding slipways each capable of accommodating 10,000 ton ships, and one ship repair dock. Has an annual shipbuilding capacity of 150,000 tons, and can repair 50 ships. Produces foils for Boeing hyfrofoil craft. Manufactures containers, boilers, pressure containers, large steel structures, port machinery, lifting machinery, reinforced glass fibre life boats, machinery and equipment, etc. Builds oil tankers, cargo carriers, bulk goods carriers, container ships, passenger ships, etc.

Guangzhou Titanium Dioxide Factory

Shixi, Dongpu, Tianhequ

Guangzhou, Guangdong 510660

Tel: +86 (20) 227-0952

Foreign joint venture.

Guiyang Aviation Hydraulic Parts Plant

PO Box 99, Guiyang

Guizhou 550202

Tel: +86 (851) 232-3371, 232-3101 ext. 751

Fax: +86 (851) 232-3411 ext. 293

Under the AVIC, the plant is a specialist manufacturer of hydraulic pumps and motors for aviation, spacecraft and navigation systems. It has been commended by the State Council, Central Military Commission, PLAAF, PLAN and AVIC. Of its 23,000 employees, 400 are engineers. It has some 500 metal cutting machines, 50 of which are imported from the UK, US and Germany. Facilities cover 300,000 square meters, with building floor space totalling 140,000 square meters. Facilities include: a research and design institute; technology institute; quality inspection and control centre; physico-chemical testing; linear value measuring; product property testing; and medium sized analogue and digital computers applied to system analogue, and CAD/CAM. With a focus on new product development, it has developed 30 product types in 12 series for military aircraft, satellites, missiles and ships. Specific military products have included the JB-27 and JB-34 hydraulic pumps used on the J-7 fighter, and the PV3-205 aviation hydraulic pump manufactured under US and British patents, and which reportedly raised China to international calibre in this technical area. Hydraulic pump and motor designs for long-range missiles, telecommunications, meteorological, scientific and education satellites have passed ground test and flight examination for design, advanced structure, and quality requirements for space flight. It has an annual production capacity of 20,000 hydraulic pumps and motors. It has GB/T19001-ISO9001 quality certification. Since 1996 it has been listed on the Shanghai Stock Market.

Guiyang Huafeng Electrical Appliance General Factory

PO Box 184

Guiyang, Guizhou 550009

Tel: +86 (851) 383-3195, 384-7685

Fax: +86 (851) 383-3379

Founded in 1970, this AVIC affiliate specialises in aero micro and special motors and electrical connectors, and has developed some 300 different types. Its GE-16 and J20XX-10 sensors are widely used in aerospace systems. The firm has 2,600 employees including 363 enginers, 500 major pieces of equipment, and assets totalling some 160 million Rmb yuan. It has research institutes for motors and electrical appliances, 10 sub-factories, and a test centre.

Guizhou Aero-Industry Corporation

Shanghai Material Business Department

Bldg. 1, 1001 Chang'an Lu

Shanghai 200070

Tel: +86 (21) 6317-3172

Fax: +86 (21) 6317-1805

Guizhou Aircraft (Aviation) Industrial Corporation

China National Guizhou Aviation Industry Group

Longyan Aircraft Manufacturing Factory

PO Box 38

35 Shixi Road

Anshun, Guizhou 561000

Tel: +86 (851) 385-1027, 385-4523, 385-1747 (853) 222-228, 223-619, 223-429, 224-401

Fax: +86 (851) 385-1236, 385-6007

and

Beijing Office

2(A) Xidawang Road

Tel: +86 (10) 501-5544 ext. 2110

and

Shenzhen Office

Rooms 701-705 East Apartment of Futian Bldg.

Shennanzhong Road

Tel: +86 (755) 335-3835

and

Shanghai Office

Rooms 1411-1412, Lianhe Bldg.

2650 Zhongshanbei Road

Tel: +86 (21) 257-0738

Incorporated in the mid-1960s, GAIC consists of 62 enterprises and institutions with a registered capital base of over 1.5 billion Rmb yuan and fixed assets of 1.2 billion Rmb yuan. It has 70,000 employees, including 18,000 engineers, economists and technicians. Workshop area totals 140,000 square meters, with some 30,000 pieces of equipment including 2000 imported machines, 1,000 forging presses, and 700 "sophisticated, large or heavy machines". For over the past two decades it has researched, developed and manufactured military aircraft, trainers, aeroengines and aircraft gears, electrical devices, accesories, etc., including a two-seater training fighter manufactured for export. Production aircraft have included the JJ-7 trainer, and single-seat J-7 fighter, in addition to two series of turbojet aeroengines. It also manufactures rocket launchers. The associated Longyan plant manufactures aircraft landing gearing, hydraulic accessories, fuel and oxegen system accessories, etc., and has some 1,500 employees, and ISO9000 certification.

Guizhou Honghu Machinery Factory

PO Box 102, Pingba

Guizhou 561104

Tel: +86 (851) 385-1780

Fax: +86 (851) 385-1882, 385-6144

This AVIC firm produces aeroengine hot section components, and has staff of 1,000 professionals, of whom 400 are engineers. It has over 1,300 major pieces of equipment, including 100 advanced systems such as NC machines, and plasma spraying and arc welding robots.

Guizhou Honglin Machinery Factory

PO Box 177

Guiyang, Guizhou 550009

Tel: +86 (851) 383-3448

Fax: +86 (851) 383-3453

Founded in 1966, this AVIC plant is a specialised manufacturer of aviation (aeroengine and afterburner) fuel pumps and regulators. The firm is ISP9000 certified, has 160,000 square metres of manufacturing area, some 1,200 pieces of major equipment, and 3,000 employees, over 800 of which are engineers and technicians. It has an affiliated Military Product Research Institute

Guizhou Liyang Aero Engine Corporation

PO Box 5

Pingba, Guizhou 561102

Tel: +86 (851) 385-1779, (8631) 688-041, 688-050

Fax: +86 (851) 385-4220, 385-2528, (8631) 688-104, 688-091

Established in 1970, this is a key AVIC R&D and manufacturing centr for turbjets such as the WP7 and WP13 in 16 versions, including the current WP13B used for the J-8IIM fighter. It has some 13,000 employees, including 1,750 senior technical staff, has an area of 800,000 square metres, and some 6,000 major pieces of manufacturing and measuring equipment. The firm has three specialised factories and a research and design institute, and various advance systems such as NC machining centre, CAD/CAM systens, 3-axis measuring machines, etc. Since 1995 it has ISO9001 certification.

Guizhou Xinyi Machinery Plant

PO Box 204

Manchang, Pingba, Guizhou

Tel: +86 (851) 385-1672, 385-1935, 385-3334, 385-3212

Fax: +86 (851) 385-3151, 385-4767

Founded in 1965, this specialised precision casting centre of aeroengine turbine blades and vanes for military aircraft reports to AVIC, and is a unique national facility. It covers an area of over 1 million square meters, with building floor space totalling 200,000 square meters, and with fixed assets and annual sales of over 100 Rmb million yuan. Since 1986, annual output value and profits have grown at a rate of over 10 percent. The 3,700 employees include 900 engineers and technicians. Among its 2,000 pieces of equipment are 600 metal cutting machines, 30 forging presses, 70 precision casting facilities, a large forging workshop with 1,600 to 4,000 ton hot die forging crank presses, ceramic core production line, a 630 ton hydraulic spiral hammer and a 630 ton horizontal forging press, a 200 kilogramme foundry alloy vacuum furnace, a 25 kilogramme three-compartment semi-continuous vacuum electrical furnace, a 12,000 square meter precision casting workshop, specialised machining, electric and pulsed-electrolytic processing, chemical processing, special hot and surface treatment workshops, technical research centre, physico-chemical testing centre and a measuring centre. During the end of 1989 to 1990 it co-operated with the No. 621 Research Institute of the former Ministry of Aerospace Industry and the PLAAF to develop aeroengine directional set turbine blades with China-made D24 high-temperature alloy, which have since went on to mass production, and reportedly resulted in increased aeroengine performance, life, safety and reliability. Precision blade casting technology is a particular area of R&D focus in high-temperature alloys and titanium alloy vanes. It has a complete titanium alloy vane production line from forging to final machining. Since 1986 has developed blades and nozzle cascades for various marine gas-turbine engines used by the China National Shipbuilding Corporation. It international joint venture activities have included the development of CFM56-7 aeroengine vanes with SNECMA of France. It has ISO9000 quality certification.

Hangjiang Machinery Plant

PO Box 162

Xiangfan, Hubei 441002

Tel: +86 (710) 224-233

Fax: +86 (710) 224-613

This firm designs and produces aircrew and sea survival equipment, air supply masks, anti-shock trousers and impact protection helmets.

Hanguang Electronics Plant

PO Box 40, Xiaogan

Hubei 432100

Tel: +86 (712) 223-404, 224-404, 224-746

Fax: +86 (712) 223-424

Major producer and research centre for electronic vacuum devices and high-power klystrons. It occupies 200,000 square meters, with building floor space totalling 110,000 square meters, and fixed assets of over 75 million Rmb yuan. It has 1,100 pieces of equipment and employs 2,000 people, with 500 of these being engineers and technicians. Organisation includes eight subsidiaries, two design institutes, one measuring centre and two joint companies. R&D and product areas include microwave electron tubes, vacuum electronic devices, power electronics, functional ceramics, photoelectric sources, high power transmission wave guides, cryogenic cooling devices, and applications of microwaves and power sources. Applications areas include linear accelerators, infrared probes, radar systems, and telecommunications. Klystrons produced in two major series: pulsed wave and continuous wave, with complete range of wave bands (annual production of 500 units). Produced the 34 megawatt klystron and 822 pulse modulator for the Beijing Electron-Positron Collider. Klystrons used for Taconic navigation and beyond-the-horizon communications are in mass production. Other R&D and foreign technology transfer areas of interest include high-energy pulse magnetic control tubes and continuous wave magnetic control tubes, overvoltage and overcurrent protection discharge devices for communications lines, high-power microwave transmission wave guide elements, piezoelectric ceramics and transformers, cryogenic cooling systems, and pulsed modulating power sources.

Hangwei General Medical Systems Co. Ltd. (GE Hangwei Corporation)

50 Yongdinglu

Haidian, Beijing 100854

Tel: +86 (10) 838-7701, 465-1584

Fax: +86 (10) 838-8912, 465-1589

Chinese joint venture partner is the 2nd Academy of the former Ministry of Aerospace Industry (AVIC), along with the Ministry of Health. R&D and product areas include medical devices such as clinical diagnostic imaging equipment (CT scanners, Magnetic Resonance imagers). Sales of 160 million Rmb yuan in 1994. Production space of 600 square meters, with 130 employees. Joint venture established with Medical Systems Division Asia of the General Electric Company from the US during October 1991.

Hangzhou Applied Acoustics Research Institute

PO Box 401

16 Hangxin Road, Fuyang, Hangzhou

Zhejiang 311400

Tel: +86 (5813) 25-122, 555-051

Fax: +86 (5813) 22-969

A subsidiary of the China State Shipbuilding Corporation, this institute has over 1,500 staff, including 600 engineers, and over 3,000 sets of equipment and instrumentation, including 700 pieces imported from abroad. It was China's first, and now largest, research establishment engaged in the study of applied acoustics, and has nine R&D offices for acoustics, electronics, systems engineering, and energy exchange materials, in addition to a computer centre, measurement centre, quality control centre, and a trial production factory. Major R&D activity areas include sonar, magnetic anomaly detection, echo sounders, infrared systems, digital display instrumentation, various piezoelectric materials and elements, and various transducers.

Hangzhou Electrical Connector Factory

Hangzhou Electrical Connector Institute

PO Box 1501

62 Taizhou Road

Hangzhou, Zhejiang 310015

Tel: +86 (571) 813-114

Fax: +86 (571) 813-117

Under the CAIC this R&D and production organisation is an electrical connector technology centre for China's space industry. It has 400 employees, 36% of which are technicians, facilities cover 20,000 square metres, and assets are valued at over 10 million Rmb yuan. Equipment includes CNC lathes, CNC vertical machine centre, precision optical boring machine, CNC grinding machine, infrared spectrophotometers, atom absorption analyser, microsclerometer, and vibro bench. It operates nine co-operative factories with 2000 workers in various other cities. Products include interstage and umbilical electrical connectors, widely used for space, aviation, and marine systems, and EMI/EMP shielding and filtering electrical connectors.

Harbin Aerodynamics Research Institute

PO Box 13

Harbin, Heilongjiang 150001

Staff of 500 for subsonic, transonic and supersonic wind tunnel experiments.

Harbin Aircraft Manufacturing Corporation

(formerly Harbin Aircraft Factory)

PO Box 201

15 Youxie Dajie, Pingfang

Harbin, Heilongjiang 150066

Tel: +86 (451) 650-1122

Fax: +86 (451) 650-2273

Established in 1952, HAMC is a major aviation industry manufacturer (China's largest producer of helicopters such as Z-5 and Z-9) and employs 17,000 workers (including 3,500 engineers and technicians) in facilities totalling 5.12 million square meters with 4,000 major piece of manufacturing and testing equipment. It has an aircraft design and research institute, and 20 technical sections in areas including casting, forging, machining, moulds, metal riveting, welding, heat surface treatment, engineering assembly, and die set manufacture. By the mid-1990s it claimed global level composite technology expertise, and used largecapacity IBM computers for various applications, and had implemented CAD/CAM systems. The firm has developed and manufactured light bombers, various types of helicopters, amphibious aircraft and general purpose Y-12 light transport aircraft. It has ISO9001 and ISO9002 quality certification. Establishing a Third World market niche (Sri Lanka, Laos, Mongolia, Peru, etc.) with the Y-12II light multi-purpose STOL transport, with input of US technology, the firm provides extensive after-sale service. Follow-on to Y-12II under development; by 1998 a total of 83 Y-12s had been exported to 18 nations. Builds Y-11 piston-engine powered light cargo and agricultural sprayer aircraft. Aerospace comprises two-thirds of the firm's business. Licensed development of the Aerospatiale/Eurocopter AS365 Dauphine (Dolphin) helicopters for military applications; after joint-production of 50 helicopters, nationalised production of a modified design in 1991. HAMC now produces the Z-9A helicopter, a modified version of the AS365N Dauphine helicopter, for both military and civilian applications including anti-tank versions and patrol duty for the PLA Hong Kong garrison, the government forestry service, state-owned general aviation and offshore oil support firms, with domestic manufacture of components at 75 percent. Has also produced the H-5 light bomber and SH-5 flying ASW patrol boat, and its EC120 light helicopter has went into pre-production testing.

Harbin Chemical Import and Export Corporation

66 Herun Jie, Daoliqu

Harbin, Heilongjiang 150076

Tel: +86 (451) 460-1802

Fax: +86 (451) 460-1823

Possible production of chemical warfare agents.

Harbin Dongan Engine Manufacturing Company

Harbin Turbine Works (formerly Harbin Engine Company)

PO Box 51

1 Daqing Lu

Dongliqu, Harbin

Heilongjiang 150066

Tel: +86 (451) 650-1120, 650-2120

Fax: +86 (451) 650-2266

This major AVIC controlled aeroengine manufacturer of turboprop, turboshaft aeroengines, helicopter gearboxes (for Z-8) and transmissions (for Z-9 and Z-11) was founded in 1948. It has over 10,000 employees, including 3,600 technicians and engineers, occupies an area of over 2 million square metres and has over 5,000 pieces of major equipment. It has three research institutes, and various technical capabilities in cold and hot work processing, and automatic ferrous metal prpoduction. Technical assistance received from the US General Electric Company during the late 1980s to improve the performance of the WJ5A1 turboprop aeroengine that powers the domestic Y-7 transport, and now also produces the WJ5E version. It has developed a 1,500 kW gar-turbine engine for ground applications.

Harbin Institute of Technology

166 Xidazhijie, Harbin

Heilongjiang 150006

Tel: +86 (451) 321-000

Areas of specialization include a space technology college, high-energy cadmium/nickel and hydrogen/nickel battery power sources, CAD/CAM software and robotics R&D. Has developed a high-technology industrial development zone covering 50 hectares. Specific R&D departments include:

· Academy of Astronautics

· Academy of Material Science and Engineering

· Department of Astronautics and Physics

· Department of Applied Chemistry

· Department of Applied Physics

· Department of Communications Engineering

· Department of Computer Science and Engineering

· Department of Control Engineering

· Department of Electrical Engineering

· Department of Mathematics

· Department of Mechanical Engineering

· Department of Power Engineering

· Department of Precision Instrumentation

· Department of Radio Engineering

· Department of Space and Opto-Electronic Engineering

· Robotics Research Institute

· Plating Research Center

· Analysis and Measurement Center

· Inertial Navigation Test Equipment Center

· Simulation Center.

Harbin Marine Boilers and Turbine Research Institute

74 Gongbin Road, Harbin

Heilongjiang 150030

Tel: +86 (451) 52-881, 54-931

Fax: +86 (451) 52-885

Operating under the China Shipbuilding Industrial Corporation, this institute has 1,340 staff, including some 800 engineers and technicians, and has twelve research offices, one manufacturing factory, 35 large test stands and jigs, and occupies buildings with a total floor space of 110,000 square metres. Its gas-fired turbine and combined power equipment test stand is the largest in China and is located at Wuxi, Jiangsu. R&D areas include steam turbines, boilers, gas-fired turbines, combined cyclic power plants, nuclear power plants and thermo-nuclear projects (double-loop circulation systems), mechanical transmissions, thermodynamic computer controls and automatic controls. Has produced three 107 ton-per-hour testing boilers for the Daya Bay nuclear power plant project in Guangdong Province, that were installed early in 1992. The institute also undertakes the translation of foreign technical publications. R&D areas include central heating systems, energy recovery and savings, hydrophobic systems, industrial boilers, transmission devices, pressurised containers, chemical containers, heat exchange equipment, etc.

A production line for making magnesite tiles was established in Russia, and other co-operative relations have been established with a dozen countries and regions.

Harbin Turbine Works

1 Daqing Lu

Dongliqu, Harbin

Heilongjiang 150040

Tel: +86 (451) 268-1404, 268-2780

Fax: +86 (451) 268-1364

Hebei Academy of Sciences

Institute of Lasers

Youyi Nan Dajie

Shijiazhuang, Hebei

Tel: +86 (311) 303-3654

Fax: +86 (311) 303-2060

Hebei Yanxing Machinery Plant

4 Dongxi Street, Qiaodong

Zhangjiakou, Hebei 075041

Tel: +86 (313) 461-905, 461-906, 461-907

Fax: +86 (313) 460-929

Affiliated with NORINCO this plant employs 4,000 people, including 700 technicians, occupies an area of 1.56 million square meters, including 210,000 square meters of building floor space, and has 2,175 sets of equipment for casting, forging, mechanical processing, heating, welding, pressing, and assembling.

Hefei Chemical Works

Heyu Lu

Hefei, Anhui 230011

Tel: +86 (551) 448-3545

Director's Office 448-4131

Fax: +86 (551) 448-3124

Possible production of chemical warfare agents.

Hefei Cryoelectronics Institute

PO Box 1019, Hefei

Anhui 230061

Tel: +86 (551) 256-918, 277-497

Fax: +86 (551) 257-940

An affiliate of the Ministry of Information Industry, this institute has over 1,000 staff, 40 percent of which are engineers and technicians. It occupies an area of over 70,000 square meters and has fixed assets of over 25 million Rmb yuan. It was the first cryoelectronic R&D organisation in China, with research focussed on cryogenic technology (120K or 153 degrees below Centigrade), superconductor electronic technology, cryoelectronics, and microwave and millimetre wave (radar receivable end, radar surveillance receiving end, and communications receiving end) technologies. The institute is comprised of twelve research offices and four workshops. Superconducting technologies cover superconducting materials, films, detectors, frequency mixers, resonant cavity, quantum interferes and their active and non-active devices. Has developed the superconducting Josephson tunnel diode and related technologies.

Hefei Wanan Machinery Factory

PO Box 6115

Hefei, Anhui 230022

Tel: +86 (551) 556-3033

Fax: +86 (551) 556-0754

Founded in 1958, this firm designs and manufactures auxiliary fuel tanks, light aircraft landing gear and integrated fuel pump test rigs, hydraulic jacks and accessories, and is a member of the Xi'an Aircraft Industrial Group. It has some 1,400 employees, production space of 173,000 square meters, and over 800 pieces of major manufacturing and testing equipment.

Heilongjiang Military and Technology

Industrial Trading Company

69 Hongjun Jie, Nangangqu

Harbin, Heilongjiang 150001

Tel: +86 (451) 364-3611, 364-5829, 363-5235, 262-6730

Fax: +86 (451) 262-5910, 364-3496

Henan Honyu Machinery Factory

PO Box 107 Yunyang

Henan 474675

Tel: +86 (3877) 661-500

Affiliated with ordnance production, this plant has 3,900 workers, incliding over 500 engineers and technicians, 2,070 sets of equipment and fixed capital assets of over 85 million Rmb yuan.

Henan Qinghua Machinery Plant

PO Box 1, Xuchang

Henan 461101

Tel: +86 (374) 334-334, 334-332

A subsidiary of NORINCO, this plant has 2,500 workers, including 417 engineers and technicians, and occupies a total area of 950,000 square meters, including building floor space of 129,957 square meters. It undertakes mechanical processing with over 1,300 sets of equipment, including 411 metal cutting machines, and systems for precision casting, forging, punching, heat treatment, surface treatment, machinery manufacture, etc. Products include inner combustion valve rockers and vanes for gas turbines.

Henan Xiangdong Machinery Plant

PO Box 102, Yunyang

Henan 474677

Tel: +86 (3877) 66-011, 66-066

and

Beijing Office

130 West Diaoyutai, Haidian

Beijing 100036

Tel: +86 (10) 842-2840

Affiliated with NORINCO, this military production plant occupies a total area of 3.63 million square meters, with building floor space totalling 315,000 square meters, and employs some 6,000 people, including 900 engineers and technicians. Fixed assets total 137.5 million Rmb yuan. It has 3,200 sets of equipment, including 196 NC machines and 56 imported machines.

Henan Zhongyuan Special Steel Plant

Jiyuan, Henan 454685

Tel: +86 (373) 352-026, (391) 229-500

Fax: +86 (391) 229-502

Under the administration of the China Weapons Industry Corporation, this plant covers an area of over 2.4 million square meters, has fixed assets of over 360 million reminbi yuan, and 5,700 workers, including over 1,100 technical personnel. It owns over 2,300 pieces of equipment such as an electric arc furnace, electric slag refining furnace, steel ladle refining furnace, hydraulic press, steel rolling mills, various large metal cutting and heat treatment equipment, etc. Products include forged materials, modules, and pieces, rolled steel, oil drilling boat, reinforced drilling rod, artificial crystal autoclave, motor axles, and steam turbine shafts.

High and New Technology For Peace

and Development Company Ltd.

2-12 Nanlou, 1 Aimin Street

Western District, Beijing 100034

Tel: +86 (10) 842-7909

Fax: +86 (10) 842-7909

and

Huizhou Office

Rooms 203-204, Bldg. No. 1

Rongyuan Residential Quarters

Huangtang Road, Huizhou

Guangdong 516001

Tel: +86 (752) 228-454, 225-907

Fax: +86 (752) 228-454

and

Shenzhen Office

3 Shoujing Dao, Yijing Garden

Shenzhen, Guangdong 518018

Tel: +86 (755) 553-3134

Fax: +86 (755) 553-3134

R&D and product development of bioengineering projects, instrumentation, electronics, office automation systems, and computer software. Its major operation is at the Daya Bay Economic and Technological Development Zone at Huizhou. R&D and product areas include super-thin semiconductor radios, low temperature ceramic composite filming technology, shielding techniques for EMI/RFI, titanium alloys and a mini meteorological satellite image/date receiving system. This company was originally structured as a joint venture between the China New Era Science and Technology Development Company, the Huamin Group Company of the US and a "Japanese friend".

Hongfeng Tools Factory

PO Box 27

Hanzhong, Shaanxi 723007

Tel: +86 (916) 277-217

Fax: +86 (916) 277-230

This firm produces drills, vernier height gauges, and heavy-duty three and four purpose vernier calipers.

Hong Kong Industrial Technology Centre Corporation

1/F HKITCC, 72 Tat Chee Avenue

Hong Kong

Tel: (852) 2788-4433

Fax: (852) 2788-4261

E-mail: enquiry@hkitc.org

Internet: www.hkitc.org

Hong Kong Science Park

Hong Kong Government Industry Department

14F, Ocean Centre, 5 Canton Road

Hong Kong

Tel: (852) 2737-2220

Fax: (852) 2730-4633

Internet: www.info.gov.hk/id/infrast/hksp.htm

Hong Kong Telecommunications Ltd.

Level 15, 3 Exchange Square

Hong Kong

Tel: (852) 848-8718

This is the HKSAR's foreign telecommunications carrier.

Hong Kong Special Administrative Region

Office of the Telecommunications Authority

29/F Wu Chung House

213 Queen's Road East, Wan Chai

Hong Kong

Tel: (852) 961-6333

Fax: (852) 803-5110

Hongwei Machinery Factory

PO Box 206

Xiangfan, Hubei 441022

Tel: +86 (710) 514-121, 514-623

Fax: +86 (710) 514-881

Manufacturer of parachutes applied to pilot emergency escape, aircraft braking, ejection seat stabilization, recovery, cargo, bombs, airships and balloons.

Hongyuan Aviation Forging and Casting Industry Company

PO Box 2

Sanyuan, Xi'anyang

Xi'an, Shaanxi 713801

Tel: +86 (910) 242-1191, 242-1195

Fax: +86 (910) 242-1196

Founded in 1956, this AVIC enterprise undertakes the manufacture and distribution of die and hammer forged parts that are fabricated from steel and alloy metals, the precision forging of gas-turbine blades, discs, compressor discs, shafts etc., forging for fuselage and wing structural components, forgings for landing gear, and the precision casting of fast pipe coupling equipment. Has received Boeing titanium forging orders in co-operation with Shenyang Aircraft, and has provided various other follow-on export orders to different firms such as Siemens, Toshiba, GE, etc. In 1995, it was awarded ISO9002 compliance by the China Aviation Conformity Centre. It is the Inspection Centre for the Import and Export Forgings and Castings confirmed by the State General Administration for Inspection of Import and Export Commodities. It has a production area of 180,000 square metres, 3,400 employees, of which some 850 are engineers, and fixed assets of 330 million Rmb yuan.

Huachang Engineering and Contracting Inc.

CNNC

1 Bayi Dadao

Nanchang, Jiangxi 330002

Tel: +86 (791) 621-1464, 626-4941

Fax: +86 (791) 622-4380

Hua Feng Helicopter Service Company Ltd.

PO Box 5411

Beijing 100028

Tel: +86 (10) 426-3397

Fax: +86 (10) 426-3311

This firm is a subsidiary import-export enterprise of the China Helicopter Company, and is an AVIC affiliate.

Huaguang Industry Corporation

PO Box 241, Hanzhong

Shaanxi 723014

Tel: +86 (29) 51-341 ext. 204

HIC is a large backbone enterprise directly controlled by the CNNC, and occupies an area of some 2.66 million square metres with a floor space of industrial facilities of about 80,000 square metres. It has an original fixed asset base of 40 million Rmb yuan and a circulation fund of 9 million Rmb yuan for the production of civilian products. Workers total 3,030, of which 400 are technicians. HIC has over 2,600 sets of major equipment, and special railway and highway lines connected to the Yang-An Railway and No. 108 State Highway which run through Hanzhong City.

Huazhong Electro-Optical Technology Research Institute

PO Box 74010

46 Luxiang Minyuan Road

Hongshan, Wuhan

Hubei 430074

Tel: +86 (27) 702-551, 701-634

Under the China State Shipbuilding Corporation, this institute has over 900 staff, 400 of which are technical personnel, total floor space of 50,000 square meters (with an additional 80,000 square meters planned), and has total fixed assets valued at over 45 million Rmb yuan, including 2,000 units of precision instruments and equipment. Organisation includes seven research offices, a trial production factory, and a technology development firm. R&D areas include large precision optical instruments, electro-optical automatic control systems, astronomical navigation systems, special purpose TV monitoring systems, low-light level night vision systems (eg. BY-I and TY-I portable low-light level night vision telescopes), laser and infrared systems, various precision static angle and length testing instruments, integration of electronic devices and machinery, and computer development. Has also developed various types of electro-optical detection/tracking systems, periscopes, special colour CCTV systems for high-pressure oxygen cabins, and other related products. Advanced R&D interests include infrared-thermal imaging systems, laser technologies, signal detection and digital image processing systems.

Huaxia Installation Company (CNI 23rd Construction Company)

Dongyanjiaozhen, Sanhe

Hebei, Sanhei City 101601

Huaxing Construction Company

Xupu, Yinzheng, Jiangsu, Yzzheng City 211451

Hua Ye Optical Material Corporation

124 Tiandu Cun, Chaoyang

Changzhou, Jiangsu

Tel: +86 (519) 882-0469

Fax: +86 (519) 881-0790

E-mail: info@hyoptical.com

Webpage: http://www.hyoptical.com/

Firm specialises in optical materials and optoelectronic technologies.

Huazhong Pharmaceutical Plant

Xiangfan, Hubei 441002

Tel: +86 (27) 225-594

Fax: +86 (27) 223-321

Under NORINCO, this plant employs 2,000 people, including 450 engineers and technicians, with pharmaceutical production occupying and area of 370,000 square meters, and building floor space of over 100,000 square meters. Invested capital assets of over 140 million Rmb yuan.

Hubei Dongfang Chemical Plant

PO Box 214, Yicheng

Hubei

Tel: +86 (7203) 22-175

Affiliated with armaments production, this plant has some 300 engineers and technicians. Products include toluene (annual capacity 10,000 tons), trinitrotoluene, P/O/N/M-nitrotoluene, iron oxide red, silicon metal corrosion resistant pumps and valves, and plastic products.

Hubei Jiangshan Machinery Plant

PO Box 225 Laohekou

Hubei 441813

Tel: +86 (7207) 22-811, 22-812, 22-844

Fax: +86 (7207) 21-424

Plants and offices also located in Wuhan, Beijing and Shanghai. Under NORINCO, this plant has over 7,000 workers, including 600 engineers and technicians, occupies an area of 3.82 million square meters, including 450,000 meters of building floor space, and has fixed assets totalling over 200 million Rmb yuan. Equipment includes nearly 3,000 production sets such as NC machine tools, tri-coordinate measuring instruments, scanning electronic mirror, a 40,000 KN hot mould forging unit, and a heat treatment production line imported from the US. Major products are motor vehicle gear boxes and parts, hydraulic oil cylinder and parts, and wear-resistant iron alloy castings.

Hudong Shipyard

2581 Pudong Dadao

Shanghai 200129

Tel: +86 (21) 5871-3222, 5871-1705

Fax: +86 (21) 5871-2603

Under the China State Shipbuilding Corporation, this shipyard employs 12,000 workers, including 2,800 engineers and technicians, covers 870,000 square meters, and has 5,500 sets of equipment, including 350 systems imported from abroad. Its two shipways can accomodate ships of 10,000 dwt, and it also has eight horizontal shipways. Can build ships up to 70,000 tons, medium and low speed high-powered marine diesel engines, and large steel structures. Build various kinds of bulk goods carriers, tankers, floating oil storage tankers, container ships, etc. Constructs bridges, TV towers, diesel engine power plants, etc. Has cooperated with the Japanese Mitsui shipbuilding company, German and other foreign firms for technology transfer of marine diesel engine and other technologies, and shipbuilding joint ventures.

Hunan Aeronautics Industrial Sales Company

10 Wuyi Dong Lu

Changsha, Hunan 410001

Tel: +86 (731) 443-5801

Hunan Electronic Device Plant

PO Box 73, Luonan

Shaanxi 726112

Tel: Xi'an Liaison Office +86 (29) 335-135, 752-006

Fax: +86 (29) 753-853

and

Beijing Liaison Office

Room 303, Hostel of PO Box 142

68 Yongding Road, Haidian, Beijing

Tel: +86 (10) 838-8207, 838-5285

This plant is a member of the Xi'an Xijing Electronics Devices Industrial Company of the China Electronics Industrial Corporation. It has 1,150 staff, of which some 385 are engineers and technicians. Its primary R&D and production emphasis is on thick-thin film hybrid integrated circuits (HIC), and it is the first facility of this kind in China. US technology has been transferred for HIC, resistor network, chip resistors and thermal printer heads used for computer, aerospace, telecommunications and instrumentation systems.

Hunan Shaoyang Auto-Parts Factory

87 Baoqing Xilu, Shaoyang

Hunan 422000

Tel: +86 (739) 227-473, 224-654

Member of the China Auto-Parts Joint Marketing Department and the Beijing Jeep Company, and is a specialist producer of support air brake chambers and shock absorbers for Liberation brand trucks. Also produces these products for cars, motorcycles, aircraft, ships, and various other machines. The factory occupies an area of 49,000 square meters, with building floor space totalling 19,619 square meters. Total staff is 321, including 56 engineers and technicians. Equipment includes 209 pieces of mechanical and electrical equipment, including 94 metal cutting machines and 17 forgers and pressors. Has recently invested 10 million Rmb yuan on technological transformation.

Hunan Space Agency (068 Base)

Changsha, Hunan

Reportedly develops aerospace electromechanical equipment associated with surface-to-air missiles, and R&D of special materials, and has one research institute and five factories, centred at Changsha, Hunan:

· 7801 Research Institute, Changsha

· 7803 Factory/ Hunan Taishan Machinery Factory - superhard materials (chaoying cailiao)

· 804 Factory

· 861 Factory

· Hunan Zhujiang Instrument Factory

· Hunan Electromechanical Instrument Factory.

Inner Mongolia Number One Machinery Plant

Qingshan, Baotou

Nei Mongol 014032

Tel: +86 (472) 33-011, 34-041

Fax: +86 (472) 33-322

A major subsidiary of NORINCO, this plant occupies an area of 18.2 million square meters, with building floor space totalling 1.43 million square meters. Workers number 25,500, including 5,592 technical personnel. Some 700 pieces of new equipment imported from the US, Germany and Japan. Produces and undertakes R&D on "third generation of tracked vehicles" (eg. AFVs).

Inner Mongolia Number Two Machinery Plant

PO Box 3041, Baotou

Nei Mongol 014033

Tel: +86 (472) 33-071 ext. 389

Fax: +86 (472) 35-641

A subsidiary of NORINCO, this plant occupies an area of 275 square kilometers, with 2.23 million square meters of production area, with building floor space totalling 1.24 million square meters. It has over 23,000 workers, with engineers and technicians accounting for 8.5 percent, over 6,400 pieces of mechanical and power equipment, and assets valued at over 500 million Rmb yuan. Speciality areas include steel alloy production, casting, forging, production of engineering machinery, various kinds of heavy trucks, hydraulic transmissions, etc. It operates research institutes (defence and civilian), metallurgical department, technology department and a quality control department.

Institute for Astronautics Information

PO Box 1408

1 Binhe Street, Hepingli

Beijing 100013

Tel: +86 (10) 6837-2847

Fax: +86 (10) 8422-1606

e-mail: anb@space.cetin.net.cn

Publishes over 1,000 technical reports on the mostly leading advances in

Chinese aerospace, missilery and defence fields.

Institute of Applied Nuclear Techniques

Chengdu Institute of Technology

1 Erxianqiaodongsan Road

Chengdu, 610059

Tel: +86 (28) 333-4712

Fax: +86 (28) 334-1299

Develops nuclear analytical instruments, and provides related engineering and architectural services.

Institute of Composite Special Structures

Research Institute for Special Aeronautical Composites

9 Jiaoxiao Road, Jinan

Shandong 250023

Tel: +86 (531) 597-4323, 597-4325, 597-7682

Fax: +86 (531) 597-7824

Founded in 1970, this institute reports to the Academy of Science and Technology of the AVIC/CAIC, and engages in R&D pertaining to the structure and application of composite materials for aerospace systems. It has some 500 staff, mostly engineers, technicians and scientists. Equipment includes 120 sets of machining facilities and 300 experimental devices in a 86,000 square metre facility. It has ISO9000 quality certification. Facilities include research divisions for electromagnetics, structural strength, materials technology, microwave testing, nondestructive testing, mechanical function, chemical metering and analysis, thermal analysis, engineering assembly for nonstandard designs, information and data, technological development, computer software, and workshops for experimental and mass production. *Primary products include composite shields for airborne radar, ship radar shields, shields for meteorological air sounding ground radar, phased array radar shields, conformal skins for conformal or intelligent radar arrays, composites for aircraft stealth structures, and 'composite components transparent to electromagnetic waves', or stealth designs*. The institute also conducts R&D on other special structures and composite structure cores such as carbon fibre composite components, Nomex honeycombs, foamed cores and artificial dielectric cores. Composite bullet-proof armours, electronics, and composite wave guide systems have also been developed.

Institute of High Energy Physics

PO Box 918

Academica Sinica

Beijing 100039

Tel: +86 (10) 821-3344

E-mail: username@machine.ihep.ac.cn

Institute of Mechanics

Chinese Academy of Sciences

15 Zhong Guan Cun Road

Beijing 100080

Tel: +86 (10) 6255-8226

Fax: +86 (10) 6256-1284

Space sciences applications and research and development.

Institute of Nuclear Energy Technology

Tsinghua University

Beijing 100084

Tel: +86 (10) 6259-4808

Fax: +86 (10) 6256-4177

The "863" Programme is providing support to the Institute of Nuclear Energy Technology, Tsinghua University, for the development of high-temperature gas-cooled reactors. Tsinghua University is also developing low-temperature nuclear district heating technology using 200MW nuclear reactors under the National Key Technologies R&D Projects initiative.

Institute of Plasma Physics

Chinese Academia Sinica

PO Box 1126, Hefei

Anhui 230031

Tel: +86 (551) 559-1366, 559-1387

Fax: +86 (551) 559-1310

Institute of Remote Sensing Applications

PO Box 9718, Datun Road

Village of Asian Games

Beijing 100101

Tel: +86 (10) 491-9268, 491-9458, 491-9740

Fax: +86 (10) 491-5035

Institute of Scientific and Technical Information of China

Information Research Centre

15 Fuxing Road

Beijing 100038

Tel: +86 (10) 6851-4699

Fax: +86 (10) 6851-4027

E-mail: consult@istic.ac.cn

Provides market reports and other data concerning Chinese industry sectors.

Institute of Software Academia Sinica

PO Box 8718, Beijing 100080

Tel: +86 (10) 257-2328, 256-2561

Fax: +86 (10) 256-2533

Intelligence Control Engineering Company,

General Aerospace Industry Company

1 Yungang Beili, Fengtaiqu

PO Box 7203-8

Beijing 100074

Tel: +86 (10) 837-6594, 837-4652

Fax: +86 (10) 837-6025

Jialing Industry Co. Ltd.

100 Shuangbei Ziyoucun

Chongqing, Sichuan 630032

Tel: +86 (811) 986-5847

Fax: +86 (811) 986-1089

Directly under NORINCO, this plant employs 8,510 people, including 2,000 technicians, has a net asset value of over 168 million Rmb yuan, covers an area of 45,000 square meters and has some 2,805 sets of various equipment. Likely has a major ordnance capability. Main civilian and dual-use products are

Jialing brand motorcycles, hunting rifle bullets, industrial steel balls and industrial bearings. Produces over 350,000 motorcycles per year, plus parts and components. Has an automotive joint venture with a Japanese firm.

Jianghan Aviation Life-Support Industry Corporation

PO Box 157

Xiangfan, Hubei 441003

Tel: +86 (710) 322-4145

Fax: +86 (710) 322-4010

This company manufactures rocket ejection seats, helmets, pilot parachutes, drag parachutes, bomb parachutes, compensation anti-G suits, and marine rescue equipment. It has a dedicated research institute, staff of of 5,000, 38 percent of whom are engineers and technicians, over 600 hectare grounds and some 350,000 square meters of floor space. Specialised facilities include various CNC systems, 2.5 metre low-speed wind tunnel, upward ejection equipment, precision centrifugal machines, a parachute dropping test range and a 3 kilometre long rocket sled test range which can achieve speeds as high as 413 metres per second.

Jianghuai Aviation Instrument and Metre Factory

PO Box 341

Hefei, Anhui

Tel: +86 (551) 32-355

Fax: +86 (551) 31-473

This firm produces aircraft oxygen breathing systems.

Jiangling Machinery Plant

Dashiba, Jiangbei, Chongqing

Sichuan 630021

Tel: +86 (811) 752-461, 752-465

Fax: +86 (811) 756-181

Under the administration of NORINCO, this plant has an employment of over 10,000 people, including some 750 engineers and technicians, and fixed assets valued at over 170 million Rmb yuan. It occupies an area of 11.85 million square metres, with building floor space totalling 520,000 square metres. Technical emphasis is on precision mechanical processing, forming technology, heat treatment, surface treatment, and testing technology. Ammunition is one likely defence product. Products include micro-engines for autos and coaches, cloud seeding shells fired from 37mm anti-aircraft guns, electroplated parts, machine tools, and other mechanical and electrical products. Has imported advanced technology from the Japanese Suzuki company to produce the JL462Q gasoline engine used for cars and other vehicles, and used this technology as the basis for more advanced follow-on designs.

Jiangmen Centre for Biotechnological Development

113 Jianghai Lu

Jiangmen, Guangdong 529081

Tel: +86 (750) 379-3520, 379-3525, 379-3528

Fax: +86 (750) 379-3404

Jiangnan Machinery Plant

PO Box 5, Xiangtan

Hunan 411207

Tel: +86 (732) 22-911

Fax: +86 (732) 63-369

Under NORINCO, this plant has almost 11,000 workers, including 967 engineers and technicians, occupies 6.2 million square metres, with building floor space totalling 800,000 square metres, operates 4,814 pieces of equipment, and has fixed assets valued at 189.51 million Rmb yuan.

Jiangnan Shipyard

2 Gaoxiong Road

Shanghai 200011

Tel: +86 (21) 328-4158, 328-4157

Founded in 1865, this is one of the largest shipyards in China, and has some 14,000 workers, including 2,700 technical personnel, occupies 770,000 square metres, with six shipbuilding slipways, three dry docks, five 100/150 ton cranes, and more than 4,000 pieces of processing and machining equipment capable of the production, modification and repair of vessels up to 80,000 tons. Operates a design technology institute, a materials testing institute, a welding institute, computer and information centres, and has CAD/CAM and management information system technologies. Products include commercial ships, various large non-standard equipment, port machinery, pressure containers and steel structures. Produces bulk goods carriers, LPG boats, ro/ro ships capable of carrying 34,000 cars, oil tankers, refrigeration ships, container ships, science survey ships, train ferry boats, fishing boats, engineering boats, etc. Has manufactured China's first 12,000 ton hydraulic press, China's biggest tunnel shielding structure of 11.3 metres in diameter, the rotating sphere of China's largest astronomical observatory, etc.

Jiangsu Automation Research Institute

PO Box 102

32 East Road of Hailian, Xipu

Lianyungang, Jiangsu 222001

Tel: +86 (518) 414-051

Fax: +86 (518) 410-360

A subsidiary of the China State Shipbuilding Corporation, this institute has over 1000 staff, with engineers and technicians accounting for 650 of this total, has a production area of 33 hectares, with building floor space totalling 30,000 square metres, and fixed capital assets of over 50 million Rmb yuan. Organisation includes R&D units for automatic controls systems engineering and devices, fibre optics data buses, simulation, shallow gauging technology, display technology and computer systems and software engineering, and a trial production factory with more than 200 pieces of equipment.

Jiangsu Huaning Electronics Group

PO Box 277

21st Floor, New Era Mansion

402 Zhongshan Donglu, Nanjing

Jiangsu 210002

Tel: +86 (25) 451-875, 541-015

Fax: +86 (25) 418-428

This is a conglomerate for R&D, production and export, and is comprised of over 50 member enterprises from Beijing, Wuxi, Liyang, Shuling, Suzhou, Zhenjiang, Yangzhou, Kunshan, Shenzhen, Xiamen and Hainan. It has a combined workforce of 10,000 people, of which 60 percent are engineers and technicians. R&D and product areas include telecommunications, satellite ground stations, radars, LED multi-colour large screen displays, special power sources, computer engineering, microwave engineering, and instrumentation. Has capabilities in thick film circuits, special low-voltage switches, and special transformers. Research being conducted on express highway communications and monitoring system, electronic information exchange system, industrial process automatic control system, small data station, and video-cameras.

Jiangsu Leisheng Electronic Equipment Plant

20 Liangxi Road, Wuxi

Jiangsu 2114061

Tel: +86 (510) 807-234

Fax: +86 (510) 801-948

A subsidiary of the China State Shipbuilding Corporation, this plant has over 2,380 staff members, including over 600 engineers, occupies an area of 210,000 square metres, with building floor space totalling 150,000 square metres, owns 1600 sets of major production equipment and 3000 sets of instrumentation, and has fixed assets totalling 50 million Rmb yuan. It is China's largest research and production enterprise specializing in underwater sound equipment. Developed since 1983 precision pressure/temperature/moisture transducers for space satellite use, and is currently developing a second generation of such systems.

Jiangsu Shipbuilding Industry Corporation

16 Shengzhou Lu

Nanjing, Jiangsu 210001

Tel: +86 (25) 662-4517

Sales Dept. 662-6853

Financial Dept. 662-6506

Production Dept. 662-3912

Fax: +86 (25) 220-2645

Jiangsu Shugang Opto-Electronics Instrument Factory

32 Yingxin Road

Yangzhou, Jiangsu 225001

Tel: +86 (514) 349-171

Fax: +86 (514) 347-527

Under NORINCO, this factory undertakes the R&D, production and integration of lasers, optics, machines, electronics, numerically-controlled machines, etc. Products include lightweight laser range-finders. Printed circuit board production technology imported from the US and Germany during the 1980s.

Jiangsu Xingsu Machinery Plant

Zhongnan Road, Wuxi

Jiangsu 214024

This factory employs 1,320 people, including 148 engineers and technicians, and occupies 134,000 square metres, including building floor space of 35,000 square metres. Likely firearms producer.

Jianshe Machine Tool Works (Jianshe Industries Group Corporation, Jianshe Motorcycles)

47 Zhengjie, Xiejiawan, Jiulongpo

Chongqing, Sichuan

630050

Tel: +86 (811) 881-3741

Fax: +86 (811) 62190

Under NORINCO, this plant occupies 1.83 million square metres, with 18,000 workers (200,000 total workers in group) and 5,000 machines, and is the largest automotive plant in China. Net worth assets are valued at over 331 million Rmb yuan, original fixed assets of 438 million Rmb yuan, and general assets of some 1.8 billion Rmb yuan. A major ordnance producer. Total group consists of over 300 enterprises and research institutes, this plant is the central enterprise. Major producer of various models of motorcycles, motorcycle engines, vehicle air conditioners and civilian guns (4.5mm to 5.6mm). It is the core of the conglomerate Jianshe Motorcycle Economic Group, which has a production capacity of over 1 million motorcycles per year, has 9,000 manufacturing machines, 120 production lines, and thousands of technicians and engineers. Claim that over 95 percent of production output is now civilian. Motorcycle technology and production agreement with Japanese Yamaha company. Joint venture firms include Chongqing TK Yamaha Carburetor Corporation, and the Sichuan Huachuan Yamaha Spare Parts Production Corporation.

Jianzhong Chemical Industry Corporation

PO Box 273, Yibin

Sichuan 644000

Tel: +86 (831) 226-976 ext. 40203 and 50202

Fax: +86 (831) 223-622

Dual-use nuclear fuel component production. JCIC has 500 million Rmb yuan in fixed assets and nearly 10,000 personnel, including some 2,640 engineers. Subsidiary organisations include: Yibin Nuclear Fuel Component Factory; metallurgical and chemical branch factory; Chengdu Jianzhong Lithium Battery Factory; Jianzhong Physico-Chemical Research Institute; and the Jianzhong Designing Institute. The Yibin facility is a production base of fuel components for China's nuclear power plants, and has developed fuel packages for the Qinshan and Daya Bay Nuclear Power Plants and others. Has autonomous railway and land transportation systems. Technology transfer arrangement with the US based Energy Conversion Company for the production of cylindrical and button shaped lithium batteries of more than 20 specifications.

Jidong Chemical Plant

32 South Street, Yangquan

Shanxi 045000

Tel: +86 (353) 34-821, 34-827 ext. 282

Fax: +86 (353) 38-380

and

Taiyuan, Office

83 Nanxiaoqiang, Taiyuan

Shanxi

Tel: +86 (351) 229-314

This plant is a subsidiary of the China Weaponry Industrial Corporation, and has over 3,800 staff, including 835 technical personnel. It is a major producer of explosives and pyrotechnics. Products include detonating cords and fuses (SB-5, SB-3, SB-11, SB-25, 3-40g/m plastic prima cords, ordinary and slow igniting fuses, granular powder fuse, safe fuses, fast igniting fuses, and fireworks fuses) for industrial use, black powder, fireworks (50mm to 300mm high altitude fireworks and ground fireworks), warning signal flares, ABS plastic suitcases and metallised films.

Jincheng Corporation

PO Box 202

518 Zhongshandong Road

Nanjing, Jiangsu

210002

Tel: +86 (25) 459-6161, 459-3388

Fax: +86 (25) 459-1758

This AVIC firm manufactures prachutes and air training targets, and fuel, hydraulic, mechanical and pneumatic aircraft accessories. The firm has over 5,300 employees, annual industrial output of over 4 billion Rmb yuan, uses flexible manufacturing systems, and has ISO9001 quality certification. It is the development centre of the National Aviation Hydraulic and Pneumatic System and Secondary Power System. It is the core facility of the Jincheng Group that has 222 subsidiaries across China.

Jingdezhen Aviation Forgings and Casting Company (JAFCC)

PO Box 942

Jingdezhen, Jiangxi 333039

Tel: +86 (798) 269-1201, 269-1391

Fax: +86 (798) 269-1395

Founded in 1970, this AVIC affiliate produces specialised medium and large castings and forgings. It has ten plants involved with isothermal precision forgings, large die forgings, etc.

Jinling Petrochemical Company

Chemical Plant Number Two

Yanziji, Nanjing, Jiangsu 210038

Tel: +86 (25) 550-2990

Possible manufacturer of chemical warfare agents.

Jinning Radio and Appliances Factory

PO Box 3704, Nanjing

Jiangsu 210037

Tel: +86 (25) 503-452

Fax: +86 (25) 501-420

Under the China Electronics Corporation, this factory employs over 1,900 staff, with engineers and technicians comprising over 21 percent of this total. Its total floor space is 60,000 square metres. Main product and R&D areas are permanent magnet alloys, soft ferrite cores and components, microwave ferrite devices, rare earth permanent magnets, switching power sources, with applications in radar, navigation, telecommunications, electronics, sound and video systems. R&D activities for superhigh-conducting ferrite materials, high-frequency/high-power/low-power-consumption ferrite materials and various ferrite magnetic cores. Microwave ferrite devices cover a full range of frequencies from UHF to millimetre wave bands. Plans to build a production line for pellet electronic transducers.

Jiujiang Shipbuilding Industry Corporation

48 Gantang Nan Lu, Jiujiang

Nanchang, Jiangxi

Tel: +86 (791) 822-4711, 822-3692, 822-3696, 822-7512, 822-3901

Fax: +86 (791) 822-3691

Keli High Technology Enterprises Group

5 Nan Road, Zhongguancun

Beijing 100080

Tel: +86 (10) 256-5376

Fax: +86 (10) 256-4649

Products include graphics and image display systems.

Kunming Machine Tool Company Ltd.

23 Ciba Lu

Kunming, Yunnan 650203

Tel: +86 (871) 515-0290, 515-0816

Fax: +86 (871) 515-0317

Suspected defence production role in such areas as machine tools and machinery.

Kunming Ship Equipment Group Corporation

81 Renmin Dong Lu

Kunming, Yunnan 650051

Tel: +86 (871) 313-7700, 313-7869

Production Quality Dept. 313-6866

Trading Planning Dept. 313-9179

Fax: +86 (871) 313-5511

Under the administration of the China State Shipbuilding Corporation, this company has over 10,000 workers, including some 3,000 technical personnel, and has fixed assets totalling 300 million Rmb yuan. Organisation consists of seven large and medium sized production enterprises, six R&D insitutes, one material supply company, and one education and training centre. R&D areas include computer technology and software, microcomputer control of industrial production processes, underwater salvaging and sounding, noise monitoring and analysis, precision plastic injection moulds production technology, and precision machining.

Lantian Corporation

Historically has conducted commercial activities for the PLAAF.

Lanzhou Airforce Rear Service Department

Automobile Repair Factory

13 Jiankang Lu

Anningqu, Gansu 730070

Tel: +86 (931) 766-8092, 766-6614

Lanzhou Flight Control Instrument Factory

PO Box 57, Anning

Lanzhou, Gansu 730070

Tel: +86 (931) 666-157, 666-620

Fax: +86 (931) 666-430

Employs 4,000 staff manufacturing military autopilots for fixed and rotary winged aircraft, amplifiers, gyroscopes, actuators, computers, compasses and naval equipment.

Lanzhou Radiation Technology Development Centre

Number 634 Xijin Road West

Lanzhou, Gansu 730050

Tel: +86 (931) 332-652

Laser Single Atom Detection Lab

Tsinghua University

Beijing

Tel: +86 (10) 259-4531

Legend Computer Group Company

PO Box 2704

70 Haidian Lu

Beijing 100080

Tel: +86 (10) 256-2946, 256-8678, 256-7606, 256-4446

Fax: +86 (10) 256-1056, 256-4842

Liao Yuan Aero-Mech Corporation

PO Box 43

Yangxian County, Shaanxi 723313

Tel: +86 (916) 216-323, 212-974

Fax: +86 (916) 216-410

This company produces landing gear, hydraulic accessories, and rubber and plastic parts for medium to large size aircraft.

Liaoning Qingyang Chemical Industrial Corporation

PO Box 15, Liaoyang

Liaoning 111002

Tel: +86 (419) 23-757

Offices also located in Beijing, Shanghai, Shenzhen and Dalian. Under NORINCO, this plant has 20,000 workers, including 2,340 engineers and technicians, occupies an area of 32.85 square kilometres, with building floor space totalling 810,000 square metres, over 7000 pieces of equipment, and fixed assets valued at 350 million RMB yuan. Organisation includes 16 factories, two product R&D institutes, one design institute, and import/export firm and a collectively owned large industrial firm. It produces explosives and devices for military and civilian use based on ammonia dynamite and gum dynamite, has developed focused case dynamite, relay setting-off devices, water-proof emulsified explosives, nitroglycerin powder, metal stress eliminating explosives, benzene and toluene nitro materials, etc. Produces up to 30,000 tons of gum explosive per year, and 3,000 tons of TNT.

Liaoning Xiangdong Chemical Plant

Yangzhangzi, Lingyuan

Liaoning 122522

Tel: +86 (4286) 24-802

and

Beijing Office

1 Wujiachun, Fengtai

Beijing 100039

Tel: +86 (10) 821-7898, 921-1163

Fax: +86 (10) 822-1949, 821-2223

A subsidiary of NORINCO, this plant cover an area of 792.4 square kilometres, with fixed assets valued at over 369 million Rmb yuan. It owns 4,000 pieces of equipment and has some 8,000 workers, including 1,350 engineers and technicians, along with 15 branch factories. Only plant in China that produces dinitro used for explosives and dyes.

Product and R&D areas in chemical, light industry, construction materials, and electricity generation.

Liuzhou Changhong Machinery Manufacturing Company

PO Box 115, Liuzhou

Guangxi 545012

Tel: +86 (771) 212-132

Under the AVIC, this firm occupies an area of 1.6 million square metres, with building space totalling 160,000 square metres. It has fixed assets worth some 100 million Rmb yuan, and has several thousand workers, with engineers and technicians accounting for 20 percent of this total. It owns over 2,600 pieces of equipment, including over 500 metal cutting machines, optical and precision machine tools, dies processing, numerically controlled processing centres (US technology processing centre, numerically controlled machine tools and line-cutting machines, 3-D measuring machines, CAD/CAM work stations), heat treatment, electroplating, paint spraying, precision casting, welding, physiochemical testing and environmental testing systems. Other products include a "YAG-80 laser therapeutic machine" (dual-use technology) and accelerators.

Liyang Machinery Corporation

PO Box 5

Pingba, Guizhou 561002

Tel: +86 (851) 551-779, 523-311

This firm is a key AVIC manufacturer of WP7 and WP13 aeroengines in some twelve versions.

Luoyang Aviation Electrical Factory

Luoyang Nanfeng Machinery Factory

PO Box 069

Luoyang, Henan 471003

Tel: +86 (379) 475-8888, 475-9999

Fax: +86 (379) 475-9069

Founded in 1966, this AVIC enterprise manufactures electrical connectors and modules for airborne systems, satellites, launch vehicles, missiles, and fire control systems. The firm has over 900 engineers, over 3,000 sets of machine tools, space of 160,000 square metres, and fixed assets of some 83 million Rmb yuan. Specialised capabilities exist for optical processing and infrared elements.

Luoyang Institute of Electro-Optical Equipment

PO Box 017

Luoyang, Henan 471009

Tel: +86 (379) 393-8591

Fax: +86 (379) 393-8146

This is a key R&D establishment for Chinese airborne fire control systems for over the past two decades. It has over 1,500 employees, including some 100 senior scientists and 300 engineers. It departments include: fire control engineering; fire control computer; electro-optical display technology; rate gyro sensor; TV, laser and infrared technology; fire control simulation technology; opto-electronic aiming technology; trial production factory, etc. It has developed three generations of fire control and electro-optical systems (eg automatic tracking systems, helmet-mounted tracking and display systems, airborne video recording systems, HUD/fire targeting system, etc.), some of which the institute claims have reached Western levels of sophistication. It has ISO9001 quality certification, and a simulation lab for airborne fire control systems.

Luoyang Optoelectro Technology Development Centre

PO Box 030

Luoyang, Henan 471009

Tel: +86 (379) 393-8811

Fax: +86 (379) 393-7441

This AVIC affiliated firm conducts the R&D and production of optical, electronic and mechanical technologies, including thermal imaging systems and laser weapon R&D, optics, microelectronics, semiconductors, simulation systems, etc. It has over 2,800 personnel, including 1,500 engineers and technicians, and 3,300 pieces of advanced equipment It has developed the IR guidance system for the PL-9 air-to-air missile.

Luoyang Ship Material Research Institute

21 Xiyuan Road, Luoyang

Henan 471039

Tel: +86 (379) 413-611

Fax: +86 (379) 413-642

Under the Administration of the China State Shipbuilding Corporation, this institute has 1,300 staff, including over 800 technical personnel, occupies a total area of 270,000 square metres, with building floor space totalling 120,000 square metres, and has 2,800 units of equipment and instrumentation. Its main R&D emphasis is on ferrous metals, non-ferrous metals, non-metallic coatings, welding and welding technology, special steel and castings, surfacing technology, physio-chemical testing and information, bellows expansion joints of corrugated metal tubes, composite metal materials, pressurised containers, metal corrosion and protection. Products include explosive welding technology and explosive clad materials, anodes for cathodic protection, electrolysis anti-fouling systems, titanium alloy castings, special steel castings, composite metal materials, etc. Product applications for shipbuilding, ports, petroleum exploration and development, chemicals, metallurgy, machinery and electronics, power industry, etc.

Ma'anshan Iron and Steel Company Ltd.

8 Hongqi Bei Lu

Ma'anshan, Anhui 243003

Tel: +86 (551) 228-8349, 228-8342

Suspected defence role in the areas of machine tools and machinery.

Marine Design and Research Institute of China

1340 Xinzhaozhou Lu

Shanghai 200011

Tel: +86 (21) 6377-0171

Fax: +86 (21) 6377-9744

Under the China State Shipbuilding Corporation, this institute has 1,800 staff, most of which are engineers and technicians, and has R&D facilities that include ship resistance and propulsion test pool, manoeuvring test pool, sea keeping test pool, lab for testing propeller cavitation, wind tunnel, hydraulic propelling lab, etc. Has designed and developed warships, ro/ro ships, ocean-going survey and scientific survey vessels, space tracking ships, double-hulled hovercraft and other hovercraft platforms, hydraulic jet-propulsion technology, 20 seat amphibious augmented RAM wing craft, and boats.

It has also designed and developed bulk goods carriers, container ships, multipurpose cargo ships, large tonnage oil tankers, LPG boats, chemical boats, large passenger ships, tug boats, engineering ships, fishing boats, self-lifting/semi-submersible and submersible drilling platforms and large single-point mooring systems.

Meiling Chemical Works

705 Zhonghua Road, Zunyi

Guizhou 563003

Tel: +86 (852) 2952

Offices and plants also located in Suzhou, Shanghai and Zhuozhou. Affiliated with the Guizhou Space Industry Corporation under the CAIC, and specialising in R&D and production of chemicals and physical power supplies for the aerospace industry. Produces zinc-silver batteries for fighter aircraft, and various zinc-air, zinc-silver and lead acid batteries. In co-operation with foreign investors and the Zhuozhou municipal government, established the Heibei Kaifeng Industrial Corporation specializing in the production of nickel cadmium storage batteries.

Microelectronics Research and Development Centre

of the Chinese Academy of Sciences Company

Behind Building 2, Zhongkeyuannei

Qijiahuozi, Deshengmenwai

Beijing 100029

Tel: +86 (10) 202-1133, 201-1443, 202-3377

Fax: +86 (10) 202-1601

Electronic equipment and components R&D.

Ministry of Aerospace Industry

(China Aerospace Industry Corporation, Aviation Industries of China Corporation, China National Space Administration)

Bureau of International Cooperation

67 Jiaonan Street

PO Box 1671

Beijing 10072

Tel: +86 (10) 401-3645

Fax: +86 (10) 401-1632

Ministry of Aerospace Industry

Factory Number 691

8 Taiyi Lu, Hepingmenwai

Xi'an, Shaanxi 710054

Tel: +86 (29) 727-9310

Fax: +86 (29) 721-0478

Ministry of Communications

Foreign Affairs Office

11 Jianguomennei Street, Beijing 100736

Tel: +86 (10) 6529-2201

Fax: +86 (10) 6529-2201

Ministry of Information Industry

China Electronics Industry Corporation (CEIC or "Chinatron")

27 Wanshou Lu, Haidianqu

Beijing 100846

Tel: +86 (10) 6820-8155

Fax: +86 (10) 6822-1838

Main government organisation responsible for the development of civil, dual-use and defence IT. Organisations with reported defence-related IT R&D and production (names may vary for the same organisation) are thought to include:

· China Academy of Electronics and Information Technology (CAEIT): general systems design department involved in formation of national information infrastructure, and works closely with COSTIND's Beijing Institute of Systems Engineering (BISE) in developing China's national C41infrastructure

· 2nd Research Institute, Taiyuan

· 5th Research Institute - environmental testing

· 6th Research Institute, Huasun Computer Company - computer systems engineering

· 7th Research Institute, Guangzhou Communications Research Institute - field mobile communications systems and digital mobile communications systems

· 8th Research Institute, Anhui Fiber Optical Fiber Research Institute

· 10th Research Institute, Southwest Institute of Electronics Technology, Chengdu - defence-related programmess involving UHF, microwave, and millimetre communications and radar equipment

· 11th Research Institute - solid state laser systems, laser range finders

· 12th Research Institute - TACAN systems

· 13th Research Institute, Shijiazguang - integrated circuits, solid state lasers, gallium arsenide integrated circuits (has reported imported advanced French technology)

· 14th Research Institute, Nanjing - early warning, phased array, HF, and space tracking radars R&D centre

· 15th Research Institute, North China Computer Institute (Taiji Computers)

· 18th Research Institute, Tianjin Institute of Power Sources.

· 20th Research Institute, Xi'an - primary navigation R&D centre

· 21st Research Institute, Shanghai

· 22nd Research Institute, China Institute of Radiowave Propagation - timing sources, such as those associated with Shaanxi Astronautical Observatory Timing Station

· 25th Research Institute - signal processing systems, long wave infrared (LWIR) imaging seeker R&D

· 26th Research Institute, Chongqing - surface acoustic wave (SAW) devices, piezoelectronic acousto-optics, electronic ceramics, and crystals

· 28th Research Institute, Nanjing Research Institute of Electrical Engineering - C 4 1 systems integration for air defence and ATC systems

· 29th Research Institute, Southwest Institute of Electronic Engineering, Chengdu - radar reconnaissance and ECM

· 30th Research Institute - switching systems, advanced common channel signalling seven software

· 33rd Research Institute, Taiyuan

· 34th Research Institute, Guilin Institute of Optical Communications - fibre optics R&D; has a joint-venture with with Nokia

· 36th Research Institute - communications ECM

· 38th Research Institute, East China Institute of Electronic Engineering, Hefei - early warning and artillery radars

· 39th Research Institute, Northwest Institute of Electronic Equipment - SATCOM ground stations, microwave relays, and missile range equipment.

· 40th Research Institute, Bengbu - connectors and relays

· 41st Research Institute - signal generators and test equipment for infrared focal plane arrays

· 43rd Research Institute, Hengli Electronics Development Corporation, Hefei

· 44th Research Institute, Chongqing Institute of Optoelectronics - CCDs, infrared focal plane arrays, and fibre optics

· 45th Research Institute, Pingliang, Gansu - integrated circuit production technology

· 46th Research Institute, Tianjin - silicon and gallium arsenide materials

· 47th Research Institute - reduced instruction set computing ICs

· 49th Research Institute, Northeast Institute of Sensor Technology, Harbin - vibration and other sensors

· 50th Research Institute, Shanghai Institute of Microwave Technology - automated command systems for SAM units

· 51st Research Institute - radar reconnaissance and ECM

· 53rd Research Institute, Institute of Applied Infrared Technology, Liaoning - passive jamming and optoelectronics

· 54th Research Institute, Communications Technology Institute, Shijiazhuang - military electronic systems

· 55th Research Institute - semiconductors

· 605th Factory - fibre optic cable

· 701 Factory - radios

· 707 Factory, Chenxing Radio Factory

· 710 Factory, Zhongyuan Radio Factory, Wuhan - telecommunications equipment

· 711 Factory - shipborne UHF systems

· 712 Factory, Tianjin - airborne UHF systems

· 713 Factory

· 714 Factory, Panda Electronics Factory - HF and airborne UHF systems

· 716 Factory - digital communications equipment

· 719 Factory - airborne navigation equipment

· 720 Factory - primary radar factories; co-operates with 14th Research Institute, Nanjing.

· 722 Factory - ECM plant; co-operates with 29th Research Institute

· 730 Factory - submarine cable

· 734 Factory - fibre optic cable and wireless equipment

· 738 Factory - computers; co-operates with 15th Research Institute

· 741 Factory - optoelectronics and infrared systems

· 750 Factory, Guangdong Radio Group Telecommuications Company

· 754 Factory, Tianjin.

· 756 Factory - aviation navigation equipment

· 760 Factory - troposcatter systems

· 761 Factory, Beijing Broadcast Factory - high-powered VLF systems

· 764 Factory, Tianjin Broadcasting Equipment Company - aviation navigation equipment

· 765 Factory Baoji - aviation navigation equipment

· 769 Factory - airborne UHF systems

· 780 Factory - airborne radar countermeasures

· 781 Factory - ECM and bombing control radars

· 782 Factory, Baoji - airborne radars and transponders

· 783 Factory, Fujiang Machinery Factory (Sichuan Jiuzhou Electronic Factory), Mianyang - secondary radars and I FF transponders

· 784 Factory, Jinjiang Electronic Machinery Factory, Chengdu - surveillance radars

· 785 Factory - optoelectronics, SAM guidance radars, and AAA computers

· 786 Factory, Xi'an - SAM guidance radars

· 789 Factory - AAA computers

· 834 Factory - tactical communications equipment

· 913 Factory - ECM; co-operates with 36th Research Institute

· 914 Factory, Lanxin Radio Factory, Lanzhou

· 924 Factory - radar reconnaissance and ECM; co-operates with 29th Research Institute

· 4500 Factory - computer systems

· 4508 Factory, Tianjin

· 6909 Factory - ECM

· Nanjing Radio Factory - tactical communications systems

· Nanhai Machinery Factory - airborne navigation radars

· Huajing Electronics Group, Wuxi - submicron ICs

· Huadong Computer Technology Institute - minisupercomputers

· Great Wall Computer Group - largest computer manufacturer in China

· Bejing Institute of Electronic Technology Applications - Internet firewall systems

· North China Research Institute of Optoelectronics - lidar subsystems, and infrared technologies

· Zhongchen Electronics Industry Development Corporation - systems engineering

· Zhongruan Corporation - computer software

China's largest IC producers:

· Shougang-NEC

· Tianjin-Motorola

· Huajing Microelectronics Group

· Shanghai Beijing Microelectronics Company

· Shanghai Advanced Semiconductor Corporation

· Shanghai Huayue Microelectronics.

Ministry of National Defence

25 Huangsidajie, Deshengmenwai

Beijing 100011

Jingshanqianjie, Dianmen

Beijing 100034

Tel: +86 (10) 6201-8305, 6401-1238

Fax: +86 (10) 6201-8356

The "August First" complex is China's plush, new Defence Ministry. The *China Air Defence Command Centre*, Beijing, reportedly coordinates regional aircraft and missile defences.

Ministry of Posts and Telecommunications

13 Xi Changan Jie

Beijing 100804

Tel: +86 (10) 602-3989, 601-4249

Foreign Affairs Dept. 601-1365

Telecommunications Bureau 601-1235

Ministry of Public Security (MPS)

Headquarters

14 Dongchang'anjie, Beijing

100741

Tel: +86 (10) 6512-2831

MPS First Research Institute

1 Capital Gymnasium Road South

Beijing 100044

Tel: +86 (10) 842-0099

Fax: +86 (10) 841-8801

Conducts R&D on communications systems, electronics components and accessories, and optoelectronics, related to security applications.

MPS Third Research Institute

76 Yueyang Road

Shanghai 200031

Tel: +86 (21) 6433-6810

Fax: +86 (21) 6433-3563

Conducts R&D on communications systems, measuring and control devices for security applications.

Ministry of Science and Technology (MOST)

15B Fuxing Lu

Beijing 100862

Tel: +86 (10) 6851-5544, 6851-5050, 6801-2594

Fax: +86 (10) 6801-2594

Department of Science and Technology Achievements

Technology Export Division

54 San Li He Road

Beijing 100862

Tel: +86 (10) 6801-1570, 6801-1133 ext. 3421, 6851-2614

Fax: +86 (10) 6851-2614

MOST oversees the management of aspects of China's space programme such as the National Remote Sensing Centre, and is generally responsible for developing policy and guidelines for China's scientific and technological development, and managing R&D support programmes dedicated to transitioning China to a knowledge-based economy (Spark, Torch, "863").

Ministry of State Security (MSS)

Headquarters

14 Dongchang'anjie

Dongcheng District, Beijing

100741

Tel: +86 (10) 6524-4702

Nanchang Aircraft Manufacturing Company

Hongdu Aviation Industrial Group (HAIG)

(formerly Nanchang Aircraft Company and China Nanchang Aircraft Manufacturing Company)

PO Box 5001-506

Nanchang, Jiangxi

330024

Tel: +86 (791) 251-833, 252-883

Fax: +86 (791) 251-491

Estabished in 1951, this plant produces the Silkworm SY and HY (FL-1/Fl-2/FL-3A) anti-ship missile series and Q-5III and Q-5M (export, developed with Aeritalia during the mid 1980s) attack aircraft series, N-5A agricultural and CJ-6 trainer aircraft. Nanchang's K-8 tandem-seat acrobatic jet trainer has been developed as a joint venture with the Pakistan Aeronautical Complex as a replacement for the Shenyang JJ-5 trainer and as a light-attack successor for Mig-17 derivatives worldwide. Nanchang has also produced, during the 1950s and 1960s, large numbers of CJ-5 trainers (licensed Soviet Yak-18s) and J-6 fighters. Nanchanh occipies 1,235 acres, and has 10,000 square metres of work space and a workforce during the early 1990s of 20,000.

During the 1999-2000 aerospace-defence industry reorganisation the Nanchang Aircraft Manufacturing Company was reportedly renamed (or possibly subsumed within) a new Hongdu Aviation Industrial Group (HAIG). During 2000, HAIG plans to raise some 500 million Rmb yuan by issuing "A" share on the Shenzhen or Shanghai stock markets to be used for technological upgrading and aircraft R&D. HAIG is part of the China Aviation Industry Corporation II which was reorganised from AVIC in 1999 following the re-structuring of the aerospace-defence industry.

Nanchang College of Aero-Technology

11 Shanghai Lu

Nanchang, Jiangxi 330034

Tel: +86 (791) 833-1812, 833-2372

Fax: +86 (791) 833-3248

Nanhua Power Machinery Institute

PO Box 215, Zhuzhou

Hunan 412002

Tel: +86 (733) 223-451

Fax: +86 (733) 224-142

NPMI is an aeroengine research institute under AVIC. It occupies an area of 360,000 square metres, and employs over 2,000 people, of which 50 percent are technicians and engineers. It specialises in technology for aeronautical power, mechanical transmission and testing instruments, as well as computer auxiliary equipment.

Nanjing Aeronautic Accessories Factory

PO Box 202

Nanjing, Jiangsu

Employs 5,000 personnel manufactuing fuel, hydraulic, mechanical and pneumatic aircraft accessories.

Nanjing Aeronautical and Astronautical University

29 Yudao Street

Nanjing, Jiangsu 210016

Tel: +86 (25) 646-131

Fax: +86 (25) 646-752

Seven associated colleges specialise in such areas as civil aviation, aerospace engineering, science, management and business, etc. Departments cover the areas of aircraft engineering, power engineering, automatic control, electronics engineering, mechancial engineering, aerodynamics, computer science and engineering, materials science and engineering, measurement and test engineering, etc. It has associated Pilotless Aircraft (RPV) Institute, Helicopter Institute, Light Aircraft Institute, Vibration Institute, Automatic Control Institute, Sensor and Testing Technical Institute, Electrical Engineering Institute, Electronic Engineering Institute, Aerodynamics Institute, Scientific Research and Technological Development Centre of Civil Engineering, etc. Floor space totals some 333,000 square metres, with a library collection of some one million books. Over 30,000 students have been graduated over the past four decades; currently has over 7,000 full-time students, of which some 800 are post-graduates studying for Masters and Doctors degrees. The staff complement is over 3,000.

Nanjing Chemical Industrial Group

Dachangqu, Nanjing, Jiangsu 210048

Tel: +86 (25) 779-1848, 779-2455

Fax: +86 (25) 779-2812

Nanjing Composite Materials General Factory

Youfangqiao, Yuhuaqu

Nanjing, Jiangsu 210041

Tel: +86 (25) 241-4241, 241-4244, 241-1504, 241-1609, 241-5443, 241-5444

Fax: +86 (25) 241-1504

Nanjing Defence Industry

People's Products Industrial Company

3/F, West, 275 Shengzhou Lu

Nanjing, Jiangsu 210004

Tel: +86 (25) 662-7595, 662-6981

Nanjing Honghuang Airborne Equipment Factory

PO Box 1204

Nanjing, Jiangsu 210012

Tel: +86 (25) 220-3513

Fax: +86 (25) 220-1902

This firm manufactures parachutes, arresting gear and air-training targets.

Nanjing Maritime Radar Research Institute

346 Zhongshan Beilu, Nanjing

Jiangsu 210003

Tel: +86 (25) 805-906, 805-956

Fax: +86 (25) 801-624

This institute is a subsidiary of the China State Shipbuilding Corporation, occupies an area of 220,000 square metres, and has 1,500 staff, including 800 technical personnel. It has a dozen R&D departments for such areas as radar engineering, radar systems, combat command and control systems, navigation radar, navigation and positioning systems, structures, technology transfer, electronics and power sources, quality control, measurement, and computers. It also has a small, well equipped trial production factory. Products include portable digital speed radar, contactless radio water current metre, computerised ultrasonic flowmetre, computer controlled multiple telephonometre management system, multiple-access radio system, sequence-controlled telephone exchange, medical systems, computer systems, etc.

Nanjing University of Aeronautics and Astronautics

29 Yudao Street

Nanjing, Jiangsu 210016

Tel: +86 (25) 449-2492

Fax: +86 (25) 449-9752

E-mail: uod01@dnsl.nuaa.edu.cn

Founded in 1952, this polytechnical university has a teaching staff of 3,000, and 8,000 regular students in a 360,000 square metre facility with 58 labs and a library with over 1 million books. R&D specialities are aircraft design, aerodynamics, CAD/CAM software, and mechanical manufacturing. It has developed the CK-1 RPV series. It is a polytechnical university in aerospace science and engineering under AVIC and the CAAC. Colleges and departments within the university specialise in civil aviation, aerospace engineering, aircraft engineering, power engineering, automatic control, electronic engineering, aerodynamics, materials sciences, etc. The university has various R&D institutes in such areas as pilotless aircraft, helicopters, automatic controls, sensors, aerodynamics, etc. It has graduated and trained over 50,000 students and technicians over the past four decades, currently has some 7,000 fulltime students and 3,000 distance

learning students, with a staff complement of 3,000.

Nanjing Xuguang Instruments Plant

PO Box 1206, Nanjing

Jiangsu 210012

Tel: +86 (25) 200-528

Under NORINCO, this plant covers an area of over 400,000 square metres, and has 2,000, workers including 300 senior engineers. It has research institutes specialising in product design, NC machine tools, precision instruments, fibre optics and optical technologies. Micro corridor plate (MPC) second generation electronic image multiplier technology is applied to night vision systems, X-ray and ultraviolet astronomy, electron beam fusion research and nuclear science. Major R&D and product areas include colour developing and printing systems, colour enlarging systems, machine numerical control systems, fibre optical plate and micro corridor plate systems applicable to microbeam enhancers or similar electron beam tubes for superior image transmission.

Nantong Laser Hologram Company Ltd.

115 Gongnong Lu

Nantong, Jiangsu 226008

Tel: +86 (513) 551-6166, 551-6167

Nanyang Explosion-Proof Motor Plant

22 Wancheng Lu, Nanyang

Henan 473011

Tel: +86 (371) 224-961, 225-955

Fax: +86 (371) 224-273

National Remote Sensing Centre of China

15B Fuxin Road

Beijing 100862

Tel: +86 (10) 6851-2081

Fax: +86 (10) 6851-5048

Remote sensing applications; foreign joint venture established for the interpretation of Landsat imagery recorded by a Beijing ground station. Telespazio has recently transferred Olivetti computers and Italian developed satellite imagery interpretation software, along with technical training, to the centre. Includes the Satellite Meteorological Centre of Beijing

National University of Defence Sciences and Technology

137 Yanwachi Zheng Jie

Changsha, Hunan 410073

Tel: +86 (731) 443-4601

Fax: +86 (731) 444-8307

Also has offices in Shenzhen, Fuzhou and Nanjing. Established in 1954, this institute of higher learning offers bachelor, masters and doctorate degrees. Has conducted R&D on the "Yinhe (Milky Way)-1 one million times giant computer, the Yinhe-2 one billion times giant computer" (parallel supercomputers), digital simulation/emulation computers, Zhinu series of sounding rockets, walking robots, magnetic suspension train prototype, photo-electronics, modulating broadcasting systems, large-screen display systems, high-speed data collecting and processing systems, and precision machine tools control and image monitoring systems. Organisation includes an experimental factory, Yinhe computer factory, and operating enterprises. Products include various types of computers, telephone exchanges, intelligent alarms, and machinery such as numerical controlled machine tools. It has ten departments, twelve research centres, and eight research institutes, and offers both graduate and undergraduate degrees in a variety a technical disciplines. It has a faculty of 1,600 full and part-time members, of whom 208 holed professorships and 630 are senior engineers and associate professors.

Ningbo Tongmuo Powder Metallurgy Company Ltd.

147 Jiangdong Nan Lu

Ningbo, Zhejiang 315040

Tel: +86 (574) 783-3776

Fax: +86 (574) 783-1133

Foreign joint venture.

North China Research Institute of Electro-optics

Thermal imaging and laser R&D.

Northeast Machinery Plant

42 Zhengxin Road, Dadong

Shenyang, Liaoning 110045

Tel: +86 (24) 890-207

Fax: +86 (24) 891-170

Affiliated with NORINCO, this plant occupies an area of 44 square kilometres and employs 13,000 people, including 4,000 engineers, technicians and managers. It has 14 sub-factories and 13 workshops, and a 4.7 kilometre feeder railway line and independent water and power supply systems. It is the standardisation centre for the NORINCO Group, a "new technology popularisation station", a precision machine tool repair centre, a welding centre, and the location of the Northeast China regional measuring station.

Northwest Polytechnical University

127 Youyin Road West

Xi'an, Shaanxi 710072

Tel: +86 (29) 849-3119, 849-2261

Fax: +86 (29) 525-0199

This university has some 1,000 professors and 10,000 enrolled students in 540,000 metres of facilities that include 9 colleges, 89 labs, and a library with 1.4 million books. R&D areas include weaponry science and technology, aircraft structural strength, computer science and information engineering, underwater technology, aircraft structural strength, lightweight RPVs (eg. D-4, B-9, Z-5, T-6), materials 'hot working technology', computer integrated manufacturing systems (CIMS), vibration, industrial robots, automatic controls, composite materials, computational themophysics, electromagnetics, advanced airfoils, advanced dipping sonar, space technologies, etc. Formed from the former Northwestern Engineering Institute and Xian Aeronautical Institute in 1957, and subsequently joining with the Harbin Engineering Institute in 1970, NPU has subordinate Key State Laboratories that include:

· State Key Laboratory of Solidification Processing (eg. artificial crystals, single crystal and directional solidification, rapid solidification, metallurgical quality control, structural ceramics, etc.).

· State Special Laboratory of Thermal Engineering Information Processing (simulation technique of thermal machinery, etc.).

· Acoustic Engineering and Detection Technology Laboratory.

· Laboaratory of Aeronautical Fluid Dynamics (including largest two dimensional low-speed wind tunnel in Asia, plus a 3-D laser velocimetre, infrared imaging system, etc.).

· National Specialty Laboaratory of CAD/CAM.

Nuclear Industry Physiochemical

Engineering Research Institute

168 Jintang Road, Hedong

Tianjin 300189

Tel: +86 (22) 490-605

Fax: +86 (22) 491-190

This CNNC institute is an applied technology research organisation specialising in lasers, chemicals, machinery, automation, raw materials, and physiochemical analysis. It has 800 researchers and technical personnel. It has undertaken nuclear industry environmental impact analyses for Nanjing, Tianjin, and large mining areas, and performs, nuclear waste treatment and storage R&D.

Nuclear Industry 6th Institute

PO Box 48, Hengyang

Hunan 421001

Tel: +86 (734) 822-3681, 822-3682

Fax: +86 (734) 822-6415

Nuclear Power Institute of China

PO Box 291

Chengdu, Sichuan 610005

Tel: +86 (28) 558-2199

Fax: +86 (28) 661-1021

Number Two Research and Design Institute

of the Nuclear Industry

1 Mashenmiao, Huchengmenwai

Beijing 8423311

Tel: +86 (10) 842-3311

Fax: +86 (10) 841-8086, 841-5067

Plays a major role in China's fission and fusion nuclear weapons programmes, and nuclear submarine reactor power systems. Formerly known as the *Beijing Nuclear Engineering Research and Design Institute*, this institute has a complement of 2,035 workers, of whom 1,678 are engineers and technicians. Active in all major aspects of nuclear R&D, including the design and construction of the Qinshan, Daya Bay and Guangdong nuclear power plants. Defence conversion activities include the design of breweries, thermal power plants, waste disposal projects, and major civil engineering and factory designs. Located in Haidian District, Beijing's special economic zone, the institute has established spin-off ventures including the BINE New Technology Development Company, Beaney In-Line Analysis Technology Development Company, BINE Cleaning Technology Development Company, BINE Water Supply and Sewage Development Company, and the BINE Automatic Control Technology Institute, and is quite active in the technical fields of automatic control, water supply, sewage discharge and in-line analysis. Branches have been established at Shenzhen, Beidaihe, and Hainan.

Number 41 Research Institute of the Ministry of Machine Building and Electronics Industry

PO Box 101, Bengfu

Anhui 233006

Tel: +86 (552) 245-183

Fax: +86 (552) 482-977

This institute is China's centre for the R&D of electronic measuring and surveying instruments, including microwave, millimetre wave, "parameters of elements", and photoelectronic systems. Specialised research in microwaves, electronic circuits, computers and optical technology, precision machinery and processing technology.

Number 54 Research Institute

Mobile satellite communications earth stations, narrow-band small capacity over-the-horizon microwave communications systems, and satellite TV receiver R&D.

Number 615 Research Institute

R&D on avionics, electromagnetic interference (EMI) filters, microprocessors, emulators, large screen multi-functional display systems, etc.

Number 809 Institute of the Shanghai Space Bureau

492 Anhua Road, Changning

Shanghai 200050

Tel: +86 (21) 252-2530

Fax: +86 (21) 252-496

This is a scientific R&D unit under the CAIC that primarily undertakes military space projects that integrate R&D, design, trial operation and production in the areas of computers, automatic launch systems, and control and test equipment. It has over 800 workers, including 360 engineers and technicians, and is organised into four military mission research offices and two workshops. Facilities total 15,800 square metres, with fixed assets of over 10 million Rmb yuan. Equipment includes CAD work stations, over 1,500 radio and electrical apparatuses, 20 mini computers, a complete set of testing equipment for ageing, screening and testing electronic parts, 50 metal cutting machines and two assembly lines.

Number 8511 Institute

Nanjing, Jiangsu

Directly under the CAIC, this institute has 240 engineers and technicians engaged in the R&D and manufacture of electronic systems. It is organised into eleven research offices, a trial production workshop, a microwave production line, electronic engineering, computer applications, mechanical design and application chemicals, along with speciality areas for radio testing, data information and other areas. The institute also has a working relationship with the Ministry of Public Security for the development of various sensor and alarm systems.

Panda Electronics Group Company

301 Zhongshan Dong Lu

Nanjing, Jiangsu 210002

Tel: +86 (25) 664-1442, 440-7148, 440-0855

Import/Export Company 664-7482, 440-8817

Fax: +86 (25) 440-5030

Dual-use technologies; lead factory formerly named the Nanjing Radio Factory. Has 9,500 employees, of which 3,500 are engineers and technicians in the base company. Total group comprised of 173 enterprises, institutes and other facilities in twenty provinces, including 12 "wholly-owned" enterprises and 15 stock-holding corporations. R&D and product emphasis on short wave communications, HF SSB communication system, VHF/UHF mobile and satellite communications systems and uninterrupted power supplies. Current products include TVs, VCRs, and digital switches, with product development in multimedia PCs, fax machines, mobile-phone base stations, and airborne transmitters. Industrial output worth over 5 billion Rmb yuan by mid-1990s. Employee share-ownership plan instituted in 1992, and firm listed on the Hong Kong stock exchange in 1993. International co-operation agreements with Motorola, Ericsson (mobile communications equipment), Rockwell International, and other major Western firms.

Pingyuan Machinery Plant

PO Box 5

41 Jiefang Road, Xinxiang

Henan 453019

Tel: +86 (373) 202-1233

Fax: +86 (373) 202-0641

Under AVIC and a division of the Xinxiang Aeronautical Machinery Corporation, this is a specialised manufacturer of hydraulic, pneumatic, engine oil and loop control valves and various filters, and is the largest filter plant in China. It has over 3,700 employees, of which some 1,000 are engineers and technicians. Covering a total area of 310,000 square metres, the plant has buildings with floor space totalling 92,000 square metres, 1,000 machines and facilities, and fixed assets of 420 million Rmb yuan. The plant consist of over six subplants and four workshops for machining, stamping-welding, hot and surface treatment, plastic moulding press, vulcanisation, engineering assembly and nonstandard facilities manufacturing. Testing facilities include a cryogenic lab, thermokinetic lab, vibration test bed, etc. The firm has NC tool systems and ISO9000 quality certification.

PLA Factory Number 3530

Xianyang Zhongxing Printing and Dyeing Mill

Xianyang

Xi'an, Shaanxi 712099

Tel: +86 (29) 341-2276, 341-2278

Fax: +86 (29) 341-2288

PLA Science and Technology Exchange Centre

PLA Logistics Science and Technology Development and Exchange Centre

22-A1 Fuxinglu

Beijing CH-100842

Tel: +86 (10) 6822-5207

Fax: +86 (10) 6822-5207

PLAAF Engineering Design and Research Institute

12 Yangqiao, Yongding Menwai

Beijing 100077

Tel: +86 (10) 721-2277, 721-2548

Under the PLA General Logistics Department, this institute has a staff complement including some 140 engineers. Has provided military and civilian airport design services, airport pavement test and evaluation, engineering reconnaisance, underground engineering, computer software development, dynamic structural experiments, aerial mapping, hydrographic and geologic analysis, uninterrupted power supply installation development, transducer development, and geotechnics test data automatic collecting and processing equipment.

Poly Electronic Technologies Inc.

7/F, Instrument Bldg., 25 Xibinhe Lu

Andingmenwai, Beijing 100011

Tel: +86 (10) 426-3302, 426-3316

Fax: +86 (10) 421-9681

Poly Electronic Technologies Inc. is a foreign joint venture; relationship to parent firm is not known.

Poly Technologies Incorporated (subsidiary of the China Poly Group)

5/F CITIC Bldg.

19 Jian Guo Men Wai Lu

Beijing

or Baoli Tower

14 Dongzhimen

Beijing 100027

Tel: +86 (10) 500-3334

Fax: +86 (10) 500-4484

Reports to the PLA's General Equipment Department, affiliated with the China International Trust and Investment Corporation (CITEC), and is the PLA's purchasing arm. General arms exporter, including advanced systems reportedly not yet in use by the PLA. Key activity area is armaments trading for such products as complete air defence command and control systems, mortars and ammunition, anti-tank mines, fast attack missile craft, Hoku/Hegu class patrol boats, etc., and PLA surplus equipment (eg. intermediate-range DF-3/CSS-2 ballistic missiles that were exported to Saudi Arabia).

Purple Mountain Observatory

Purple Mountain, Nanjing

Astronomy, physics and satellite dynamics.

Qing'an Aerospace Equipment Corporation

Qing'an Group Corporation Ltd.

PO Box 20, Xi'an

Shaanxi 710077

Tel: +86 (29) 426-2193, 426-2174, 425-6603

Fax: +86 (29) 426-2235

Offices also located in Beijing, Shanghai, Guangzhou, Fuzhou, Tai'an and Shenzhen. Founded in 1955, QAEC is a subsidiary of the AVIC, and specialises in the production of airborne equipment such as remote control armament launching systems, actuators, boosters, servovalves, hydraulics and pneumatics, and electronic and electrical systems. It is the core enterprise of the Qing'an Group. Staff numbers over 9,000, with engineering and technical staff accounting for 13 percent. Facilities cover 700,000 square metres, with building floor space totalling 380,000 square metres. It owns a 2.58 kilometre long feeder railway and 2,000 sets of various processing and testing equipment. It has four subordinate research institutes and fourteen subsidiaries, and sterong capabilities in such areas as NC, quality, CAM and standardisation . Assets total some 940 million Rmb yuan. Areas of specialisation include the R&D, design and production of precision machinery, pneumatic and hydraulic products, automatic controls, rubber sealing parts, engineering plastics, special welding, casting, and non-standard tools and dies. It has developed microprocessor control systems for NC machine tools. Joint ventures include Space Standard Parts Company and the Qing'an Instrument and Metres Company, Shenzhen.

Qingdao Qianshao Machinery Factory

11 Luoyang Road

Qingdao, Shandong 266045

Tel: +86 (532) 485-2028, 485-6190, 485-5619

This firm produces precision aerospace measuring tools.

Qinghua Machinery Factory

Qinghua Street

Changzhi, Shanxi 046021

Tel: +86 (355) 32-634

Products include launch vehicle systems, rocket transporters, aerospace hydraulic systems, etc.

(Shaanxi) Qinling Electric Corporation

PO Box 45

Xingping, Shaanxi 713107

Tel: +86 (910) 882-2801, 882-2837

Fax: +86 (910) 882-2843

Founded in the early 1950s, this company is now a major national R&D and production centre for main power supplies and aeroengine ignition systems. This firm produces airborne power supplies and aeroengine ignitions, generators, AC voltage regulators, protectors, controllers, group control units, electromagnetic and mechanical hydraulic constant speed drives, and integrated drive generator inverters. Facilities cover 1.65 million square metres, including a floor space of 150,000 metres, and include over 7,100 employees of which 860 are technicians and engineers, and over 3,300 major pieces of equipment. It has five design and research institutes and 14 specialised factories, and is ISO9001 certified.

Qiuxin Shipyard

132 Jichang Road

Shanghai 200011

Tel: +86 (21) 328-9830

Fax: +86 (21) 377-2100

Subordinate to the China State Shipbuilding Corporation, this shipyard occupies an area of 140,000 square metres, with 100,000 square metres of floor area, has over 4,000 employees, including 700 engineers and technicians, various slipways, docks and wharves, and 1,366 sets of equipment. Designs, builds, repairs and refits military and civilian craft. Undertakes the manufacture and installation of large metal structures, non-standard machinery, electrical equipment, automobile repair and indoor decoration.

Has acquired US processing technology for Boeing hydrofoil craft Type 929-115.

Research Centre for Space Science and Application

Academia Sinica

PO Box 8701

Beijing 100080

Research Institute of Nuclear Power Operations

PO Box 74501, Wuhan, Hubei 430074

Tel: +86 (27) 701-701

Fax: +86 (27) 701-701

and

Wuhan Development and Advisory Service Centre

for Science and Technology in Nuclear Industry

5 Boacheng Road, Hankou, Wuhan, Hubei

Reportedly "it is China's only scientific research unit for studies of nuclear power operation techniques combining military with civilian projects". CNNC has invested 42 million Rmb yuan on RINPO in two phases for the construction of laboratories, facilities and living quarters. It occupies an area of seven hectares and has a total floor space of 36,800 square metres. Staff number some 460, over 75 percent of which are engineers and technicians. The associated Wuhan Development and Advisory Service Centre for Science and Technology in Nuclear Industry (Number 5, Baocheng Road, Hankou) is a CNNC "window" for the popularisation and transfer of various technologies to other industries in the central south China region. Important R&D activities are concentrated on the Qinshan and Daya Bay nuclear power facilities, and the overall design and development of nuclear power equipment. Since 1986 RINPO has established business relationships with the International Atomic Energy Agency (IAEA), World Association of Nuclear Power Operators, and has technical agreements and business agreements with various nations including the United States, France, Canada, Russia, Germany, Britain, Pakistan and Korea. R&D and production units include:

· Research and Appraisal Centre for Nuclear Power Operations

· Research Centre for Nuclear Power Emulation Technique

· Nuclear Power In-Service Testing Centre

· Nuclear Power Training Centre

· Quality Control and Supervision Centre

· CNNC Nuclear Accidents Emergency Technical Support Centre

· Nuclear Power Equipment Research and Design Office.

Research Institute of Physical and Chemical

Engineering of Nuclear Industry

168 Jintang Lu

Tianjin 300180

Tel: +86 (22) 439-0605, 439-0608, 439-1082

Fax: +86 (22) 439-1190

Research Institute of Production Technology for

Military Supplies, General Logistics

PO Box 326

71 Lumicang, Dongchengqu

Beijing 100010

Tel: +86 (10) 513-5551

Research Institute of Surveying and Mapping

16 Bei Tai Ping Lu

Beijing 100039

Tel: +86 (10) 6821-2277

Remote sensing applications; joint venture established for the analysis of SPOT remote sensing imagery with Tradeglobe.

Research Institute of Uranium Mining

PO Box 48, Hengyang, Hunan 421001

Tel: +86 (734) 223-681

Conducting dual-use activities under CNNC, the RIUM is one of China's main research institutes for the R&D of dipping and surfacing of non-ferrous metals such as uranium, gold and copper, and has been a leader for uranium mining techniques since its establishment in 1962. It has over 500 workers, of whom some 37 are technicians. It has fixed assets totalling over 14 million Rmb yuan and a floor space of 42,000 square metres. R&D technologies include the solvent mining method for uranium mining, heap leaching technology for uranium, etc. RIUM has engaged in international co-operation and exchanges with eight nations including the United States, Russia, Japan and Yugoslavia.

Sanjiang Machinery Plant

PO Box 51

72 Minjing Road North

Yibin, Sichuan 644007

Tel: +86 (831) 221-956, 221-722, 223-931 ext. 5, 226-931

Fax: +86 (831) 221-956

This aviation equipment manufacturer is affiliated with the AVIC. It employs over 2,500 staff, including 500 technicians specialising in the R&D, design and production of aeronautic hydraulic, pneumatic and atmospheric pressure systems, aircraft fuel system accessories, ejection systems, fuel, oil, and ammunition. Facilities include R&D, testing and inspection systems.

Sanjiang Space Group

91 Qianjin Road, Liuduqiao

Wuhan, Hubei 430022

Tel: +86 (27) 552-445, 564-037

This firm (or 'Base 066') has offices in Shenzhen and Beijing, and production bases in Yuan'an, Anjian and Xiaogan. Subordinate to the CAIC, this large enterprise group engages in the R&D and production of space systems. It has 16,000 staff, with 34 percent of these professionals, including some 2,460 engineers. The group has floor space of 1.25 million square metres and owns 8,500 sets of metal cutting and forging equipment, and 6,000 instruments and metres. The group has five research institutes and over 100 member enterprises and research and production bases. Its primary activities are the R&D of solid-fuelled tactical ballistic missiles and stealth/counterstealth technology. Base 066 was established in August 1969 as a Third Line production base for 3rd Academy anti-ship missiles. In 1975, it began independent R&D of M-11 missile, designed by Wang Zhenhua, who completed system R&D in 1984. Subordinate organisations include:

· Sanjiang Space Group Design Institute

· Hubei Redstar (Hongxing) Chemical Institute, 42nd Research Institute, Xiangfan, Hubei

· Hubei Hongfeng Machinery Plant, Yuan'an - electromechanical integration

· Wanshan Special Vehicle Machinery Factory, Yuan'an

· Hubei Jianghe Chemical Factory, Yuan'an

· Xianfeng Machinery Factory, Yuan'an

· Wanli Radio Factory, Yuan'an

· Honglin Machinery Factory, Xiaogan

· Hubei Hongyang Machinery Factory, Yuan'an

· Jiangbei Machinery Factory, Yuan'an

· Wanfeng Factory, Yuan'an.

Satellite Communications Experimental Station

Nanjing Radio Factory

Weigang

Nanjing, Jiangsu

771 Mine of Zhejiang Chengyuan Industry General Company

PO Box 6, Quzhou

Zhejiang 324008

Tel: +86 (570) 294-1771

Fax: +86 (570) 294-1771

Produces uranium-radium-vanadium ores.

Shaanxi Aeronautic Carbide Tool Company

PO Box 9

Mian, Shaanxi 724200

Tel: +86 (916) 220-2028

Fax: +86 (916) 220-2025

Founded in 1968, this AVIC affiliated firm produces precision measuring and carbide tools and indicators. It has over 2,300 employees, including 170 technicians and engineers, occupies over 250,000 square metres, and has various specialised equipment such as NC machines, an electron scanning microscope for tests, and carbide powder metallurgy systems. It is ISO9001 quality certified.

Shaanxi Aircraft Company

PO Box 35

Chenggu, Shaanxi

723215

Tel: +86 (916) 221-4974, 221-4976, 220-2035

Fax: +86 (916) 220-2031

Founded in the early 1970s, this firm has co-operated with Lockheed in the modification of the Y-8 medium transport during the late 1980s to improve general design and flight characteristics; Western military and FAA production standards transferred. The firm has continued production of the Y-8 four turboprop aeroengine dual military/civil transport aircraft. It has a workforce of approximately 10,000, including some 1,400 engineers. Its production area is over 380,000 square metres and includes 4,000 major pieces of equipment. Major capabilities exist in NC and other advanced manufacturing systems.

Shaanxi Chemical Import and Export Corporation

37 Lianhu Lu

Xian, Shaanxi 710003

Tel: +86 (29) 721-4169, 721-8922

Fax: +86 (29) 721-7327, 728-4309

Possible production of chemical warfare agents.

Shaanxi Institute of Applied Physics and Chemistry

20 Zhuque Street

Xi'an, Shaanxi 710061

Tel: +86 (29) 754-515, 55-881

This institute specialises in the chemistry and physics of explosives, fireworks, electronics instruments and precision machinery. It occupies over 95,000 square metres and employs 800 workers, 547 scientific and technological personnel and 74 senior engineers. Application areas include defence and aerospace products.

Shaanxi Huaxing Aircraft Wheel Corporation

PO Box 48

Xingping, Shaanxi 713106

Tel: +86 (910) 882-2713

Fax: +86 (910) 882-2745

Founded in 1956, this AVIC firm develops and produces aircraft wheel and braking accessories, hydraulic and pneumatic accessories, large magnesium alloy castings for aircraft structural components and aeroengine casings, etc. It has 390,000 square metres of production floor space, 2,200 pieces of major equipment, 7,800 employees, and fixed assets of 266 million Rmb yuan. The Number 46 Research Institute of wheen and braking systems is subordinate to the firm, and is a national quality and test centre for this area.

Shaanxi Liaoyuan Aero-Mech Corporation

PO Box 43

Yang Xi'an, Shaanxi 723313

Tel: +86 (916) 830-7209

Fax: +86 (916) 830-7043

This is a specialist manufacturer of aircraft landing gear, hydraulic and pneumatic accessories, and rubber and plastic parts. It has some 3,000 staff, has a production area of 60,000 square metres, and assets of 150 million Rmb yuan. It is ISO9000 certified, and has a wide array of CNC equipment and other major manufacturing and testing systems. It claims that its special processing technologies standards are up to US MILSPEC standard.

Shaanxi Lingnan Machjinery Corporation (067 Base)

Shaanxi

Reportedly an R&D centre for liquid engines and inertial guidance systems for launch vehicles that has over five associated research institutes and four factories and over 1,100 personnel:

· Shaanxi Engine Design Institute

· Bejing Fengyuan Machinery Institute

· Shaanxi Institute of Power Test Technology

· Xi'an Changda Precision Electromachinery Institute

· Shaanxi Hongguang Machinery Factory

· Shaanxi Cangsong Machinery Factory

· 16th Research Institute

· 165 Research Institute

· 204 Factory

· 710 Factory

· 7103 Factory, Hongguang

· 7107 Factory

· 7171 Factory - inertial devices.

Shandong Chemical Plant

PO Box 152

1 Xinchengzhuang, Beijiao

Jinan, Shandong 250033

Tel: +86 (531) 552-544

Fax: +86 (531) 552-544 ext. 254

This arms production plant is over 100 years old and is now an affiliate of NORINCO. It has 3,000 workers, over 300 of which are engineers and technicians. The plant occupies 800,000 square metres, with building floor space totalling 200,000 square metres. Organisation includes an R&D institute and a testing and metering office. A two km. feeder railway connects the plant with the Tianjin-Shanghai trunk railway. It has an annual output value of some 100 million Rmb yuan. R&D interests in new adhesives, high polymer materials, and advanced composite materials.

Shandong Machinery Plant

Shitanwu, Boshan, Zibo

Shandong 255201

Tel: +86 (533) 410-218

Fax: +86 (533) 412-602

Affiliated with NORINCO, this plant has 6,000 employees, including 400 technicians. The plant occupies an area of 2.7 million square metres, with building floor space totalling 160,000 square metres. Total fixed assets are valued at 100 million renminbi Rmb yuan and include 2,000 pieces of equipment (including 588 metal cutting machines, 156 forging machines, 70 large and precision machines and 13 computers). Primary emphasis is on physio-chemical testing for arms production, and the operation of the plant includes casting, forging, stamping, mechanical processing, assembling, die making, heat treatment, surface treatment and pressure container design and manufacturing. Products include hydraulic presses, textile machines, dynamite equipment (dual-use), plastic case sound bomb to detect depth and quantity of oil fields based on the theory of the spread and reflection of sound waves, kiln bomb to clean the accretion of kiln inner chambers, and bainite dectile iron grinding ball and tubings.

Shandong Non-Metallic Materials Research Institute

PO Box 108

120 Xincheng Street, Tianqiao

Jinan, Shandong 250033

Tel: +86 (531) 554-487, 554-488

Serving the defence industry, R&D and product emphasis is on: theories of macromolecular synthesisation, insulation for ablation, functions of materials dynamics mechanics, and non-destructive testing; development of resin-based compound materials, functional materials, special adhesives, ablation materials, agent coupling, special coverings, rubbers and plastics; materials choice, structure designs, mould design and construction, technical formation and specific equipment; testing and analogue of physiochemical, mechanical, ageing functions of non-metallic materials; appraisal of non-metallic materials, sample examination, testing methods, industrial standards, chemical metering, and inspection of import/export commodities. Organisation includes a machinery plant, a chemical materials testing plant, and a plastic formation factory. Future R&D interests in advanced composite materials, special fibre reinforced materials, precision chemical products, plastic formation technology, high quality engineering plastics, functional plastics products, refined alloy and porcelain products.

Shandong Optoelectronic Instruments Plant

PO Box 40, Tai'an

Shandong 271039

Tel: +86 (538) 333-346, 334-623

A subsidiary of NORINCO, this plant employs nearly 1,000 people, including 230 technical and research specialists, occupies an area of 120,000 square metres, has some 500 pieces of equipment, and a fixed asset value of over 25 million Rmb yuan. It produces incandescent, infrared and laser finder optics for military use. In 1991 it imported US laser holography narrow moulded products technology and complete production line, and launched a joint venture with a US firm for holographic products. Plans to import a plant for fibre testing instruments production.

Shanghai Academy of Spaceflight Technology

Shanghai Aerial Survey Instruments Factory

330 Shuangyang Lu

Shanghai

Shanghai Aeroengine Manufacturing Plant

PO Box 300

600 Guang Zhong Road

Shanghai 200083

Tel: +86 (21) 5665-0644

Fax: +86 (21) 5665-1482

Affiliated with the Shanghai Aviation Industrial Corporation, this firm employs 1,500 staff of who over 400 are technicians and engineers, and manufactures the WS8 tubofan aeroengine, the 3K42 light gas-turbine engine, and various aeroengine components. It has floor space of 56,000 square metres and 600 sets if major equipment. It has three subordinate factories and various affiliated joint ventures. Advanced manufacturing capabilities include plasma spraying, Ni-Cd plating, shot peening, titanium alloy welding, fracture surface analysis with electronic microscopes, high temperature ceramic spraying, etc. It has specialised equipment such as 1,000 ton hydraulic press, NC and CAD/CAM systems, etc.

Shanghai Aeronautical Machinery Plant

PO Box 254

100 Zhangwu Road

Shanghai 200092

Tel: +86 (21) 541-5590

Fax: +86 (21) 545-6373

This firm is a major manufacturer of aero-hydraulic and other aviation products.

Shanghai Aeronautical Measurement Controlling Research Institute

PO Box 020-058

Shanghai 200030

Tel: +86 (21) 6439-7490

Fax: +86 (21) 6438-1447

This institute was founded in 1962 to undertake R&D on aeronautical measurement and control techniques, and related systems such as integrated optics, electronics and mechanics. It has some 1,000 employees conducting R&D in aeroengine testing, on-line diagnostics, aircraft structural strength mode analysis, automatic controls, laser applications, dynamic signal processing, etc. The institute has developed the industrial robot SIR-II.

Shanghai Aerospace Bureau

Institute Number 809

492 Anhua Lu

Shanghai 200050

Tel: +86 (21) 6252-2530

Fax: +86 (21) 6252-4596

Shanghai Aircraft Manufacturing Factory

PO Box 436-840

Baibuqiao, Wanping Nan Lu

Shanghai 200232

Tel: +86 (21) 6438-3311, 6438-4518

Fax: +86 (21) 6439-0471

A division of the Shanghai Aviation Industrial Group of China, this plant undertakes dual-use aviation functions such as manufacturing, repair and overhaul, aircraft parts and components. Under the AVIC, consists of the Longhua and Dachang sites which are separated by 20 kilometres. The plant has a total of some 5,000 employees including 1,600 engineers and technicians. It covers a total area of 1.3 million square metres and has floor space of 478,000 square metres, and 2,000 major pieces of equipment. There are extensive CAD/CAM systems, nine imported NC machine tools, a 4x18 metre numerical control 3-axis 5-coordinate milling planer, a 400 ton numerical control skin stretch mill and a 45,000 ton rubber bag hydraulic press. Labs conduct mechanical functions, chemical and metallographic analysis. Technical areas include machining, manufacture of metal and non-metal honeycombs, advanced composite materials manufacturing, casting of magnesium alloys, manufacture and test of electrical appliances, metal surface and hot treatment and flaw detection, and the firm has an overall advanced aircraft production capability including high levels of quality certification. Advanced management techniques transferred from the former McDonnell Douglas during sub-contract for the co-production and assembly of the MD-80/82/83 transport aircraft series. It manufactures the complete indigenous Quickie Q-2 and SB-582 microlight aircraft and indigenous Y-7 transport, hovercraft, Boeing 737-700 horizontal tails, and during the 1970s developed the prototype Y-10 jet transport aircraft which currently may be revived in some form. It has participated with the multinational AE100 transport aircraft programme.

Shanghai Aircraft Research Institute

PO Box 232-003

Shanghai 200232

Tel: +86 (21) 6438-8606

Fax: +86 (21) 6439-0584

This institute is a member of the Shanghai Aviation Industrial Group and is a specialised AVIC R&D centre. It has some 900 employees, with 75 percent being engineers and technicians. It has 9 research departments, 8 labs, a computer centre, a subordinate factory, and undertakes R&D in aerodynamics, airworthiness, reliability, stress analysis, structures, electronics, controls and hydraulics, powerplants, etc., related to large transport aircraft. It has the largest simulation test facility for aircraft systems in China. The institute has been active in large transport aircraft development programmes such as the indigenous Y-10 jet passenger transport during the 1970s, developing a presurised cabin version of the Y-8 transport during the 1980s, and participating with the 'ultra high bypass technology readiness programme' of the former McDonnel Douglas Corporation, as well as MD-82 and MD-90 trunk airliner work. It has participated with the recent international AE-100 airliner programme, as well as indigenous helium airship designs.

Shanghai Astronautics Bureau

805 Research Institute

819 Jiang Chuan Road

Min Hang District

Shanghai 200240

Tel: +86 (21) 430-1251

Fax: +86 (21) 430-2254

Provides launch services and organisation, launch vehicle R&D direction for the Long March 4 (three stages) and Long March 2 (two stages) launch vehicles. Controls ten research institutes and six factories, with a total workforce of 30,000.

Shanghai Astronautics Bureau Systems Laboratory

100 Hua Yin Road

Ming Hang District

Shanghai 200240

Tel: +86 (21) 435-8251

Research, development, design and manufacture of space launch vehicles and the provision of launch services.

Shanghai August First Film Machinery Factory

910 Quyang Road

Shanghai 200437

Tel: +86 (21) 6531-5160

Fax: +86 (21) 65742-0124

This factory is a major film machinery and camera producer, employs 1,200 people, including 135 engineers and technicians, occupies an area of 90,000 square metres, and has fixed assets valued at over 34 million Rmb yuan. Has developed products including 35mm moving film projectors, stationary film projectors, panorama projectors, colour film processing machines, copying machines, optical medical instruments, cameras, printing machines, etc.

Shanghai Aviation Equipment Works

990 Chanping Lu

Shanghai 200042

Tel: +86 (21) 6253-1335, 6255-2312

Shanghai Aviation Industrial (Group) Corporation (SAIC)

29th Floor, 2650 Zhongshan Beilu

Shanghai 200063

or 3113 Changzhong Road

Shanghai 200436

Tel: +86 (21) 6257-3351

Fax: +86 (21) 6257-3350

The SAIC conglomerate co-produces aircraft and components with international partners, and is organised into over twenty enterprises and research institutes, including the following enterprise divisions:

Aero Casting Forging Corporation

Aero Materials Supply and Marketing Corporation

Aero Products Marketing Corporation

Aviation Industrial (California) Corporation

Changzhou Aircraft Factory

Hongtu Aircraft Factory

Shanghai Aeroengine Manufacturing Plant

Shanghai Aircraft Manufacturing Plant

Shanghai Aircraft Research Institute

Shanghai Aviation Industrial (Group) Corporation

Shanghai Far East Aero-Technology Import/Export Corporation.

SAIC has fixed assets of over 500 million Rmb yuan, some 15,000 employees, 2,500 primary pieces of primary manufacturing equipment (including recent imported NC systems and hydraulic presses), and 480,000 square metres of production area. In addition to aircraft it produces hovercraft.

Shanghai Aviation Maintenance Engineering Company

Longhua Airport

Shanghai 200232

Tel: +86 (21) 438-4911

Fax: +86 (21) 438-4988

Shanghai Aviation Standard Pieces Factory

351 Xiaomuqiao Road

Shanghai 200032

Tel: +86 (21) 431-3038

Shanghai Avionics Corporation

PO Box 052-312

Shanghai Technology Park, Caohejing

Shanghai 200052

Tel: +86 (21) 6485-1817 (switchboard), 6280-2764, 6485-4238

Fax: +86 (21) 6485-0150, 6280-2662

This AVIC firm was based upon the former Chinese Aeronautical Radio Electronics Research Institute and the former Shanghai Aero-Electrical Appliance Plant. It has registered capital of over 100 million Rmb yuan, 2,500 employees, including 800 engineers and technicians, and has advanced facilities that include a system simulation laboratory, microwave anechoic chamber, environment test lab, computer centre, CAD lab, and an optical illumination lab. It main areas of R&D and product development include avionics and systems integration technologies, digital simulation, radio communications, radar, computer and software, display control, microwave test and measurement, electromagnetic compatibility, optical fibre data communications, aeronautical illumination, etc. It has developed integrated aircraft electronic and control systems, data transmission equipment, integrated processing systems, Doppler navigation systems, satellite navigation landing systems, GPS navigation systems, digital map systems, fibre optics, etc. It claims its avionics technical sophistication is now at the international level.

Shanghai High and New Technology Industry Development Zone

30 Fuzhou Road

Shanghai 200002

Fax: +86 (21) 470-0247

Includes aircraft and space technology activities.

Shanghai Huayin Machinery Plant

Shanghai

Produces and tests satellites and related subsystems and components, including complete meteorological satellite systems.

Shanghai Institute of Laser Technology

770 Yishan Lu

Shanghai 200233

Tel: +86 (21) 6470-0560, 6470-0629

Science and Technology Directorate 6470-0973

Sales Division 6436-1584

Fax: +86 (21) 6470-0037

Shanghai Institute of Nuclear Research

Chinese Academy of Sciences

PO Box 800-204

Shanghai 201800

Tel: +86 (21) 5953-0998, 5952-9630

Fax: +86 (21) 5952-8021

Shanghai Institute of Satellite Engineering

Founded in 1969, has developed satellites including the FY-2, China's first geostationary weather satellite, and the FY-1 series of polar orbiting remote sensing satellites. Previously a part of CAST, it was subordinate to CALT following a reorganisation in 1993.

Shanghai Laser Group Company Ltd.

Bldg. 12, 470 Guiping Lu

Caohejing, Shanghai 200233

Tel: +86 (21) 6485-2848

Fax: +86 (21) 6485-1293

Shanghai Leiou Laser Equipment Factory

450 Qinghe Lu, Jiading

Shanghai 201800

Tel: +86 (21) 5953-4351

Fax: +86 (21) 5953-3902

Shanghai Marine Diesel Engine Research Institute

Lane Number 105, Qinghai Road

Shanghai 200041

Tel: +86 (21) 253-0009

Fax: +86 (21) 255-1934

Under the Administration of the Number Seven Institute of the China State Shipbuilding Corporation, this institute has over 1700 staff, of which over 950 are engineers and technicians, building floor space of 73,470 square metres, R&D departments in diesel engine and power devices, 12 specialised research offices, two large experimental stations, and a trial production factory. Has developed high-speed marine engines, China's first water-free cold ceramic motor, electronics and electrical systems, computer systems applications, etc. Has developed the aspherical holographic polariscope for COSTIND, a nonspherical holographic photoelastic device that is used for aerospace, nuclear, radar, communications and other applications.

Shanghai Marine Electronic Equipment Research Institute

(formerly Shanghai Number 22 Radio Factory)

390 Jianguo Donglu

Shanghai 200025

Tel: +86 (21) 326-3434

Fax: +86 (21) 320-3132

Under the administration of the China State Shipbuilding Corporation, this institute has over 760 staff, including 350 technical personnel, occupies an area of 27,000 square metres, including 20,000 square metres of floor space, and has some 1,000 units of advanced equipment and instrumentation. Organisation includes nine research offices and five trial production workshops. Has undertaken extensive R&D on underwater sound electronics (sonar) and "supersonic technology", radio, marine electronics and electrical appliances. Products designed include echo sounding apparatus for shallow/medium/deep waters, CRT multi-functional shoal detectors, sound correlated rangers, "supersonic series", various underwater "sound and supersonic energy exchangers", sea bottom geomorphographs, multi-functional cloud chart facsimiles, marine radio receiving and transmitting systems, etc.

Shanghai Marine Equipment Research Institute

10 Hengshan Lu

Shanghai 200031

Tel: +86 (21) 6471-8118, 6571-9119

Fax: +86 (21) 6433-9552

Shanghai Medical Nuclear Instruments Factory

65 Nanhua Lu, Huacao

Shanghai 201106

Tel: +86 (21) 6220-0321, 6241-0168

Director's Office 6233-4242

Fax: +86 (21) 6220-0210

Shanghai Merchant Ship Design and Research Institute

221 Zhao Jia Bang Road

Shanghai 200032

Tel: +86 (21) 6431-3937, 6431-3600

Fax: +86 (21) 6433-8213

This institute has over 600 staff, including 360 engineers and technicians, and is active in the R&D of new ships, marine machinery, electrical products, and software applications. Ship designs include bulk carriers, oil tankers, chemical tankers, multi-purpose cargo ships, container ships, self-unloading bulk carriers, passenger ships, hopper dredgers, and floating docks.

Shanghai Navigation Aids Factory

4 Shangnan Lu, Pudong

Shanghai 200126

Tel: +86 (21) 5883-9256

Fax: +86 (21) 5876-9238

Shanghai Navigation Instrument Plant

1-504 Lane, Lujiazui Lu

Pudong, Shanghai 200120

Tel: +86 (21) 5884-1484

Fax: +86 (21) 5884-0584

Produces navigation equipment.

Shanghai Nuclear Engineering Research and Design Institute

PO Box 223-008

Shanghai 200233

Undertakes major design and research projects for domestic and export markets.

Shanghai Nuclear Technique Development Corporation

PO Box 800-204

Jialuo Highway, Jiading District

Shanghai 201800

Tel: +86 (21) 5952-9992

Fax: +86 (21) 5952-8021

Shanghai Radio Equipment Research Institute

207 Liping Road, Yangpu

Shanghai 200090

Tel: +86 (21) 543-1838

The SRERI is engaged in the R&D, design and production of radio and electronic equipment for space systems. It employs 1,000 staff, of which some 430 are engineers and technicians. Its buildings total 28,888 square metres in floor space and it has fixed assets of over 22 million Rmb yuan. Organisation consists of six research offices, four production and processing workshops and various technical management departments. The institute operates 3,700 instruments and 480 pieces of machinery equipment. Facilities include a simulation lab, a nearfield radar scattering cross section testing site, an automatic antenna testing room, an antenna random testing site, a precision guidance appliance testing room, a control system testing room, a precision microwave testing room, a CAD application centre, and a reliability test lab for environmental testing. Primary product and R&D areas are remote controllers for aircraft and spacecraft, airborne radars, telecommunications and data transmission, large electronic measuring systems, emulation and simulation testing, electronic equipment, computer development and applications, and applied satellite equipment. Specific technical achievements have included the development of anti-interference digital coding and decoding radio remote control systems, the low sidelobe, low noise and high efficiency circular polarised antenna feeder for satellite ground stations, the single point to multi-point direct array band expansion multi-address duplex digital transmission system, the FSK-FM-fm digital voice synthesization system, remote control receiving and transmitting systems for anti-air raid systems, the Ku-Band line-of-sight microwave TV transmission monitoring systems, and the multi-terminal radiophone dispatch system.

Shanghai Scientific Instruments and Materials Corporation

1 Taojiang Lu

Shanghai 200031

Tel: +86 (21) 6437-9506

Import/Export Dept. 6437-6011

Service Dept. 6325-6581, 6325-6589

Shenda Instrument Company 5889-1346

Fax: +86 (21) 6433-0024

Satellite ground station electronics research and development, and the manufacture of satellites.

Shanghai Shipyard

Jimo Lu, Pudong, Shanghai 200120

Tel: +86 (21) 5884-0451, 5878-1640

Fax: +86 (21) 5884-2840

Shanghai Xinxin Machinery Plant

PO Box 297

229 N. Yantai Road

Shanghai

Tel: +86 (21) 841-251

Fax: +86 (21) 841-018

Manufactures liquid propellant rocket engines.

Shanghai Xinyue Instruments Factory

PO Box 7604

710 North Yishan Road

Shanghai 200233

Tel: +86 (21) 436-3587

Fax: +86 (21) 470-1975

Under the CAIC this factory has 2,200 personnel of whom some 800 are technicians and engineers. The factory occupies an area of 70,000 square metres, with buildings totalling 40,000 square metres in floor space. It is equipped with 1,800 instruments and metres and 100 pieces of special testing equipment, and 500 production machines. Products and areas of R&D include automatic piloting systems, inertia devices, servo systems for launch vehicles, infrared optical systems, spacecraft, computers, and data-base development.

Shanghai Xin Zhong Hua Machinery Factory

Shanghai Aerospace Refrigerator Factory

Long March Rocket Factory

PO Box 4430

100N Minhang Huayin Road

Shanghai 200240

Tel: +86 (21) 6430-0107, 6430-1161

Fax: +86 (21) 6430-0107

Manufactures satellite launch vehicle components, Long March 3 launch vehicle first and second stages, Long March 4 stages, and military missile systems. Has some 1,000 employees, including 400 engineers and 100-200 quality control inspectors.

Shantou Institute of Electronic Technology

4/F, East, Building 4

Longhu, Shantou

Guangdong 515041

Tel: +86 (754) 826-0054, 826-3604

Fax: +86 (754) 826-3604

Shanxi Forging Mill

PO Box Yicheng

Shanxi 043514

Tel: +86 (351) 44-888

Affiliated with the Machine Building and Electronics Company of the China International Trust and Investment Corporation (CITIC), this firm has a total area of 500,000 square metres, with building floor space totalling 90,000 square metres. It has fixed assets of some 100 million Rmb yuan and 2,000 workers, including some 200 engineers and technicians. It operates over 1,500 pieces of equipment that annually produce 15,000 tons of forgings ranging from one to sixteen tons. Products include heavy-duty truck steel plate springs, auto front axles, couplings and crankshafts.

Shanxi Qiyi Precision Machinery Plant

Dongjie, Beihewan

Dunhuafang, Taiyuan

Shanxi 030009

Tel: +86 (351) 345-771, 343-490

A subsidiary of NORINCO, this plant employs 1,045 workers, including 108 technical staff, has building floor space totalling 51,855 square metres, and net value fixed assets of 15.36 million Rmb yuan. It undertakes the servicing of precision equipment and the production of precision parts. Products include hydraulic props, machine cylinders, ball guide screws and nut assembly, and high precision cold rolling and precision machine tools fittings. Has established the Shanxi Yongcheng Machinery Company Ltd. with Hosar Investment Ltd. of Hong Kong for the production of high-speed-precision computer-controlled machine tools.

Shenzhen Kaili Industrial Development Corporation

6th Floor, Lianxing Building (N),

No. 8 Wenjing Road

Shenzhen, Guangdong 518001

Tel: +86 (755) 223-0492

Fax: +86 (755) 222-9872

SKIDC is reportedly under the administration of the CNNC, but likely is also closely linked to COSTIND. SKIDC has branch offices in Bao'an, Daya Bay, Beijing, Shanghai, and Guangzhou, and 27 enterprises reporting to it. It develops, produces and markets technology-intensive products such as computers, electronics, machinery, pharmaceuticals and fine chemicals. It reportedly produces China's best quality stainless steel parts and components. Activities also include civil engineering projects and real estate ventures at Bao'an and Daya Bay. Future production and R&D plans are to be focused on stainless steel production, industrial computers, industrial plasma cutting machines, high-grade multi-layer printed circuit boards, computerised automatic control equipment, and computer magnetic tapes. Facilities include a multi-purpose building with a floor space of 23,000 square metres ('Kaili Nuclear Industrial Mansion'), commercial residential buildings of 18,000 square metres, and 30,000 square metres of factory buildings.

Shenzhen Shipbuilding Trading Company Ltd.

35/F, International Trade Centre, Renmin Lu

Shenzhen, Guangdong 518016

Tel: +86 (755) 225-1092

Enterprise Management Dept. 225-1096

Overall Development Dept. 225-1497

Fax: +86 (755) 222-3913

Shijiazhuang Aircraft Manufacturing Company

PO Box 164

25 Beihuan Xi Lu

Shijiazhuang, Hebei 050062

Tel: +86 (311) 777-0554

Fax: +86 (311) 775-2993

This firm is a division of the Xi'an Aircraft Industrial Group founded in 1970, and manufactures the rugged Y-5B/C transport, and single engine, two seat light and microlight aircraft. Its worksforce consists of 3,500 workers, including 1,000 engineers and technicians, in a 100,000 square metre facility that includes over 1,300 major pieces of manufacturing and testing equipment. It became part of the Xi'an Aircraft Industrial group in July 1992, and has its own affiliated aircraft research institute.

Shijiazhuang Radiation Technology Development Centre

12 Xinshi Road South, Shijiazhuang

Hebei 050091

Tel: +86 (311) 302-2648, 302-2607

Fax: +86 (311) 302-2923

Shipbuilding Technology Research Institute

(032-201) 851 Zhongshan Nanerlu

Shanghai 200032

Tel: +86 (21) 439-9626, 439-0908

Fax: +86 (21) 439-0908

This is China's primary research institute for applied shipbuilding technology, and has 600 staff, of which 430 are technical personnel, building floor space of 17,000 square metres, and over 900 computers, test and production machines. It operates five specialised research offices and the Applied Software Development Centre of the China State Shipbuilding Corporation. R&D areas include ship construction and technology, ship machinery installation, electricity and pipe systems, welding and cutting technology, non-destructive testing, coatings, automatic equipment, materials, and computer systems. Product areas include offshore platforms and steel structures, information management systems, micro-computer controlled production machinery, etc. It co-operated with a Japanese company for the establishment of the Shanghai Xiyou Information Technology Company Ltd., and a US firm for the creation of the Shanghai-GRACO Technical Service Centre.

Shuangyang Aircraft Manufacturing Factory

PO Box 8

Anshun, Guizhou 561018

Tel: +86 (851) 385-5047 (853) 222-923

Fax: +86 (851) 385-3140

Founded in 1965, this firm is a member of the China National Guizhou Aviation Industry Group, and manufactures military and civil aircraft such as the JJ-7 fighter trainer and the Y-11 and Y-12 transports. It has 88,000 square metres of manufacturing space, fixed assets of over 175 million Rmb yuan, and staff pf 2,600, including 310 technicians and engineers. The firm has achieved ISO9000 certification.

Shuguang Electrical Machinery Factory

PO Box 2404

Beijing 100028

Tel: +86 (10) 467-4131

Fax: +86 (10) 466-1996

The products of this National Airborne Equipment Corporation subsidiary include aircraft power supply generators, aircraft microelectrical machines, flight simulators, and motors.

Sichuan Aero Electrical Appliance Factory

PO Box 16

Yaan, Sichuan 625000

Tel: +86 (835) 222-483, 222-484

Fax: +86 (835) 223-442

This firm produces aeroengine and afterburner ignition systems and other aviation electrical systems.

Sichuan Aero-Hydraulic Machinery Factory

PO Box 9

Yaan, Sichuan 625003

Tel: +86 (835) 2949

Fax: +86 (835) 3628

This firm manufactures hydraulic boosters and actuating cylinders.

Sichuan Gear Box Plant

PO Box 211

Jiangjin, Sichuan 632284

Tel: +86 (8221) 522-363

Fax: +86 (8221) 521-296

A subsidiary of the China State Shipbuilding Corporation, this specialised producer of gear boxes, couplings and vibration reducers has 1,400 workers, including 120 technical personnel, occupies an area of 203,000 square metres, has over 900 pieces of various equipment such as metal-cutting and testing machines, and has fixed assets valued at over 50 million Rmb yuan. During the early 1980s, amortisation spring coupling, vibration reducer and three series of marine gear box design and manufacturing technology was imported from Austria and Germany.

Sichuan Nanshan Machinery Plant

Nanxi Town, Nanxi County

Sichuan 644100

Tel: +86 (8413) 322-170

Affiliated with NORINCO, this plant employs about 3,000 people, including 400 engineers and technicians, and has 160,000 square metres of building floor space and fixed assets worth 50 million Rmb yuan. Major producer of power actuators, power loads and fasteners.

Sichuan Province Institute of Nuclear Technology Applications

124 Sha He Bao

Chengdu, Sichuan 610066

Tel: +86 (28) 444-4267

Fax: +86 (28) 444-3380

Sichuan Space Industry Corporation (Sichuan Aerospace Corporation - 062 Base)

PO Box 1, Gongnong, Baisha

Sichuan 636450

Tel: +86 (811) 813-911, 810-899

Fax: +86 (811) 813-911, 810-899

and

Chengdu Space Technology Development Company

PO Box 418, Chengdu

Sichuan 610016

Tel: +86 (28) 665-712

Fax: +86 (28) 665-712

and

Chongqing Space Mechanical and Electronic

Products Designing Company

(Chongqing Space Company)

207 Shiqiao Pushi Xiaolu

Chongqing, Sichuan 630039

Tel: +86 (811) 813-911

Fax: +86 (811) 813-911

and

Shenzen Office

Room 508, Sichuan Mansion, Hongli Road

Shenzen, Guangdong 518028

Tel: +86 (755) 355-144

Fax: +86 (755) 355-144

This group of affiliated firms is a major space technology production base for the CAIC. A total of over 30 enterprises and institutes, such as design institutes, R&D institutes, large and medium sized firms, measuring and testing stations, and foreign trade companies are spread throughout Chengdu, Chongqing, Luzhou and DaXi'an in Sichuan Province, in addition to offices in Beijing, Shenzhen, Weihai, Beidaihe and Haikou. Over 3,000 workers at the main plant operate some 10,000 machines including punching, welding and machining systems, precision processing equipment, NC systems, remote surveying equipment and firing facilities. Products include telecommunications systems, floppy discs, hard alloy metal cutters, and satellite ground stations. Future R&D and technology transfer efforts focussed on electronics, applied satellite technology, electromagnetic technology, marine radars and applied laser technology. Developing a "Space Town" industrial/research park development in Chengdu, with special economic zone preferential tax treatment etc., for foreign investors.

With overall 20,000 personnel of the enterprise group headquartered at Chengdu, the role of this firm is the development of systems associated with liquid-fuelled ballistic missiles, launch vehicles, andanti-ship missiles. Subordinate organisations include:

· Chongqing Aerospace Electromechanical Design Institute

· Sichuan Changzheng Mechanical Factory, Wanyuan, Sichuan

· Chongqing Bashan Instrument Factory - telemetry equipment

· Fenghuo Machinery Factory - servo-mechanical devices

· Liaoyuan Radio Factory, Xuanhua, Sichuan - space flight controls

· Tongjiang Machinery Factory - metals processing

· Mingjiang Machinery Factory, Dachuan

· Pinqjiang Instrument Factory, Dachuan - control systems

· Chuannan Machinery Factory missile system ignitors.

Si-Lian Titanium Equipment Design

and Manufacture Company Beijing Office

2A Taipingjie, Xuanwuqu

Beijing 100050

Tel: +86 (10) 304-7296

Fax: +86 (10) 304-3951

and

Si-Lian Titanium Equipment Design

and Manufacture Company

General Machinery Research Institute

Xijiao, Anhui 230031

Tel: +86 (551) 556-1393, 556-3814

Fax: +86 (551) 556-2185

Sino Satellite Communications Company, Ltd.

(SINOSATCOM)

PO Box 849-49

Beijing 100830

Tel: +86 (10) 6845-2370

Fax: +86 (10) 6845-2371

Website: http://www.sinosat.com

Provides voice, data, ATC and direct TV broadcasting services via the Sinsosat telecommunications satellite series

South Motive and Machinery Complex

PO Box 211

107 Zhuzhou, Hunan 412002

Employs 10,000 to produce the WJ6 turboprop engine and WZ8 turboshaft engine.

Southwest Institute of Nuclear Physics and Chemistry

18 Mianxing Zhong Lu, Mianyang

PO Box 515-22

Chengdu, Sichuan 610003

Tel: +86 (28) 248-0390

Fax: +86 (28) 233-6215

Southwest Research Institute of Technical Physics

(Southwestern Institute of Physics)

PO Box 432, Nijia Bridge

Number 7, 4th Section, Remin Nan Road

Chengdu, Sichuan 610041

Tel: +86 (28) 558-1122

Fax: +86 (28) 558-1458, 558-1053

For over three decades, this institute conducts applied R&D on controlled nuclear fusion, plasma technologies, military lasers and photoelectricity technology in such areas as laser crystals and components, laser photoelectric detectors, laser rangefinders, laser control/guiding/tracking/"confrontation" systems, simulators, image processing, TV systems, photoelectric systems, etc. Also produces dual-use products such as laser warning systems, "multi-functional TV detection systems", wireless communication systems, satellite TV receivers, surface sonic wave filters, etc. It has over 2,200 employees, including 350 senior scientists and engineers. Facilities include the China Huan Liu Number One (HL-1) TOKAMAK fusion reactor, and it is China's largest research centre for fusion R&D. R&D is also conducted on 'plasma technology spin-offs', high current ion sources, cryogenic superconductors, high field magnets, etc. The military '493 High-Flux Reactor' Programme is believed to have been conducted at this institute.

Space Centre for Payloads and Applications

Beijing

Recently established space R&D centre.

Special Vehicles Research Institute

PO Box 307

Jingmen, Hubei 448035

Tel: +86 (724) 233-2521

Fax: +86 (724) 233-2551

Founded in 1961, this is China's main centre for the development of special vehicles such as unique water-based vehicles, airships and surface-effect and wing-in-ground (WIG) effect vehicles. It has over 1,300 employees. Its facilities include the only high-speed hydrodynamic test water tank in Asia. It conducts R&D on aerodynamic surface effect, longitudinal dynamic stability of water-based vehicles, spray and drag characteristics of water-based vehicles, water impact load of three-dimensional flying bodies, take-off and landing of amphibian aircraft, manned helium airships (FK-4, FK-100) and remote-controlled airships (FK-6, FK-11, FK-12), seaworthiness and model test techniques for surface effect vehicles, etc. It had developed the large SH-5 seaplane suring the 1970s and the follow-on SH-5B version.

Stone Group Company

PO Box 2748

Zhongguancun

Beijing 100081

Tel: +86 (10) 256-3648

Fax: +86 (10) 256-2748

Synchrotron Radiation Laboratory

Institute of High Energy Physics

PO Box 918, Beijing, 100039

Taihang Instruments Factory

PO Box 2

Sanyingpan, Bingzhou Nanlu

Taiyuan, Shanxi 030006

Tel: +86 (351) 707-2815, 707-2646, 707-4249

Fax: +86 (351) 704-0211

Found in 1951, this AVIC enterprise manufactures multi-function dynamic atmospheric pressure parameter integrated test equipment, airborne vibrating cylinder air data computers, computer-controlled fuel units, digital electronic balances, instruments that measure altitude, speed and vertical speed, and precision and piston manometers. The firm has 3,500 employees, including some 720 engineers, occupies an area of 600,000 square metres, and has over 1,600 sets of major equipment including NC systems. Since 1996 it has ISO9001 quality certification. It has 3 research institutes and 15 sub-factories.

Taiji Computer Company

Huabei Computer Technology Institute

PO Box 619 (5)

6(A) Wohuqiao, Weizikeng

Deshengmenwai, Beijing 100083

Tel: +86 (10) 201-8702, 201-7661 ext. 725

Fax: +86 (10) 201-8902

Branches and offices throughout China, including Shenzhen, Xiamen, Zhuhai, and Shekou. Established in 1958 (incorporated in 1987) this firm is an affiliate of the Ministry of Electronics Industry and under the administration of the China Electronics Corporation, and with the parent Huabei Computer Technology Institute (North China Institute of Computing Technology) as its main division, undertakes the R&D, production, marketing and servicing of all aspects of computer technology. The Huabei Computer Technology Institute participated with China's atomic and hydrogen bomb tests, completed the computer projects for the survey and control systems used for the launching of China's first satellite, first ICBM launched to the South Pacific, SLBM launches, and synchronous satellites. The Taiji Computer Company is the main civilian operating arm of the Institute (although much of its activities are of a dual-use nature), and has 2,450 personnel, including 1,600 technical staff and 400 software workers. The firm occupies 202,769 square metres, and by the early 1990s had over 200 million Rmb Yuan in production output, becoming China's largest producer and supplier of microcomputers. It has five major departments: basic research (eg. large scale parallel processing technology, multimedia, artificial intelligence (AI), and mainframe/super-computers); software and applied technology (eg. microcomputers, systems engineering for large state projects, financial applications, industrial process control, telecommunications networks, office automation, graphics and image processing, computer systems software, support software and software tools); computer research, development, marketing and servicing (eg. microcomputers, minicomputers, RISC systems, industrial control systems, and banking computers); computer manufacturing centre (eg. printed circuit R&D centre, test centre, mechanical processing factory, and computer site development centre); and a computer service centre (eg. computer quality monitoring and testing, printed circuit quality monitoring and testing, computer room quality control and monitoring, and lab for certifying export and import computer products). Computer products have been used by China's space programme and other industrial applications. Co-operative relations have been established with a number of major computer companies in the US, Japan and Germany. In 1987 established a training centre in co-operation with IBM, in 1990 formed a Taiji-DEC software centre in Shenzhen, and more recently has established development centres for large scale integrated circuits and applied software in foreign countries.

Taikoo (Xiamen) Aircraft Engineering Company Ltd. (TAECO)

203A Douxi Road, Xiamen, Fujian

Tel: +86 (592) 207-0766

Fax: +86 (592) 207-0753

Taiyuan Chemical Plant

Import and Export Corporation

Nanyan, Hexi

Taiyuan, Shanxi 030021

Tel: +86 (351) 604-0349, 606-5901

Fax: +86 (351) 604-0349

Possible manufacturer of chemical warfare agents.

304th Research Institute

Taizhouwu, Haidian District

Beijing 100095

Tel: +86 (10) 256-7355

Tianda Aero-Industry Corporation

PO Box 51

Hanzhong, Shaanxi 723001

Tel: +86 (916) 221-5073

Fax: +86 (916) 221-3786

Founded in the mid-1960s, this firm produces medium size and range transport aircraft (eg. Y-8), airborne equipment (eg. gyroscopes and electro-optic systems), and other military and defence aerospace products. It has 20 subsidiary firms.

Tianjin Aviation Electromechanical Corporation

PO Box 208

Tianjin 300123

Tel: +86 (22) 2735-7348

Fax: +86 (22) 2735-1285

This firm is China's primary manufacturer of military aviation electrical apparatus. It produces aviation electrical equipment such as electromagnetic relays, temperature relays, controllers, high-energy igniters, fire alarm detectors, switches, circuit breakers, and bomb release systems. The firm has 3,000 employees, including over 500 engineers. It is the metrological centre for Tianjin military industrial enterprises, and the reliability research and test centre for AVIC. It modern equipment includes laser welding systems, optical curve grinders, and CAD and NC systems.

Tianjin Electronic Materials Research Institute

PO Box 412

5 Yanfeng Road, Chentangzhuang

Hexi, Tianjin 300220

Tel: +86 (22) 841-344, 842-986

Fax: +86 (22) 368-310

This is a comprehensive research institute specialising in the R&D, testing, and production of specialised electronic materials. It covers an area of some 98,000 square metres, with building floor space totalling 51,000 square metres. Extensive equipment and instrumentation includes ion mass spectrometers, X-ray fluorescence spectrometer, photo-electro spectrometer, Auger electron spectroscope, Fourier transform spectrometer, inductive coupling, atomic absorption spectrometer, spectrophotometre, scanning electron microprobe, high-voltage transmission electron microscope, and deep level transient spectroscope. Staff number some 815, with engineers and technicians accounting for over 400. TEMRI was one of China's first units to undertake research and production of semiconductor materials, gallium arsenide, and fibre optics, and work is ongoing on the application of these. Computer software, including artificial intelligence (AI) systems, is also developed.

Tianjin Institute of Laser Technology

Research Area on Hongqi Lu

Nankaiqu, Tianjin 300192

Tel: +86 (22) 336-0081, 336-0082

Tianjin Integrated Fibre Optics Information

Technology Development Corporation

15 Keyan Dong Lu, Yuanqu

Nankaiqu, Tianjin 300192

Tel: +86 (22) 239-4384, 730-3300

Engineering Division 730-4310

Fax: +86 (22) 239-4384

Tianjin Navigation Instruments Research Institute

24 Sanhaolu, Dingzigu, Xinqiao

Tianjin 300131

Tel: +86 (21) 671-882, 670-933

Fax: +86 (21) 674-177

Under the China Shipbuilding Industrial Corporation, this institute has 1,700 staff, including some

1,000 engineers and technicians, and is organised into 14 research offices, a trial production factory, a training centre, an advanced technology developnment company, and a navigation products testing centre. Its R&D areas include radio communications, navigation equipment, platform gyro compasses, computers, motors and electrical devices, automatic steering control and logs, precision machinery, information systems, standards and measurement. Produces precision radio positioning systems, various radio, infrared, laser and radar warning systems, gyro compasses and gyro theodolites, and other electronic equipment.

Taiyuan Bada Scientific and Technological Development Company

China Institute for Radiation Protection

PO Box 120, Taiyuan

Shanxi 030006

Tel: +86 (351) 704-0266

Fax: +86 (351) 704-0407

Tianyi Electromechanical Factory

PO Box 9

Zunyi, Guizhou 563002

Tel: +86 (852) 225-653

Fax: +86 (852) 225-653

This firm manufactures sealed, force-balanced and polarised relays, contacts, and control boxes.

Ultrafast Laser Spectroscopy Lab

Zhongshan University

Tel: +86 (20) 442-5563

Wan'an Machinery Factory

Hefei, Anhui 230022

Tel: +86 (551) 562-455

Affiliated with the Xi'an Aircraft Industrial Group, this firm's products include auxiliary fuel tanks, landing gear, integrated fuel pump test rigs, hydraulic jacks, and accessories.

Wangjiang Machinery Plant

Guojiatuo, Nanan

Chongqing, Sichuan 630071

Tel: +86 (811) 271-107

Fax: +86 (811) 273-329

Under NORINCO, this plant occupies a building space area of 600,000 square metres, and has 12,000 workers, including 1,000 engineering technicians. Products include front axles, motorcycles, motorcycle engines, and light duty motor vehicles. Motorcycle technology imported from Suzuki Company of Japan.

Wanli Electro-Mechanical General Factory

PO Box 56, Lanzhou

Gansu 730070

Tel: +86 (931) 766-6146, 766-6521

Fax: +86 (931) 766-7486, 766-6141

Founded in 1956 and now under AVIC, this firm develops and produces some 268 types airborne electric motors in 18 series. CAD/CAM and NC systems have also been developed by the company, as well as isotope instruments for the nuclear industry. It has over 4,500 employees, including 150 technicians, covers 700,000 square metres, has some 4,000 major pieces of equipment, and possesses fixed assets of 120 million Rmb yuan.

Wuchang Shipyard

2 Ziyang Road, Wuchang, Wuhan

Hubei 430060

Tel: +86 (27) 743-575

Fax: +86 (27) 877-801

A subsidiary of the China State Shipbuilding Corporation, this shipyard has over 8,000 workers, including 1,600 technical personnel, over 2,500 pieces of mechanical and processing equipment, and 16 subsidiaries specialising in custom shipbuilding, large steel structures, pressure containers and machinery manufacture. Has developed the launch vehicle tower for the Xichang space launch centre (96 metres high, 5,000 tons in weight, used for launching the Long March 2 rocket). Other products include multi-purpose cargo ships, passenger ships, offshore oil development ships, container ships, dredgers, heavy oil catalytic cracker, gas storing and shipping tanks, large shipdocks, plastic injection machines, etc.

Wuhan Heavy-Duty Casting and Forging Plant

1 Wudong Road, Qingshan, Wuhan

Hubei 430084

Tel: +86 (27) 664-002, 663-090

Fax: +86 (27) 612-217

Under the China State Shipbuilding Corporation, this specialist of large and medium-sised casting has over 5,200 workers, including 900 technical personnel, occupies an area of 1 million square metres, and has fixed assets of over 160 million Rmb yuan. It is the forging and casting centre for China's shipbuilding industry in central south China, and has a large assortment of heavy equipment. Has recently been seeking foreign electroslag fused forging plant technology.

Wuhan Instrument Factory

PO Box 74003

Wuhan, Hubei 430074

Tel: +86 (27) 780-1161, 780-1162, 780-1163

Fax: +86 (27) 780-1207

Founded in 1963 and currently an AVIC affiliate, this firm undertakes the development and production of aircraft metres related to pressure, dropping unlock devices, transducers for attack angle, pressure and acceleration. It has over 1,600 employees, including 550 engineers, occupies some 200,000 square metres, has total assets of over 96 million Rmb yuan, and has over 900 pices of major equipment. There are 8 subordinate factories and three research institutes, and various foreign joint ventures. Facilties include an ice-rain wind tunnel for instrumentation tests, and a low-speed conventional wind tunnel.

Wuhan Maritime Communications Research Institute

PO Box 70005, Wuhan

Hubei 430070

Tel: +86 (27) 715-851

Fax: +86 (27) 714-429

A subsidiary of the China Ship Institute of the China State Shipbuilding Corporation, this institute has over 1,100 staff, including over 600 technical personnel, occupies a total area of 210,000 square metres, including building floor space of some 60,000 square metres, and has over 1,800 sets of equipment and instrumentation. It is also a member of the China Giant Panda Electronic Group. R&D areas include ship commications systems, land-based communications, inter-communications, mobile communications networks, personal communications systems, antennas, transmitters and receivers, high-frequency series parallel modulation-demodulation terminals, very-low frequency communications channels and demodulation terminals, regional communications networks, telegraph exchange and processing, communications control, data-collecting and processing, secure communications and computer applications. Has helped develop ocean-going precision survey ships for military and civilian applications. New R&D areas include communications systems engineering, signal processing, and self-adapting communications technology.

Wuhan Shipbuilding Industry Corporation

250 Jianghan Lu, Hankou

Wuhan, Hubei 430021

Tel: +86 (27) 281-4166, 281-4291

Fax: +86 (27) 281-4292

Wuxi Aeroengine Research Institute

PO Box 206

Wuxi, Jiangsu 214063

Tel: +86 (510) 551-4071

Fax: +86 (510) 551-7302

This AVIC affiliated research institute was founded in 1975, and undertakes R&D primarily in full-authority digital engine control (FADEC) systems and the production of digital controllers. It is a member of the China National Industrial Gas Turbine Power Group. It has over 500 employees, including some 180 engineers. Specialised equipment includes CAD/CAM/CAT systems, and a comprehensive aeroengine control system simulator. The institute recently has claimed to have made important breakthroughs in FADEC system research.

Wuzhou Industry Corporation

PO Box 345 A12, Chengdu

Sichuan 610006

Tel: +86 (28) 222-207 ext. 966

WIC is a large industrial enterprise controlled by the CNNC with a fixed asset base of 560 million Rmb yuan and over 7,800 personnel, of which over 300 are engineers and technicians. The main equipment and technology for the factory has been imported from Japan. It has designed capacity for 30,000 tons of aluminium ingots per year and 15,000 tons of anode paste.

Xiamen Torch CAD/CAM System Engineering Company Ltd.

Guangxia Bldg., Torch Hight TIDZ

Xiamen, Fujian 361006

Tel: +86 (592) 602-6025, 602-6029

Fax: +86 (592) 602-6027

Dual-use computer and office automation systems; foreign joint venture.

Xi'an Aeroengine Corporation

(formerly Xi'an Engine Company)

Xujiawan, Beijiao

PO Box 13

Xi'an, Shaanxi 710021

Tel: +86 (29) 661-3888, 661-3411

Fax: +86 (29) 661-4019, 661-4035

Founded in 1958, this is a major AVIC enterprise that manufactures turbojet and turbofan aeroengines, 6,000 and 13,000 horsepower gas turbine engines, and aeroengine parts and components such as fuel and hydraulic pumps, regulators and aeroengine actuators. Maintenance, overhaul and repair services also offered. Xi'an and Shenyang Liming have produced CFM56 engine blades and Mirage 2000 parts under contract to France's Snecma. In 1984 the US General Electric Corporation awarded Xi'an a contract for manufacturing the turbine disc of the LM2500 gas turbine engine. it has recently supplied components to AlliedSignal and Rolls-Royce. The firm has over 16,000 employees, including 4,000 professionals, 16 subsidiary enterprises, and over 5,000 pieces of major manufacturing and testing equipment including various advanced NC systems.

Xi'an Aircraft Design and Research Institute

PO Box 72

Xi'an, Shaanxi 710089

Tel: +86 (29) 620-3603

Fax: +86 (29) 620-2493

Founded in 1961 as the Engineering Development Department of the Xi'an Aircraft Industrial Group, this AVIC R&D centre specialises in the design of medium to large aircraft. It has 2,800 personnel, including 1,650 engineers and technicians and 39 research fellows. Since its inception it has designed and modified some thirty aircraft types. 'Trunkliner' transport aircraft research continues at the institue in copperation with European partners. The institute has departments of configuration development, aerodynamics, strength analysis, structural design, control and hydraulics, landing gear, power plant and fuel systems, environmental control, ejection and life support systems, airborne equipment, armaments and weapon systems, reliability, airwothiness, standards, materials, flight test, ground equipment, market development, metrology, and instrumentation, as well as a computer centre and advanced labs for flight control and hydraulics, fuel, environmental control, and electrical systems, and a model production factory.

Xi'an Aircraft Industry (Group) Company Ltd.

(Xi'an Aircraft Company)

PO Box 140-148

Yanliang District

Xi'an, Shaanxi 710000

and

Xi'an Aircraft Industry

Civil Product General Company

Yanliangqu

Xi'an, Shaanxi 710089

Tel: +86 (29) 728-2473, 728-6417, 684-5000, 684-5052

Fax: +86 (29) 620-2069, 620-2263

This firm is currently a division of the Xi'an Aircraft Industrial Group, and was originally established in 1958. Some thirty types of aircraft have been developed. Military production has included the H-6 bomber. An emphasis has recently been placed on improved Y-7-200A/B and Y-7H-500 transport production and foreign parts subcontracts, and seeking international support for a new 64-seat transport. Xi'an's derivative Y-7H-500 medium cargo aircraft is being marketed at developing countries, and is powered by Harbin WJ-E5 turboprop engines, and can be used to carry paratroops and civilian applications such as water bombing and oil and mineral exploration supply. Plant uses modern quality assurance techniques, and has advanced imported equipment such as a five-axis numerically controlled machine tool and a large rubber metal-forming press. The factory has over 140 computers, including an IBM 4381 mainframe and several workstations, and the use of CATIA and other CAD/CAM software. An eight floor Engineering Research Building has specialised R&D labs for fuel, hydraulic, environmental and electrical power testing. Other facilities include: anechoic chamber; advanced array of nondestructive test equipment such as an electron scanning microscope; large aircraft spare part support service; metal bonding and composite materials shops with four modern autoclaves up to 11 metres in length; massive assembly and paint hangers with a total assembly area of 90,000 square metres, and total factory grounds of 3 million square metres. Military work has included the advanced JH-7 (FBC-1) multi-role two-seat combat aircraft, which is now in service with the PLAAF and PLAN. The company employs some 20,000 workers, including 6,000 technical personnel, of which 2,600 are in the engineering department, and 800 are senior engineers. Xi'an has built: forward and aft fuselage sections, wing components and wings for MD-80/90 series; Boeing 737 tail assemblies, vertical fins and forward access doors, and Boeing 747 trailing edge flap ribs; Canadair/Bombardier CL-215 water-bomber pylons, water tanks and doors; and ATR42 wing boxes and doors for Alenia and Airbus Industrie A300 transport access doors, etc.

Xi'an Aircraft Industry (Group) conglomerate has the following corporate divisions:

· Hefei Wanan Machinery Factory

· Hong Hai Industrial Corporation

· Meian Industrial Corporation

· Shijiazhuang Aircraft Plant

· Xiamen Feida Industrial Company

· Xi'an Aircraft Company

· Xi'an Aircraft Industrial Shanghai Company

· Xi'an Aviation Engineering Manufacture Works

· Xi'an Xifei Industry and Commerce Corporation

Xi'an Aviation Electric Corporation

PO Box 31

Xi'an, Shaanxi 710077

Tel: +86 (29) 741-811

Fax: +86 (29) 741-930

This firm manufactures electrical accessories, sealed relays, and power supplies.

Xi'an Fareast Machinery Manufacturing Company

(Xi'an Yuandong Machine Building Corporation)

PO Box 19, Xi'an

Shaanxi 710077

Tel: +86 (29) 741-492, 742-251 ext. 491

Under the AVIC this firm occupies 320,000 square metres and employs 10,000 people, including 3,000 engineering, technical and managerial personnel. It has 1,224 metal cutting machines, over 2,000 testing and inspection instruments and fixed assets of over 170 million Rmb yuan. It has 26 production, technical and managerial departments, 18 production workshops, and 14 special factories and branches including an industrial trade company, import/export company, and science and technology development company. XFMMC provides a precision R&D, production, training and maintenance base for aeroengine components such as fuel and hydraulic systems, automatic controls for civil and military aircraft and helicopters, fuel systems for light-duty gas-turbines, and automatic control devices. Branches also located at Beijing, Shenzhen, Hainan, Shanghai, Chongqing, Suzhou, and Qingdao.

Xi'an Huian Chemical Plant

Xi'an, Shaanxi

This plant employs 20,000 people, including 2,000 technical and managerial staff, occupies an area of 5 million square metres, and has over 270 million Rmb yuan of fixed assets. Organisation consists of 19 sub-factories, three military and civilian research institutes, and a labour service company. Produces chemicals for military use. It has major product areas in cellulose and its derivatives, organic solvents, nitrocellulose, carboxymethyl cellulose, low-hydroxypropyl cellulose, amd hydroxypropyl-methyl cellulose.

Xi'an Institute of Space Radio Technology

Xi'an, Shaanxi

Has recently established a joint-venture with the Canadian firm Com Dev International for the development and production of advanced satellite subsystems such as space-qualified microwave filters and antennas, and wave guide switches for ground stations.

Xi'an Kunlun Machinery Plant

28 North Xingfu Road, Xi'an

Shaanxi 710043

Tel: +86 (29) 337-010

Fax: +86 (29) 338-433

Under NORINCO, this plant employs 6,300 people, including 1,560 engineers and technicians, has 3,000 sets of equipment (cold treatment and electrical, advanced machinery imported from US, Germany, U.K. and Japan), occupies an area of over 600,000 square metres, and has a special railway feeder line. Fixed assets valued at over 150 million Rmb yuan. Has comprehensive mechanical processing capability, particularly for super long and thin products. Also manufactures electronic control products and integrates electronics with machinery.

Xi'an New Technology Industry Development Zone

Torch Building, Gao Xin Road

Xi'an Road 710075

Tel: +86 (29) 426-5021, 426-4792

Fax: +86 (29) 426-3549

Contains aerospace and aviation activities.

Xi'an Northwest Optical and Electrical Instruments Plant

2 Wanshou Road North, Xi'an

Shaanxi 710043

Tel: +86 (29) 336-360, 336-370

Fax: +86 (29) 338-249

Offices are also located in Beijing, Zhuhai, Shenzhen, Waihai and other cities. This firm is affiliated with NORINCO and has a vertical technology structure encompassing optics, machine and electronic industries, and comprehensive design and manufacturing. The Xi'an plant employs some 7,000 people, including 1,000 engineers and technicians, and occupies an area of 740,000 square metres, with building floor space of 110,000 square metres. Interests in foreign technology transfers include powder spraying, electric casting, welding, cold treatment, non-ball face processing, and optical plastics.

Xi'an Qinchuan Machinery Plant

13 Central Xingfu Road, Hansenzhai

Eastern Suburb of Xi'an, Shaanxi

710043

Tel: +86 (29) 335-771, 335-761

Fax: +86 (29) 335-085

and

Beijing Office

5 Yuetan West Road, Xicheng

Beijing 100045

Tel: +86 (10) 864-537

Under NORINCO, this plant employs 10,000 people, including 840 engineers and technicians. It has 550,000 square metres of building floor space, and 3,700 machines (including 700 metal cutting machines, and 200 casting machines). Fixed assets total over 240 million Rmb yuan.

Xi'an Yuandong Company

Number 29, Daqing Xilu

Xi'an Shaanxi 710077

Tel: +86 (29) 426-4001, 424-1931

Fax: +86 (29) 424-2882

This AVIC firm develops and produces aeroengine fuel system accessories and automatic control systems. It was founded in 1953 and has over 8,000 employees, including 1,700 engineers and technicians, an area of 610,000 square metres, 2,400 pieces of production equipment (including over 100 pieces of precision or NC equipment) and 20,000 quality and measuring devices. It has a NC processing centre and associated equipment and CAD/CAM and CAE systems.

Xiangfan Parachute Factory

Hongwei Machinery Factory

PO Box 206

2 Tanxi Road, Xiangfan

Hubei 441022

Tel: +86 (710) 356-4121, 356-4623

Fax: +86 (710) 356-4881

Founded in 1965 and now under the AVIC, this factory has 2,000 employees, including 32 percent who are engineers and technicians. It has fixed assets of over 42 million Rmb yuan , industrial buildings with a floor space of 110,000 square metres and 1,130 machines, including 115 machining facilities, 700 sewing machines, 40 forging and stamping facilities, heat and surface treatment facilities, and NC machine tools. In 1996 it received ISO9000 quality certification. It integrates specialised parachute R&D and production for pilot emergency life parachutes, ejection seat deceleration parachutes, aircraft drag chutes, reconnaissance drone and target drone recovery chutes, light and heavy cargo parachutes, various aerial bomb and torpedo chutes, and various other specialised systems. Facilities include a lowspeed 2.5 metre diameter wind tunnel, an aerodynamic gun, high and low temperature cabin, and explosive decompression chamber.

Xianghua Machinery Plant

Xinhua Road, Zhuzhou

Hunan 412003

Tel: +86 (731) 221-315, 224-504, 223-219

This plant employs 2,407 people, including 513 engineers and technicians, occupies 81,259 square metres of factory space, has 1,019 machines, and posseses over 65 Rmb million yuan of original fixed assets.

Xiangling Machinery Factory

PO Box 16

Zhangjiajie, Hunan 427302

Tel: +86 (744) 851-2465

Fax: +86 (744) 851-2216

Founded in 1971, this AVIC firm produces aero-hydraulic components, has a staff of 900, some 685 major pieces of equipment, and fixed assets of over 70 million Rmb yuan. It has specialised in the development and production of landing gear for the J-7 fighter aircraft series.

Xiangyang Precision Machinery Plant

PO Box 112

Baoding, Hebei 071064

Tel: +86 (312) 309-9800

Fax: +86 (312) 303-6794

This AVIC firm is a precision machine repair centre, and also manufactures injection and cold punching moulds, large and medium tools and dies and precision machinery. Ir has over 1,500 employees, 226 of which are engineers and technicians, it has production space of 140,000 square metres, and 500 pieces of major machinery. It makes extensiveuse of CAD/CAM systems and NC tools.

Xingguang Machinery Plant

4 Xingguangjie, Power District

Harbin, Heilongjiang 150046

Tel: +86 (451) 281-616

Fax: +86 (451) 281-969

Under the AVIC, this plant has a total area of 420,000 square metres, with building floor space totalling 260,000 square metres. It has 7,000 staff, including 700 engineers and technicians, with fixed assets of over 160 million Rmb yuan and an annual average circulating capital of 130 million Rmb yuan. Facilities include 2,255 pieces of primary production equipment, including 583 sets of metal cutting equipment, 103 forging machines, and 72 large numerically controlled machines.

Xinghua Instruments Plant

PO Box 709

Qingshen, Sichuan 612461

Tel: +86 (8433) 61-698, 61-721

Fax: +86 (8433) 61-782

and

Beijing Office

PO Box 937

14 Xueyuan Road, Haidian

Beijing 100083

Tel: +86 (10) 202-8522, 202-8355, 202-2080

and

Chengdu Marketing Centre

Sichuan Electronic Mansion

20 Hongxing Zhonglu Erduan

Chengdu, Sichuan

Tel: +86 (28) 662-386

Under the China Electronics Corporation this plant was established in 1970 and specialises in the R&D and production of "military radio time unified standard signalling equipment", radio time frequency measuring instruments, and intelligent mathematics (AI) measuring instruments. Systems developed by this firm have been applied to space launch vehicles in 1979/80, underwater nuclear tests, SLBM tests, ICBM tests during the 1980s, various satellite launches and tracking and monitoring equipment. It has over 1,350 staff, including over 400 engineers and technicians, and a total area of 96,000 square metres. Organisation consists of a research centre, design and manufacturing centre, and a management centre. Product and R&D areas include high-precision time-frequency timing equipment, Rubidium nuclear frequency standards, quartz frequency standards, automatic testing systems, intelligent digital frequency counters, AC/DC emergency power sources, voltage stabilisers, telecommunications and electronics. Seeking foreign technology transfer, R&D co-operation and funding for Rubidium nuclear frequency standards, frequency parameter automatic testing instruments, general counters, frequency metres, and digital clock allocation devices product development.

Xingping Aircraft Wheel Corporation

PO Box 48

Xingping, Shaanxi 713006

Tel: +86 (9201) 22-701

Fax: +86 (9201) 22-745

Products include aircraft wheels, brakes, and hydraulic and pneumatic braking accessories.

Xinguang Electronics Devices Factory

Longquanyi Industrial Zone

Chengdu, Sichuan 610223

Tel: +86 (28) 445-754, 446-520, 448-931

This firm occupies an area of 13.33 hectares, employs 1,200 people, including over 380 engineers and technicians, has 1,445 pieces of equipment (including key imported systems from the US, Netherlands, and Japan), and semi-conductor production facilities. R&D and product areas include VHF high-power transistors, switching transistors, power transistors, high voltage transistor, high EB voltage transistors, bi-directional transistors, double emitter transistors, TV reception systems, SAW filter, SAW devices, SAW delay lines, SAW resonator, piezoelectric systems, etc. Aerospace and naval applications for products.

Xinhai Corporation

PLAN commercial activities.

Xinjiang Institute of Physics

Chinese Academy of Sciences

PO Box 139, Wulumuqi

Xinjiang, 830011

Tel: +86 (991) 383-5823, 383-8931

Fax: +86 (991) 383-5459

Xinxiang Aeronautical Machinery Corporation

(Yubei Machinery Factory)

PO Box 17

Xinxiang, Henan 453002

Tel: +86 (373) 338-4111

Fax: +86 (373) 338-2984

Under AVIC, this firm is also a subsidiary of the China National Airborne Equipment Corporation, and employs 5,300 staff supplying military mass flow-metres and aviation accessories such as wire cloths, filters, pumps, ECS components, heat exchangers, switches and valves. It has some 10,000 employees, of which 2,300 are engineers and technicians, and 1,000 major pieces of equipment.

Yangtze Aeroengine Plant

PO Box 18, Yueyang

Hunan 414001

Tel: +86 (730) 222-926, 222-357

Fax: +86 (730) 222-357

Under the AVIC, this plant specialises in inspection and testing methods, and aeroengine production with facilities for mechanical processing, stamping, welding, casting, forging, heat treatment, physical and chemical testing, assembly equipment, etc. It occupies an area 40,000 square metres and employs 2,000 people.

Yangzhou Marine Electronic Instruments Research Institute

PO Box 204

26 Nanhexia, Yangzhou

Jiangsu 225001

Tel: +86 (514) 233-911

Fax: +86 (514) 232-229

A subsidiary of the China State Shipbuilding Corporation, this institute has some 1,200 staff, over 60 percent of which are engineers and technicians, occupies building floor space of 83,126 square metres, and has 2,145 sets of instrumentation and 174 pieces of cutting, heat treatment, surface treatment, and other equipment. It undertakes R&D and product development in the areas of electronic technology, instrumentation, computer software, communications satellite equipment, and microwave technology applications. Has developed power sources for satellite ground station transmitters. Recent developments have included focus imaging systems for computer software, fibre optics and mobile telecommunications systems, and household satellite receivers.

Yong Hong Machinery Factory

PO Box 182

Guiyang, Guizhou 550009

Tel: +86 (851) 383-3175, 383-3178

Fax: +86 (851) 383-4610

Under AVIC, this firm produces aircraft high-altitude cabin equipment, turbine coolers, temperature and regulating equipment for aeroengines, etc. It has 90,000 square metres of production space, 1,800 employees including some 500 engineers and technicians, over 1,200 pieces of major equipment, and fixed assets of 130 million Rmb yuan. It has the sole simulated high-altitude environmental test lab in southwestern China.

Yubei Machinery Plant

322 Heping Road, XinXi'ang

Henan, 453003

Tel: +86 (371) 354-981

Fax: +86 (371) 352-095

Under the AVIC, this plant specialises in the production of aviation fuel and hydraulic components and gears, such as gear pumps, centrifugal pumps, spiral plate pumps, and gravity pumps, including some 80 types of aircraft gears and other types of high-tech hydraulic products in mass production. It has over 2,000 employees including over 460 engineers and technicians, and its area covers 170,000 square metres, including buildings with a total floor space of 70,000 square metres, fixed assets of over 48 million Rmb yuan, and 600 modern machine installations. The plant consists of 10 workshops, a technology transfer centre and a design institute, in addition to 15 service centres throughout China.

Yuhe Machinery Plant

2 Huangpu Road, Nanjing

Jiangsu 210016

Tel: +86 (25) 642-133, 643-958

Fax: +86 (25) 411-018

This plant has traditionally been an affiliate of the Headquarters of the General Staff department of the PLA, and specialises in the manufacture of mechanical and electronic military training equipment.

Yunan Packaging Factory

Dadong Chemical Industrial Group Corporation

Letter Box 603, Luliang

Yunan 655613

This factory produces explosives, and has 1,100 workers, including 157 engineers and technicians, an area of 1.8 million square metres, and fixed assets worth over 21 million Rmb yuan. Annual output of 18,000 tons of assorted explosives and 10,000 tons of calcium carbide. Diversifying production into anti-corrosion and heat preservation systems, metal surface treatment, furnaces, fabric fibres, and acetylene carbon black and chemical fertilisers derived from calcium carbide.

Zhang Yingxin Research Institute of TV and Electro-Acoustics

Ministry of Electronics Industry

PO Box 743

Beijing 100015

Tel: +86 (10) 436-3131 ext. 951

Fax: +86 (10) 436-2324

This institute has developed the Model 341TVT-B TV tracker and fire control system for acquiring and automatically tracking aerial targets in conjunction with the "341 radar servo system", that has a low-level target capability by improving radar angle tracking performance.

Zhejiang Shipbuilding Industry Corporation

140 Huancheng Bei Lu

Hangzhou, Zhejiang 310006

Tel: +86 (571) 515-8905

Technical Division 515-8052

Manager's Office 515-8016

Trade Dept. 515-7083

Fax: +86 (571) 515-4163

Zhengzhou Airborne Equipment Manufacturing Factory

Zhengzhou Aircraft Gear General Plant

Zhengzhou Xinwei Aircraft Equipment Company (Xinwei Machinery Factory)

PO Box 2, Lingbao

Henan 472501

Tel: +86 (398) 885-0511

Fax: +86 (398) 885-0593

Development and Marketing Department

PO Box 1084

104 Fu Huanghedong Road, Zhengzhou

Henan 450001

Tel: +86 (371) 898-4524

Under the AVIC, this plant was founded in 1960 and undertakes the R&D, design and production of aircraft gears, aero suspension and launching devices, hanging equipment, low pressure pumps, etc. Military production includes ejection bomb hooks, double bomb carriers, misile launchers, rocket launchers, etc., and it is a major national producer for these systems. It has 6,200 employees, with 1,400 engineers and technicians. The firm has three subsidiary plants, a research institute and training facility, and various joint ventures, and occupies a facility of almost 1 million square metres. It has 3,500 pieces of major equipment, including a NC processing centre, large vibration test bed, and 3-coordinate measuring machine. Capabilities include machining, rubber and plastic processing, stamping, welding, heat and surface treatment, aluminium alloy casting, die casting, and precision casting of ferrous metals and copper alloy.

Zhengzhou Institute of Aeronautics

2 Jinhai Road

Zhengzhou, Henan 450052

Tel: +86 (371) 898-6633

Fax: +86 (371) 888-9638

E-mail: nliu@zia.whnet.edu.cn

This institute specialises in the training of managers for the aviation industry, including such areas as operations research, quality management and engineering, and information management and science. It has a staff of 1,300 and some 6,000 students.

Zhengzhou Mechanical and Electrical Engineering Institute

1 Hanghai Road, Zhengzhou

Henan 450052

Tel: +86 (371) 669-931, 666-201

A subsidiary of the China State Shipbuilding Corporation, this institute has over 800 personnel, and specialises in the R&D of mechanical engineering, automatic control, hydraulic technology, chemicals, electronic equipment, servo-mechanisms, and microcomputers. R&D and product areas include automatic control devices, hydraulic stepless speed governor, large current/low-voltage power sources, gas for medical and chemical use, liquid filtering devices, electrostatic spray coating technology, pressure containers, digital recorders, servo systems, etc.

Zhenjiang Marine Diesel Works

PO Box 415, Zhenjiang

Jiangsu 212011

Tel: +86 (511) 421-880, 421-882

Under the China State Shipbuilding Corporation, this works occupies a total area of 210,000 square metres, with building floor space totalling 50,000 square metres, has 800 total staff, of which some 100 are technical personnel, and operates workshops for mechanical processing, assembly and testing, casting, metal structure, heat treatment, etc. Produces diesel engines used for various types of ships including survey ships and "marine monitoring ships". Diesel engines applied for ocean-going, coastal and riverine ships, and as generating units can be used to power land power plants, pumping stations and offshore oil drilling platforms. In 1980 imported B&W company's L23/30 and L28/32 medium speed diesel engine manufacturing technology under license.

Zhonghua Shipyard

130 Gongqing Road, Fuxingdao

Shanghai 200090

Tel: +86 (21) 6519-9948, 6519-2000

Fax: +86 (21) 6543-2859

This shipyard has over 6,000 employees, occupies an area of 0.36 million square metres, has 3 berths, 650 metres of mooring quay, and more than 1500 sets of equipment. Builds, repairs and refits up to 20,000 dwt passenger and cargo ships, and major surface combat and auxiliary ships, including guide-missile destroyers and new scientific research ships. Has manufactured the research ship "Kancha 3" and a 258 seat sidewall hovercraft. Produces assorted civilian ships such as engineering ships, chemical tankers, train ferries, LPG carriers, etc. Also produces oil-drilling platforms, oil exploration equipment, pressure vessels, tools, steel and iron castings and forgings, etc.

Zhongnan Optical Instruments Factory

PO Box 5 Zhicheng

Hubei 443301

Tel: +86 (7275) 224-388, 224-453

Fax: +86 (7275) 224-475

Under the China Shipbuilding Industrial Corporation, this factory has over 2,500 staff members, including 600 technical personnel, occupies an area of 380,000 square metres, including 120,000 square metres of building floor space, and has fixed assets valued at over 80 million Rmb yuan, including over 1,500 sets of precision instruments. R&D and production areas include optics, and liquid crystal display optical material such as composite polarisation discs. R&D interest in barium fluoride crystal processing.

Zhongnan Transmission Machinery Factory

PO Box 521

Wangcheng County

Changsha, Hunan 410200

Tel: +86 (731) 817-0300

Fax: +86 (731) 806-2355

This enterprise produces gears for the HS5, HS6, WJ6, WJ9, WZ6, WZ8, WZ9, WP13, and WP14 aeroengines, main tail and reducing gears, accessories such as air compressors and transmission casings, and middle and tail speed reducers for the Z-8 helicopter. The firm has over 3,000 employees, including some 500 technicians and engineers, and has ISO9001 quality certification. It has five processing centres with various types of gear maching and testing equipment, including CAD/CAM systems.

Zhongxing High Technology Corporation

43 Beisanhuanxi Road

Haidian District

Beijing 100086

Tel: +86 (10) 257-3465

Fax: +86 (10) 257-2740

This National Airborne Equipment Corporation subsidiary produces and designs satellite microwave and auto-control systems.

Zhongyuan Electrical Measuring Instruments Factory

PO Box 2

Hanzhong, Shaanxi 723007

Tel: +86 (916) 257-7212

Fax: +86 (916) 257-7213

Founded in 1965, this AVIC firm produces aviation electrical measuring instruments such as altitude and air speed sensors. The firm has 56,000 square metres of production space, 558 major pieces of equipment, 6 sub-factories and 3 affiliated research institutes. It is ISO9001 certified.

Zhongyuan Foreign Engineering Corporation

43 Hucheng Road, Haidian

Beijing 100037

Tel: +86 (10) 841-6614, 841-6615

Fax: +86 (10) 841-6616

CZEC has overall contracting responsibility for the overseas export of nuclear power station projects and related nuclear activities. Services include project contracting, agents, consultants, joint-venture partners, etc. CZEC has branch offices or representative organisations in the United States, Europe, North Africa, Middle East, Southeast Asia, Hong Kong and Macao.

Zhong Zi Satellite Application Technology Company

131 Baiduizi, Fucheng Lu

Haidianqu, Beijing 100037

Tel: +86 (10) 837-1895

Fax: +86 (10) 837-1681

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APPENDIX B - KEY ACRONYMS

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Key Acronyms

AAA - anti-aircraft artillery

AAM - air-to-air missile

ABM - anti-ballistic missile

AC - alternating current

ADS - automatic dependent surveillance

AEW - airborne early warning

AFV - armoured fighting vehicle

AI - artificial intelligence

AIP - Air-independent propulsion

ALCM - air-launched cruise missile

APC - armoured personnel carrier

APU - auxiliary power unit

ASAT - anti-satellite

ASIC - application specific integrated circuits

ASM - air-to-surface missile

ASM - anti-ship missile

ASW - anti-submarine warfare

AT - anti-tank

ATC - air traffic control

ATGM - anti-tank guided missile

ATM - air traffic management

ATM - asynchronous transfer mode

AVIC - Aviation Industries of China

AWACS - airborne warning and control system

BMD - ballistic missile defence

BVR - beyond visual range

CAAC - Civil Aviation Administration of China

CAD/CAM - computer-aided design/computer-aided manufacturing

CAE - Chinese Aeronautical Establishment

CAEIT - China Academy of Electronics and Information Technology

CAEP - China Academy of Engineering Physics

CAIC - China Aerospace Industry Corporation

CALT - Chinese Academy of Launch Vehicle Technology

CANDU - Canada Deuterium Uranium (reactor)

CAPUMIT - China Association for the Peaceful Use of Military Industry Technology

CAS - Chinese Academy of Sciences (Academia Sinica)

CASC - China Aerospace (Aviation) Supplies Corporation

CAST - Chinese Academy of Space Technology

CATIC - China National Aerotechnology Import and Export Corporation

CCD - charged-coupled device

CCP - Chinese Communist Party

CEP (circular error of probability)

C4I - command, control communications, computers and intelligence (systems)

CGWIC - China Great Wall Industry Corporation

CHAIC - Changhe Aircraft Industries Corporation

CIAE - China Institute of Atomic Energy

CIMS - computer integrated manufacturing systems

CITIC - China International Trust and Investment Corporation

CMOS - complementary metal-oxide semiconductors

CNNC - China National Nuclear Corporation

CNSA - China National Space Administration

CNS/ATM - communication, navigation, surveillance/air traffic management

COCOM - Co-ordinating Committee for Multilateral Export Controls

COSTIND - Commission of Science, Technology and Industry for National Defence

CPMIEC - China Precision Machinery Import and Export Corporation

CPKM - commercial perigee kick motor

CSS - Chinese surface-to-surface (missile)

CSSC - China State Shipbuilding Corporation

CTBT - Comprehensive Test Ban Treaty

CWC - Chemical Weapons Convention

CZ - *Changzhen (Long March* launch vehicle)

COMINT - communications intelligence

COSCO - China Overseas Shipping Company

COSTIND - Commission of Science and Technology Industry for National Defence

CPKM - commercial perigee kick motor

CPMIEC- China Precision Machinery Import and Export Corporation

CSQC - Chinese Society for Quality Control

CZ - Chang Zheng (Long March or LM)

DC - direct current

DSMAC - digital scene matching and correlation

CDMA - Code Division Multiple Access (standard)

DEW - directed-energy weapon

DFH - *Dongfanghong* ("the East is Red")

DF - *Dong Feng* (*East Wind* ballistic missile)

DU - depleted uranium

ERFB-BB - extended full bore base bleed

ECCM - electronic-counter-counter-measures

ECM - electronic countermeasures

ELINT - electronic intelligence

EMI - electromagnetic interference

EMP - electromagnetic pulse

ERA - explosive reactive armour

ERFB-BB - extended full bore base bleed

ESM - electronic support measures

ESR - electro-slag manufacturing techniques

EVA - (space) extravehicular activities

EW - electronic warfare

FADECS - full-authority digital engine control system

FAE - fuel air explosive

FBL - fly-by-light

FBW - fly-by-wire

FLIR - forward-looking infrared (sensors)

FMS - flexible manufacturing system

FOBS - fractional orbit bombardment system

GaAs - gallium arsenide

GED - (PLA) General Equipment (Armaments) Department

GEO - geosynchronous, or geostationary earth, orbit

GGWIC - China Great Wall Industry Corporation

GIS - geographic information system

GLD - (PLA) General Logistics Department

GPS - (US) Global Positioning System (GLONASS is Russian equivalent)

GPMG - general purpose machinegun

GTO - geosynchronous transfer orbit

GPS - global positioning system

GSD - (PLA) General Staff Department

HAIG - Hongdu Aviation Industrial Group

HDTV - (digital) high definition television

HE - high explosives

HEAT - high-explosive anti-tank

HGP - Human Genome Project

HLW - high-level (radioactive) waste

HPC - high-performance computer

HPM - high-powered microwave

HUD - head-up display

IAEA - International Atomic Energy Agency

IC - integrated-circuit

ICBM - intercontinental ballistic missile

IEAS - Institute of Electronics of Academia Sinica

IFF - identify friend or foe

IFV - infantry fighting vehicle

ILS - instrument landing system

IMINT - imagery intelligence; deriving intelligence from photographs or other forms of imagery (eg. SAR -synthetic aperture radar systems)

IN - inertial

INS - inertial navigation system

IR - infrared

IRBM - intermediate-range ballistic missile

IRSA - Institute of Remote Sensing Applications

ISO - International Standards Organisation

IT - information technology

IW - information warfare

JL - *Ju Lang (Giant Wave)*

kt - kiloton

kw - kilowatt

LAV - lightly armoured vehicle

LEO - low earth orbit

L/ILW - low and intermediate level (radioactive) waste

LMG - light machinegun

LST - landing ship - tank

LWIR - long wave infrared

M - Mach

MAD - mutual assured destruction

MANPADS - manportable air-defence system (missile launcher)

MARV - manoeuvring re-entry vehicle

MBT - main battle tank

MEMS - microelectromechanical systems

MIRV - multiple independently targeted re-entry vehicle

MLS - microwave landing systems

MLRS - multiple-launch rocket system

MMW - millimetre wave

MOFTEC - Ministry of Foreign Trade and Economic Co-operation

MOST - Ministry of Science and Technology

MRV - multiple re-entry vehicle

mt - megaton

MTCR - Missile Technology Control Regime

MW - megawatt

NBCW - nuclear, biological and chemical warfare

NC - numerically controlled

NORINCO - (China) North Industries Corporation

NPT - Nuclear Non-Proliferation Treaty

NRSCC - National Remote Sensing Centre of China

NSG - Nuclear Suppliers Group

OTH - over-the-horizon (radar systems)

PC - personal computer

PCB - printed circuit board

PENAIDS - (ballistic missile) penetration aids

PERT/CPM - Project Evaluation and Review Technique/Critical Path Method

PGM - precision guided munition

PLA - (Chinese) People's Liberation Army

PLAAF - People's Liberation Army Air Force

PLAN - People's Liberation Army Navy

PRC - People's Republic of China

PSYOP - psychological operations

PWR - pressurised water reactor

RADAG - radar digital area guidance system

RCS - radar cross section

R&D - research and development

RF - radio frequency

RFI - radio frequency interference

RMA - Revolution in Military Affairs

Rmb - renminbi yuan (Chinese currency unit)

RPG - rocket propelled grenade

RPV - remotely piloted vehicles

RSGS - Remote Sensing Ground Station

RV - re-entry vehicle

SAIG - Shenyang Aircraft Industry Group

SAST - Shanghai Academy of Spaceflight Technology

SAR - synthetic aperture radar

SAW - surface acoustic wave

SDH - synchronous digital hierarchy

SEZ - special economic zone

SIGINT - signals intelligence

S&T - science and technology

SLAR - self-loading assault rifle

SLBM - submarine-launched ballistic missile

SLOWPOKE - Safe Low Power Critical Experiment miniature reactor

SLV - space (satellite) launch vehicle

SOE - state-owned enterprise

SP - self-propelled

SPAAG - self-propelled anti-aircraft guns

SPATG - self-propelled anti-tank gun

SPG - self-propelled gun

SRBM - short-range ballistic missile

SSBN- nuclear-powered ballistic missile submarine

SSK- diesel-electric powered submarine

SSN - nuclear-powered attack submarine

SSTO - single-stage-to-orbit (space launcher)

STOL - short take-off and landing

TEL - transpolar-erector-launcher

TERCOM - terrain-contour matching (guidance system) or terrain comparison; matches radar pictures of terrain with a computer database of terrain images to guide a missile to its target

TFR - terrain following radar

TMD - theatre missile defence

TOW - optically-aimed, wired-guided

TQC - total quality control

TSTO - two-stage-to-orbit (space launcher)

TT&C - tracking, telemetry and control

UAV - unmanned aerial vehicle

UHF - ultra high-frequency

VFAC - variable frequency alternating current

VHF - very high-frequency

VLS - vertical launch system

VLSI - very large-scale integrated (circuits)

VSAT - very small aperture satellite terminals

V/STOL - vertical/short take-off and landing

W - Watt

WIG - wing-in-ground

WMD - weapon of mass destruction

WVR - within visual range

XAIG - Xi'an Aircraft Industrial Group

XISRT - Xi'an Institute of Space Radio Technology

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APPENDIX C - ELECTRONIC SYSTEMS

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Electronic Systems

BM/DJG 8715 jamming system

Type: Mobile I/J-band (8 to 20 GHz) radar jamming system.

The BM/DJG 8715 is a ground-based jammer designed to counter airborne radars including missile guidance, missile seekers, navigation and terrain-following emitters. The configuration incorporates one Electronic Support Measures (ESM) station with up to eight Electronic Counter Measures (ECM) sites, all of which are integrated by data-links to ensure automatic control, direction of jamming and feedback of ECM data. BM/DJG 8715 is stated to feature a wide frequency coverage; automatic classification and identification of a variety of threat radars; mono-pulse auto-angular tracking with high direction-finding accuracy; multi-threat jamming in different frequencies and bearings; the capability of countering sophisticated radars and a high jamming power using a travelling wave tube output. A variety of ESM displays are provided at the ESM station, including polar displays, alphanumeric displays and an air track display showing the graphical background of the territory. Both the ESM and the ECM stations are mounted on self-propelled vehicles to ensure high mobility. The BM/DJG 8715 is thought to be in service with the PLA.

ESM Station Frequency

coverage: 8-18 GHz IFM

Accuracy: 5-12 MHz RMS

Azimuth coverage: 360º DF

Accuracy: 5-8º

Measurable pulsewidth: 0.1-100 Ás

ECM Station Frequency

coverage: 8-16 GHz IFM

Accuracy: 10 MHz RMS

AFC spotting accuracy: <2 MHz

Angular tracking accuracy: 1º RMS

Output power: 2 x 100 W (CW) min

Manufacturer: Southwest China Research Institute of Electronic Engineering (SWIEE), Chengdu, Sichuan

BM/HZ 8610 Electronic Support Measures (ESM) system

Type: Shipborne ESM system.

The BM/HZ 8610 is a high-sensitivity ESM equipment which provides direction-finding and analysis of threat radar equipment. It can operate in conjunction with both passive and active electronic countermeasures systems and provides maximum prior warning and threat identification. The system is suitable for warships of all types and sizes. BM/HZ 8610 possesses a sophisticated radar signal processing capability and provides both tabular and graphic displays to the operator. The high direction-finding accuracy and acquisition capability enable cueing of radar and optical systems, and passive designation of the fire-control systems and onboard missiles. The BM/HZ 8610 is understood to be in service aboard the Hainan, Hegu, Hola, Huangfen, Huchuan, Shanghai, Shanghai II, Soju and Taechong class patrol craft operated by the PLAN and a number of Asian and African navies.

Frequency coverage: 2-8 GHz; 7.5-18 GHz

Azimuth coverage: 360º

Elevation coverage: -10 to +30º

Frequency accuracy: 5 MHz

RMS DF accuracy: 2.5 RMS

Sensitivity: greater than -70 dBWi

Dynamic range: 40 dB

Pulsewidth range: 0.1-99.9 Ás

Environmental signal density:10 pps

Radar data store capability: 500-1000 modes

Manufacturer: Southwest China Research Institute of Electronic Equipment, Chengdu, Sichuan

BM/KG 8601/8605/8606 jammers

Type: Self-protection noise and repeater jammers.

The Southwest China Research Institute has developed a range of airborne jamming systems for the self-protection of various types of aircraft. BM/KG 8605 is one of these and operates in the I/J-band (8 to 20 GHz). It is a smart noise jammer which produces a hybrid type of jamming which incorporates some of the features of both noise and deception jammers. BM/KG 8606 is another of the same series which operates in the I-band (8 to 10 GHz) and features orthogonal and dual circularly polarised jamming techniques. These jamming systems operate in conjunction with chaff/flare dispensers providing cross polarisation jamming and fast and accurate set on. The jammers are small, lightweight and have a low-power consumption. BM/KG 8601 type repeater jammers operating in the E/F- (2 to 4 GHz) and G/H- (4 to 8 GHz) bands are also available for installation in strike and fighter/bomber aircraft to counter airborne tracking, anti-aircraft fire-control and surface-to-air missile guidance radars. These jammers have a high power output, minimal repeater delay time, threat management through radio frequency channelling, a wide antenna coverage and provide multijamming techniques.

Manufacturer: Southwest China Research Institute of Electronic Equipment, Chengdu, Sichuan

BM/KJ 8602 airborne radar warning system

The BM/KJ 8602 is a radar warning receiver designed for tactical and other combat aircraft. It consists of a digital signal analyser, a CRT display unit, control box, several receivers and a number of antenna units. It features wide frequency coverage in two bands, 0.7 to 1.4 GHz and 2 to 18 GHz, and is capable of dealing with multiple threats. Automatic sorting and identification of threat emissions are provided. The system can operate in conjunction with ECM units and chaff/flare dispensers. The BM/KJ 8602 system is compact and lightweight, making it suitable for tactical aircraft where space and weight are strictly limited.

Weight: 20 kg

Frequency: 0.7-14 GHz and 2-18 GHz

Response time: 1 s

Capacity: 16 threats simultaneously

Coverage: (azimuth) 360º (elevation) -30º to +30º

Accuracy: 15º RMS

Manufacturer: Southwest China Research Institute of Electronic Equipment

BM/KG 8605/8606 smart noise jammers

The BM/KG-8605 operates in the I/J-band as a smart noise jammer performing a hybrid type of jamming which incorporates some of the features of both noise and deception jamming. The BM/KG 8606 operates in the I-band and features both orthogonal and dual circularly polarised jamming techniques. Both the BM/KG 8605 and the BM/KG 8606 operate in conjunction with chaff/flare dispensers providing cross polarisation jamming and fast and accurate set on. They are small, lightweight and have a low power consumption. Operational status - in production.

Manufacturer: Southwest China Research Institute of Electronic Equipment

BM/KJ 8608 airborne ELINT system

The BM/KJ 8608 ELINT system detects, locates, identifies and analyses radar emitters deployed on the ground and at sea with high interception capability, high sensitivity and accurate measurement of parameters. It features wide frequency coverage, high sensitivity and long operational range, automatic signal identification, emitter position fixing capability, and can operate in a dense RF environment and BITE.

Power supply: 115 V AC, 400 Hz 28 V DC

Frequency: 1-18 GHz

Frequency accuracy: 5 MHz

Coverage: (azimuth) 360º

Accuracy: (bearing) (1-8 GHz) 5º, (8-18 GHz) 3º

Manufacturer: Southwest China Research Institute of Electronic Equipment

BM/KZ 8608 ELINT system

The BM/KZ 8608 is an airborne ELINT system developed by the Southwest China Research Institute. It is designed to detect, identify, analyse and locate land-based or shipborne radar emitters with high sensitivity and accurate measurement of parameters. It consists of five main parts; antennas, super-heterodyne receiver, instantaneous frequency measuring receiver, processor and display unit. Although very few technical details have been released, it is claimed to have a wide frequency coverage, long range, ability to operate in dense electromagnetic environments, automatic signal identification and an emitter fixing capability. No information is available on the size of the processor library.

Operational status: As of 1995, BM/KZ 8608 was reported to have been installed on at least one Xian Y-8 (An-12) aircraft of the PLAAF.

Frequency range: 1-18 GHz

Frequency accuracy: 5 MHz

Azimuth coverage: 360º

Bearing accuracy: 5º (1-8 GHz); 3º (8-18 GHz)

Sensitivity: -100 dBW

Dynamic range: 50 dB

Signal density: 200,000 pps

PRF range: 100 Hz-20 kHz

PRF accuracy: +-1% (100 Hz-2 kHz); +-2% (2-20 kHz)

Pulse width range: 0.1-99.9 Ás

Power supply: 28 V DC; 115 V 400 Hz AC

Manufacturer: Southwest China Research Institute of Electronic

Equipment, Chengdu, Sichuan.

BWT-133 15 W HF/SSB transceiver

The BWT-133 is a solid-state 15 W HF/SSB transceiver for voice and telegraphy applications in the 1.6 to 29.999 MHz range. Power supply is Ni/Cd battery and high-speed AC/DC charger or hand generator. Channel spacing is 1 kHz.

Technical specifications

Modes: A3J and A2J, A3H JAM compatible

Frequency range: 1.6-29.999 MHz

Power output: 15 W PEP SSB voice, 15 W average SSB telegraph, 4.5 W AM voice carrier

Temperature range: -40 to +50ºC

Height: 262 mm (without battery box), 352 mm (with battery box) Width: 286 mm

Depth: 98 mm

Weight (without battery): 6.5 kg, 13 kg in manpack configuration

Manufacturer: Shaanxi Fenghuo Group Company, Baoji.

Cheetah Artillery Radar

Type: J-band (10 to 20 GHz) surveillance and gun fire-control radar.

The Cheetah is a J-band mobile radar designed for battlefield use by artillery formations for surveillance and gun fire correction purposes. The complete unit, except for a small engine-driven portable electrical generator located a short distance from the radar unit, is carried on a six-wheeled military truck. Deployment time is less than 10 minutes after the vehicle has halted, and march order time is less than 7 minutes. The complete system is probably a Chinese version of the Russian Federation and Associated States SNAR-2 radar known to NATO as Pork Trough, except that the latter equipment is carried on a tracked vehicle. The Cheetah system is mounted on a flatbed truck in a cab that contains the electronic equipment and also serves as the operators' cabin. A low profile rotating antenna is mounted on the roof of the cab with part of the turning gear probably protruding below into the working space. The operational function of the Cheetah radar is battlefield surveillance for targets such as tanks and armoured concentrations and for correction of artillery gunfire. Although performance details are sparse, there are claims of some relevance, as indicated in the specifications, and references to a two-colour display which shows moving targets in a different colour from the main picture, anti-jamming facilities, and moving target indicator. The Cheetah system should be considered obsolete. Despite this, the equipment is thought to be still in service with the PLA.

Frequency: J-band (10-20 GHz)

Detection range: 300 m-16 km (tank target)

Peak power: >70kW

Elevation coverage: +-10º

Accuracy: 5 m (range); 1 mil (azimuth)

Resolution: 35 m (range); 0-16 mils (azimuth)

Displays: 1 panoramic display; 1 section display (red and green)

Weight: 7,500 kg (including truck)

Chinese OTH radar

During the Asian Defence Technology Exposition, Beijing, in November 1986, the Chinese authorities stated that China was carrying out a full-scale development programme into an Over-The-Horizon (OTH) radar system. Very little information was provided other than a few parameters which are given here. The system is claimed to have a range of between 700 and 3,500km over an azimuth of 60º and uses pole antennas similar to those of the Australian Jindalee system.

The system is said to be deployed. The degree of current operational effectiveness has not been released but it seems likely that the system is in the development phase with trials being carried out.

Frequency: HF

Waveform: FM/CW

Transmission beamwidth: 7.5º horizontal; 5-36º vertical

Reception beamwidth: 2.5º horizontal; 5-36º vertical

Polarisation: vertical

Output power: 1 MW (20 sets of 50 kW transmitters)

Range: 700-3,500km

Capacity: 100 batches of target per 12-24s

Type HF band (3 to 30 MHz) OTH radar.

Frequency: HF band (5-28 MHz)

Configuration: bistatic transmitting and receiving sites

Illuminated sector: 60º

Transmitting antenna: log-periodic antennas

Receiving antenna: monopoles

Ground screen: 120 m in front of array

Waveform: FM/CW

Transmission beam width: 7.5º (horizontal); 5-36º (vertical)

Reception beam width: 2.5º (horizontal); 5-36º (vertical)

Polarisation: vertical

Output power: 1 MW (20 sets of 50 kW sub-transmitters)

Range: 700-3,500 km

Capacity: 100 batches of target per 12-24 s

MTBF: 200 h

Manufacturer: Nanjing Research Institute of Electronics Technology, Nanjing; Chinese Research Institute of Radio Wave Propagation

Coast tracking radar

This is a mobile X-band coastal radar used for surface vessel tracking and control of coastal weapon systems. The rotating antenna is mounted on a flatbed truck which also carries the operations cabin containing processing equipment and displays.

This is in production and service.

Frequency: X-band

Antenna beamwidth: 1 x 2º

Peak power: 200 kW

Pulsewidth: 0.2 Ás

Accuracy: 30 m (range); 1.5 mil (azimuth)

Resolution: 60 m (range); 20 mil (azimuth)

Manufacturer: China National Electronics Import & Export Corporation, Beijing

Colour weather radar

The colour weather radar designed for civil aircraft is now under development and testing, with assistance from Rockwell International Corporation, Collins General Aviation Division. The radar system incorporates a variety of new technologies including narrowed waveguide planar slotted array, high-performance transmitter, miniaturised logic-controlled receiver, and digital colour indicator. The transmitter employs a pulse-modulated magnetron. It also has ground-mapping features.

Weather avoidance range: >500 km (for strong thunderstorm areas)

Scan range: (azimuth) +-60º (elevation) +-15º

Antenna stabilisation range: (roll) +-30º (pitch) +-10º

Weight: 20 kg (no cables)

Antenna beamwidth: <6º

Manufacturer: China Leihua Electronic Technology Research Institute

DT-802 radio modem

The DT-802 modem serves as the interface between a computer and a transceiver, altering transmission speed according to propagation conditions. Designed for point-to-point or point-to-multipoint applications, it can be used on HF, UHF and VHF networks. Speeds are 150, 300, 600 and 1,200 baud and the modem has error correction capabilities. It is powered from 13.5 V DC, and weighs around 1.5 kg. It is claimed to have high jamming immunity.

Manufacturer: China National Electronics Import and export Corporation, Beijing.

DZ9001 ELectronic INTelligence (ELINT) system

Type D- through J-band (1 to 18 GHz) ground-mobile ELINT system.

The DZ9001 ground-mobile ELINT system comprises a three-truck convoy in which two-vehicles carry deployable (scissors lift) antenna radomes with the third being configured as a control centre. The system is completed by what appears to be a generator or logistics trailer. The DZ9001 is understood to be available.

Frequency range: 1-18 GHz

Dynamic range: >50 dB

Sensitivity: >=70 dBm

Direction-finding accuracy: >3º RMS

Frequency accuracy: 2 MHz

Manufacturer: China National Electronics Import and Export Corporation

Eagle coastal radar

Under the name of `Eagle' the Chinese authorities are offering for export a Ku-band mobile radar designed for use by coastal artillery units, presumably for target detection and location as well as for fire correction by means of splash-spotting techniques, although this is not publicly stated. The general arrangement consists of a small (1 to 2 ton) four-wheeled van with a modestly sized mesh antenna unit with its turning gear mounted on the roof of the cab. The latter houses the transmitter/receiver and display equipment in addition to providing working space for the operating crew. Power for the radar is derived from a small portable engine-driven electrical generator that can be located a short distance from the vehicle, which is equipped with corner jacks for stability on site. The radar is in production and available for export.

Frequency: Ku-band

Range: 50 km (1,000-3,000 ton ship target); 27 km (75 ton craft) Accuracy: 0.09º (bearing); 15 m (range)

Weight: 300 kg (radar only)

Manufacturer: China National Electronics Import & Export Corporation, Beijing

15 W HF/SSB transceiver

The 15 W synthesised HF transceiver is of solid-state construction and covers the 1.6 to 29.999 MHz range. It weighs 13 kg.

Modes: LSB(J3E), LSB(J2A), H3E (also USB if sideband filter is changed)

Frequency range: 1.6-29.999 MHz

Frequency stability: +-0.7x10

Antennas: 3 m whip, 12 m variable slant, 24 m dipole.

Transmitter power output: SSB voice: 15 W (PEP),

SSB telegraph: 15 W (average)

AM voice: >4.5 W (carrier)

Receiver sensitivity: Greater than 5 ÁV for 20 dB, SSB voice and telegraph

Signal-to-noise ratio: Greater than 10 ÁV for 10 dB (s+n)/n

Weight: 13 kg (for manpack).

Manufacturer: China National Electronics Import and Export Corporation, Beijing.

41A00 HF/SSB transceiver

The 41A00 is an HF/SSB transmitter for fixed station, mobile and maritime use. The modular equipment and its antenna are capable of fast automatic tuning and there is an ALE option. Features include 100 individual addresses and 20 net addresses; networks of up to 30 individual radios; secure voice; high-speed data, facsimile and slow scan television capabilities; VHF/HF relay; ARQ and FEC;

and local or remote control.

Manufacturer: China National Electronics Import and Export Company, Beijing.

41B00 adaptive HF communication system

The 41B00 is a 1 kW adaptive communication system which has ALE to MIL-STD-188-141A and the Chinese military standard GJB 2077-94. It has 100 simplex or duplex channels and can be used for fixed station applications, in vehicles and ships. System components are the 41B40 frequency synthesised exciter, the 41B30 1 kW solid-state transmitter, the 41B90 switching power supply, the 41B50 adaptive controller, the 41B20 receiver, the 41B60 pre/post selector and the 41B70 digital antenna coupler. The transmitter can scan up to 100 preset channels at 5 or 2 channels/second and it has a 100-channel SELCALL capability. Frequency range is 2 to 29.99999 MHz and modes are CW, AM, ISB, USB, LSB and data. The receiver element operates over 10 kHz to 29.99999 MHz. With appropriate add-ons, the 41B00 offers secure communication, high-speed data, digital image transmission and facsimile.

Modes: CW, AM, ISB, USB, LSB, data

Frequency range: 2-29.99999 MHz

Power output: 1 kW

Power supply: 220 V AC

Temperature range: -10 to +55ºC operating

Manufacturer: Panda Electronics Group Co, Nanjing.

41B70/41F73 antenna coupler

The 41B70/41F73 2 to 30 MHz antenna coupler uses a microprocessor to control changes in a binary digital matching unit to achieve impedance matching of whip, long wire, dipole and wideband antennas. It features status information tested by a general HF discriminator; VSWR of <=1.5; input power handling of 1 kW (41B70) and 400 W (41F73); 512 frequency storage; storage tuning time <=75 ms; and self-test. The 41B70 unit measures 280 x 420 x 760 mm. The 41F73 measures 280 x 420 x 690 mm. Powered by 220 V AC +- 10Hz, the units conform to the Chinese military standards GJB 880-90 (interface) and GJB 150.16 - 86 2.3.3 (shock and vibration).

Manufacturer: Panda Electronics Group Co, Nanjing.

41C30/H/TJF-441 HF/SSB transmitter

The 41C30 transmitter is designed for fixed base station and vehicular applications, and the H/TJF-441 for shipboard applications. Both are composed of a switching power supply, a fully solid-state power amplifier and a microcomputer-controlled exciter. Modes are CW, ISB, USB, LSB, AM and data, and output power is 400 W (PEP), 400 W (CW) and 100 W (AM). The transmitters cover 2 to 29.9999 MHz at 10 Hz intervals, and meet the Chinese military standard GJB 150. 1-86 for vibration. The transmitters' repertoire extends to data, telex, facsimile and still image transmission, and there is built-in over-heating, over- voltage, under-voltage and over-current protection.

Power supply: 220 V AC.

Measurement (41C30): 850 x 540 x 600 mm and

Weight: 140 kg.

Measurement (H/TJF-441): 950 x 540 x 600 mm

MTBF: > 600 hours

Modes: CW, ISB, USB, LSB, AM, data

Frequency range: 2-29.9999MHz

Channel spacing: 10 Hz

Power output: 400 W (CW), 400 W (PEP), 100 W (AM)

Power supply: 220 V AC, 50 Hz

Temperature range: -10 to +55ºC operating

Manufacturer: Panda Electronics Group Co, Nanjing.

41F00 400W adaptive HF communication system

The 41F00 is a 400 W adaptive HF communication system conforming to the GJB 2077-94, MIL-STD-188-141A and FED-STD-1045 ALE standards. Modes include CW, ISB, USB, LSB and AM, frequency range is 2 to 29.99999 MHz, and output power is 400 W. With the use of relevant terminal equipment, the system can handle voice, data, telex, facsimile and slow scan colour image transmission. The 41F00 is suitable for shipboard, vehicular and fixed base station applications. With a suitable antenna array, communication over distances up to 2,000 km is possible.

Operating temperature: -10 to +55ºC

Transmitter cabinet

Measurement: 850 x 540 x 600mm

Weight 145kg

System's receiver

Cabinet measurement: 850 x 540 x 600mm

Weight: 100 kg.

Note: The Model 41F73 antenna coupler measures 280 x 420 x 690mm and weight is 50 kg.

Manufacturer: Panda Electronics Group Co, Nanjing.

Gin Sling radar

Type: Target acquisition/tracking and missile guidance radar.

Gin Sling is the NATO name for the acquisition and tracking radar employed with the HQ-2 SAM system (Chinese designation HQ-2J). The HQ-2 is a redesign of the HQ-1 - a licence-built version of the RFAS Guideline system. Gin Sling is similar in appearance to the RFAS Fan Song radar and has a matching performance in the ability to track a single target and guide up to three missiles. The basic elements of Gin Sling are a pair of orthogonal `trough' antennas, one horizontal and one vertical. The vertical antenna emits a fan-shaped beam which scans from side-to-side, the horizontal antenna scans up and down (for other details see Fan Song entries). In support of Gin Sling is the SJ-202 early warning acquisition and height-finding radar (see separate entry). Gin Sling is thought to be in service with the PLA.

Manufacturer: China Precision Machinery Import and Export Corporation

GT-1 dispenser

Type Airborne chaff and Infra-Red (IR) flare dispenser.

GT-1 is a chaff and IR flare dispensing set which has been developed to provide self-protection for fixed- and rotary-wing aircraft. It provides chaff dispensing countermeasures in the 2 to 18 GHz band and IR countermeasures in the 1.5 to 5 Ám wavelength. The complete system consists of a programme controller, an operations control, dispensers and cartridges. It is intended to be interconnected with an appropriate radar warning receiver. The system is able to dispense 68 chaff cartridges or 32 IR cartridges. For salvo firing the GT-1 can be controlled for the number of payloads in a salvo, interval between salvos and number of salvos. Other options are continuous dispensing, random dispensing, double or single cartridge dispensing and jettison. Two dispensers must be employed for chaff and IR cartridges respectively, as chaff and IR cartridges cannot be mixed in the same dispenser.

Manufacturer: China National Import and Export Corporation

Hai Ying air surveillance radar

Type G-band (4 to 6 GHz) air surveillance radar. Hai Ying (Sea Eagle) is a 3-D air surveillance radar developed by the Chinese Nanjing Marine Institute. The system operates in G-band and utilises a phased scanning, plannar-array antenna. Hai Ying incorporates a stabilised high power wideband amplifier with a frequency agile synthesiser and microcomputer. Comprehensive electronic counter-countermeasures facilities are understood to have been included in the design, and a maximum target capacity of 25 tracks is quoted. Jane's recent sources suggest that the Hai Ying radar is fitted to a number of the PLAN's `Luhu' class destroyers.

Azimuth coverage: 360º

Altitude coverage: 25,000 m

Range: up to 180 km

Elevation: 0-7.2º or 0-28.8º

Accuracy: +-100 m (range); +-0.8º (azimuth/elevation)

Manufacturer: Nanjing Marine Institute

HF 100W power amplifier

The HF 100W power amplifier is used with the BWT-133 15 W transceiver and an AAT to form a 100 W SSB radio station. It is mainly used in mobile applications but can be used at fixed stations.

Modes: SSB telegraphy and voice

Frequency range: 1.6-30 MHz

Power output: 100 W voice, 70 W telegraph

Power supply: 24 V DC (negative grounded)

Temperature range: -40 to +50ºC

Height: 132 mm

Width: 310 mm

Depth: 296 mm

Weight: 6.8 kg

Manufacturer: Shaanxi Fenghuo Group Company, Baoji.

HN-401R mobile surveillance radar

This is a Type UHF band (0.3 to 1 GHz) 2-D mobile air defence radar. The HN-401R is a mobile long-range air defence 2-D surveillance radar. It consists of a large horizontally polarised dipole planar-array with an aperture of 17 x 8 m, an operations cabin containing all the electronics and two display units, and a power cabin. The system employs coherent pulse compression techniques and uses a highly stable frequency source. The signal processing system is able to adapt to pulse-to-pulse or burst-to-burst frequency agility, and moving target indicator. Low-azimuth side-lobes are achieved by feeding unequal power.

The HN-401R comprises three units: an operations shelter, an antenna trailer and a prime power shelter. It is transportable by road or rail. HN-401R is reportedly no longer in production but is thought to remain in service.

Operating frequency: UHF band (0.3-1 GHz)

Antenna Type: dipole planar-array

Aperture: 17 x 8 m

Gain: 24 dB

Polarisation: horizontal

Transmitter: coherent amplification chain

Output power: 20 kW (peak); 2 kW (average)

Range: 300 km (1.5 m^2 target)

Resolution: 450 m (range); 9º (azimuth)

Manufacturer: China National Electronics Import and Export Corporation,

Beijing.

HN-503 surveillance radar

The HN-503 is a mobile long-range VHF band (30 to 300 MHz) 2-D air surveillance radar. In addition to long range it features high electronic counter-countermeasures capability, high reliability, ease of assembly and disassembly and good mobility. The system makes wide use of solid-state components, with the circuits designed into cards and modules. Reliability is enhanced by the use of high average transmitting power and low-peak power. To counter countermeasures interference, the system employs adaptive and pseudo-random pulse-to-pulse frequency agility and manual fixed-point frequency-hopping. The HN-503 uses a coherent pulse compression system with the exciting stages of the transmitter employing solid-state modules. The final stages use high power, wideband electron tube amplifiers. The receiver has low-noise and wide dynamic range, and its signal processing system has adaptive functions. Blind speed is countered by three staggered pulse repetition frequencies. The processing and display equipment is contained in a shelter, with three operators. The complete system consists of an antenna vehicle, electronic shelter containing the processing and display equipment, and diesel engine vehicles. The HN-503 is believed to be in service with the PLA.

Antenna: aperture 17 x 8 m^2; horizontal polarisation

Rotation speed: 1-6 rpm (clockwise or anti-clockwise)

Polarisation: horizontal

Peak power: 20 kW

Average power: 2 kW

Detection range: 450 km (in free space)

Resolution: 450 m (range); 7º (azimuth)

Accuracy: 150 m RMS (range); 1º (azimuth)

SCV: 35 dB

MTBF: >350 h

Pulse-width: 430 Ás

ECCM: adaptive pulse-to-pulse frequency agility; pseudo-random pulse-to-pulse frequency agility; manual fixed-point frequency-hopping

Manufacturer: Nanjing Research Institute of Electronics Technology.

JLG-43 height-finding radar

Type: E-band (2 to 3 GHz) mobile height-finding radar.

The JLG-43 is a nodding height-finder which follows the pattern of the well-known Soviet Cake series of equipment. It is a mobile system in as much as it is readily transportable by military road vehicles, and the complete system can probably be carried in a two-truck load. Operating frequencies are in the E/F-band and a 2 MW transmitter provides for coverage out to a range of 200 km and gives a height coverage of up to 25,000 m. JLG-43 is no longer in production. Outside China, JLG-43 radars are reported to have been supplied to the Myanmar (Burmese) Air Force.

Frequency: E-band (2 GHz)

Pulsewidth: 3 Ás

Peak power: 2 MW

Nodding frequency: 32.37 cycles/min

Antenna dimensions: 5.5 x 2.13 m

Range: 200 km

Height: 25,000 m

Elevation coverage: 0-30º

Accuracy: 300 m (height); 2º (azimuth)

Manufacturer: China National Electronics Import and Export Corporation Beijing.

JLP-40 surveillance radar

The JLP-40 is a tactical air defence radar designed for use with height-finder radars for GCI or similar applications. It is similar in design to the CIS Bar Lock radar from which it may well have been derived, and features the same arrangement of two large scanners attached to front and rear sides of a rotating cabin that houses the transmitter/receivers. Operation is in the S- and L-bands, each parabolic scanner being illuminated by stacked horn feeds to generate families of multiple beams. There are five S-band transmitter/receivers and these are thought to operate with the lower of the two antennas, while the L-band feeds illuminate the upper scanner. An IFF interrogator is also incorporated into the system. There are three PPI displays provided, and one azimuth/range display, plus from two to four additional PPIs. MTI facilities are provided in the L-band transmitter/receiver chains. The whole system is transportable, though hardly `mobile' despite the use of wheeled trailers for much of the equipment and clearly preparing such a large and complex system for operation must occupy several hours from the time of arrival at a surveyed site. The JLP-40 is no longer in production and is reported to be supplied to the Myanmar (Burma) Air Force.

Operating frequencies: L- and S-bands

Range: 270 km

Height: 20,000 m

Azimuth coverage: 360º

Elevation coverage: 0.5-30º

Accuracy: 500 m (range); +-0.5º (bearing)

Manufacturer: China National Electronics Import & Export Corporation, Beijing.

JY-8 mobile tactical 3-D radar system

The JY-8 is a mobile 3-D air surveillance, target acquisition and interception control radar system operating in the C-band. It can be employed as the main radar sensor for an automated tactical defence system, or can be used as an independent radar. The equipment uses advanced signal/data processing techniques and is fully solid-state, with the exception of the magnetrons and thyratrons of the transmitters.

The JY-8 consists of four units: an antenna/transmitter/receiver shelter, an operations/reporting shelter, a maintenance shelter and a towing truck. The complete system can be transported by road, rail or sea and can be assembled or disassembled within one hour. The system is designed to make use of amplitude comparison for height-finding. With the aid of two computers it is able to provide automatically accurate real-time three-dimensional information on targets. Frequency diversity is used to increase detection probability and enhance ECCM ability. Other facilities such as digital MTI, automatic clutter map, automatic residue map and CFAR are incorporated. A multi-beam antenna assembly, mounted on the transmitter/receiver shelter and rotating at 6 rpm, is employed to form a group of stacked beams. RF power generated by two transmitters is fed to a power-dividing network and then illuminated to the reflector via the waveguide assembly and feed array, creating a group of individual beams stacked vertically to form a wide cosecant squared pattern. In reception, both individual and combined beams are employed, 11 beams formed by a receive network connected with an 11-channel frequency diversity receiver. The received signals are sequentially mixed, amplified, detected and finally sent for data processing and display. The JY-8 is in production and in service.

Antenna beamwidth: 0.55º (horizontal); 0.9º (vertical) for the focus beam

No. of receive beams: 11

Rotation speed: 3/6 rpm

Power output: 800 kW x2 (peak)

Pulsewidth: 3-3.3 Ás

PRF: 365, 500 Hz

Azimuth coverage: 360º

Altitude cover: 20 km

Range: up to 350 km (max)

Elevation: up to 20º

Accuracy: 500 m (range); 0.3º (azimuth); 500 m (RMS) at 185 km range (height)

Target resolution: 1,000 m (range); 0.6º (azimuth)

Target capacity: 36 tracks

Manufacturer: ECRIEE (East China Research Institute of Electronic Engineering), Hefei, Anhui Province.

JY-9 Mobile Search Radar

The JY-9 is a mobile S-band low-altitude search radar intended for use in air defence, gap filling, airport surveillance and coastal defence. It is designed for the effective detection of targets at low altitude in both ECM and natural clutter environments.

The JY-9 consists of a radar/operations shelter, an antenna pallet and a power station shelter, and is transportable by air, rail and sea. Setting-up or disassembly time with an experienced crew of six is 60 minutes. The JY-9 employs a dual-beam antenna assembly consisting of a deformed parabolic reflector, two horns and two feed channels. One channel is used for transmission, both are used for reception. The antenna rotates at 6 rpm to provide 360º surveillance in azimuth and can be mounted on the ground or on a steel tower. The JY-9 has high anti-jamming and anti-clutter capability due to the use of advanced techniques, including pulse-to-pulse frequency agility, dual channel, JATS, a wide operating band, low sidelobes, MTD automatic spectrum processing, automatic clutter map and automatic clutter threshold control circuit. MTBF is better than 500 hours, a BITE subsystem is included and automatic fault detection reaches the level of functional modules. The JY-9 is in service.

Frequency: S-band

Antenna: dual beam with super-cosecant pattern

Rotation speed: 6 rpm

Beamwidth: 1.5º horizontal; 40º vertical

Transmitter Power output: 200 kW (peak)

Pulsewidth: 20 Ás

PRF: 790 Hz

Coverage: 360º (azimuth); 0-40º (elevation)

Altitude cover: 10 km

Range: 150 km

Detection accuracy: 80 m range; 0.3º azimuth

Resolution: 120-140 m; azimuth 1.3º

Tracking capacity: 1,000 plots; 72 tracks

Manufacturer: ECRIEE (East China Research Institute of Electronic Engineering), Hefei, Anhui Province.

JY-9F low-altitude surveillance radar

The JY-9F 2-D low altitude surveillance radar, is a new derivation of the JY-9 low altitude radar. It is a fully coherent pulse compression radar with a high reliability and mobility and can provide low-flying target information for national air defence information networks or for AAA or air traffic control systems.

The JY-9F consists of an antenna assembly, an operations shelter, a trailer-installed shelter housing two diesel generators and an optional trailer-installed shelter. The antenna can be folded down or erected by a motor-driven mechanism and the assembling and disassembling of the system can be accomplished by a crew of eight men within one hour. This advanced radar incorporates the state-of-the-art techniques. The low sidelobe antenna employed in the system has greatly enhanced the radar's anti-clutter capability and ECCM performance, giving improved low altitude detection performance. Three AMTI processing channels are used, each equipped to handle a particular environmental condition, thereby providing maximum low altitude target detection. The wide-band and highly stable TWT+CFA transmitter guarantees a super-clutter visibility in excess of 40 dB in the presence of ground clutter. The quadriphase Taylor code ensures a desirable consistency, high reliability and high stability. Meanwhile, the waveform agility can be realised. The JY-9F radar is characterised by high reliability and maintainability with an MTBF of more than 400 hours and MTTR of less than 30 minutes. Due to extensive BITE adopted in the system, troubleshooting probability reaches 95 per cent while 85 per cent of faults can be isolated to PCB level and all faults can be isolated to the replaceable unit level. It is in service.

Instrumented range: 203 km (max)

Minimum detectable range: 3 km

Height: 10,000 m

Azimuth: 360º

Elevation: radar horizon to 40º (pre-tuneable between -2º and +3º) Accuracy (RMS): range 60 m; azimuth 0.3º

Data rate: 6 rpm

Temperature: operation -40 to +50ºC; storage -50 to +70ºC

Relative humidity: 95-98% (at 30ºC)

Barometric pressure: sea level to 3,000 m

Wind load: 20 m/s (normal operation); 35 m/s (no damage)

Resolution (with a resolution

probability of 50%): range 120 m; azimuth 1.4º

Manufacturer: ECRIEE (East China Research Institute of Electronic Engineering), Hefei, Anhui Province.

JY-10 Radar Information Processing Post (RIPP)

In order to update the traditional 2-D radars with height-finders, and to ensure 3-D coverage, the ECRIEE has developed a mobile 3-D radar information processing post. The intention is to co-ordinate the existing equipment in an automated tactical air defence system to provide 3-D target information. The post combines plan extraction with height extraction, incorporates dual microcomputers and microprocessor technology to form a real-time target information processing network. This is in service.

Accommodation range of pulsewidth: >0.4 Ás

radar parameters:

PRF: 100 Hz to 1 kHz

Extraction mode: manual (manual plot entry); semi-automatic (manual track initiation); fully automatic (hardware/software implementation)

Plan extraction capability: 256 tracks/10 s

Manual extraction capability: 2 x 12 tracks/10 s

Heightfinding capability: with nodding heightfinder providing height data after first nod, or automatic amplitude comparison heightfinding in co-operation with multibeam 3-D radar

System error: range, 100 m; azimuth, 0.1º; height, 300 m

Manual intervention: 20 modes or more

Data communication mode: bi-directional transfer of radar information according to RS-232C interface standard or modem (CCITT 22bis) standard

Recording mode: printer for data retention; and able to incorporate simple magnetic tape and disk unit for playback

Manufacturer: ECRIEE (East China Research Institute of Electronic Engineering), Hefei, Anhui Province

JY-11 surveillance radar

Type: Ground-based, 3-D low-altitude surveillance radar.

The JY-11 is a solid-state, ground-mobile surveillance radar that is designed for autonomous function or as a gap filler in a regional air defence network. System features include a low-sidelobe, dual-frequency, frequency scanning antenna; a modular, solid-state transmitter; low probability of intercept function; a large dynamic range receiver; digital wave-forming; pulse compression; a constant false alarm rate and automatic set up/tear down. The JY-11 was recently understood to be available in both ground-mobile and fixed-site configurations.

Range: 180 km

Altitude coverage: 12,000 m

Angular coverage: 0-30º (elevation); 360º (azimuth),

Accuracy: 0.5º RMS (azimuth/elevation); 200 m (range)

Antenna rotation speed: 6 rpm

Target processing: 128 tracks/10 s

Anti-clutter performance: >= 45 dB (ground clutter); >= 30 dB (chaff)

MTBF: >= 1,000 h

MTTR: <= 0.5 h

Set up/tear down time: <= 0.5 h

Manufacturer: East China Research Institute of Electrical Engineering, Hefei.

JY-14 medium/long-range 3-D radar

The JY-14 radar can detect multiple targets within its coverage and acquire their three-dimensional parameters even in clutter and jamming. Among its features are:

(a) high-gain, low sidelobe and vertically offset multibeam antenna;

(b) wideband frequency diversity and adaptive pulse-to-pulse frequency agility;

(c) fully coherent high-power transmitter, multi-element modulator assembly;

(d) high-stability frequency synthesiser;

(e) low noise, wide frequency band, large dynamic range and frequency diversity multi-channel receiver;

(f) linear FM pulse compression;

(g) adaptive MTI;

(h) adaptive threshold, automatic clutter mapping;

(i) automatic target extraction/target tracking; and

(j) BITE. In operational service.

Frequency: up to 30 frequencies used in agile mode in the range 1.85-2.15 GHz

Range: >= 320 km

Coverage: up to 20º (elevation), 360º (azimuth)

Altitude cover: 25 km

Accuracy: range <=90 m; azimuth <=0.2º; height <=400 m (at 200 km range and height of 20 km)

ECCM operating 30 frequencies pre-set over a 15% band and with an

frequencies: interval of 10 MHz

Frequency diversity 150 MHz

interval:

Azimuth sidelobe: -40 dB (average)

MTI improvement factor: 40 dB

Antenna beams: 9 beams stacked in vertical plane

Antenna rotation rate: 6 rpm

Power supply: 380 V 400 Hz and 380 V 50 Hz

Wind resistance capacity: 25 m/s, normal operation; 25-35 m/s, operation with degraded accuracy; >= 35 m/s, stopped operation

Ambient temperature: -40 to +50ºC

MTBF: >= 150 h

MTTR: <= 30 min

Manufacturer: ECRIEE (East China Research Institute of Electronic Engineering), Hefei, Anhui Province.

JY-17 battlefield reconnaissance radar

Type: J-band (10 to 20 GHz) portable battlefield surveillance radar.

The JY-17 is a man-portable, lightweight, solid-state battlefield reconnaissance radar which is designed to detect, recognise, identify and locate moving targets. It can be used to survey the battlefield, detect moving targets, such as armoured vehicles, soft-skinned vehicles and personnel, and identify them. Range and azimuth are presented on a control unit, and identification is carried out aurally by the operator. Visual and aural alarms are provided. The radar is normally tripod mounted. The JY-17 is stated to be highly efficient in a number of roles, such as protecting landing fields for helicopters and vertical take-off and landing aircraft, munition storehouses, command posts, oil pipelines, airports, roads and borders. The frequency of operation has not been disclosed but it is assumed that it operates in J-band.

The main features of the equipment are given as:

(a) Automatic sector scan of antenna with axes and widths selectable through a keyboard;

(b) Microstrip antenna;

(c) All solid-state transmitter;

(d) Pulse compression techniques employed;

(e) Fully coherent transmitter/receiver;

(f) Adoption of advanced programmable signal processing techniques;

(g) Automatic detection ability;

(h) Liquid crystal display or 11.4 cm B-scope (optional);

(i) Aural warning and Doppler monitoring;

(j) Remote operation by use of a control unit and keyboard;

The JY-17 is thought to be in service.

Manufacturer: East China Research Institute of Electronic Engineering (ECRIEE), Hefei.

JY-17A ground surveillance radar

Type: Medium-range ground surveillance radar.

The JY-17A is a modular, fully coherent, pulse Doppler battlefield surveillance radar that is designed to detect, locate and identify moving ground or low-altitude air targets. The equipment can be vehicle mounted or ground deployed and features a solid-state, low probability of intercept transmitter; a high stability frequency synthesiser; selective linear and circular polarisation; digital pulse compression; pulse Doppler filter bank processing; a raster scan display and automatic target detection and tracking. Display format options comprise terrain profile (ground clutter) and moving target; plot and track; electronic map with moving targets; composite (built-in test, target data and system status); zone enlargement/zone alarm and target data storage/replay.

Frequency: 8-12 GHz

Range: 10 km (single pedestrian); 15 km (light vehicle); 20 km (helicopter); 25 km (tank/heavy vehicle); 30 km (ship)

Elevation coverage: -15 to +24º

Sector axis: 0 to 360º (selectable)

Sector width: 60, 90, 120, 150 or 180º (selectable)

Accuracy: +- 10 mils RMS (azimuth); +- 10 m RMS (range)

Track processing: 10 tracks (automatic extraction)

Power consumption: < 300 W

MTBF: +-1,000 h

MTTR: < 0.5 h

Manufacturer: East China Research Institute of Electrical Engineering, Hefei

JY-27 surveillance radar

Type: A-/low B-band (0.03 to 0.3 GHz sub-band) surveillance radar.

The JY-27 surveillance radar is designed for the long-range detection of air targets including anti-radiation missiles and vehicles incorporating low observability. System features include a fully coherent, solid-state transmitter; frequency agility; transmission spectrum filtering; digital pulse compression; an unattended operation facility and three channel airborne moving target indication/constant false alarm rate processing.

Frequency: 0.03-0.3 GHz

Maximum range: >= 330 km

Elevation coverage: 12º

Altitude coverage: 20,000 m

Accuracy: 1º RMS (azimuth); 150 m RMS (range)

Resolution: 5º (azimuth); 600 m (range)

Track processing: 128 tracks/10 s

Antenna rotation speed: 6 rpm

Manufacturer: East China Research Institute of Electrical Engineering, Hefei

LR61 coastal defence radar system

Type I-band (8 to 10 GHz) coastal defence radar. The LR61 is designed automatically to detect and track surface targets and hand-off targeting data to surface-to-surface missile batteries. The system comprises the radar, a data processing station, a communications subsystem and a transportation vehicle. The equipment utilises a 31 cm plan position indicator to display raw video, target counting/plotting and weapon fire-control data together with a 24 x 40 character 23 cm cathode ray tube for tabulated target range, azimuth, velocity and heading information.

Frequency: 8-10 GHz

Range: <= 5 km (min); >= 120 km (max), 80%, 10-, RCS 3,000 m, HA >= 800 m

Azimuth coverage: 360º

Accuracy: <= 0.2º (azimuth); <= 6 m (range)

Set up tracking time: <= 12 s

Target tracking: up to 16 batches (with TWS)

Communication range: > 5 km

Environment: -10 to +40ºC (shelter); -20 to +60ºC (outside shelter)

Dimensions: 2 x 1.3 x 2.2 m (antenna with pedestal); 5 x 2.4 x 2 m (equipment/operator shelter)

Weight: <= 1,400 kg

Manufacturer: China National Electronics Import and Export Corporation

LR62 splash spotting radar

Type: J-band (12 to 18 GHz sub-band) splash spotting radar.

The LR62 electronically scanning splash spotting radar is designed for use with 130 mm and 150 mm surface ship guns and comprises the radar itself and a power generator. LR62 utilises 13 cm `B' type search, 13 cm `B' type tracking, 18 cm `B' type deviation measurement and 5 bit tabular displays.

Frequency: 12-18 GHz

Range: <= 0.5 km (min); >= 60 km (max) 80%, 10, RCS 1,000 m^2, HA > 100 m

Azimuth coverage: 360º

Measuring accuracy: <= 0.1º (azimuth); <= 15 m (range)

Environment: -30 to +60ºC (topside equipment)

Dimensions: 2 x 0.66 m (antenna); 4 x 2.4 x 2 m (operator cabin)

Weight: <= 3,000 kg (complete system)

Manufacturer: China National Electronics Import and Export Corporation

LR63 splash spotting radar

Type: G/H-band (4 to 8 GHz) splash-spotting radar.

The solid-state, phased-array LR63 is designed to provide a fire correction capability for coastal 130/155 mm gun and surface-to-surface missile batteries and is vehicle mounted for mobility. The radar utilises 36 cm `B' type tracking, 36 cm `B' type deviation measurements (with four sub-pictures) and tabular information displays.

Frequency: 4-8 GHz

Range: <= 1 km (min); >= 120 km (max), 80%, 10-, RCS 3,000 m, HA 800 m

Azimuth coverage: any 120º sector (automatic tracking); 360º (manual search) Measuring accuracy: <= 0.1º RMS (azimuth); <= 15 m RMS (range)

Environment: -10 to +40ºC (shelter); -20 to +60ºC (outside shelter) Dimensions: 2.5 x 1.5 x 0.5 m (antenna); 4 x 2.4 x 2 m

(equipment/operator shelter)

Weight: <= 1,500 kg

Manufacturer: China National Electronics Import and Export Corporation

MD-90 Central Air Data Computer (CADC)

The MD-90 CADC is a co-development product by Chengdu Aero-Instrument Corporation and Honeywell Inc of the USA and features a 32-bit Motorola MC68332 microprocessor. The first flight test was in 1993 and FAA certification was granted in October 1994.

Manufacturer: Chengdu Aero-Instrument Corporation (CAIC)

Model 378 battlefield radar

Type: I-band (8 to 12 GHz) portable detection radar.

The Type 378 is a portable battlefield radar operating in I-band which is used for the detection of vehicles and ships. It is a coherent-pulse Doppler system which consists of an antenna/transceiver mounted on a tripod, a rectifier, a signal processor, a generator and a display. After detecting the target, a visual and audible alarm is activated and the position of the target is displayed on the screen. Although claimed to be a portable system, the total weight of 86 kg would appear to require the use of a vehicle to transport it, particularly with the use of a generator for the power source. The Model 378 is thought to be in service with the PLA.

Frequency: I-band (8-12 GHz)

Max range: 6 km (personnel); 20 km (vehicles)

Accuracy: 30 m (range); 1.5º (azimuth)

Discrimination: 60 m (range); 3º (azimuth)

Power output: 4,800 W peak

Pulse Repetition Frequency: 3,125 +- 5 Hz

Polarisation: horizontal

Beamwidth: 3.2º (horizontal); 5.5º (vertical)

Weights: antenna/transceiver 18 kg; display set 17 kg; rectifier 11 kg; processor 5 kg; generator 30 kg; tripod 5 kg

Manufacturer: China Fujian Radio Equipments Factory, Taijung.

Model 970 system

Type: Mobile I/J-band (8 to 20 GHz) radar jamming system.

The Model 970 is a mobile, ground-based radar jammer designed primarily to protect ground targets from air attack. The system operates in I/J-band and uses noise-modulated 'blanket' jamming to produce a continuous interference sector on the screen of the aircraft surveillance radar. It can also be used to jam an airborne guidance radar as a protection against air-launched missiles. Model 970 has a variety of jamming types and can be operated either automatically or manually. Normally a number of 970 jammers are placed some 3 to 5 km from the protected target and are used in conjunction with a target indicating radar. Model 970 measures the bearing, frequency and antenna rotation speed of the hostile radar and may be used in conjunction with a pulse analyser to measure other parameters such as pulsewidth, pulse repetition frequency, and radar illumination. The system consists of a number of units including antenna feed, transmitter, coarse and fine receivers, servoes, display and power supply. It is installed in a trailer, and has the antenna system mounted on the trailer roof. The Model 970 radar jammer is thought to be in service with the PLA.

Frequency: 8-12 GHz

Receiver sensitivity: better than -76 dBm

Power output: better than 120 W; a 200 W output transmitter is also available.

Manufacturer: China National Electronics Export and Import Corporation

Model 3907 colour image communication system

The model 3907 image communication system is designed to process still colour video signals and transmit them over radio links - particularly short wave channels - or telephone lines. The system images from a video camera, camera or CD and has a compression factor selectable from 5 to 250. Image resolution is 320 x 240, and images are processed at a rate of 24 bits per pixel. The system has error correction and ARQ, and operates to the PAL or NTSC standard. The format of the system's image file facility is JPEG or TGA.

Manufacturer: Panda Electronics Group Co., Nanjing.

Model 17-C surveillance radar

Model 17-C is an intermediate range mobile early warning radar designed for medium- and high-altitude surveillance. The Yagi-array type antenna is mounted on a six-wheel truck which also contains the electronics and displays. Alternatively the antenna can be mounted on the ground. The system is small and lightweight and is normally used in the forward area for aircraft detection. The complete system consists of two vehicles, the second truck being a power vehicle containing two diesel generators. It is in operational use by the PLA.

Antenna: Yagi-array with 4 rows, 2 layers and 8 units

Frequency: UHF band

Accuracy: 2 km (range); 2º (bearing)

Resolution: 2 km (range); 15º (bearing)

Manufacturer: China National Electronics Import & Export Corporation, Beijing.

Model ST-312 ground surveillance radar

Type: Medium range ground surveillance radar.

The ST-312 is a medium range ground surveillance radar that is designed to detect, identify and locate moving ground targets and low-flying helicopters. System features include a low-noise, wide dynamic range receiver; digital signal processing; coherent pulse Doppler technology; microprocessor control and a TV scanning, multifunction display. ST-312 can be tripod mounted or deployed from a vehicle using a tower-mounted antenna.

Frequency: 8-12 GHz

Range: 15 km (pedestrian); 25 km (light vehicle); 40 km (tank/truck); 35 km (helicopter)

Accuracy: 0.5º (azimuth); 12 m (range)

Resolution: 2.8º (azimuth); 50 m (range)

Receiver: < 3 dB (noise); 6 MHz (IF bandwidth); 78 dB (dynamic range); < -135 dBW (sensitivity)

Transmitter: 0.33 Ás (pulse duration); > 3 kW (peak power); 3.125 kHz (PRF)

Antenna: 2.8º (horizontal beam width); 4º (vertical beam width); > 32 dB (gain)

Antenna polarisation: linear vertical or circular

Environment: -20 to +50ºC (operating)

Power consumption: < 200 W

Weight: < 90 kg (tripod mounted)

Manufacturer: China National Electronics Import and Export Corporation

Model TRK-90 HF/SSB transceiver

The Model TRK-90 HF/SSB PLL synthesised transceiver covers the 2 to 29.9999 MHz transmit frequency and the 0.5 to 29.9999 MHz receive frequency in 100 Hz steps. It has high- power outputs of 35 W (USB, LSB, CW) and 15 W (H3E) and low-power outputs of 15 W (USB, LSB, CW) and 5 W (H3E). The receiver section has a sensitivity of 0.4 ÁV (USB, LSB, CW) and 1.5 ÁV (H3E) for 10 dB (s+n)/n. The transceiver weighs 3.9 kg.

Manufacturer: China National Electronics Import and Export Corporation, Beijing.

MR33 naval surveillance radar

Type I-band (8 to 10 GHz) air and surface surveillance radar.

The MR33 surveillance radar is designed for use aboard vessels of more than 200 tonnes and comprises the radar, a data processing station and interfaces to onboard weapon systems and other sensors. MR33 utilises 51 cm colour raster plan position indicator and 640 x 400 pixel 23 cm equal-ion displays.

Frequency: 8-10 GHz

Range: <= 500 m (min); >= 25 km (aircraft, RCS = 2m^2); >= 120 km (max) 80%, 10, RCS 3,000 m, HA > 10 m

Azimuth coverage: 360º

Tracking accuracy: <= 0.3/<= 05º (azimuth - ship/aircraft); <= 50/<= 150 m (range - ship/aircraft)

Resolution: <= 2º (azimuth); <= 100 m (range)

Set up tracking time: <= 6 s (ship); <= 12 s (aircraft)

Tracking capacity: up to 16 batches (with TWS)

Environment: -30 to +60ºC (topside equipment)

Power consumption: <= 10 kW

Dimensions: 1,650 x 674 x 550 mm (equipment cabinet - three installed); 1,800 x 820 mm (antenna with stabilised pedestal)

Weight: 250 kg (antenna); 350 kg (equipment cabinet); 1,200 kg (complete system)

Manufacturer: China National Electronics Import and Export Corporation

MR66 missile defence radar

Type: J-band (10 to 20 GHz) missile defence radar.

The MR66 is a shipboard system that is designed to track incoming anti-shipping missiles and hand off targeting data to onboard defensive weapon systems. The equipment is quoted as being fully automatic, having a very short response time and as comprising the radar and fire-control computer and/or gun director interfaces.

Frequency: 10-20 GHz

Range: <= 600 km (min); >= 10 km (max) RCS 0.1 m^2

Azimuth coverage: 360º

Elevation coverage: -10 to +85º

Altitude: < 10 m

Environment: -30 to +60ºC (topside equipment)

Dimensions: 1,600 x 800 mm (antenna with pedestal); 1,650 x 674 x 550 mm (equipment cabinet - three installed)

Weight: 150 kg (antenna); 300 kg (equipment cabinet); 1,100 kg (complete system)

Power consumption: <= 10 kW

Manufacturer: China National Electronics Import and Export Corporation

MW-5 fire-control radar

Type: E/F- (2 to 4 GHz) and I/J-band (8 to 20 GHz) mobile fire-control radar for artillery.

The MW-5 is a mobile artillery fire-control radar operating on I/J- and E/F-band frequencies. It is similar to the Russian Federation and Associated States Fire Can radar and may well be a derivative of that equipment. All the main elements of the equipment are housed in or on a four-wheeled trailer that consists of a container which also serves as a cabin for the operating crew. A circular dish antenna for target search and tracking is mounted on the roof of the cabin, and can be raised or lowered. The E/F-band is employed for target detection and acquisition, possibly with designation by a different long-range search/air warning radar associated with the military unit, and the I/J-band is used for target tracking. The conical scan technique is probably employed for the latter function. Good electronic counter-countermeasures characteristics are claimed for the MW-5 by its manufacturer. The MW-5 has three modes of operation. In Mode 1 the system uses conical scanning in the E/F-band for automatic target tracking. In Mode 2 the equipment uses false monopulse tracking for automatic target tracking in the I-band. In Mode 3 range is measured manually using E/F-band, while the angles of the noise source are automatically followed in I-band. The MW-5's operational status is uncertain.

Frequencies: E/F-band (2-4 GHz) search; I/J-band (8-20 GHz) tracking Detection range: 55 km (bomber)

Max tracking range: 35 km

Tracking accuracy: 20 m (range); 1.6 mil (azimuth); 1.8 mil (elevation)

Transmit power: 120 W in Modes 1 and 2; 180 W in Mode 3

Pulsewidth: 0.6 +- 0.1 Ás (Mode 1); 0.5 +- 0.05 Ás (Mode 2); 1.2 +- 0.05 Ás (Mode 3) PRF: 1,875 Hz (Modes 1/2); 2,937 Hz (Mode 3) Weight of trailer: 7.5 t

Manufacturer: China National Electronics Import and Export Corporation

MW-7-JB fire-control radar

Type: I/J-band (8 to 20 GHz) mobile anti-aircraft fire-control radar.

The MW-7-JB is a mobile artillery fire-control radar operating in the I/J frequency band. It appears to be a later variant of the MW-5 system (see previous entry). All the main elements are contained in or on a four-wheeled trailer, consisting of a container which also serves as an operations cabin for the crew. A circular dish antenna for target search and tracking is mounted on the roof of the cabin, using a conical scan technique for target tracking. The antenna can be raised and lowered as required. It is stated to have a diversified countermeasures system, including wide range frequency agility. Other features include moving target indicator processing, automatic change of operation mode and an interface for an identification friend-or-foe system. The MW-7-JB is thought to be in service with the PLA.

Frequency: I/J-band (8-20 GHz)

Agility band: 4% of centre frequency

Detection range: 55 km

Tracking range: 35 km

Tracking accuracy: 20 m (range); 1.6 mil (azimuth); 1.8 mil (elevation)

Angular speed of tracking: 600 m (range); 15º/s (elevation); 30º/s (azimuth)

MTBF: 40 h

Manufacturer: The Huanghe Machine Building Factory

921-A ESM equipment

Type: A wideband pulse radar direction-finding receiver.

The 921-A is installed on submarines to detect emitters of airborne, shipborne and shore-based radars. It provides coarse measurement of azimuth, frequency band and operational state of the hostile emitters.

Frequency: 2-18 GHz in four bands

Sensitivity: 1.5 x 10 to 10 W/M

Bearing accuracy: better than +-30º

Dimensions and weights

Antenna unit: 560 mm diameter x 515 mm height; 80 kg

Receiver and display: 450 x 468 x 124 mm; 40 kg

Distribution unit: 145 x 214 x 291 mm; 6 kg

Manufacturer: China National Electronics Import and Export Corporation, Beijing.

146-1 target indication radar

Type: UHF band (0.3 to 1 GHz) 3-D mobile Surface-To-Air Missile (SAM) surveillance/tracking radar.

The 146-1 radar is a mobile target indication radar for use with surface-to-air missiles. It provides air situation surveillance, multi-target tracking, real-time data processing, optimum target assignment, firing data computation and co-ordinate transformation. The system consists of a trailer for the antenna and transceiver/receiver unit, an electronics van, and three vans each with a 75 kW power source. The complete system can be assembled or disassembled in approximately two hours. Operation and maintenance personnel strength is given as 12 to 14.

The design features include:

(a) Fully solid-state and electronic phase-scanning system;

(b) Array antenna with distributed active solid-state modules;

(c) Fully coherent digital moving target indicator with high performance against ground clutter and passive electronic countermeasures;

(d) Good electronic counter-countermeasures performance which is achieved by adaptive wideband pulse-to-pulse frequency agility;

(e) Low-elevation angle height-finding techniques;

(f) Microprocessor-controlled data processing and management; and

(g) Customer-oriented datalinks and optional interfaces.

The 146-1 is thought to be in service with PLA ground-to-air missile regiments.

Frequency: UHF band (0.3-1 GHz)

Antenna: aperture 6.7 x 6.5 m

SCV: >30 dB

Surveillance coverage: 360º (azimuth); 0-65º (elevation); 25 km (altitude)

Range: 15-200 km

Max tracking range: 200 km (2 m^2 target)

Accuracy: 1º (azimuth); 2º (elevation); 500 m (range)

Range resolution: 120 m (within 90 km)

Data rate: 6 or 12 rpm

Tracked target numbers: 32 batches ECCM capability: pulse-to-pulse and burst-to-burst frequency agility; DMTI; pulse compression

System reliability: MTBF 120 h (excluding computer); MTTR 0.5 h

Antenna operation

wind speed: ca 19 m/s

Manufacturer: Nanjing Research Institute of Electronics Technology, Nanjing.

Oriole XDD-925 HF/SSB transceiver

The Oriole XDD-925 is a 25/5 W HF/SSB transceiver for manpack, fixed station, vehicle or shipboard applications in the 2 to 8,999 MHz range. Offering medium- and long-distance links through a high-gain double antenna (a whip is used for mobile roles), the transceiver has 7,000 channels. Other features are 1 x 10- frequency stability; inter-modulation distortion of less than 25 dB; and sensitivity of less than 1 ÁV. Power is AC or Ni/Cd DC.

Manufacturer: China National Electronics Import and Export Corporation, Beijing.

PRC-90 VHF/FM manpack radio

The PRC-90 is a VHF/FM manpack covers 30 to 87.975 MHz with output powers of 0.2 or 3.5 W and channel spacing of 25 kHz. Some ten channels can be preset from a total of 2,320 and there is a 16 kbits/s data capability. Other features include: deviation of 5.6 kHz; harmonic suppression of >45 dB (3.5 W); sensitivity of -115 dBm for 10 dB (s+n)/n; headphone output of 50 mW (600 {ohm}); baseband output of 0.775 V (600 {ohm}); IF rejection of >100 dB; and intermodulation of >80 dB. The manpack is powered from Ni/Cd BA-2188 batteries and has an operating temperature range of -40 to +65ºC. Size, including battery but without optional units, is 80 x 250 x 260 mm and weight is 7.2 kg. With optional units, dimensions and weight are 80 x 380 x 260 mm and 10.9 kg.

Manufacturer: China National Electronics Import and Export Corporation, Beijing.

RF-41A00 HF/SSB radio

The RF-41A00 is an HF/SSB radio for long haul, transportable, vehicular and base station applications. System components are the RF-41A10 transceiver, RF-41A50 adaptive controller, RF-41A70 digital antenna coupler and the RF-41A90 power supply. The radio covers the 1.6 to 30 MHz transmit and 0.1 to 30 MHz receive ranges in 10 Hz synthesised steps and has a power output of 125 W. ALE is to MIL-STD-188-141A and FED-STD-1045. Operating modes are J3E USB/LSB, H3E AME, CW, simplex or half-duplex. There are 370 programmable channels and a keyboard is used for secure access. Dimensions of the RF-41A10 are 145 x 344 x 406.5 mm and the weight is 12 kg. Operating temperature range is -25 to +55ºC.

Manufacturer: Panda Electronics Group Co., Nanjing.

RF-41A00A frequency-hopping HF/SSB transceiver

The RF-41A00A is a frequency-hopping HF/SSB transceiver with an output power of 125 W and ALE to MIL-STD-188-141A and FED-STD-1045. Comprising the RF-41A10 transceiver, RF-41A55 frequency-hopping controller, RF-41A50 adaptive controller and the RF-41A70 digital antenna coupler, performance, dimensions and weight are the same as those of the RF-41A00 HF/SSB radio (see separate entry) with the addition of DSP-based frequency hopping with digital synchronisation and late entry. Hopping rate is 5, 10 or 20 hops/s programmable and there is pseudo-random change of channel dwell time. Hopping bandwidths are 64, 128 and 256 kHz (narrowband) and 1 MHz (wideband). A user key of 10 can be loaded from the front panel keyboard or loader. The frequency-hopping code can be erased in an emergency by pressing the front panel keys.

Manufacturer: Panda Electronics Group Co., Nanjing.

RF-41A61 HF modem

The RF-41A61 HF modem uses 39-tone TDPSK modulation combined with FEC and ARQ to give a channel transmission rate of 3,571 bits/s and a data rate from 150 to 2,400 bits/s. Other features include data interleaving; inband diversity; digital filtering and frequency tracking. The full- or half-duplex modem is designed for use in networks, on point-to-point and relay links, or for broadcasting applications. Data types include computer data and digital video imagery. Power supply is 200 to 250 V AC, 50 Hz, and consumption is <12 W. The RF-41A61 measures 50 x 230 x 260 mm and weighs <3 kg.

Manufacturer: Panda Electronics Group Co., Nanjing.

RF-41A81 radio/telephone interface

The RF-41A81 radio/telephone interface unit is a DSP-based equipment that provides a bridge between HF, VHF, UHF or satellite systems and a telephone or other two-wire link for full duplex, half duplex or simplex applications. Transmitter keying can be controlled by a built-in VOX facility. From 100 to 199 net addresses, and input or output level and so on can be programmed by telephone. Use is as with a conventional telephone. Features include: nominal -9 dBm output level to phone line (adjustable -15 to +6 dBm in 3 dB steps); nominal -9 dBm input level from phone line (adjustable -15 to +6 dBm in 3 dB steps); VOX sensitivity of 16 +-2 dB below phone line input level setting; output impedance of 600 ohms; +-2 dB, 300 to 3,200 Hz frequency response; -20 to +10 dBm radio interface input level, with AGC adjustable; and -20 to +6 dBm adjustable radio interface output level. The RF-41A81 is powered from 200 V AC +-15 per cent, 47-63 Hz. It measures 60 x 310 x 266 mm and weighs 2.7 kg. It operates over -20 to +50ºC in up to 95 per cent humidity. It meets MIL-STD-810D for shock and vibration for fixed installations.

Manufacturer: Panda Electronics Group Co, Nanjing.

RF-41D00A frequency-hopping HF/SSB transceiver

The RF-41D00A is a frequency-hopping HF/SSB transceiver system covering the 1.6 to 30 MHz (transmit) and 0.1 to 30 MHz (receive) frequency ranges with an output power of 200 W. Modes are J3E USB/LSB, H3E AME, CW, simplex or half-duplex. The system comprises the RF-41D10 transceiver, RF-41A55 frequency-hopping controller to give the same performance as the RF-41A00A system (see separate entry), RF-41A50 adaptive controller, RF-41D70 digital antenna coupler and the RF-41D90 power supply. ALE is to MIL-STD- 188-141A and FED-STD-1045. Dimensions for the RF-41D10 are 220 x 510 x 470 mm and weight is 30 kg.

Manufacturer: Panda Electronics Group Co., Nanjing.

698 side-looking radar

The I/J-band 698 side-looking radar is designed specifically for detection of periscopes and ships. The radar features coherent moving target detection, slotted feed double parabolic reflector antenna, parametric amplifier, high-stability local oscillator, coherent receiver, IF log amplifier and digital filter. Detection ranges are quoted as 60 km against ships and 17 km against a periscope.

Detection range: periscope 17 km; ship 60 km

Display ranges: (transversal) 60 km (normal) (longitudinal) 30 km (searching)

High resolution: (transversal) 300 m (searching) (longitudinal) 50 m Operational altitude: 50-500 m (searching)

Volume: 0.8 m

Weight: 230 kg

Manufacturer: China Leihua Electronic Technology Research Institute

Shipborne radar ESM receiver 921-A

The 921-A is a wideband pulse radar direction-finding receiver and is installed on submarines to detect emitters of airborne, shipborne and shore-based radars. It provides coarse measurement of azimuth, frequency band and operational state of the hostile emitters. The equipment is derived from the Russian Stop Light EZM system. In service with the PLAN on `Xia', `Han', `Song', and North Korean `Romeo' class submarines.

Frequency: 2-18 GHz in four bands

Sensitivity: 1.5 x 10 to 10 W/M

Bearing accuracy: Better than +-30º

Dimensions and weights

Antenna unit: 560 mm (diameter) x 515 mm (high); 80 kg

Receiver and display: 450 x 468 x 124 mm; 40 kg

Distribution unit: 145 x 214 x 291 mm; 6 kg

Manufacturer: China National Electronics Import and Export Corporation

SJ-202 target acquisition/tracking radar

Type: Target acquisition/tracking radar.

The SJ-202 is the latest acquisition/tracking radar for use with the HQ-2 series of surface-to-air missile systems. The equipment utilises an automated radar van together with a command and control vehicle. Maximum detection range is 115 km with a tracking range of 80 km. The SJ-202 operates in conjunction with the Gin Sling radar (see separate entry). The SJ-202 is thought to be in service with the PLA.

Manufacturer: China Precision Machinery Import and Export Corporation

10 W SSB transceiver

The solid-state 10 W SSB transceiver is intended for voice and telegraphy applications over intermediate and long distances in demanding terrain. The 1.6 to 5.999 MHz equipment can be used as a manpack. It operates with a 1.5 or 2.4 m whip, a 15 m slant or a 44 m dipole antenna. Power is via Ni/Cd batteries or an AC/DC voltage regulator and a hand generator.

Modes: USB voice and telegraph

Frequency range: 1.6-5.999 MHz

Number of channels: 4,400

Channel spacing: 1 kHz

Power output: 10 W PEP min SSB voice, 8 W average SSB telegraph min Power supply: 25 V DC

Temperature range: -40 to +50ºC

Height: 355 mm

Width: 275 mm

Depth: 115 mm

Weight: 5 kg main set, 9.8 kg manpack configuration

Manufacturer: Shaanxi Fenghuo Group Company, Baoji.

Type 311-A/B/C fire-control radars

Type: I/J-band (8 to 20 GHz) fire-control radar for anti-aircraft guns.

The Type 311 series fire-control radar is for use with anti-aircraft guns and is normally employed with batteries of either 37 mm or 57 mm calibre. It operates on I/J-band frequencies and is capable of both search and target tracking functions and is generally used with a computer and an optical rangefinder. The Type 311 consists of an operations trailer with the main electronic and mechanical elements of the radar, and a towing vehicle in which the operators are carried, together with a power generating set, tools and spare parts. The antenna is mounted on a pedestal on top of the trailer. The complete system can be set up or dismantled to move within about 15 minutes and the weight of the radar trailer is less than four tons. The towing vehicle with equipment weighs under eight tons. Detection range on a fighter-size aircraft target in the search mode is at least 30 km, with a maximum tracking range of 25 km. Minimum reliable tracking range is about 500 m. The radar can be switched to any one of three pre-programmed operating frequencies by the operator, and target position data in the tracking mode can be fed to the computer in either rectangular or spherical co-ordinates. In the search mode, the radar beam is oscillated in the vertical plane at a rate of 4 Hz to broaden the effective beam. A target within this beam that subsequently deviates in either elevation or azimuth by 20 mils or more from the radar boresight axis can then be tracked automatically. Further development of the Type 311 has led to the 311-B and 311-C. The Type 311-B introduces an integral identification friend-or-foe subsystem, increased frequency coverage and a maximum range of 35 km using a new antenna design.

The Type 311-C goes one stage further and has a frequency agile radar with a maximum range of 40 km. The Type 311 series radars are thought to be in service with the PLA and the armed forces of a number of other countries.

Operating frequencies: I/J-band (8-20 GHz - 3 switchable sub-bands)

Transmitter Type: magnetron

Peak power: 200 kW (0.3 Ás pulse); 180 kW (0.9 Ás pulse)

Pulsewidth: 0.3 Ás (narrow); 0.9 Ás (broad)

PRF: 2,500 Hz (narrow pulse); 833 Hz (broad pulse)

Antenna gain: at least 35 dB

Horizontal beamwidth: 2.6º

Vertical beamwidth: 2.4º

Sidelobe: -18 dB (max)

Receiver sensitivity: -92 dB/mW (CW)

Maximum range: Type 311-A 30 km;

Type 311-B 35 km;

Type 311-C 40 km; 25 km (tracking)

Manufacturer: China National Electronics Import and Export Corporation

Type 313 fire-control radar

Type: I/J-band (8 to 20 GHz) fire-control radar for anti-aircraft guns.

The Type 313 is a development of the Type 311 described previously. It is intended primarily for use with up to eight 37 mm Type 74 air defence guns, but can also be configured for other applications according to a user's requirements. The system combines an I/J-band radar with a TV tracker and a laser rangefinder. With a theoretical maximum range of 35 km, a 90 per cent probability of detection is claimed against a target of 2 m^2 or more at up to 25 km. A version, known as the Type 313A, which has a frequency agile radar has also been developed. The Type 313 is thought to be in service with the PLA.

Manufacturer: Chuanbei Electronic Industry Company, Beijing.

Type 404A coastal surveillance radar

The Type 404A is an X-band surveillance radar for use by coastal defence forces. There are two receiver channels operating in frequency diversity and comprehensive signal processing facilities are provided. The elliptical antenna is equipped with a remotely adjustable circular polarising device to reject rain and other clutter. Display arrangements include a PPI, and A- and B-scope presentations. The Type 404A is in production.

Frequency: X-band

Range: to radar horizon

Antenna gain: 39 dB

Accuracy: 100 m (range); 0.35º (bearing)

Resolution: better than 200 m (range); 0.8º (bearing)

Manufacturer: China National Electronics Import & Export Corporation, Beijing.

Type 408-C long-range air warning radar

Type: VHF band (30 to 300 MHz) air defence radar.

The Type 408-C is a mobile long-range air defence warning radar system operating in the VHF band, at 150 to 180 MHz and 100 to 120 MHz. It employs a dipole planar-array antenna type, mounted on a pedestal, having two back-to-back dipole arrays which can be operated simultaneously at the high- and low-bands, giving two transmit/receive channels. The equipment has a wide operating frequency range within each band, enabling it to counter active jamming by rapid change of frequency within the bands. By integrating the video signal it is able to suppress asynchronous pulse jamming, and by modulating the transmitter pulse repetition frequency, it counters repeater pulse jamming. The transmitter system employs air-cooled tower triodes, and uses Hi-Q coaxial cavity tanks to improve frequency stability. The display system consists of one azimuth/range display and three Plan Position Indicators (PPIs) which can scan in opposite directions and display the signals received at the same time from the two antennas within the two bands. The transmitter and receiver can be controlled remotely from the control cabin. The receiver provides high-sensitivity, high-frequency stability and a wide operating frequency range. It uses both the normal channel and the coherent channel to distinguish moving targets in ground clutter or passive jamming. The complete system is mobile with its units installed in eight operation vehicles forming four transport units; two transmitter/receiver vehicles, one display unit vehicle, one antenna unit vehicle, two transport vehicles, and two power supply vehicles (one is a spare). The Type 408-C is thought to be in service with the PLA.

Frequency range: 150-180 MHz (high band); 100-120 MHz (low band)

Antenna Type: 2 back-to-back dipole planar-arrays

Dimensions: 6 x 16 m

Polarisation: horizontal beamwidth: 8º (high band); 12º (low band)

Rotation speed: up to 6 rpm

Transmitter peak power: 800 kW

Pulse length: 10 Ás

PRF: 200 Hz

Manufacturer: China National Electronics Import and Export Corporation

Type 571 surveillance radar

Type: D-band (1 to 2 GHz) 2-D low-altitude surveillance radar.

The Type 571 is a 2-D D-band radar designed specifically for low-altitude air defence warning. Although apparently operating in a different frequency band, it bears a striking resemblance to the Russian Flat Face target acquisition radar, with its two elliptical paraboloid reflectors mounted one on top of the other, and is almost certainly derived from the latter. The Chinese authorities state that it includes both a frequency-hopping and moving target indicator capability. Two vehicles are required to transport the system, one being the operations cabin and the other the power supply. The antenna system is erected on top of the operations vehicle. The Type 571 is thought to be in service with the Chinese defence forces.

Frequency: D-band (1-2 GHz)

Antenna type: two elliptical paraboloid net reflectors and horn-shaped radiators

Antenna size: 5.5 x 2 m (2 reflectors)

Beamwidth: 4.5º

Rotation speed: 3 or 6 rpm

Peak power: 210 kW

Pulsewidth: 2 or 4 Ás

PRF: 500, 600 or 680 pps

Manufacturer: China National Electronics Import and Export Corporation

Type 581 air warning radar

Type D-band (1 to 2 GHz) tactical air warning radar. The Type 581 is a medium- and low-altitude air warning radar for tactical applications. It is a transportable system with the 9.7 m span scanner mounted on turning gear that is carried on a wheeled trailer, which is stabilised for operational use by large folding legs with screw-jacks at their ends. The antenna rotates at up to 6 rpm. Sector scan is 90 or 30º with selectable scan centres. The operating frequency is in the D-band, giving a detection range of up to 190 km against a fighter aircraft target. There are two units in a Type 581 mobile convoy, one consisting of the scanner and turning gear (and probably the diesel-electric generator unit also), and an electronics vehicle which includes the transmitter/receiver and operators' cabin. The Type 581 is no longer in production but is thought to remain in service.

Frequency: D-band (1-2 GHz)

Peak power: 500 kW

Pulsewidth: 4Ás; 2Ás

PRF: 300 Hz/600 Hz

Noise figure: 3 dB

Antenna: 9.7 x 3 m

Polarisation: linear

Gain: 34 dB

Range: 190 km (fighter target)

Accuracy: 1 km (range); 1.2º (azimuth)

Resolution: 1 km (range); 4º (azimuth)

MTI: 20 dB (clutter visibility); 34 dB (cancellation ratio)

Displays: PPI (30.5 cm); A/R (18 cm)

Manufacturer: China National Electronics Import and Export Corporation

Type 702 air defence fire-control system

Type: G/H/I-band (4 to 10 GHz) automatic anti-aircraft fire-control system.

The Type 702 is a mobile automatic all-weather ground-to-air fire-control system consisting of radar, optical unit and computer. Its primary use is against aircraft attacking from low and medium altitude, but it can also be used against ground and sea surface targets. The system will operate with various calibre anti-aircraft guns or surface-to-air missiles. It consists of two wheeled vehicles (a towing van and a trailer) with the antenna mounted on the trailer, and folded down for transit. Operating crew is three. The Type 702 comprises mainly the radar system for both search and tracking roles, television tracking device, computer and power supply. The fire-control radar is used for fast capture and tracking of the target at low and medium altitude. It determines continuous information on the azimuth angle, elevation angle and slant range of the target, and passes this information to the fire-control computer. Automatic target search is in the G/H-band, with tracking in either G/H- or I-bands. The Type 702 is thought to be in service with the PLA, as part of the 37 mm Type 80 weapon system.

Frequency: 4-10 GHz

Antenna range: 360º (azimuth); -3 to +87º (elevation)

Detection range: 40 km

Tracking range: 0-40 km

Tracking accuracy: 15 m (range); 1.5 mil (angular)

Tracking speed: 600 m/s (range); 40º/s (elevation); 60º/s (azimuth)

Transmitter: automatic pulse-to-pulse frequency-hopping and self-adaptive frequency agility; G/H-band (4-8 GHz) coaxial magnetron; I-band (8-10 GHz) TWT amplifier chain

Bandwidth: 200 MHz (G/H-band); 1,000 MHz (I-band)

Beamwidth: 1.4º x 1.4º (I-band); 2.2º x 2.2º/2.2º x 22.5º (G/H-band)

MTBF: 100 h

Weight: 5.5 t

Manufacturer: China North Industries Corporation

Type 704 artillery locating radar

Type: I/J-band (8 to 20 GHz) weapon location and fire correction radar.

The Type 704 radar is used for the location of hostile artillery (including mortars, guns, howitzers and rocket launchers). It can also be used for tracking friendly artillery fire, calculating the impact error and providing automatic correction parameters. The system features multitarget ability, wide sector scan range, effective electronic counter-countermeasures ability, automatic operation, and easy maintenance.

The system response time from detection of a projectile to providing location when using automatic altitude correction is given as eight to nine seconds. The transmitter is a coherent amplifier chain system which uses a high stability frequency synthesiser as its frequency source. A travelling wave tube with an average power of 300 W is used in the end stage to provide range in the I/J-band. The receiver has a field-effect transistor high-frequency amplifier with high sensitivity and low noise characteristics at the front end. Three computer systems are included, one for operations control and data processing; one for antenna beam steering, azimuth elevation and azimuth data extraction, and transceiver/antenna vehicle control; and the third for failure checking of the operations vehicle. The Type 704 is located on two vehicles, an antenna/transceiver vehicle and an operations vehicle. The first carries the phase-frequency scanning array, transmitter, receiver and beam steering computer, with the antenna folded flat during transit. The second vehicle consists of two cabins, one for operations control, data processing, displays and so on, and the other containing the power supply. Three crew members are needed; a driver, power supply operator and radar operator, although only the latter is required during operation. The Type 704's operational status is uncertain.

Frequency: I/J-band (8-20 GHz)

Antenna Type: electronic scanning in phase frequency scan mode

Azimuth: +-45º (electronic scan); +-60º (rotation)

Elevation: -0.5 to +27º (tilt angle); -0.5 to +90º (rotation); 6º (beamwidth)

Range: 12 km (81 mm mortar); 15 km (120 mm mortar); 16 km (155 mm howitzer)

Location accuracy (CPE): 30 m (mortar); 40 m (flat trajectory gun/registration fire); 60 m (rocket launcher)

Target capacity: 8

Weights: antenna/transceiver vehicle 3,820 kg; operations control vehicle 3,920 kg

Manufacturer: China North Industries Corporation

Type 706 (IBIS) ultra-low level search radar

Type: Ultra-low level search radar for air defence.

The Type 706 (IBIS) search radar is a frequency agile air defence system designed for the detection of low level attack aircraft. It uses fully coherent pulse Doppler techniques and digital signal processing to enable it to detect and track 10 different types of target which are operating at ultra-low level in difficult topography. It provides multitarget recognition and tracking with a good electronic counter-countermeasures performance, and is particularly suitable for use with anti-aircraft weapon systems. It consists of an operations cabin, with the antenna mounted on top, which is transported by a suitable flatbed truck or trailer. The IBIS system can be operated whilst on the vehicle with the legs providing stability, or the vehicle can be removed (as illustrated). The antenna can be raised or lowered to suit the particular terrain. The transmitter is a coherent type with characteristics of high stability, high purity and low phase noise. It employs a format of main oscillating amplifier chain and a dual-stage grid-control travelling wave tube amplifier. Peak power is approximately 60 kW with a working bandwidth of +-5 per cent. The digital signal processor provides advanced moving target detector, and a clutter pattern memory and post-processing system. The data processor has the capability of multitarget adaptive recognition and flight path tracking. It carries out auto-extract and semi-auto-extract of target data recording with a capacity of 200 batches, automatically or semi-automatically as required. Target flight path tracking has a maximum capacity of 20 batches. The display system consists of two displays, a plan position indicator with a 31 cm cathode ray tube that can display the primary or secondary information of the radar, and an alphanumeric display to provide information on target parameters, operation mode, and fault detection and analysis. The Type 706 (IBIS) is thought to be in service with the PLA.

Antenna maximum 12 m

working height:

Revolution: 27 rpm

Power output: 60 kW peak

Range: to 40 km

Height coverage: 50-4,000 m

Bearing: 360º

Beamwidth: 3º (horizontal); 45º (vertical)

Resolution: 500 m (range); 3º (azimuth)

Accuracy: 400 m (range); 0.5º (bearing)

Continuous operating time: 12 h Radar response time: 4-8 s

Manufacturer: China North Industries Corporation

Type 791-A Precision Approach Radar (PAR)

Type: I/J-band (8 to 20 GHz) military PAR.

The Type 791-A PAR is a typical military mobile radar equipment. It is mounted on a six-wheeled truck, although the manufacturers state that both mobile and fixed installations are available. This Chinese-manufactured system closely resembles the former Soviet RSP-7 PAR (NATO reporting name Two Spot) and it could well be a licence-made version although there are slight differences. For example, in the former Soviet version the PAR antenna heads are located between the driver's cab and the radar cab, whereas in the Chinese model the antennas are at the rear end of the whole assembly. However, this could be nothing more significant than the fact that the equipment was designed as a cabin-housed equipment meant to be carried on a flat bed truck, and capable of being loaded either way round. There are similar slight differences in the scanner outlines. Operation is in the I/J-band and dual transmitter/receivers are provided to ensure continuity of service; for the same reason the display indicators are also duplicated. The two scanners, for search and azimuth guidance and for elevation guidance, are co-located on a mounting at the rear of the vehicle. There is an operators' cab in front of this which also contains communications facilities. Circular polarisation is provided to combat weather clutter and the receiver includes a logarithmic intermediate frequency amplifier. Double B scope displays are used to improve the accuracy at short range. When operating the antenna is able to change direction rapidly to cope with aircraft landing on different runways. Dual transceivers, indicators and generators are supplied. The Type 791-A PAR is understood to be in service with the PLA.

Frequency: I/J-band (8-20 GHz)

Range: 35 km (15 km in rain)

Coverage: 1-8º (elevation); 20º (azimuth)

Accuracy: 0.35º (elevation); 0.5º (azimuth)

Range accuracy: approx 60 m

Resolution: 200 m (range); 1.2º (angular)

Manufacturer: China National Electronics Import and Export Corporation

XD-D2B 15/25 W frequency synthesised SSB radio set

The XD-D2B 15 W transistorised radio provides SSB voice and telegraph communication. It is mainly used as a fixed equipment, but can appear in a backpack version. It has 8,000 channels and a power output of not less than 15 W PEP and not less than 8 W average. The radio uses frequency synthesis and is constructed in medium-scale integration CMOS circuitry. It can be used with a 1.5 m whip, a 15 m slant antenna or a 44 m dipole antenna and is powered from Ni/Cd batteries, a hand generator or AC/DC regulators.

Modes: SSB (USB, LSB) voice and telegraph

Frequency range: 2-9.99 MHz

Number of channels: 8,000

Power output: 15 W

Power supply: 25 V DC

Temperature range: -20 to +50ºC

Height: 293 mm

Width: 280 mm

Depth: 120 mm

Weight: 10 kg complete, 5.2 kg main set

Manufacturer: Shaanxi Fenghuo Group Company, Baoji.

XD-D3C 5 W synthesised SSB transceiver

The XD-D3C 5 W synthesised transceiver covers the 2,700 to 6,299 kHz range with 3,600 channels at 1 kHz spacing. Modes are USB voice and telegraphy and output power is 5 W PEP. Powered by 12 V DC, the XD-D3C uses 20 or 44 m antennas and operates over -20 to +50ºC. It measures 80 x 280 x 230 mm and weighs 5.7 kg with battery.

Manufacturer: Shaanxi Fenghuo Group Co, Baoji.

XD-D6M 5 W HF/SSB transceiver

The XD-D6M is a 5 W HF/SSB transceiver operating at 3,000 to 7,999 kHz. It uses either a 2.4 m whip, 12 m slant, 44 m dipole or a 2.4 m steel-skin antenna. Power is 12 V DC (negative grounded), Ni/Cd battery, or 12 V hand generator.

Modes: LSB, USB, AM (voice), CW telegraph

Frequency range: 3,000-7,999 kHz

Number of channels: 8 stored

Power output: 5 W

Temperature range: -10 to +50ºC

Weight: 4 kg

Manufacturer: Shaanxi Fenghuo Group Company, Baoji.

XD-D6 5 W HF/SSB transceiver

The XD-D6 is a 5 W HF frequency synthesised SSB transceiver that incorporates microprocessor and LCD facilities. It is designed for fixed, manpack or mobile applications communicating over medium or short ranges. It covers 3,000 to 7,999 kHz with 1 kHz intervals. Modes are LSB, USB, AM (voice) and CW telegraph. Eight channels can be stored.

Manufacturer: China National Electronics Export and Import Corporation, Beijing.

XD-D6C 50 W HF transceiver

The XD-D6C is a 50 W HF microprocessor-controlled transmitter with an AATU, digital display and a 16-channel memory. Operating over 3 to 13.999 MHz at 1 kHz spacing, the radio provides USB and LSB voice capabilities. It functions in a temperature range of -10 to +50ºC, is powered from 24 V DC and weighs 5 kg.

Manufacturer: Shaanxi Fenghuo Group Co., Baoji.

XD-D9 25 W HF/SSB transceiver

The microprocessor-controlled XD-D9 is a 25 W HF/SSB transceiver with an AATU, an LCD and a storage capacity of 16 channels (expandable to 32). It covers the 2 to 17.99999 MHz range with 100 Hz spacing, and offers USB and LSB voice, LSB CW and tune modes. It operates over -10 to +40ºC and is powered by 12 V DC. It measures 100 x 285 x 275 mm and weighs 6.5 kg.

Manufacturer: China National Electronics Import and Export Corporation

YLC-4 surveillance radar

Type UHF (0.3 to 1 GHz) band 2-D long-range surveillance radar. The YLC-4 is a UHF 2-D solid-state, fully coherent long-range surveillance radar which features a low-sidelobe antenna, built-in test equipment, pulse-to-pulse, burst-to-burst frequency agility, system redundancy for reliability and airborne moving target indicator. In terms of data manipulation, the radar incorporates semi-automatic or automatic target performance extraction and the ability to synthesise, display and (communicate) data from up to four other radars such as height-finders and gap fillers. The operational status of YLC-4 is uncertain.

Frequency: UHF band (0.3-1 GHz)

Detection range: 380 km (automatic extraction); 410 km (manual extraction) Coverage: 360º (azimuth); 0-25º (elevation)

Detection Ceiling: 30,000 m

Accuracy: 300 m RMS (range); 0.5º RMS (azimuth)

Antenna dimensions: 16.5 x 7.12 m

MTI improvement factor: 41 dB

Peak power: 40 kW

Manufacturer: Nanjing Research Institute of Electronics Technology

ZJ9301-1 radar Electronic Support Measures (ESM) system

Type D- through H-band (1 to 8 GHz) or I- through J-band (8 to 18 GHz sub-band) man-portable radar ESM system. The ZJ9301 man-portable, battlefield ESM system is available in 1 to 8 GHz and 8 to 18 GHz configurations and includes an operator display/control/processing unit and a tripod-mounted antenna. The equipment is described as being able to handle between three and five detected radars simultaneously. The ZJ9301-1 ESM system is understood to be available.

Frequency range: 1-8 GHz or 8-18 GHz

Receiver sensitivity: -60 dBm

Direction-finding accuracy: >4º RMS

Frequency accuracy: 15 MHz RMS

Manufacturer: China National Electronics Import and Export Corporation

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 Ben Sheppard; Dr Howard DeVore

APPENDIX D - SMALL ARMS AND EXPLOSIVE DEVICES

Date Posted: 05-Dec-2000

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Small Arms and Explosive Devices

NORINCO 7.62 mm Type 54 pistol and 9 mm Pistol Series 213

The NORINCO 7.62 mm Type 54 pistol is a direct copy of the Soviet 7.62 mm Tokarev TT-33 pistol and is the standard pistol in the People's Liberation Army. The Chinese version may be distinguished from the Soviet or Polish equivalents by the serration on the slide. The Soviet and Polish pistols have a series of alternate wide and narrow vertical cuts and the Chinese pistols have uniform narrow vertical serration. The Chinese pistol can be further distinguished from the Hungarian Model 48 and Serbian Model M57 (which also have uniform narrow slots) by the Chinese markings on the receiver or top of the slide. The Serbian pistol carries '7.62 mm M57' on the left side of the slide, and the Hungarian Model 48 has an emblem consisting of a star, wheatsheaf and hammer, in a wreath, on the grip. The Pistol Series 213 are commercial models chambered for 9 x 19 mm Parabellum ammunition. There are three models. The base Model 213 is essentially a Type 54 revised to fire 9 x 19 mm Parabellum ammunition. It is provided with a double safety. The Model 213A is a Model 213 with a 14-round capacity box magazine. The Model 213B is a Model 213 with revised moulded grips to enhance fire comfort. This is available for export sales and in service with PLA and countries in Southeast Asia.

Type 54

Cartridge: 7.62 x 25 mm 'P' cartridge (Type 51)

Operation: recoil, semi-automatic

Locking: projecting lugs

Feed: 8-round box magazine

Weight: empty, 890 g

Length: 195 mm

Barrel: 115 mm

Rifling: 4 grooves, rh

Sights: fore, blade; rear, notch

Muzzle velocity: 420 m/s

Maximum effective range: 50 m

Pistol Series 213 Model 213A

Cartridge: 9 x 19 mm Parabellum

Operation: recoil, semi-automatic

Locking: projecting lugs

Feed: 14-round box magazine

Weight: empty, 900 g

Length: 195 mm

Barrel: 116 mm

Rifling: 4 grooves, rh

Sights: fore, blade; rear, notch

Muzzle velocity: 335 m/s

NORINCO 7.65 mm Type 64 and Type 67 silenced pistols

The NORINCO Type 64 is a pistol produced solely in silenced form. It may be used either as a manually operated single-shot arm or as a self-loader. When the maximum silencing effect is required, the selector bar is pushed to the left and the lugs of the rotating bolt in the slide engage in recesses in the receiver and the weapon fires from a locked breech. After the round has been fired the slide is hand-operated to unlock the bolt, retract the slide and extract the fired case. When the selector bar is pushed to the right, the locking lugs do not engage in the recesses in the receiver and the pistol functions as a blowback-operated semi-automatic. This results in a more noisy method of operation as the slide reciprocates and the empty case is ejected. The cartridge is 7.65 x 17 mm. It is rimless and unique. No other round can be used in this pistol. The silencing effect is obtained by placing a large bulbous attachment on the front of the receiver extending well forward of the muzzle. The gases leave the muzzle and expand into a wire mesh cylinder surrounded by an expanded metal sleeve. The bullet passes through a series of rubber discs which trap the gases. Used as a single-shot manually operated pistol it is extremely quiet but its reduced muzzle velocity greatly affects its powers of penetration. The Type 67 is an improved model; in essentials it is the same as the Type 64 above but the silencer has been reshaped, making the weapon easier to carry in a holster. There are some small changes in the assembly of the silencer but the principle of operation remains the same. It is chambered for the 7.62 mm Type 67 cartridge, a rimless, necked round of reduced velocity. In production, and in service with the PLA.

Differences for the Type 67 are shown in parenthesis

Cartridge: 7.65 x 17 mm rimless (7.62 Type 67 rimless)

Operation: (a) manual, single shot or (b) blowback, semi-automatic

Locking: (a) rotating bolt or (b) nil

Feed: 9-round box magazine

Weight: empty, 1.81 kg (1.05 kg)

Length: 222 mm (226.2 mm)

Barrel: 95 mm (89 mm)

Rifling: both 4 grooves, rh

Sights: fore, blade; rear, notch

Muzzle velocity: 205 m/s (230-250 m/s)

Maximum effective range: 30 m

NORINCO 7.62 mm pistol Type 77

The NORINCO 7.62 mm Type 77 is a light pistol intended for equipping senior officers, military attaches and police. It fires the rimless 7.62 mm Type 64 cartridge, the round used with the Type 64 silenced pistol (see previous entry). There have been several 'single-handed cocking' pistol designs. This version, one of the few to have any commercial success, originated in 1913-15 and was marketed by Bergmann and later by Lignose in Germany in the early 1920s.

The design of the NORINCO Type 77 is rather unusual, reviving a long-defunct German system of operation. The pistol is a simple blowback weapon which can be carried with a loaded magazine and empty chamber. When required for use, the trigger finger is hooked around the front edge of the trigger guard and the guard pulled to the rear. This moves the slide back against its return spring and, if the finger is then released, the slide will run back and chamber a cartridge. By simply transferring the finger to the trigger the weapon is ready to fire almost instantly. The trigger guard is not permanently linked to the slide and so does not move during normal firing. This method of operation also has the advantage that, in the event of a misfire, the cartridge can be ejected single handed. The chamber is fluted to reduce the slide recoil velocity by reducing the gas pressure acting on the base of the cartridge case. This pistol should not be confused with the NORINCO 9 mm Type 77B.

Cartridge: 7.62 x 17 mm (Type 64)

Operation: blowback

Feed: 7-round box magazine

Weight: 500 g

Length: 148 mm

Muzzle velocity: 318 m/s

NORINCO 7.62 mm machine pistol Type 80

The NORINCO 7.62 mm machine pistol Type 80 is based on the long-obsolete Mauser Model 712 (System Westinger) machine pistol. This was manufactured from 1932 to 1936, with an estimated 70,000 being supplied to China. Numerous copies were also locally manufactured in the late 1930s, but the design then fell into disuse.

The NORINCO Type 80 uses the same basic mechanism, an internal reciprocating bolt locked by a plate beneath it, with an external hammer, but has a canted magazine (probably for more reliable feed) and a lengthened barrel. There are also a few minor differences in the contours of the frame and the grip angle has also been improved. A clip-on folding stock is available, as is a bayonet and, with the stock attached, the weapon can be used at ranges up to 150 m with good effect.

Cartridge: 7.62 mm Tokarev (Type 51, 7.63 x 25 mm Mauser)

Operation: locked-breech, recoil-operated, selective fire

Feed: 10- or 20-round detachable magazines

Weight: with empty 10-round magazine, 1.1 kg

Length: 300 mm

Muzzle velocity: 470 m/s

Rate of fire: effective, 60 rds/min

NORINCO 9 mm pistol Type 59

The NORINCO 9 mm Type 59 pistol is a copy of the RFAS PM Makarov pistol so it is a blowback weapon with a double-action trigger. For further information on the design, refer to the RFAS PM Makarov entry. There is also a commercial Type 59A model chambered for 0.380 ACP ammunition. This is in production.

Cartridge: 9 x 18 mm Soviet (known as Type 59 in China)

Operation: blowback, double-action

Feed: 8-round box magazine

Weight: empty, 730 g

Length: 162 mm

Barrel: 93.5 mm

Rifling: 4 grooves, rh

Sights: fore, blade; rear, U-notch

Sight radius: 130 mm

Muzzle velocity: 315 m/s

NORINCO 9 mm pistol Model 77B

The NORINCO 9 mm pistol Model 77B is marketed for commercial and military sales and should not be confused with the 7.62 mm pistol Type 77 (see separate entry). Not only does it fire the 9 x 19 mm Parabellum cartridge but it appears to have a different locking system based on Browning principles. However, the Model 77B does carry over the 'single-handed cocking' principle used with the 7.62 mm Type 77, operated by pulling back the front of the trigger guard with one finger. The external appearance of the Model 77B is greatly different and dimensions overall are much larger compared to the 7.62 mm Type 77. Once cocked, the 9 mm Model 77B is fired double action only, and is provided with manual and magazine safeties. Recoil forces are claimed to be light. Offered for export sales.

Cartridge: 9 x 19 mm Parabellum

Operation: short recoil, semi-automatic

Feed: 9-round box magazine

Weight: 1 kg

Length overall: 193 mm

Barrel: 127 mm

Sights: fore, blade; rear, adjustable ramp

Muzzle velocity: 310 m/s

Chamber pressure: 2,200 kg/cm^2

NORINCO 7.62 mm Type 84 pistol

The NORINCO 7.62 mm Type 84 pistol is described in Chinese literature as a 'special purpose anti-riot weapon'. This miniature pistol is intended for use by security personnel aboard aircraft, ships and trains. It was designed for undercover use and is intended to subdue criminals attempting to commit crimes where the penetration of higher-velocity, larger calibre weapons would damage the aircraft or vehicle on which the weapon is used. The Type 84 pistol fires only one type of 7.62 x 17 mm cartridge, produced only in China. It is blowback operated and striker fired. While the Type 84 round will not penetrate the passenger compartment walls of an aircraft at 2 m, it is claimed to be lethal against human targets at 15 m. The standard Type 84 cartridge has a velocity of 200 m/s. The pistol also is intended to be used with the 7.62 x 17 mm Type 64 subsonic cartridge with a velocity of only 160 m/s. Service life of the Type 84 Pistol is claimed to be only 500 rounds, an astonishingly low expectancy. This is in production.

Cartridge: 7.62 x 17 mm Type 84

Operation: blowback

Feed: 6-round detachable box magazine

Weight: 380 g

Length: 121 mm

Barrel: 56.3 mm

Sights: fore, blade; rear, notch, adjustable for windage

Muzzle velocity: 160-200 m/s

NORINCO 0.22 Type 85 Bayonet Pistol

This unusual weapon appears to be a Chinese version of a Spetsnaz pistol/knife. Known as the 0.22 Type 85 Bayonet Pistol it contains four barrels in the grip, chambered for standard 0.22 LR cartridges. These barrels are aligned so that two lie each side of the blade with the muzzles at the base of the blade. By pressing in a spring-loaded catch at the rear of the handle, the rear cap is removed, exposing the four chambers. After loading, the cap is replaced and locked in place. There is a serrated rotary catch at the front end of the handle which acts as a safety catch. Rotated clockwise, this locks the trigger (which forms half the handguard of the knife) and makes the pistol inactive so that the knife can be used. When rotated anti-clockwise, the safety catch uncovers a red warning mark alongside the foresight and allows the trigger to function. Pulling the trigger then fires one barrel at a time. To reload, the rear cap is removed and the trigger pulled, whereupon the empty cases are ejected from two barrels; a further pull ejects the cases from the other two barrels. The safety catch is applied and the chambers can then be reloaded. A notch rearsight is built into the rear end of the handle and a foresight forms part of the handguard. To fire, the pistol is held at arm's length so that aim can be taken. It is claimed that the projectiles can penetrate pine boards 8.5 mm thick and a covered quilt with cotton wadding 40 mm thick 5 m from the muzzle. It is further claimed that the projectile fired from the Type 85 cannot penetrate an aircraft's pressure bulkhead. There is a further variant of this weapon on which the blade can be folded for concealment. This version has three barrels and is chambered for 0.22 rimfire ammunition only. The 0.22 Type 85 Bayonet Pistol is in production.

Cartridge: 0.22 LR

Operation: single shot

Feed: 4 preloaded barrels

Weight: empty, 330 g

Length overall: extended, 265 mm; folded, 150 mm

Barrels: 86.3 mm

Rifling: 4 grooves, rh, 1 turn in 224 mm

Muzzle velocity: ca 140 m/s

Effective range: 5-8 m

NORINCO 7.62 mm Type 79 light sub-machine gun

Description The NORINCO Type 79 light sub-machine gun is an extremely lightweight weapon, firing the 7.62 x 25 mm (Type 51) pistol cartridge. The receiver is rectangular and made from steel stampings, and it has a safety lever and fire selector on the right side, above the pistol grip, which appears to have been modelled upon that of the Kalashnikov AK series rifles. A user trained in using the AK system will find no difference if they pick up one of these weapons. Operation is by gas, using a short-stroke tappet above the barrel. This drives a short piston attached to a bolt carrier, operating a rotating bolt. This is a rather complex way of operating a sub-machine gun but, as with the external controls, it has some similarity to the rifle design and thus facilitates training, and, more importantly, does away with the need for a heavy bolt and long bolt travel, making the weapon lighter and more controllable.

Cartridge: 7.62 x 25 mm

Pistol (Type 51) Operation: gas, selective fire

Locking: rotating bolt

Feed: 20-round box magazine

Weight: with empty magazine, 1.9 kg

Length: stock folded, 470 mm; stock extended, 740 mm

Muzzle velocity: 500 m/s

Rate of fire: cyclic, ca 650 rds/min

NORINCO 7.62 mm Type 85 light sub-machine gun

The NORINCO 7.62 mm Type 85 light sub-machine gun is a modified and simplified version of the Type 79 (see previous entry). It is a plain blowback weapon, with a cylindrical receiver into which the barrel is fitted and which carries the bolt and return spring. There is a folding butt and the weapon uses the same magazine as the Type 79. The manufacturers claim the ability to fire reduced-velocity Type 64 pistol ammunition as well as the standard Type 51 cartridge. This is in production and available for export.

Cartridge: 7.62 x 25 mm Pistol (Type 51)

Operation: blowback, selective fire

Feed: 30-round box magazine

Weight: empty, 1.9 kg

Length: butt folded, 444 mm; butt extended, 682 mm

Sights: fore, blade; rear, flip aperture; sighted to 200 m

Muzzle velocity: ca 500 m/s Rate of fire: cyclic, 780 rds/min

Maximum effective range: 200 m

NORINCO 7.62 mm Type 64 silenced sub-machine gun

The NORINCO 7.62 mm Type 64 silenced sub-machine gun is a Chinese-designed and constructed gun which combines a number of features taken from various European weapons. The bolt action is the same as that of the Type 43 sub-machine gun which was copied from the Soviet PPS-43. The trigger mechanism, giving selective fire, may have been taken from the Bren gun, numbers of which fell into Chinese hands during the Korean War, although the Bren mechanism was derived from that of the series of light machine guns purchased by pre-war Chinese government forces from the former Czechoslovakia. Offered for export and in service with the PLA.

The Type 64 is blowback actuated using the 7.62 x 25 mm (Type 51) pistol cartridge held in a curved magazine under the receiver. The chamber contains three flutes each 0.1 mm wide and 0.075 mm deep, extending from the commencement of the small cone to just beyond the mouth of the chamber: a total length of 10 mm. The suppresser is of the Maxim type. The barrel is 200 mm long and is plain for the first 131 mm after which it is perforated by four rows of holes for a distance of 57 mm, each following the rifling groove and each having nine holes of 3 mm diameter, making 36 holes in all. The tube surrounding the barrel continues forward for a further 165 mm and then there is a muzzle cap. Between the end of the barrel and the cap is a stack of baffles each of which is dished with a central hole of 9 mm diameter; two rods passing down through the baffles keep the stack together and properly lined up. The rods can be rotated and then are free to come out through the baffles, allowing ready disassembly. The suppresser is reasonably effective and also has the virtue of preventing any flash from either muzzle or breech. This unusual sub-machine gun was specifically designed and made as a silenced weapon. In most other cases the silencer is fitted to an existing gun, which at least reduces the cost and manufacturing effort.

Cartridge: 7.62 x 25 mm Type P Ball (Type 51)

Operation: blowback, selective fire

Feed: 30-round curved box magazine

Weight: empty, 3.4 kg

Length: stock closed, 635 mm; stock open, 843 mm

Barrel: 244 mm

Rifling: 4 grooves, rh

Muzzle velocity: 513 m/s

Rate of fire: cyclic, 1,315 rds/min

Effective range: 135 m

NORINCO 7.62 mm Type 85 silenced sub-machine gun

The NORINCO 7.62 mm Type 85 is a simplified and lightened version of the silenced 7.62 mm Type

64 sub-machine gun, produced principally for export. It appears to be based on the simple mechanism of the Type 85 light sub-machine gun, but is of about the same size as the Type 64 and uses similar silencing arrangements. The Type 85 is regulated for the 7.62 x 25 mm Type 64 silenced cartridge but it is also possible to fire the standard Type 51 pistol cartridge, although the silencing effect is much reduced and there will also be the problem of bullet noise. With the Type 64 cartridge, the sound of discharge is reduced to less than 80 dB. This weapon is in production and is available for export sales.

Cartridge: 7.62 x 25 mm Type 64; 7.62 x 25 mm Type 51

Operation: blowback, selective fire

Feed: 30-round box magazine

Weight: empty, 2.5 kg

Length: butt folded, 631 mm; butt extended, 869 mm

Sights: fore, blade; rear, flip aperture; sighted to 200 m

Muzzle velocity: ca 300 m/s

Rate of fire: cyclic, 800 rds/min; practical, 200 rds/min

Maximum effective range: 200 m

5.8 mm Bullpup assault rifle

During the handover of Hong Kong to the People's Republic of China in 1997, it was noted that at least some of the troops involved in the ceremonies were equipped with a model of Bullpup rifle not previously seen. As yet few details are available regarding this rifle, which may form part of what has been described as the Type 95 Modular Weapons System, although it appears to involve a new 5.8 x 42 mm cartridge. It seems very likely that this rifle is a NORINCO product as they have produced at least one Bullpup 7.62 mm model, the semi-automatic rifle Model 86S offered for commercial sales. The Bullpup rifle is believed to be in production and in service with elite PLA units.

The receiver of the 5.8 mm Bullpup rifle is shrouded in a moulded polymer butt-stock, with the fore-end and pistol grip made from the same dark-coloured material. The cocking lever is protected under a carrying handle which also contains the rear sight; the foresight is on a post protected by a small cylinder. A three-position fire selector and safety switch is on the right-hand side of the body just above the pistol grip, although this switch is not present on some examples. The front trigger guard is much larger than usual as it provides the rear location point for an optional underslung spin-stabilised grenade launcher; it also provides a convenient location for the non-firing hand. The grenade launcher appears to have a calibre of 40 mm and is of the M203 pattern. A flash eliminator attachment on the muzzle can be used to launch rifle grenades. The top of the carrying handle can also be used to mount optical or night sights. Preliminary estimates place the overall length at about 780 mm. If this is correct, the barrel would be about 510 mm long.

A light support weapon version of this rifle is also in service. It has a longer and heavier barrel, a light bipod and a drum magazine, probably holding 75 rounds. There is no provision on the light support weapon for a grenade launcher. See entry under Machine guns for an illustration. Reports have also been made regarding a short carbine-pattern variant, described as a sub-machine gun but retaining the

5.8 mm cartridge. There is no provision for mounting a grenade launcher. There is also a selective fire sniper rifle variant. The latter has a longer barrel, making the weapon about 920 mm overall, an optical sight together with folding iron sights and an adjustable height bipod. A 10-round box magazine appears to be standard. As the optical sight is secured to a rail over the receiver the cocking lever is switched to the right-hand side of the receiver. Weight of this variant is understood to be 4.2 kg. There is no provision for mounting a grenade launcher.

NORINCO 7.62 mm Type 79 sniper rifle

The NORINCO 7.62 mm Type 79 is a precise copy of the Soviet/RFAS SVD Dragunov sniper rifle, except that the butt is slightly shorter. It is equipped with a x4 magnification optical sight which is a copy of the PSO-1 and has the same ability to detect infrared emissions. This is in production, available for export sales and in service with the PLA.

Cartridge: 7.62 mm x 54R Type 53

Operation: gas, short-stroke piston, self-loading

Feed: 10-round box magazine

Weight: rifle only, 3.8 kg; with optical sight, 4.4 kg

Length: 1.22 m Barrel: 620 mm

Rifling: 4 grooves, rh, 1 turn in 254 mm

Sights: fore, adjustable post; rear, U-notch, tangent; x4 optical sight

Sight radius: 585 mm

Sight range: iron, 1,200 m; optical, 1,300 m

Muzzle velocity: 830 m/s

0.22 in Long Rifle

The 0.22 Long Rifle rimfire cartridge was developed in 1887 by the J Stevens Arms & Tool Company of the USA, by taking the existing 0.22 Long cartridge and fitting it with a 0.324 g powder charge and a 2.59 g lead bullet instead of the conventional 1.88 g bullet. It was probably first commercially manufactured by the Union Metallic Cartridge Company in 1888. The first high-velocity loadings were developed by Remington in 1930. Over the years it has become the most highly developed and accurate of all rimfire cartridges, and is generally found with either 2.59 g solid lead or 2.4 g hollow point bullets, though innumerable variations can be found. In military hands this cartridge is invariably used for training purposes, though clandestine agencies, resistance forces, Special Forces and similar organisations have, from time to time, used it in combat roles where the low signature and accuracy were of particular value.

The cartridge case is rimmed and usually of brass, copper- or brass-plated steel. The priming composition is distributed around the rim, therefore the ductility of this area is critical. Rounds are of lead, occasionally with a light plating of copper and usually with lubricating cannelures, although lubricant may not always be present. Round-nose or hollow point bullets are the normal types.

Round length: 24.76 mm

Case length: 15.11 mm

Rim diameter: 6.98 mm

Bullet diameter: 5.66 mm

Bullet weight: 2.6 g

Muzzle velocity: 330 m/s

Muzzle energy: 142 J

7.65 mm Type 64 Cartridge

Used only in Chinese Type 64 and Type 67 silenced pistols and Type 85 standard and silenced sub-machine guns. Little is known of the development history of this cartridge, which was first known to Western agencies in the 1960s after its use in Vietnam.

The round generally resembles the 7.65 mm Browning but is a true rimless round rather than semi-rimmed and is not therefore, interchangeable. The case is brass, straight tapered and Berdan primed. The bullet is a conventional jacketed round-nose type but the propelling charge is reduced so as to deliver the optimum combination of silence and performance.

Round length: 24.38-24.9 mm

Case length: 16.75-17 mm

Rim diameter: 8.42 mm

Bullet diameter: 7.8 mm

Bullet weight: 4.8 g

Muzzle velocity: 230-250 m/s

Muzzle energy: 180 J

NORINCO Type JWJ machine gun low light level sight

The NORINCO Type JWJ is a second-generation image intensifying sight intended for use on machine guns and other crew-served weapons and also as an independent surveillance instrument. It is provided with bright light protection circuitry which prevents interference from flashes and bright illumination in the target area. An accessory handle is provided, for when the sight is used for hand-held observation.

Weight: 2.1 kg

Magnification: x4.5

Field of view: 10º

Focusing range: 20 m to infinity

Dioptric adjustment: +-2.5 dioptres

Night vision range: person, 500 m; vehicle, 1,000 m

Resolution: 0.5 mrad (E = 10 lux, C = 0.85); 1.2 mrad (E = 10

lux, C =0.35)

Chinese hand grenades

The armed forces of the People's Republic of China use a variety of grenades, some of which are local designs and others, principally older models, are copies of Soviet/RFAS designs. The Chinese copies are similar to the Soviet/RFAS models, except that in most cases they have different dimensions and, as the same design is often made by a number of factories, there are minor differences between copies of the same type of grenade. Listed below are some copies or near-copies of Chinese manufacture whose designations are known.

Type 42 offensive/defensive hand grenade

This is a direct copy of the Soviet/RFAS RG-42 grenade and its method of operation is identical.

Type 1 defensive hand grenade

This is a copy of the former Soviet F-1 grenade.

Type 59 defensive hand grenade

This is similar in design to the Soviet/RFAS RGD-5 grenade and operates in the same manner.

Type 73 prefragmented mini-grenade

This is a smaller version of the Type 59, using an internally pre-notched body to which is attached a prominent percussion ignition set similar in operation to that used with the Type 59 and Soviet/RFAS RGD-5. It weighs 190 g, is 88 mm high and has a diameter of 42 mm. It contains 580 3 mm steel balls.

NORINCO Type 82 hand grenades

NORINCO Type 82 grenades are basically of the offensive pattern though the makers claim they can be used in either role. The body is internally serrated to give fragmentation control. The Type 82-1 has a smooth, slightly irregular, oval shape and is fitted with a friction pull igniter beneath a removable cap. Delay time is 3 to 4 seconds. On detonation the grenade will produce more than 280 casualty-producing fragments over a radius of 6.25 m. The Type 82-2 (illustrated) is built up from two halves and has a prominent joint around the centre. There is a close-fitting protective cap which covers the working parts and retains the safety pin and ring while being shipped or carried. After removing this cap the pin is pulled and the grenade thrown in the usual way. Light and compact, it can be thrown for a considerable distance and several can be carried. The Type 82-3 uses the same body as the Type 82-1 but has a percussion igniter of somewhat different type from that used on the Type 82-2.

Type 82-2

Length: ca 85 mm

Diameter: 48 mm

Weight: ca 260 g

Filling: 62 g TNT

Number of fragments: ca 280

Lethal radius: 6 m

Safety radius: 30 m

Delay time: 2.8-3.8 s

Operational temperature: -40 to +45ºC

NORINCO Type 86 hand grenade

The NORINCO Type 86 is a plastic-bodied hand grenade of conventional design with the interior walls surrounded with about 1,600 steel balls each 2.5 to 3 mm in diameter. When the grenade detonates the steel balls are scattered over an effective lethal radius of 6 m. Due to the small size of the steel balls the critical safety distance for the thrower is 25 m.

Weight: total, 260 g

Diameter: 52 mm

Lethal radius: 6 m

Safety radius: 25 m

Number of steel balls: ca 1,600

Diameter of steel balls: 2.5-3 mm

Chinese stick grenades

The Chinese have manufactured a wide variety of stick grenades for defensive operations. Scored, serrated and plain types have been encountered. Their contents have included picric acid, mixtures of TNT or nitroglycerine with potassium nitrate or sawdust and schneiderite. The grenades are operated by pulling the cord of the pull-friction fuze, which is underneath the cap at the end of the throwing handle. This ignites the delay element which lasts between 2.5 and 5 seconds, after which the detonator explodes the main charge. A typical example of a defensive stick grenade is illustrated here and is known to be still in use. It is a fragmenting type with a serrated head made of grey cast iron. This produces a small number of large fragments and a very large number of fragments so small that they could well be described as `dust'. The filling is picric acid which was discarded as an explosive filling in the West many years ago, principally because it forms dangerous and unstable compounds. It is essential that the inside of the container is varnished.

Weight: 500 g

Length: 228 mm

Diameter: 50 mm

Weight: 99 g filling

Filling: picric acid

Fuse delay: 2.5-5 s

Effective fragmentation 10 m

radius:

NORINCO Type 77-1 stick grenade

Description The Type 77-1 stick grenade is commercially available through NORINCO, as well as being on issue to the People's Liberation Army. As with the stick grenades described previously, the Type 77-1 uses a friction pull igniter, revealed by removing a screwed cap from the plastic handle. The head is of cast metal, smooth and ovoid. A special treatment is applied to the wooden handle to ensure it is not adversely affected by extreme environmental factors. In production and in service with the PLA.

Length: 171-173 mm

Weight: 355-385 g

Diameter: 48 mm

Filling: 70 g TNT

Delay time: 2.8-4 s

Lethal radius: 7 m

Operational temperature: -40 to +45ºC

NORINCO Type 79 rocket hand grenade

The NORINCO Type 79 rocket hand grenade is an unusual design in that the user has the option of either using it as a normal stick grenade or selecting the rocket-powered option to hand launch the grenade warhead to a range of up to 400 m. Exactly how each mode is selected is unclear. It may be that the entire grenade is employed for either mode or the central portion may be removed from the launcher tube for throwing as a stick grenade. On target the 45 mm diameter grenade body produces a lethal radius of 8.65 m. The Type 79 rocket hand grenade is in production and available for export sales. It is in service with the Chinese armed forces.

Weight: total, 650 g

Diameter: 45 mm

Lethal radius: 8.65 m

Max range: as rocket grenade, 400 m

Operational temperature: -40 to +50ºC

NORINCO 70 mm rifle grenade Type 67

The NORINCO 70 mm rifle grenade Type 67 is intended for firing from the muzzles of 7.62 mm Type 56 or Type 81 rifles. It is claimed to be effective against light armoured vehicles and field fortifications at ranges up to 50 m. The 70 mm diameter warhead is of the shaped charge type, while the nose fuse appears to have some form of serrated anti-ricochet surface to ensure functioning at slight angles of incidence. Launching appears to involve some form of ballistic cartridge.

Weight: 785 g +-15 g

Length: 411-414 mm

Warhead diameter: 70 mm

Initial velocity: 42 m/s

Range: >50 m

NORINCO 60 mm rifle grenade

The characteristics of the NORINCO 60 mm rifle grenade follows the same general lines as the 70 mm Type 67 (see previous entry) and is intended for firing from the muzzles of the same rifles, the 7.62 mm Type 56 or Type 81. The 60 mm diameter warhead is again of the shaped charge type. Launching appears to involve some form of ballistic cartridge.

Weight: 560 g

Length: 410 mm

Warhead diameter: 60 mm

Initial velocity: 56 m/s

Range: >70 m

NORINCO trip flare Type 81

The NORINCO trip flare Type 81 is used for perimetre or border security by creating visual and aural indications of attempts by personnel to pass certain points. The Type 81 consists of a 38 mm flare body placed on a post or stake driven into the ground. Included with the flare body and post are reels of tripwire which are placed across areas to be covered. If the tripwire is disturbed or if an alternative form of triggering, such as a pressure pad, is actuated a percussion fuse will cause the flare body to be launched upwards to a height of more than 80 m while creating an aural signal audible from a distance of 1,000 m. The flare, which burns for at least 10 seconds, is visible for distances up to 500 m by day and 1,000 m by night.

Flare body diameter: 38 mm

Length: with fuse and post, 397 mm, flare body, 198 mm

Weight: 800 g

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 Ben Sheppard; Dr Howard DeVore

APPENDIX E - REMOTELY PILOTED AND UNMANNED VEHICLES

Date Posted: 05-Dec-2000

China's Aerospace And Defence Industry - December 2000

Previous

Remotely Piloted and Unmanned Vehicles

AVIC FK-11 and FK-12

Remotely piloted airships

These two airships were developed by the Huahang Airship Development Group (HADG) and first flown in 1994, two prototypes of the FK-12 being shown at the Guangzhou Aviation Fair in December of that year. They differ only in size and engine power. HADG's former airship Research and Development centre became the No 605 Research Institute of AVIC in 1995.

Non-rigid helium airship. Conventional envelope shape with cruciform tail surfaces. Small gondola with tubular landing gear. Vectored thrust ducted propellers.

Used for advertising:

12.0 m^2 (129.2 sq ft) of space available on envelope of FK-11.

Guidance and control:

Remotely piloted by radio-command uplink.

Conventional airship launch.

Recovery:

Conventional airship landing and docking.

Used for aerial advertising. Total of 15 FK-11s sold by mid-1995.

Power plant:

One Chinese YH-40 piston engine in FK-11; two Japanese OS BGX-1 piston engines (each 3.06 kW; 4.1 hp) in FK-12.

Dimensions:

Envelope:

Length: FK-11 10.40 m (34 ft 1.5 in)

FK-12 11.80 m (38 ft 8.6 in)

Maximum diameter: FK-11 3.40 m (11 ft 1.9 in)

FK-12 3.32 m (10 ft 10.7 in)

Volume: FK-11 38.0 m^3 (1,342 cu ft)

FK-12 40.0 m^3 (1,412.5 cu ft)

Height overall: FK-11 3.70 m (12 ft 1.7 in)

FK-12 4.06 m (13 ft 3.8 in)

Weights:

Weight empty: FK-12 43 kg (94.8 lb)

Maximum payload: FK-11 10 kg (22.05 lb)

FK-12 8 kg (17.6 lb)

Max T-O weight: FK-12 55 kg (121.25 lb)

Performance:

Maximum level speed: FK-11 27 kt (50 km/h; 31 mph)

FK-12 32 kt (60 km/h; 37 mph)

Ceiling: FK-11 200 m (660 ft)

FK-12 500 m (1,640 ft)

Endurance: FK-11 1 h

Manufacturer:

No 605 Research Institute (Special Surface Vehicle Institute), Jingmen, Hebei.

BSST Observer I

Small observation and intelligence-gathering RPV. Existence revealed November 1996 at Airshow China. Parasol-wing monoplane with pod-and-boom fuselage and conventional tail unit; GFRP construction. Twin-skid landing gear. Wings and tailboom/tail unit detachable for transport and storage. Man-portable.

Mission payloads: TV camera and video downlink.

Guidance and control: Computer-controlled via PCM radio command uplink; pre-programmed GPS navigation and positioning; flight duration and track can be superimposed on ground control TV monitor.

Launch: Hand-launched.

Recovery: Skid landing or parachute recovery.

Power plant: One four-stroke piston engine (type and rating not known); two-blade propeller.

Dimensions:

Wing span 2.70 m (8 ft 10.3 in)

Length overall 2.40 m (7 ft 10.5 in)

Weights:

Maximum launching weight: 10 kg (22.1 lb)

Performance:

Maximum level speed 65 kt (120 km/h; 74 mph)

Stalling speed 21 kt (40 km/h; 25 mph)

Operating height range: upper 1,600 m (5,250 ft)

lower 200 m (660 ft)

Control radius 2.7 n miles (5 km; 3.1 miles)

Endurance 70-90 min

Manufacturer: Beijing Strong Science and Technology Development Company

BUAA Chang Hong 1

High-altitude air-launched multipurpose UAV. The Chang Hong (Long Rainbow) 1 is based on the US Teledyne Ryan Model 147H (AQM-34N), several of which were shot down over mainland China before the banning of reconnaissance overflights in 1972. Its development by the Beijing Institute (now University) of Aeronautics and Astronautics, under the original designation WZ-5, began when the Institute was tasked in 1969 with developing a high-altitude drone for daylight photographic reconnaissance. Two prototypes were built and flown in 1972, followed by two more in 1976. Government technical certification was received in February 1980, and the Chang Hong 1 entered service for both training and tactical reconnaissance in the following year. Series production continued until the early 1980s. The reverse-engineered airframe has no visible external differences from the American RPV, and the Chinese Wopen 11 (WP11) power plant is based on the American vehicle's 8.54 kN (1,920 lb st) Teledyne CAE J69-T-41A turbojet.

Airframe:

Based on that of Teledyne Ryan BQM-34A Firebee (see Aerial Targets section). Fuselage is subdivided into a radar (tracking) compartment, camera compartment, fuel cells, engine bay, avionics bay and parachute compartment.

Mission payloads:

Only known payload is an optical camera, which can be rotated to any one of five positions to photograph to either side of the aircraft as well as directly beneath the flight path. May have been upgraded to permit carriage of more advanced sensors such as TV or FLIR.

Guidance and control:

Pre-programmed flight profiles, aircraft climbing automatically to operating altitude after release to follow a preset flight plan. Altitude, airspeed, flight time and range/endurance are controlled by the programme.

Launch:

Air-launched. Original carrier aircraft were modified Tu-4 bombers, but a dedicated version of the Shaanxi Y-8 transport, the Y-8E, is now in use as a drone carrier.

Recovery:

On arrival at recovery site, aircraft automatically deploys a parachute for helicopter mid-air (MARS) recovery.

System composition:

Y-8E drone control aircraft, six UAVs, Mi-8 recovery helicopter, two mobile GDTs, three truck-mounted GCS shelters, crew bus and 15 personnel.

Operational status:

In service. Used for geological survey and scientific research purposes such as atmospheric sampling, as well as for military reconnaissance and target drone roles.

Customers:

PLA

Power plant:

One 8.34 kN (1,874 lb st) BUAA WP11 turbojet.

Dimensions:

Wing span 9.76 m (32 ft 0.25 in)

Length overall 8.97 m (29 ft 5.1 in)

Weights:

Mission payload 65 kg (143.3 lb)

Maximum launching weight 1,700 kg (3,748 lb)

Performance:

Max level speed at 17,500 m (57,415 ft) 432 kt (800 km/h; 497 mph)

Operational ceiling 17,500 m (57,415 ft)

Endurance 3 h

Manufacturer:

UAV Research Institute of Beijing University of Aeronautics and Astronautics

NUAA Soar Bird

Remotely piloted helicopter. Revealed at Airshow China in November 1998.

Two-blade main and tail rotors; pod and boom fuselage with skid landing gear. Metal frame with glass fibre honeycomb skin; composites rotor blades.

Mission payloads:

Described only as "multiple special sensors"; proposed applications include surveillance, reconnaissance, BDA, electronic jamming, communications relay, forest fire detection and fisheries patrol.

Guidance and control:

Digital flight control system; telemetry and telecontrol system with GPS and laser altimetre; real-time imagery display.

Launch:

Conventional helicopter take-off.

Recovery:

Conventional helicopter landing.

Power plant:

One unidentified two-cylinder water-cooled piston engine (rating not quoted).

Dimensions:

Main rotor diameter 5.84 m (19 ft 1.9 in)

Tail rotor diameter 1.17 m (3 ft 10.1 in)

Length overall, rotors turning 7.07 m (23 ft 2.3 in)

Height overall 2.25 m (7 ft 4.6 in)

Weights:

Weight empty 280 kg (617 lb)

Maximum payload 30 kg (66.1 lb)

Performance:

Maximum level speed 81 kt (150 km/h; 93 mph)

Hovering ceiling IGE 1,500 m (4,920 ft)

Operational ceiling 3,000 m (9,840 ft)

Remote control radius 81 n miles (150 km; 93 miles)

Endurance 4 h

Manufacturer: Nanjing University of Aeronautics and Astronautics

SARI Shen Zhou-1 and Shen Zhou-2

Remotely piloted airships. A development study for these two airships began in 1989. The Shen Zhou-1 flew for the first time in April 1992, the Shen Zhou-2 in May 1993. SARI is a division of the Shanghai Aviation Industrial Group.

Variants:

· *Shen Zhou-1:* Initial version. Third engine mounted ahead of gondola and can be swiveled to augment turning and maneuvering.

· *Shen Zhou-2:* Slightly larger envelope; third engine mounted aft of gondola for faster forward speed, but without swivel mechanism.

Airframe:

Non-rigid helium airship. Conventional envelope shape with cruciform tail surfaces; VTOL capability by vectoring paired ducted propellers. Envelope of coloured nylon fabrics; ballonets of three ply nylon film; tail surfaces are frame structures with tough silk covering. Helicopter type twin-skid landing gear under gondola.

Mission payloads:

Video camera.

Guidance and control:

Radio-control command uplink; real-time video imagery downlink. Helium provides neutral buoyancy; ducted propellers, one each side of gondola, can be pivoted through 270º for VTOL, climb and descent. Elevators assist pitch control; yaw control by rudders on lower fin only of Shen Zhou-1, on both fins of Shen Zhou-2. Internal ballonets.

Launch:

Conventional airship take-off.

Recovery:

Conventional airship landing and docking.

Operational status:

Both airships sold in 1994. SARI believed to be continuing research and development for future manned and unmanned airships.

Power plant:

Three 2.24 kW (3 hp) OS MAX-108 FSR piston engines, two mounted on gondola sides and driving ducted propellers that can be swiveled through 270º. Third engine mounted ahead of gondola on Shen Zhou-1 and able to swivel independently 60º to left and right to assist turning and maneuvering. On Shen Zhou-2, third engine is mounted aft of gondola and does not swivel.

Dimensions (envelope):

Length overall: SZ-1 8.70 m (28 ft 6.5 in)

SZ-2 9.20 m (30 ft 2.2 in)

Maximum diameter: SZ-1 2.80 m (9 ft 2.2 in)

SZ-2 2.40 m (7 ft 10.5 in)

Volume: SZ-1 29.0 m^3 (1,024.1 cu ft)

SZ-2 30.0 m^3 (1,059.4 cu ft)

Weights:

Maximum T-O weight: SZ-1 33 kg (72.8 lb)

SZ-2 24 kg (52.9 lb)

Performance:

Maximum level speed: SZ-1 27 kt (50 km/h; 31 mph)

SZ-2 32 kt (60 km/h; 37 mph)

Max cruising speed: SZ-1 21.5 kt (40 km/h; 25 mph)

SZ-2 27 kt (50 km/h; 31 mph)

Minimum air turning radius: SZ-1 30 m (100 ft)

SZ-2 40 m (132 ft)

Maximum flying altitude: both 2,000 m (6,560 ft)

Maximum control distance: both 3,000 m (9,840 ft)

Endurance: both 30 min

Manufacturer:

Shanghai Aircraft Research Institute (SARI)

Xian ASN-104 and ASN-105

Reconnaissance and surveillance UAVs. China's Pilotless Vehicle Research Institute, on the campus of the Northwestern Polytechnical University, has been involved in the development of UAVs for more than 30 years. Eleven individual types have been developed, seven of which have received government approval. Some have been produced in small numbers, including two types of which 33 examples were exported. Development of the D-4 began in March 1980, originally as a low-altitude, low-speed UAV for civil aerial survey applications. First flight was made in November 1982, government technical certification was granted in December 1983, and production started in late 1985. The Xian ASN Technology Group, created in 1992, has a workforce of more than 400.

Variants:

· D-4 RD: Initial production version, originally used mainly for civil tasks (large-scale aerophotogrammetry, geophysical survey, aerial mapping and remote sensing). Early production rate was 15 per year, but this was subsequently increased for supplies also to Chinese armed forces, with whom roles include front-line reconnaissance and electronic jamming.

· ASN-104: Increased-capability, shorter range development of D-4 RD.

· ASN-105: As ASN-104 except for increased control range.

Airframe:

Mid-wing monoplane, with tapered outer wings; wings and tailplane detachable for transportation and storage. Honeycomb sandwich and GFRP construction. Twin underfuselage landing skids.

Mission payloads:

Usual D-4 RD sensors are a 100 mm (3.9 in) aerial photogrammetry camera (frame size 18 x 18 cm; 7.1 x 7.1 in), and a CCD video camera, with real- time video downlink transmitter, or a single infra-red linescanner. Wingtip equipment pods can also be fitted. An onboard generator driven by the piston engine provides electrical power for the UAV's avionics and sensor equipment.

The ASN-104/-105 can provide real-time reconnaissance and surveillance for up to two hours, payloads consisting of an 18 x 18 cm (7.1 x 7.1 in) panoramic camera and an LLTV camera with zoom lens; the latter can cover an area of 1,700 km^2 (656.4 sq miles) during a typical mission. Provision is made for CCD TV camera or IR linescanner alternative payloads.

Guidance and control:

Remote-control uplink; video and telemetry downlinks; or can be flown autonomously by preprogramming the onboard analogue autopilot.

System composition:

ASN-104/-105 system comprises six air vehicles, two mobile command shelters, and two other shelters for film and data processing, plus ground crew of six to eight persons.

Launch:

From lightweight zero-length launcher, assisted by reusable underfuselage solid rocket booster that is jettisoned after take-off.

Recovery:

By parachute, deployed from a dorsal compartment near the tail; lands on under-fuselage skids which have oleo-pneumatic shock-absorption to absorb landing impact.

Operational status:

In production and service.

Customers:

PLA

Power plant:

One 22.4 kW (30 hp) SAEC (Zhuzhou) HS-510 four-cylinder two-stroke engine; two-blade propeller.

Dimensions:

Wing span 4.30 m (14 ft 1.3 in)

Length overall 3.32 m (10 ft 10.7 in)

Height overall, excl skids 0.93 m (3 ft 0.6 in)

Payload bays (three) 14, 36 and 39 dm^3 (0.49, 1.27 and 1.38 cu ft)

Weights:

Maximum payload 30 kg (66.1 lb)

Maximum launching weight 140 kg (308.6 lb)

Performance:

Maximum level speed: D-4 RD 111 kt (205 km/h; 127 mph)

Cruising speed: ASN-104/-105 81 kt (150 km/h; 93 mph)

Operating height: lower 100 m (330 ft) upper (D-4 RD) 3,000 m (9,840 ft) upper (ASN-104/-105) 3,200 m (10,500 ft)

Radio control range:

D-4 RD, ASN-105 54 n miles (100 km; 62 miles)

ASN-104 32 n miles (60 km; 37 miles) Endurance 2 h

Manufacturer:

Xian ASN Technology Group, Northwestern Polytechnical University, Xian, Shaanxi.

Xian ASN-206

Short-range multirole UAV. Public debut at China Air Show November 1996. Military and civil applications include day and night reconnaissance, battlefield surveillance, artillery target location and adjustment, border and traffic patrol, NBC detection, atmospheric sampling, aerial photography and survey, and disaster monitoring.

Airframe:

Tapered, high-mounted wings; pod fuselage; twin tailbooms with twin fins and rudders, bridged by mid-mounted tailplane with elevator. Twin underfuselage landing skids.

Mission payloads:

Film camera; TV camera; IR imager; target location/artillery adjustment equipment; or other according to mission. Real-time data downlink.

Guidance and control:

Radio-command flight control and management system. Telemetry uplink and imagery downlink.

System composition:

Air vehicle(s) and launch truck; six other truck-mounted shelters for command and control, mobile control station, information processing, power supply, maintenance and transportation.

Launch:

By booster rocket from zero-length launcher.

Recovery:

Parachute recovery.

Operational status:

In production. Offered to Turkey in late 1998.

Power plant:

One 37.3 kW (50 hp) SAEC (Zhuzhou) HS-700 four-cylinder two-stroke engine; two-blade wooden pusher propeller.

Dimensions:

Wing span 6.00 m (19 ft 8.2 in)

Length overall 3.80 m (12 ft 5.6 in)

Height overall 1.40 m (4 ft 7.1 in)

Weights:

Maximum payload 50 kg (110.2 lb)

Maximum launching weight 222 kg (489 lb)

Performance:

Maximum level speed 113 kt (210 km/h; 130 mph)

Ceiling 5,000-6,000 m (16,400-19,685 ft)

Range 81 n miles (150 km; 93 miles)

Endurance: typical 4 h, maximum 8 h

Manufacturer:

Xian ASN Technology Group, Xian, Shaanxi.

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CHAPTER 1 - INDUSTRY BACKGROUND AND OVERVIEW

Date Posted: 05-Dec-2000

China's Aerospace And Defence Industry - December 2000

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INDUSTRY BACKGROUND AND OVERVIEW

"Our national defence will be consolidated and no imperialist will be allowed to invade our territory again. Our people's armed forces must be maintained and developed with the brave and steeled People's Liberation Army as their foundation. We will have not only a powerful army but also a powerful air force and a powerful navy."

Chairman Mao Tsetung -Opening address at the First Plenary Session of the Chinese People's Political Consultative Conference (21 September 1949).

1.1 New Strategic Doctrines TOP

The last Gulf War graphically illustrated the type of modern combat conditions the PLA would be faced with in any major conflict, and, along with the sudden collapse of the Soviet Union, triggered a doctrinal shift from the post-Mao doctrine of 'fighting people's war under modern conditions' (in other words defending against a land invasion by an external power, trading territory for time, and the massive use of infantry), to an outright high-tech strategy of achieving quick, decisive military victories in border and peripheral areas in short time periods. An earlier stimulus for modernisation was the less than optimal performance of the PLA against Vietnam during 1979. However, other previous historical lessons, such as the series of humiliating defeats inflicted upon China by foreigners since the 1842 Opium War, also deeply reinforced the military value of S&T (science and technology) innovation and breakthroughs. Since 1949, China was quick to develop the technologies and grasp the fundamental military doctrines related to the strategic 'Revolution in Military Affairs' (RMA) of nuclear weapons and long-range ballistic missiles. This has been equally apparent with regard to Chinese involvement in the development of various space technologies.

The new RMA is primarily related to information technologies (IT) and their integration with weapons and related command, control, communications, computers and intelligence (C^4I) systems, and new military doctrines (for example deep stand-off precision strikes; flexible, operational manoeuvre units; combined services co-ordinated operations; and force multipliers and synergies) to effectively employ these technologies. As indicated in following sections of this report, China is currently investing heavily in various IT systems and related weapons technology R&D that could be used to implement its own RMA, by some estimates within a decade. A major practical challenge will be the integration of innovative technologies within an effective RMA doctrine 'with Chinese characteristics'.

The *White Paper on China's National Defence*, issued by the State Council on 27 July 1998, specifically indicates that the PLA:

'*seeks to adapt to profound changes in the world's military sphere, and makes proper preparations for defensive combat in the situation where modern technology, especially high technology, prevails. ...During the new historical period, the Chinese army is working hard to improve its quality and endeavouring to streamline the army the Chinese way, aiming to form a revolutionised, modernised and regularised people's army with Chinese characteristics. Reducing quantity and improving quality is a basic principle upon which the army is to be modernised. ...The Chinese army strengthens itself by relying on science and technology, and strives to make the transition from a numerically superior type to a qualitatively efficient type, and from a manpower-intensive type to a technology-intensive type. In view of the characteristics of modern wars, no effort will be spared to improve the modernisation level of weaponry...*'

A corresponding shift to fighting and winning local wars (*jubu zhanzhen*) and contingencies (*tufa shijian*) in post-Cold War conditions is necessitating the development of mobile, rapid-reaction, and fully modernised forces (*quantou* or 'fist' units that can reportedly deploy anywhere in China within 24 hours) for use within and in close proximity to China's borders (but with steadily evolving power projection capabilities). The PLA itself has characterised its current short-fall in power projection as 'short arms and slow legs' but PLAAF commander Lt. General Liu Shunyao has recently stated that his service is evolving from a relatively short-range force to one capable of regional power projection. This also reflects China's gradual transition from that of a continental power with large land forces to guard against external invaders, to that of a combined continental-maritime power with a variety of forces to deal more flexibly with various contingencies. Admiral Liu Huaqing, the former vice-chairman of the Central Military Commissions, was apparently a key figure in this doctrinal shift. While not having a military background, Jiang Zemin is a former Minister of Electronics Industry and reportedly favours the modernisation of China's defence industrial base and the development of advanced technology weaponry.

Overall, a veil of secrecy surrounds China's detailed military modernisation activities and specific geostrategic intentions. Like China's economic transformation, the PLA's military modernisation could be achieved relatively rapidly. Some general trends are now apparent but are often distorted by a Western media emphasis on declining 'old economy' state-owned enterprises (SOE) that are linked to the defence sector, and coverage of past PLA commercial ventures such as discos and real estate deals. Furthermore, the West has widely ignored China's efforts in 'new economy' industries that also have great military potential.

A major effort will be made over the next decade by the PLA and China's defence industrial base to develop and implement a new RMA that will, as a minimum, adopt elements of the 1980s-level US doctrine of Air-Land Battle (in other words, precision deep strike, all-weather and around-the-clock mobile warfare) and current Western efforts to develop the so-called 'digital battlefield'. In the PLA General Political Department's newspaper *Beijing Jiefangjun Bao*, (28 June 1998) a senior PLA official made direct reference to China adopting elements of the US military's RMA with an emphasis on the application of advanced technologies. Instituting a new RMA is also a view held by many younger up-and-coming members of the PLA leadership hierarchy. The PLA's Academy of Military Science and central government military think tanks such as the 'Society for the Study of Future Warfare' and the 'Institute for Grand Strategy' are also major proponents. During February 2000, General Cao Gangchuan, director of the PLA General Equipment Department, indicated a major new PLA policy of 'Developing the Army With Science and Technology.' He also reaffirmed the traditional Chinese policy of the transfer of advanced foreign technologies leading to eventual self-sufficiency.

A common Western perspective is that all three services of the PLA lag at least a decade behind the most advanced nations with regard to major weapon systems, operations and training. Some observers have termed the PLA little more than a 'junkyard army' comprised of obsolete and piecemeal equipment acquisitions that are not integrated and lack the extensive training and IT systems to be used effectively. However, this evaluation may soon require a major reassessment given rapid developments in PLA modernisation and professionalisation over the past several years. The 1996 National People's Congress passed the 'Outline of the Ninth Five Year Plan for National Economic and Social Development and the Long-Range Objectives to the Year 2010', in which the PLA is designated to train 'crack troops' based upon new technological developments. To date, this modernisation has apparently been slowly and selectively implemented but is currently increasing in tempo. While the PLA has trained for 'high-tech regional wars' since the 1980s, major exercises, much larger than their predecessors, began in 1998.

Defence Minister Chi Haotian announced on 1 August 2000, the 73rd anniversary of the founding of the PLA, that 500,000 Chinese soldiers had been decommissioned since 1997, when the Communist Party ordered the PLA be reduced to a standing army of 2.5 million soldiers. In addition, the PLA is increasingly moving towards a modern professional force structure, rather than the current selective quasi-conscript system. These force reductions are in a sense relative as the Chinese military is still the largest in the world. Recent estimates suggested that PLA troops numbered 2.5 million, with 1.2 million reserves, and 1 million personnel in the paramilitary People's Armed Police (PAP) force. In addition, the exact number of additional paramilitary forces from predominately rural militia organisations such as the 'Xinjiang Production and Construction Corps Agricultural 1st Division' is not really available but is probably immense (with potential mobilised forces of light infantry in the tens of millions during a time of crisis). Hence, the PLA will remain the world's largest military force into the foreseeable future. China's potential to field huge forces is, in addition to its current technological modernisation, of somewhat more immediate concern to its immediate neighbours than is commonly appreciated in the West.

PLA professional journals are currently dedicated to the study of advanced RMA concepts and related Western military articles are regularly translated. A recent priority for PLA ground forces has been the development of information warfare (IW) capabilities that include technologies relating to electronics, satellites, telecommunications and computer systems. National C^4I systems are being upgraded, including the fielding of secure digital and fibre-optic telecommunications networks. Field units are experimenting with various IW techniques. During the October 1998 'West-98' exercise a Lanzhou Military Region group army in the Gobi Desert employed 'electronic combat groups' to undertake 'electro-magnetic offensives' during critical points of the manoeuvres.

The PLA's RMA will be implemented with 'Chinese characteristics' in technology and doctrine, and, at least initially, will be mostly applied to elite elements. The majority of the PLA ground force divisions, currently numbering over 100, will probably remain low to medium technology forces used for internal and border defence. This force will also take the brunt of planned troop reductions with further domestic responsibilities assumed by the PAP. Perhaps from 12 to 18 elite divisions (*zhu li bu dui*, or 'main force units'), plus integral rapid reaction or 'fist units', comprising a total of up to 300,000 or more troops, will become fully modernised for large-scale joint-service operations. They will be equipped with long-range precision weapons, high-firepower and high-mobility systems, night vision systems, advanced C^4I, surveillance, technical reconnaissance, IW, electronic warfare (EW) and targeting systems. These elite units will be able to deploy anywhere within and near China's borders within 24 hours. The PLA's traditional weapons procurement policy was *you shenmo wuqi, da shenmo zhang* (weapons determine how war is fought, or make do with what you readily have), but has now been changed to *da shenmo zhang, zao shenmo wuqi* (make whatever weapons to meet the requirement of war). The major 1995 and 1996 missile and combined forces exercises near Taiwan were seen by some as the initial stages of a long-term practical effort to develop forces to realistically wage 'a limited war under high technology conditions' (*gaoji jixu tiaojian xia jubu zhanzheng*).

In addition to the army, the PLA Air Force (PLAAF) and Chinese Navy (PLA) are undertaking a more technically sophisticated modernisation process. This will see the introduction of significant numbers of modern aircraft including Jianjiji J-8IIM/J-8III, JH-7/FBC-1, FC-1, Su-27/J-11, Su-30, J-10, strategic airlifters, aerial refuelling tankers and electronic surveillance aircraft. The navy is seeking to acquire new frigates, destroyers, conventional and nuclear submarines, and possibly aircraft carriers, along with correspondingly increased anti-submarine warfare, surface warfare, shipborne air defence, sustained naval operations, and amphibious warfare capabilities. Air and naval modernisation efforts will also include related weapons capabilities, particularly precision-guided munitions (PGMs). These programmes have been accorded an even greater priority than ground force modernisation and could to a great extent be realised before the year 2010.

China has also reportedly taken steps to alter its strategic nuclear doctrine from one requiring just a secure second-strike countervalue capability to a more flexible strategy of nuclear deterrence requiring increased counterforce tactical, theatre and strategic nuclear weapons. China's nuclear forces are possibly proportionately increasing as those of the US and Russia decline in number. New missile technologies (ballistic and cruise) are being developed domestically and through foreign technology transfers, particularly from Russia and other ex-Soviet states. The 1996 'Shanghai Five' security initiative comprising China, Russia, Kazakhstan, Kyrgyzstan, and Tajikistan, is one avenue of direct defence technology transfers from former Soviet states. Conversely, China has now taken on a proactive regional role, agreeing for the first time in August 2000 to provide military equipment (night-vision systems, flak jackets, radios, small arms and ammunition) to the Uzbek army to use against Islamic guerrillas infiltrating Uzbekistan from Afghanistan, thus attempting to pre-empt Islamic activities in its own far western provinces.

The current US RMA is undoubtedly the yardstick against which to measure all other attempts, as it is both massive, sophisticated and recently tried in battle (although there is also a revisionist school of thought in the US that questions the overall RMA approach). However, China's efforts in this area are relatively new and may eventually take on quite unique, if not radical, characteristics, therefore postponing an in-depth comparison at least for the near-term. It is probably not valid to predict the PLA's future regional capabilities simply through a comparative analysis of specific potential high-end weapon platforms. China's RMA will probably integrate its traditional strategic culture (from Sun Tzu to Mao) with modern technological developments.

It is also probable that China will seek to develop aspects of innovative asymmetrical warfare. For example using IW techniques such as sabotaging military and commercial computer/telecommunications networks, and exploiting global multimedia coverage through focusing on the current Western societal squeamishness about the potential for large civilian or military casualties in any conflict. Asymmetric warfare generally is defined as 'attacks by a weaker or more technologically backward opponent on a stronger foe's vulnerabilities using unexpected or innovative means, while avoiding the adversary's strengths.' Asymmetrical targets, intended to paralyse an enemy and induce a loss of a will to fight, include electrical power systems, civilian transportation networks (aviation, ground transport, railways and highways, seaports and shipping), television networks, and computer and telecommunications systems.

Another important point to consider is that China appears to be rapidly developing dual-use IT that could be applied to various weapons systems - potentially at low-cost and high-volume. For its nuclear weapon and ballistic missile programmes China was able to mobilise and apply massive intellectual and collective resources through political-ideological pressure to produce practical results in a relatively short period of time. Today, while the political focus is on rapid economic development and modernisation through (often dual-use) technological and business innovation, and from these developments to simultaneously stimulate military modernisation and professionalisation, the scale and scope of the overall effort appears to be as massive as the earlier strategic weapons programmes. China's RMA must also take into account that while select units may be technically equipped to elite Western standards, the bulk of its regular military forces, and potentially immense reserve forces, will probably remain as some form of light or irregular infantry, possibly mechanised to a certain extent. If integrated within an innovative RMA doctrine these large manpower levels could effectively be employed as an asset rather than a liability in regional conflicts.

Highly probable objectives of this RMA modernisation drive are to secure China's claims to South China Sea and other historically disputed territories, and, particularly, to provide a credible Taiwan invasion option. Conflicting scenarios exist on China's ability to develop such a capability. A 1994 series of computerised war game simulations conducted by the US Naval War College projected a sophisticated year 2010 PLA capability in remote-controlled and precision-guided cruise missiles, battlefield robotics, anti-satellite (ASAT) weapons and space-based weapons, which resulted in the defeat of the US Navy's 7th Fleet off the China coast. Regardless of the technical validity of this scenario, in the near-term it may encourage the new generation of PLA leadership to continue developing such capabilities. An unconfirmed report indicates that the PLA has conducted various computer simulations of conflict scenarios in which it challenges the Japanese Self-Defence Forces over control of the Senkaku Islands (Chinese name, the Diaoyu Islands). In recent years sovereignty over this group of small, uninhabited but oil-rich islands in the East China Sea has placed an increasing strain on relations between the two countries. The results of the computer simulations, based upon current and near-term PLA capabilities, generally emphasised Japanese technical superiority.

Related to these strategic developments is the concept of a so-called 'Greater China', which is often used to describe interconnected ethnic-Chinese economic activities throughout mainland China, Hong Kong, Taiwan and Singapore, plus regional nations such as Malaysia, Indonesia, Vietnam, Myanmar, Cambodia and the Philippines, where numerically Chinese are a minority but comprise the majority of the business class. At some future date, Greater China's economic power could see a consolidation into a single political base, although most overseas Chinese prefer to keep distanced from Beijing's political reach. However, this process has already begun with Hong Kong's and soon Macao's reunification with the mainland. It is probable that Beijing also has a firm agenda for Taiwan and disputed South China Sea Territories, which could have implications for persecuted Chinese minorities throughout the region.

Aircraft carriers could be useful for enforcing regional territorial claims or supporting an invasion or blockade of Taiwan. China has recently been unable to directly apply military pressure to cease repeated atrocities against ethnic Chinese in nations such as Indonesia; an aircraft carrier task group and related amphibious assault capabilities would also provide a highly visible power projection solution for this problem area.

An overriding consideration is that as a 5,000 year old civilisation that has been humiliated by outsiders in the recent past, China strongly feels that it should be paid more respect by the rest of the world and a strong blue water navy is one means of achieving this due recognition. These sentiments, which were reinforced by the US bombing of the Chinese Embassy in Belgrade during the Kosovo crisis, will probably result in an emphasis on the domestic construction of aircraft carriers rather than simply procuring foreign vessels.

1.2 Defence Industry Related Innovation TOP

China's recent rapid progress in modernising various aspects of commercial and dual-use science and technology (S&T), research and development (R&D), and production infrastructure that also have potential military applications is an area that is commonly ignored or underestimated in many analyses of China's defence industry's current and potential capabilities. These initiatives are crucial for an understanding of China's construction of an overall 'new economy' and the PLA's evolving RMA. The 6 May 1995, 'Decision of the Central Committee of the Chinese Communist Party (CCP) and the State Council on the Acceleration of Scientific and Technological Progress' provides a detailed policy blueprint of China's S&T strategy for the next decade as approved by the nation's senior political leadership. In particular, it identifies R&D priorities and their linkage to military modernisation:

'The research on and development of high technologies is the forerunner of the present economic expansion and the source of the development of high technology industries. The development of high technology should be made responsive both to the requirements of the national economy and national defence... The state shall continuously initiate efforts to implement high technology research and development programmes by identifying key items, putting together a competent task force composed of young and middle-aged expertise to overcome major stumbling blocks with concerted efforts and strive for major breakthroughs and innovations. We should endeavour to enable the development in the major fields such as electronics and information, biotechnology, advanced materials, new sources of energy, aerospace and oceanography to approach or reach the world advanced levels and secure a prominent position in some important areas of high technology.

We should bring into full play the leading role of high technology in the development of national defence, particularly in the development of weaponry. Efforts should be undertaken to strengthen the pre-study of defence science and technology and tackle major problems with concerted efforts so as to ensure the development of key weaponry. Continuously and fully carry forward the policy of combining the military with the civilian, stress the development of dual-use technology for both military and civil applications, and promote the conversion of defence technology to civil applications.'

China is currently restructuring its S&T system to facilitate the integration of modern technology within its liberalised economy, and is focusing on the selective development of world class innovative technologies and the enhanced training of scientific and technical personnel. The former State Science and Technology Commission (SSTC, now known as the Ministry of Science and Technology, or MOST) has traditionally been responsible for the development and implementation of central government S&T policy frameworks in China. It has also managed various R&D programmes devoted to improving China's planned transition to a knowledge-based economy over the next several decades. The SSTC was upgraded to ministry status in March 1998, with an accomplished female polymer chemist and former SSTC vice minister, Zhu Lilan, as its new minister. During March 1996, a National Leading Group for Science and Technology was established under the chairmanship of then Premier Li Peng to provide 'macroscopic decision-making and management for scientific and technological undertakings.' However, the group is probably also operationally co-ordinated across various ministries by MOST. The MOST has various regional branches (including Guangdong Science and Technology Commission) for the implementation of central government policies and programmes within provinces and major cities.

The current Premier Zhu Rongji, also head of the National Leading Group for S&T, has recently characterised S&T as 'the current administration's top concern', and in recent years the CCP's Central Committee has seen increased representation by prominent scientists and engineers. A primary question is how China's state-dominated 'socialist market economy' and its S&T infrastructure (which tends to favour large, state-planned projects) will stand-up following the future accession by China into the World Trade Organisation (WTO). Membership of the WTO is likely to release ferocious private sector international competition into China's relatively protected domestic market, although the defence sector is expected to remain somewhat sheltered with invited foreign participation in certain areas. Primary national S&T development problems remain insufficient market forces (domestic and access to foreign) to spur innovation, a lack of intellectual property protection to reward innovators, and insufficient capital markets to create a truly commercial innovation-driven S&T sector. China signed an accord with the US for entry into the WTO in November 1999.

A specific national target is the use of 1.5 per cent of China's gross domestic product (GDP) for R&D by 2000, with 15 per cent of this total allotted for basic research. (Some sources have stated 3 per cent but perhaps this includes related total S&T activities such as technology transfer, innovation and commercialisation.) Even the goal of 1.5 per cent may be somewhat optimistic as in 1995 only 0.48 per cent of GDP officially supported R&D (compared to about 2.5 per cent by the US, 2.2 per cent by the UK, and 2.9 per cent by Japan), of which total only 7 per cent was for basic research. Any such increases can only help the PLA's modernisation drive because defence research appropriations often come from the civilian budget following the rubric of developing 'dual-use' technologies and 'defence conversion'. MOST claims that China invested 4.9 billion Rmb yuan on basic research activities during 1999.

China has a general tendency to emphasise applied technology development over basic (or fundamental) research, and S&T has been merged into the single word *keji* (scitech) in Chinese. Chinese science reportedly currently rates only 14th place in the international league tables of papers published in major scientific journals and even lower in terms of total citations. A recent International Competitiveness Report by the Switzerland-based International Management and Development Institute placed China in 13th world place in S&T competitiveness, up from 20th in 1997. Chinese sources indicate that while China's GDP ranked seventh in the world during 1996, its international S&T competitiveness was only 28th. However, it should also be noted that while in recent years China annually produces over 30,000 specific examples of notable scientific research results, according to the MOST, relatively few of these likely find their way into the international scientific literature because of both official restrictions (for example, ministry summaries of total civilian S&T annual accomplishments were made public for the first time in 1998) and difficulties in translation.

China's emphasis on S&T applications could prove useful for more measured military innovations but could hinder radical scientific breakthroughs. However, the historical importance of basic research for the creation of radical breakthroughs of national strategic importance was noted by President Jiang Zemin during November 1997 in a written address to the National Leading Group for S&T. In his address the president echoed similar sentiments of past paramount leader Deng Xiaoping on the requirement for China to aggressively pursue all facets of S&T development for economic modernisation. New programmes to support basic research are being established, in addition to increased support for applied research efforts. However, purely domestic R&D is only one indicator of China's innovation and S&T modernisation, with foreign technology transfer also being an important factor.

China's total S&T budget for 1998 was 128.98 billion Rmb yuan, mostly concentrated in the Beijing, Shanghai, Jiangsu, Guangdong, Shandong, Sichuan and Liaoning regions. The official MOST 1997 budget for total national S&T funding (state, universities, enterprises) was reportedly over 96 billion Rmb yuan, about a third of which was for R&D. It is unclear if this total included related S&T activities such as all defence and space R&D and dual-use technology transfer programmes. During 1996, some 30 billion Rmb of total 'technological contracts' were also undertaken in another apparent category of spending. In 1998, China announced spending totalling 470 billion Rmb (over US$56 billion) for 'technical upgrading projects' in various industrial sectors. Most of China's laboratory instrumentation (up to 80 per cent) is believed to be no older than 10 years. However, the majority of the overall industrial manufacturing base (up to 90 per cent) is considered obsolete by Western standards, particularly in large state-owned enterprises (SOE) with large worker overhead costs. Foreign-invested enterprises and joint ventures tend to use more advanced production and product technologies. About 6 to 15 per cent of China's overall exports are currently considered high-tech, with this figure projected to rise to about 25 per cent during the next decade.

In 1999, China had some 5,014 government R&D establishments that employed some 330,000 S&T personnel. In 1997, there were 600,000 S&T personnel working for 1,590 R&D establishments under institutions of higher learning. Also in 1997, there were a reported 20.495 million professional technicians working for SOEs or S&T institutions, including 1.68 million scientists and engineers, and there were 5,819 'independent' R&D institutions with a total staff of 970,000, including 430,000 scientists and engineers, 3,400 university R&D institutes, and over 14,000 R&D institutes affiliated with large and medium industrial enterprises. During the next decade, about 10 per cent of this total will concentrate on basic research, although bloated research establishments are also to be downsized, commercialised and rationalised, with surplus state personnel 'spun-off' to form new advanced technology enterprises. Less than a third of China's R&D is thought to be conducted by industry laboratories, with the majority being conducted by government and university organisations. Despite the difficulty of determining exact S&T-related expenditures, given the absolute immensity of China's overall S&T infrastructure it is very probable that its current defence technology innovation and breakthrough capacity is considerable.

Technology trade is another important indicator of innovative S&T activity. During 1997, a total of US$15.9 billion 'technology import contracts' were secured by China according to the MOST, and during 1998 such imports were made largely exempt from equipment tariffs. China's high-tech exports reached an estimated value of US$25 billion in 1999 - a net value increase of US$5 billion, or 25 per cent, on 1998. Chinese sources estimate that this figure will reach US$30 billion in 2000, 15 per cent of the country's total exports. China currently has a significant net deficit in high-technology trade. Specific MOST statistics for China's recent export and import of high-technology dual-use products by category are summarised in Table 1.1.

Table 1.1 China's Trade Balance In Advanced, Dual-Use Technologies (US$millions,1994)

Category	*Exports*	*Imports*	*Balance*
Total	6,342	20,595	-14,253
Computers and Telecommunications	3,544	7,204	-3,660
Electronics	782	2,705	-1,923
Computer Integrated Manufacturing (CIM)	316	5,820	-5,504
Optoelectronics	384	159	225
Biotechnology	39	18	21
Life Science	782	852	-70
Weapons	266	69	197
Aerospace/Aviation	183	3,562	-3,379
Nuclear	6	61	-55
Material Design	39	145	-106

Table 1.2 provides estimates for recent production and R&D personnel levels for China's advanced technology sectors. Other sources indicate these levels could be considerably higher, particularly in the aerospace-defence and IT sectors.

Table 1.2 1998 Production and R&D Estimated Personnel Levels For China's Advanced Technology Industry Sectors (in 1,000s)

Sector	*Production Personnel*	*R&D Personnel*
Total Medium to Large Sized Organisations	38,699.0	290.0
Total Manufacturing Sector	30,070.1	227.4
Total 'High-Tech' Industries	3,871.6	71.6
Electrical Machinery and Equipment	1,325.7	17.2
Electronics and Telecommunications	979.5	15.4
Aerospace	535.6	24.7
Pharmaceutical	605.6	9.5

Specialised Scientific Equipment 323.4 3.2	
Computers and Office Equipment 100.1 1.6	

The military also has its own specialised S&T development infrastructure, although in practice this is often likely intertwined with that of the MOST. The PLA reports to the state Central Military Commission; its Chairman is the PLA commander-in-chief and he is also the head of the political State Council which controls the MOST. The CCP Military Commission exercises *de facto* policy making and operational control over the military but its organisation usually parallels that of the state Central Military Commission. Beneath the two Military Commissions are the Ministry of National Defence and the Commission of Science, Technology, and Industry for National Defence (COSTIND), but these do not have operational control over the PLA. The Defence Ministry is responsible for military modernisation and administrative support, while COSTIND is responsible for defence R&D, weapons procurement and the overall co-ordination of the defence and civilian economic sectors. The PLA's General Equipment Department (GED, or General Armaments Department by some accounts) is another key organisation concerned with defence R&D that works closely with COSTIND (see section 1.3.3).

Recent State Council claims indicate that 'in the last 10 years China's armed forces have supported more than 1,000 national economic construction projects with their advanced scientific and technological achievements, solved urgent and key problems for more than 150 scientific research projects, transferred some-10,000 scientific and technological findings to the civilian sector, trained nearly one million scientific and technological personnel...' (see section 1.3.4).

1.3 Key Organisations and Programmes *TOP*

1.3.1 Sector Overview

China's aerospace-defence sector is certainly not 'dead' or 'dormant' as it has been characterised by some critics, but is manufacturing a wide range of increasingly advanced products, as well as developing advanced prototypes that are influenced by Western advanced technology 'hybridisation'. Some recent estimates that China lags one to two decades behind the West and Japan in production technologies and weapon systems are now clearly inaccurate. Over five decades of production and R&D has resulted in one of the world's most comprehensive 'systems-of-systems' research, design, development, production and testing capability. Modern management is increasing skilled, aggressive and export-for-profit oriented, and enjoys extensive state backing for foreign technology transfer programmes and advanced domestic R&D efforts. In some areas, such as commercial space launch services and tactical ballistic missile systems, China has become a world leader.

Taiwanese military officials have warned that Western nations have a tendency to underestimate the PLA's strength because of assumptions based upon cultural bias and outdated impressions. The US intelligence community has recently admitted that China has effective countermeasures capable of thwarting advanced satellite and airborne surveillance systems. The PLA is adopting, based upon lessons gained from observing the Kosovo conflict, advanced techniques of camouflage, deception, hiding and dispersion.

Western critics often charge that China's aerospace-defence industry will remain uncompetitive with the West, particularly the US, because of its outdated structure and enterprises, poor technology systems integration, sub-standard quality assurance and management, and an overly prolonged weapons development and procurement system (in some cases up to 15 years) that is overly dependent upon reverse-engineering foreign systems. According to this critical view the PLA will remain poorly equipped and be unable to mount power projection combined arms operations. Lacking basic technological innovation the Chinese will remain dependent upon a declining Russian defence industry for an infusion of new weapons. Critics maintain that PLAAF training does not meet the US standard of excellence in terms of hours or sophistication, while aircraft carriers and other advanced ships remain beyond the PLAN's capabilities.

While many of these views have indeed had past merit, the present study will address current and projected positive Chinese activities in these and other areas. It will also examine the defence modernisation role of new dual-use technologies that are increasingly flowing into China from a variety of sources. A great deal is to be learned in these areas. In 1997, the US deputy assistant secretary of defence for Asian and Pacific Affairs admitted that in regards to Chinese defence modernisation "there are areas that we don't know about, that we think there's more to know about", particularly in asymmetrical warfare.

China places a high value on its domestic aerospace-defence capabilities. During September 1999, the China Aerospace Foundation commented in the *People's Daily* on the importance of the aerospace industry in promoting overall national economic development:

'...China's aerospace industry, as an elite industrial branch of high technology, plays a prominent role in motivating an overall development of high technologies in advancing the technological development of the country's communications, new material production, computer industry, energy and medicine production, etc. Inestimable economic and social benefits will be achieved...'

This historic concentration of most military-industrial complexes in the remote regions of central provinces to protect them from potential military threats (the so-called 'Third Front' strategy) and the resulting isolation from today's more prosperous coastal special economic zones, has made current efforts to modernise, relocate and diversify such plants very costly. This dispersal of much of the aerospace-defence industry into the hinterland was a facet of the Maoist doctrine of 'People's War' to allow armed resistance, even after nuclear strikes on major urban centres or foreign occupation. The remote, sometimes mountainous and desert-like, areas where traditional defence industries are concentrated today include the provinces of Guizhou, Shaanxi, Sichuan, Yunnan, Hubei, Henan, Hunan, and Jiangxi. In a positive sense, the aerospace industry did bring modern amenities such as piped water, electricity, transportation systems, schools and department stores to some of China's poorest people, and remains an important facet of these local economies.

The map of Figure 1.1 provides the geographical locations of the current major advanced technology centres of China, which, as is outlined in the following chapters, is primarily where aerospace-defence industry clusters of R&D and manufacturing are concentrated. Figure 1.2 summarises the overall organisation of China's aerospace-defence industries, with an emphasis on the linkages between key structures for military and dual-use R&D and production, trade, and economic and military modernisation.

China's aerospace-defence enterprises, while today still ultimately controlled by the state, are increasingly motivated by decentralisation and corporate restructuring in which they are more accountable for their profits and losses. SOEs sign economic and technical contracts for domestic projects in which the responsibilities, rights and liabilities of each party are stipulated, and have a more important role in the management of research institutes and training. Greater emphasis is also being placed on the development of commercial products for profit, many of which are not related to aerospace-defence. Much of China's civil aerospace activity and other advanced technology areas such as telecommunications is of a fundamental dual-use nature that is simultaneously being used to modernise the PLA. Direct central government funding for aerospace-defence is increasingly applied to R&D, education and training, and the reconstruction of key enterprises (for example Shenyang and Chengdu as key fighter aircraft R&D and manufacturing sites). Some R&D projects, such as the development of new commercial space launch vehicles, have apparently been funded through commercial revenues. However, companies frequently have to compensate the central government for a portion of its design and development cost support.

Government agencies, primarily the Central Military Commission and COSTIND, continue to centrally plan and closely control the development of military and space projects. The State Aerospace Bureau is also closely linked to such strategic direction through the powerful State Council. A project approved by COSTIND is subcontracted to relevant manufacturers and research institutes, which in turn provide COSTIND with separate cost estimates for each component of the compartmentalised project which remain state secrets. Thus, COSTIND has the overall co-ordinating role and knowledge of the total costs of such projects and programmes. Wage, overhead and material costs of China's aerospace manufacturers remain low compared to Western competitors, although inflation is continuing to increase the cost of all of these production factors.

Figure 1.3 provides an illustration of the significant growth of the official PLA defence budget throughout the 1990s. China's 2000 defence budget is officially 120.5 billion Rmb yuan (US$15.5 billion), up 12.7 per cent from 1999. This was the 12th consecutive year of double-digit growth. While Beijing claims much of these increases were used for personnel costs and to cover for inflation, the actual annual budget magnitude could be as much as US$45 billion or more as a result of related expenditures being spread throughout various ministries, the development of dual-use technologies through civilian R&D programmes, low overhead, personnel and material costs, and, until recently, a somewhat unique degree of self-sufficiency resulting from the development of a wide array of profit-generating business ventures owned both directly and indirectly by the PLA. Some past studies have placed the PLA's annual budget during the mid-1990s as high as US$60 to 140 billion, based on a purchasing power parity rate of exchange analysis. The official budget could cover little more than active personnel and operational costs. Whatever the exact amount, it is apparent that overall China has one of the world's largest defence expenditures, probably of a value on par with those of Japan, UK, France and Germany. The Asian economic downturn of the past several years has apparently had little effect on PLA modernisation and training.

Even if China's defence expenditure just keeps pace proportionally with its rapid economic ascent, this will probably place it in a position to advance to superpower status within a generation. With its current rate of economic growth, China will easily be capable of doubling its overall defence budget within a decade without increasing the share of its gross domestic spending allocated to defence. Some, perhaps unlikely, estimates have suggested that China's GDP could be US$8 trillion by 2020, which would overtake the US economy.

China's aerospace-defence industry's rate of growth is expected, if current trends hold, to continue into the next decade. China's aerospace-defence complex is currently undergoing a vast reorganisation, and may eventually evolve into a core defence industrial base of some 200 to 300 larger enterprises, in addition to various suppliers and specialised R&D centres, which are merging into still larger conglomerates, perhaps 30 in all. By some estimates China's aerospace-defence sector currently employs some five million people in up to 30,000 manufacturing and R&D centres, and is the world's largest. Redundancies in this sector have been relatively small, compared to overall SOE downsizing, consisting of perhaps several thousand workers over the past three years. During 1997, Liu Huaqing, then vice-chairman of the powerful Central Military Commission, announced China's intent to privatise domestic defence companies and entice foreign investment in an effort to modernise the PLA and its defence industrial base to Western standards. The defence electronics sector was earmarked for early foreign investment, possibly by Japanese firms in the coastal SEZs and Hong Kong. Russian and Western European technology and investment has also been targeted.

In terms of global defence exports the sector is still not apparently strong and its most important market is internal. However, China has traditionally provided developing nations with simple, rugged equipment. As the list of states the US regards as 'rogue' continues to grow (North Korea, Iran, Iraq, Yugoslavia, Indonesia, Myanmar, Pakistan, etc.), China will find a corresponding growing market for its defence exports. Recently, China offered to provide US$90 million to Indonesia towards the development of its new 68-seat N-250 passenger aircraft. The Indonesian military is considering the purchase of Chinese defence systems because of Western boycotts.

According to the US Arms Control and Disarmament Agency, in 1996 China was the world's sixth largest arms exporter at 1 per cent of world market (US$600 million), and the fifth largest defence importer at 4 per cent of world market (US$1.5 billion). It is unlikely, however, that China's export totals in this analysis included all of its dual-use WMD-related exports in such areas as missile sub-components and nuclear reactor power systems. In addition, China has in recent years provided billions of dollars of weapons to Iran, much of it through barter trade in oil. In 1997 a US$4.5 billion arms deal apparently failed to materialise, possibly due to a lack of Iranian funding options, cultural differences and Iranian dissatisfaction over Chinese weapon quality. Nevertheless, China had previously exported an estimated US$3 billion in arms to Iran.

During the 1990s, China has exported significant numbers of artillery, aircraft and surface-to-air missiles (SAMs) to Latin American nations. Trade with developing nations or those perceived as 'rogue' by the West, for less expensive but increasingly sophisticated, Chinese defence systems can be expected to increase in the future. For example, China currently has an expanding security co-operation arrangement with Yugoslavia, the exact nature and dimensions of which remains unclear. In November 1999, Zhongxing Telecommunications signed a contract with Yugoslavia's BK Group to provide mobile telecommunications equipment worth some US$225 million. In December 1999, China provided Yugoslavia with US$300 million in easy terms loan support. Despite the virtual isolation of the President Slobodan Milosevic's regime from the rest of the international community following the Kosovo conflict, China reportedly provided a further US$200 million in aid in September 2000.

China has traditionally refused to provide information on its military holdings and arms exports and imports to the UN Arms Register because of the inclusion of Taiwan in the annual publication. CATIC (the China National Aero-Technology Import and Export Corporation) has recently claimed annual exports of approximately US$750 million, one-third of which is derived from military products such as fighter aircraft and spare parts, matched by aerospace imports of about the same amount. The dual-use nature of many of the products produced and sold by China's aerospace-defence sector also raises concerns over the accuracy of these estimates.

Great emphasis is currently placed on the transfer of key foreign technologies in order to raise the technical level of China's aerospace-defence industrial base and ultimately to ensure national self-reliance in every important technical area. The import of foreign technology is considered within the context of complementing domestic R&D efforts and priorities. During 1994 to 1997, China purchased some US$8.1 billion of defence imports; while undertaking some controversial missile and nuclear weapons related sales. During the same period China's official defence exports only averaged about US$500 million annually, mostly to developing nations, but peaked during 1990 at some US$2.6 billion. A recent US Congressional report claims that the total value of China's 'arms transfer agreements' in 1999 was US$1.9 billion. However, other sources indicate that total defence and non-defence exports produced by China's military-industrial complex amounted to approximately US$7 billion during 1997 (almost as high as the official national defence budget).

There are currently believed to be some 270 R&D institutes and university centres directly undertaking military projects but this number will probably decrease as the PLA and Chinese defence industry undergoes consolidation and restructuring. The PLA and COSTIND are known to have ongoing programmes to develop new generations of 'smart weapons' and to generally increase the technical sophistication of China's defence industrial base. One stream of official defence production and R&D organisation has traditionally been through the military itself, and another through ministries (or ministry level corporations or commissions) under the State Council. COSTIND has traditionally played a key co-ordination role between the two hierarchies, which in practice often overlap in activity areas such as R&D, product development and production, technology transfer (to and from China), and product marketing.

1.3.2 Commission for Science, Technology and Industry for National Defence (COSTIND)

The COSTIND 'super ministry' currently incorporates the national defence administrative functions of the National Defence Department of the former State Planning Commission, as well as the government functions of a large number of military industrial corporations and R&D organisations. The commission co-ordinates with the relevant agencies of the Central Military Commission to undertake the production and supply of military equipment, and the development and implementation of military scientific research programmes, including military and civilian nuclear developments. It is responsible for developing programmes and regulations for various military industrial trades and implementing sectoral management. Table 1.3 summarises COSTIND strategic facilities, although recent reorganisations and retirements may have caused some changes involving transfers of responsibilities to the PLA General Equipment Department (GED).

Table 1.3 Key COSTIND Strategic Facilities

· Satellite Launch and Control Department, Beijing
· Nuclear Testing Base (Base 21), Lop Nor
· Experimental Engineering Technical 1st Regiment, Nuclear Testing Base (Lop Nor)
· Jiuquan Satellite Launch Centre (Base 20)
· Taiyuan Satellite Launch Centre (Base 25)
· Xichang Satellite Launch Centre (Base 27)
· Xi'an Satellite Monitor and Control Centre (Base 26)
· Baicheng Conventional Weapons (Missiles) Testing Centre (Base 31)
· Survey Ship Base (Base 23), Wuxi
· Unidentified Base in Nei Monggol (Inner Mongolia)

COSTIND is responsible for China's defence R&D, weapons procurement and co-ordination of the defence and civilian economic sectors. The current director of COSTIND is Liu Jibin. Reportedly during the mid-1990s the then director of COSTIND, General Ding Henggao, and his deputy, Lt. General Shen Roujun, were active in promoting commercial ties with US space firms such as Loral, Hughes and

Motorola in order to advance China's ballistic missile modernisation programmes. Through securing such successes, the CCP has recently strengthened COSTIND's role and power in the national aerospace-defence industry hierarchy. COSTIND has traditionally played a intermediary role to ensure greater PLA sensitivity of the budgetary aspects of defence acquisition, and to encourage the ministries to adopt new technologies that will effect dual-use industrial and military modernisation. It also provides an R&D facilitating function similar to that of the US Directorate of Defense Research and Engineering within the Office of the Secretary of Defense. However, COSTIND's growing R&D mandate is much broader, with responsibility for the specification, assessment and application of all advanced technologies both within the PLA and the defence industrial base as a whole. COSTIND's subordinate corporations are now believed to include various cross-linked firms active in international defence technology transfer and export-import deals, including those major ones outlined in Table 1.4.

Table 1.4 Major COSTIND Subordinate Corporations

· China Carrie Enterprises Ltd. (China Carrie Group or the 'Kaili Corporation')
· China Everbright Holdings Company Ltd.
· China International Trust and Investment Corporation (CITIC)
· China Ping He Import and Export Corporation
· China Poly Group (Poly Technologies Inc.)
· China Resources (Holding) Ltd.
· China Xiaofeng Technology and Equipment Corporation
· China Xinshidai (New Era) Corporation (Group)
· China Xinxing Corporation (Group)
· Continental Mariner Investment Company, Ltd./Poly Investment Holdings (China Poly Group subsidiary)
· High and New Technology for Peace and Development Company Ltd.
· Rainbow Development Corporation (China Rainbow International Corporation) (nuclear technical representative and consultant for foreign customers of the CNNC)
· and other recently assigned defence conglomerates and their subordinate corporations such as NORINCO manufacturers, the State Aerospace Bureau, State Atomic Energy Agency, CATIC, the China Great Wall Industry Corporation, and the China Precision Machinery Import and Export Corporation.

Until it was transferred to COSTIND, the PLA controlled Poly *(*or Baoli - literally *'*keep the profits') Technologies Inc. (part of the China Poly Group). Poly is a major corporation affiliated with the China International Trust and Investment Corporation (CITIC), one of the most influential trading corporations resulting from Deng Xiaopings' economic reforms. It is also the PLA's major armaments purchasing agency and arms exporter. Poly Technologies reportedly offers its executives lavish life styles and high salaries, has few written records, conducts its secret business mostly through secured scrambler phones, and operates in a *guanxi* network of Chinese and 'foreign friends'. Most of its some 70 senior employees have PLA experience and CCP connections. The China Poly Group is not only a major arms export agency, but has some 100 subsidiaries of which defence products reportedly only account for 20 per cent of activities, and has established its head office at 'Poly Plaza' in Beijing, which is a major up-market business, shopping and hotel complex. Recent Poly activities included the building of Shanghai's new stock exchange, the development of a special economic zone on Hainan Island, involvement with shipping companies, and real estate development firms in Hong Kong.

Other influential COSTIND-related organisations are CITIC Pacific and China Everbright Holdings Company Ltd. (Everbright). Founded in 1979, CITIC describes itself as a 'socialist conglomerate engaged in production, technology, finance and services', and is very much involved with advanced technology manufacturing, large-scale fund raising and finance, and domestic and foreign trade. CITIC is a group organisation comprised of various subsidiaries with a holding company providing management expertise. During 1997, CITIC had 'red chip' listings on the Hong Kong stock exchange valued at US$12 billion, invested in interests that included toll roads, airlines, power stations and shopping centres. The related Everbright Bank posted 6.69 billion Rmb yuan in profits for the first half of the year 2000, its total assets reached 182.42 billion yuan and total liabilities reached 173.14 billion by the end of June 2000. The CITIC conglomerate's scope of operations include:

· Investment domestically and overseas.

· International and domestic trade, and the development of various forms of foreign economic co-operation.

· Overseas engineering projects and export labour services.

· Foreign exchange, banking, international finance, and guarantee business.

· International and domestic leasing.

· Consultancy services.

· Tourism and real estate.

· Insurance for foreign investment in China.

Everbright was formed and incorporated during 1982 in Hong Kong as an entry point for global business activities that include co-production manufacturing, joint ventures, investment, finance, trade, consulting, etc. It has major offices and branches in Beijing, Guangzhou, Tianjin, and Wuhan, and various subsidiary firms such as its industrial arm Everbright International, electronics manufacturer Everbright Technology, and the Everbright Bank. Everbright also has a major share holding in Hongkong Telecom.

Defence conversion activities, through such agencies as COSTIND's China Association for the Peaceful Use of Military Industry Technology (CAPUMIT*)*, remain important avenues for the acquisition of advanced foreign technologies for the modernisation of China's defence industrial base. Senior personnel hold dual key posts in both COSTIND and CAPUMIT. A major recent defence conversion project was the creation of Shenyang Aerospace Mitsubishi Motors Ltd., China's largest foreign joint-venture in automobile production with registered capital of some 738 million Rmb yuan and a total investment of 2.19 billion Rmb yuan. It plan to annually produce 150,000 automobile motors in seven types.

During 1998-99, the Chinese defence industry, which comprised tens of thousands of enterprises and over five million workers, underwent a major reorganisation (the fourth since 1979). This included the separation of the military and civilian components of COSTIND. The five large defence groups (*zong gongsi*) covering the aerospace, shipbuilding, ordnance, aviation, and nuclear industries were split into 10 smaller group corporations (*jituan gongsi*). This split was intended to dismantle the monopolistic nature of these 'big five' defence conglomerates and to foster increased competition within each aerospace-defence sector. While the effects and success of this reorganisation are still far from clear and various previous organisational relationships appear to have been maintained, COSTIND's new responsibilities still include R&D, weapons production, defence conversion and management of national arms trades.

Various major commercial PLA operations, including the China Poly Group, a key arms trading and business conglomerate, were reportedly transferred to the civilian component of COSTIND. Liu Jibin, a former civilian deputy finance minister and deputy manager of the Shenyang Aircraft Company (J-8 fighter aircraft development and production responsibilities), is COSTIND's new minister level chief executive officer. COSTIND's reorganisation along apparent commercial lines includes the transfer of management responsibilities for key defence conglomerates from the State Development Planning Commission, and is intended to bolster competition through the creation of dual conglomerates (parent organisation is in brackets) that are summarised in Table 1.5.

Table 1.5 Recent Restructured COSTIND Organisation

· China Nuclear Group (China National Nuclear Corporation)
· China Nuclear Construction Group (China National Nuclear Corporation)
· China Aerospace Technology Group (China Aerospace Industries Corporation)
· China Aerospace Machinery and Electrical Group (China Aerospace Industries Corporation)
· Aviation Industries of China Number One Group (AVIC)
· Aviation Industries of China Number Two Group (AVIC)
· China Ordnance Industries Group (China Ordnance Industry and China North Industries Corporation - NORINCO)
· China Ordnance Equipment Group (China Ordnance Industry and China North Industries Corporation - NORINCO)
· China Shipbuilding Industries Group (China National Shipbuilding Corporation)
· China Shipbuilding Heavy Industries Group (China National Shipbuilding Corporation).

Each of these smaller conglomerates is headed by a vice-minister of COSTIND as chief executive officers; further details are lacking at this time and the previous similar corporate designations will be used in this report. COSTIND has retained control of most conventional weapons research institutes and various space launch and tracking centres. However, the PLA's General Equipment (Armament) Department (GED) has reportedly taken over control of the Lop Nor nuclear weapons facility, other testing facilities, and space launch bases. Naval shipbuilding will probably see an increased emphasis, with the most important naval shipbuilders being Dalian and Jiangnan Shipyards for surface vessels and Wuhan Shipyard for submarines. NORINCO will probably continue to dominate ordnance and ground force equipment development such as tanks and artillery, but may reorganise its defence operations into a separate entity (reportedly, only 10 per cent of NORINCO's current revenue stems from defence production, with the balance coming from civilian products). Defence electronics will be of increased importance as the PLA focuses on high-tech warfare. The new Ministry of Information Industry, in charge of China's telecommunications, electronics and broadcasting sectors, has created a specialised department for defence-related telecommunications and electronics R&D and production, which is probably linked to COSTIND.

The development of these large aerospace-defence conglomerates have parallels with the Japanese *keiretsu* model of closely linked and exclusive supply and support firms and pre-competitive R&D partnerships to support a dual-use defence industry structure. The Chinese central government's banking structure is providing the low-cost development capital for the nurturing of these advanced technology conglomerates that are also networked together through *guanxi* (pronounced gwan-shee) social relationships and connections (in other words insider knowledge needed for bureaucratic approvals, finding the right person for the job, tips on new opportunities, etc.).

COSTIND's political power remains substantial, with several of its members recently also sitting on the State Council and the Central Military Commission. Nevertheless, its ultimate influence and structure under new central government reorganisation reforms are yet to be seen as these reforms are proceeding at a leisurely pace. The recent COSTIND and PLA GED reforms are also reportedly proceeding very slowly.

1.3.3 People's Liberation Army (PLA)

The PLA reports to the Central Military Commission of the CCP. Within the PLA the most important procurement organisations have traditionally been the General Staff's Equipment Department and the General Logistics Department. The Equipment Department determined and co-ordinated operational parameters for equipment procurement for the PLA's air, land and sea elements. The General Logistics Department was responsible for logistics and quartermaster duties, mostly for food and uniforms. Both departments also controlled their own corporations that used defence production factories to produce both equipment for the PLA and military and civilian export items.

China is divided into seven major military regions (sub-divided in turn into various military districts and garrisons), with all services grouped in the PLA. Chinese forces, the largest in the world, amount to over 2.5 million, with 1.7 million in the army (but with massive reserve forces), 470,000 in the PLAAF, 100,000 in the Strategic Missile Force, and 280,000 in the PLAN, with previously higher numbers downsized to ease modernisation and a shift towards rapid deployment forces for power projection. PLA reserves associated with regular units number another 1.2 million but paramilitary militia forces could conceivably be mobilised during a crisis by the tens of millions. The PLAN includes a coastal defence force of 25,000, a naval air force of 25,000, and a marine force of at least 8,000 (likely division level strength).

The PLA undertook profound organisational changes during 1998-1999, which are now continuing. PLA ground forces deactivated three group armies, converted various divisions into brigades, extensively reorganised reserve units, and placed an increased emphasis on military professionalism. The force structure was reduced by 500,000 men, from 3 million to 2.5 million. This entailed reductions of 19 per cent in PLA ground forces, 11.6 per cent in the PLAN and 11 per cent in the PLAAF. Some have even suggested further reductions to an overall force structure of 1.75 million by 2010. However, the final results of these cutbacks are unclear as 14 PLA divisions have been transferred to the paramilitary People's

Armed Police (PAP), 'deactivated' units such as divisions and regiments have been transferred to other group armies and local commands, or turned into reserve units, and divisions have been turned into motorised infantry brigades. Little is known of PLAAF and PLAN reorganisation. Five new comprehensive military universities were established through the reform and integration of existing PLA schools and academies: National University of Defence Technology (absorbing three other institutes in Changsha); Science and Engineering University, Nanjing; Information Engineering University, Zhengzhou; Navy Engineering University, Wuhan; and the PLAAF Engineering University, Xi'an.

There has been some recent consideration of converting the seven military regions into just five 'war zone regions' (Nanjing, Guangzhou, Jinan, Sheyang, and Chengdu, with Beijing and Lanzhou being dropped) styled after US military commands, but this has apparently not yet occurred due to entrenched traditional regional interests within the PLA. The Nanjing military region remains key to operations against Taiwan.

Some recent reports claim that PLAAF restructuring will reduce the force structure from 43 divisions in 1997 to 33-34 divisions (27 fighter, 4 to 5 bomber and 2 transport, or some 4,500 aircraft in all), in addition to specialised units such as 16 air defence divisions and the 15th Airborne Army rapid-reaction force. Large numbers of obsolete J-6 fighters are to be replaced by more modern aircraft such as the Su-27 (J-11), Su-30, FC-1, JH-7/FBC-1, and J-10.

In 1999, the revised PLA/PAP Soldiers' Service Regulations provided the basis for a professional NCO system with an eight level system of ranks that emphasised technical proficiency for promotion. Selective compulsory service has been reduced from four to two years, with professionals being allowed to serve for up to 30 years. 'Compulsory servicemen' are recruited from the population pool above the age of 18; a small percentage of compulsory servicemen, with special skills or education, formerly remained in the PLA for up to 12 years. China does not have an overall national service draft in place, and most army recruits are traditionally peasants from the countryside who volunteer their services and have a keen desire to remain in the military and become 'professionals'. Physical qualifications are quite high. While theoretically, all young people could be conscripted, this is in practice avoided through the use of various exemptions, and the PLA could not maintain the huge force level a universal draft would provide during peacetime. Commissioned officers are all volunteers who now face extensive training and technical education requirements (the exception to the volunteer basis being the requirement for some technical specialists to provide military service as required). By the end of 2000 some 35 per cent of the PLA is to be fully 'professional', with a higher percentage found in technologically intensive units.

During the late Deng Xiaoping's 'Four Modernisations' strategy for agriculture, industry, science and technology, and defence, defence conversion was intended both to strengthen the civilian economy and to modernise the long-term defence industrial base. The PLA in turn, shifted to a more modern, professional military doctrine that emphasised sophisticated weapons technology. With smaller budgets defence industries were now managed by civilian administrators, rather than directly by the military, with the intent of using existing resources more efficiently. The PLA, following its traditional doctrine that 'the Army and People are one', has long been integrated into the general Chinese economy through such services as transportation infrastructure development and assisting agricultural production.

Today, the PLA still employs the national civilian communications network comprised of the telephone system, microwave radio, telex and multiplex wireless. Civilian airlines commonly ferry troops on military operations. However, the current trend is now for the PLA to divest itself of the large number of various non-defence commercial enterprises it has operated on a for-profit basis until very recently. Along with all aspects of military aerospace, the PLA has responsibility for China's overall air traffic control (ATC) system. However, since January 1994, the Civil Aviation Administration of China (CAAC) has operated the three major airport control towers at Beijing, Shanghai and Guangzhou, forming a small, but important, triangular area of civilian ATC authority. It appears likely that the CAAC will increase its ATC responsibilities in coming years.

A new PLA General Equipment (Armament) Department (GED, or *Zhong Zhuang Bei Bu*) was created in April 1998. It arose from the reorganisation of COSTIND and elements of the PLA General Staff Department (specifically, its equipment division and bureau of military equipment and technology co-operation that oversees foreign military sales to the PLA) and the PLA General Logistics Department. The GED was created to improve co-ordination of the development of information and advanced technology defence systems, and to improve, consolidate, and better co-ordinate weapons R&D, procurement and maintenance amongst various military and industrial organisations. The most recent commander of the GED is Lt. General Cao Gangchuan, director of the old COSTIND. The creation of the GED, headquartered in Beijing, represents a recognition by the PLA's senior command of the unique importance of S&T and R&D towards force modernisation and professionalisation, rather than the old Maoist doctrine of the supremacy of the human factor over weapons and technology. Parallel GED structures will be created for each service and military region, with logistics units brought closer to actual combat units. In addition, the 1 January 1999, promulgation of the PLA Joint Logistics Regulations will provide the first PLA application of joint service logistics for increased efficiencies, and the GED is the lead organisation for all PLA joint logistics operations.

The new COSTIND will report to the State Council, while the GED is under the Central Military Commission, but in practice both organisations will probably continue to work closely together. Past frictions have resulted from the PLA's desire for increasingly sophisticated equipment without concern for cost, while production organisations were often not sensitive to PLA operation and maintenance requirements, and continued to produce familiar designs of somewhat obsolete equipment. Maintaining centralised control through COSTIND could also hinder the type of innovative technological development necessary to fully implement China's RMA.

GED has now reportedly inherited various departments, bases (including. space launch and nuclear testing) and the Science and Technology Committee that were formerly associated with COSTIND, and other units such as the Vehicles and Vessels Department of the General Logistics Department, but the eventual outcome of the reorganisation remains far from clear. The GED now has a comprehensive armament system that extends from its central authority to regimental armament offices, in a structure parallel to the staff, political and logistics systems.

In early July 2000, Beijing claimed it had completed its programme of divesting thousands of firms formerly owned by the PLA and judicial departments. The PLA's divestiture is being managed by the Production and Management Department of the PLA General Logistics Department. The most current, but still incomplete data, indicates that the PLA and departments of the judiciary used to own 37,670 businesses. By April 2000, 19,459 (52 per cent), 3,928 of which belonged to the PLA, had supposedly been disbanded or divested. However, the PLA and PAP has retained 1,346 likely defence-oriented SOEs under its control and judicial bodies (civilian police, prosecutors and courts) have retained 4,757 ventures.

Large defence conglomerates could still retain close commercial links with the PLA at the central (Beijing) and regional levels, although they will probably assume the role of passive or majority shareholders rather than hands-on managers. See Appendix A under the entry for COSTIND for a summary of various commercial businesses recently operated by the PLA but now probably under the control of the commercial sector. The arms-length distancing of these SOEs from the PLA may also be a ploy to attract increased foreign funding of defence-related and dual-use commercial developments. The commercial divestiture of PLA enterprises has also been combined with an anti-corruption drive to increase military professionalism. For example, Major General Ji Shengde, the former head of PLA Second Department military intelligence, has recently been indicted on various charges of criminal corruption.

1.3.4 Defence R&D Establishments

In March 1998, General Fu Quanyou, Chief of the PLA General Staff, warned that the PLA "cannot catch up with the advanced world levels simply by introducing foreign armaments....It should develop high-tech weapons of its own."

The capacity of the PLA to actually use new technology-intensive defence systems is increasing. Currently, some 90 per cent of senior PLA officers from all three services are graduates of the National Defence University (over 5,300 commanders at the army group level). This university's education facilities include 'a ground satellite receiving system, a phonetics laboratory, a speech-screen integrated system, and a simulated fighting teaching building...a system for simulated offensive and resisting manoeuvres in united campaigns'. The PLA currently has some 145,000 officers who have received college diplomas, and a further 150,000 are enrolled in military colleges and universities. Training reportedly includes various aspects of high-tech warfare including electronic warfare (EW) and electronic countermeasures (ECM).

The number of officers with Masters and Doctoral degrees is increasing, and 'a contingent of military personnel, knowledgeable about modern sciences, culture, scientific management, modernised weaponry, equipment and methods of organising and commanding modern warfare has emerged'. The PLA also operates an Academy of Military Science (emphasising war-gaming and simulation research), a Military Command College (emphasising 'fighting tactics used in a high-tech future'), and a National University of Defence Technology. It also operates various specialised R&D establishments such as the PLAAF Military Studies Research Institute, the Naval Military Studies Research Institute, and the Second Artillery's (Strategic Missile Force) Strategy Department. During 1997, the Second Artillery also formed a new specialised R&D institute comprising a number of China's leading scientists and engineers.

Reports that PLAAF and PLAN pilots are ill-trained, in terms of flying hours and technical and tactical sophistication, compared to their Western and Russian counterparts may no longer be completely valid. Actual training hours are still considered a state secret but likely increases in training hours and higher accident rates, and the development of a more aggressive doctrine may in part have been stimulated by Western criticisms during the past several years. An air combat aggressor training system, comparable to Western military flight training schemes, has now reportedly been developed in China; a so-called PLAAF 'Blue Force' test flight regiment. Overall, the educational and technical training levels of PLA officers continues to significantly improve.

The top institutes of higher aerospace education are the Beijing University of Aeronautics and Astronautics, the Northwest Polytechnic University, and the Nanjing Aeronautical and Astronautical University, which provide programmes to the doctoral degree level and are also major R&D performers. Other important education and training centres include the Zhengzhou Institute of Aeronautical Industrial Management, China Civil Aviation College (includes the Pan-Aviation Simulation Centre, which is affiliated with the Civil Aviation Administration of China), Shanghai Aviation Training Centre (affiliated with China Eastern airline), Zhuhai Aviation Training Centre (affiliated with China Southern airline), China Test Pilot Institute in Shaanxi Province, and AVIC's Ding Yuanjie Institute established for advanced student pilots.

By the late 1980s China's aerospace education and training infrastructure included six universities and colleges (with over 5,000 professors and teachers), five secondary and worker training schools, 26 technical colleges, and some 80 training programmes run by industry. This was in addition to a wide variety of other vocational and continuing education programmes. The thousands of annual graduates of these programmes satisfy the needs of the aerospace and nuclear industries and the PLA. Related academic research establishments include seven R&D institutes or centres, 32 research departments and three dedicated computer centres. Aerospace R&D areas include computer and software simulation and emulation, optronics, robotics, advanced composite materials, flexible manufacturing systems, CAD/CAM, and reliability engineering.

China's major aerospace professional research organisation is the Chinese Society of Aeronautics and Astronautics, which is subordinate to the China Association for Science and Technology. It consists of professionals from all aspects of aerospace-related R&D, with a total membership of over 30,000 experts from across China. The society's major activities are organising academic exchanges with foreign nations, providing technical consultation to industry and government, and promoting and popularising aerospace science and technology. It publishes the academic technical journal *Acta Aeronautica et Astronautica Sinica* and the popular science magazine *Aerospace Knowledge*. Extensive CD-ROM data-bases are now being created of translated foreign technical publications. Significant work has been undertaken by its members on the modernisation and application of operational research and systems engineering techniques to China's defence industry, and specialised seminars have been organised on such topics as the development of a domestic early warning aircraft.

The Logistics Science and Technology Exchange Centre is the organisation responsible for the management of technology transfer and logistics operations for the PLA. This centre relies upon a large network of military research establishments, colleges and universities, hospitals, defence businesses, and factories, to engage in R&D, technical consultation, technology trade, technology diffusion to industry, and technical exchange activities with foreign interests.

In practice, the majority of the PLA's R&D programme expenditures have probably been allocated to its air, missile and naval forces because of the higher level of technological sophistication required for their major weapon systems, compared to those of the army. However, PLA ground force requirements are now also seeing increased attention devoted to developing the modern equipment required for high-tech, mobile warfare. The PLA Navy Research Institute in Beijing and COSTIND recently indicated that key areas of R&D for future defence systems include:

· high-performance microwave weapons to 'destroy the opponent's electronic equipment'

· tactical laser weapons for anti-missile ship defence

· lasers, particle beams and microwave beams for precision strikes

· plasma weaponry and electromagnetic pulse systems

· computer viruses, jamming and other forms of electronic attack against enemy computer and communications networks

· robotic 'smart' systems such as robot sentries and unmanned tanks

'arsenal' ships and undersea mine-laying robots

· submarine-launched air defence systems.

1.3.5 China North Industries Corporation (NORINCO)

A key army defence production and R&D establishment, NORINCO, was formed in the early 1980s, and today the NORINCO Group conglomerate is China's largest single defence industry manufacturer and exporter. Its presence spans across China with at least 157 large and medium sized factories, over 30 research institutes, over 200 sales companies and branches, and over 60 subsidiaries abroad, and has a total workforce of some 800,000 personnel, including 160,000 engineers, scientists and technicians. It undertakes the R&D, manufacture, upgrading, servicing and trade of defence ordnance equipment including a full range of nuclear, biological and chemical warfare equipment.

During 1998-99, NORINCO undertook a major reorganisation under COSTIND with new spin-off groups emerging, the China Ordnance Industries Group and the China Ordnance Equipment Group. Details remain unclear on these two apparently competing major SOE conglomerates but the overall organisation of NORINCO subordinate organisations is believed to remain valid.

NORINCO is the major PLA affiliated defence company and is China's largest producer of army equipment for domestic and export requirements. Since 1984, the NORINCO Group has made notable progress in attracting and utilising foreign investment and technology, establishing joint ventures and co-operative enterprises through its own technology, personnel and equipment. NORINCO has also become the single most successful and experienced organisation in China's defence conversion programme, and provides an illustrative case study of a major Chinese aerospace-defence firm that has established extensive co-operative activities with foreign partners.

Since the establishment of its first joint venture in 1984 to the end of August 1992, co-operative activities between NORINCO and foreign interests numbered some 70 joint ventures, with 41 being established by NORINCO controlled enterprises and eight by affiliated research institutes and academic organisations. Total foreign investment during this period amounted to US$196 million. By 1995, NORINCO reportedly had a total of 150 foreign joint ventures with a cumulative worth of US$500 million. Statistics released by Beijing in 1997 suggest that almost US$1 billion of foreign investment has been made in some 600 joint ventures involving the Chinese defence industry. Other Chinese statistics indicate that some 1,200 Chinese aerospace-defence firms have received a total of US$4.5 billion in foreign investment since the late 1970s.

With the acceleration of economic reform after 1992, foreign joint ventures with NORINCO increased. For example, in North China alone, six such ventures were established between December 1991 to June 1992, accounting for 43 per cent of total Chinese-foreign joint ventures during that period. Geographically, more foreign-NORINCO joint ventures were established in coastal areas because of Special Economic Zone (SEZ) benefits. The joint ventures established by NORINCO in the coastal Guangdong and Fujian Provinces accounted for 34.2 per cent of total joint ventures during 1991-92. However, as Beijing is China's locus of politics, culture and economy in a centralised geographic location, increasingly more joint ventures have been established in the capital. Beijing accounted for 12.9 per cent of total NORINCO joint ventures in 1995. 'North Fund' is an effort by NORINCO to co-operate with foreign financial capital markets, and has in recent years attracted some US$200 million in foreign project investment funds 'in the works'. Plans include providing an investment base worth some US$2.5 to 3 billion to foreign investors up to 2000.

NORINCO's recent total annual exports (defence and non-defence products) have been some US$2 billion, the ninth largest amongst foreign trade companies in China. While NORINCO now claims that over 80 per cent of its activities are of a civilian nature, a more likely estimate is that military and dual-use products account for some 60 per cent of its output, with the remaining 40 per cent comprised of strictly civilian products. While technology-related joint ventures may theoretically allow up to 50 per cent foreign ownership, in practice this rarely exceeds 20 to 25 per cent.

1.3.6 Aviation Industries of China Corporation (AVIC)

AVIC is the holding company for the aircraft, aero-engine, and avionics sectors, and has responsibilities for managing and allocating state assets, developing new technologies, promoting exports, contracting state projects, and aligning planning for the overall aviation industry with the policies of the State Council and Central Military Commission. AVIC ultimately reports to COSTIND. Aircraft and aircraft component manufacturers come under its sphere, and recently included military and civil aircraft production organised into four major enterprise group conglomerates:

· Xi'an Aircraft Industrial Group of China

· Shanghai Aviation Industrial Group of China

· China National Guizhou Aviation Industry Group

· China National South Aero-Engine and Machinery Group.

However, during 1998-99, AVIC was reorganised into two major apparently competitive SOE conglomerates under COSTIND, Aviation Industries of China Number One Group and Aviation Industries of China Number Two Group (AVIC II). Details remain unclear although the former AVIC organisational structure is believed to be largely intact. AVIC II is a large state-owned aviation industrial group engaged in the development and manufacture of aircraft, aero-engines and airborne equipment for the transport, trainer and helicopter markets, among others. According to some sources, AVIC II is set to become the main supplier of the Chinese domestic aviation market, and is currently headed by general manager Zhang Yanzhong.

During the 1999-2000 aerospace-defence industry reorganisation the Nanchang Aircraft Manufacturing Company was reportedly renamed (or possibly subsumed within) a new Hongdu Aviation Industrial Group (HAIG*)*. During 2000, HAIG plans to raise some 500 million Rmb yuan by issuing 'A' share on the Shenzhen or Shanghai stock markets to be used for technological upgrading and aircraft R&D. HAIG is reportedly now part of the AVIC II.

The AVIC's subordinate structure is believed to remain valid following the reorganisation. AVIC's specific primary responsibilities are summarised in Table 1.6.

Table 1.6 AVIC's Organisational Responsibilities

· Unifying the operation, management and utilisation of the state owned assets in the aviation industry and realising the preservation and appreciation of these assets. · Contracting and managing the major new aviation production programmes of the country, and continuously providing military and civil aviation with new technology equipment. · Tracking international aeronautical science and technology development trends, and leading related R&D and educational activities. · Pushing enterprises and enterprise groups under AVIC into new domestic and international markets, encouraging new product development, tertiary industries, and the expansion of export production. · Organising and establishing technical standards for the aviation industry, and supervising and controlling product quality. · Undertaking the state-level flight test evaluation of aircraft types and models. · Administering foreign affairs activities for the aviation industry according to the authorisation of the central government.

In total, AVIC comprises some 250 manufacturing enterprises and other organisations, including over 30 research, education, training establishments, which employ about 540,000 people (including 210,000 scientists, engineers and qualified technicians). However, there may be a process of consolidation to about 100 organisations with a required reduction of about 100,000 jobs. Military aerospace is reportedly to be concentrated at Chengdu in Sichuan Province and Shenyang in Liaoning Province. Significant commercial aerospace operations are conducted at Shanghai and Beijing, with helicopter work in the northern city of Harbin. AVIC expects its output to reach 36 billion Rmb yuan by 2005, and exporting some 200 aircraft during the same time period. Its 1999 production output was 15.7 billion Rmb yuan. In 1998, AVIC claimed to have built 14,000 aircraft, 15,000 missiles and 50,000 aviation power plants during the past five decades. The targeted annual growth rate for the aerospace sector is 20 per cent.

AVIC has established economic and trade relations with some 70 countries and regions, and its foreign trade enterprises, in terms of sales volume, ranks in China's top 20 foreign trade groups. AVIC is aiming to mature as a global marketing corporation that combines R&D, production, trade and financing.

AVIC has established the China National Aviation Leasing Corporation to lease Chinese-built aircraft, and to explore joint R&D and manufacturing opportunities with Russia and other former Soviet states. Another important objective is to raise China's aviation manufacturing technical and quality capabilities to comparable Western levels to reduce the need for imported parts for most airline repairs and servicing, in addition to military programme objectives. A strategic long-range goal is to establish a domestic jet airliner manufacturing capability through the expertise gained from continued foreign aircraft manufacturing joint ventures.

AVIC's import and export trading corporation is the China National Aero-Technology Import and Export Corporation (CATIC) which undertakes foreign equipment and technology trade. One of China's largest trading corporations, it is uniquely allowed to export Chinese manufactured aircraft, represent the aviation manufacturing sector abroad, and promote foreign technology transfer, joint venture and subcontract agreements. CATIC has the important responsibility for the export of military aircraft. Since its establishment in 1979, CATIC has expanded to 12 domestic subsidiaries, 130 associated enterprises, and 39 representative offices abroad in 26 countries. During 1997, CATIC's Shenzhen division opened to foreign investment a new venture known as CATIC-SZ, which produces printed circuit boards and LED displays for a variety of high-tech applications.

CATIC's China Aero-Technology Service Company provides after sale support, training, and service to foreign customers of Chinese built aircraft and other aerospace products. Other CATIC subsidiaries include the CATIC Design and Construction Engineering Company, CATIC Civil Aircraft Sales Company, and the CATIC Nonaero Product Department. CATIC has also organised a large components and spare parts network for foreign customers. CATIC industry and trade centres have been established at the special economic zones of Shenzhen, Xiamen, and Zhuhai, along with special foreign trade branches at Shanghai, Hong Kong, Fuzhou and Guangzhou. Foreign representative office have been established at London, New York, Los Angeles, Montreal, Hamburg, Paris, Marseilles, Tokyo, Amman, Abu Dhabi, Kuwait, Cairo, Islamabad, and Mogadishu. Duties of the foreign offices include technology export/transfer, purchasing, contract/co-operation negotiations, and overall representation.

A 1994 CATIC spin-off is the China National Aero-Technology International Supply Corporation (CATIC Supply), CATIC's former purchasing division that is now financially and administratively autonomous. CATIC Supply imports aircraft parts and technology for domestic aircraft and components manufacturers, and arranges foreign joint ventures for aircraft components and light aircraft production. For foreign co-operation projects up to US$20 million CATIC Supply also provides a brokerage function without AVIC approval.

1.3.7 China Aerospace Industry Corporation (CAIC)

Space-related activities in China are controlled by the China National Space Administration (CNSA) and CAIC, which also report to the State Council. The CNSA is responsible for intergovernmental and international business co-operation. The CAIC and its subordinate organisations controls the vast majority of China's space and missile industry, from research to commercialisation, and ultimately reports to COSTIND.

Major elements of CAIC include the China Academy of Launch Vehicle Technology (CALT) and the Chinese Academy of Space Technology (CAST) and all of their subordinate R&D and manufacturing organisations (see Chapter Four for further details).

The China Great Wall Industry Corporation (CGWIC) is the major international relations and trading arm of this ministry-level corporation. It has responsibilities that include satellite launch services, aerospace technology, defence electronics, commercial negotiation, and contract execution for the import and export of aerospace products and technologies. CGWIC is headquartered in Beijing but has major establishments across China in such cities as Chongqing, Dalian, Guangzhou, and Jinan. In 1998, the Bank of China provided CGWIC some 1.5 billion Rmb yuan of export seller's credit to help boost the national aerospace industry. To October 1999, CGWIC had secured 23 commercial launches and five 'carrying services' for international customers. Italy's Alenia Space Corporation announced in 1999 that it would sign a contract with CGWIC for the launch of a telecommunications satellite on a CZ-3A SLV in the first half of 2001.

The China Precision Machinery Import and Export Corporation (CPMIEC) was established in 1980 and reports to CAIC and is also associated with the Xinshidai Group. CPMIEC's product areas include missile systems (surface-to-surface, surface-to-air, air-to-ship, ship-to-ship, and shore-to-ship), rocket propellants, systems engineering, space hardware, satellite techniques and products, precision machinery, automatic control, electronics and electrical apparatus, optics, radars, antennas, instrumentation, vehicles, broadcasting and communication equipment, magnetic materials, chemicals, and computer software development. CPMIEC has reportedly negotiated with CAIC for all military export systems except ballistic missiles. Associated CPMIEC manufacturing plants include:

· Shanghai Bureau of Space Xinjiang Machine Plant

· Shanghai Bureau of Space New China Machine Plant

· Ministry of Aerospace Industry First, Second and Third Departments.

During 1998-99, CAIC was restructured under COSTIND, and the two new units were created: the China Aerospace Technology Group and the China Aerospace Machinery and Electrical Group but details remain unclear. The overall organisation of CAIC's subordinate units is believed to remain valid and the space and missile role continues.

1.3.8 Civil Aviation Administration of China (CAAC)

Established in 1949, CAAC is the regulatory body of the airline industry, and still retains a degree of overall control which has been lessened through the effects of deregulation. However, CAAC continues to have a major influence over expansion plans and key personnel decisions, and procuring aircraft for state-run airlines through the China Aerospace Supplies Corporation (CASC). It is possible that its role may evolve to one similar to that of the FAA (in other words, safety, airworthiness certification and route approvals). It has links to China's defence capability through ATC monitoring functions, dual-use foreign technology transfers, and the potential mobilisation of China's large civil aircraft fleet during wartime.

CASC is the buying agency for CAAC, and the sole authorised importer of complete aircraft and aero-engines for China's airlines (including the so-called independents which still require CASC final approval for such imports). However, CASC no longer has a monopoly on spare parts acquisitions, with most Chinese airlines now directly purchasing their spares through their own trading companies or directly from foreign manufacturers.

CAAC is currently facing a restructuring with the creation of three or four major civil aviation groups centred around Air China, China Southern Airlines, China Eastern Airlines, and perhaps the China Civil Aviation Company, and the merger of all 34 existing airlines within these groups. These restructured groups are expected to have assets worth more than 40 billion Rmb yuan and almost equal market shares.

1.3.9 Dual-Use Programmes

The 1993 'Law of the People's Republic of China on Science and Technology Progress' provides a comprehensive modernisation framework that defines and details Beijing's perspectives on the relationships between S&T and national economic and social development, 'high-tech research and high-tech industries', basic research and applied research, R&D institutions, scientific and technical workers, 'measures to guarantee science and technology progress', the use of S&T for defence modernisation, foreign S&T-related co-operation and investment, etc. China's current S&T development programmes generally follow the principles prescribed by these official guidelines. The dual-use nature of modern S&T is very apparent to the PLA leadership. During 1993, the then Vice-Minister for COSTIND, Huai Guomo stated:

'*Because national defence high technology is by its nature having multiple technologies, the differences between defence and civilian technology is becoming smaller and smaller. The trend of interchangeability between the military and civilian is on the rise, allowing the technical foundation for an accelerated modernisation of national defence and to realize the steady improvement of weapons*.'

Until the late 1970s, China's top designated priorities were directly related to the development of military capabilities but with the rise of Deng Xiaoping this has shifted in favour of a much broader industrial development programme. However, it is of fundamental importance to realise that China also views defence-civilian integration and defence conversion as a means of stimulating foreign capitalist economic relations and long-term military modernisation, rather than any pacifist attempt at disarmament. In fact, the overall theme of China's defence modernisation efforts has been called the 'Sixteen Character Slogan', which translated roughly means military production first.

By the mid-1990s it is estimated that China allocated up to US$5 billion on purely military R&D. However, many technologies, particularly at lower subsystem and component tiers, have a both military and civilian dual-use potential. It is not necessary to organise and manage the research and production of such components separately for military and civilian end-users. Civil-military integration, as opposed to defence conversion, involves the sharing of fixed costs by advocating the use of common technologies, processes, labour, equipment, materials, and facilities, including co-operative R&D, manufacturing and maintenance operations in common facilities. Such integration can occur at the individual facility or firm level, or throughout a particular sector. Not only can this approach lower overall costs, but can transfer advanced commercial products and processes to the defence sector. Such integration is often more easier to achieve at the component and subcomponent supplier and service levels, rather than at the prime contractor level where system integrations are performed.

Chinese defence factories sometimes produce civilian and military products side-by-side on the same production lines. In some instances, such as jeep-like command cars and motorcycles originally intended for military dispatch riders, the only civilian product difference is the application of a non-military coat of paint. However, the more common civilian products made at defence facilities are generally produced using equipment different from that for defence products made at the same site. It is at higher levels of technology where the dual-use factor becomes more important.

A major state R&D organisation is the Chinese Academy of Sciences *(*CAS, or Academia Sinica*)*, which operates some 120 research institutes with a total staff complement of about 68,000. CAS is currently in the process of closing or consolidating about one-third of these institutes into regional 'mega-institutes'. Its primary orientation is basic research, which it shares with major Chinese research universities (about 40 out of a national total of 1,020 universities and colleges). The bulk of basic research funding is believed to be monopolised by a relatively small group of elite scientists and their support units.

CAS has established its own S&T university with an advanced technology zone in Beijing that supports over 400 new venture companies. It is currently organising a national Knowledge Innovation Programme over three years costing US$650 million. The programme is designed for basic research and the transfer and exchange with industry of innovative S&T knowledge. CAS has also implemented a 'Hundred Institutes Network' project to interconnect various R&D centres via a computer-based telecommunications and management information system.

Current CAS priorities reportedly are 'next-era' nuclear technology, high-energy astrophysics, human genetics, information technology, nanosciences, infrared remote sensing, and robotics. Life science and 'high-technology' CAS R&D activities are to be clustered in the Shanghai region, IT in Beijing, and advanced materials and manufacturing in the Northeast China region. The Chinese Academy of Engineering Sciences appears to be closely linked with CAS, and both employ a 'senior academician' system to honour senior researchers.

The Chinese central government has also implemented the 'Torch Programme' of the MOST since the 1980s to help accelerate the commercialisation of R&D results and to foster the establishment of new high-tech, value-added businesses. A major portion of Beijing's civilian (and often dual-use) R&D budget is allocated through this programme, which has targeted the technology areas of advanced materials, biotechnology, IT, mechatronics, advanced energy systems, and 'other new and high technologies'. Torch is aimed at stimulating the commercial application of the results of both domestic and foreign R&D, and promotes the participation of foreign joint ventures, but usually not wholly foreign-owned enterprises, as technology transfer mechanisms. Such advanced technology developments are closely linked to designated coastal SEZs and larger cities such as Beijing and Shanghai, within a current economic strategy that emphasises redeploying large numbers of scientists and engineers from state institutes to new technology industrial sectors through supporting entrepreneurship and appropriate business training.

In an attempt to capture a 'Silicon Valley type spirit', various new research and technology parks and zones are enjoying preferential tax and other incentive treatments. In 1996 alone, some 15,000 new and high-tech enterprises employing 1.2 million people were reportedly established in 110 technology development zones across China. Dozens of technology development business 'incubation' centres have been established to assist innovative start-up businesses by providing comprehensive support services, and by 1997 some 52 research parks had been established throughout China by the Torch Programme. In 1996, total programme funding was over US$320 million for 596 national projects; 1997 output value from supported projects was reportedly 125.6 billion Rmb, including US$1.77 billion from export sales. In 2000, the Torch Programme has the specific objectives of achieving:

· total revenues of US$72 billion in high and new technology industries

· total revenues of US$60 billion in research ('technology industrial') parks, of which annual revenue for industrial project sales should account for US$48 billion

· the implementation of 12,000 or more individual projects, one third of which should be oriented for the development of international export products, the establishment of 30,000 high-technology enterprises, and the development of 50,000 high-technology products

· the training of 500,000 new personnel in the development, operation and management of advanced technology industries.

In 1986, the SSTC (MOST) implemented the '863' National High Tech Research and Development Programme to sponsor focused elite R&D activities in such areas as space research ('large, advanced carrier rockets...and to continue research and development of space technology for peaceful purposes'), lasers (pulsed power techniques, plasma technology), biotechnology, energy, advanced materials (high-temperature/strength composites, optoelectronic materials), IT (artificial intelligence, optoelectronic systems, information acquisition and processing), and robotics (intelligent robots, automation, computer integrated manufacturing systems). The '863' Programme (the name of which is presumably based upon the year and month of its initial establishment) has an apparent major cross-disciplinary 'technology push' philosophy in common with the former US Strategic Defense Initiative (SDI), with its attempt to 'strive for breakthroughs in areas where China is strong'.

In addition to its basic research, innovation, educational and commercial aspects, the '863' Programme has a specific mandate to "develop advanced dual-use technologies", transfer technology to domestic industry, and to monitor strategic foreign S&T developments and 'narrow gaps between Chinese and foreign technologies'. During 1996, US$54 million was officially allocated to support 12 research projects on key technologies, eight technology transfer projects, and 63 'special research projects', although this modest amount would appear to be somewhat insufficient to fund the programme's wide areas of interest. Reportedly, '132 experts and more than 10,000 S&T workers' under the programme support eight new R&D centres: CIMS Experimental Engineering and Research Centre; Intelligent Computer System R&D Centre; Intelligent Robot R&D Centre; Optoelectronic Processing Centre; Genetic Vaccine Centre; Genetic Medicine Centre; Genetic Bio-Products Centre; and Joint R&D Centre for Artificial Crystal.

Additional operational and special project funding will probably be shifted from other R&D support programme and ministry budgets. The MOST recently indicated that support for large-scale scientific projects is to increase by US$240 million over the next five years, presumably of the type supported by the '863' Programme, which is probably supporting much of China's most advanced defence R&D. The '863' Programme in 1997 had some 326 projects.

The central government is supporting various other advanced S&T development programmes. The 'Dragon Plan' is an attempt at creating a computerised sub-contracting network to increase the indigenous technology content of Chinese enterprises. The 'Five Goldens' and 'Three Golden Projects' programmes are reportedly major components of China's attempt at creating an 'information superhighway', along with other efforts to develop the infrastructure required for the telecommunications and microelectronics sectors. Other MOST R&D support programmes include:

· the National Key Technologies R&D Programme established in 1982 to support national economic development, which received some US$300 million of funding during 1996;

· the Spark Programme established in 1986 for improving agriculture and rural industry, with some US$92 billion in support provided for 35,000 projects by 1996 (some US$245 million of new funding allocated during 1996);

· the National S&T Achievements Spreading Programme to enhance advanced industrial technology, with over US$120 million in funding in 1996;

· the State Key Laboratories Programme currently supporting some 200 R&D centres prioritised by the State Planning Commission for basic research;

· and the National Basic Research Priorities 'Climbing Programme' supporting key state basic research projects, sectoral research under ministries, and individual institute projects in areas that include IT, medical sciences and energy.

A National Science Foundation of China was established in 1985 to support basic research through thousands of individual grants from its National Natural Science Fund (almost US$900 million in 1996) to researchers at universities and institutes. Its recent National Scientific Prizes programme awarded scientific excellence in basic research, technological progress and specific inventions. A new joint initiative of the MOST, CAS and the National Science Foundation in support of basic research has been termed the '973′ Programme, and reportedly will allocate US$300 million over the next five years for projects in the life sciences, information science, energy, new materials, agriculture, resources and the environment.

A 'Technical Transformation Programme' recently targeted some 550 electronics and machinery manufacturing firms for manufacturing hardware and software technical upgrading, along with plant layouts, quality assurance and managerial techniques. Productivity Promotion Centres provide technical support for the commercialisation of new technologies by small to medium sized enterprises (over 100 such centres established since 1992, with the number expected to increase to some 500 networked across China by the year 2000). The Trial-Production and Appraisal Programme assists firms in the development of new, innovative products, preferably those derived from advanced foreign technologies (although reportedly not for 'purely military uses').

In 1998, China's Ministry of Education established a new National Technology Transfer Network linking major research universities and Chinese industry to decrease the latter's dependence upon imported foreign technologies. The MOST has implemented a China S&T Personnel Information Network as a nationwide platform for the exchange, development, training, management and service of S&T personnel for government agencies as well as domestic and foreign-invested enterprises.

While the central government's S&T policy now frequently refers to a *ming ying* private sector with its own research laboratories, and various tax incentives have been established to promote mostly foreign-invested R&D intensive enterprises, in practice the state infrastructure remains the primary supporter of advanced R&D for defence-related S&T programmes. However, during 1998 alone, over 4,000 small-to-medium sized scientific research establishments were reportedly in the process of being commercialised.

The MOST's National Engineering Research Centres Programme has established and funded R&D centres throughout China that specialise in areas that include energy, IT (for example integrated circuits, flat panel displays, parallel computer systems, mobile satellite communications, digital switching systems), advanced manufacturing (e.g. computer-integrated manufacturing systems, solid state lasers, automation, optical instrumentation), and advanced materials.

Space science, aerospace technology, IT areas such as microelectronics, optoelectronics, and optical-mechanical-electronics integrated systems, and advanced materials are fields of research that are encouraged to locate in Chinese research parks and SEZs. Extensive tax concessions and other benefits are provided to foreign advanced technology firms developing joint ventures in these locations. Those with specific known aerospace/defence activities include the Xi'an New Technology Industry Development Zone, and the Shanghai High and New Technology Industry Development Zone.

1.4 Defence Project Management *TOP*

1.4.1 R&D Management

Little is known about the PLA's specific R&D programme management and related equipment procurement practices. However, unverified sources indicate that PLAAF aerospace programmes progresses through a standardised multistage process that could be typical for advanced technology weapons programmes for all three services:

· **General procedures -** Basically, a three report/request and three approvals process is followed. Initially the PLAAF submits a report to the General Staff Department (and now probably GED), COSTIND and the Central Military Commission requesting a specific weapon system. If this is approved, the request is included in the annual and medium-long term plan. A request for proposals (RFP) is then sent by the PLAAF to appropriate domestic industry/ministries and/or foreign firms. After programme definition, the PLAAF and contracting organisation (notably AVIC) submit a joint report to the General Staff Department (and now probably GED) and COSTIND. This is followed by a design and production finalisation process.

· **Theoretical evaluation (Luzheng) phase -** In the context of the PLAAF's annual and medium-long term plan, the PLAAF Scientific Research Department's subordinate research institutes, units and schools conduct a theoretical evaluation of the weapon system's operational performance requirements, in addition to technical and tactical criteria. This evaluation process includes an analysis of operational mission objectives, basic and key system and equipment requirements, plus the development schedule. A subsequent report is submitted to higher authorities, and if approved the next phase of the process is initiated.

· **Programme (Fangan) phase -** In this phase an RFP is submitted to the appropriate potential contractors (*Zhan Biao*), and a contractor is selected based upon national strategic criteria (*Xuan Ding Yan Zhi Dan Wei*). Following contractor selection, the PLAAF research institute(s) and military representatives conduct a joint programme development evaluation with the contractor, including a prototype/mockup development and implementation (*Yang Ji*). Critical technology is selected and a development mission report (*Yan Zhi Ren Wu Shu*) is drafted based upon the development plan's feasibility. This report is submitted to higher authorities, and if approved the next phase of the process is initiated.

· **Engineering development (Gongcheng Yanzhi) phase -** The contracted production organisation is now charged with designing the weapon system and producing and testing a prototype/mockup based upon the approved contract and development mission report. The testing phase is usually some 12 to 18 months in duration. Military representatives review programme development progress and expenditure levels during this phase.

· **Design finalisation (Sheji Dingxing) phase -** Following the successful completion of engineering development and the achievement of design criteria, the PLAAF initiates testing trials at a testing base or functional unit. The National Finalisation Commission (*Guo Jia Ding Xing Wei Yuan Hui*) initiates design finalisation testing based upon the results of operational testing. If these series of tests are acceptable, the design is finalised. The senior members of the National Finalisation Commission are reportedly AVIC's minister and the PLAAF Deputy Commander responsible for R&D and equipment, with other members including the responsible deputy chief of staff, AVIC and/or other relevant ministry representatives, and the director of the PLAAF Scientific Research Department. PLAAF representatives are also members of the PLAAF Aviation Commission (*Hang Kong Bing Wei Yuanhui*), which is chaired by a Deputy Commander. Routine administrative affairs for design finalisation and the PLAAF Aviation Commission are managed by an Aviation Finalisation Office (*Hang Kong Ding Xing Ban Gong Shi/Hang Ding Ban*).

· **Production finalisation (Shengchan Dingxing) phase -** A set number of production tests and examinations are conducted based upon the final design. After these are completed, production finalisation testing and completion is implemented. Production finalisation permits the complete examination of a production batch to verify the achievement of required quality standards. A production finalisation organisation then sends a final report to appropriate authorities for approval, the equipment is procured and transferred to the General Logistics Department for equipping operational units.

An important point to consider in this iterative approach is the apparent emphasis placed on a unique R&D and design stages of development, rather than the simple mass 'copy production' reverse-engineering approach that China employed for the first three decades following the 1949 revolution. In 1996, the State Council announced plans to increase competitive tendering for defence R&D projects and the requirement to focus such funding on fewer organisations. While foreign investment (for defence electronics) and technology transfer for defence programmes is to be increased, the PLA will ultimately remain dependent upon the domestic defence industrial base for its R&D and equipment production requirements. Chinese sources have recently reported that it now takes China only two to three years to produce equipment such as transport and armed helicopters. Some small weapons can be produced in only half a year from design concept to their successful development.

In 1997, the PLA introduced regulations to govern the auditing of its financial activities and improve the management of equipment funds. The new system empowers military audit departments to: oversee the purchase and maintenance of weapons and logistics; the spending of R&D funds; the management, use, storage and disposal of military equipment and materials; the use and maintenance of 'war reserve storage funds'; and the authenticity, legitimacy and efficiency of defence-related enterprises.

1.4.2 Systems Integration

Systems integration and engineering has traditionally been a major weakness in Chinese defence R&D programmes. Major efforts are now being made to close this gap. Important Chinese aerospace-defence organisations related to systems engineering and systems integration include:

· Beijing Institute of Systems Engineering

· China Academy of Electronics and Information Technology, Systems Engineering Department

· China Institute of Astronautical Systems Engineering

· First Academy CAIC

· Beijing Institute of Electronic Systems Engineering (CAIC's Second Academy)

· Beijing Institute of Electromechnical Systems Engineering (CAIC's Third Academy)

· 41st Research Institute (CAIC's Fourth Academy)

· 501st Research Institute (CAIC's Fifth Academy)

· Shanghai Institute of Systems Engineering (CAIC's Shanghai Academy of Space Technology)

· 701st Research Institute, Beijing Institute of Aerodynamics - wind tunnel testing

· 707th Research Institute, Institute for Astronautics Information - collects, analyses, and distributes aerospace information

· 708th Research Institute, Institute of Space Standardisation

· 710th Research Institute, Institute of Computer Systems.

The long delays in aircraft development experienced during the 1960s and 1970s caused by political turmoil have strongly motivated the Chinese aerospace industry to implement shorter development cycles. Modern systems engineering techniques have been adopted since the 1980s, beginning with the Jianjiji J-8II, J-7III, JJ-7 fighter aircraft and Z-8 helicopter programmes, to improve overall management, administration, planning and co-ordination, from design through tests, prototype production, flight test, and serial production. The China Institute of Aeronautical Systems Engineering, Beijing, has 130 specialist employees, and has undertaken research on economic development strategy for the aerospace sector in China, aerospace market research, planning aero-weapons series, and future project study concepts (including 'Countermeasure to New Technology Revolution' and 'Computer Simulation Technology') for the PLA, AVIC and CAAC. It has also developed software for such areas as CAM and real-time production processing.

1.4.3 Quality Assurance Systems

China's aviation sector was dogged by quality problems during the early 1960s, although during its initial development stage in the early 1950s process regulations and quality supervision to ensure product quality had been emphasised with some success. During the late 1950s period of 'the Great Leap Forward' scientific management practises were devalued as 'taboos and commandments fettering productivity'. Quality inspection systems under a unified leadership were neglected, and quality management lagged, despite efforts by the Bureau of Aviation Industry to re-establish quality assurance programmes. After former quality levels were regained by the mid-1960s, they plummeted again as a result of the Cultural Revolution in January 1967, which promoted the belief that all 'systems' were counter-revolutionary, and should be smashed.

From 1978 to 1981 a special effort was made to reinstate the overall inspection of product quality and the reorganisation and improvement of quality management systems. China joined the International Standardisation Organisation (ISO) in 1978. In 1981 the 'Technical Standard System of the Aviation Industry' was introduced. To a large degree it was modelled upon Western military and space specifications standards. The development of the J-7III and J-8II fighters in the 1980s emphasised the systematic quality control in their process engineering development, and also during follow-on operations product support.

Chinese manufacturers now generally set higher standards for the production of military systems compared to civilian products. Historically, this has been due to the defence sector receiving the best materials, facilities and trained labour force. However, serious quality problems still periodically emerge: during the 1970s and 1980s it is believed that the quality of aerospace manufacturers was very uneven, with entire military aircraft types being recalled to their factories for serious problems such as hydraulic system contamination. As recently as June 1995, Professor Xia Guohong, Vice Administrator of the China National Space Administration, openly admitted that "poor manufacturing technique and poor reliability of electronic elements" remains a problem for China's space programme (which has been reflected in a recent series of serious launch vehicle failures).

In the wake of commercial aircraft joint ventures and parts supply contracts with foreign partners, such as McDonnell Douglas and Boeing, the overall level of Chinese commercial aircraft workmanship was required to rise to international standards. This expertise has now been transferred to military aircraft production through a flow of personnel. Ever higher levels of military quality control (including ISO 9000) will be necessary for the domestic production of the sophisticated aerospace-defence systems China now increasingly desires.

In order to improve quality assurance and management practises for its advanced export-oriented industries, China has adopted a continuing policy of reforming its quality practises and importing advanced equipment and techniques. Advanced quality systems are recognised as a necessity for modern defence technology development and participation in joint international programmes. Scientific 'total quality control' (TQC), as refined by Japan, was first introduced in China 1978 but has only recently being adopted on a widespread basis as the result of an increased emphasis on productivity and competitiveness in world markets. Most, if not all, Chinese aerospace and defence related enterprises have today adopted advanced TQC and continuous process improvement practises, and have well defined quality control and quality inspection offices in their organisational structures. The former Ministry of Aerospace Industry (predecessor to AVIV and CAIC) established a Quality Bureau to ensure the conformity of these practises.

The Chinese Society for Quality Control *(*CSQC*)*, ministries in the central and regional governments, and academic organisations have established a Quality Control Award system to encourage the adoption of advanced methods, but the requirement for external expert consultation is still great. The CSQC's consultation department employs over 300 local consultants divided into 10 groups in various regions. Initial quality control consultation services were managed by the Chinese Machinery Industry Society for Quality Control in 1981. Chinese quality professionals are now introducing international auditing standards, a national registration programme and advanced computer-based expert systems as quality assurance management techniques. Quality programme standards of the ISO 9000 series are now available in the Chinese language but China still needs to be further linked into the international auditing and registration system to see significant gains.

The Metrology and Inspection Research Institute is responsible for the development of techniques related to the measurement and inspection of force, pressure, vibration, length, temperature, flow rate, time, frequency, and other mechanics metrologies, which are important quality factors in the aerospace industry. Measurement and detection techniques such as lasers, microprocessors, ultrasonics, electroprobe, eddy flow detection, scanning electron microscope, infrared beamsplitter, holography and acoustic emission are used. Practical developments have included g-meters for ejection escape systems and impact g-meters for missiles.

National standards activities began in China in 1955 with the central government establishing a State Technology Commission. In 1960 a State Bureau of Standards was established with responsibilities for creating a national standards system based on technical consensus requirements. Today this is a key area for modern quality management in China. In 1988, the State Bureau of Standards, State Bureau of Metrology and the Quality Control Bureau were merged to form the China State Bureau of Technical Supervision. This resulting organisation was recently renamed the China State Bureau of Quality and Technical Supervision. Standards activities have been created at different administration levels, with 19 standards departments and 25 subordinate institutes of standardisation across China that manage municipal, provincial and regional programmes and other activities. The China State Bureau of Quality and Technical Supervision administers the China National Accreditation Council for Product Certification Bodies, the China National Accreditation Council for Registrars, the China Registration Board for Auditors, and the China National Accreditation Committee for Laboratories. These various organisations accredit quality system registrars and certification, testing and inspection bodies in compliance with the standards of the ISO and International Electrotechnical Commission.

The China State Bureau of Quality and Technical Supervision joined the ISO in 1978. Active participation, which began in 1988, has resulted in current Chinese membership on 134 technical committees and 345 subcommittees, as well as observer status on another 45 technical committees and 223 subcommittees. It is also a member of the International Accreditation Forum, signing its multilateral agreement in 1998, as well as an International Auditor Training and Certification Association agreement that has helped bring many of China's current industries to global quality standards.

Today, China also recognises that aerospace-defence quality is a direct function of technological progress, in addition to statistical and management techniques. A number of very recent bodies appear to have been established to raise the overall quality levels of China's aerospace-defence sector. The China Xinshidai Quality System Certification Body is a recent ISO9000 certification organisation and is probably related to

COSTIND's Xinshidai Group defence export-import enterprise. COSTIND probably takes an active role in the aerospace-defence sector in maintaining advanced ISO and US-type MILSPEC quality standards in its production facilities, as another COSTIND entity, New Era (or the 'New Decade Institute'), is active with its New Era System Attestation Centre for ISO9000 series certification in such areas as Long March space launch vehicles. The China Aviation Conformity Centre appears to be affiliated with AVIC and certifies ISO9002 compliance. In 1998, China had 4,500 product quality control institutions, of which 228 are rated as national quality control centres, as well as 3,875 meteorological institutions that have verified some 22.12 million metrical instruments on a mandatory basis to promote standardisation.

1.5 Foreign Technology Transfer *TOP*

1.5.1 Overview

While traditionally China has professed a policy of 'self-reliance' in all matters related to national defence, in practice it is also eager to obtain knowledge and key technologies from almost any possible source so that it can it eventually establish its own R&D and production base for such technologies. The transfer of foreign military and dual-use aerospace and IT technologies are central to China's defence modernisation drive, even as it continues its own national efforts to develop key enabling technologies and defence systems. China's massive R&D infrastructure will be a key factor for the transfer and assimilation of these new technologies, and appears to be increasingly adept at the integration of technologies from multiple foreign sources (examples include the reported use of Russian, Israeli and domestic technologies for the PL-9 helmet-sighted air-to-air missile). China's transfer of advanced foreign aerospace-defence technologies are being conducted as a key component of a long-term strategy to complement and strengthen its own industrial R&D and manufacturing base. In particular, China is currently taking advantage of Russia's declining economic and political situation to obtain technological bargains that will permit it to forge ahead in the innovation cycle.

Methods of foreign technology transfer used by China include:

- the direct purchase of limited numbers of defence and dual-use systems for reverse engineering (international intellectual property conventions remain largely ignored in China);
- The commercial establishment of foreign-Chinese joint ventures in areas such as aerospace and telecommunications;
- The promotion and attraction of commercial foreign-invested high-technology production facilities to China;
- Scientific and educational exchange programmes abroad;
- Educating Chinese technical students abroad (although it is now increasing difficult to lure many Chinese postgraduates back from financially lucrative Western jobs);
- Official foreign trade and technical missions;
- Establishing memorandums of understanding on S&T co-operation with other nations (including sub-national levels of government such as cities and provinces);
- Participating in multinational R&D programmes;
- Attending foreign technical conferences and exhibitions;
- Promoting the organisation of foreign technical conferences and exhibitions in China;
- Subscriptions to foreign scientific journals and technical/defence trade publications;
- Playing upon the patriotic and nationalistic sympathies of ethnic Chinese scientists and engineers

abroad who are active in foreign defence and advanced technology programmes;

- Direct defence and industrial espionage.

Since 1986, the National Science Foundation of China alone has signed bilateral scientific co-operation agreements with 35 organisations or academic institutions in 28 nations. China has currently established S&T co-operation and exchange relationships with some 150 nations and regions, signed S&T agreements with over 86 nations and regions, and participated with some 800 international scientific collaboration projects. During 1995, about 59,000 Chinese went abroad and 35,000 foreigners visited China as part of such various S&T co-operation and exchange programmes. Between 1978 to 1999 some 320,000 Chinese students and scholars studied abroad (only 110,000 returning), and a similar number of foreigners visited China to study.

The '863' Programme is targeting bilateral, multilateral, governmental and non-governmental channels in 'various ways for expert exchange and academic links... to train high-level Chinese S&T personnel in an international high-tech R&D environment and invite foreign experts to give lectures and do joint research in China'. During the 8th Five Year Plan Period (1991-1995), Beijing's so-called 'Intelligence Import Project' funded over 300,000 foreign economic, technical, managerial and other foreign experts from various fields to work in China. In 1997, then Premier Li Peng announced that China would over the next two years recruit some 170,000 foreign experts and send some 90,000 Chinese abroad for training. Current priorities (1996-2000) for these activities include national key construction projects, critical industrial upgrading projects, key R&D projects, industrialisation of new/high technology, new research disciplines, national key laboratories, and technical training and scientific education.

Special efforts were made to 'attract overseas Chinese specialists and foreign experts of Chinese descent to work in the Chinese mainland.' A notable example was CAS's so-called 'Hundred Talents Recruitment Programme' initiated in 1994 that targets young, brilliant researchers in the 'latest trend and frontier areas of international importance and emerging scientific fields'. However, China has also recently made efforts through increased benefits and opportunities to stem a 'brain drain' of skilled scientists and engineers associated with such areas as information technology and its manned space programme. Many of these scientists are being actively recruited by Western firms for highly paid overseas positions after a decade or more of training and experience.

The key organisations involved with co-ordinating foreign technology transfer schemes are believed to be the MOST, CAS, the National Science Foundation, the State Education Commission, the Ministry of Foreign Trade and Economic Co-operation (MOFTEC), COSTIND (particularly its Poly Technologies and Xinshidai New Era import-export subsidiaries), and the various organisations of the Chinese political and military intelligence community. A Bureau of Foreign Experts provides financial support for foreign experts conducting S&T research in China. China's official policy on technology transfer activities was summarised in the 6 May 1995, 'Decision of the Central Committee of the Chinese Communist Party (CCP) and the State Council on the Acceleration of Scientific and Technological Progress'.

'Effectively assimilate advanced technologies and intelligence from abroad and welcome foreign experts to work and carry out scientific and technological exchanges in China. Encourage high technology enterprises and competent research institutions to open their branches overseas... Carry out extensive international academic exchanges in the fields of basic research and widen the channels and scopes for international academic exchanges. Jointly establish research bases in some important fields together with foreign counterparts or enterprises. Create conditions for scientific and technical personnel, especially the young and middle-aged scientific and technical personnel to conduct international collaborative research, study or visit in foreign countries, participate in international academic exchange, and learn from others' strong points and raise their academic levels at the world scientific frontiers.'

The ultimate objective of much of this foreign technology transfer remains the improvement of China's indigenous S&T infrastructure and defence industrial base. As President Jiang Zemin indicated at the May 1995 Chinese National Conference on S&T while assessing the role of S&T in 21st century China:

'We must understand clearly that the world's most advanced technology is not for sale. Science and technology advances rapidly with each passing day; any advanced technology soon becomes obsolete. New ideas are the very soul of national progress and are indispensable to the development of any country. If we do not have our own autonomous ability to create innovation and just depend on technology imports from abroad, we will always be a backward country...As we continue to learn from others and to import advanced foreign technology, we must remain focused on raising China's ability to do research and development on its own.'

However, China is extremely careful with technology flows originating from its own domestic R&D, and the MOST has recently taken measures 'to prevent the disclosure of technical know-how and policy secrets', when, for example, 'technicians involved in research for national defence and military projects quit their work without permission of the authorities, causing projects to be suspended and programme secrets to be divulged to other institutions and enterprises'.

As an example of the utility of foreign technologies for the modernisation of China's defence S&T infrastructure, it is likely that the licensed production of Russian Su-27 fighters (Chinese designation J-11) will evolve, following China's historical pattern, into the large-scale production of reverse-engineered indigenous versions equipped with advanced avionics and radar systems developed domestically and transferred from Western sources. Weapons, avionics and propulsion sub-systems transferred with the Su-27 will be applied to other new aircraft types such as the J-8IIM/J-8III, FC-1 and J-10. Advanced materials, avionics, electronics and manufacturing technologies acquired through foreign civil aircraft purchases and joint ventures will also be used for defence projects. Advanced foreign ATC systems will be modified for military applications such as air defence systems, as will the extensive civil pilot and maintenance technician training infrastructure currently being put in place.

A summary of key sources of foreign defence S&T hardware and expertise follows, and are also included in more detail in later chapters for specific technical areas. In addition to the countries mentioned below, other nations such as Japan, France and Italy are also sources of aerospace, defence and dual-use technologies and equipment.

1.5.2 Russia and Former Soviet States

Russia is now annually selling China an estimated US$2 billion of new weapons, with increasing technology transfer requirements, and is China's major supplier of new aerospace-defence technologies of all types. Some reports indicate that thousands of scientists, engineers and technicians from the financially devastated defence industries of ex-Soviet states, particularly Russia, are now working as part of the Chinese defence industry and R&D infrastructure. Chinese funding is also reportedly financing the continuation of Russian military R&D projects (including the advanced Su-37 thrust-vectored variant of the Su-27 fighter aircraft), possibly more than 100 projects to adapt Russian weapon prototypes to PLA requirements, and various joint ventures. Much of this appears to be occurring at the individual business or institute level, out of the official control of the Russian government. Elements of the Russian military and defence industry are becoming increasingly wary of China's growing defence and future export capabilities.

China has allegedly formed secure E-mail links with Russian military, scientific and nuclear organisations, and has received such benefits as computer technologies for simulating nuclear tests. Co-ordinated through a Chinese 'Military-Technical Co-operation Co-ordinating Centre', these activities have, according to unconfirmed Chinese sources, saved hundreds of millions of dollars and reduced up to two decades of R&D effort by Beijing for some areas. Manchuria reportedly has a high concentration of traditional defence manufacturing industry for such products as tanks and other AFVs, aircraft, and artillery, in addition to defence-related educational and R&D institutes that have strong pre-1960s historical ties to Russia. Hence, the 'new' defence relationship with Russia is hardly surprising in some respects.

Reports during early 2000 indicated that some 2,000 Russian technical personnel are engaged in Chinese R&D efforts in directed energy weapons (DEWs), nuclear weapon miniaturisation, cruise missiles, space-based weapons, and nuclear submarines. China has a long-standing tradition of employing Russian/Soviet weapons, which are considered cheap to manufacture in mass numbers and easy to use and maintain compared to Western systems. By 1998, Russian arms sales to China had exceeded US$6 billion.

The recent transfer of more advanced Russian defence technologies to China characterises an emerging close Sino-Russian security arrangement to counter a perceived US global hegemony in the wake of Western actions during the Kosovo crisis, and particularly the US bombing of the Chinese Embassy in Belgrade. However, some recent unconfirmed reports indicate that the new Russian regime under President Vladimir Putin and associated ruling elites may be scaling back the transfer of highly sensitive military technologies to China. Moscow is reportedly concerned over China's growing military power and potential threat and its refusal to make large direct purchases in favour of technology transfers and eventual indigenous production (for example S-300 anti-ballistic missiles, advanced mines, mortars, ATGMs, flame-throwers, and advanced manportable anti-aircraft missiles). China's potential as an arms exporting competitor to Russia's traditional markets is a further source of unease. From Moscow's perspective, it prefers to sell complete systems rather than technology transfer packages. Russian negotiations with China over specific systems have often been prolonged due to wide differences in pricing and technological specifications. However, a declining relationship with the West, perhaps spurred by US-led ballistic and theatre missile defence systems that threaten perceived Chinese and Russian security, and fears of a US-led NATO with ever increasing interventionist global roles, could conceivably lead to further Russian advanced arms transfers such as Oscar-class SSNG and Akula-1-class SSN submarines, Tupolev Tu-22M3 'Backfire' strategic bombers, and the MiG-31 'Foxhound' interceptor aircraft.

Various agreements have also been reportedly been made between Beijing and alternative suppliers for Russian defence technologies such as the Ukraine and Belarus, as well as directly with Russian firms rather than through the official Moscow bureaucracy.

Indeed, China has no illusions concerning the long-term utility of Russia's declining armaments infrastructure to support PLA requirements. Nevertheless, China is currently taking advantage of Russia's misfortunes to obtain the end results of decades of effort by the former Soviet Union. If both countries continue to collaborate China may also benefit from the results of Russia's new programme, introduced in 1999, to modernise its defence electronics and other advanced weapons systems, which lag behind the West. In 1999, China announced that it would increase collaboration with Russia in such areas as space, space stations, aviation and nuclear energy.

1.5.3 United States

The Tiananmen Square tragedy resulted in the US cancelling planned modest defence technology programmes with China, such as the Grumman Aircraft 'Peace Pearl' project to update the J-8 fighter aircraft's avionics systems. However, in recent years, China and the US have openly collaborated in supposedly non-defence S&T areas such as technology management, IT, satellite transmission technology, and nano technology for the production of extremely small machines and mechanisms. A US-China Joint

Commission on S&T has, since the mid-1990s, promoted collaboration between Chinese and American organisations in R&D on innovative advanced materials, pharmaceuticals, energy production and environmental technologies. While the commission is restricted to non-military projects, in 1997 it expanded R&D co-operation to include electricity-driven motor vehicles. However, China has continued to be very active in using other means to obtain advanced US military technologies that reportedly include weapons designs from nuclear laboratories, leading-edge computers, and missile and satellite systems.

Some sources indicate that China has hundreds of US front companies used to obtain key American technology, with a particular emphasis on the California 'Silicon Valley' region and its advanced IT systems. Some 50 per cent of the recent 900 illegal technology transfer cases investigated annually on the US west coast reportedly have Chinese involvement. During 1996, a Chinese firm reportedly obtained advanced US power transmission devices used for airborne missile guidance, fire-control radar, targeting systems, and navigation pods. In the same year, Chinese firms also bought some 77 high-speed supercomputers from US firms that could be used for such applications as communications encryption and nuclear weapons design and simulation. Reportedly during 1997 China had purchased another 47 US supercomputers (some of which were supposed to have been returned following official US government complaints). By 1998 almost half of the 390 advanced US supercomputers exported to so-called 'Tier 3' high-risk nations were exported to China according to American sources.

The controversial May 1999 Congressional report *US National Security and Military-Commercial Concerns with the People's Republic of China* (sometimes referred to as the 'Cox Report', after the select House of Representatives committee chaired by Christopher Cox) focused initially on Chinese nuclear espionage activities in the US but later broadened its mandate. Other technology at least partially obtained by China from the US according to the Cox Report is listed in Table 1.7.

Table 1.7 Alleged US-Chinese Illegal Technology Transfers

· Electromagnetic weapons technologies developed for the US Strategic Defense Initiative (SDI) during the mid-1990s that could be developed as anti-satellite and anti-missile systems.

· Accelerometer missile guidance systems during 1980 that were reverse-engineered.

· Supercomputer technologies, perhaps used for defence applications such as nuclear weapons modelling.

· Ballistic missile technologies that include nose cone designs (a commercial launch vehicle payload 'shroud' is generally considered to be very similar to the 'faring' used to house the MIRV stage of a modern ICBM), improved design and reliability of guidance systems, payload load analysis techniques, quality control and reliability procedures to minimise launch failures from the US firms Hughes Electronics and Loral Space and Communications, and solid rocket motor technologies from other foreign sources.

· Radar technologies.

· Stealth technologies and related manufacturing technologies. (China probably cannot build stealth aircraft or missiles with the same capabilities as the F-117 and B-2, now or in the near future but is likely to try to acquire most of the key elements necessary to build them. Even acquisition of these elements will be insufficient to permit China to build effectively stealthy aircraft or missiles. System integration of stealth is a major additional task facing the PRC.)

· Modern aero-engine systems.

1.5.4 United Kingdom

UK industry has more modest military embargo restrictions for China compared to the USA, and can in theory export non-lethal systems such as avionics, aero-engines, sensors such as AEW radars and surveillance systems, and non-combatant transports.

1.5.5 Canada

A space co-operation memorandum of understanding was signed between the China National Space Administration and the Canadian Space Agency in 1995. Canadian RADARSAT (a space-based synthetic aperture radar system) data applications, L-Band synthetic aperture radar (SAR), geomatics, communications systems, and space robotics technologies are the most likely areas of technology transfer to China.

During 1996, Canada's Com Dev International and the Xi'an Institute of Space Radio Technology moved towards establishing the Com Dev Xi'an joint venture to produce components and electrical subsystems for Chinese communications, remote sensing and meteorological satellite systems into the 21st century. Such components will include space microwave filters, antennas, and ground station wave guide switches, with the agreement including significant associated advanced technology transfer benefits for China that also have defence applications.

1.5.6 Israel

China and Israel have enjoyed a close, if somewhat clandestine and strange, military relationship since at least the early 1980s (some sources state since the late 1960s), when Israel began to transfer key defence technologies to China in such areas as avionics and missile systems. Some estimates have placed total Israeli weapons sales to China in excess of US$6 billion, even though China has simultaneously maintained close defence relations with a number of Islamic states.

1.5.7 Hong Kong

The Hong Kong Special Administrative Region remains a significant conduit to mainland China of advanced foreign technologies but has also in recent years developed a significant R&D and production capability of its own in the IT area that will now become more fully integrated with China's (see Chapter Nine, section 9.2). For example, after the 1989 ban on defence-related technologies imposed on China by the US, Hong Kong firms reportedly supplied China with Vax computer systems, milspec versions of which are used for advanced military systems such as the US Joint Surveillance and Target Attack Radar System (JSTARS). The MOST reported that during 1991 to 1996, the Chinese mainland undertook some 1,812 contracts for introducing new technology from Hong Kong worth a total of US$1.78 billion.

1.5.8 Germany

In 1998, Germany and China celebrated the 20th anniversary of the signing of a China-Germany Intergovernmental Agreement on Scientific and Technological Co-operation that includes the areas of energy, aviation and space, IT, and other areas. China considers Germany to be an important and reliable scientific partner, whose assistance in military-related areas dates back to the 1930s. For example, Beijing's CAS General Establishment of Space Sciences and Applications agreed to a long-term co-operation accord with the German Ministry of Research in 1987, which has recently continued with joint microgravity balloon experiments in biological sciences and gas-combustion with the German Aerospace Centre. Such technical co-operation has continued even during periods of poor relations with other Western nations such as with the US following the Tiananmen Square crackdown in 1989, and now includes the transfer of important space technologies (see Chapter four, section 4.4) when the US is restricting such sales to China.

Unconfirmed reports have suggested that an automotive apprenticeship programme at Baotou, Mongolia, was reportedly jointly funded by NORINCO and Daimler Benz (MTU Division), while other German tank design assistance may have been obtained from Krauss-Maffei and Rheinmetall (see Chapter Six, section 6.1). It has also been recently rumoured that senior officers from the former East German Army are now serving with the PLA in an advisory capacity on rapid reaction force training and operations.

China is now acquiring a significant number of the Russian Sukhoi Su-27SK (shown above) and Su-30MKK fighter-bombers, plus associated advanced weapon systems, and is to develop its own indigenous production capability. The next version purchased may be the Su-32 strike version.
(Source: Jane's)

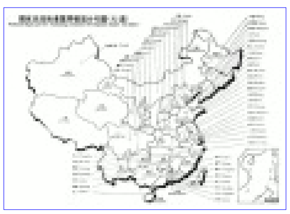


Figure 1.1 Geographical Locations of China's Major Aerospace-Defence Related Centres

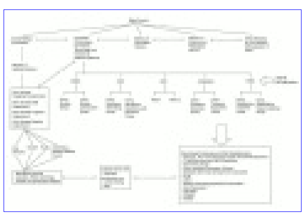


Figure 1.2 Summary of the Overall Organisation of China's Aerospace-Defence Industry

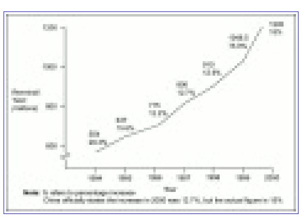
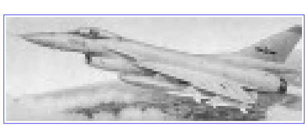


Figure 1.3 China's Official Growth in Defence Spending (1994-2000)

According to some US reports, China may be developing even more advanced fighter or bomber aircraft, such as the supposed "XXJ", indigenously or in co-operation with Russia.
(Source: Fowler Media Graphics/Jane's)



The J-10 is China's current effort to develop an advanced generation of indigenous fighter aircraft for the PLAAF and PLAN, but, like the FC-1, it has been slow to materialise.
(Source: Jane's/K Fretwell)

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CHAPTER 10 - CHINA RISING?

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CHINA RISING?

10.1 Military and Technological Outlook TOP

During August 1999, President Jiang Zemin proclaimed that the PLA "should focus our limited funds on cutting-edge areas of military science and technology" and "improve its ability to fight regional high-tech wars" through a "positive defence" to counter a perceived Western military superiority. He had reportedly been working closely with General Cao Gangchuan, head of the *PLA General Armament (Equipment) Department*, to implement innovations in this direction. A panel head by PLA intelligence chief General Xiong Guangkai was established to prioritise and co-ordinate advanced military R&D, and includes representation from COSTIND, MOST, Ministry of Information Industry, Ministry of Education, CAS, and the Chinese Academy of Engineering. In a sense, these urgent efforts have a parallel with China's past crash programmes to develop nuclear weapons, nuclear submarines, ballistic missiles, and space technologies under Marshal Ni Rongzhen during the 1950s to 1970s. Co-operation with Russia to create a "multipolar world" are also ultimately aimed at a rapid modernisation of the PLA. These views were also outlined in the State Council's 1998 defence white paper, "China's National Defence" that emphasised countering US global hegemonism, defence support for Taiwan, and the growing US-Japanese defence relationship. A book written by serving PLA officers in 1996, "*Can China Win the Next War?*", ranked China's most important enemies in order of importance as the US, Japan, Vietnam, India and Russia. In September 2000, General Cao Gangchuan, at the initial meeting of representatives of the PLA bureaux responsible for dispatching representatives to armaments factories, called for an acceleration of the pace of reform of China's aerospace-defence industry, including improved mechanisms for competition, appraisal and supervision.

S&T development, R&D programmes and foreign technology transfers are crucial for China's defence modernisation plans and efforts to implement a version of its own "Revolution in Military Affairs" (RMA). Potential threats spurring such developments include confrontation with Taiwan, possibly with US and Japanese intervention, and India's ongoing development of strategic weapon systems. China also has significant territorial claims in the South China Sea that it must be prepared to defend against various regional contenders. In addition, there remains historical territorial losses to Russia which, regardless of the current friendly *rapprochement* between the two nations, could once again become a security issue in the future, particularly as China grows economically stronger and Russia weaker and both nations become more nationalistic. Independence movements in Tibet and western provinces with large Islamic populations could also pose serious internal threats that could be exploited by external opponents. However, for at least the near- to mid-term, China's geopolitical-military centre of gravity will likely focus on its south-eastern flank, within its current '*Two Island Chain*' strategy of pushing outs its defensive perimeter.

China's strategic outlook could have dangerous consequences. The PLA may have different perceptions than that of the West on overall US military effectiveness. This is particularly so for logistics capability, the view of the US as a superpower in decline, and the resulting effects of China using force against US and Japanese regional forces in scenarios involving particularly Taiwan and South China Sea territorial claims, and possibly also Korea.

China's evolving RMA doctrine of local war, active peripheral defence, and rapid regional power projection, is being supported by the formulation of new strategic concepts and operational techniques. The "*strategic frontier*" entails a full range of competitive boundaries related to the notion of comprehensive national strength, including land, sea and aerospace frontiers, and more abstract strategic realms related to economic and technological development. "*Strategic deterrence*" implies the non-violent use of military power to deter war or to achieve national political objectives, and "*gaining the initiative by striking first*", rather than passively waiting for an enemy's first blow. This reflects the need for decisive action to pre-empt an attack, restore lost territories, protect economic resources, and resolve a conflict before it escalates.

Purported obstacles to implementing an innovative RMA doctrine include rigid, tradition-minded lines of authoritarian thinking of both the Confucian and Maoist type, and the ingrained historical '*tiyong*' concept of the superiority of all things Chinese over all other nations and cultures (including Western S&T developments). Many older PLA officers remain committed to the traditional Maoist '*People's Warfare*' and the more recent Dengist '*Local War of Limited Duration*' doctrines. However, current indications are that the RMA-with-Chinese-characteristics school of thought is ascending within the younger, more progressive PLA officer corps, and that China will modernise its military with the most advanced technology available to it; as one senior PLA officer recently indicated: 'There is no interest in developing 1980s technology'.

A Chinese asymmetric RMA strategy will emphasise the development of niches of technical excellence (for instance ASAT, anti-stealth, advanced sensors, EMP, DEW, IW, EW). This targets an enemy's weaknesses, rather than attempting to match a major potential opponent such as the US across the board in all areas of leading defence technology. IT systems are seen as both an opportunity and a weakness through the use of innovative IW techniques. Quick, pre-emptive strikes, possibly using ballistic and cruise missiles, are intended to prevent an enemy build-up of strength. It is a common misperception that the PLA will only be capable of Western 1980s-style manoeuvre warfare by as late 2010. The PLA is now changing its fundamental military doctrine and paradigm and will skip generation so equipment, and simply bypass or omit other not suitable for its paradigm, within the next decade. However, modern IW and RMA concepts are to be combined with traditional Chinese military concepts such as those stemming from respected strategists such as Sun-Tzu and Mao Tse Tung. The reality continues to be that the massive PLA's underlying strength is largely dependent upon the traditional *'one rifle, two legs, three meals, and four hand-grenades'* infantry concept, but increasing supplemented, particularly in elite units, through qualitative technical advances.

In addition to changes in doctrine, PLA modernisation must proceed simply because much of its current weapons inventory is comprised of ageing systems based upon 1960s and older technologies that is facing block obsolescence. China also has an increasing nationalistic desire to have military power commensurate with its growing economic power, allowing it to become a more active regional and global player. However, conflicting messages have been sent as to how this power will be obtained. During March 1998, General Fu Quanyou, Chief of the PLA General Staff, warned that China must develop self-sufficiency in high-technology weapons, and not become reliant upon foreign imports, while during July 1997, Beijing had announced that it was opening its defence industry to foreign investors to spur its technological modernisation. As reviewed in previous sections of this report, the answer is likely the integration of domestic R&D capabilities with leading-edge foreign technology transfers. By and large, by the year 2010 all branches of the PLA will likely be fully modernised to a level approaching that of Western militaries.

Improved Chinese defence technologies could also allow China to gain a large part of the international arms export market that was previously served by the Soviet Union (and Russia is attempting to regain). China could use these exports to fuel further economic development and economic reform, and allow an overall strengthening of Beijing's internal domestic and external regional political leadership.

However, a fundamental question remains: is China's defence industry capable of converting the results of its myriad R&D programmes into sustained weapons production of high volume and quality? A somewhat tongue-in-cheek comment about the Chinese defence industry is that it is 'capable of putting together at least one of almost anything'. The approach taken to date has been to produce and procure relatively small batches of new major systems (the PLA has in the past been referred to as the 'junkyard army' because of the variety and varying levels of quality of its fielded systems). Overall, China's space (launch vehicle and satellite), missile, nuclear submarine, nuclear weapon and high-energy physics programmes have historically demonstrated its latent technical ability to successfully complete major, institutionalised, complex S&T-derived defence programmes if sufficient resources are allocated from the top political-military hierarchy.

China lost an important opportunity for a broader-based and more sustained S&T infrastructure development during the 1960s and 1970s when the Cultural Revolution stifled most innovation. This occurred at a time when the economies of the US, Europe and Japan benefited profoundly from high-tech advances to spur economic growth and military modernisation. Recent S&T programmes through COSTIND, the PLA's GED and the MOST to improve co-ordination of national R&D and related product development and manufacturing efforts should improve the overall capability of the Chinese defence industrial base. So should the rapidly expanding national system of research parks, innovation centres and special economic zones (SEZs) for advanced technology R&D and manufacturing. In addition China is likely to possess the world's largest pool of talented young people to draw upon for S&T modernisation. Some forecasts indicate that China will have the world's largest economy by the year 2020, potentially making large resources available for the efforts needed to achieve the PLA's RMA.

China's increasing domestic dual-use technological capabilities, largely orchestrated by COSTIND and MOST, are also being enhanced by large-scale technology transfers from the West and Russia. This is so in such areas as various leading-edge information technology (for instance highly miniaturised integrated circuits, rapid-transmission and large data capacity telecommunications systems, and various types of supercomputers), advanced composite materials, state-of-the-art nuclear power systems, and a broad range of innovative aerospace systems. The military implications of China's current technological transformation has been largely ignored and is sure to result in more than a few surprises related to aircraft carriers and other defence systems within the next several years.

However, major short-term obstacles remain concerning the ability to functionally absorb advanced foreign technologies. These include:

- The associated difficulties of reverse-engineering many high-tech components and sub-systems;
- Insufficient linkages between R&D and product innovation, and between the traditional defence industrial base and the new emerging commercial high-tech sectors;
- Lingering Soviet-style bureaucratic management practices in government R&D establishments; and
- The potential loss of the best scientists and engineers to the non-defence commercial sector.

Problems also exist with shortages of specialist scientific and technical personnel and infrastructure in some areas, although significant progress is now being made to address this shortfall.

Quality assurance for production in areas such as aerospace and IT often reportedly remains below Western standards, but is now improving, as is systems integration. Logistics often similarly suffers for operational systems, and is a major current focus for R&D activity by organisations such as the PLA's *Logistics Science and Technology Development and Exchange Centre*, Beijing. While the Chinese economy continues its modernisation drive, the basic nature of the Chinese socio-political-economic system is that considerable leadership direction is still necessary from 'the top-down' before innovation and change can be implemented from 'the bottom-up'. This could tend to stifle the implementation of any radical military S&T developments. Economic modernisation itself has been related to increasing levels of bureaucratic, commercial and military corruption and overt profiteering. Another cycle of political upheaval along the lines of the past Cultural Revolution, while now increasingly unlikely, would certainly halt China's economic and S&T modernisation and any efforts to achieve a new RMA.

In summary, areas of China's most *likely* defence innovation and related R&D include:

· Continued incremental technical improvement for the PLA in the areas of mobility and transport (for instance heavy airlift), combined-force operations, C4I systems, logistics, and equipment standardisation;

· The evolutionary improvement and procurement of major weapons systems such as combat aircraft, missiles, fighting ships (including aircraft carriers and more advanced surface combatants, and conventional and nuclear submarines), artillery (including guided multiple launch missile systems) and armoured fighting vehicles through both domestic developments and foreign procurements; and

· The development of elite, relatively small, rapid-reaction combat units (for instance mechanised, airmobile, marine), suitable for contained regional conflicts, that are equipped and trained to a standard approaching or equalling that of modern Western forces, and gradually leading to an increased regional (ie. Asia-Pacific) power projection capability over the next decade.

In the above *likely* scenarios the PLA would overall continue to lag technologically, perhaps by a decade or more, compared to the military forces of the US, UK, Japan and other advanced Western nations. This scenario is likely underway now, and will increase in momentum during the next decade as a new RMA doctrine is implemented.

Potential areas of more *radical* innovation could conceivably take the form of new capabilities realised through the unique ('with Chinese characteristics') integration of various ITs, advanced materials and advanced manufacturing systems:

· A mobilisation scenario could include mass units of light infantry equipped with effective, but cheaply manufactured, high-tech weapons, linked together with adequate modern C4I systems (including mobile digital communications systems) all within a common combat doctrine to permit operational integration with more sophisticated rapid reaction elite 'fist units'. The latter could be a high-tech form of 'People's Warfare' through a fusion of conventional and irregular techniques.

· In combination with the above, the use of various cost-effective innovative technology weapons (for instance IW, PGMs, and advanced sea mines), combined with unconventional tactics, could provide an effective *asymmetrical warfare capability* against superior, more conventionally structured, enemy forces

· An *accelerated* domestic development through foreign technology transfer and procurement of advanced aerospace systems such as stealth fighter aircraft, long-range GPS-guided cruise and ballistic missiles for precision deep-strikes together with improved conventional munitions and more flexible mobile launch operations

· An *accelerated* qualitative, and perhaps quantitative, build-up of tactical and strategic missile forces (including mobile solid-propellant ballistic missiles), and related military space-based C4I assets, together with a corresponding shift in doctrine from a countervalue retaliatory to a pre-emptive counterforce strategy.

The above radical scenarios could provide the PLA with a regional comparative advantage, or even 'leapfrog' capability, compared to advanced Western militaries (including Japan). Such scenarios could become increasingly likely during the next decade.

Potential military S&T *breakthrough* areas for China include:

· Advanced ITs used for various IW and EW applications to provide an overall *asymmetrical warfare strategy* against superior enemy forces. In particular leveraging relatively inexpensive technologies against costly enemy weapons platforms. This could include specialised radars or other sensors to detect high-tech manned stealth aircraft, which could then be destroyed by PGM or DEW systems.

· DEWs such as laser and RF systems, that could provide broad tactical and strategic advantages for ASAT, BMD, anti-aircraft, anti-optics, and anti-personnel applications.

· Procurement and mass production of sophisticated long-range stealth cruise missiles with precision guidance systems (combined inertial/TERCOM/GPS), advanced RPVs and space satellites for reconnaissance and other IW applications. This could be supplemented with a new generation of ballistic missiles, combined with a fusion of advanced sensors such as SAR, laser radar and OTH radar systems. This could then see the PLA move towards an '*unmanned missile strategy*' in which manned combat aircraft would become of decreasing importance - a so-called '*reconnaissance-strike complex*'.

· Space systems, including some high-value sophisticated manned platforms and vehicles (for instance hypersonic aero-spacecraft). In addition advanced telecommunications, unmanned reconnaissance, surveillance, targeting, ASAT and BMD systems could be used to counter the space-based defence assets that the US and other Western powers are becoming increasingly reliant upon. This could be referred to as a '*Tianjun*', or '*space army with Chinese characteristics*'

· The development of some form of a genetically-tailored biological warfare capability is considered a long-shot because of likely political restraints, potential ethical considerations, and intense international opposition. However, this is likely to be technically feasible based upon China's R&D trends in biotechnology.

The above *breakthrough* scenarios are probably not likely until 2010 or later. Combined with the more near-term *likely* and *radical* scenarios, this could have profound implications for both the military capabilities of the PLA and China's aspiration to be an global economic and military superpower. These unique RMAs would also have economic implications for the Western defence aerospace-industry as many heavily funded systems (including the F-22, JSF, large aircraft carriers, and vulnerable satellite systems) could be perceived as being inappropriate or obsolete in the new strategic environment and possibly cancelled or heavily scaled-back in procurement. As a 1997 US Defence Intelligence Agency (DIA) assessment concluded:

'Following the doctrinal change to prepare for local war under high technology conditions, China's military is also emphasising key force multipliers (eg. electronic countermeasures, low observable technologies, advanced SAMs, information warfare capabilities and unconventional countermeasures and tactics)... Overall, China is one of the few powers with the potential - political, economic and military - to emerge as a large-scale regional threat to US interests within the next 10 to 20 years.'

Another recent US Department of Defence analysis concluded that an increased Chinese missile force, backed by space-based systems, will be the 'cornerstone of PLA warfighting early in the 21st century', and a 'devastating weapon of military utility':

'*In the most likely scenario for their use, the PLA's growing arsenal of highly accurate and lethal theatre missiles, and a preemptive doctrine could give Beijing a decisive edge in any future conflict with Taiwan... The PLA has indicated a willingness to use highly accurate short-range ballistic missiles, medium-range ballistic missiles and land attack cruise missiles against US assets, to include key bases in Japan and aircraft carriers operating in the Western Pacific*.'

10.2 Future Strategic Options TOP

Many analysts currently believe that under most circumstances, it appears unlikely Beijing will aspire to much more than the Chinese equivalent of the French strategic nuclear *force de frappe*. However, as discussed, the PLA does not completely accept the idea that nuclear weapons will have no utility in future wars. This is a view held predominantly by elements within the PLA. There are also many Chinese officials, particularly within the Ministry of Foreign Affairs, that have argued for the reduction or elimination of nuclear weapons. Beijing has continued the steady modernisation of its relatively small arsenal of nuclear weapons and delivery systems, and opposes cuts to this arsenal while the US and Russia perhaps each maintain over twenty times the number of weapons that China likely possesses.

Some Chinese strategists have proposed that limited deterrence requires:

1. A greater number of smaller, more accurate, survivable, and penetrable ICBMs, SLBMs as countervalue retaliatory forces;
2. Tactical and theatre nuclear weapons to hit battlefield and theatre military targets;
3. Ballistic missile defence system;
4. Improve survivability of their limited deterrent forces;
5. Procure space-based early warning and command and control systems; and

6. Develop ASATs to destroy enemy satellites during a major conflict.

As China's nuclear doctrine evolves and its growing counterforce requirements become more obvious through the potential advantages of destroying and threatening military capabilities before they can be used, some Chinese strategists have expressed frustration over the military restrictions placed by China's traditional 'no-first-use' of nuclear weapons doctrine. Some recent writings attempted to qualify China's no-first-use doctrine to allow a retaliatory strike on warning or even a first strike when clearly threatened. Although China's no-first-use doctrine has not yet been officially repudiated, it is under assault by elements within the PLA and its future may be in question. China may have originally developed the neutron bomb for use on its own territory against invading Soviet forces. US physicist Sam Cohen in '*Father of the Neutron Bomb*' claims that the US government during the Reagan and Bush administrations secretly provided this technology to China to help counter a potential massive ground attack by the former Soviet Union. He believes this would be useful to China in a future conflict with Taiwan, since the PLA would intend to occupy a Taiwan left relatively intact.

The Persian Gulf war provided a breakthrough in Chinese doctrinal development for battlefield and theatre-level tactical missile systems. The Iraqi use of conventionally armed Scuds and the US use of Tomahawk precision-guided cruise missiles led the PLA to conclude that shorter-range cruise and ballistic missile systems could have an important role in demoralising an adversary by inflicting unacceptable levels of losses on important political, economic, and military targets. This could be supplemented with warnings of further escalation of the conflict to a nuclear level. In essence, the Chinese have come to recognise the value of missiles in combat and see them as an essential component in establishing a credible escalatory ladder that ties those systems to the national strategic deterrent forces. The implications for a future conflict with Taiwan are clear.

A number of recent articles by PLA authors have outlined China's evolving strategic doctrine and related thinking. It is claimed that over the past two decades considerable progress has been made on command systems, battlefield construction, weapon tests and maintenance systems, and weapons quality has been improved. General objectives of the current strategic modernisation programme are the development of a new generation of ballistic missiles with increased range, accuracy, survivability and penetration against BMD systems, along with smaller warheads that could be MIRVed or fitted to tactical missiles. This would be accompanied by improved command, control and communications systems and related space-based assets. The well-educated officer corps of the Second Artillery will likely have a significant influence on the development of future Chinese strategic force structures and doctrines. Future specific R&D directions, according to Second Artillery Force writings, are summarised in Table 10.1.

The Cox Report notes that the deployment of a new generation of thermonuclear weapons provides China with additional doctrinal and operational options for its strategic forces that could be troublesome for the US. This is because smaller, more efficient MIRVed warheads could overcome BMD systems. China has recently expressed considerable opposition to the deployment of BMD systems by the US and its allies in Asia, what it terms 'the practice of grabbing the spear in one hand while holding a shield in the other'. Other advantages of increased warhead yield-to-weight ratios include extended missile ranges and accuracy improvements, with smaller warheads resulting in a more compact missile payload, extending the range of ballistic missiles, and allowing the use of smaller-diameter SLBMs and mobile missiles to strike long-range targets. Longer range SLBMs could permit PLAN ballistic missile submarines to strike the long-range from the safer bastion of home waters, protected by friendly air and naval forces. It is also forecast that China's current modernisation programme could result in the deployment of a PLA missile force consisting of up to 100 modern ICBMs equipped with 'upwards of 1,000 thermonuclear warheads', in addition to the stockpiling of additional numbers, within fifteen years.

A 1997 US Department of Defence report to Congress indicated that China has the potential to build "as many as a thousand" new ballistic missiles over the next decade. Various sources have suggested that China is developing a variety of new ballistic, cruise, and anti-missile systems, as well as associated advanced guidance systems and satellites to improve missile accuracy. In addition to domestic R&D efforts, foreign technology projects are being undertaken to improve future PLA missile systems. Increasingly, the Second Artillery will be equipped with highly destructive non-nuclear warheads. Evolving PLA doctrine will likely see, in addition to the use of a strategic nuclear-armed missile deterrence force, a range of uses for nuclear and non-nuclear armed missiles at the regional level. An *asymmetrical missile strategy* could allow the PLA to exploit deficiencies in the military forces of the US and potential regional adversaries. Information warfare (IW) and space-warfare activities could also see an increased future emphasis by the Second Artillery. China could rely on short-range ballistic missiles to overcome the current technical superiority of Taiwan's air force during an invasion attempt. Recent US intelligence estimates have indicated that the Second Artillery could deploy up to 650 DF-15 and DF-11 short-range ballistic missiles to areas near Taiwan (Fujian Province). Some believe that the correlation of forces in Asia-

Table 10.1 Areas of Chinese Strategic Weapons R&D

· *Improved Strategic Weapons Survivability* - '...an important factor in waging a nuclear counter strike." We should strengthen research on small, solid fuel and highly automated mobile missiles and on the technology of invisibility (stealth) for revamping defence works against nuclear or non-nuclear strike and improve survivability of the missiles before launch and in flight."

· *Improve Striking Power* - To improve the striking ability of strategic nuclear weapons through increased accuracy and power; "To increase the credibility of limited nuclear deterrence, we should work to improve accuracy and our new generation of strategic weaponry should be of higher precision."

· *Improve Penetration Technology* - "Strategic weapons can be used in actual fighting only when they can penetrate enemy defences and reach and strike the target. This is a necessary condition to protect itself and destroy the target." Regarding strategic and space based BMD under development by the US and others, "In an era when space technology is developing rapidly and a defence system with many new methods and many layers is appearing, we should pay particular attention to breakthrough technology."

· "We should strive to build a small in number but effective strategic Missile Corps with Chinese characteristic. In future development, the advanced quality of strategic weapons will rely to a large degree on the development of high technology and reflect the comprehensive power of a country." We should develop a limited number of high quality strategic nuclear weapons that could be used effectively to strike back against an enemy using nuclear weapons to attack us."

· *Small Sized Ground Penetrating Nuclear Weapons* - With an equivalent of ten tons of TNT, these explode 10 to 15 metres beneath the ground surface and are ideal for destroying command posts and all underground defence works. These could also be used against enemy air-fields for creating significant radioactive craters.

· *Small Sized Anti-Missile Nuclear Weapons* - With an explosive equivalent of 100 tons of TNT. These could be used to intercept incoming nuclear tipped missiles.

· *Small Sized Ground or Air to Ground Nuclear Weapons* - With a yield equivalent of 1,000 tons of TNT. One senior member of the PLA has indicated that such tactical nuclear weapons 'could have stopped the retreat of Dunkirk' (thus providing an interesting insight into the PLA's thought processes on nuclear issues).

· *Unintended Nuclear Fallout* - of conventional wars in which nuclear reactors and similar sites are attacked. "In a high technology conventional war, a nuclear environment may still emerge even if nuclear weapons are not used". In a future high-tech war, if an enemy intentionally or unintentionally attacks nuclear power plants or other facilities using nuclear energy with high-tech conventional weapons, the secondary nuclear radiation produced would likewise do unmeasurable harm.

areas near Taiwan (Fujian Province). Some believe that the correlation of forces in Asia-Pacific may have already tipped towards China because of its ever growing superiority in theatre ballistic and cruise missiles. In addition to improving and expanding their inventory of strategic missiles, the Chinese are also likely to undertake R&D to reduce the radar cross-section of their RV warheads, harden these against electromagnetic pulse (EMP) effects, and improve their capabilities for penetrating missile defences. China is assuming that nations such as the US, Japan, South Korea and the contested Chinese territory of Taiwan will be developing sophisticated BMD systems. This will likely stimulate the creation of a larger, more capable, survivable and lethal Chinese nuclear deterrent force to maintain China's credibility as a strategic power into the 21st century.

10.3 China's Future Aerospace-Defence Infrastructure Development TOP

The future development of China's aerospace-defence sector lies in the effective integration of domestic R&D efforts with key foreign advanced technology transfers, and developing appropriate product manufacturing and maintenance systems. One definition of technology transfer is the transmission, and sometimes the creation of technological knowledge with or without the concurrent transfer of goods and services. In practice this is normally accomplished either through a complete or limited purchase, or by licensing limited rights usually for a fixed period of time. The factors involved in the transfer will include patents, trademarks, industrial design, copyright, and trade secret "know-how" or "show-how". In its entirety this includes the functional relationships between R&D, innovations and know-how, and alternative methods for the international flow of proprietary technology. This includes the export of commodities; licences; direct investment abroad; sale of turn-key plants; joint ventures; and the direct sale of know-how. A related concept is "technology diffusion" which refers more to the general, progressive spread of established technologies nationally and internationally, compared to technology transfer which is more of an organisation-to-organisation process. Technology transfer, particularly for sensitive military systems, is not always accomplished through legal mechanisms. Covert acquisition of knowledge, hardware and personnel, and the unauthorised reverse-engineering of equipment are practical means of obtaining new technologies.

A primary factor to consider is that in today's environment of advanced computer and telecommunications technologies (where complete blueprint files can be e-mailed at the stroke of a key). It is difficult to hinder for very long the technology transfer and diffusion of even advanced strategic technologies. This is further exacerbated by multi-national education and R&D programmes, and a decreasing monopoly on almost any advanced technology by any one nation,

The original Chinese nuclear, strategic missile and space programmes were an amalgamation of Chinese ingenuity, Western scientific experience, and largely Soviet technology. China is now achieving an overall qualitative technical "Great Leap Forward" through the acquisition of a broad range of civil, military and dual-use technologies from a variety of foreign sources. This has been accomplished through an "Open Door Policy" and a corresponding "Four Modernisations Plan" for the transfer of such advanced technologies through such mechanisms as joint-ventures and partnerships with Hong Kong firms and the ethnic Chinese communities of other nations (office of such firms are often located at key locations such as California's "Silicon Valley" to obtain first-hand knowledge on leading-edge developments). To arguably further accelerate this innovation process, Chinese defence industries have traditionally been vertically integrated and produce both military and civilian products. For inward technology transfer flows, China generally prefers arrangements that provide access to technologies that will eventually permit the development and production of domestic systems, rather than the continued purchase of "off-the-shelf" weapons. China's bitter experience with the Soviet Union withholding some of its most advanced military technologies during the 1950's, followed by a complete split in 1960, has reinforced the need for domestic self-reliance for defence requirements. For instance the recent sale of Russian Su-27 fighter aircraft also includes extensive technology transfer and co-production provisions.

China's strategic (*zhanlue*) development activities could also be viewed in the context of a "techno-nationalism". This views advanced, dual-use technologies as basic aspects of both national security and economic development, and that a national development policy must have specific strategic underpinnings. In addition strategic technologies must be indigenised and diffused throughout the nation as a high priority and as a means of stimulating a high-technology and self-reliant (*zili gengsheng*) industry. The PLA, perhaps beginning with the technocratic and visionary *Marshal Nie Rongzhen* during the 1950s and 1960s nuclear and ballistic missile programmes he guided, has used this doctrine to rationalise expensive, esoteric strategic defence systems as a means of advancing the national technological infrastructure. Sophisticated (*jianduan*) technology is a prerequisite, in the Chinese perspective, for modern "great power" (*daguo*) status. Marshal Nie used such an argument for the development of, doe example, dual-use heat-resistant materials, precision alloys, artificial crystals, and other advanced technologies used for strategic defence programmes. This comprised of not just strategic weapons, but of strategic technologies of broader economic competitiveness scope and significance. In 1999, the State Council announced a new national S&T policy that stated: *"The increasingly fierce competition of integrated national strength, a nation's level of high tech development and its associated industrialisation has become the niche for such competition and the lifeblood in defending a nation's sovereignty and economic security. It is a strategic decision to ensure the Chinese nation's invincible position in the international competition in the new century... Domestic research activities shall be integrated with the introduction and digestion of imported technologies".*

In this doctrine, Marshal Nie, and China's current leadership, may have been influenced by the modern Japanese model of the relationship between advanced defence technology and overall national industrial competitiveness (ie. the notion of "rich nation, strong army"). The related argument has been made that from the Second World War technologies of British radar, American computers, American nuclear weapons, and German guided missiles were derived the underpinnings for modern technological change and today's so-called "information economy" with its emphasis on R&D programmes and innovation. In the Chinese perspective, key central government organisations at the very apex of the central planning system that still underlies China's contemporary mixed economy (eg. COSTIND, MOST, CAS, Ministry of Information Industry) have responsibility for funding and managing all large forward-looking R&D programmes because of the large costs, long timelines, and strategic national security implications. Such long-range R&D planning is simply not viewed as feasible at the individual firm level which tends to focus on short-term gain. Even when seemingly contrary to traditional Maoist notions of anti-elitism, Chinese scientists and engineers working on strategic programmes have usually been allowed a fair amount of freedom, decision making, and flexibility to pursue innovative concepts and ideas, often cutting across traditional bureaucratic and organisational boundaries through network-based co-operation. However, the PLA has also enforced a strategic programme performance metric based upon universal standardisation and rigorous benchmarking against international technological standards and developments. Even during the darkest days of the Cultural Revolution when much of China was isolated from the outside world, strategic programme scientists had access to current foreign literature related to their projects. For instance the competing reactor designs for the first Chinese nuclear submarines were based upon foreign designs - one West German, the other Soviet). Large-scale bureaus were developed as clearing-houses for the collection, translation and dissemination of important foreign information. These are still very active in the aerospace, nuclear and defence sectors. Today's "863 Programme" for the development of new and innovative strategic dual-use technologies of national importance is a direct legacy of earlier strategic programmes with their military-style management structures.

The international political and business environment currently exists for China to obtain advanced foreign technologies to significantly upgrade its weapons of mass destruction capabilities. During the Cold War, the Coordinating Committee for Multilateral Export Controls (COCOM) established multilateral controls on exports to the Warsaw Pact allies and mainland China of machine tools that restricted linear positioning accuracy below microns, and could be used for missile and nuclear weapon development. However, since the collapse of the Soviet Union, the consensus for relatively strict export controls has to a large extent dissolved. The post-Cold War control regime was embodied in the 1996 Wassenaar Arrangement, and the 1978 Nuclear Suppliers Group Agreement (NSG, or London Suppliers Group established in 1974). These govern the export of machine tools that can be used for nuclear weapons development, and have both generally adopted similar control parameters for advanced machine tools. China is not a proscribed destination for machine tools and other commodities under the Wassenaar Arrangement; Wassenaar regime members treat exports to China according to their individual national discretion. China, although qualified, was not a member of the Wassenaar Arrangement for conventional arms and dual-use export restrictions as of 1999.

However, exports to China of NSG-covered items require individual validated licences. A wide range of composite materials and structures fabrication equipment is included in the MTCR, subject to export control regimes at some threshold of capability, including composite filament winding, tape laying, weaving, and fibre production equipment. However, most of these manufacturing technologies and processes are dual-use in nature and can be widely obtained for ostensibly civil applications. For example, China has likely obtained stealth design technologies and advanced composite materials from US and European firms through civilian joint ventures that can be applied to advanced unmanned cruise missiles and manned military aircraft that are nuclear-capable.

However, China is simply not dependent upon foreign technology and materials transfer for its strategic programmes, and has in the past been near-autonomous in this field. Beijing could again become so if required by political events, and is in fact a *major supplier state* for missile technologies and nuclear systems (including. enriched uranium and uranium enrichment technology, research reactors, nuclear scientific and technical training). China is blessed with a vast natural storehouse of the radioactive materials and metallic ores required for the production of almost any imaginable strategic system, and has developed the vertically and horizontally integrated infrastructure to exploit these resources. The abrupt disruption of Soviet military assistance by 1960 taught China a bitter lesson: never totally depend on another nation for national security requirements and technologies, and implement a strong policy of national self-reliance (for which Mao had reportedly suggested that 'Khrushchov should be awarded a one-ton medal'). However, China will continue to seek to obtain advanced foreign technologies to incrementally improve its domestic capabilities from any source and by any means possible. This is why China simultaneously exports its proven dual-use nuclear systems to states such as Iran and Pakistan, and imports new commercial reactor systems from Canada, Russia and France.

While traditionally China has professed this policy of 'self-reliance' in all matters related to national defence, in practice it is also eager to obtain knowledge and key technologies from almost any source possible so that it can it eventually establish its own R&D and production base for such technologies. The transfer of foreign military and dual-use technologies, in such areas as advanced aerospace and nuclear systems, are central to China's defence modernisation drive, even as it continues its own national efforts to develop key enabling technologies and defence systems. China's massive R&D infrastructure will be a key factor for the transfer and assimilation of these new technologies, and appears to be increasing adept at the integration of technologies from multiple foreign sources. While the US and other Western nations can attempt to place safeguards on the direct transfer of technologies and materials, attempting to halt the diffusion of related knowledge is an almost impossible task in today's world. *China's proliferation of aerospace-defence technologies to third party nations will also have a 'multiplier effect' on its own technological capabilities because of increased opportunities for technology transfer and diffusion. China's national interest motives for such transfers are economic gain, plus regional and global strategic and political influence. The strategic technologies that China can transfer abroad are directly related to those it develops and deploys domestically. Almost all export items are deployed or used by the PLA or domestic nuclear and space agencies.*

The PLA amphibious tanks assault a beach during a week-long exercise a week before Taiwan's parliamentary elections, on an island off the southeastern province of Fujian.
(Source: PA)

The Chinese '863' R&D programme gave rise to a mobile, remotely controlled robot with sensors and end-effectors.

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 Ben Sheppard; Dr Howard DeVore

CHAPTER 2 - AIRCRAFT AND PROPULSION SYSTEMS

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AIRCRAFT AND PROPULSION SYSTEMS

2.1 R&D and Production Infrastructure TOP

Some estimates indicate that China's aerospace industry has developed and manufactured over 15,000 military and civil aircraft in 27 models, 54,000 aero-engines in 25 models, and a massive amount of manufactured airborne subsystems and avionics equipment (3,000 types of systems as of 1998). Specialised capabilities for the R&D and production of fighters, bombers, attack aircraft, transports, helicopters, trainers and special purpose aircraft such as RPVs (remotely piloted vehicles) and ultra-lights have been maintained. Some 35 independent R&D, product design, manufacturing process, and materials research institutes, and 116 enterprises, many with their own varied research capabilities, had been established. The Chinese central government claims that over 60 per cent of its production was now civil-oriented, and related to many non-aerospace economic development activities, many in the areas of advanced technologies.

China's aviation sector alone currently consists of some 200 enterprises that produce and manufacture products such as aircraft, aero-engines, aircraft components and subsystems, industrial gas turbines, and various electro-mechanical products. Some estimates indicate that the sector employs of over half a million trained designers, engineers, technicians, and factory workers. The total number of major aerospace-defence organisations that include aviation, space, missile, ship, electronics and weapons related activities would probably increase this total significantly. Supporting the major enterprises is a much larger network of subcontractors and suppliers. For example, the development of the J-8II fighter apparently involved the co-ordination of some 47 manufacturers and R&D institutes.

However, the sector is facing serious challenges. PLAAF personnel numbered some 370,000 until recent reductions and are organised into seven air force military regions, while PLAN aviation has approximately 34,000 men. Undoubtedly the bulk of today's massive PLAAF and PLA Navy fighter, attack and bomber aircraft inventory (an estimated total of over 4,000 fighters/trainers and over 1,000 bombers and attack aircraft) is comprised of obsolete designs dating from 1960s and earlier technology. Thousands of retired PLAAF and PLAN aircraft are believed to be stored in central China. With many of its military aircraft nearing the end of their serviceable life, China is today facing a serious block obsolescence problem.

Only a small portion of China's potential aircraft manufacturing capacity is believed to be in use. Since the early 1980s to the mid-1990s, some estimates placed Chinese combating and military training aircraft production at approximately 100 to 200 per year. For example, about 50 J-7s and 10 to 24 J-8s were produced annually. Some other estimates suggest that the Hengdu plant alone has the capability to manufacture 500 fighter aircraft per year, while others believe that China's annual fighter production capacity may be about 1,000 aircraft. Military production often accounts for only 20 per cent of production in many defence plants, and this is probably a low percentage of actual inherent defence production capacity that could be increased during a crisis.

PLAAF/PLA Navy technological deficiencies, particularly when compared against technologically advanced threats posed by the United States, Russia, Japan and Taiwan, include the need for more advanced aircraft, modern avionics, electronic countermeasure (ECM) systems, more powerful airborne weaponry, and improved surface-to-air missile systems. Military operational structures, doctrine and supporting technical assets are also thought to be up to two decades behind, in some respects, compared to other major powers. The economic and political turmoil of the Cultural Revolution had a serious negative impact on pilot training and logistics during the 1960s and 1970s that the PLA is only today recovering from. The PLA has made serious efforts since the 1980s to increase the education and training level of its pilots. Superannuated pilots were retired or assigned to ground duties, while all new pilots are at least middle-school (senior high school) graduates. A key core of the PLA aviation force structure is today rapidly proceeding towards modernisation and should see significant gains during the next decade.

Key current clusters of aircraft manufacturing, maintenance, education and training, and R&D in China by city and province are summarised in Table 2.1.

Table 2.1 Current Chinese Aviation Industry Geographical Clusters

Beijing

· Aviation Industries of China Corporation (AVIC)

· Beijing Aeronautical Manufacturing Technology Research Institute

· Beijing Aircraft Maintenance and Engineering Corporation (AMECO)

· Beijing Aircraft Materials Institute (Beijing Institute of Aeronautical Materials)

· Beijing Chang Cheng Aeronautical Measurement and Control Technology Research Institute

· Beijing Flexible Manufacturing Systems Experimental Centre

· Beijing Institute of Aerodynamics

· Beijing University of Aeronautics and Astronautics

· Changcheng Institute of Metrology and Measurement

· China Aero-Information Centre

· China Aeronautical Project and Design Institute

· China Aero Polytechnical Establishment

· China Aerospace Tooling Association

· China Aero-Technology Import and Export Corporation (CATIC)

· China Aviation Construction Development Corporation

· China Aviation Industry Civil Products Corporation

· China Aviation Industry Supply and Marketing Corporation

· China Defence Science and Technology Key Laboratory for High-Energy Density Beam Processing Technology

· China Institute of Aeronautic Systems Engineering

· China National Airborne Equipment Corporation (CNAEC)

· China Precision Engineering Institute for Aircraft Industry

· Chinese Aeronautics and Astronautics Establishment

· Chinese Society of Aeronautics and Astronautics

· National Engineering Research Centre for Computer Integrated Manufacturing Systems Seek (China) Opticals Technic Company, Ltd.

Anhui Province

· Hefei Artillery Academy, Hefei

· Hefei Wanan Machinery Factory, Hefei

Fujian Province

· Taikoo (Xiamen) Aircraft Engineering Company Ltd. (TAECO), Xiamen

Guangdong Province

· Guangzhou Aircraft Maintenance Engineering Company Ltd. (GAMECO), Guangzhou

· National Engineering Research Centre for Powder Metallurgy of Titanium and Rare Metals, Guangzhou

· Shenzhen General Aircraft Company Ltd., Shenzhen

Guizhou Province

· Aircraft Design Institute of China National Guizhou Aviation Industry

· Guizhou Aircraft Industrial Corporation, Anshun

· Shuangyang Aircraft Manufacturing Factory, Anshun

Hebei Province

· Shijiazhuang Aircraft Manufacturing Corporation, Shijiazhuang

Heilongjiang Province

· Harbin Aerodynamics Research Institute, Harbin

· Harbin Aircraft Manufacturing Corporation, Harbin

Henan Province

· Luoyang Institute of Electro-Optical Equipment, Luoyang

· National Engineering Research Centre for Superhard Materials and Related Products, Zhengzhou

· Zhengzhou Institute of Aeronautics (Aeronautical Industrial Management), Zhengzhou

Hubei Province

· China Research Institute of Aero-Accessories, Xiangfan

Hunan Province

· National University of Defence Technology, Changsha

Jiangsu Province

· Changzhou Aircraft Factory, Changzhou

· Nanjing University of Aeronautics and Astronautics, Nanjing

Jiangxi Province

· Changhe Aircraft Industry Corporation, Nanchang

· Chinese Helicopter Research and Development Institute, Jingdezhen

· Jiangxi Blue Sky Advanced Technology Development Company, Nanchang

· Jiangxi Research Institute of Meteorological Sciences, Nanchang

· Jingdezhen Helicopter Group, Jingdezhen

· Nanchang Aircraft Manufacturing Company/Hongdu Aviation Industrial Group (HAIG), Nanchang

Liaoning Province

· Huaxia (China) Magnesium Products Export Group, Haicheng

· Shenyang Aircraft Industry Group of China (Shenyang Aircraft Manufacturing Corporation), Shenyang

· Shenyang Aircraft Research Institute, Shenyang

· Shenyang Research Institute of Automation (National Engineering Research Centre for Robot Technology), Shenyang

Shaanxi Province

· Acoustic Engineering and Detection Technology Laboratory, Xi'an

· Aeronautical Fluid Dynamics Laboratory, Xi'an

· Aircraft Strength Research Institute, Xi'an

· China Aeronautics Computing Technique Research Institute, Xi'an

· China Flight Test Establishment (Flight Test Research Institute), Xi'an

· Flight Automatic Control Research Institute, Xi'an

· Northwest Polytechnical University, Xi'an

· Shaanxi Aircraft Company, Chenggu

· Shaanxi Liaoyuan Aero-Mech Corporation, Yang Xi'an

· State Key Laboratory of Solidification Processing, Xi'an

· State Special Laboratory of Thermal Engineering Information Processing, Xi'an

· Tianda Aero-Industry Corporation, Hanzong

· Xi'an Aircraft Company, Xi'an

· Xi'an Aircraft Industrial Group, Xi'an

· Xi'an Aircraft Design and Research Institute, Xi'an

· Xi'an Aisheng Technology Corporation, Xi'an

· Xi'an ASN Technology Group, Xi'an

Shandong Province

· Institute of Composite Special Structures (Research Institute for Special Aeronautical Composites), Jinan

· Shandong Non-Metallic Materials Research Institute, Jinan

Shanghai

· Shanghai Aeronautical Measurement-Controlling Research Institute

· Shanghai Aircraft Factory

· Shanghai Aircraft Maintenance Engineering Company (SAMECO)

· Shanghai Aircraft Research Institute

· Shanghai Aviation Industrial Group of China

· Shanghai Aviation Training Centre

· Shanghai Jiatong University

· Tongji University

Sichuan Province

· Chengdu Aircraft Design Institute, Chengdu

· Chengdu Aircraft Industrial Corporation, Chengdu

· China Aerodynamic Technology Development Centre (China Aerodynamics Research and Development Centre; Research and Development Centre for Aeromechanics), Mianyang

Tianjin

· Bohai Aeronautical Composite Material Components Company

2.2 Enabling Aircraft Technologies TOP

Technological Information', which apparently involve massive databases of technical information gleaned from around the world. Technical information networks in such areas as aircraft, aero-engines, and instrumentation have been organised by the Aeronautical Science and Technology Information Institute. This institute undertakes extensive translation, editing and reporting of foreign aerospace related research publications. It also provides China's aerospace industry with an important service in monitoring key technological developments. Other major information, technology transfer and testing centres include the Changcheng Institute of Metrology and Measurement, the China Aero Polytechnical Establishment, and the China Aerospace Tooling Association, all located in Beijing.

If China has the equivalent of the US 'Area 51' for the flight test of radical aircraft types, it is probably located in the vicinity of the China Flight Test Establishment, Xi'an. The institute has had responsibility for the flight tests of aircraft, power plants and airborne equipment for some four decades. Its accomplishments have included the free-flight delivery test of China's prototype atomic bomb model and initial ICBM (inter-continental ballistic missile) model, parabolic weightlessness aircraft tests related to the space programme, and R&D on the influence of weapons launch on aero-engine performance. Founded in 1959, this is China's only establishment for the flight test certification of new military and civilian aircraft, aero-engines and related equipment, and test pilot flight training on civilian and military aircraft. It has over 2,000 personnel, including '50 famous scientific and technical specialists and flight test pilots'. It has evaluated over 25 aircraft designs, 18 aero-engine designs and over 300 types of airborne equipment. Areas of R&D include flight mechanics, strength, flying qualities, flutter, power plants, airborne equipment, electronics, fire control systems, high-altitude protection and survival, simulation, measurement and testing, automatic controls, and identification techniques. Facilities include two all-weather navigation runways of 3,400 m, in-flight test platforms for aero-engines, ejection seat experimental aircraft, variable stability systems, simulation rigs, antenna test site, laser radar station, and a vehicle with a real-time data processing system. It has developed a third generation data recording and processing system, and as of 1998 was developing a fourth generation magnetic system.

Active control technology has been designated a national aerospace priority, and the Aircraft Accessory Research Institute, Aeronautical Computational Technology Institute, and the Flight Automatic Control Research Institute, have undertaken the development of fly-by-wire (FBW) and quadruple redundancy fault-tolerant computer technologies. The Flight Automatic Control Research Institute, Xi'an, Shaanxi, was established in 1960, and conducts R&D on flight control and inertial navigation, aerospace vehicle control, guidance and simulation, as well as small-batch production of such systems and the related training of technical professionals. It has undertaken recent research breakthroughs in quadruple redundancy FBW systems, inertial/GPS (global positioning system) combined navigation systems, and quadruple redundancy combined servo actuators. Fly-by-light (fibre optic) control system R&D is also believed to be underway by the China Avionics Research Institute. Ongoing R&D has also been conducted on manoeuvre load control, direct force control, and active flutter suppression for active controls, and fire, flight, and propulsion integrated controls.

During December 1997, COSTIND announced that China had successfully tested Asia's largest and most advanced transonic wind tunnel (33 m wide, 66 m long, with a test section measuring 2.4 x 2.4 m). The test was conducted at Chengdu's China Aerodynamic Technology Development Centre - an important facility for strengthening the national aerodynamic R&D base. This facility is variously known as 'Base 29', China Aerodynamic Technology Development Centre, China Aerodynamics Research and Development Centre, Research and Development Centre for Aeromechanics, and is believed to be located near Chengdu at Mianyang in Sichuan Province. A Chinese government report of 10 February 1999 indicated that a "transonic wind tunnel developed by Chinese Military Air Dynamics Research Base was first used on 30 December 1998 to test a new prototype air fighter and the test achieved satisfactory results". Also during 1999, the Institute of High Velocity Air Dynamics Research Base of the PLA announced the completion of an eight year development of a transonic wind tunnel system with full automatic balancing mechanisms for measuring air dynamic parameters of test models. The Chinese designed and produced transonic wind tunnel has undertaken air seal tests, static and dynamic debugging, flow field calibration tests, and standard model tests, and is equipped with the most advanced international testing technologies. High-frequency plasma and supersonic/hypersonic windtunnels have also reportedly been established at Chengdu for aerospacecraft and missile testing.

China claims to have the largest wind tunnel base in Asia that is being used for the development of aircraft, missiles, satellites, spacecraft and 'space shuttles'. For the manned spacecraft programme, 'blunt wedge technology' and 'semi-oval drizzling technique' in electric arc wind tunnels and low density material thermal tests for returnable vehicle modules have performed related tests, as well as 'the launch and retrieval of sub-transonic models'. The Northwest Polytechnical University is believed to operate at least 11 windtunnels of various types. To develop new generation aero-engines, high-altitude simulation test facilities have also been developed at these various facilities. Tongji University**,** Shanghai, operates the TJ-3 wind tunnel (5 m wide, 2 m high, and 14 m long, with a wind velocity ranging from 0.2 m/s to 17.6 m/s). Associated facilities include smaller wind tunnels, and advanced instrument systems for measuring aerodynamic forces, pressure distribution, local wind speeds, and model vibrations.

Low-speed wind tunnels with cross sections of 1.5 m have been located at the Harbin Military Engineering Institute/Harbin Aerodynamic Research Institute and the Beijing Institute of Aeronautics and Astronautics. An intermittent subsonic, transonic and supersonic wind tunnel with a test section of 0.6 m x 0.6 m has been operational at the Shenyang Aerodynamic Research Institute, and a low-speed facility with a test section area of 4 m x 3 m at the Chinese Aerodynamic R&D Centre. China has over 25 wind tunnels, and has integrated these with computer-based computational systems, laser colour schlieren, laser holography, and other test systems. Specialised facilities exist for hypersonic, high-vacuum stratospheric, and plasma zone space related R&D.

Weaknesses in China's indigenous aircraft development capabilities have historically included design, systems integration, airframe durability and aero-engine thrust and durability, and these are likely areas of emphasis for current R&D and targeted foreign technology transfer efforts. Computational fluid dynamics research is currently being undertaken in China by:

· Academia Sinica (Chinese Academy of Sciences)

· Beijing Institute of Aerodynamics

· Beijing (Peking) University

· Beijing University of Aeronautics and Astronautics

· Changsha Institute of Technology

· Chengdu Institute of Technology

· China Aerodynamics Research and Development Centre, Sichuan

· Hong Kong University of Science and Technology

· Hong Kong Polytechnic University

· Nanjing University of Aeronautics and Astronautics

· Northwestern Polytechnical University

· South China Institute for Environmental Sciences

· Tianjin University

· Tsinghua University

· University of Hong Kong

· University of Science and Technology of China.

The Aircraft Strength Research Institute, Xi'an, Shaanxi, was founded in 1965. This AVIC institute is the only Chinese R&D establishment dedicated to aircraft and aerospace vehicle strength research. Specialised facilities include a large structural test building with load-bearing floor and ceiling, integrated test, measuring and control systems, shimmy test rigs, drop test rigs, thermal test rigs, and integrated environment test rigs. It is headquartered in the High-Tech Development District of Xi'an, with test bases at Yao County and Chang'an County. Specialised R&D is conducted on static and fatigue strength, vibration, dynamic strength, thermal strength, aeronautical acoustics, computational mechanics and software engineering.

High-temperature aero-engine alloys and superalloys (steel, iron-nickel, titanium, aluminium-magnesium, etc.) and associated coating (high-energy plasma spraying), welding (electron beam and micro-beam plasma welding) and casting techniques (directional solidification, powder metallurgy, single crystal alloy, and net shape casting) have been developed by the Iron and Steel Research Establishment, Guizhou Aero-Engine Company, Chengdu Aero-Engine Factory, and the Aeronautical Materials Research Institute, along with various steel factories such as the Fushun Steel Plant and the Great Wall Steel Plant. China tends to seek alloys with as little rare and noble elements, such as nickel and chromium, as possible because of the scarcity of domestic sources of these strategic materials. Advanced aero-engine turbine blades capable of operating at high-temperatures were reportedly developed by 1998.

China has recently announced that it will use the following technologies for the automation of its metallurgical industry during the 10th five-year plan (2001-2005):

· **Automation of production**: satellite positioning of mining areas, localisation of low-cost and open basic automation software and hardware system, automation engineering software development tools and engineering platform, testing and control of continuous hot- and cold-rolled plates and sections, virtual reality technology for steel rolling and visibility of metallurgical process.

· **Modernisation of management**: enterprise decision support systems, information platform integrating multimedia, video, virtual reality technology and management, modern enterprises management mode, function mode and management, and the e-commerce system for supply and sales.

· **Intelligent control of production techniques**: intelligent sintering control system, intelligent furnace process optimising control system, intelligent converting process control system, intelligent electric furnace process control system, intelligent rolling co-ordinating and setting system, intelligent belt control system and tools for the development of expert system, vague control and nerve network intelligent software and compound system platform.

The Aeronautical Materials Research Institute took the lead in the introduction of damage tolerant designs and associated new materials applications. Non-destructive inspection methods such as eddy current inspection, penetrative inspection, radiographic inspection, ultrasonic inspection, acoustic emission inspection, infrared inspection, liquid crystal inspection, and laser and ultrasonic holography have also been developed. The Beijing Atmospheric Environment Test Station conducts R&D related to the corrosion resistance and ageing resistance of metallic and non-metallic materials. The PLAN College of Navy Aviation Technology is a national centre of technical excellence in aircraft erosion and fatigue detection and prevention, and uses advanced techniques such as laser surface treatment, composite materials and adhesives.

Titanium superalloy forging capabilities are advanced by international standards, and have recently been improved with the transfer of Russian Su-27 manufacturing technology. During June 2000, the State Development Planning Commission gave approval to the Baoji Non-ferrous Metal Processing Plant to launch a pilot project for the production of high-performance titanium alloy rods and forgings for aerospace and defence applications. The project requires an investment of 99.65 million Rmb yuan (US$12 million), including US$1.334 million in foreign exchange. Advanced melting equipment will be imported from foreign suppliers. Boeing has recently certified titanium sheet products manufactured by the Baoji plant, which is China's largest titanium producer; quality reportedly meets that of US producers.

The Aeronautical Material Research Institute has conducted long-term R&D and trial production efforts of various sealing materials, gold based alloys, superalloys, high-strength aluminium alloys, synthetic rubber, and orientated acrylic plastic sheeting for aircraft canopies. The Chinese claim that compared to similar alloys of the US and Russia, their high-strength aluminium alloys have unique advantages in anti-stress corrosion and anti-crack elongation. Iron and nickel based superalloys, non-nickel structural steel and cast titanium alloys developed in China also have unique characteristics such as reducing the need for expensive nickel imports, aircraft weight savings, and aero-engine process improvement.

The Beijing Institute of Aeronautical Materials and the Beijing University of Aeronautics and Astronautics are currently active in the R&D of advanced aerospace materials, including the precision casting of titanium alloys, superalloy castings, and coatings. Currently, China is conducting advanced materials R&D and aerospace-defence applications in areas that include composite silicate heat-insulated coatings, lightweight calcium silicate products, microglass fibre air filter papers, and the production of titanium sponge by the magnesium reduction method (Fushun Aluminium Plant). Chinese advanced material research supported by the '863' Programme in areas such as high-performance optoelectronics, ceramics and resin-based composites have now reportedly reached world calibre levels.

The Huaxia (China) Magnesium Products Export Group, was established in August 2000 at Haicheng City, Liaoning Province. Haicheng City has long been renowned as the so-called 'World's Magnesium City', and it supplies over 80 per cent of sales for the international market. To change the current low profit export situation, 25 magnesium producers in Liaoning, Beijing, Tianjin, Jilin and Dalian agreed to form a joint export cartel that will handle over 55 per cent of China's total export of magnesium products.

Under the AVIC, the Beijing Institute of Aeronautical Materials was originally founded in 1956 and is a comprehensive applied research institute on aerospace materials with 22 research offices (including 86 specialities), two experimental factories, an advanced composite materials laboratory, six pilot production lines, and various advanced equipment and instrument facilities. Its advanced carbon-reinforced and honeycomb composite materials capability is considered a key national defence asset, and it has specialised capabilities in thermal processing and the small-batch production of high-performance materials (e.g. titanium and high-temperature alloys) and unique components. The institute probably undertakes stealth and anti-stealth related research.

Directionally stretched acrylic plastics were used for the canopy of the J-8 fighter. Carbon-carbon composites have been in development since the mid-1970s. By the early 1980s significant advances had been made in the raw material, fabrication process, and quality control of advanced carbon fibre reinforced resin matrix composites. Carbon fibre composites retrofits have been applied to such aircraft as the J-8 and Q-5 series. Kevlar honeycomb material has been applied to aircraft such as the J-8 and J-7III fighters. New generation fighter aircraft programmes are expected to major extensive use of advanced composite materials.

Organisations in China with R&D and production capabilities for aerospace composites include: the East China University of Science and Technology; Huachang Polymer Company; Guangdong Applied Institute of Si&F Fine Chemicals; Huadong Chemical College Chemical Plant; MCI Nantong, Synthetic Materials Experimental Plant; Shanghai Synthetic Resins Research Institute; Shanghai Jinsi Fine Chemicals Experimental Plant; Tianjin University Chemical Experimental Plant; Xi'an Modern Chemical Research Institute; and the PLA Plant Number 5712, Changsa, Hunan. Xi'an Aircraft has applied large composite materials components to aircraft types such as the Y-7 transport's vertical tail. The Number 621 Aviation Research Institute was reportedly established in 1995 to undertake composite materials R&D.

Both the Beijing Institute of Aeronautical Materials and the Institute of Composite Special Structures/Research Institute for Special Aeronautical Composites, Jinan, Shandong Province, are known to be involved in the development of aircraft stealth materials and structures that will probably be applied to current fighter aircraft programmes such as the J-10 and XXJ, in addition to the application of radar signal absorbing coatings applied to less sophisticated new (FC-1) and existing aircraft types (the J-7 and

J-8 series). A private firm, Seek (China) Opticals Technic Company, Ltd., is reportedly marketing such materials and coatings (for example, SF18 and SM07 materials that absorb radiation from specific bandwidths) for aircraft, cruise missiles, tanks and warships, as well as a software package to optimise stealth designs. For example, the PLAN's new Luhai-class destroyer will reportedly include such stealth material, in addition to the deliberate design of its hull and superstructure to avoid direct radar reflections. New and in-service Chinese aircraft such as the JH-7 fighter-bomber and the most recent versions of the J-8 fighter will also possibly have such materials applied. The firm was established by a group of university professors but the R&D of such materials has also been linked to the '6th Institute of the Third Ministry of Machine Industry' during the 1980s, and may have been influenced by earlier Japanese work in this area. Seek Opticals has also apparently developed stealth vehicle CAD software.

The National Key Technologies Programme has recently funded R&D projects in 'high-standard composite materials, 'concealed materials', structural and functional ceramic materials and products, and functional high-polymer materials and products'. The '863' Programme is supporting advanced materials R&D in: optoelectronic information materials; high-performance, anti-corrosion, and lightweight structural materials; 'special function materials'; high-temperature, high-strength composite materials; and 'research on special process testing and examination and modern material science and technology, combining material design, development and application under various levels of micro-structure theory to guide the development of new materials'. In 1997, the Qiqiha'er Northeast Super Micro-Powder Manufacturer announced a nanometer silicon-based ceramic powder 'breakthrough in the field of new materials' achieved under the '863' Programme, an accomplishment reportedly only previously technically achieved by the US and Japan.

The China Zhonghuan Corporation, Beijing, negotiated several years ago with the Canadian firm Venga Aerospace Systems Inc. for the technology transfer of production techniques and carbon-fibre materials technologies to be used for a proposed all-composite 'Brushfire' jet trainer/lightweight fighter aircraft that could have considerable stealth characteristics. The current status of this project is unknown.

AVIC (Aviation Industry Number One Group), Boeing and Hexel have established a US$100 million joint venture at Tianjin during 2000, the Bohai Aeronautical Composite Material Components Company, that will manufacture aircraft secondary structures from composite materials. Established at the Tanggu Maritime New and High-tech Zone of Tianjin during July 2000, the company is to be equipped with the most advanced production and testing equipment, with key engineering and management staff members undergoing training programmes in the US. Boeing will provide its quality test standards for the 6,000 square metre production facility.

Manufacturing techniques used in China's aerospace industry include integral panel manufacturing, aluminium honeycomb structure adhesive bonding, sheet forming, titanium sheet hot forming, shear spinning, numerically-controlled (NC) machining, CAD/CAM, and composite material fabrication. Shear spinning techniques have been developed by the Beijing Aeronautical Manufacturing Technology Research Institute for use in the manufacture of tungsten nozzles for rocket engines, aircraft nose domes, and the inlet cone, front case, combustor case and tail cone of aero-engines. Chinese NC systems originally benefited from the transfer of French multi-axis NC plane milling machines over a decade ago. The Beijing Aeronautical Manufacturing Technology Research Institute (and the affiliated Beijing Flexible Manufacturing Systems Experimental Centre and the China Defence Science and Technology Key Laboratory for High-Energy Density Beam Processing Technology) and the Precision Machinery Research Institute were established to introduce various advanced manufacturing technologies to the aerospace industry. In 1998, the PLAAF unveiled specific automated test equipment to accelerate the development of its next generation of aircraft and to reduce technical training time and costs.

In the 1980s the Beijing Aeronautical Manufacturing Technology Research Institute and the Shenyang

Aircraft Design and Research Institute developed advanced CAD/CAM and NC systems in co-operation with MBB of Germany, in addition to various other imported advanced software systems. Recently, CATIC has formed a joint-venture with AMS Precision Engineering Ltd. of Singapore, called CASIN Precision Technologies, to provide totally integrated aerospace manufacturing services for US and European aerospace customer firms. The '863' Programme has recently funded automation technology R&D in such areas as computer integrated manufacturing systems (CIMS) for flexible manufacturing systems (FMS), and intelligent robots for precision assembling tasks (as well as underwater and hazardous environment duties). The CAS Shenyang Research Institute of Automation (National Engineering Research Centre for Robot Technology*)* has developed over 70 application projects and 170 robot systems over the past several years. In 1985, the institute produced China's first submarine robot, in 1990 China's first industrial robot controller, and in 1998 China's first laser processing robot. The National Engineering Research Centre for Computer Integrated Manufacturing Systems, Beijing, conducts R&D on various advanced manufacturing technologies applicable to the aerospace-defence sector. The Chinese aerospace industry is now believed to be capable in various modern manufacturing techniques such as the use supercomputer design facilities, advanced aerodynamic layout technology, system integration technology, composite material fabrication technology, superplastic forming, and diffusive bonding technology. Unconfirmed sources claim that the Chengdu Aircraft Industrial Corporation has one of the best CIMS in the world today. The major aircraft manufacturing centres at such as those located at Chengdu, Xi'an and Shenyang have now all acquired advanced CIMS.

The Shenyang Aircraft Research Institute, Shenyang, Liaoning, was founded in 1961, and has helped develop 10 domestic aircraft, including China's first subsonic trainer/fighter J-5, the first high-altitude and supersonic fighter, the J-8, and its derivatives including the all-weather J-8IIM. It has over 20 specialised departments for aircraft configuration, aerodynamics, stress analysis, airframe structure, functional systems, electrical systems, electronics, advanced materials, etc. It has over 1,300 engineers, including 400 senior engineers and 60 research fellows. Facilities include a large-scale computing centre, a software development department, over 20 labs for structures, systems, environment, fuel, integrated electronic fire controls, and an advanced experimental factory.

The Xi'an Aircraft Design and Research Institute, Xi'an, Shaanxi was founded in 1961 as the Engineering Development Department of the Xi'an Aircraft Industrial Group, and is now an AVIC R&D centre specialising in the design of medium to large aircraft. It has 2,800 personnel, including 1,650 engineers and technicians and 39 research fellows. Since its inception it has designed and modified some 30 aircraft types. 'Trunkliner' transport aircraft research continues at the institute in co-operation with European partners. The institute has departments of configuration development, aerodynamics, strength analysis, structural design, control and hydraulics, landing gear, power plant and fuel systems, environmental control, ejection and life support systems, airborne equipment, armaments and weapon systems, reliability, airworthiness, standards, materials, flight test, ground equipment, market development, meteorology, and instrumentation. This is in addition to a computer centre and advanced labs for flight control and hydraulics, fuel, environmental control, and electrical systems, and a model production factory.

The Chengdu Aircraft Design Institute, Chengdu, Sichuan, was founded in 1970 for advanced fighter aircraft design and research. It has some 2,000 employees including 1,400 engineers and technicians, and 47 research fellows. Areas of research include fluid dynamics, engineering mechanics, mechanical structures, strength, vibration, electronics, electrical systems, instrumentation, radar, lasers, vacuums, automatic controls, environmental controls, advanced materials, and computer and software development (CAD/CAM). It conducts some of China's leading-edge R&D in advanced aircraft configuration layout, design system optimisation for multi-constrained structures, wing flutter active control, static aero-elasticity calculation, air inlet/outlet design, and aircraft structure damage limitation design. The institute's facilities include extensive static, dynamic, temperature, fatigue strength and simulator systems, as well as high and low speed wind tunnels. It has an advanced experimental production plant and is closely involved with the development of the J-10 next generation fighter aircraft.

The Shanghai Aircraft Research Institute is a member of the Shanghai Aviation Industrial Group and is a specialised AVIC R&D centre. It has some 900 employees, with 75 per cent being engineers and technicians, nine research departments, eight labs, a computer centre and a subordinate factory. The institute undertakes R&D in aerodynamics, airworthiness, reliability, stress analysis, structures, electronics, controls and hydraulics, power plants, etc., related to large transport aircraft. It also has the largest simulation test facility for aircraft systems in China. The institute has been active in large transport aircraft development programmes such as the indigenous Y-10 jet passenger transport during the 1970s. It developed a pressurised cabin version of the Y-8 transport during the 1980s and participated in the 'ultra high bypass technology readiness programme' of the former McDonnell Douglas Corporation, as well as MD-82 and MD-90 trunk airliner work. The institute has participated in the now cancelled international AE-100 airliner programme, as well as indigenous helium airship designs.

The Beijing University of Aeronautics and Astronautics was founded in 1952. It is China's major aeronautical university, with building space of some 500,000 square metres, over 1 million books, a staff of 4,300 including 350 professors, and some 12,000 enrolled students. R&D areas include advanced metallics, super conductive material, composite materials, fine casting, telemetry, radio and satellite navigation, microwave technology and antennas, automatic controls, gyro and inertial navigation, sensors, hydraulic transmissions and control, aero-engines, space propulsion, fluid mechanics, aerodynamics, solid mechanics, astronautical human factor engineering, environmental engineering, aircraft design, computer software engineering, AI, and computer applications (e.g. CIMS, CAD/CAM, FMS). It has developed helium airships and ultralight aircraft.

The Northwest Polytechnical University, Xi'an, Shaanxi, has some 1,000 professors and 10,000 enrolled students in 540,000 m of facilities that include nine colleges, 89 laboratories, and a library with 1.4 million books. R&D areas include weaponry science and technology, aircraft structural strength, computer science and information engineering, underwater technology, aircraft structural strength, lightweight RPVs (examples include D-4, B-9, Z-5, T-6), materials 'hot working technology', CIMS, vibration, industrial robots, automatic controls, composite materials, computational themophysics, electromagnetics, advanced airfoils, advanced dipping sonar, and space technologies. Formed from the former Northwestern Engineering Institute and Xi'an Aeronautical Institute in 1957, and subsequently joining with the Harbin Engineering Institute in 1970, NPU has subordinate Key State Laboratories that include:

· State Key Laboratory of Solidification Processing (including artificial crystals, single crystal and directional solidification, rapid solidification, metallurgical quality control, and structural ceramics).

· State Special Laboratory of Thermal Engineering Information Processing (including simulation technique of thermal machinery).

· Acoustic Engineering and Detection Technology Laboratory.

· Laboratory of Aeronautical Fluid Dynamics (including the largest two dimensional low-speed wind tunnel in Asia, plus a 3-D laser velocimeter, and infrared imaging system).

· National Speciality Laboratory of CAD/CAM.

The Nanjing University of Aeronautics and Astronautics, Nanjing, Jiangsu, founded in 1952, is a polytechnical university in aerospace science and engineering under AVIC and the CAAC. It has a teaching staff of 3,000 and 8,000 regular students housed in a 360,000 square metre facility with 58 laboratories and a library with over one million books. R&D specialities are aircraft design, aerodynamics, CAD/CAM software, and mechanical manufacturing. It has developed the CK-1 RPV series. Colleges and departments within the university specialise in civil aviation, aerospace engineering, aircraft engineering, power engineering, automatic control, electronic engineering, aerodynamics, and materials sciences. The university has various R&D institutes in such areas as pilotless aircraft, helicopters, automatic controls, sensors, and aerodynamics. It has graduated and trained over 50,000 students and technicians over the past four decades, currently has some 7,000 fulltime students and 3,000 distance learning students, with a staff complement of 3,000.

It should be noted that various aviation related enabling technologies, particularly advanced materials and advanced manufacturing, are also applicable to the space, missiles and other defence systems discussed in following chapters.

2.3 Aero-Engines *TOP*

2.3.1 Aero-Engine R&D and Production Establishments

China's current propulsion sector now consists of over 10,000 engineers and technicians located at some eight aero-engine manufacturers, four research and design institutes, and five factory managed design institutes, in addition to a varied rocket propulsion infrastructure. Table 2.2 summaries some of the key propulsion sector manufacturing and R&D clusters in China by province and city. Over 50,000 aero-engines and support parts in 25 types have been manufactured for the PLAAF and PLAN, and over 800 aero-engines in 10 types for domestic civil aviation, plus numerous exports abroad. Over 40 improved and new types of aero-engines have been developed, and a number put into serial production. While most of China's early aero-engines were based upon Soviet designs, technical documentation was often incomplete and extensive indigenous modifications were required.

Table 2.2 Current Chinese Aero-Engine Sector Geographical Clusters

Shanghai

· Shanghai Aero-Engine Manufacturing Plant

· Shanghai Air Turbine Factory

· Shanghai Xinxin Machinery Plant

Sichuan Province

· Chengdu Engine Company, Sichuan

· Gas Turbine Establishment of China, Jiangyou

Beijing

· Aviation Industries of China Corporation (AVIC)

· Beijing Chang Kong Machinery Corporation

· Beijing Motive Power Machinery Research Institute

· China National Aviation Industry Gas Turbine Power (Group) Corporation

· China National Light-Weight Gas-Turbine Development Centre

· China National Aero-Engine Corporation

Guizhou Province

· China National Guizhou Aviation Industry Group (Guizhou Aircraft Industrial Corporation), Anshun

· Guizhou Honghu Machinery Factory

· Guizhou Liyang Aero Engine Corporation, Pingba

· Guizhou Xinyi Machinery Plant, Pinba

Heilongjiang Province

· Harbin Dongan Engine Manufacturing Company, Harbin

Hunan Province

· China National South Aero-Engine and Machinery Group, Zhuzhou

· Nanhua Power Machinery Institute, Zhuzhou

· Yangtze Aero-Engine Plant, Yueyang

· Zhongnan Transmission Machinery Factory

· Zhuzhou Aviation Power Plant Research Institute

Jiangsu Province

· Changzhou Lanxiang Machinery Works, Changzhou

· Jincheng Corporation, Nanjing

· Wuxi Aero-Engine Research Institute, Wuxi

Liaoning Province

· Dalian Haiyang Chemical Technology Company, Dalian

· Shenyang Aero-Engine Research Institute, Shenyang

· Shenyang Liming Engine Manufacturing Corporation, Shenyang

Shaanxi Province

· Baoji Non-ferrous Metal Processing Plant

· Xi'an XRA Aerocomponents Ltd., Xi'an

· Xi'an Aero-Engine Corporation, Xi'an

· Xi'an Yuandong Company

Specialised R&D institutes and test facilities to explore advanced aero-engine technologies include the Gas Turbine Research Institute and the Shenyang Aero-Engine Research Institute. Aero-engine control systems were originally copy produced by the Xi'an Accessories Factory and Nanjing Accessories Factory during the 1950s, and then domestic designs were developed at the Xi'an Engine Accessories Factory and Guizhou Engine Accessories Factory for the WP6, WP7, WP8 and other aero-engines. The import of foreign aero-engine control systems for the WS9 and WZ8 aero-engines during the 1970s also afforded technology transfers in such manufacturing areas as super-precision processing, numerically-controlled processing, various types of heat treatments and welding technologies, and an overall order of magnitude improvement in processing accuracy. During 1982 to 1985, the Xi'an Engine Accessories Factory developed digital electronic control systems for the WJ6 and WZ6 aero-engines.

Electrical starter and powder turbine starter systems were first copy produced by the Xingping Aeronautical Electrical Apparatus Factory and the Nanjing Aeronautical Accessories Factory during the late 1950s. However, by the early 1980s the Nanjing Aeronautical Accessories Factory had imported the production technology for advanced foreign systems, which were applied to various aircraft types.

High-temperature aero-engine alloys and superalloys (steel, iron-nickel, titanium, aluminium-magnesium) and associated coating (high-energy plasma spraying), welding (electron beam and micro-beam plasma welding) and casting techniques (directional solidification, powder metallurgy, single crystal alloy, and net shape casting) have been developed by the Iron and Steel Research Establishment, Guizhou Aero-Engine Company, Chengdu Aero-Engine Factory, and the Aeronautical Materials Research Institute, along with various steel factories such as the Fushun Steel Plant and the Great Wall Steel Plant. In 1986 the first net shape casting of a hollow turbine blade made of a directional solidification alloy was successfully accomplished, and represented an important advance for Chinese aero-engine development. China tends to seek alloys with as little rare and noble elements, such as nickel and chromium, as possible because of the scarcity of domestic sources of these strategic materials. Titanium superalloy forging capabilities are advanced by international standards.

Laser technologies are used in China for aero-engine test and instrumentation. They include laser holography, laser fuel particle sizers, laser fuel vaporisation analysis units, and double focus laser anemometers. The Wuxi Aero-Engine Research Institute is China's leading R&D centre for aero-engine FADECS (full authority digital engine control systems). These systems are being used for the new generation J-10 fighter aircraft.

The Wuxi establishment is an AVIC affiliated research institute that was founded in 1975, and undertakes R&D primarily in FADEC systems and the production of digital controllers. It is a member of the China National Industrial Gas Turbine Power Group. It has over 500 employees, including some 180 engineers. Specialised equipment includes CAD/CAM/CAT systems, and a comprehensive aero-engine control system simulator. The institute recently has claimed to have made important breakthroughs in FADEC system research.

The Gas Turbine Establishment of China, at Jiangyou in the Sichuan province, is a key high-performance aero-engine R&D centre that has for the past two decades focused on new gas-turbine aero-engine development. The establishment is China's major centre for the R&D, testing, design and production support for gas-turbine propulsion systems. It has over 1,000 professional staff, some 10 R&D departments and workshops, and some 10,000 major pieces of equipment. A high-altitude simulation test bed was developed in 1995.

An unconfirmed report indicated that the Beijing Aircraft Materials Institute made a breakthrough during 1998 on the development of high-operating temperature turbine blades, a previous roadblock for advanced Chinese gas-turbine aero-engines. The Beijing Institute of Aeronautical Materials claims it had mastered the manufacturing technology for the casting of single crystal turbine blades by the mid-1990s. Another unconfirmed report also indicated that the 'Ison Group of China' has recently developed a miniature turbojet aero-engine suitable for cruise missile and RPV applications.

While China recognises that new structures and materials must be incorporated in modern aero-engines if higher thrust, reduced weight and longer life-cycles are to be achieved, it is generally thought that the ex-Soviet legacy of early Chinese aero-engine development has resulted in domestic designs that are deficient by modern standards in these qualities. Soviet/Russian-designed aero-engines require major overhaul after only 750 flying hours, compared to 10,000 flying hours for current Western military aero-engines. Hence, aero-engine technology transfers from Western sources are a priority in addition to domestic efforts.

The US Sikorsky Aircraft Corporation is reportedly establishing a joint venture aero-engine repair and parts supply centre in co-operation with the Chengdu Engine Company. Subcontracts for foreign aero-engine manufacturers are becoming increasingly sophisticated. Notable examples include Snecma CFM56 blades and components for the Mirage 2000's M53 aero-engine produced by plants at Xi'an and Shenyang Liming. Significant recent US and Russian technologies have reportedly been integrated into the new generation WS10 Chinese turbofan aero-engines for the J-10 and other advanced fighter aircraft programmes, possibly with thrust vectoring capabilities. The Xi'an XRA Aerocomponents Ltd. is a new joint venture between Xi'an Aero-Engine Corporation and the UK's Rolls-Royce for the casting and machining of Rolls-Royce and BMW Rolls-Royce aero-engine components.

France is believed to be another potential source of new military aero-engine technologies, such as those developed for its Rafale fighter aircraft. The French SNECMA M-88-2 turbofan that powers the Rafale fighter has in recent years been a topic of discussion as a potential power plant for Chinese aircraft such as the JH-7, J-10 and J-8III. However, no actual technology transfers have been confirmed and Russian aero-engine technology appears to be more likely.

A recent consortium of Pratt and Whitney, Northrop Grumman and Hispano-Suiza offered the PW6000, specifically designed to power the now cancelled AE-100 transport, and had planned to establish an aero-engine joint venture at Chengdu, Sichuan Province. CFM International is offering its CFM56-Lite (derivative of the CFM56-7 used for the latest series of the Boeing 737).

In 1997, Xi'an Aero-Engine, Pratt and Whiney, and Blades Technology International (Israel) formed a joint venture, Xi'an Airfoil Technology Company, to manufacture compressor airfoils and precision components for commercial aero-engines and industrial gas-turbines. In the same year, Rolls-Royce furthered the joint venture with Xi'an and CATIC to produce steel and light alloy ring components for various aero-engines, such as the Ardour that powers the British Aerospace Hawk.

During January 1997, Pratt and Whitney of Canada and the China National South Aero-Engine and Machinery Group (which is believed to currently produce WP11 aero-engines for cruise missile propulsion) agreed to form a joint venture for the development and production of small civil aviation gas-turbine aero-engines that potentially could be modified for cruise missile propulsion. Earlier efforts to engage in similar joint ventures with the US firms AlliedSignal and Williams International were blocked by the US government for national security reasons.

In 1998, General Electric and the Xi'an Aircraft Engine Group Company formed a joint-venture, the Asian Aircraft Spare Parts Manufacturing and Technical Centre, at a cost of 250 million Rmb yuan, and with over 100 advanced production lines with state-of-the-art equipment to manufacture aero-engine discs and rings.

Some recent reports have indicated that China is attempting to recruit laid-off US military aero-engine specialists from Pratt and Whitney and other American firms to gain Western expertise. The Canadian firm MDS Aero Support Corporation reportedly recently helped AVIC to attempt to recruit US aerospace engineers with expertise in gas-turbine aero-engine hot-section technology from the Pratt and Whitney F-100 and General Electric F-110 aero-engines (similar US technology has probably been obtained through Israel).

2.3.2 Piston Aero-Engines

China initially gained experience with modern piston aero-engines through the repair, overhaul and eventual production of the M-11FR engine for the Yak-18 primary trainer during the 1950s at the Zhuzhou Aero-Engine Factory (China National South Aero-Engine and Machinery Group). This was followed by the production of the HS5 aero-engine (Soviet Ash-621R) for the Y-5 transport, the HS6 aero-engine (Soviet AI-14R) for the CJ-6 primary trainer, the HS6C for the '701' and 'Yan'an II' light helicopters, and the uprated HS6D for the Y-11 transport, at the same factory. Modifications and applications of the HS6 type continue.

The HS7 aero-engine was developed by the Harbin Aero-Engine Factory, based upon technical documents of the Soviet Ash-82V engine, for use in the Z-5 helicopter. Production of this type ceased in 1980 after a run of 1,500 aero-engines.

The Harbin Aero-Engine Factory HS8 was developed and modified extensively by China for re-engining a mixed fleet of older Soviet and US transport aircraft, and some 1,300 units were produced before production ceased in 1980.

2.3.3 Turbojet Aero-Engines

The Wopen WP5A was China's first turbojet aero-engine developed during the mid-1950s at the Shenyang Aero-Engine Factory, and based upon the Soviet VK-1F. Production of upgraded WP5s was also undertaken at the Xi'an Aero-Engine Factory for powering such aircraft as the H-5 bomber and its derivatives.

The Shenyang Aero-Engine Factory WP6 aero-engine was based upon the Soviet RD-9B design, and used to power both the supersonic J-6 fighter and Q-5 attack aircraft. It was concurrently manufactured at the Chengdu Aero-Engine Factory. Modifications and upgrades of the WP6 continued into the 1980s.

The Hong Qi (Red Flag) 2 aero-engine was developed by the Shenyang Aero-Engine Design Office, as an advanced version of the WP6 to power the ill-fated 'East Wind' 107 fighter, but was also cancelled in 1960.

The WP7 was developed from the Soviet R11-F-300 aero-engine to power the Mach 2 class J-7 fighter. Development was undertaken at the Shenyang Aero-Engine Research Institute, Beijing Aeronautical

Manufacturing Technology Research Institute and various other R&D establishments, with production at the Guizhou Aero-Engine Factory beginning in 1970, in co-operation with the Shenyang Aero-Engine Factory. The WP7A was developed to power the twin-engined J-8 fighter. The more advanced WP7B superseded the original design in 1980, and was developed by the Guizhou Aero-Engine Design and Research Institute as an evolutionary improvement of the WP7A, with the major difference being a more powerful afterburner and increased operational life. The export version is designated the WP7B(M batch). The WP7F powers the upgraded J-7E fighter.

The WP8 was developed from the Soviet RD-3M design to power the H-6 medium bomber. Development was jointly undertaken by the aero-engine factories at Harbin, Xi'an and Shenyang, in co-operation with research establishments including the Beijing Aeronautical Materials Institute and Shanghai Jiaotung University. The Xi'an Aero-Engine Factory was the primary production centre. The development of improved versions continued into the late 1980s.

The WP11 low-thrust aero-engine was developed for the WZ-5 high-altitude pilotless reconnaissance aircraft, other RPVs and short-range cruise missiles by the Beijing Institute of Aeronautics and Astronautics, and saw certification in 1980. It was subsequently produced in Hunan Province.

The WP13A aero-engine developed for the J-7III and J-8II fighter aircraft was a co-operative effort between the Guizhou Engine Design Institute, Guizhou Engine Company, and Chengdu Engine Company. It was a major technical improvement over the WP7 and offered increased dry and reheated thrust. Guizhou was given responsibility for the compressor casing, combustion and afterburner; Chengdu was responsible for compressors, turbine rotors and turbine casings. Development began in 1978 and certification was provided in 1985. A major feature of the WP13 aero-engine is the use of castings and die-forgings of creep resistant titanium alloy for the compressor disc and casing (China's initial application of this technology). The TC11, ZT3, and ZT4 creep resistant titanium alloys were developed by the Beijing Aeronautical Materials Institute, Guizhou Aero-Forging Factory, Shanghai Number 5 Steel Works and Chengdu Engine Company. Guizhou Liyang Aero Engine Corporation's current WP13B version is used for the new J-8IIM fighter. In 1996 a new version of the WP13, the WP13F2, was reportedly tested using vortex flame stabilisation and FADCS, and powers the J-7FS demonstrator.

In the early 1980s the Shenyang Aero-Engine Factory began the subcontract manufacture of the US General Electric CJ610 turbojet aero-engine. China is currently interested in the development or foreign acquisition of small turbojet aero-engines (e.g. the US Williams FJ44-class) for cruise missile propulsion.

2.3.4 Turbofan Aero-Engines

Over the past three decades the Chinese aerospace industry has developed a number of turbofan aero-engines: WS5, WS6, WS6A, Number 4 Lift-fan, WS8, and WS9. While a number of these were less than successful and did not see deployment, valuable experience was gained for more current efforts.

The WS5 turbofan was developed from the WP6 turbojet by the Shenyang Aero-Engine Research Institute and the Chinese Aeronautical Establishment during the late 1960s and early 1970s to re-engine the H-5 bomber, but while apparently successfully developed to the prototype stage, did not see certification. The WS6 was a domestic design also developed by Shenyang during the 1960s. However, WS6 development was delayed by the Cultural Revolution, and while prototypes were developed in the early 1980s they did not see certification.

The WS8 was a front-fan, axial flow, two spool turbofan type with a short bypass duct developed by the Chengdu Aero-Engine Factory and Shanghai Aero-Engine Factory during the early 1970s as the proposed power plant for the domestic Y-10 heavy transport aircraft. New machining and welding production techniques were used in its development, as was the use of titanium alloy (17 per cent of engine weight), and new surface treatments such as Ni-Cd diffused coating against corrosion at moderate temperatures, graphite varnish, and aluminising siliconizing of turbine blades against high-temperature corrosion. As the Y-10 did not reach full production, and the two prototype aircraft were powered by foreign aero-engines, the WS8 did not reach certification. However, infrastructure constructed for its development in Shanghai was retrofitted to be a standard open test bed for the thrust calibration of new aero-engines.

A major aero-engine milestone for China was the mid-1970s purchase of the manufacturing license for the Rolls-Royce Spey MK202 turbofan (developed from the commercial Spey MK511, and used on RAF F-4 Phantom fighters and US A-7 attack aircraft). This technology transfer purchase was made with the recognition of the steadily declining level of Chinese aero-engine technology by international standards. The Chinese designation for this aero-engine was WS9. It was produced by the Xi'an Aero-Engine Factory, with massive technical assistance from various sub-suppliers, institutes, colleges and universities in Shaanxi Province to produce toolings and translate technical documents (translation and copying of 420,000 pages of documentation, plus 30,000 tooling design drawings and manufacture).

With WS9 certification completed by 1980, general manufacturing techniques in the Chinese aerospace industry were significantly advanced in such areas as electro-chemical machining, electron beam welding, laboratory control, inspection and measurement, metal spray, vacuum heat treatment, numerically controlled (NC) machines, precision casting and forging.

Transferred Spey techniques have been used as reference guides for the design and development of new domestic aero-engines, and the manufacture of other advanced Western aero-engines. Xi'an was transformed into a globally competitive aero-engine manufacturing base. These spin-off benefits were probably more important than the actual WS9 itself, which strangely did not see an immediate Chinese aircraft application (although today derivative WS9 aero-engines are reportedly used to power the FBC-1/JH-7 fighter-bomber). Beyond aero-engine manufacturing, these innovations were transferred to other military and commercial enterprises.

A WS11 turbofan in the same class as the 3,600 pound thrust US Garrett TFE-731-2A aero-engine is reportedly being developed by the China National South Aero-Engine and Machinery Group as a domestic power plant for the Sino-Pakistan K-8 trainer/ground attack aircraft. This same plant had produced the Garrett power plant under license.

The Shenyang Aero-Engine Factory began the subcontract manufacture of the General Electric CF6 and CFM56 commercial turbofan aero-engines during the early 1980s. To meet GE specifications, Shenyang put in place quality and advanced manufacturing systems to meet US airworthiness standards. GE also provided a contract to the Xi'an Aero-Engine Company to manufacture the turbine discs for the LM2500 naval and industry gas-turbine engine.

Recent unconfirmed reports have indicated that China has attempted to obtain the technology for Pratt and Whitney's F-100 aero-engine used for the USAF's F-15 and F-16 fighters, and the General Electric's F-110 aero-engine used for the US Navy's F-14 Tomcat fighter. A particular interest is in 'hot section' technology such as materials and coatings inside the turbine that can withstand extreme heat and associated cooling systems, and could be used to increase the power and durability of Chinese aero-engine designs.

Some sources claim that new generation WS10 (e.g. F-100) and WS12 (e.g. AL-31F) turbofan aero-engines make extensive use of US and Russian technologies. Reports suggest that they have been developed with FADECS from the mid-1990s. The WS10 may employ axial symmetry vectoring nozzle technology. In 1998 the Beijing Aircraft Materials Institute reportedly made a breakthrough in aero-engine turbine blades capable of operating at high temperatures. The WS10 turbofan was reportedly developed in

1996 for the J-10 programme by the related 606th Institute, and is the first indigenous engine to use FADECS, although the aero-engine was probably originally derived from analogue Russian technologies.

As part of the Su-27 fighter technology transfer package, China has acquired the production capability for Russian Klimov/Sarkisov RD-33/93 and Saturn Lylulka AL-31F/A turbofan aero-engines, which will provide a significant advance for modern military propulsion systems. The 1,500 hour life AL-31F produces 27,600 pounds thrust with afterburning. The AL-31F will likely be the power plant for domestically produced Su-27s, while the RD-93 (improved version of the RD-33K) could be used to power domestic designs such as the J-10, FC-1, and JH-7. However, an all-aspect vectored thrust version of the AL-31FN was revealed at the 1998 Zhuhai Air Show, and could be used for future versions of the J-10 fighter aircraft (some reports indicate it has been installed on a prototype J-10). There are other reports indicating that China has obtained significant Russian aero-engine production capability through the official Su-27 programme as well as covert technology transfer activities since the 1980s. In 1999, Alexey Ogarev, the director general of the Russian arms exporting agency Rosvoorouzhenie, announced that a facility was to be established in China specialising in the production of spares and repairs for the AL-31A/F aero-engine used for the Su-27. Other recent reports have indicated that AL-31FN aero-engines are to be sold directly from Russia to power Chinese J-10 fighter aircraft.

China may be developing an advanced turbofan aero-engine for its XXJ future fighter programme. This aero-engine may be designated 'F-125', and could benefit from advanced Russian aero-engine technologies such as those of the AL-41F, which is being developed to power the next generation of Russian fighter aircraft (e.g. derivatives of the MiG '1.44' and Sukhoi S-37 Berkut). There are also rumours of a WS14A turbofan aero-engine capable of supercruise performance but this cannot be confirmed.

2.3.5 Turboprop Aero-Engines

The Harbin Aero-Engine Factory, Zhuzhou Aero-Engine Factory and Zhuzhou Aero-Engine Research Institute pioneered the development of Chinese turboprop aero-engines during the 1960s and 1970s for transport and water-based bomber applications. Types include the WJ5 for the Y-7 transport, the WJ5A for the Chinese Navy's SH-5 bomber, WJ5AI for the Y-7 transport, and the WJ6 for the Y-8 transport. Upgraded fuel efficient WJ5E aero-engines were developed for the Y-7-200B transport designed for domestic markets.

The WJ9 aero-engine was developed during the late 1980s from the WZ8 aero-engine core (i.e. turbo-shaft modified into turboprop), by the Zhuzhou Aero-Engine Company (created in 1983 through the merger of the factory and institute), with an immediate application for the Y-12 transport. This development was illustrative of the Chinese trend of using common core aero-engine designs for developing new derivatives.

During the early 1980s General Electric provided the Shenyang Aero-Engine Company with a manufacturing subcontract for the CT64 turboprop aero-engine, and helped improve the performance and reliability of the domestic WJ5AI in co-operation with Shenyang and the Harbin Aero-Engine Manufacturing Company.

China has also recently explored the development of propfan powered passenger aircraft with Germany's MBB but no details were forthcoming.

2.3.6 Turboshaft Aero-Engines

Since the mid-1960s China has developed the WZ5, WZ6 and WZ8 turboshaft aero-engines as power plants for helicopters. The WZ5 was developed from the WJ5 (i.e. modification of the mechanical transmission and free turbine governor) by the Zhuzhou Aero-Engine Research Institute and the Harbin Aero-Engine Factory, and was produced in Jiangsu Province since 1976 for the Z-6 helicopter. Upgraded twin WZ5As were also planned for the cancelled Z-7 helicopter. In 1975 the WZ6 aero-engine development was initiated by the Jiangxi Helicopter Engine Factory for the Jiangxi Helicopter Factory Z-8 helicopter but did not begin production until the late 1980s.

The WZ8 aero-engine was a version of the French Arriel-1c produced under licence from Turbomeca, for use on the Z-9 helicopter (twin aero-engines). The design and manufacturing techniques and performance specifications of this system provided a considerable boost to China's turboshaft capability and quality, and precision manufacturing in general. The Zhuzhou Aero-Engine Factory began initial production with French assistance in 1980, and by 1986 China had obtained an autonomous manufacturing capability. Technologies transferred included heat and surface treatments, physical and chemical metrology, non-destructive testing, numerically controlled machines, precision electric spark machining, electronic beam drilling, welding and plasma spraying.

China's original production capability for power transmission systems for piston aero-engine helicopters had been established at the Harbin Aero-Engine Factory during the late 1950s (P-5 reduction gear box for the Z-5 helicopter, and the reduction gear box for the Z-6 helicopter). However, new facilities were established during the 1980s in Southern China at the Zhuzhou Aero-Engine Company and the Hunan Aero-Gear Factory for turboshaft aero-engine power transmission systems for the Z-7, Z-8 and Z-9 helicopters.

2.3.7 Non-Aerospace Applications

During the 1960s China began to modify gas turbine aero-engines into light-duty industrial gas turbines. By the 1970s derivatives of the WZ5, WJ5 and WJ6 were used for oil production, with this application progressing rapidly during the 1980s. For example, the Zhuzhou Aero-Engine Company has co-operated with the Beijing Heavy Electric Motor Factory to develop the mobile YD-2000 container-type movable power station developed from the WJ6. The Zhonghua Gas Turbine Company, Xi'an Aero-Engine Factory, Wuxi Aero-Engine Research Institute, and Beijing 'Dong Fang Hong' (The East is Red) Oil Refinery Complex, jointly developed a conversion of the WS9 to generate heat and electricity from residual oil refinery gas during the late 1980s. Other applications have included water pump power stations (Wuxi Aero-Engine Research Institute, Jiangxi Helicopter Engine Factory and Shenyang Aero-Engine Factory), natural gas compressor power plants (Zhuzhou Aero-Engine Company and Hubei Aero-Accessory Research Institute), and power plants for offshore platforms.

China is currently conducting R&D on the use of coal (gasified, slurried or powdered) or heavy oil as alternative light-duty gas turbine fuels. The Zhuzhou Aero-Engine Company is conducting research in this area, and had, by the late 1980s, modified a WJ6 to power a locomotive using heavy oil as fuel.

The Zhuzhou Aero-Engine Company and the Harbin Marine Boiler and Turbine Research Institute have developed a marine power plant for hovercraft through modifying the WJ6. The Xi'an Aero-Engine Factory has converted the WS9 into a 11,000 kW (15,000 hp) industrial power plant, and research is under way on a 22,000 kW (30,000 hp) marine system that would be suitable as a naval power plant. Research is also being conducted on the use of gas-turbine engines to power main battle tanks and potentially suitable gas turbines in the range of 600 to 2,000 hp are being developed.

In August 1986, CATIC licensed the technology for the US Pratt and Whitney FT8 gas turbine engine, including joint development, production and international marketing rights for 25 years. The FT8 is a development of the JT8D-219 aero-engine (used to power Boeing 727, Boeing 737, and MD-82 aircraft), and can produce 24,000 kW (33,000 hp), and represented another significant technical leap for China's gas turbine capability with an initial operations in 1996. Parts were also produced by firms such as the Chengdu Aero-Engine Factory for the Pratt and Whitney JT8D, JT9D and PW4000 aero-engines, which included flame gas tubes, gas collectors, compressor cases, stator shrouds, and turbine exhaust cases. These production agreements involved a considerable transfer of production management and manufacturing technologies such as non-destructive inspection, welding, arc plasma spraying, and NC machining. Chinese students were also sponsored by Pratt and Whitney for graduate level aerospace training in the United States.

The China National Aviation Industry Gas Turbine Power (Group) Corporation/China National Light-Weight Gas Turbine Development Centre, Beijing, is the national centre for the R&D, design, construction, commissioning, installation and service of gas-turbine systems. It is also the centre for the import and export of related products and technologies in the fields of aero-derivative, industrial, marine, and mechanical drive applications. The FT8 gas-turbine system transferred from Pratt and Whitney is a major product. R&D is all conducted on wind power generation. All of the current major aero-engine-related manufacturers and R&D centres are members of this group: the Shenyang Liming Engine Manufacturing Corporation; Chengdu Engine Company; Xi'an Aero-Engine Corporation; Guizhou Liyang Aero Engine Corporation; Harbin Dongan Engine Manufacturing Company; China National South Aero-Engine Company; Baoding Propeller Factory; Shenyang Aero-Engine Research Institute; Zhuzhou Aviation Power Plant Research Institute; Wuxi Aero-Engine Research Institute; China National Gas Turbine Research Institute; and the China Aeronautical Project and Design Institute.

2.4 Fighter Aircraft TOP

At least 19 versions of four basic types of fighter aircraft have been developed for the PLAAF and Navy by the 1990s: Shenyang/Chengdu Jianjiji J-5 (MiG-17PF derivative), Shenyang/Nanchang /Guizhou J-6 (MiG-19P/M/C derivative), Shenyang /Chengdu/ Guizhou J-7 (MiG-21-F-13 derivative, export version designated F-7) and the domestically designed J-8 series. Various examples of the J-5 and J-6, while obsolete and no longer in production, continue to serve on with the PLAAF and PLAN. Since the 1980s the PLAAF's J-6s have gradually been replaced by J-7s and J-8s, although an advanced version, the J-6Xin (or 'new' J-6) incorporated improved gun radar systems.

China is today simultaneously developing and directly acquiring various new and updated fighter aircraft types (J-7 modifications, J-8IIM/III, FBC-1/JH-7, FC-1, J-10, Su-27 (J-11), Su-30 and XXJ, with the last five being the most significant from an innovative technological perspective). A 1997 report by the US Office of Naval Intelligence noted that China is developing some half dozen combat aircraft "at a time when many nations are finding it difficult to finance a single programme".

China has historically attempted to achieve technological breakthroughs in indigenous fighter aircraft designs. During the late 1950s, trial development and production programmes had begun for two advanced fighter-interceptor types, the Shenyang Aircraft 'East Wind (Dong Feng) 107' and the Harbin Aircraft 'East Wind 113'. Both were intended to break the 'thermal barrier' and reach a maximum of Mach 1.8 to 2.5 in level flight at a 20,000 m to 25,000 m service ceiling. However, both were cancelled, apparently because such technical achievements were simply beyond China's thermal stress and aerodynamic heating capabilities at that time.

In 1969 the PLAAF proposed to develop the Nanchang Aircraft J-12 STOL (short take-off and landing) lightweight, agile supersonic fighter. This was an indigenous design and an apparently radical departure from the MiG design tradition. Take-off and landing were achieved at under 500 m. Unconfirmed reports indicated the swing-winged aircraft would be powered by Rolls-Royce Spey aero-engines. While apparently successfully developed, changing PLAAF acquisition plans terminated production at only six copies. However, new structural and materials technologies developed for this design, such as metal honeycomb skin panels, foamed-sandwich structures, and titanium alloys, would prove useful for later light fighter designs such as the current J-10. Other fighter designs that were not put into production included the J-11 reverse-engineered MiG-23 and the Shenyang J-9 interceptor, which apparently was the J-10's direct design predecessor. It is possible, because Chinese defence R&D programmes rarely completely die, that elements of these various research aircraft could have been incorporated in more current programmes such as the J-10 and FC-1 fighters.

The J-7M export version and J-7III made the initial use of advanced domestic and foreign technologies (head-up display - HUD, avionics, fire-control systems, long-distance radar, communications and ECM) by the mid-1980s. The J-7III's interception radar is the indigenous JL-7; other versions have been equipped with the British GEC-Marconi Skyranger (as well as electro-optics and HUD) and the Italian FIAR Grifo-7. The J-7P is another export version that has been sold to Pakistan, where it has been equipped with AIM-9P air-to-air missiles (AAM), external fuel tank, GEC-Marconi HUD, Skyranger radar, and more recently the Italian Grifo-7 fire control radar. The J-7P has also been linked to the Super 7 and, hence, the FC-1 programmes. It was reportedly developed with a paperless computer integrated manufacturing system (CIMS). A so-called 'J-7M2000' may have been used as a testbed for the French Mirage 2000 wing shape during the early 1980s.

The PLAN version J-7E is equipped with the recent PL-9 AAM, external fuel tanks, redesigned wings, an upgraded WP7F aero-engine, increased agility, and modernised avionics such as a HUD and air-data computer. The J-7 is also capable of carrying the PL-2A and PL-5B IR AAMs, as well as the all-aspect PL-8 IR AAMs. The J-7MG was offered both the GEC-Marconi Skyhawk and Russian Kommar radar; Western avionics were used, along with an improved WP13 turbojet. An advanced trainer version the JJ-7A, was developed specially for the Pakistan market with HUD, air-data computer, longer-range, etc. Experimental versions such as the J-7FS (Fei Shi, or 'flying experiment') have been reported with new aero-engine (WP-13FII), nose intake, avionics, GPS, radar and weapons control system, etc. The latest J-7 developments may provide a medium technology, multi-role capability, and has only a superficial resemblance to its MiG-21 ancestor.

The next attempt at an indigenous high-performance design with a Mach 2.2 maximum flight speed and over 20,000 m ceiling was the Shenyang Aircraft J-8, with its initial design beginning in September 1965. It was heavily influenced by Soviet MiG and other foreign designs, and required four years and 10 months from concept definition to first flight. However, design certification was not achieved until March 1980, due to the disruptive effects of the Cultural Revolution. The all-weather Shenyang Aircraft J-8I incorporated improvements in more advanced avionics including a fire-control radar, canopy environment and pilot systems, and gun and missile armaments, and achieved designer certification in July 1985. Its development was much faster than the J-8 because of the more stable political climate in China by the late 1970s.

The Shenyang Aircraft J-8II was an evolution of the basic J-8 design, but with significant improvements in armaments, fire-control systems, avionics and propulsion systems (up-rated twin WP13A aero-engines), which recognised the need for improved combat manoeuvrability at low and medium altitudes, rather than the past approach of high-speeds at high-altitude. Conceptual design began in April 1981, with the initial flight test on 12 June 1984. Current versions of the J-8IIM (or J-8D, estimates suggest that 50 to 100 of the most advanced version of this aircraft are in service with the PLAAF and PLAN) are believed to be equipped with the same multi-purpose Russian Zhuk ('Beetle')-8II look-down, shoot-down radar that is used by the MiG-29M, and medium-range semi-active radar homing AAMs with an all-aspect, all-azimuth attack capability. The J-8 series will see upgrades into the next century because it will not be possible for the PLAAF to introduce all of its new fighter types (Su-27, J-10, FC-1) during the next decade. Such technical upgrades should see its combat effectiveness approach that of current generation fighters such as the MiG-29M with the correction of past deficiencies such as inadequate avionics and lack of a modern medium-range AAM system. J-8-IIs are capable of carrying the domestic PL-2A, PL-5B, PL-8, and the BVR semi-active radar PL-4, PL-9 and PL-10 AAMs, as well as new Russian missiles. The PLAAF had also contracted the US Grumman Corporation to upgrade the J-8II's fire-control system during the late 1980s but this assistance was terminated following the 1989 Tiananmen Square massacre.

The newest version of the J-8, the J-8IIM, is heavier with improvements in propulsion, advanced domestically produced HUD, radar and fire control system, integrated INS/GPS and ECM with greater accuracy and weapons payload. It is being built at a slow rate (perhaps two to three per month), probably for an export market (potentially Iran) in addition to possibly for the PLAAF. The prototype has reportedly been equipped with a Russian improved Zhuk-27 radar and fire control system, compatible with the R-77 and active radar homing AAMs and with multi-target engagement capability. Further systems may have been purchased for pre-production aircraft. Its radar reportedly can detect a target with a 3 square metre radar cross section (RCS) at 70 km and 5 square metres RCS at 80 km (e.g. J-7 at 74 km). Some Chinese aircraft designers claim that the latest version approaches a US F-16A/B capability and has an export price of only US$10 million. The J-8IIM is also likely to be re-equipped with an improved WP13AIII aero-engine (or Russian RD-33K). The use of digital FBW controls, the enlargement of the centre fuselage for improved fuel and electronics volume, a more powerful fire control radar system and infrared search and track systems, and retrofitted radar-absorbent composite materials for improved stealth characteristics, could also dramatically improve capabilities. It is not clear if the PLAAF is to purchase the J-8IIM, or whether older models of the J-8 will be upgraded to its standard.

There have been some reports of the development of a J-8III, possibly a navalized J-8 version, with such features as close-coupled canards and improved avionics, larger horizontal and vertical stabilisers, digital FBW or FBL, increased use of composite materials, and new weapons systems. The J-8D is a recent in-flight-refuelling capable version of the J-8IIM, having entered PLAN service supported by modified H-6 tankers. A forward looking infrared/laser targeting pod developed by the Number 607 Institute, the KG300G ECM pod developed by the Southwest China Research Institute of Electronic Equipment, and the Number 607 Institute's Blue Sky low-altitude navigation pod are reportedly to be configured on the latest versions of the J-8 for improved air-to-ground capabilities, as is the JL-10A radar developed for the J-10 fighter programme. The improved J-8D probably has an attack performance approaching that of the specialised aircraft such as the JH-7 and Su-30. At the very least, advanced versions of the J-8 provide an indigenous alternative to foreign imports such as the Su-27 and Su-30.

China made an agreement to buy 24 Sukhoi Su-27s (believed to be less capable export models of 22 Su-27SK and two Su-27UBK dual-seat trainers) before the August 1991 demise of the old Soviet Union, and is currently believed to operate at least 48 of this type. Various reports indicate that the total number of Su-27s in operation in China may be in the order of 48, 72 or 100+ aircraft, but the higher limit may be a result of confusion caused by 'double-counting' the same batches of ordered aircraft, and whether or not more than a third batch has been delivered, as well as the success rate of recent indigenous production efforts. A number of PLAAF Su-27s were reportedly severely damaged on the ground by a typhoon during 1996-97 but are now believed to have been fully repaired to operational status again. Su-27 technology represents a two generation jump in fighter aircraft capability for the PLAAF. In February 1996, Russia sold full Su-27 production rights to China for a total of some 2,000 aircraft worth US$2.5 billion. This was in addition to up to 200 Phazotron Design Bureau Zhuk multimode radars for China's new J-8IIM and J-10 fighters.

A Sino-Russian joint-venture has been established at the Shenyang Aircraft Company for the production of at least 200 Su-27SK and its RD-93 or Lyulka AL-31F turbofan aero-engines. Reportedly, the initial production batch included some 21 to 24 aircraft delivered from Russia in kit form. Initial domestic production of two Su-27s from imported components were reportedly completed during late 1998. A June 2000 report indicated that China will receive some 20 assembled Su-27s fighters from Russia to make up for apparent shortfalls in its own production programme. Russian technicians (of which some 100-300 are still believed to be at Shenyang) reportedly also had to rebuild the first two Chinese-built aircraft following their inaugural flight because of quality concerns, and only five Su-27s had been produced in China by early 2000, including the initial two which are now operationally deployed. Chinese production was originally expected to see six or seven Su-27s assembled annually over three years until 2002, when production was due to rise to 15 annually, but this timetable may prove unrealistic. Russian supplied elements are to eventually decline to 30 per cent of the aircraft. Chinese estimates of eventual domestic J-11 production are up to 100 aircraft annually. However, Western estimates range from 10 to 20 per year.

The official Russian position is that China will not produce non-licensed versions of the Su-27, and that "all bans and restrictions, imposed on the Chinese side, are supplemented by the latter's practical inability to modernise and export Chinese assembled Su-27SK planes without Russia's participation...due to the fact that the AL-31F engines and all the sets of radio-electronic equipment for these planes will be delivered to China from Russia." However, reports indicating that the Chinese aerospace industry is unable to maintain or manufacture Su-27 technologies may at least be partially deliberate misinformation from various parties.

Another direct benefit to China's aerospace industry arising from the Su-27 agreement is knowledge of manufacturing techniques of advanced titanium structural elements. The advanced AL-31FP thrust-vectoring aero-engine is also reportedly being offered for sale to China. While the licensing agreement is only for the eventual production of 50 aircraft per year to a total limit of 200, China could abrogate the terms of the licence as it has with other co-production agreements in the past and develop its own indigenous version. China will probably pursue the same strategy with future Su-27 production that it has followed with aircraft such as the J-7 and J-8 (which are also derivatives of Russian designs); to employ the basic airframe design but to add refinements and new technologies acquired from foreign sources or indigenously developed. This is particularly true in such areas as avionics and advanced composite materials, which have been steadily integrated even in older designs such as the J-6.

Other Su-27 technological spin-offs and increased power projection capabilities are considerable for China. The Su-27 radar type is believed to be an improved export version of the Zhuk-27 look-down, shoot-down radar that can track-while-scan multiple targets, and has a 100 km range. For ground attack the Zhuk system has imaging, display freezing, enlarged demonstration, and terrain following capabilities. Initial radar, fire control and aero-engine systems are to be produced in Russia and installed into airframes produced at Shenyang. INS/GPS navigation systems have been requested. Advanced AA-10 and AA-11 AAMs and ECM pods are also believed to be part of the transferred package. Even the basic export version of the Su-27 provides China the basis for a much more potent beyond-visual-range and short-range fighter capability, and will provide improved air cover over the disputed South China Sea territories, all of

Taiwan, the Korean Peninsula, and most of Japan. Improved Chinese manufactured Su-27 variants could also be deployed on a future Chinese aircraft carrier, used in a strategic nuclear delivery role as a replacement for the ageing H-6 bomber, and exported to other nations. However, China will require an extensive in-flight aerial refuelling capability to use the Su-27 to its full potential, in addition to improvements in its pilot training programmes.

For the several past years there have been rumours of China's interest in purchasing another Su-27 variant, the Su-30MKK, in a deal comparable to Russia's US$1.5 billion contract with India to purchase 40 highly modified Su-30MKs with eventual co-production rights. The Su-30MKK is an advanced long-range, low-level, fighter attack aircraft. When combined with AWACS and aerial refuelling capabilities (thus possibly allowing Chinese air strikes against Guam, Australia, or Indian Ocean targets, as well as significant periods of loitering over contested areas of the South China Sea) the aircraft has an impressive combat potential, which includes an unrefuelled combat radius of over 900 miles, and precision weapons such as the Zvezda Kh-31 ramjet-powered anti-ship and anti-radiation missile.

During August 1999, China signed an agreement with Russia for the purchase of 40 or more Su-30MKK (i.e. *modernizirovannyi kommerchesky dla Kitaya*, or 'modernised commercially for China') fighter-bombers from the Irktusk Aircraft Production Association in a contract worth up to US$2.5 billion. Negotiations have also reportedly been undertaken on a co-production agreement for another 250 of the aircraft, and for a second batch of 40 constructed aircraft. Some Western defence observers had been sceptical of the sale due to perceived inadequacies of Chinese training, technical maintenance capability and logistics, budget resources, etc. Negotiations for the purchase had reportedly been ongoing since 1997. First delivery of 10 aircraft is to be made by the end of 2000.

The weapons package with the aircraft could include: the R-27ER (AA-10C 'Alamo-C'); the R-27ET (AA-10D 'Alamo-D'), and the RVV-AE (R-77/AA-12 'Adder') medium-range AAMs; and the R-73E (AA-11 'Archer') IF homing close-range AAM. It could also include a variety of sophisticated air-to-surface weapons such as the Kh-29L/T (AS-14 'Kedge') medium-range laser/TV-guided ASM, the Kh-31A/P (AS-17 'Krypton') medium-range radar-guided ASM; and possibly the Kh-59M (AS-18 'Kazoo') long-range TV command-guided ASM with APK-9 datalink pod.

There has been speculation that China is interested in obtaining production capabilities for other advanced Russian military aircraft such as the Su-37 and I.42 composite material stealth fighter, and may have provided financial support for the continued development of these aircraft. The Su-27 'extended family' (one source indicates some 36 sub-variants) consists of the Su-30 attack version, Su-32 maritime strike version, Su-33 carrier version, Su-34 long-range bomber, and the Su-35 and Su-37 advanced technology versions with such features as FBW control systems, canards, and thrust-vectoring. China is anticipated to be Russia's first export customer for the Su-32 by 2002, stemming from Chinese interest since 1998. China hopes to barter for, rather than pay hard cash, for much of this Russian equipment. For example, some reports indicate that at least part of the Su-27 sales were paid for with consumer goods such as vodka, canned food and clothing, with perhaps only 25 per cent of the deal paid in hard currency. The Director General of VPK MAPO, Nikolai Nikitin, has recently denied that China will be participating with the 1.42 programme. Unconfirmed reports during 2000 indicated that a Russian sale of its advanced thrust-vectoring Su-37 design to China was pending. Rumours have also persisted that China may have acquired up to 30 Russian MiG-31s, possibly through unofficial channels. While still unsubstantiated, MiG-31s could be employed for reverse-engineering purposes to develop a high-speed interceptor. Russia has recently offered to export a 'bolt-on' stealth device that supposedly renders non-stealthy aircraft invisible to radar, as well as reducing drag, through enveloping the aircraft in a cloak of ionised plasma gas that would give a glowing image!

The FC-1 (previously designated the 'Super 7') is a new all-weather, single-seat fighter intended to possibly replace the large numbers of obsolete J-6 and J-7 series aircraft still in wide PLAAF and Chinese Navy service, and as an export aircraft to replace ageing J-7, US F-5E and Mirage 3 fighters. It is currently under development at the Chengdu Aircraft Industrial Corporation. Originally intended only for export at a medium technical level as an advanced derivative of the J-7 series, it has subsequently undergone major design revisions since 1993 to provide more sophisticated capabilities. The prototype is believed to have flown by 1997 and initial production reportedly commenced during 1999. Some sources indicate that flight tests have been delayed until 2000.

Chinese sources have claimed that the FC-1's combat effectiveness will be over 70 per cent of that of modern Western third generation fighter aircraft such as the F-16 (which its redesign makes it superficially resemble). However, this improved capability has also increased its export price by over 35 per cent. Consequently, nations interested in FC-1 purchases, such as Pakistan which is co-funding the design and hopes to procure about 150, have requested its adoption by the PLAAF to lower overall procurement costs. The FC-1's original design has probably benefited from a subsequent infusion of significant new Russian and Western technology. One unconfirmed report indicates that the FC-1 could have an advanced real-time multiple sensor data-fusion and inter-aircraft data-link/sharing capability made possible by the use of eight 64-bit processor computers in its avionics suite. Other advanced systems reportedly being integrated in the FC-1 include look-down shoot-down targeting, night combat capabilities, track-while-scan, and electronic jamming systems.

Reportedly, China has received Russian Mikoyan OKB assistance in the redesign of the FC-1 new generation fighter aircraft (with the integration of MiG-29/33 technologies), which could see wide PLAAF deployment by 2000 as an alternative to upgrading the near-obsolete J-7II and J-7III inventory. The FC-1 could also employ Russian designed aero-engines (RD-93 or AL-31), radar systems (Kapyo) and missiles (R-27) transferred with the Su-27. One report from 1998 indicated that Russia was offering a lightweight close-air-combat 'Product 33' fighter powered by a single RD-33 aero-engine used to power the MiG-29, and similar in appearance to the US F-16, as a complete solution for the FC-1 Three European suppliers have reportedly bid on the FC-1 radar contract since 1997: GEC-Marconi's Bluehawk or Super Skyranger; Alenia's Grifo S7 with the Aspide AAM system; and Thomson-CSF/Sagem's RC-400. Russia has also offered the Kopyo radar. It may have conventional mechanical control systems with back-up FBW control systems. Preliminary statistics for the FC-1 are a top speed of mach 1.6 at 16,500 m, and a maximum take-off weight of 12,700 kg. A unit cost range of US$15-25 million has been suggested by various sources.

The FC-1 programme may have been delayed due to an inability to obtain some Western avionics systems, which Pakistan reportedly prefers, and this may result in an increased use of Russian or indigenous systems. Difficulties have also been reported in the development of FBW systems and BVR radar and targeting systems. While reports continue on the potential cancellation of the programme, the FC-1 could fill a crucial specific PLAAF/PLAN requirement to replace its thousands of ageing fighter and attack aircraft, mostly J-6s and Q-5s (approximately 4,000-5,000 of all types, including trainers). An inexpensive lightweight fighter such as the FC-1 is necessary because the PLAAF and PLAN air corps will remain massive services with many pilots requiring flight experience even after planned force reductions. Despite numerous security responsibilities covering a vast area, it seems improbable that Beijing would be able to replace its current inventory with more advanced designs such as the J-10 and J-11 on a basis even approaching one-to-one. The FC-1 would provide the 'low' end of a future PLAAF/PLAN 'high-low' fighter force structure. Without such a replacement aircraft programme, the PLAAF/PLAN could develop a relatively 'hollow' force structure by 2015. This might consist of approximately 300 ageing, but upgraded, J-7s with possibly some obsolete Q-5s, 300 to 400 upgraded J-8s, 200 JH-7s, about 500 Su27s and Su30s, and possibly 200 or more J-10s. While precise numbers are difficult to estimate, China might be operating with a 1,500 fighter attack aircraft force under this scenario.

The J-10 is China's current initiative to develop a new, fourth/fifth generation indigenous fighter aircraft for the PLAAF and PLAN, and is an important programme from innovative R&D, foreign technology transfer, systems integration, and advanced manufacturing perspectives. It is intended as a lightweight, multi-role fighter to complement the Su-27 and will have a broader radius of operations even without aerial refuelling. Its development is thought to have begun during the mid-1980s with the input from Israel's Lavi (and, indirectly, US F-16) fighter technologies such as aerodynamic configuration, airframe, and avionics. However, the programme has also probably benefited from Su-27 and other foreign technology transfers. Israeli co-operation on the J-10 programme may have began as early as 1982 at the Chengdu plant. The J-10 may also directly employ US F-16 technologies acquired through Pakistan.

The conventional intelligence wisdom is that the J-10 closely resembles Israel's Lavi prototype fighter and that Sino-Israeli co-operation on this programme began during the early 1980s. A minority view is that it is a redesigned and improved version of the indigenous J-9/J-11 experimental fighters that did not progress beyond the prototype stage, which were in turn partially based upon Soviet MiG-23 technology, but with features such as a fixed delta wing, canard foreplanes, and stealth features that could provide a superficial resemblance to a Lavi. (In possible support of this minority view a Chinese aviation magazine has recently published photos of an apparently unmanned Tai Shi 'lift type' fighter sub-scale prototype used in remote control testing that has forward canards but does not specifically resemble the Lavi.) Stealth-like features include the extensive use of advanced composite materials and the burrowing of the aero-engine deep within the aircraft fuselage. Active flight control, control configured vehicle (CCV) systems for relaxed stability and decoupled flight (that is abrupt changes of nose direction), direct lift control, and quadruplex FBW technology (with a possible future use of more advanced fly-by-light systems), with integrated fire control, are believed to have been applied. This could result in very agile flight characteristics.

Some tentative specifications are a top speed in the area of M 2.1, an eight missile and one fuel-tank load, service ceiling of 18,000 m, combat radius of 1,200 km, and the possible use of RAM coatings to provide some stealth features. A aero-engine 2-D inlet lip and composite structures may also be used to reduce RCS. A K-8FBW prototype was reportedly developed by the Flight Test Establishment to model FBW and active control systems and to help eliminate pilot-induced oscillation. CIMS and advanced flight test facilities have also been developed for the programme. Development and flight tests of the J-10 have been undertaken at the Chengdu and possibly Xi'an aircraft development facilities, and a twin-engined aircraft carrier version could also be under development.

Previous Chinese fighter aircraft including the J-7 and J-8 series have emphasised the air superiority role, but the J-10 is to be a multi-role fighter-bomber, and would be inherently capable of aerial refuelling. Its multi-purpose pulse-Doppler radar type is believed to be either the improved Russian Phazotron Zhuk-27 or the more capable Russian Zhemchoug (Pearl) series, an indigenous '14th Technology Research Institute' designed JL-10A pulse doppler radar, or the Israeli Elta EL/M-2032 developed for the cancelled Lavi fighter. An advanced avionics suite is believed to include HUD, a head-down display, and other multi-functional displays, in addition an assortment of advanced air-to-air and smart air-to-ground weapons. The Russian Lyulka AL-31FU turbofan aero-engine has been rumoured as a likely power plant, which could provide a 1.25:1 thrust-to-weight ratio, and could employ thrust-vector-control. Other conflicting reports indicate the less capable AL-31F or AL-31L, while other claims indicate that the J-10 prototype may be powered by a Russian RD-35 aero-engine, or that it may even be powered by an indigenous aero-engine with a digital fuel management system. Like the Su-27, an annual production rate of 20 to 25 aircraft can be expected, perhaps increasing to 50 or more per year once the learning curve has been optimised, with an ultimate procurement of several hundred or more.

Current activities surrounding the J-10, which did not make an anticipated fly-by public appearance at the 50th Anniversary National Day celebrations in Beijing, on 1 October 1999, are highly speculative, and the posting of fake J-10 photos on the Web is now somewhat of a growth industry! AVIC 'Number 611 Laboratory' and Tsinghua University, Beijing, have also been associated with the aircraft's R&D programme in such areas as CIMS by some accounts, as have the presence of large numbers of foreign technicians at the Chengdu plant. Some unconfirmed reports indicate that while the first successful J-10 test flight was made on 24 March 1998, a prototype may have crashed during a previous test flight during 1995. A 1999 intelligence leak on the Internet, for which a Chinese aerospace engineer from Chengdu was arrested, indicated that only two of six prototypes are flying, with the others undergoing static test or assembly completion. During the 1998 Zhuhai Airshow, a mock-up of the J-10 cockpit had three multi-functional displays (other reports indicate two large and two smaller LCD colour displays). This avionics suite will likely be combined with a helmet targeting system. The new Chinese 'Twin Star' GPS, possibly to be launched by 2001, may be used for navigation and target positioning.

With the integration of a full array of advanced avionics, sensors and weapons, the J-10 could provide the PLAAF with a 21st century aircraft of a level of sophistication and manoeuvrability comparable to that of many modern Western fighter aircraft. The J-10 may have been designed to specifically counter at WVR and BVR, through superior acceleration and subsonic and supersonic turning capability, the most recent versions of the US F-16, F-15 and F-18, Russian MiG-29 and Su-27, and Japanese F-2 fighters, and it will have a multi-role function carrying a wide range of weapons. Unconfirmed estimates suggest the cost of the J-10 programme is over US$10 billion, with each individual aircraft costing some US$20 million. It is still conceivable that serial production could begin within the next two years, with operational deployment in strength by 2005.

According to recent unconfirmed reports from the US Navy's Office of Naval Intelligence, the next-generation XXJ fighter aircraft programme is believed to be in the early development stage (possible Chinese designation of J-12, although this was also the designation for a previously cancelled lightweight fighter). The reports suggested that the Chinese were developing a large, multi-role aircraft with advanced stealth, twin-engined supersonic cruise, and air combat capabilities. R&D may be centred at the Chengdu aerospace complex. A possible initial service date with the PLAAF and Chinese Navy could be 2015, representing a breakthrough in capabilities possibly several generations beyond current systems. It may be intended as China's successor to the J-10 and J-11, and may attempt to match the US F-22 in sophistication, perhaps with Russian assistance. At least one unconfirmed report has indicated that over the past two decades China has developed a number of prototype stealth aircraft, as well as retrofitting stealth components and subsystems to existing aircraft types. Recent Chinese television reports have indicated wind tunnel tests of forward-swept-wing designs.

2.5 Bombers and Attack Aircraft TOP

China's nuclear bomber fleet is comprised of older-generation H-5, H-6 and Q-5 bombers that are now becoming quite obsolescent. However, they could be supplemented by new generation aircraft now operational such as the Su-27 and FBC-1/JH-7 fighter-bombers that are believed to be potentially nuclear-capable, as could the indigenous J-10 and FC-1 fighter aircraft currently under development.

China has recently demonstrated an aerial refuelling capability that could be used to extend the bombing range of such aircraft.

The Harbin Aircraft Hongzha H-5 light bomber and Harbin Aircraft/Xi'an Aircraft H-6 medium bomber were developed as derivatives of Soviet designs during the 1950s and 1960s but with major local modifications. The H-5 was retrofitted as a nuclear bomb carrier, the HZ-5 photo as a reconnaissance aircraft, and the HJ-5 as a bomber-trainer in the late-1970s.

In addition to the Harbin Aircraft Factory and Xi'an Aircraft Factory, the Shenyang Aircraft Factory and Aircraft Structure Analysis Research Institute played a supportive role in the development of the H-6. One of the largest aircraft China has ever developed (maximum take-off weight of 75,800 kg), in its final form the H-6 is capable of delivering nuclear gravity bombs, missiles and torpedoes. The H-6A had been updated since the 1980s with automated bombing, fire control and navigation systems, Doppler and bombing radar systems, and new avionics. The PLAN's H-6D has incorporated two under-wing air-to-ship missiles and associated delivery systems. Although by modern standards largely obsolescent, the H-6 is still widely used by the PLAAF and PLAN, and the Flight Research Institute as a test-bed for new aero-engines, a carrier vehicle for high-altitude/speed RPVs, and as an ECM aircraft. Modernised H-6 bombers could be used as an ALCM (air launched cruise missile) platform, possibly carrying four cruise missiles each.

The Harbin Aircraft Factory and the Water-Based Aircraft Design Institute also developed the indigenously designed SH-5 water-based anti-submarine bomber (flying boat), which entered limited service with the PLAN in 1987. It is equipped with Doppler search radar, magnetic anomaly detectors, torpedos, and four supersonic C-101 air-to-ship missiles.

The Nanchang Qiangjiji Q-5 (export version designated the Nanchang A-5 'Fantan-A') supersonic attack aircraft began development in 1965 and did not see delivery until 1970 after a number of prototype testing setbacks. The Q-5 is primarily of Chinese design (with input from the Soviet MiG-19 design) that incorporated a number of local innovations. Developmental assistance was also provided by the Shenyang Aircraft Factory and the Shenyang Aircraft Design Department. Derivatives developed in the 1970s and 1980s included the Q-5 tactical nuclear weapons carrier, the Q-5 naval attack torpedo carrier, the overall improved performance Q-5I and Q-5IA, and the Q-5III advanced avionics version. Export versions have been delivered to Pakistan beginning in 1982/83.

The Q-5M was a late 1980s Sino-Italian joint venture between CATIC, the Nanchang Aircraft Company, Aeritalia, Societa Aerospaziale Italiana, and Gruppo Sistemi E Teleguidati. The objective of the consortium was to develop an improved Q-5 version with more advanced avionics, navigation and fire control systems originally developed for the joint Aeritalia-Brazil AMX attack aircraft. Specific systems transferred to the Q-5M included a digital central computer, dual data bus, Litton inertial navigation system, Agusta HUD, air data computer, weapons aiming computer, FIRR P-2500 radar, IFF system, and VHF/UHF radio. The Q-5B version is currently in service with the PLAN and is equipped with a ranging radar, torpedos or two C-801 sea-skimming air-to-ship missiles, and possibly new laser-guided bombs.

China recognises it still has a wide technological gap in bomber development compared to the US and Russia (the only other true medium-heavy bomber manufacturers today), but has indicated intentions to develop future designs incorporating new technologies. To a large extent, the development of increasingly sophisticated cruise and ballistic missile systems may limit the development of future Chinese heavy bombers. However, some reports indicate that fair numbers (25+) of H-5s and HJ-5s (ECM conversion) continue to be based at locations such as Huxian airbase, and H-6s at Nanyuan and Litong airbases. Photos have recently shown H-6s in a dark, non-reflective stealth-like paint scheme, so it is possible that significant technical upgrades to China's bomber fleet (after the practise of the US Air Force's near-continuous B-52 modernisation effort) continue.

The Xi'an Aircraft Company has developed the more advanced Jianjui Hongzhaji-7 (JH-7)/FBC-1 'Fighter-Bomber-China-1' or 'Flying Leopard' multi-role two-seat supersonic (Mach 1.7) combat aircraft,. The JH-7 reportedly first flew in 1988/89 and has seen limited service since 1993/94 with the PLAN as a dedicated maritime attack aircraft. (An alternative to the JH-7 was reportedly the Nanchang Aircraft Manufacturing Plant's 1975 design for the supersonic Q-6 attack aircraft, which would have succeeded the Q-5, and blended design elements of the MiG-23 and F-16, and would have featured a variable geometry wing.) China's Zhuhai '98 Air Show provided a showcase for the latest version of the JH-7, a large aircraft with a gross weight over 28,000 kg (62,000 lbs). It has been developed as a platform for precision-guided and stand-off munitions such as anti-ship missiles, and is essentially China's first indigenously designed and produced attack aircraft. Like the European Panavia 'Tornado' and the Russian Sukhoi Su-24 'Fencer' it is a tandem-seat design with significant air-to-air capabilities. Some observers also believe the design was influenced by the 1970s US F-4 Phantom series, examples of which might have been obtained from Vietnam.

Believed to have been in development since the late 1980s, the FBC-1 finally entered limited service with the PLAN during 1994, replacing obsolete bombers as a true air-to-ground and maritime strike aircraft with a self-defence air-to-air capability. At Zhuhai, the FBC-1 was described as a "multi-mission all-weather supersonic fighter bomber fully independently developed by China" by the Xi'an Aircraft Design and Research Institute and manufactured by the Xi'an Aircraft Industry Corporation (Xi'an Aircraft Manufacturing Company), with input from the Flight Test Establishment. The aircraft was designed at Xi'an using computer-aided design (CAD) techniques with input from the Flight Test Establishment. The FBC-1 now employs a digital FBW flight control system with computers networked to the aircraft's flight navigation and attack computers (prototypes were reportedly developed using Q-5 'Fantan' testbeds.)

Reportedly, the FBC-1's leading edge slats, rudder-elevon and inboard/outboard elevon integrated servo-actuators are digitally networked to aircraft rate gyros and accelerometers, sensor assemblies and cockpit panels. An internal ECM suite is believed to include passive warning gear, active jammers and expendable chaff/flare dispensers. The original version of the JH-7 was believed to have been equipped with an unreliable terrain following radar, possibly derived from US RF-4C systems captured during the US war against Vietnam. Other development difficulties were believed to have included problems with the integration of the GPS into navigation and attack systems, determining the appropriate anti-ship missile, and aero-engine reliability. It is possible that EW and reconnaissance versions of the JH-7 could be equipped with specialised systems such as multi-spectral sensors.

The JH-7 was designed for two YJ-8 anti-ship missiles (ASMs) with over-water pulse radar modes for enemy ship acquisition, and was initially revealed on CCTV during an October 1995 PLAN exercise. Some subsequent reports indicated it had been rejected by PLAAF in favour of the Su-27 (J-11), with superior weapon systems, range and payloads, in addition to shortcomings of the JH-7's two unreliable and underpowered Wopen WS9 turbofans (licence produced Rolls-Royce Spey MK202s). However, the updated FBC-1 now appears to have found a niche with the PLAN as a maritime attack aircraft (some 24 were in service by 1996 and could now total over 70), and possibly a testbed for the PLAAF for more advanced types such as the J-10. Recent improvements made to the FBC-1 are believed to have included:

· Integration of a new family of direct fire and stand-off cruise ASMs (YJ-21 and YJ-22);

· Compatibility testing of the JL-10 pulse Doppler fire control radar system (export version of the Russian Phazotron Zhuk radar, although some sources indicate that the JL-10 is a domestic design, and the KLJ-1 is a licence copy of Phazotron Zhuk-811, a variant of NO1011 radar), also utilised with the J-8IIM;

· Development of a new 'Blue Sky' low altitude navigation pod with terrain following radar (TFR);

· Wide field-of-view forward looking infrared (FLIR);

· Improved onboard control computer system, and likely mission planning systems;

· Independent environmental control unit and power supply;

· Upgrading onboard avionics for an optically guided weapons capability;

· Integration of an air-to-ground helmet mounted sight system;

· Testing for an upgraded WS9 engine or replacement with the Russian AL-31 (also used by the Su-27);

· Modernised fire control system with INS/GPS and automated terrain following modes;

· US MILSPEC standards reportedly used for systems such as software and data communications protocols;

· Integration of a helmet mounted sight (produced by the Luoyang Electro-Optical Equipment Research Institute) integrated with the PL-9 air-to-air missile for an off-boresight engagement capability; and

· Optical aid in designating air-to-ground and anti-ship missiles, and surface targets and reference points.

China's purchase of Russian Su-30 fighter-attack aircraft, as discussed in section 2.4, also perhaps exceeds and duplicates the JH-7's capabilities, and may result in a decreased production life. However, further advanced versions may be designated the FBC-2.

Some sources have indicated that China is interested in acquiring (or has already acquired some) Russian Tu-22M 'Backfire' supersonic bombers equipped with long-range AS-15 (RK-55) cruise missiles. While the Backfire represents 1970s bomber technology at a design level comparable to the US B-1, it has a large growth potential as a weapons platform which would provide a significantly increased precision strike capability to the PLA Air Force. It is conceivable that the PLAAF is also interested in Tu-160 'Blackjack' aircraft technology that would offer greater strategic capabilities. China would also probably eventually like to produce its own reverse-engineered variants if examples of these aircraft types were indeed somehow acquired.

Some recent reports indicate that China may have obtained the wreckage of the US F-117A Nighthawk stealth fighter that was downed over Yugoslavia during March 1999. There is currently some debate as to whether China is now capable of designing or reverse-engineering stealth aircraft comparable to the US F-117 and B-2, or more likely stealth cruise missiles and unmanned aerial vehicles (UAVs). China's aerospace industry has access to the required components of such aircraft including high-performance computers, advanced composite materials and associated manufacturing techniques. It also has finite element analysis software used to assess aerodynamic forces and stresses on three dimensional structures. These include Maxwell's equations related to radar reflectivity and electromagnetic wave scattering used for determining a vehicle's radar cross section (RCS). Attempts to develop stealth systems are therefore quite likely and other reports indicate the use of special coatings to provide some radar avoidance capabilities for older aircraft.

Other unconfirmed and speculative reports indicate that a H-9 medium bomber (Yuan Hong), possibly with some stealth characteristics (including special radar absorbent coatings), is under development at Xi'an. However, this may also be closely related to the XXJ fighter project, or possibly an Internet-inspired hoax. The H-9, if it exists, could be a co-operative programme between aircraft development centres at Xi'an and Shenyang, and involve a twin-engined, Mach 2+ class design benefiting from the surmised sale of several Russian Tu-22Ms to China during the 1990s. Prototype H-9 designs may possibly have undertaken flight tests by the late 1990s. The aircraft could be powered by turbofan aero-engines adapted from the Tu-22M's, with a potential weapons payload that could include conventional bombs, precision guided munitions (PGMs) and cruise missiles. In any event, it is likely that the PLAAF will be loath to abandon its bomber capability, and will be seeking some form of replacement for the H-5 and H-6 beyond fighter bombers such as the JH-7/FBC-1 and Su-30.

2.6 Trainers TOP

One of the first aircraft designs produced by the PRC's aerospace industry was a licensed version of the Soviet Yak-18 (Chinese designation CJ-5) primary trainer. Initial CJ-5s were first produced in 1954 at the Nanchang Aircraft Factory, equipped with M-11 piston engines produced at the Zhuzhou Aero-Engine Factory. Early training was also conducted on procured Soviet MiG-15UTI trainers (JJ-2) and, later, on domestically produced versions of this aircraft (JJ-4).

The Jianjiji Jiaolianji JJ-1 jet fighter trainer, and its PF-1A turbojet power plant, was the first aircraft entirely designed and manufactured in China itself. Development was undertaken at the Shenyang Aircraft Factory and Shenyang Aero-Engine Factory, starting in 1956, and an initial test flight was conducted during July 1958. This design helped set the technical basis for later Shenyang aircraft types such as the CJ-6 primary trainer, Q-5 attack series and contemporary J-8 fighter series, but was not put into batch production reportedly because of changing PLAAF training requirements.

By the late 1980s a total of over 4,000 aircraft trainers of various types had been produced by China's aviation sector, some one-third of total aircraft production. Variations of the Shenyang/Nanchang CJ-6 primary trainer (the CJ-5's successor) continued into production until at least the late 1980s. The CJ-6 and its piston HS6 aero-engine design dates back to 1957, with the initial flight test in August 1958. It was the first aircraft designed and batch-produced by the Chinese aerospace industry, and its total development required only four and a half years.

Derivative trainers of jet fighters include the Chengdu Aircraft Factory JJ-5 (as a replacement for MiG-15UTI trainers, and used for flight and combat training, with a first test flight in May 1966), Shenyang Aircraft Factory JJ-6 (first Chinese supersonic trainer, with the initial test flight during November 1970, and December 1973 production certification; FT-6 trainer export versions have been exported to Albania, Bangladesh, Egypt, Iraq, Pakistan, Tanzania, and Vietnam), and supersonic Chengdu/Guizhou JJ-7 (first test flight during July 1985). The development of Chinese fighter flight trainers has followed a pattern of eventually employing each successive generation in a training role. Nevertheless. it is unlikely that a training version of the J-8 will be developed because of recent Su-27 purchases and the significant changes made to the next generation domestic fighter designs such as the J-10 and FC-1.

The development of the JJ-7 advanced trainer was a co-operative effort between the Guizhou Aircraft Company, the Guizhou Aircraft Design Institute, and the Hubei Escape System Research Institute, with Yu Xiuming the chief designer. The FT-7P 'Mongul' export version of the JJ-7 has been sold to Pakistan to train its F-7P pilots, and is equipped with HUD and air data computer, and has increased range. The latest JJ-7A/FT-7 version is reportedly equipped with an afterburner Russian RD-93 aero-engine derived from the RD-33 aero-engine used to power the Russian MiG-29. It also incorporates features such as advanced avionics that are to be used for the new FC-1 fighter. The JJ-7A is used as an advanced trainer for the most current versions of the J-7 and J-8 fighter series, and export versions have been delivered to Pakistan, Bangladesh, Myanmar, Sri Lanka and Zimbabwe. However, production rates from 1991 to 1994 were low, with only 'a few' aircraft produced annually.

The Nanchang K-8A 'Karakorum' is a new generation Sino-Pakistan basic/intermediate trainer/light ground attack aircraft. Prototype production began in 1989 and six aircraft were delivered to the Pakistani Air Force during 1994, with a total of over 30 now believed to be in Pakistan's inventory as replacements for older T-37 trainers. Nanchang's K-8A tandem-seat acrobatic jet trainer has been developed as a joint venture with the Pakistan Aeronautical Complex also as a replacement for Pakistan's FT-5 (JJ-5) trainer and as a light-attack successor for MiG-17 derivatives worldwide. It is equipped with Collins EFTS-86 multi- successor for MiG-17 derivatives worldwide. It is equipped with Collins EFTS-86 multi-functional displays and a Garrett/AlliedSignal TFE-731-2A turbofan aero-engine (a total of 58 aero-engines were delivered by June 1996). There has been some uncertainty as to whether the K-8A was to be purchased by the PLA, or was intended solely for export to Third World nations such as Bangladesh, Myanmar, Laos, Sri Lanka and Zimbabwe (the China National Aerotechnology Import and Export Corporation did apparently make an unsuccessful 1994 bid to interest the US military in the K-8A as a candidate for its Joint Primary Aircraft Trainer programme). The addition of the aircraft to the PLAAF inventory was complicated by the Chinese military's requirement for a cheaper alternative to the 'expensive' US power plant, which could be either developed domestically (possibly by the Zhuzhou Power Machine Factory WS11 turbofan), or purchased from an alternative supplier such as the Ukraine (Progress AI-25TL turbofan; one recent report has indicated a contract for 30 aero-engines of this type for the PLAAF during 1997/98, with a potential order of up to 300). Another alternative supplier was Russia, to circumvent current US export restrictions on military and dual-use technology deliveries to China (emphasised by the fear of TFE-731-2A applications to power new generation Chinese cruise missiles). However, as early as 1991 the PLAAF indicated interest in an initial purchase of up to 10 copies (with three test flight prototypes under evaluation). Some reports indicate a limited delivery of the K-8A is now underway for the PLAAF (an initial batch of over 20 out of a possible total future purchase of some 200 to 250 aircraft for the PLAAF and PLAN), while other reports claim that China and Pakistan have not purchased more than six pre-production K-8s each since 1994. The Pakistan Aeronautical Complex delivered the initial PLAAF batch of airframe subassemblies to the Nanchang Aircraft Manufacturing Company in June 1997 in preparation for apparent serial production.

During June 2000, it was reported that China's sale of HAIG K-8 two-seat basic jet trainer and light ground-attack aircraft to Myanmar was substantially greater than initially believed (i.e. seven K-8s in a deal worth about $US 20 million). It is now believed that 12 aircraft were delivered to Myanmar during 1999-2000, the most recent batch in January 2000. Myanmar's current inventory stands at 12 to 14 K-8s, which could be doubled once the programme is completed, perhaps to as high as 30 aircraft.

China has also sold 80 K-8s to Egypt under a US$350 million local manufacturing deal, and eight to Zambia.

2.7 Airborne Early Warning (AEW), Electronic Warfare (EW), and Intelligence Aircraft TOP

A primary motivation for the PLAAF to improve its AEW and surveillance capabilities is the current superiority Taiwan enjoys in these areas, and the limitations this places on potential military actions against this contested island province, as well as surveillance activities over the South China Seas. China had its own prototype AEW radome project during the mid-1980s that was installed on a Tupolev transport but this was apparently cancelled due to technical difficulties. The Institute of Composite Special Structures, Jinan, Shandong, has developed composite shields for airborne radar, phased array radar shields, conformal skins for conformal or intelligent radar arrays, and composites for aircraft stealth structures.

China's Tu-4 AEW project began in 1967 under the name Kongjing (KJ)-1, using a modified Tu-4 and a '843' radar. An example of the KJ-1 can be found at the Datangshan Aerospace Museum, Beijing. The radar system made the aircraft underpowered and new engines were installed and small fins were fitted on the horizontal stabilisers due to areodynamic changes. Flight testing began in August 1970, with mixed results on radar performance, which was good for detecting targets over water, desert, or at high altitude, but poor for low flying targets due to ground clutter effects. Reportedly, the programme was terminated by September 1971. Other reports indicate that the Tu-4 Bull AEW aircraft (a Russian design derived from the US B-29 Superfortress) entered the PLAAF inventory during the 1980s to counter Soviet threats, but probably did not see service beyond that decade. A follow-on prototype model may have been based on the Y-8 transport. Computer data-processing systems were also probably minimal, as were sophisticated communications systems. The probable lack of advanced radar processing technology such as fast fourier algorithms, made it difficult for the system to detect low flying targets. It is interesting to speculate now that the Israeli Phalcon project has been cancelled, due to pressure from the US, whether China will revive its domestic AEW programme or directly purchase or lease Russian systems such as the Beriev A-50/A-50U 'Mainstay'. The most recent version of the A-50 would include Russian phased array radar, electronic surveillance measures and ECM.

The PLAAF is believed to operate at least several dozen specialised aircraft for reconnaissance and ELINT operations. The Hongdian H-5 bomber has been retrofitted as the Hong Zhen HZ-5 photo reconnaissance aircraft and a ELINT version. Jet fighters such as the J-6 and J-7 have been modified as a reconnaissance version, the Jianjiji Zhenchaji JZ-6, with its forward fuselage cannon replaced by a camera array. In 1994 China had reportedly requested the purchase of the Canadair Challenger business jet aircraft possibly to be equipped with Elta (Israel Aircraft Industries) EL/L-8300 SIGINT (signal intelligence) systems for advanced electronic surveillance capabilities.

While until recently China was over a decade behind the most advanced AEW systems, there is now some reason to suspect it may now be rapidly catching up. For example, it has attempted various domestic development and foreign technology transfer programmes for AEW aircraft, which include advanced phased-array radar and other sensors on either domestic Yun Y-8 and/or Russian transport aircraft. Domestic aircraft such as the Hongdian H-6 bomber and D4 RPV have been modified for ECM and ELINT applications. About four Russian-built Tupolev Tu-154M transports have currently been modified to serve as first-generation EW, AEW and ELINT aircraft with a capability roughly comparable to the Ilyushin Il-20 ELINT used by the Soviet Union during the 1980s. Systems possibly include a Raduga side-looking SAR with 3 m resolution, IR imaging with 0.5 m resolution, and an electro-optical camera with 0.3 m resolution. At least eight to 10 more are believed to be on order, and will soon fill a major technical intelligence and long-range surveillance gap for the PLAAF. Some have been located at the Nan Yuan Airfield south of Beijing, which is also the location of several research institutes specialising in avionics, electronics and airborne weapons, and others have been deployed to the Nanjing Military Region directly opposing Taiwan.

During the late 1980s Thorn-EMI and CATIC undertook discussions on the development of an early-warning aircraft for the PLAAF that would have involved the installation of a Skymaster radar system on either Y-8 or Y-12 Chinese transport aircraft. While these discussions did not result in an immediate procurement, during June 1996 the UK's Racal Electronics reportedly agreed to supply the PLAN with up to eight Racal Thorn Searchwater 2000-type radar systems installed in Y-8s for about US$67 million. With the Y-8 as the carrier aircraft, the Searchwater could have a 200-mile range, with a possible footprint some 400 miles wide, and an endurance of approximately 11 hours. Furthermore, unconfirmed reports indicate this system may have been deployed following China's purchase in 1996-97 of to six to eight Searchwater/Skymaster radar systems. Another programme, 'Argus', has also reportedly been under negotiation with the UK's GEC-Marconi. It is possible that China may have acquired at least one of the more capable Argus 2000 AEW radars that was originally intended to be installed on an Il-76 airframe. The Searchwater/Skymaster radar systems may have been intended to upgrade the SH-5 ASW flying boat fleet. A modest capability of some eight AEW equipped Y-8 aircraft could significantly increase the PLA's regional offensive and defensive operational capabilities in such areas as aircraft and missile acquisition and targeting and sea-surveillance. Nevertheless, it is still a stop-gap measure until a full capability AEW system such as the Russian A-50 system is acquired or developed.

Israel was another recent proposed supplier of AEW technology for the PLAAF in the form of Israel Aircraft Industries' EL/M-2075 Phalcon AEW radar system. An initial batch of four Phalcon-equipped aircraft (the A-501 version of the Il-76) were to have been sold at US$250 million each. This order for perhaps an ultimate total of eight such systems, which could have provided China with significant new regional operational capabilities, was cancelled in July 2000 due to US pressure on Israel. During the March 1997 summit between the then Israeli Prime Minister Benjamin Netanyahu and the then Russian President Boris Yeltsin discussions resulted in an initial joint venture to produce the aircraft for China between Russia's Taganrog Aviation Complex and Israeli Aircraft Industries. Israel had reportedly demonstrated the Phalcon system to the PLAAF onboard Chilean aircraft equipped with a version of the system.

This aircraft's radomeless, solid-state D- or L-band radar system reportedly includes a series of conformal phased array antennas, monopulse IFF system, and varied signals intelligence systems (i.e. ELINT, COMINT). With an advanced fusion system that continuously integrates data gathered by the entire sensor suite and additional advanced software systems to eliminate background noise that could provide anti-stealth capabilities, it is by some measures comparable in capability to the US Navy's Aegis system. The system can reportedly monitor a 500-mile wide circle to support offensive and defensive missions, with the A-501 carrier aircraft having an endurance capability of approximately 10 hours. Such varied electronics and communications intelligence collection and processing systems would have permitted improved communications surveillance and the acquisition of enemy radars, as well as improved battlefield C^4I, over broad areas such as the Taiwan Straits and South China Sea, and was viewed as a distinct threat to regional US forces. China views the cancellation as further US meddling in its internal affairs. Another possibility, to date but mere speculation, is that the Phalcon systems could be sold to China via a third party intermediary. However, intense opposition to any forms of the sale within Congress and threats to cut US military assistance to Israel if the deal proceeds in some fashion, appears to make this approach equally unlikely. China has already paid some US$100 million for a partially converted A-501 system and it is possible that Beijing may seek legal compensation from Israel. The episode may also have released China from its vague unofficial commitments to restrict weapon proliferation (notably ballistic and cruise missiles) to Middle Eastern states such as Iran and Syria.

However, it can be concluded that China is developing and acquiring relevant advanced technologies from a broad base, and within a decade will be supporting a fleet of various AEW, AWACS and EW aircraft.

2.8 Transport and Passenger Aircraft TOP

China's six transport aircraft manufacturers are located at Harbin, Nanchang, Xi'an, Shaanxi, Shanghai and Shijiazhuang; its two transport aircraft design institutes are at Xi'an and Shanghai. As of 1998, China had exported some 81 Y-12s, eight Y-7s, and 11 Y-8s, mostly to developing nations.

China's development of transport aircraft began with the production of the Soviet An-2 biplane by the Nanchang Aircraft Factory during the 1950s, which was redesignated the Yunshuji Y-5. Production of this rugged and versatile design as the Y-5B/C has continued apparently at the Shijiazhuang Aircraft Manufacturing Company, Hebei. Over 900 examples have been produced to date, with recent designs including GPS and winglets for an improved climb rate. The Y-5, also used in large numbers by North Korea, is considered by many as having excellent inherent stealth characteristics and ideal for inserting commando parachutists into enemy territory at low altitudes.

The Harbin Aircraft Y-11 light transport was certified in 1977, and has general purpose civil and military applications. The Harbin Aircraft Factory followed the development of the Y-11 with another general purpose aircraft, the Y-12, powered by twin Pratt and Whitney of Canada PT6A-11 turboprop engines. The Y-12 was the first Chinese civil transport to enter the international market, and by 1998 a total of 83 Y-12s had been exported to 18 nations. The upgraded Y-12II is a 17-seat passenger version powered by two of the more powerful Pratt and Whitney PT6A-27 turboprops. It received CAAC certification in December 1985, and British CAA type certification in June 1990. The Y-12-4 received Federal Aviation Administration (FAA) certification by 1995.

The Xi'an Aircraft Company Y-7 48 to 52 passenger commuter aircraft saw development during the late 1960s and into the 1970s by the Xi'an Aircraft Factory, Xi'an Aircraft Design Institute, Nanchang Aircraft Factory, and Chengdu Aircraft Factory, only

receiving certification after much delay in July 1982. Its domestic development was based upon experience gained from the development of small transports and medium bombers, and the establishment of a large airliner design institute. The Xi'an Aircraft Company co-operated with the Hong Kong Aircraft Engineering Company in 1985 to upgrade the Y-7-100 with more advanced foreign technology and equipment such as communication and navigation systems, winglets, and new cabin interiors for increased noise reduction. The Y-7-200A model was developed for international markets and features Pratt and Whitney PW-127 turboprop aero-engines. The Y-7-200B was a follow-on domestic version with upgraded Chinese WJ5E aero-engines. Boeing provided assistance for the design of an aerodynamically efficient Y-7-3000 wing. Advanced instrumentation for the Y-7-200 series' two pilot crew (unlike the Soviet-style four pilot crews of earlier versions) includes an autopilot capable of Category 2 landings. A recent version, the Y-7H-500, is being marketed in both civil and military transport versions (the latter featuring rear ramp, side-mounted observation windows, and strengthened landing gear), and is scheduled for FAA certification. Some 15 Y-7s are built per year at Xi'an but could easily surge to an annual production rate of up to 40.

The Xi'an Aircraft Industrial Corporation's Xinzhou 60 (or 'AE60' or 'MA60', a Y-7 derivative) short-haul 60 passenger aircraft powered by Pratt and Whitney PW-127J turboprop aero-engines was officially announced in March 2000. Xi'an had also recently conducted R&D on an even more advanced 60 to 64 passenger commuter transport design similar to the British Aerospace ATP or Saab 340, perhaps as a further refined version of the new AE60 aircraft. Power plants considered were the Pratt and Whitney PW-120 series and General Electric CT7-11 turboprop aero-engines. The aircraft will feature a more advanced aerodynamic design with flush-mounted rivots, higher-lift wing and winglets, and the use of lower weight advanced composite materials.

The Xi'an Aircraft Factory and Shaanxi Aircraft Factory developed the Y-8 medium transport from December 1968 until certification in February 1980. It is used for both military and commercial transport applications. Maritime patrol and US Black Hawk helicopter carrier versions have been developed, with the recent Y-8X maritime patrol version being equipped with new radar, navigation and communications systems, optical and infrared cameras, infrared submarine detection equipment, and sonobuoys. The Shaanxi plant has offered to produce the aircraft in various versions for domestic and export applications including metrology, measuring and surveying. In 1997, an improved Y-8F200 was provided with CAAC certification, bringing the total number of Y-8 model types to 10.

Aviation Industries of China Number Two Group *(*AVIC II*)* and Pratt and Whitney of Canada signed a Memorandum of Understanding during July 2000 confirming AVIC II's choice of the PW-150 for the power plant of its most recent Y-8F600 transport aircraft development programme. AVIC II has chosen the PW-150 as part of its strategy to widen the Y-8 market, further improve operational performance and reduce direct operating costs. The PW-150 is a latest-technology engine developed based on the PW-100 engine family's almost 60 million hours of flight experience to 2000.

The 178 seat Y-10 heavy transport was the largest aircraft of this type fully developed by China to date, with design work and prototype development initiated during the early 1970s by the Shanghai Aircraft Research and Development Institute and the Shanghai Aircraft Factory. Test flights of this smaller version of a Boeing 707 were made throughout China by the two prototypes powered by four Pratt and Whitney JT3D-7 turbofan engines during the early 1980s. While not put into production because of an apparent lack of domestic demand and the availability of superior Western aircraft, the Y-10 development provided valuable experience for the McDonnell Douglas MD-80 airliner series and other co-production programmes. Some recent unconfirmed reports have indicated the possible revival of this development programme in some experimental form, probably benefiting from significant recent transfers of US and European large transport aircraft technologies.

The Shanghai Aviation Industry Corporation is the controlling firm of the Shanghai Aircraft Factory and co-ordinates co-production agreements with foreign aerospace firms. The Shanghai Aircraft Factory, commencing in 1979, agreed to a co-production agreement with the US McDonnell Douglas Corporation for the MD-80 series of commercial transport aircraft, China's first subcontract production of a Western civil aircraft. This co-operation has extended through the 1980s and 1990s, and has included the assembly of the MD-80/90 series, including manufacturing main and nose landing gear doors, avionics maintenance and service doors, freight doors, and tailplanes. The plant also currently manufactures aero-engines, aerospace electrical components, and undertakes aircraft repairs. It is operationally affiliated with the Shanghai Aircraft Research and Development Institute, Shanghai Aero-Engine Manufacturing Factory, and the Shanghai Far-East Aero-Technology Import and Export Corporation.

The production of components such as fuselages and nose cones for export to the US results from FAA certification and a guarantee of higher quality than previous Soviet-era Chinese standards. The Shanghai Aircraft Factory was the first Chinese aircraft manufacturer to obtain FAA production certificates for both parts production and aircraft final assembly. CATIC ratified a US$1.6 billion agreement in November 1994 for the joint-production of 40 additional MD-90 'Trunkliner' transports and components at aircraft manufacturing plants in Shanghai, Chengdu, Xi'an and Shenyang. (Shanghai is responsible for major manufacturing and assembly, and the other plants for empennage, forward and aft fuselage sections, major wing components, nose sections, doors, spare parts and accessories). This agreement firmly established China as a comprehensive manufacturer of large, modern aircraft.

Following US President Richard Nixon's visit to China in 1972, the CAAC ordered 10 Boeing 707 transport aircraft. Today, all of China's large modern transport aircraft are imported and this will probably remain the case for the foreseeable future. The main competitor to the US is Airbus, who has made significant investments for maintenance, training and spare parts facilities in China. Aircraft from Russia and other former Soviet states are still imported by some northern regional Chinese airlines but are generally being phased out for airline use. China today has around 25 per cent of the world's commercial airline fleet, and this percentage can only be expected to grow in the decades ahead. In October 1997, China placed its largest commercial aircraft order in history, for 50 Boeing aircraft worth US$3 billion (36 B-737s, five B-757s, one B-747, and eight B-777s). Boeing forecasts that China will require some 1,900 commercial aircraft over the next two decades. By 1998, Boeing claimed that it had a 68 per cent commercial aircraft market share in China, with Airbus at 14 per cent.

By June 2000, China's aviation industry reportedly reached a record high level of international co-operation, winning more than US$1 billion worth of subcontracts, according to Yang Yuzhong, Deputy General Manager of the Number 1 Group Corporation of China's Aviation Industry (AVIC-I). Yang Yuzhong, together with Hao Fude, President of Boeing (China) and Li Fangyong, General Manager of Shenyang Aircraft Industry Group, also made a joint announcement that digital transmission technology has been successfully applied in the subcontract production of China's civil aircraft, and that the Shenyang Aircraft Industry Group has officially delivered the first new generation tail for the Boeing 737 aircraft to Boeing.

This is reportedly the largest high-tech project ever subcontracted to a Chinese aircraft enterprise by an international aircraft manufacturer, and under the subcontract, the Chinese enterprise is due to produce 1,000 tails, each of which is valued at over US$300,000. The tail section's manufacturing is quite complex, and involves more than 50 special technologies and 2,420 spares made with digital technology. Co-operation between China and all the major international aircraft manufacturers also covers the construction of basic transport facilities, flight training, air support, air traffic management, spare and accessory support, and training of senior management personnel.

Shenyang also recently successfully delivered the 1,000th emergency door for the A319/A320 passenger plane to Airbus. According to state statistics, the co-operation between China's aviation industry enterprises and major international aircraft manufacturers has produced significant export results. For example, amongst all Boeing aircraft in service around the world, 3,100 are equipped with major spares and knockdowns parts made in China. The current collaboration between Boeing and China mainly manifests itself in the supply of Boeing 737 horizontal stabilisers in Shanghai, Boeing 737 fins and Boeing 747 rear tails in Xi'an, Boeing 757 horizontal stabilisers, fin and rear fin supports in Chengdu, Boeing 757 door of freight holds and Boeing 737 tails in Shenyang, and titanium-aluminium forged products in Sanyuan and Chongqing.

In addition to the Shenyang Aircraft Industry Group, Airbus has also co-operated with the Xi'an Aircraft Manufacturing Company, the Guizhou Aviation Industry Group and the Chengdu Aircraft Manufacturing Company in the production of aircraft components and maintenance of equipment. Currently, Chinese engineers are participating in the manufacturing of the state-of-the-art A318 passenger plane. The initial knowledge gained from co-operative ventures with Airbus such as the former AE-100 (AE-31X) Asian Express programme should have helped China obtain some new manufacturing technologies such as high-pressure flow compressors and low-pressure turbine assemblies, even though the programme itself was unsuccessful. By 1997, the joint Chinese, Singaporean and European programme to develop a 100-seat commercial transport aircraft had faltered and was terminated in 1998. There are other opportunities for Chinese participation with other new Airbus aircraft programmes. For example, in 1999 AVIC joined the Airbus A318 transport aircraft development programme.

In an effort to modernise and upgrade its military airborne forces and armour airlift capability, the PLAAF has purchased up to 20 Russian Il-76MD heavy transports (40 ton payload, 5,000 km range) beginning in 1992, and others may have been purchased from Uzbekistan. During July 2000 it was indicated that Russia will possibly sell another 10 Il-76s to China, in a deal worth between US$30-35 million. A second contract for a further 10 planes is also possible. Russia's previous sale of Il-76s to China was in 1994. A major application is believed to be the transport of PLA airborne divisions to increase the military's rapid reaction capability. Reportedly, Russian-built Tu-154M large transports are now in the PLAAF inventory and based at Nan Yuan airbase south of Beijing (CAAC purchased a total of 25 of these trijets during the 1980s, and there are now about 46 reportedly in use by Chinese airlines). Recent negotiations Berlin and Beijing have resulted in the Germans saying they would not support the joint Ukrainian-Russian An-70 new generation heavy military transport aircraft project, and Russia would rather complete the project with China.

Other foreign transport aircraft types in the PLAAF inventory include British Aerospace Tridents and BA 146s. The expansion of the civilian transport fleet, particularly wide-bodied Boeing and other Western aircraft, represents a major boost for the PLA's air mobility capabilities. These aircraft could be redeployed within hours, for all domestic airlines in China have PLAAF liaison officers attached to them.

A July 2000 report that the CAAC has ordered all Y-7, Y-11, Y-12 and Russian Tupolev (e.g. Tu-154M) transport aircraft to be removed from scheduled passenger service by mid-2001 because of a poor safety record has not been confirmed, and does not indicate the fate of the large number of such aircraft in military service as well as the fate of the most recently developed commercial versions.

An August 2000 official report indicated that China is expected to be the third country, following US and Japan to have a special command aircraft for its political leadership. China's 'PLAAF One' would be an advanced Boeing 767-300ER according to CATIC. If it follows the US design pattern, it could be equipped with advanced surveillance systems to avoid missile and aircraft attack, and have the capability to undertake high-speed encoded data transmission. The Chinese aircraft is also to be upgraded to VIP comfort status for use by China's top leaders.

2.9 Airborne Refuelling Aircraft TOP

The lack of an extensive airborne refuelling capability, like the lack of AEW systems, is a serious current deficiency of the PLAAF for operations beyond its traditional territories. However, China has been experimenting with airborne refuelling techniques for years. Interim air-to-air capabilities were initially developed by converting some H-6D bombers to tankers to refuel J-8II fighters during 1997-98, in addition to 'buddy' refuelling systems by Q-5 attack aircraft. A refuelling capability has also been attributed to modified Y-8 turboprop transports. Recently purchased Russian Il-76 transport aircraft could be modified into tanker versions.

China is believed to have acquired air-to-air refuelling technology from Iran and Israel, (i.e. Iran's Sargent-Fletcher Boeing 707 wingtip drogue systems installed in H-6D bombers, and refuelling tanker technology from Bedek Aviation, a division of Israel Aircraft Industries). A probe and drogue aerial tanker design study for the H-6D was undertaken in the mid-1980s by the UK-based firm FRL, although a proposed joint-production project was not implemented.

The PLAAF has reportedly expanded the aerial refuelling capability it introduced two years ago to include the PLAN. Six H-6Ds were originally converted into tankers, with the first training exercise held in Guangzhou in early 1998. These tankers are believed to be deployed at Laiyan Air Base in Guangzhou military region; the number of platforms now possibly exceeds 10. PLAN fighters conducted their first aerial refuelling mission in late March 2000, using an H-6 tanker provided by the PLAAF, and J-8D air-superiority fighters. The J-8D was previously known to be in service only with the PLAAF, with more than 30 now believed to be operational. The J-8D production facility at Shenyang is believed to have begun supplying the PLAN as well from mid-1999, or earlier. The number in naval service is unknown but are likely to be serving in the Nanjing Military Region.

Since 1996 there have been unconfirmed reports of China's interest in purchasing Ilyushin Il-76 'Candid' aerial tanker aircraft. Such a system could allow China to make maximum use of its recently purchased long-range Su-30MK aircraft and growing Su-27 fleet. The use of the Il-76 could provide a common platform for troop transport, AEW and aerial tanker versions.

2.10 Helicopters TOP

The China Helicopter Industry Corporation, Beijing, is the AVIC subsidiary that co-ordinates and oversees military and commercial helicopter development and production in China. Its membership organisations are currently the Changhe Aircraft Industries Corporation, Harbin Aircraft Manufacturing Corporation, and the Chinese Helicopter Research and Development Institute.

The Chinese Helicopter Research and Development Institute, Jingdezhen, Jiangxi, is an AVIC affiliated R&D centre that was founded in 1969 to undertake helicopter design, research and testing, and is the largest and most advanced facility of this kind in China. It has over 2,200 employees, including 1,300 engineers and technicians, and has 1,500 major pieces of equipment in a facility of 110,000 square metres. Specific R&D activities include helicopter general configuration aerodynamics, structural design, dynamic and static strength, hydraulics, electronics, airborne systems, and software development. The institute has a mainframe computer, RISC work station, vehicle test tower, and various simulators for static, dynamic, fatigue and system tests. It has established research ties with organisations in the US, UK, Germany, Russia, France and Italy.

The Harbin Aircraft Zhi Z-5 (Soviet Mi-4) helicopter was certified for production in 1959, and some 545 in various versions were produced by 1979. On the basis of Z-5 experience a number of other helicopter types were developed: the Harbin Aircraft 701 light helicopter; the *Yan'an* 2 light helicopter; the Harbin Aircraft Z-6 medium helicopter; and the Z-7 and Z-8 heavier lift helicopters. The turboshaft powered Z-6 suffered severe technical problems and was not put into serial production, but did move China's aerospace industry beyond piston-engine helicopter production. The Z-7 type was dropped in favour of the Z-8, which was a copy of a foreign design (the French SA-321G 'Super Frelon').

However, Z-8 development proceeded slowly at the Jiangxi Helicopter Factory during the 1980s, with the initial test flight on 11 December 1985, and production seems to have been limited even by 1989. Only about eight Z-8s have so far been delivered to the PLAN for anti-submarine warfare applications, and these are capable of being carried by various destroyer and frigate classes. They are equipped with surface search radar, Italian Whitehead A244 torpedos, and possibly C-801/802 air-to-ship missiles.

The licensed transfer of manufacturing techniques for the French AS365N/NI Dauphin II general purpose helicopter and its aero-engine between Aerospatiale, Turbomeca and CATIC on 10 October 1980, allowed China to develop a new generation of modern helicopters in the Z-9. The agreement allowed the licensed assembly of 50 Dauphins/Z-9s and 100 aero-engines by the Harbin Aircraft Company (airframes), Zhuzhou Aero-Engine Company (aero-engines), Harbin Engine Factory (transmission systems), and the Baoding Propeller Factory (hubs and tail rotor blades), and led to the technical modernisation of these facilities. Transferred technologies included the extensive use of composite materials, advanced main and tail rotor systems, and advanced airfoils, in addition to various advanced manufacturing and testing techniques. Production was nationalised in 1991, and extensive civil and military applications are now made of the Z-9 line. Turboshaft aero-engines are now produced at Zhuzhou as the WZ8/WZ8A. The Z-9A is the PLAN's primary search and reconnaissance mission helicopter, in addition to a PLA anti-tank version equipped with 'Red Arrow' HJ-8 wire-guided anti-tank missiles (first flown during 1988-89), and a navy shipborne version equipped with a Thompson Sintra HS-12 dipping sonar, Whitehead A244 torpedos, and C-801/802 air-to-ship missiles. The Z-9 is the patrol helicopter for the PLA's Hong Kong Garrison. Harbin claims that 75 per cent of the Z-9 is now domestically produced.

A light 1.5-2 ton class Z-11 helicopter has apparently been under recent domestic development for reconnaissance and training applications at Changhe since the mid-1990s. Harbin has co-developed with France and Singapore the EC-120B Colibri light helicopter, which entered the test flight and pre-batch production by 1998, and reportedly is now in co-production with China receiving a work-share for each delivered aircraft (it is not known if China has purchased any).

The PLA inventory currently has several different types of foreign military helicopters in addition to the French Dauphin, which must result in spare parts logistics and maintenance complications. These include a purchase of 24 US Sikorsky S-70C Black Hawks during the mid-1980s, and a 1990 purchase of a similar number of Russian Mi-17 Hips after Washington refused to sell China more S-70Cs (some sources indicate that China now has 28 or more Mil-17s). In addition, eight French SA-342 Gazalle anti-tank helicopters were purchased as a first generation of attack helicopters, and are equipped with cockpit optical sights/laser range-finders, and six HJ-8 wire-guided anti-tank missiles. At least eight to 12 Sikorsky S-76A+ helicopters of the former Royal Hong Kong Auxiliary Air Force were also inherited by the PLA in 1997. In 2000, China was to receive five Mi-171 transport helicopters from Russia, as a followed-up to five delivered in 1999.

During 2000 it was reported that China had begun development of a new twin-engine utility helicopter designated the Z-10, with design work on the aircraft understood to have been launched during early 1999. Expected to weigh between 8 tonnes and 10 tonnes, the Z-10 reportedly could be based on the smaller Franco-German Eurocopter Tiger anti-tank and ground support helicopter design. The Z-10 may succeed Changhe Aircraft Industries Corporation's *(*CHAIC*)* Z-8, a version of France's Aerospatiale Super Frelon transport helicopter. Capable of deploying 27 fully armed personnel, only 12 Z-8s may have been produced for the PLAN. It is unknown whether the Z-10 is under development with the CHAIC or Harbin but aero-engines and additional components may be imported. Some reports have indicated the PLA may be developing a dedicated attack helicopter (the rumoured 'WZ-X' programme) with Mangusta/Tiger Eurocopter features, or possibly the South African Atlas Rooivalk.

Broader PLA plans to bolster its approximately 400-strong helicopter force could also lead to the upgrade of some of its current platforms, including the proposed re-engining of its 20 Sikorsky S-70C-II Black Hawk utility helicopters. The aircraft have been grounded for several years because of a lack of spare parts caused by the continuing US embargo of defence-related goods against Beijing. However, spare parts for the PLA's S-70C-II Black Hawk fleet may now be flowing through the current Hong Kong Air Rescue

Service inventories as parts intended for the service's commercial Chinese S-76 helicopters (a Black Hawk derivative). As of 1999, CATIC and the Jingdezhen Helicopter Group were participating in a consortium that includes Taiwan, Brazil, Spain, Japan and the US to develop the Sikorsky S-92 medium-lift helicopter, a version of the S-70 Black Hawk, which is intended for various civilian and military roles. Jingdezhen is to produce vertical tail fins and stabilisers.

During 1999, China reportedly took delivery of eight to 12 Russian ship-borne Kamov Ka-27 and Ka-28 ASW helicopters, as part of a previously agreed but delayed sale. Each helicopter is priced at between US$4million to US$5 million. There have been unconfirmed reports of Chinese negotiations for purchases of the Ka-50 attack helicopter. In 1997, China concluded a contract with the Russian aero-engine manufacturer Aviadvigatel to design and develop a new helicopter transmission system.

The future objective of China's helicopter developments will be to improve reliability, maintainability and availability, and to develop various derivatives that will use a common lift system, power plant and similar airframes for a variety of civil and military applications. By the early 1990s, the PLA had created a new army air corps of helicopters, initially with helicopters transferred from the PLAAF, but with the intent of eventually equipping each group army with a helicopter regiment. The use of military helicopters for transport and attack functions will be broadly increased by the PLA as it reduces its overall numbers of troops, further improves its professionalism, and moves towards a force structure of mechanised rapid deployment units. However, to date China's aerospace industry has yet to produce true modern attack or heavy transport helicopters.

2.11 Remotely Piloted Vehicles (RPVs) TOP

China began investigating pilotless aircraft during the 1950s, and by the late 1960s began development of the Changkong 1 drones, WZ-5 high-altitude photographic reconnaissance aircraft, and the small D4 RPV. China's RPV development capabilities were established at the Beijing Institute of Aeronautics and Astronautics (Pilotless Aircraft Design and Research Institute established in 1978), the Northwest Polytechnic University (Pilotless Aircraft Design and Research Institute established in October 1984) and the Nanjing Aeronautical Institute (Pilotless Research Institute established in 1979). Most early Chinese RPVs were reverse-engineered US and Russian systems. The PLA has reportedly recently established a modern RPV R&D centre at the Hefei Artillery Academy devoted to battlefield reconnaissance.

The Nanjing Aeronautical Institute during the 1970s and 1980s developed the Changkong 1 (CK-1) medium to high altitude target drone derived from the Soviet La-17 drone, the Changkong 1 Nuclear Sampling Aircraft derivative used during nuclear tests, the Changkong 1 low altitude target drone, and the Changkong 1 highly manoeuvrable target drone. The latter is one of China's most advanced drones for missile training requirements and was developed by the late 1980s. A more advanced supersonic CK-2 version with digital flight control has reportedly been developed for the PLA. Some sources indicate that the CK-2 programme is attempting to develop a supersonic UAV capable of combat activities. The Beijing Institute of Aeronautics and Astronautics and Lanzhou Aero-Instrument Factory developed the WZ-5 for certification in 1978. The high-altitude, high-subsonic WZ-5 is used for advanced photographic missions, is parachute recoverable, and is equipped with a Doppler radar.

The miniature low-altitude, low-speed D4 RPV was developed by the Northwest Polytechnic University and certified in December 1983. It is powered by a piston engine and launched by a solid rocket booster, is parachute recoverable, and is used for photo-reconnaissance, ECM, and civil aerial surveying and mineral prospecting. Xi'an's Northwest Polytechnic University facility is believed to be China's largest current R&D and production base for PLA RPV requirements. Its current Xi'an ASN Technology Group ASN-206 model is probably China's most advanced RPV, and is used for day/night reconnaissance, battlefield surveillance, target positioning, artillery spotting, border patrol, nuclear radiation sampling, aerial photography and civil natural resources prospecting. The ASN-206 (possibly a reverse-engineered version of the Israeli Tadiran 'Searcher-2' RPV) is reportedly configured with optical, laser, thermal and infrared sensors with near real-time capability, ECM and ELINT systems, a ceiling of 5,000 m to 6,000 m, a range of 150 miles and a loiter time of four to eight hours. The ASN-206 has recently been marketed to Turkey.

Other very low-altitude and supersonic RPV types are planned or underway. For example, the Chinese Society of Aeronautics and Astronautics has worked with the PLAAF on the development of remotely controlled helicopters with glass fibre rotors. China's first pilotless helicopter of this type, the 'Seagull', made its prototype introduction during 1996, following three years of development by the Beijing Institute of Aeronautics and Astronautics. It is a co-axial RPV with a total weight of 300 kg., aero-engine power of 80 hp and does not have a tail rotor. Potential applications include land-based and ship-borne military reconnaissance.

In 1999, Shanghai Jiatong University claimed to have developed the world's smallest and lightest helicopter that has dual propellers and a length of 18mm, and height of 5mm.

In 1998, the Jiangxi Research Institute of Meteorological Sciences announced the development of China's first specialised meteorological observation 12 kg RPV with a 3 kg payload and 300 km, four to eight hour flying radius. It was equipped with GPS/INS, 'self-navigation and self-piloting functions' and 'digital exploratory apparatus and a ground data receiving and processing device'. This project is also believed to be related to the miniature military reconnaissance vehicle developed by the Jiangxi Blue Sky Advanced Technology Development Company, which is a 2 m wide reconnaissance RPV.

In 1999, the Nanjing Aviation and Space University (Nanjing Aeronautical Institute) announced the development of a palm-sized 350 gram miniature aircraft equipped with a video camera and transmitter, and capable of travelling at 80 km per hour with a remote control radius of 1,000 m and cruise duration of 20 minutes. The aircraft is capable of continuously uplinking video transmissions via satellites to ground stations, has a wing span of 45 cm and is powered by a tiny internal combustion engine.

The National University of Defence Technology and the Guangzhou Military Region Logistics Department reportedly recently developed a drone with real-time photographic capabilities, while a research centre in Xi'an has developed the 'B-7' drone with a 40 km, one hour flight-time range. Appendix E provides a technical summary of current Chinese unmanned aerial reconnaissance vehicles.

2.12 Aircraft Subsystems *TOP*

2.12.1 Flight Control Systems

During the mid-1960s the Lanzhou Aeronautical Instruments Factory reverse-engineered the Soviet AP-5 autopilot, which provided only a 1940s level of technology. The Aeronautical Automatic Control Research Institute, the Aeronautical Instruments Design Department, and Qinghua University developed an improved autopilot, the KJ-3, based upon the Type-601 autopilot originally intended for the cancelled 'East Wind 107' fighter. Production began at the Lanzhou Aeronautical Instruments Factory in 1967, and batch production continued through the 1970s.

Follow-on flight control systems included: the KJ-6 developed at the Lanzhou Aeronautical Instruments Factory for the Y-7 and Y-8 aircraft; the Lanzhou KJ-10 for the Y-10 transport; and various others developed by the Beijing Aeronautical Institute (for RPVs), Aeronautical Automatic Control Research Institute, Nanjing Aeronautical Institute, and the Northwest Polytechnic University.

The Beijing Aeronautical Instruments Factory also developed the KJ-11 and KJ-12 autopilots for the J-7III and J-8II fighters, respectively, during the mid-1980s.

Flight control systems for helicopters were developed since the late 1960s by the Aeronautical Automatic Control Research Institute. In 1985, the Dong Fang Aeronautical Instruments Factory in Shaanxi Province developed the KJ-8 autopilot for the Z-8 helicopter. During the early 1980s, the Lanzhou Aeronautical Instruments Factory transferred advanced foreign technologies for the flight control system of the Z-9 helicopter.

More advanced Chinese designed flight control systems have included the 1985 Type 622 system developed by the Aeronautical Automatic Control Research Institute (digital-analogue hybrid, high authority control augmentation and built-in test capability), and the 1986 variable stability aircraft flight control system (dual redundant, digital-analogue hybrid and full authority FBW steering) also developed by the same institute. The Aeronautical Automatic Control Research Institute and the Nanjing Aeronautical Institute also conducted R&D in terrain following flight control systems for low-level military attack applications. The Xi'an Aircraft Accessories Factory is an important manufacturer of such advanced systems.

Since the 1970s, numerical control techniques and the application of microprocessors and digital computers for flight control systems has progressed rapidly. After 1978, active control technology was designated an aerospace priority. The Aircraft Accessory Research Institute, Aeronautical Computational Technology Institute, and the Aeronautical Automatic Control Research Institute began development of fly-by-wire and quadruple redundance fault-tolerant computer technologies. Ongoing R&D has also been conducted on manoeuvre load control, direct force control, and active flutter suppression for active controls, and fire, flight, and propulsion integrated controls.

The China Avionics Research Institute has reportedly been conducting 'fly-by-light' optical fibre control system R&D, which is applicable to programmes such as the J-10 and XXJ fighter aircraft.

2.12.2 Electrical Power Systems

The original low-voltage direct current (DC) electrical power systems for China's Korean War vintage aircraft were produced at the Tianjing Aeronautical Electrical Apparatus Factory, the Xingping Aeronautical Electrical Apparatus Factory and the Beijing Electrical Motor Factory. In the 1970s, the Aeronautical Accessories Research Institute developed smaller and lighter transistor-based DC voltage regulators for use on fighter aircraft. The Xingping Aeronautical Electrical Apparatus Factory in 1981 developed a transistor-based multi-function voltage regulator for the Q-5 attack aircraft; during the same period the Hubei Aeronautical Electrical Motor Factory developed a similar unit for the J-8II fighter.

In the early 1970s China began development of variable frequency alternating current (VFAC) for the Y-8 transport, J-7III fighter, and other aircraft. The Xingping Aeronautical Electrical Apparatus Factory and the Xi'an Rectifier Research Institute were pioneers in this technical area. Mechano-hydraulic and electromagnetic constant speed, constant frequency alternating current (AC) electrical power systems were developed by the Aeronautical Accessories Research Unit, Nanjing Aeronautical Accessories Factory, and the Xingping Aeronautical Electrical Apparatus Factory for the Y-10 heavy transport and other aircraft. During the early 1980s, the Hubei Aeronautical Electrical Motor Factory developed a 6 KVA eletromagnetic combined power generating system for the J-8II, which made use of innovations such as the application of rare-earth materials for the magneto.

Variable speed, constant frequency AC and high-voltage DC power systems (AC-DC-AC type), employing large-scale integrated circuits and rare-earth permanent magnet high-energy magnetic steel, have been developed by the Nanjing Aeronautical Institute, Xingping Aeronautical Electrical Apparatus

Factory, and the Nanjing Aeronautical Institute, since the early 1980s.

Emergency and secondary aircraft power systems (with additional applications for missiles and tanks) have been developed by the Hubei Aeronautical Electrical Motor Factory, Guizhou Aeronautical Electrical Motor Factory and the Nanjing Aeronautical Institute.

The Tianjin Aviation Electromechanical Corporation, Tianjin, is China's current primary manufacturer of military aviation electrical apparatus. It is also the meteorological centre for Tianjin military industrial enterprises, and the reliability research and test centre for AVIC. The Qinling Electric Corporation, Xingping, Shaanxi, founded in the early 1950s, is now a major national R&D and production centre for main power supplies and aero-engine ignition systems.

2.12.3 Hydraulic and Fuel Systems

Hydraulic, pneumatic and wheel brake systems for the J-7III, J-8II, Y-7, Y-8, H-6, Z-8 and other domestic aircraft have been developed by the Nanjing Aeronautical Accessories Factory, Guizhou Hydraulic Accessories Factory, and the Xinping Aircraft Wheel Brake Accessories Factory. Innovations have included the use of microprocessor controllers, an electronic anti-skid brake system (used on the Y-10 heavy transport), and the use of friction couple brake systems employing carbon-carbon composite material.

The Aeronautical Accessories Research Institute has developed aircraft fuel systems including a closed automatic pressure refuelling system, hydraulic centrifugal pump, AC electric pump, ejector pump, electric double-faced pump with an inverted flight capability, and mechanical and digital controlled flow proportioners.

Chinese fighter aircraft have traditionally relied upon pneumatic power, which is simple but prone to icing, rather than hydraulic power. While the new FC-1 fighter is expected to use pneumatic brakes, the new K-8 trainer employs a 3000 psi hydraulic system to operate landing gear, flaps, aileron boost, speedbrakes, wheel brakes, and nosewheel steering.

The Jincheng Corporation, Nanjing, Jiangsu, is currently the development centre of the National Aviation Hydraulic and Pneumatic System and Secondary Power System.

2.12.4 Environmental Control Systems

The Aeronautical Accessories Research Institute developed China's first reverse flow long blade cooling turbine unit that was used in SH-5 and Y-10 aircraft.

The Flight Test Research Institute has been responsible for developing aircraft rocket ejection escape systems for the J-6, JJ-6 and Q-5 aircraft. The Chengdu Aircraft Factory developed the Type II rocket ejection seat for the J-7II fighter, and the Rescue Equipment Research Institute developed the Type III for the J-8 series (force drogue opening technique). From 1980 to 1984, the Rescue Equipment Research Institute began development of the Type IV for the J-7III fighter, based upon the Type III. Recent research has been undertaken on ejection escape systems for aircraft in adversely complicated attitude situations at speeds of up to 1,100 km/hr.

The Hefei Oxygen Equipment Factory has developed closed circuit oxygen supply systems (chemical regeneration), which have been applied to such aircraft as the Y-8 by 1983. During the 1980s research began on molecular sieve oxygen generation systems. High-altitude pressurised protective suits and helmets, including anti-nuclear flash helmets, have been developed by the Hubei Personal Protective Apparatus Factory, Shanghai Textile Institute, Chongqing Textile Industry Research Institute, and the PLAN's Sixth Research Institute.

In October 1995, the Chinese Research Institute of Aero Accessories and the US firm Allied Signal agreed to establish a joint venture factory in Nanjing for aircraft environmental control systems. Known as CRIAA Allied Signal Aero Accessories Ltd., Allied Signal will have 51 per cent control of the partnership. The facility will consolidate much of AVIC's modern environmental control systems production in one location, with new systems likely to be produced for the K-8 trainer and Y-8 transport.

Personnel parachutes have been developed by the Hubei Parachute Factory, including the ejection seat parachutes for the J-7, J-7III and J-8II fighters. Parachutes for armed paratroopers deploying from aircraft such as the Y-5, Y-8, and other transports, have also been developed (Type 6) by the Nanjing Parachute Factory. Research has produced advanced sports-type manoeuvrable parachutes/parawings using high-strength polyamide fibres. The Nanjing Parachute Factory has developed various parachutes for delivering cargo, conventional aerial bombs, and nuclear weapons. Cargo dropping capabilities include 2.5 to 4.5 tons from a Y-8 transport for the delivery of light vehicles and artillery. By the mid-1980s, some 24 types of aerial bomb parachutes had been developed for bombs, mines, torpedoes and flares. China's nuclear test parachute was first used for a nuclear test during June 1967 and newer models employ a wave ring structure for more precise deployment.

2.12.5 Fire Control Systems

During the 1950s the former Ministry of Armament Industry produced simple optical sights for the J-5 fighter, and during the early 1960s similar systems for the J-6. The former Ministry of Electronics Industry then produced a radar range-finder and firing radar for the J-6, and optical bombsights and bombing radar for the H-5 and H-6 bombers. In 1970 the former Ministry of Aviation Industry established the Aeronautical Fire Control Research Institute and the Airborne Radar Research Institute, which developed an advanced three-dimensional dynamic emulation laboratory and airborne radar test laboratory.

China has researched and developed various modern fire control systems incorporating optical gunsights, HUD (including advanced diffraction optical R&D), firing and bombing radars (look-down shoot-down Pulse Doppler), infrared detection finders, laser range-finders, allowable launch distance computers for missiles, airborne side-looking radar, airborne phased-array radar, terrain-following radar, and integrated avionics systems. The Type SM-8/A optical gunsight series (air-to-air and air-to-ground) was developed by the Aeronautical Fire Control Institute for the J-8 fighter during the late 1970s and early 1980s, and follow-on versions have been installed in various fighters, trainers and bombers. In 1979 this institute also began the crash development of HUD systems using cathode ray tube and high-speed digital computers, and produced working modes that included lead tracking, tracer-line snapshot, missile attack, and navigation. During 1984 the prototype HUD used in the J-8II was developed and interfaced with a digital air data computer developed by the Taiyuan Aeronautical Instruments Factory. This system provided the technical basis for fire control system upgrades in various other fighter, attack and bomber aircraft.

The Type SR-4 was the first airborne fire control radar independently developed by China during the 1970s, initially by the Ministry of Electronics Industry's Southwest Electronics Research Institute and the Chinese Academy of Sciences (CAS). Development was then transferred to the newly established Airborne Radar Research Institute of the Chinese Aeronautical Establishment, with production undertaken by the Sichuan Airborne Radar Factory. In 1984 the system was installed in the J-8 fighter, reportedly converting the daylight version into an all-weather fighter.

The Type 317 multifunctional fire control radar was developed during the same period as the Type SR-4, and had features including air-to-air and air-to-ground acquisition, terrain mapping, terrain avoidance and ground ranging. Based on its design the Type 317A multifunctional monopulse radar was developed with advantages in reduced weight, volume and power consumption, expanded waveband and anti-interference capabilities.

The follow-on Type JL-7 air-to-air and air-to-ground airborne fire control radar incorporated further advances in size reduction, lower power consumption, and electronic countermeasures, and was developed by the Airborne Radar Research Institute during the early 1980s, with certification in 1986. The current domestic JL-10 system is a fully digital, look-up (60 km), look-down (54 km), and tracking (30 km) system that may be used by the new J-10 fighter. A domestic SSR-type fire control radar system based upon the GEC-Marconi Super Skyranger with look-down shoot-down capability is believed to equip current models of the J-7 fighter series. All-coherent pulse Doppler radar systems capable of detecting and tracking airborne targets in a clutter environment have been developed by the Airborne Radar Research Institute.

In 1980, CATIC imported airborne radar and HUD systems from the British Marconi and Smiths Company to modify the J-7 fighter and provide a more suitable export variant. The US Grumman Corporation's US$502 million contract to develop an improved 'Peace Pearl' fire-control avionics, software and radar system for J-8II fighters was cancelled in June 1989 following the PLA crackdown on pro-democracy student demonstrators at Tiananmen Square. Some 55 J-8IIs were to be upgraded in an effort to deter overflights by the former Soviet Union over Manchuria and northern China. While China spent some US$400 million in return for incomplete systems, it is believed that two prototype aircraft were partially completed.

The Zhang Yingxin Research Institute of TV and Electro-Acoustics, Beijing, has recently developed the Model 341TVT-B TV tracker and fire control system for acquiring and automatically tracking aerial targets in conjunction with the '341 radar servo system', which has a low-level target capability by improving radar angle tracking performance.

A new Chinese weapons control system has been designed for the K-8 light jet trainer/attack aircraft, which has continuously computed impact point, continuously computed release point, and gun modes, with the sight also providing a warning flash if there is danger of a ground impact based upon radar altimeter data.

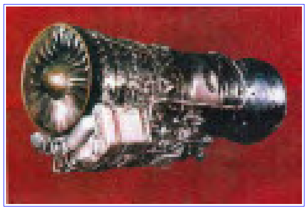
The Luoyang Institute of Electro-Optical Equipment, Luoyang, Henan, has been a key R&D establishment for Chinese airborne fire control systems for over the past two decades. It has over 1,500 employees, including some 100 senior scientists and 300 engineers. The institute's departments include: fire control engineering; fire control computer; electro-optical display technology; rate gyro sensor; TV, laser and infrared technology; fire control simulation technology; opto-electronic aiming technology; and a trial production factory. It has developed three generations of fire control and electro-optical systems (including automatic tracking systems, helmet tracking and display systems, airborne video recording systems, and HUD/fire targeting systems), some of which the institute claims have reached Western levels of sophistication. It has ISO9001 quality certification. The AVIC Research Institute Number 613, Luoyang Institute of Electro-Optical Equipment, is reportedly undertaking the R&D and development of photoelectronic tracking and detection systems, HUD, and helmet aiming and display systems such as that developed for the domestic PL-9 AAM system (with added Russian and Israeli technologies).

The radar type China is acquiring with its new Russian Su-27 fighters, and retrofitting in its J-8IIMs, is believed to be an improved version of the Phazotron Design Bureau's Zhuk-27. This X-band radar has six times the data and signal processing power of the basic variant, and can track-while-scan 24 targets, display up to eight of these, and provide a simultaneous fire control solution for two to four targets. Estimated range is 100 km. For ground attack the Zhuk system has imaging, display freezing, enlarged demonstration, and terrain following capabilities. Phazotron is also offering its Super Komar radar (upgraded Kopyo) for the FC-1 fighter programme, and Kopyo sets have already been sold to China which seeks a domestic production capability.

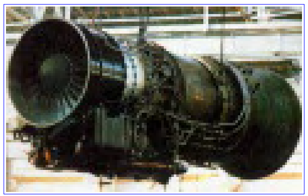
China has recently placed an order for Russian Nauchno-Issledovatelskiy Institut Priborostroyeniya (NIIP) supplied N001 fire-control radars for use with R-77 AAMs for its new Su-30MKK fighter-bombers. Chinese innovations continue in this area, with the assistance of various foreign technology transfers. A FLIR/laser aircraft targeting pod has been developed by the Number 613 Institute, the KG300G airborne self-protection jamming pod by the Southwest China Research Institute of Electronic Equipment, and the Blue Sky Navigation pod by the Number 607 Institute, Wuxi, for aircraft such as the JH-7, J-10, FC-1, J-8IIM and J-8III. HUD systems have been developed by the Number 603 Institute, and helmet-mounted sights by the Number 613 Institute.

Over 20 varieties of aircraft ordnance suspension units have been developed by the Henan Aeronautical Accessories Factory in 1960, including jettison force systems for nuclear and conventional bombs and missiles. Advanced systems have been developed for the J-8II and J-7III fighters, and the H-6D bomber for air-to-ship missiles. The Zhengzhou Aircraft Gear General Plant, Zhengzhou Xinwei Aircraft Equipment Company *(*Xinwei Machinery Factory*)*, Henan, production includes ejection bomb hooks, double bomb carriers, missile launchers, and rocket launchers. It is currently a major national producer for these systems.

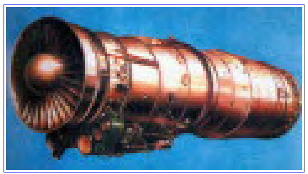
The Air-to-Air Missile Research Institute and Henan Aeronautical Accessories Factory have developed over 10 AAM launching units (electro-mechanical rail and jettison types), including recent advanced systems for the J-7III and J-8II fighters. The Xi'an Aircraft Accessories Factory has also developed various types of gun and sensor turrets for aircraft.



China has developed a wide variety of turbojet, turbofan, turboprop and turboshaft aero-engines mostly from Russian designs, but is now acquiring a variety of new generation of Russian and Western technology. Pictured here is the WP13.



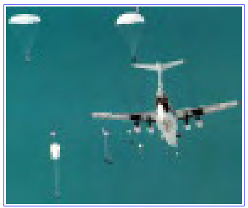
China has developed a wide variety of turbojet, turbofan, turboprop and turboshaft aero-engines mostly from Russian designs, but is now acquiring a variety of new generation of Russian and Western technology. Pictured here is the WP7A.



China has developed a wide variety of turbojet, turbofan, turboprop and turboshaft aero-engines mostly from Russian designs, but is now acquiring a variety of new generation of Russian and Western technology. Pictured here is the WS6.

Six PLAAF H-6D bombers have been converted into aerial refueling tankers, but China seeks a more capable solution for this capability, such as the Russian Ilyushin Il-76 "Candid" aerial tanker aircraft.


The FC-1 lightweight fighter is an ongoing co-operative development programme with Pakistan, but could also provide a solution for the replacement of China's huge fleet of aging J-6 and J-7 fighters and A-5 attack aircraft.


The PLAAF has acquired significant numbers of Russian Il-76MD heavy transport aircraft.
(Source: PA)


The Harbin Z-9A Helicopter.
(Source: B. Morisson)


The 'Seagull' pilotless helicopter. This indigenously developed helicopter could be used for such applications as land-based and shipborne military reconnaissance missions.


The Nanchang K-8A "Karakorum" is China's most recent jet trainer, jointly developed with Pakistan. While apparently not yet completely accepted for large-scale procurement by the PLAAF, its export sales are increasing to nations such as Myanmar and Egypt.
(Source: Jane's/H Puckering)


Aviation Industries of China Number Two Group (AVIC II) and Pratt and Whitney of Canada signed a Memorandum of Understanding during July 2000 confirming AVIC II's choice of the PW-150 for the power plant of its most recent Y-8F600 transport aircraft development programme.

Ben Sheppard; Dr Howard DeVore

CHAPTER 3 - MISSILE SYSTEMS

Date Posted: 05-Dec-2000

China's Aerospace And Defence Industry - December 2000

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MISSILE SYSTEMS

3.1 R&D and Production Infrastructure TOP

China has historically based its nuclear deterrent posture on a relatively small force of ballistic missiles. The first generation missile systems were liquid-fuelled rockets, based on Soviet technology, with each model developed with a specific target area in mind. For example, the Dong Feng (East Wind) 2 was a mobile system with a range of 1,250 km to permit strikes against Japan. The Dong Feng (East Wind) DF-2 was China's first nuclear-armed missile and the US designated it Chinese Surface-to-Surface (CSS) 1. China is believed to have built about 160 of these missiles.

While China is historically considered to be the home of the rocket, it developed its modern space programme from the Soviet SS-2 (a modified German V-2, whose liquid fuel engines set the basis for modern rocket technology), SS-3, SS-4 and SS-5 ballistic missile technology transferred during the 1950s. China traces the official beginning of its space programme to 1956 when a 12-year development plan accorded priority to rocket and jet propulsion technologies as key state projects. On 19 February 1960, a Chinese-built sounding rocket was successfully launched. A prototype ballistic missile was launched during November 1961 and in 1963 the Chinese Academy of Sciences began to examine the feasibility of a satellite launch to orbit. The first Chinese satellite, Dong Feng Hong-1, was successfully launched to low earth orbit on 24 April 1970 on a Long March (Changzhen) CZ-1 launch vehicle, and transmitted the patriotic tune, 'The East is Red'.

Tactical missile development began in China during the 1950s through the 'Aeronautical Industry Commission' under the direction of Marshal Nie Rongzhen, and deputy directors Huang Kecheng and Zhao Erlu. Key organisations during the early development of Chinese missiles were the Bureau of Aviation Industry, the Chinese Academy of Sciences (CAS), the PLAAF, the Beijing Aeronautical Institute, and the Harbin Military Engineering Institute. In October 1956, the Fifth Establishment of the Ministry of National Defence was established to specialise in missile R&D. By October 1957 the Soviet Union had agreed to supply China with tactical missile prototypes and technical documentation, and to provide experts to assist in licensed production.

In November 1964 the Seventh Ministry of Machine Building, later the Ministry of Space Industry, was established to co-ordinate various activities of missile and space programme development. This close relationship between civil and military space programmes continues to the present. The ministry was made responsible for the R&D of strategic missiles and space launchers, and consolidated a number of missile and aerospace instrumentation production sites. The Eighth General Bureau of Machine Building was formed in 1970 to specialise in ground-to-air missile systems, such as the indigenous Hong Qi (Red Flag) HQ-2J high-altitude system.

The Baoji Aeronautical Instruments Factory has developed missile flight control systems for ground-to-ground and air-to-air missiles since the late 1950s. Responsibility for such production was later transferred from the Ministry of Aviation to the Ministry of Space Industry. The Beijing Aeronautical Instruments Factory developed control systems for the SY-1, SY-1A and SY-2 ship-to-ship missiles, with an emphasis on low-altitude penetration capability.

Over nine types of solid and liquid rocket engines for air-to-air, ground-to-air, ground-to-ground and coastal defence missiles have been developed and manufactured. By 1985, over 10,000 major tactical missiles had been produced in China and this number has probably been doubled.

China's Long March (CZ) series of space launch vehicles use clustered stage and strap-on liquid propellant UDMH/N2O4 and LOX/LH2 rocket engines. Both solid fuel and liquid cryogenic upper stages have been developed for satellite insertion to geosynchronous orbit. CZ propulsion systems are derived from liquid propellant ICBM (inter-continental ballistic missile) technology. A new generation of solid-propellant tactical and strategic ballistic missiles has now been developed. China has also recently obtained advanced rocket propulsion systems from Russia and the Ukraine. The China Precision Machinery Import and Export Corporation (CPMIEC) and its subordinate plants produce rocket propellants that include dinitrogen tetroxide, red fuming nitric acid, mixed amines, anhydrous hydrazine, unsym-dimethyl hydrazine, monomethyl hydrazine, isopropyl nitrate, ammonium perchlorate, hydroxyl-terminated polybutadiene, and tris (2-methyl-1-aziridinyl) phosphine oxide. The Dailan Haiyang Chemical Technology Company, Liaoning Province, produces solid-propellants for missiles and space launchers. The Shanghai Xinxin Machinery Plant manufactures liquid propellant rocket engines. The 307 Factory, Nanjing Chenguang Machine Factory reportedly undertakes the final assembly for solid fuel missile systems, and employs 7,800 people.

The brilliant aerospace scientist Qian Xuesen (Tsien Hsue-shen) is widely considered to have been the mastermind behind the modern Chinese space and missile programmes. Born in China, he studied in the United States under the famous aerodynamist Theodore von Karman at Caltech's Jet Propulsion Laboratory during the 1940s and 1950s, and had obtained his doctorate at the Massachusetts Institute of Technology in 1938. During the Second World War he headed the rocket section of the US National Defense Scientific Advisory Board, and in 1945 was sent to Germany with the rank of colonel in the US Army Air Corps to study German rocket technology. Dr. Qian probably had no direct involvement with espionage while living in the United States. He was not formally charged by the US authorities, although in 1950 he was accused of being a spy and denied security clearance, and the 1999 US Cox Report indicates he was a spy without citing official references. Nevertheless, after returning to China, Qian did provide his country with significant technical intelligence that provided the basis for the development of its missile and space programmes.

Qian was deported to China in 1955 in exchange for US pilots shot down during the Korean War. In China he organised, through the discipline of systems engineering, the grand scheme of national strategic missile programmes. This included the Fifth Establishment of National Defence (China's original R&D centre for missile design), China's first satellite, missile tracking and telemetry systems, and specific systems such as the original 'Silkworm' anti-ship missile system. Qian's greatest intelligence contribution to China was probably derived from his accumulated knowledge based upon his own research experience and contacts in the US. He was promoted to the military rank of Major General in the COSTIND during the late 1960s, received extensive protection during the Cultural Revolution, and was actively serving until at least the late 1980s (he is still alive as of writing). Qian placed great emphasis on the importance of collecting open source technical intelligence from foreign publications, even including commercial magazines, and was convinced that much of the information required for China's missile programme was available from such public sources. Today, the phenomenon of increasing numbers of Western-educated Chinese scientists and engineers, often with industry experience in locations such as California's Silicon Valley, returning to China with dual-use knowledge, particularly in information technologies, is repeating itself.

Twenty-three scientists who designed and made China's first atomic bomb, hydrogen bomb and satellite in the 1960s and early 1970s were awarded medals on 19 September 1999 by the Central Committee of the Chinese Communist Party of, the State Council and Central Military Commission. The honoured scientists were: Qian Xuesen, Yu Min, Wang Daheng, Wang Xiji, Zhu Guangya, Sun Jiadong, Ren Xinmin, Wu Ziliang, Chen Fangyun, Chen Nengkuan, Yang Jiachi, Zhou Guangzhao, Tu Shou'e, Huang Weilu, Cheng Kaijia and Peng Huanwu. The seven scientists who were awarded posthumously were Wang Ganchang, Deng Jiaxian, Zhao Jiuzhang, Yao Tongbin, Qian Ji, Qian Sanqiang ('father of the Chinese nuclear bomb') and Guo Yonghuai.

Today, China's missile manufacturing and R&D geographic clusters are closely related to the space technology centres of excellence, which are outlined in Chapter 4, Section 4.1.

3.2 PLA Second Artillery (Strategic Missile Force) TOP

On 16 October 1964, China exploded its first nuclear device. China conducted a nuclear missile trial on 27

October 1966 and on 13 July 1967 it exploded its first hydrogen (fusion) bomb. The 'Chinese Special Artillery Corps' had been conceived in 1958 and in July 1966 it was converted into the Second Artillery Corps with the approval of the Central Military Commission. In 1984 the Second Artillery Corps was created as a separate service equal in importance to that of the traditional three services. The Second Artillery, which has also been recently termed the Strategic Missile Force *(Zhanlue daodan budui),* reports directly to the Central Military Commission. The corps is estimated to comprise 90,000 to 100,000 personnel, the majority being deployed in engineering and construction units, actual missile operators and guards probably account for less than half of this total strength. However, overall the corps has the highest concentration of university educated officers and technicians in the PLA. The Second Artillery is structured into six to seven divisions, with brigade, regiment and battalion organisation varying depending upon missile type.

It is believed that Chinese nuclear forces are deployed to a large extent in Xinjiang Province (Lanzhou Military District near Russia, Mongolia, Afghanistan and Pakistan) and Tibet. A primary missile test site is at Shuangchengzi in the Gobi desert. Its Institute of Engineering of the Second Artillery Corps is reportedly equipped with extensive computer simulator facilities for launch operations; another R&D facility is the Metal Surface Processing Institute of the Second Artillery. A primary training institute is the Second Artillery Technical Academy. Shanhaidan Enterprises is a Second Artillery affiliated firm but may now have been absorbed by COSTIND. It is believed that the Second Artillery will also control China's emerging long-range and strategic cruise missile force.

The Second Artillery organisation probably includes a headquarters, an early warning division, a communication regiment, a security regiment, a technical support regiment, and six (some sources indicate seven) ballistic missile divisions (with each missile division probably averaging about 10,000 troops, dependent upon missile types). The divisions, comprising a total of some 17 'Guided Missile Launched Brigades' deployed at seven army level missile bases, are each under the command of a major general. Each brigade comprises three or four battalions, each battalion has three companies, with each company operating at least one missile. The signal unit of the Second Artillery Corps provides communications systems to provide support for combat operations. The six divisions are independently deployed mostly in four military regions:

· Shenyang Military Region - 2 divisions

· Beijing Military Region - 1 division

· Lanzhou Military Region - 2 divisions

· Chengdu Military Region - 1 division.

Chinese ballistic missile forces have, in general, been widely dispersed, often deployed in silos and man-made caves in mountainous terrain. They have been so carefully camouflaged that satellite reconnaissance reportedly failed to discover their existence until several years after initial deployment. It is possible that the United States and Russia have yet to discover all Chinese missile deployments.

Some sources indicate that DF-21/DF-21As are deployed in provinces in the north-west and south-west where they can be targeted against northern India, the republics of central Asia, and much of Vietnam and south-east Asia. Jianshui, near the Chinese-Vietnamese border, and Datong in central China, are said to be equipped with DF-3/DF-3A and DF-21/DF-21A intermediate range ballistic missiles (IRBMs) capable of targeting much of India, Russia, Japan and Taiwan. Some analysts believe that the requirement for the DF-3 has significantly diminished given the fact that no US bases remain in the Philippines and the shorter-range DF-21, which can strike Taiwan, is deployed with the 52 Army located in Eastern China. The US Air Force, for example, estimates the DF-3 force at Lianxiwang will decline to about eight launchers until the system is retired during the next decade.

DF-15s have been deployed at Leping military base in Jiangxi Province, as well as bases in Fujian Province adjacent to Taiwan and the East China Sea. ICBM silos have reportedly been identified near Luoning in Henan Province, with an initial deployment of a pair of silo-based DF-5s completed in 1981. Recent estimates have at least four DF-5s deployed in silos at Luoning maintained in a ready-to-fire status. It is also believed that in order to enhance the survivability of the Luoning ICBMs, a large number of decoy silos have been constructed which consist of shallow excavations with headworks meant to resemble operational silos. Additional DF-5As in the Luoning area may also be deployed in tunnels, stored in a horizontal position (up to eight missiles deployed in tunnels by 1997). Table 3.1 provides additional information on Chinese missile deployments.

Table 3.1 PLA Second Artillery Missile Deployments and Bases

· Chingyu Ballistic Missile Test Complex - developed during late 1960s and early 1970s.

· Chuxiong in southern China near the border with Burma (25º02'N 101º32'E); by mid-1995 the deployment base for DF-21s.

· Dalong *(*Ta-ling*)* (26º39'N 114º02'E); DF-3.

· Da Qaidam *(*Ta-ch'ai-tan) (37º50'N 95º18'E). One of five locations at which a total of between 10 and 20 DF-4s were deployed as of early 1998.

· Datong missile garrison, in central China near Haiyan (36º36'N 103º20'E). It housed DF-3As deployed against India and Russia; it will probably deploy DF-21As based upon construction activities commencing by 1997; also the primary deployment base for H-6 bombers.

· Delingha (37º19'N 97º13'E) - one of five locations at which a total of between 10 and 20 DF-4s were deployed as of early 1998

· Dengshahe missile garrison (39º13'N 122º04'E) - deployed four DF-3As launchers. Training levels believed to be low during the 1990s.

· Dianwei *(*Tienwei*)* (23º46'N 102º42'E); DF-3.

· Fengrun *(*Feng-jun*)* (39º50'N 118º10'E); DF-3.

· Fujian Province, Huanan Mountain area - deployed DF-15s.

· Hainan Island Space Launch Complex (under consideration).

· Haiyan (Sanjiaocheng) (36º58'N 100º50'E).

· Huludao *(*Hu-lu-tao*)*, Bohai Shipyard (Xia SSBN) (40º43'N 121º00'E).

· Jianshui (Ching-yu) launch complex near the Chinese-Vietnamese border (23º37'N 102º49'E). The complex houses eight DF-3A (targeting India) and eight DF-21A (targeting south-east Asia) launchers.

· Jiuquan (Shuangchengzi) Satellite Launch Centre (Base 20 Space Facility; sometimes also referred to in the West as Shuang Cheng-Tzu) situated in the Gobi Desert in north central China (41º20'N

100º20'E). The oldest site which is used by China for low altitude posigrade missions with inclinations of 40º or more, and the site of all CZ-2C and CZ-2D launches.

· Kunming (K'un-ming) (25º04'N 102º41'E) - one of six DF-3 deployment areas operational as of early 1998, with a total of eight missiles deployed.

· Leping military base in Jiangxi Province - deployed DF-15s.

· Lianxiwang (Liangkengwang) launch complex adjacent to Taiwan (30º09'N 117º37'E). Houses a total of 16 DF-3A garrisons, with at least two being converted to DF-21As.

· Liujikou (Liu-chi-k'ou, Liuchingchou) (38º17'N 115º28'E); likely DF-3 installation located by US intelligence as early as 1972.

· Lop Nor nuclear test site; ballistic missile test range.

· Luda, Dalian, Honqui Shipyard (Golf SSB) (38º55'N 121º39'E).

· Luoning (Lo-ning), Henan Province, (34º22'N 111º38'E) is the site of two DF-5 ICBM silos.

· Qingdao (Ch'ing-tao) SSBN Base (36º04'N 120º19'E).

· Shuangta Training Facility near Wuwei - established during early 1970s.

· Sundian (Sun-tien) (33º15'N 114º45'E); one of five locations at which a total of between 10 and 20 DF-4s were reportedly deployed.

· Tai-Hang Mountain Range (38º N 113º E), located immediately to the east of the Taiyuan space launch centre, and some 400 km south-west of Beijing between Hebei and Shanxi Provinces, in an area characterised by 1,000 m to 2,000 m-deep gorges and steep bluffs. Reportedly a major site for the 'Great Wall Project' for the deployment of new generation DF-31 and DF-41 mobile ICBMs, in addition to shorter-range mobile DF-15s and DF-21s.

· Taiyun Satellite Launch Centre, south-west of Beijing.(37º52'N 112º33'E)

- commissioned for sun-synchronous missions and support for CZ-4 launches.

· Tongdao (Shuangjiang) 26º09'N 109º46'E); one of five locations at which a total of between 10 and 20 DF-4s were deployed.

· Tonghua, near North Korea (41º44'N 125º55'E) - houses 12 (some sources indicate up to 24) launcher garrisons with eight equipped with DF-3As, and four with DF-21As, for targeting both North and South Korea, Japan and Taiwan (may have currently largely converted to DF-21As).

· Wan Yuan (39º30'N 116º30'E).

· Weinan (34º30'N 109º30'E).

· Wuchai IRBM Test Complex - developed during late 1960s and early 1970s.

· Wuwei Training Facility near Shuangta (37º58'N 102º48'E) - training base for DF-3 IRBMs since the early 1970s, with actual practice launches conducted at Shuangchengtzu and Wuchai.

· Wuzhai Missile and Space Test Centre (Wuchai) (38º55'N 111º50'E), 250 miles south-west of Beijing. Ballistic missile R&D and production centre for DF-31 and others (reportedly China's primary ICBM production facility at Wanyuan was shut down and relocated to a plant near Chengdu during

1998).

· Xi'an (Sian/Hsi-an) (34º16'N 108º54'E); DF-3.

· Xiao Qaidam (Hsiao-ch'ai-tan) (37º31'N 95º25'E); one of five locations at which a total of between 10 and 20 DF-4s were deployed as of early 1998.

· Xichang (Hsi-ch'ang/Songlin) Base 27 Satellite Launch Centre (28º12'N 102º02'E). The centre supports all geostationary missions from its location in southern China but under the control of the China Satellite Launch and Control General in Beijing. It has facilities for the launch of the CZ-2E, CZ-3, CZ-3A, CZ-3C, and CZ-3E series of launch vehicles.

· Xuanhua (Hsuan-hua) (40º38'N 115º06'E); one of at least two locations at which the DF-5 ICBM was deployed as of early 1998.

· Yangang; located some 440 km from Taiwan, this base is believed to have a concentration of some 100 DF-11 ballistic missiles.

· Yidu (I-tu) (36º41'N 118º28'E); one of six DF-3 deployment areas operational as of early 1998, with a total of eight missiles deployed.

Over the past five years China has undertaken a major effort to improved its strategic missile basing systems, including command and control structures. The Second Artillery Corps, reportedly announced in May 1995 the completion of the so-called 'Great Wall Project,' which entailed the construction of modern missile launching sites throughout China . This engineering project is supposed to have taken more than a dozen years to complete using tens of thousands of workers, and the construction of up to 3,000 km to 5,000 km of dedicated roads and tunnel systems, plus dozens of dedicated bases. Hundreds of firms were also reportedly involved in the project. Specifically, this involved the redeployment of China's major missile forces and the construction of redesigned hardened actual launch sites and false sites, with vast networks of roads connecting all the various sites (reminiscent of the 'shell game' basing mode proposed but never constructed for the US MX Peacekeeper missile during the 1980s). The project also probably involved the modernisation of command, control and communications systems, improving support and logistics structures, preparing pre-surveyed alternative launch sites, and strengthening operational training. Launch sites are also hidden in tunnel locations in mountainous areas such as the Tai-Hai Mountain Range between Hebei and Shanxi Provinces for the storage of new road-mobile systems (DF-31 and DF-41). The topography of this mountain range is characterised by 1,000 m to 2,000 m deep gorges and steep bluffs. Efforts have also reportedly been made to develop dummy missile silos, and camouflage missile bases under civilian buildings with removable roofs, inside fake bridge towers, and railway cars, as well as storing them in mine shafts, caves and tunnels. The completion of this infrastructure may have made possible the 1995 deployment of DF-15 and DF-21 missile launching units to the Nanjing Military Region's Fujian Military District to conduct missile training launches with impact points in proximity to Taiwan. Recent estimates indicate that the PLA has over 400-600 'M-class' ballistic missiles (DF-11 and DF-15) in its inventory, the majority deployed against Taiwan.

Some unconfirmed sources have also indicated that ballistic missile bases in Tibet are located to the south of Lake Kokonor in Amdo, and north-west of Nagchukha. Nuclear weapons may have been stationed since the early 1970s in the Tsaidam basin, in northern Amdo, possibly up to several dozen. To the west of Dhashu (Haiyan), China may have established a nuclear missile deployment and launch site for DF-4s in the Tsaidam basin in the early 1970s. Unconfirmed reports indicate that the Larger Tsaidam site has two missiles stored horizontally in tunnels near the launch pad, with fuel and oxidiser stored in separate tunnels with lines to the launch pad. The Smaller Tsaidam site is probably organised in a similar fashion to the Larger Tsaidam deployment and launch site. Another nuclear missile site in Tibet could be located at Delingha, about 200 km south-east of Larger Tsaidam, also with DF-4s, and the missile regimental headquarters for Amdo containing four associated launch sites. A more recent nuclear division has reportedly also been established in Amdo with up to four DF-5s capable of striking the US, Europe and all of Asia. It is interesting that China has in the past rejected a proposal that included Tibet as a nuclear-free zone because this would prevent the deployment of missiles in caves and mountains in the Tibetan plateau region.

While an enemy might have difficulties in locating and pre-emptively destroying all Chinese nuclear weapons sites, it is also widely reported that Chinese missile reaction times are likely to be slow (although this may change with the newest generation of missiles). Optimal preparation and dispersal of current Chinese missile forces could require a period of several days warning. However, Chinese leaders are presumably aware of such shortcomings and have probably implemented command and control procedures for a counterattack following an enemy first strike, which resulted in the disruption of normal communication channels and the death of the majority of the Chinese political and military high command (perhaps as basic as sending soldiers as runners to convey the orders for a launch).

3.3 Tactical and Strategic Ballistic Missiles TOP

3.3.1 Overview

China's assessment of the 1991 Gulf War provided Beijing with a new insight into the potential value of battlefield and theatre missile systems, particularly when equipped with conventional warheads, against high-value targets. China is believed to have developed a variety of specialised nuclear and non-nuclear tactical missile warheads, which include neutron enhanced radiation, high-explosive variants, dual-purpose cluster munitions, scatterable mines, nuclear and non-nuclear EMP, and deep-penetration warheads for underground fortifications, and probably chemical and biological systems although China routinely denies such capabilities. Cluster munitions for ballistic or cruise missiles could be used to disable airbase runways, and such warheads could arm the missile platforms such as the uprated version of the DF-21 medium-range ballistic missile and new generation cruise missiles.

Some sources have referenced various development programmes that were cancelled. The DF-14 programme reportedly began during October 1973, to develop a two-stage storable liquid propellant missile capable of delivering a 700 kg payload at least 8,000 km. The lightweight DF-14 was intended to be road-mobile, and incorporate a rapid targeting fire control system, but was delayed in September 1975 by the higher priority DF-4 and DF-5 programmes. During August 1978 the programme was believed to have continued under a new designation, DF-22, or 'Project 202'. By 1984, solid-propellants began to take precedence over liquid fuel missile programmes, with a consequent slowdown of the DF-14/22 project, and by 1995 the DF-14/22 was completely cancelled.

China is currently developing three new strategic ballistic missiles, in probable addition to new tactical systems. This is also related to current developments in the Chinese space programme, where an unmanned version of a man-rated vehicle may be launched in the near-term, and a manned orbital launch is likely planned for 2003 or earlier. Following their dual-use philosophy, space-launch boosters could be developed from new generation DF-31 and DF-41 ICBMs. For many years, China has been suspected of trying to develop a multiple independently targetable re-entry vehicle (MIRV) warheads capability. On 20 September 1981, China conducted its first launch vehicle with three multiple satellites, indicating at least the potential to develop MIRV warheads (the US first deployed MIRVed missiles during 1970, and the Soviet Union, France and the United Kingdom in 1974, 1985 and 1994 respectively). In 1998, US Air Force General Eugene Habinger publicly stated that such programmes were underway in China. While some experts do not believe that China is currently developing MIRVs or less sophisticated multiple re-entry vehicles (MRV), most agree that it has the technical capability to develop such systems within a period of a few years given a decision to do so. The Chinese MIRV/MRV programme is reportedly code-named 'One Arrow, Three Stars' and some reports indicate at least one Chinese MIRV test was undertaken as early as 1986. Chinese MRVed or MIRVed ballistic missiles would probably be protected by a payload shroud, since only one MIRVed missile, the Russian SS-20, does not employ a shroud.

Land-based ballistic missiles with single warheads usually do not have fairings, or shrouds, as such components are more often called in missile terminology, covering the warhead. Fairings could also be used to protect road-mobile missiles from the rigours of environmental exposure, although covers that would be discarded before launch are possibly more likely. A shroud or partial shroud in the form of a nose cap might be used for drag reduction in the case of a blunt re-entry vehicle; the likelihood of hammerhead fairings being used for this purpose is not considered great by some experts. Shrouds may be used to protect warhead penetration aids (PENAIDS), such as chaff, balloons, decoys, and distributed jammers, and their deployment mechanisms.

The transfer of US dual-use rocket shroud/fairing, satellite dispensers, and guidance system technologies to China through co-operative commercial space activities (such as multiple Motorola Iridium communications satellite launches) were some of the main concerns of the Cox Report. However, in its formal refutation of the US Cox Report on Chinese nuclear espionage allegations, China claims:

'*What deserves special mention is that a distinct difference exists between the design technology of the fairing on a carrier rocket and that of a multiple-warhead missile. The fairing of a multi-warhead missile requires an all-weather, omni-bearing operating environment; hence, an integrated design is generally adopted. For carrier rockets, however, the technique of lateral separation design is normally used. Therefore, it is out of the question to make use of the rocket's fairing design technique for improving that of a multiple-warhead missile.*

The Cox report says China 'acquired' the smart dispenser technique through iridium satellite launches and has used it in its MIRV dispensing technology. In fact, before launching an iridium satellite, China had succeeded many times in launching multiple satellites atop a single rocket. In July 1990, China succeeded in its first launch of a dual payload atop a LM-2C rocket, including a Pakistani satellite. The two satellites were placed respectively in LEO (low earth orbit) and geostationary transfer orbit. In September 1990, China used a LM-4 to successfully place three satellites into solar stationary orbit. In October 1992, the LM-2C rocket carried a Sweden FREJA satellite and a Chinese recoverable satellite into space, inserting them into two different LEOs. In February 1994, a LM-3A was launched with Experiment-4 satellite and a dummy payload. This fact indicates that China has already mastered, and has been continuously improving, its dispenser design technique. There is no key technology hard to master, let alone any need to make use of iridium satellite launches for improving China's MIRV technique.'

An even more technically advanced system (in other words heavier payload of MIRVs, longer range and increased accuracy) based upon the Russian/Ukraine SS-18 ICBM may also be under development according to some sources. Recent US reports have indicated that China has the industrial capacity to produce some 1,000 new ballistic missiles of various types within the next decade.

3.3.2 M-7 (Project 8610, CSS-8)

The Chinese developed a short-range ballistic missile from their Hong Qi HQ-2 surface-to-air missile (SAM) system. This development started in about 1985 and the M-7 entered service in China around 1992.

It is thought that the M-7 programme was originally intended for export but the Army liked the design and decided to use it themselves. The Army made some changes and the system was given the code Project 8610. The NATO designation for this missile system is CSS-8.

The Russians sold some SA-2 'Guideline' (V-75 Dvina) SAMs to China in the late 1950s, and the Chinese either reverse engineered or built under license the Hong Qi 1 (HQ-1) version between 1961 and 1964. An improved version was developed in China, and given the designation HQ-2. The first HQ-2 was tested in 1965 and the system entered service in China in 1967. HQ-2 missiles have been built in several versions and were still being offered for export in 1996. There have been exports of HQ-2 missiles to Albania, Iran, North Korea and Pakistan.

The M-7 design is based upon the HQ-2B version, which is fitted to a tracked launcher vehicle developed from the Type 63 light tank chassis. The liquid propellant sustainer motor of the HQ-2 missile has been replaced with a solid-propellant motor, and the warhead enlarged. The resulting M-7 short-range ballistic missile is believed to have a length of 10.8 m, a body diameter of 0.65 m (boost stage) and 0.5 m (second stage). The missile weighs 2,650 kg at launch, and has a single high explosive warhead with a total weight of 190 kg. It is possible that a selection of warheads have been developed for this missile, with several submunition options. The solid boost motor filling has probably been changed from HQ-2, but the burn time is around 4 seconds and then the boost stage is jettisoned. The solid sustainer motor probably burns for about 20 to 30 seconds, giving the M-7 missile a maximum range of 150 km and a minimum range of about 50 km. Control is provided by aerodynamic control fins located at the rear of the second stage, and it is believed that some guidance is provided during the boost and sustainer motor burn to correct the initial trajectory at sustainer burn out. However, reports that the M-7 missile is command guided to impact are not believed to be correct, and as there is no figure for terminal accuracy it is probable that there is no terminal guidance.

It is believed that China exported about 90 M-7 missiles to Iran in 1992 and some may have been exported to Iraq. There have been conflicting reports about exports as some countries have made their own design changes to Russian built SA-2 SAMs, converting these to short-range ballistic missiles. North Korea modified either SA-2 or HQ-2 missiles but these may have not entered service. Iran, Croatia and Serbia are reported to have used modified SA-2s as short-range ballistic missiles with a range of 80 km. It is believed that these modified SA-2 missiles used the original liquid propellant sustainer motors and 130 kg warheads of the SAMs but as there is little external difference between Russian SA-2 and Chinese HQ-2 missiles a positive identification is difficult. It would also be difficult to see the external differences between the HQ-2 and M-7 missiles.

There are no estimates of the number of M-7 missiles in service with the PLA. The total number of HQ-2 missiles built could have been as high as 5,000, and so it is possible that between 100 and 500 might have been converted into ballistic missiles.

3.3.3 DF-11 (M-11, CSS-7)

The M-11 missile is believed to have been initially designed for export as a solid-propellant replacement for the Russian SS-1C 'Scud B' (R-17, 8K14). The PLA liked the design and adopted the missile with the designator Dong Feng 11 (DF-11). The NATO designation is CSS-7. It is believed that development started in 1984, the first flight test was made in 1990, and the missile entered service in China in 1992. It is reported that the M-11 was designed by the Base 066 division (formerly part of the Third Academy - Anti-Ship Missiles) of the former Ministry of Aerospace Industry, and has been marketed by CPMIEC.

The Chinese started advertising the missile in 1988, showing an initial picture with a trials missile mounted on a Russian MAZ 543 Scud transporter-erector-launcher (TEL) vehicle. The MAZ 543 vehicle can be modified by rearranging the launcher cradle and roof assemblies, and can then carry both longer or shorter missiles (than the basic R-17 Scud). There has been no reported programme in Russia to develop a solid-propellant version of the Scud and it is assumed that the Chinese objective was to produce a missile that could be exported in direct competition with the Scud to earn hard currency.

Little data has been published by the Chinese about the DF-11 missile. It is believed to be about 9.75 m long, with a maximum body diameter of 0.8 m. The launch weight is estimated at 3,800 kg. The Chinese initially stated that it conformed to the Missile Technology Control Regime (MTCR) limits set in 1987, namely with a range less than 300 km. The warhead weight was understood to be 800 kg and the range 280 km, but of course it would have been easy to modify these parameters to increase the range by reducing the payload. Chinese statements in 1988 suggested that the warhead weight was 500 kg, and the range 300 km; it is possible that both sets of figures are correct. Some recent Taiwanese sources have stated that a 1,000 kg conventional warhead is in use but this would reduce range.

The warhead assembly is believed to separate in flight, and there are four small control fins mounted at the base of this assembly. It is not known if these control fins move, or are simply there as stabilisers. It is possible that the M-11 warhead assembly has a miniature propulsion system, similar to that used in the M-9 missile to correct the alignment prior to re-entry into the atmosphere. Reports suggest that the terminal accuracy of the DF-11 did not meet the original requirements, and that an accuracy of 600 m CEP (circular error of probability) is the best that can be expected. The original M-11 export design had a unitary high explosive warhead, but it is believed that the DF-11 in Chinese service has optional nuclear (believed to be 90 kT yield; some sources state a 10 kT tactical warhead is in use) and submunition warheads. The DF-11 could also have a chemical warhead. Control during the boost phase could be by vanes in the exhaust or by small vernier motors, but the rear nozzle assembly has not been seen. Guidance during boost is probably by a simple inertial platform. The DF-11 missile with a 500 kg warhead probably has a maximum range of 300 km and a minimum range of 50 km, with a peak velocity of 1.4 km/sec and a minimum energy apogee of 100 km.

Considerable controversy has surrounded the M-11 missile and its possible export to Pakistan and Iran. It is reported that about 30 M-11 missile assemblies were exported to Pakistan in 1993, and have been stored in packing cases at an airbase near Lahore. It was also reported that another 30 or so missile assemblies were exported to Iran in 1995 to establish a local assembly line to be followed later by a full manufacturing capability. Both exports are denied by China, Pakistan and Iran, and there is scope for misunderstanding as both Pakistan and Iran state that they have their own ballistic missile development programmes. It is possible that the Chinese have exported some design and manufacturing technologies associated with the M-11 missile system, rather than complete missiles. However, it is also possible that they have exported complete and assembled missiles.

There are no estimates of the number of DF-11 missiles in service with the PLA. Designed initially as a tactical nuclear weapon it is likely that the initial order was only for about 50 missiles, bearing in mind that the longer-range M-9 was probably the more acceptable nuclear delivery system. With the development of high explosive and submunition warheads, there was probably a second order for the M-11s. However, bearing in mind the relative inaccuracy of this system it is estimated that there might be around 200 in service by the late 1990s. Some recent Taiwanese estimates have placed the number at just 100 in PLA service but this appears low and may be referring only to those missiles believed to be deployed against Taiwan.

3.3.4 DF-15 (M-9, CSS-6)

The DF-15 developed by the Chinese Academy of Launch Technology's 1st Academy, is a sophisticated solid-fuelled, single-stage mobile tactical ballistic missile, similar in appearance to the former US Pershing I-A system, with a reaction-launch time of about 30 minutes. The DF-15 is believed to be equipped with a variety of warhead types, and is now a backbone of China's tactical ballistic missile force. Four DF-15s were fired near Taiwan during July 1995, and four more in March 1996 during 'Exercise Strait 961'. Some reports suggest that the majority of the current DF-15 and DF-11 force is deployed against Taiwan, whose capital city, Taipei, lies some 204 km from the Chinese mainland. Some estimates indicate that there are 40 nuclear warheads available for about 10 per cent of the total force. The DF-15 employs warhead shaping to increase the difficulty of radar detection, as well as a second stage to confuse enemy anti-missile radars. Recent reports indicate that DF-15 improvements include satellite navigation technologies that could improve accuracies by an order of magnitude (i.e. to a 30 m CEP), in which case it is one of the world's most accurate ballistic missiles.

Development of the DF-15 (M-9) missile system probably began in 1984 and like the M-7 and M-11 it was initially designed for export. The PLA liked the design and it was adopted as the Dong Feng 15 (DF-15). The NATO designation is CSS-6. The first test launch was made in 1988 and the DF-15 is believed to have entered service in 1991. It is reported that the DF-15 missile system was refined using technologies developed for strategic ballistic missile programmes. The M-9 export version has been marketed by the CPMIEC.

The DF-15 missile is believed to be 10.0 m long, to have a body diameter of 1.0 m and a launch weight of around 6,000 kg. The warhead assembly separates from the missile after boost, and has a miniature propulsion system to correct the alignment of the warhead assembly before re-entry to improve the accuracy and to change the trajectory and range. The warhead assembly weight is believed to be 500 kg, with optional warheads that can be nuclear with a yield of 90 kT (some recent Taiwanese sources have indicated a 20 kT tactical warhead is in use), possibly enhanced radiation (neutron bomb) warheads, unitary high explosive, chemical, or submunitions. There have also been reports that a fuel-air explosive warhead was developed.

The DF-15 has a single-stage solid-propellant motor that gives a maximum range of 600 km and a minimum range of about 50 km. If the warhead were reduced in size, for example to 200 kg, then this missile might be expected to have a maximum range increased to 800 km. The DF-15 on a minimum energy trajectory over 600 km, would have an apogee of 160 km, and a peak velocity of 2.3 km/sec. Control during the boost phase may be by exhaust vanes or from small vernier motors. Guidance is reported to be from a strap-down inertial guidance system with an onboard digital computer, enabling rapid re-targeting to be made before launch and eliminating the need for wind corrections. The accuracy of the unimproved DF-15 missile is stated to be 300 m CEP. It is believed that the DF-15 missile was designed to be carried by the Russian built MAZ 543 TEL vehicle used with the SS-1C 'Scud B', but it is not known what vehicles are used in Chinese service with the DF-15 version. A report in 1995 suggested that China has constructed a countrywide system of DF-15 missile bases, with a project known as the 'Great Wall' (see Chapter 7, Section 7.2). As the missiles are carried on road mobile vehicles, this probably refers to support facilities and pre-surveyed sites.

In 1988 there were reports that Syria was negotiating to purchase M-9 missiles. Reports in 1989 suggested that Libya had ordered 140 missiles and would pass on 80 of these to Syria. China has also reportedly sold M-9 missiles to Egypt, Iran and Pakistan. Bearing in mind the strong protests that were made to China over the alleged export of M-11 missiles, it is strange that no formal protests have been recorded over the longer range M-9 system. In light of these factors one can conclude that the M-9 missile orders were either never confirmed or just not delivered by the Chinese.

Construction probably started in 1990 and from the earlier estimates of export orders it is assumed that a production rate of 50 missiles a year or more was planned. It is estimated that about 100 tactical nuclear warheads may have been required, and that the remaining missiles would be used with high explosive, chemical or submunition warheads. The total number of missiles in service with the PLA is probably about 400 (some recent Taiwanese estimates have indicated 300 but it is not clear if these refers only to those deployed against Taiwan).

3.3.5 DF-21 (CSS-5)

The Dong Feng 21 (DF-21) intermediate range ballistic missile has the NATO designation CSS-5. The DF-21 was developed from the Ju Lang 1 (JL-1) submarine launched ballistic missile, which was the first solid-propellant strategic nuclear ballistic missile programme in China. The JL-1 programme started in 1967 but the first test launch was not until 1982, and the missiles became operational in 1987 onboard the first Xia-class submarine. The road mobile DF-21 was first test launched in 1985 and is believed to have entered service in 1987. A modification programme was started in 1986 to increase the range and this version is known as DF-21A. Two DF-21 missiles were launched at sea targets close to Taiwan in July 1995 with ranges of about 1,600 km and appeared to be successful.

It is believed that R&D is ongoing to equip the DF-21A with a sophisticated terminal guidance system employing navigation satellite data similar to the US global positioning system (GPS) network or radar guidance technology similar to the former US Pershing II IRBM . The system correlates images from an onboard radar with digital map pictures in the warhead's computer, reportedly achieving accuracies within a radius of 50 m. GPS, and its Russian counterpart GLONASS, each use some 24 satellites to provide correlated satellite signals to derive highly accurate location determinations. Differential processing technology using signals from a larger number of satellites, can reportedly upgrade civil-level GPS signals to a level sufficient for precision military missions and there have been some indications that China has pursued efforts along these lines. The Beijing Research Institute for Telemetry is developing advanced missile guidance systems, as are the Second Artillery Engineering College and the China Aerospace Corporation's 2nd Academy (space interception systems) and 3rd Academy (cruise missile guidance systems). Systems that combine inertial, GPS and TERCOM (terrain contour matching) guidance systems may be under development.

It is believed that the DF-21 missile is 10.7 m long and has a body diameter of 1.4 m. The missile weighs 14,700 kg at launch and it is expected that the warhead separates after boost. The warhead assembly weighs 600 kg and initially there was a single nuclear warhead with a yield of about 250 kT. In the early 1990s there were reports that a high explosive warhead was in development for the DF-21, and there could also be chemical and submunition warheads. The missile has two-stage solid-propellant motors giving the DF-21 a maximum range of 1,700 km and the later DF-21A a maximum range of 1,800 km. Both versions are expected to have a minimum range of 600 km. With a minimum energy trajectory the apogee will be around 425 km and the peak velocity about 3.8 km/sec. The control method during boost is not known but guidance is from an inertial platform with an onboard computer. The accuracy is believed to be around 700 m CEP. The DF-21 missile is carried on a TEL vehicle, which consists of a tractor and an open flat top trailer with a simple launch platform at the rear. The missile test and target setting functions are carried out from a separate logistics and command vehicle. The missile is cold-launched from its storage canister, and at around 20 m altitude the first-stage solid-propellant motor ignites. The PLA artillery regiments operating the DF-21 system are reported to use six vehicle convoys. These are believed to include a command vehicle, a logistics support vehicle, a reload vehicle, and three TEL vehicles.

Recent report indicate that an uprated DF-21X features GPS and can be fitted with a 'radio-frequency explosive warhead', believed to refer to an electro-magnetic pulse warhead in a new nosecone. Most of the missile is identical to the DF-21, but the DF-21X has more fuel, extending its range by 1,200 km to 3,000 km. The PLAAF may have air-launched FAEs, and these may also be used by the Second Artillery on missiles such as the DF-21X.

There have been no reported exports of the DF-21 missile. There are several estimates of the number of missiles in service, varying from 10 to 50 but it is believed that the actual number is now between 35 and 50 missiles. There are reported to be two main base facilities for the DF-21, located in the Qinghai and Yunnan provinces.

3.3.6 JL-1 (CSS-N-3)

The Ju Lang 1 (JL-1) was the first generation of Chinese submarine launched ballistic missiles (SLBM) and has been given the NATO designation CSS-N-3. JL-1 development started in 1967 but the programme proceeded slowly due to difficulties with casting large (1.4 metre) diameter solid-propellant motors and the slow moving Xia nuclear powered submarine programme. The JL-1 programme also suffered from several political interventions, particularly between factions that supported submarine launched missiles and those that wanted priority given to land based systems. The first successful test firing of the JL-1 solid motor first stage took place in 1978 and two test launches of the missile were made in 1982. It is believed that JL-1 became operational in 1987, onboard the first Xia-class SSBN. The first successful launch from a submerged Xia submarine was reported in 1988. In 1978 the Chinese decided to develop a land-based missile from the JL-1 design, the DF-21, which was first tested in 1985 and is believed to have entered service in 1987.

It is believed that JL-1 is 10.7 m long, and has a body diameter of 1.4 m. The missile weighs 14,700 kg, and it is thought that the warhead separates after the boost phase. The warhead assembly weighs 600 kg and there is a single nuclear warhead with a yield of 250 kT. Although a high explosive warhead has been developed for the DF-21, and could presumably be fitted to the JL-1 as well, there have been no reports suggesting that this has actually been done. The missile has two stage solid-propellant motors giving a maximum range of 1,700 km and a probable minimum range of 600 km. With a minimum energy trajectory the missile would have an apogee of 425 km and a peak velocity of 3.8 km/sec. The control system is not known but the guidance system is inertial with an onboard computer. The accuracy is believed to be around 700 m CEP. The Xia submarine carries 12 missiles and these are cold launched from their canisters with the solid-propellant first stage motor igniting after the missile has reached the surface. The Chinese tried to develop underwater ignition for the JL-1 but were unsuccessful.

There are no known exports of the JL-1 missile system. Although two Xia-class submarines are believed to have been built, there is only one boat in service today. There are different assessments of the number of JL-1 missiles in service, varying between 12 and 38. It is believed that the total number in service is unlikely to exceed 24 and is probably between 15 and 20.

3.3.7 DF-3 (CSS-2)

The Dong Feng 3 (DF-3) intermediate-range ballistic missile has the NATO designation CSS-2. The missile system was designed by the First Academy of the former Ministry of Aerospace Industry. Development is reported to have started in 1960, with the operational requirement to produce a liquid propellant single stage missile with a range of 2,500 km (sufficient to reach US bases in the Philippines) and with a payload of 2,000 kg to carry the first Chinese hydrogen bomb (fusion weapon). The first flight test of the DF-3 missile was made in 1966 and the missile entered operational service in 1971. An upgraded version, the DF-3A, was developed in the early 1980s, with flight tests starting in 1986. It is believed that the DF-3A entered service in 1988.

The DF-3 has a length of 24.0 m and a body diameter of 2.25 m. The launch weight is 64,000 kg and the warhead assembly separates after the boost phase. There is a single nuclear warhead with a yield between 1 MT and 3 MT, and the warhead assembly weighs 2,150 kg. The single stage missile has four YF-2 motors that produce a total lift-off thrust of 96 t, with graphite control vanes. The missile uses storable liquids, with AK-27 oxidiser (nitric acid with 27 per cent nitrogen tetroxide) and UDMH fuel. A launch preparation time of between two and three hours is reported. The maximum range of DF-3 is 2,650 km and the minimum range 750 km. With a minimum energy trajectory the apogee is 500 km and the peak velocity 4.3 km/sec. DF-3 is reported to have had a ground-based radio command guidance system initially, but this was modified to an inertial strap-down system before the missiles entered service. The accuracy is believed to be 2,000 m CEP.

The improved DF-3A version has a range increased to 2,800 km and an accuracy improved to 1,000 m CEP. A high explosive warhead with a weight of 2,500 kg has also been developed for the DF-3A and it is reported that this high explosive warhead was retrofitted to the refurbished DF-3 missiles exported to Saudi Arabia. Both the DF-3 and DF-3A missiles could be modified to reduce the payload and increase the range, and a maximum range of 4,000 km could be possible with a payload reduced to 500 kg. Although some flight trials were reported using DF-3A missiles in 1985 with multiple warheads, it is believed that these were unsuccessful and that the DF-3A has just a single warhead.

Some DF-3 missiles, with high explosive warheads, were exported to Saudi Arabia in 1988. There are believed to be two sites with four to six launch pads per site and about 40 missiles in Saudi Arabia. Unconfirmed reports suggest that chemical warheads may also have been developed for the DF-3 missiles in Saudi Arabia. It is also reported that these missiles have a range of 2,400 km, with the reduced range due to the heavier high explosive warhead developed for the Saudi export order, believed to be 2,500 kg.

Initially there were believed to be 100 to 150 DF-3 missiles in service in China and while the missiles are transportable they are not mobile. There are now reported to be between 40 and 150 DF-3A missiles in service. However, the actual figure is reportedly between 60 and 80 as it is believed that the 40 missiles sold to Saudi Arabia came from Chinese stocks. The present missiles are all reported to be based in western China, with facilities at Fengrun, Xuanhua, Liujiho, Yida, Xi'an, Dalong, Jianshui and Kunming.

3.3.8 DF-4 (CSS-3)

Development of the Dong Feng 4 (DF-4) missile started in 1965, with a design by the First Academy of the former Ministry of Aerospace Industries. The NATO designation is CSS-3. The operational requirement was to deliver a 2,200 kg payload (for the Chinese hydrogen bomb) over a distance of 4,000 km to reach US bases on Guam. The range requirement was increased in 1970, to 4,500 km, to reach Moscow from bases in north west China. The first test flight was made in 1970 but the redesign work to increase the range and differences in basing options resulted in the DF-4 not entering operational service until 1980. The Long March 1 (LM-1, CZ-1) satellite launch vehicle was developed from the DF-4 design, by adding a third stage, and an LM-1 launched the first Chinese satellite in 1970. The PLA Second Artillery Corps is reported to have completed a software upgrade to the DF-4 in 1985, to improve the accuracy and to simplify pre-launch procedures.

The DF-4 is a two stage missile with a total length of 28.0 m, and a body diameter of 2.25 m. The first stage length is 16.7 m, the second stage 7.0 m and the warhead assembly about 4.3 m long. The launch weight is 82,000 kg and the warhead assembly separates at the end of the boost phase. The warhead assembly has a weight of 2,200 kg and contains a single nuclear warhead with a yield of 2 MT. The missile uses an upgraded DF-3 first stage with four YF-2A motors giving a thrust of 104 t, and a second stage with one YF-3 motor giving 32 t of thrust. The DF-4 uses the same storable liquid fuel and oxidiser as DF-3 (Ak-27 and UDMH), with graphite vanes in the exhaust for control. The maximum range is 4,750 km and the minimum range about 1,200 km. With a minimum energy trajectory the apogee is 850 km, and the peak velocity 5.3 km/sec. Control is by an inertial strap-down system and an accuracy of 1,500 m CEP has been reported. It was planned that DF-4 would be silo based and a test firing was made from a silo in 1971. Rail mobile tests were carried out in 1975 but it was then decided to base the missiles in caves for all the launch preparation activities, rolling them outside just before launch. The first cave launch was made in 1980.

There have been no reported exports of DF-4 missiles. Various reports give the total number of DF-4 missiles in service at between 10 and 25, located in cave facilities at Qaidam and Delingha (north west), Tongdao and Sundian (south east).

3.3.9 DF-5 (CSS-4)

Development of the Dong Feng 5 (DF-5) started with the First Academy of the former Ministry of Aerospace Industries in 1965. The NATO designation for this missile is CSS-4. The operational requirement was to deliver a payload of 3,000 kg over a range of 12,000 km to reach major US cities. The first test flight was made in 1971, the first silo launch in 1979, full range flight tests in 1980, and the first missiles became operational in 1981. The Chinese developed the Long March 2 (LM-2, CZ-2) series of space launch vehicles (SLV) from the DF-5, with the first launch of a LM-2 being made in 1975. The LM-2 has become the workhorse launcher of the Chinese satellite programme with over 20 launches. It is believed that the LM-2 is manufactured by the Wan Yuan Industry Corporation, Beijing and it is marketed by the China Great Wall Industry Corporation, Beijing. It is believed that both SLV and DF-5 assemblies are built together in Beijing. In 1986 a development programme was started to upgrade the DF-5 missiles to the DF-5A standard, increasing the payload to 3,200 kg and the range to 13,000 km.

There had been two other developments deriving from the DF-5 programme from about 1966. The first was known as DF-6 and would have added a third stage to the DF-5 design to create a fractional orbital bombardment system (FOBS) to attack the USA from the south west (cancelled in 1973), and the second was a penetration aid programme. The First Academy is reported to have developed both chaff and light exo-atmospheric decoys for use in the DF-5 missile in the late 1960s, and to have started a multiple independently targeted re-entry vehicles (MIRV) programme in 1970. The MIRV programme was delayed by the lack of progress on building small nuclear warheads, and DF-5 went into service in 1981 with just a single warhead. The MIRV programme was started again in 1983 but flight tests in 1985 from DF-3A missiles were unsuccessful. It is believed that the DF-5A modification still has a single warhead. It is possible that MIRVs might be fitted to the DF-5A version in the future.

The DF-5 is a two stage missile that is 32.6 m long and has a body diameter of 3.35 m. The first stage length is 20.5 m, the second stage is 7.5 m, and the warhead assembly is 4.5 m long. The missile has a launch weight of 183,000 kg and the warhead assembly separates at the end of the boost phase. The warhead assembly contains a single nuclear warhead with a yield of between 3 MT and 4 MT. There are chaff and exo-atmospheric decoys carried in the warhead assembly, to be released some time after separation from the second stage tanks. The first and second stages use storeable liquid fuel and oxidants, both using nitrogen tetroxide (100 per cent) and UDMH. The first stage has four YF-20 motors providing a total thrust of 280 t, with swivelling motors for control and carrying a total of 140 t of fuel and oxidant. The second stage has a single YF-22 motor producing 70 t thrust, carrying 35 t of fuel and oxidant, with four small vernier motors for control each producing just over 1 t thrust. The maximum range of the DF-5 missile is believed to be 12,000 km, with a minimum range probably around 3,500 km. A minimum energy trajectory would have an apogee of around 2,500 km, and a peak velocity of 7.0 km/sec. Guidance for the DF-5 missile uses a gyro stabilised inertial platform with an onboard computer. The accuracy has been estimated to be 800 m CEP.

DF-5 missiles are stored and launched from underground silos.

The DF-5A modernisation programme resulted in a missile with an increased range to 13,000 km, an increased payload of 3,200 kg, and an improved accuracy to 500 m CEP.

There are no known exports of the DF-5 or DF-5A missiles. When the system first became operational in 1981, there were just two silos at the base. Reports suggest that a second base was built with some four to 10 missiles in service. It is reported that the Chinese built decoy silos and various sources estimate the present number of missiles as between four and 50. There have been over 20 LM-2 satellite launch vehicle launches and it is expected that the Chinese probably stored some spare SLV that could be converted to ballistic missiles. Pictures released show four or five SLV assemblies together and it would seem reasonable to assume that a 10-year programme could have built some 40 to 50 missiles and SLVs. A report in 1992 suggested that only four DF-5 missiles were upgraded to the DF-5A standard and it is believed that a further 15 to 20 DF-5 missiles are in service or storage. The reported DF-5 site is at Luoning (near Xi'an), with trial silos located at the Jiuquan and Wuzhai space centres.

3.3.10 M-18

This designation was given to a small two-stage solid-propellant ballistic missile exhibited in 1988. The missile appeared to be derived from the M-9 design but with a second stage added. The Chinese stated that the M-18 had a range of 1,000 km and carried a warhead assembly weighing 400 kg. The missile exhibited had a Lockheed logo on its nose section but it has never been confirmed that the US company made any contribution to the programme. Some reports indicated that it was to be a replacement for the M-9 and M-11 systems, with conventional, nuclear, chemical or biological warheads, and in service by 2001.

Reports in 1991 indicated that China was giving assistance to Iran to develop a ballistic missile with a range of between 700 km and 1,000 km, and that this missile might have solid-propellant motors. The missile programme in Iran is believed to have the names Iran 700 or Tondar-68, although Tondar may refer to the research establishment rather than the missile itself. Two test launches were reported in 1991 in Iran, although at the time there was confusion as some reports stated that the test firings were for the liquid propellant North Korean Nodong 1 missile. The two launches flew 700 km and 1,000 km.

There have been no further reports concerning the M-18 missile to date but the ongoing development of such a system with improved precision guidance technologies could be quite likely.

3.3.11 DF-25

The Dong Feng 25 (DF-25) development programme is believed to have started in 1986, with the requirement to increase the payload of the DF-21 (600 kg) to 2,000 kg whilst retaining the range at 1,700 km. The DF-25 is a two stage solid-propellant ballistic missile, reported to use the first two stages of the DF-31 missile. The missile was planned to have a high explosive warhead, although this would probably include both chemical and submunition, and possibly nuclear, options.

Reports in the early 1990s connected the DF-25 missile programme with Iran, suggesting that China was assisting the development of a similar missile; however, this has never been confirmed.

A reduced size warhead, say to 500 kg, might give the DF-25 a range capability of 4,000 km. An initial in service date of 2000 was predicted for DF-25 but reports in 1996 suggested that the Chinese had halted the development programme, perhaps for further improvements such as a range increase and the introduction of a terminal homing system for improved accuracy. Unconfirmed reports during 1999 indicated that the DF-25 programme may have been revived, or had been covertly maintained after all (it may have been simply delayed while awaiting the development of related motor assemblies). The DF-25 would be particularly useful for targeting India, whose current nuclear weapons programme may have increased its perception as a threat by China.

3.3.12 DF-31

Unlike the first generation ballistic missiles, the JL-1 and DF-21, the Chinese have given priority to developing the land-based Dong Feng 31 (DF-31) before the submarine-launched Ju Lang 2 (JL-2) programme. Development started around 1970, for the second generation SLBM (JL-2) and its original land based version the DF-23. These two missiles were to have had a range capability of 6,000 km, with a payload of 800 kg to carry a single second generation nuclear warhead. In 1985 the operational requirement was changed, to increase the range to 8,000 km and reduce the payload to 700 kg. From this point the land based missile designator was changed to DF-31, while the SLBM designator stayed as JL-2.

The first test firing of a 2.0 metre diameter solid-propellant motor was made in 1983 and an underwater launch of a prototype JL-2 was reported in 1985. It is likely that both missiles will use global positioning system (GPS) or stellar updates for improved accuracies, advanced materials for booster and payload structures, penetration aids such as decoys and chaff (which are believed to have been tested on missiles), and improved solid-propellants. The first ground launch of what was probably a DF-31 was made in 1995. The second test was on 4 August 1999. These successful tests are believed to have been conducted with single warheads, the second with penetration aids, and the missile may now be considered operational. In July 1998, while US President Bill Clinton visited China, the DF-31 rocket motor was believed to have been test-fired as a political signal to the US and Taiwan. Development and production activities are believed to be undertaken at the Wuzhai Missile and Space Test Centre in central China (a US reconnaissance satellite has reportedly imaged DF-31 activities in October 1996). Launch or re-entry test activity probably occurs at Lop Nor in Xinjiang Province, south-east of the large city of Urumqi.

There are few specifications known for the DF-31 missile. The missile has three solid-propellant stages, a maximum range of 8,000 km and a minimum range of around 2,000 km, allowing it to target all of Russia, all of Asia, Hawaii and Alaska and parts of the state of Washington but not other parts of the continental US. Other sources indicate that it could hit targets throughout the Western US along a line running south-west from Wisconsin through California. China Central Television in August 1999, quoted a Lt. General Yuan Yunzhi of the PLA's Academy of Military Sciences as saying that the DF-31 is capable of hitting Seattle, Washington if launched from China's north-east Heilongjiang Province, Australia if launched from Guangdong Province, Africa if launched from the north-eastern provinces, and targets throughout Europe if launched from the north-western Xinjiang Province. The warhead assembly is reported to carry a single 500 kg weight nuclear warhead, with a yield of 250 kT, or 650 kT nuclear warhead, or three MIRVs with a yield of 90 kT each (total payload of 700 kg). The warhead assembly will separate from the third stage tank at the end of boost and might carry decoys or penetration aids. It is reported that the First Academy's 13th Institute (inertial guidance) has been researching star trackers to provide guidance updates since the mid-1970s, and it is likely that stellar navigation or GPS updates would be incorporated into the DF-31 design to improve the accuracy over the full range capability.

It has been reported that Russian Federation, or Belarussian, MAZ-547V TEL vehicles with six axle suspensions (similar to those used for the former Soviet SS-20 Sabre IRBM system) are used to transport the DF-31, with DF-31 and transporter production located at Nanyuan near Beijing. A new Chinese TEL based on the WS-2400 heavy transport vehicle manufactured by the Sanjiang Space Group was revealed at the 1998 Zhuhai Air Show, and shows a probable Russian design influence. The DF-31 is expected to replace the DF-4, with at least 10 to 20 missiles being built and deployed. A 1996 report by the US Air Force's National Air Intelligence Centre indicated that the DF-31 will narrow technical and operational gaps between Chinese, Russian and US ballistic missile systems, and 'will give China a major strike capability that will be difficult to counterattack at any stage of its operation, from pre-flight mobile operations through terminal flight phases... Road mobility will greatly improve Chinese nuclear ballistic missile survivability and will complicate the task of defeating the Chinese threat'. The only other road-mobile ICBM currently in service is the Russian SS-25. Road-mobile Iraqi Scud missiles were found to be very difficult to target and destroy during the Gulf War. The DF-31 was displayed as a truck-mounted version during the 1 October 1999, 50th Anniversary of the PRC Parade in Tiananmen Square, Beijing. An official November 1999 report announced that the DF-31 had been deployed in southern China, possibly at multiple launch sites connected by highways.

3.3.13 JL-2

Development of the second generation SLBM, Ju Lang 2 (JL-2), is believed to have started in 1970. Initially this missile was going to have a range of 6,000 km and a payload of 800 kg, and was being developed together with a land-based version DF-23. A 2.0 metre diameter solid-propellant motor was first tested in 1983 and an underwater launch of a JL-2 missile was reported in 1985. However the operational requirement was changed in 1985 to increase the range to 8,000 km and to reduce the payload to 700 kg (as the second generation nuclear warhead was smaller than expected). At the same time the land based version was designated DF-31 and it was decided that the DF-31 land system would receive development priority as the second generation nuclear submarine programme was delayed. A ground launch of the new design was reported in 1995 and this is believed to have been made by a prototype DF-31 missile. It is believed that the NATO designation for this missile is CSS-NX-5.

There are few specifications known for the JL-2 missile. The missile has three solid-propellant stages, a body diameter of 2.0 m and a range of 8,000 km. The JL-2 would be expected to have a minimum range of 2,000 km. The warhead assembly weight has been reported as 700 kg and it is expected to be armed with a single 250 kT or 650 kT warhead, or three 90 kT MIRV warheads. The warheads will separate from the third stage tank assembly at the end of boost and might carry decoys or penetration aids. It is reported that the First Academy's 13th Institute has been researching star trackers to update inertial guidance systems since the mid-1970s, and that stellar or GPS updates might be provided in the JL-2 to improve the accuracy over the maximum range.

The flight tests of the DF-31 are believed to have contributed to the JL-2 development programme. Up to four new generation Type 094 SSBNs are to be constructed, with each submarine carrying up to 16 JL-2 SLBMs (see Chapter Five, Section 5.3). The JL-2 will probably not enter fully operational service until the year 2005 replacing the JL-1 (although some reports indicate the single operational Xia-class has been refitted for the JL-2). It will form an essential component of China's second-strike capability, with a requirement for up to 70 to 80 missiles.

3.3.14 DF-41

The Dong Feng 41 (DF-41) development programme started in 1986, with the operational requirement to have a solid-propellant missile with a range of 12,000 km carrying a payload of 800 kg. A projected in service date of 1998 has been reported but it is believed that a more likely date would be 2000 to 2002. The DF-41 is expected to be a replacement for the DF-5 and DF-5A liquid propellant missiles.

It is reported that the DF-41 is a three-stage solid-propellant missile, with a maximum range of 12,000 km. This would suggest that the minimum range for the missile will be around 3,000 km. It is believed that it will be armed with a single 250 kT or 650 kT nuclear warhead, or three 90 kT MIRV warheads (some reports indicate up to five to eight MIRVs). The warhead assembly will separate from the third stage tank at the end of boost and decoys or penetration aids might be carried. The First Academy's 13th Institute has been researching star trackers to update inertial navigation systems since the mid- 1970s and it is possible that either stellar or GPS updates are provided to improve the accuracy of DF-41 over the full-range capability. Unconfirmed reports in 1994 and again in 1996 suggested that China has been seeking help from both Russia and the Ukraine for advanced guidance and other missile technologies associated with the SS-24 'Scalpel', SS-25 'Sickle' and SS-18 'Satan' intercontinental ballistic missiles.

The DF-41 has not yet been flight tested but it is expected to employ a similar GPS or stellar updating system to that used by the DF-31. It is being developed as a replacement for the DF-5, with a least 10 missiles to be built and deployed between 2002 and 2005. It could target almost all of the continental US and because it can be deployed throughout China, it will be significantly more survivable that the fixed-base DF-5. The DF-31 and DF-41 will probably incorporate new penetration systems such as stealth technology for warheads, electromagnetic pulse (EMP) hardening, and other systems such as decoys. Reports in October 1999 and August 2000 indicated that computer simulations of the DF-41 had been successfully completed. If these reports are confirmed a test launch could take place within the next year and deployment over five years.

3.4 Ballistic Missile Foreign Technology Transfers TOP

3.4.1 Overview

China may have accumulated significant advanced ballistic missile technologies from sources such as the US, Russia and the Ukraine. It is not clear that China requires or can assimilate all of these technologies into its own new programmes, although significant generic technology transfer and new system design benefits are a distinct possibility. A past characteristic of Chinese missile R&D was the long development time before the weapon entered service (often after a decade), resulting in it being largely obsolete. This is now changing with new generation ballistic and cruise missiles entering service that are near state-of-the-art.

3.4.2 Former Soviet Union/Russia

Russia is believed to be assisting China on a commercial basis for its strategic missile modernisation programmes in such areas as upper stage propulsion systems and even the sale of surplus space/missile tracking ships. During 1990/91, Russia and the Ukraine were reported to have sold China a small number of RD-123 engines used to power the second stage of their Zenit missile and possibly its very powerful first stage RD-170 engine system. Other technologies transferred through China's recruitment of former Soviet space experts could include composite materials used for turbine blades in advanced propulsion systems, missile electronics and navigation systems. There has also been some speculation that the Ukraine may have offered China ICBM technical development assistance (for example, strength testing, aerodynamics and vibration analysis) after a January 1996 visit by a Chinese military delegation to the Dnepropetrovsk ICBM plant. Such assistance reportedly could even involve the transfer of SS-18 ICBM and SS-20 IRBM technologies. Other reports indicate that during 1996 several Chinese engineers were arrested after attempting to steal SS-18 blueprints from the Yuzhnoye missile component factory. The Ukraine has a strong, export-oriented missile lobby and significant latent production capabilities. In addition to the SS-18, it produced the SS-24 and SS-25 Soviet ICBMs, and the Kosmos, Tsyklon and heavy-lift Zenit space launch vehicles.

The ex-Soviet SS-18 ICBM is a heavy-lift missile that can carry 10-14 RVs with a throw weight of 8,800 kg, or about 2.2 times more throw weight than the US MX Peacekeeper's and 2.75 times more than China's DF-5A ICBM. China has reportedly attempted to steal or covertly purchase the plans for the SS-18 engine from the Southern Machine Building Plant (Yuzhmash), Dnepropetrovsk, Ukraine, and it has also made efforts to commercially purchase that technology from both the Ukraine and Russia. Specifically, a leaked article from the US Defense Intelligence Agency's *Military Intelligence Digest* noted that the now retired PLAN Admiral Liu Huaqing had visited Moscow in December 1995 and "expressed great interest in purchasing SS-18 ICBM components." SS-18 technology could assist China in the development of multiple warhead busses, as well as MIRV design, accuracy, decoys, advanced liquid-fuel engines, and transportability, as well as upgrading existing DF-5 ICBMs (the leaked DIA report indicated the potential of mating MIRVs to DF-5s), and improving the MIRV capabilities of future domestic ICBMs such as the DF-31 or the DF-41.

China has also expressed interest in buying SS-18 boosters to use in its space programme. Some technical analysts believe that the SS-18's engines would be incompatible with the sensitive electronics of many satellite payloads. However, the SS-18's high G-force launch and payload vibration problem could probably both be adjusted or compensated for in various ways that would make this missile commercial payload rated. Thus, China could have a legitimate commercial use for SS-18 boosters. However, a realistic assessment indicates these would provide China with technological information which could be of significant value in improving its overall ICBM capabilities. Other ex-Soviet ballistic missiles that could be sold for ostensible space launch operations include the SS-19 and SS-25 ICBMs and the SS-N-20 SLBM.

In May 1996, near a Chinese missile plant, US reconnaissance satellites reportedly detected a TEL system made by the Minsk Automotive Factory used for transporting the SS-20 IRBM, probably the MAZ 547V, which also forms the basis for the TEL of Russia's newest ICBM, the SS-25. Russian MAZ technology could offer the PLA improvements in increased ground clearance, large variable inflation tires, driver-controlled inflation and deflation systems, and possibly inertial navigation equipment that would negate the requirement for pre-surveyed launch sites. New Chinese TEL systems could have increased off-road mobility and survivability for the new generation DF-31 and DF-41 ICBMs (precise TEL suspensions are important for avoiding the creation of potentially catastrophic hairline cracks in missile fuselages).

3.4.3 United States

A 1998 classified US Department of Defense study, which preceded the Cox Report, concluded that the Hughes Electronics Corporation transferred significant satellite launch data to China following a January 1995 Chinese launch vehicle failure that was attempting to place a Hughes' Apstar-2 telecommunications satellite into geosynchronous orbit. The study also concluded that China's level of ICBM technology sophistication could have benefited as a result of this transfer (Apstar-2R, the replacement satellite, was successfully launched from Xichang on 16 October 1997 for APT Satellite Company Ltd., Hong Kong). Other US firms believed to have recently helped China with dual-use missile technologies include Loral Space and Communications and Motorola. Examples are believed to include a Chinese-developed 'smart dispenser' for its numerous Iridium smallsat launches, which could provide an improved MIRV capability.

Some sources indicate that Iridium-derived systems for the current DF-5 or developmental DF-41 ICBMs could be converted to carry from three to eight small nuclear warheads each weighing about 470 kg, and provide an integrated post-boost vehicle with solid and liquid fuel propulsion, avionics and guidance systems, communications, with manoeuvring capabilities not previously available to China. In February 1996, a Chinese Long March 3B booster suffered catastrophic failure when launching a Loral/Intelsat telecommunications satellite, resulting in the follow-up transfer of US launch vehicle guidance technologies, and perhaps some sensitive US microelectronics systems salvaged from the wreckage by the Chinese immediately after the accident. China's ICBM and manned spaceflight effort could also benefit from such technologies that increase reliability and safety.

Ironically, China continued to faithfully launch 10 Iridium satellites in five missions until the satellite communications programme commercially collapsed in 1999 because of high user costs and technologies that have been rapidly superseded by simpler systems. A February 1999 Iridium launch from China on a CZ-2C/SD was cancelled at the last moment supposedly for technical reasons and the dual satellites returned from China to the US. However, the decision could have been related to the implications from the Cox Report. China had a contract to launch 22 of the failed network's projected 66 satellite constellation.

It is generally considered impossible not to discover technological details when integrating a satellite payload to a launch vehicle regardless of security precautions undertaken. While China has discovered details concerning US technology, American firms using Chinese launch services are believed to have provided details on Chinese launch capabilities to US intelligence agencies which previously relied primarily on national technical means such as satellite reconnaissance and ELINT. In some instances it was also discovered that US security in China was lax. Certain key facilities were left unguarded and US security officials failed to determine the nationality of technicians working at sensitive sites. Unconfirmed sources indicate that the rooms of Loral employees staying in China were electronically bugged by Chinese intelligence agencies to monitor their conversations for business and technical information. Motorola used Chinese personnel to install secure and unsecured fax, voice and data transmission systems at their facilities in China, which made it very likely their data transmissions were being intercepted.

As early as 1993, a classified DIA study reportedly raised the possibility of the diversion of US commercial space technologies to suspected PLA-related end users. In some cases Chinese officials refused inspections to verify that such technologies were only being used for civilian applications and a formal mechanism was lacking for such verifications. These concerns were played down by subsequent research by the Central Intelligence Agency (CIA). However, in 1998 CIA analysis compared the various technical similarities between space launch and ICBM technologies. Between 1990 and 1993 alone, the Commerce and State Departments approved a total of 67 dual-use technology licenses to China worth over US$530 million.

The Senate Select Committee on Intelligence recommended during May 1999 that the US government should re-evaluate its policy of permitting the launch of US satellites on Chinese boosters due to technology transfer concerns. It also urged that the State Department implement rigorous 90 day timetables for reviewing US satellite export licence requests, which would be conducted by defence and intelligence agencies, although the committee found no evidence that US space technologies had been incorporated into Chinese ICBM systems. However, these recommendations, plus those of the Cox Report, are bound to tighten overall space technology exports to China, and open the door to European Union, Russian, Japanese and Israeli competitors who do not share the US concern over potential dual-use applications. However, the US also has a vested interest in hindering the development of China's commercial space sector, which is providing launch services at a much lower cost than US companies.

Some sources (notably the USAF Air National Intelligence Center in 1998) insist that the Motorola 'smart dispenser,' developed by the Chinese with limited assistance from Motorola in 1996 for its Long March 2C/SD launch vehicle, could assist MIRV developments for new-generation ICBMs such as the DF-31 and DF-41 mobile systems. Presumably, such systems could be used for ICBM post-boost vehicle systems. The latter are the final stage of an ICBM with its own guidance and propulsion system, and are programmed to release MIRVs along different ballistic trajectories to strike different targets, as well as having the capability to dispense decoys and other countermeasures. Table 3.2 summarises allegations of transfers to China of US space technologies useful for ballistic missile development.

Table 3.2 Recent US Commercial Space Technology Transfers Potentially Applied to Chinese Ballistic

Missile Development

· Rocket guidance system on which Loral and Hughes provided advice in 1996 is capable of being adapted for use as the guidance system for future Chinese road-mobile ICBMs.

· Information on rocket fairings (i.e. nose cones) provided to China by Hughes may assist the design and improved reliability of future Chinese MIRVed missiles and future SLBMs

· Hughes' advice may also be useful for design and improved reliability of future Chinese ballistic missiles.

· Hughes corrected deficiencies in China's coupled loads analysis, a critical rocket design technology, identified changes needed in Chinese launch operations, and corrected Chinese deficiencies in a number of technical areas. These included anomaly analysis, accident investigation techniques telemetry analysis, hardware design and manufacture, testing, modelling, simulation and weather analysis.

In September 1997, there were allegations that during 1995 two civilian employees at the US Army Proving Ground Laboratory at Aberdeen, Maryland, sold technical information to China, and attempted to recruit other personnel to assist their efforts. The technical information is believed to include cruise missile guidance system components.

During September 1999, a Pennsylvania firm, Orbit/FR (owned primarily by the Israeli company Orbit-Alchut Technologies Ltd.) was being examined to determine if it had violated the US Arms Export Control Act by exporting sensitive hardware and software to the Chinese firm NORINCO. The technology, which was originally developed for the Israeli armed forces, measures the effectiveness of antennas in the nose cones of missiles and is reportedly capable of measuring accuracy within 10 feet over a distance of 10 miles.

PLA controlled enterprises also reportedly routinely (and legally) purchase US surplus military equipment and 'junk' from US bases. In this manner the Chinese may have been able to acquire examples of the defunct US Pershing 2 IRBM radar digital area guidance system (RADAG) for reverse-engineering. These materials have been labelled and sent to China as scrap, often mixed in shipping containers with actual junk. A 16-month US Customs investigation code-named 'Operation Overrun' that terminated during 1996 reportedly revealed a number of Chinese networks purchasing such materials from the US Defense Logistics Agency, which is charged with auctioning off surplus military equipment.

3.4.4 Israel

Chinese intelligence may be playing both sides in the Middle East against each other. While some Israeli government sources claim the existence of a decade old agreement to halt Chinese missile transfers to Arab nations, excluding Iran, in exchange for military assistance, others continue to deny any significant or covert defence ties with China. During 1991, both the then Israeli Defence Minister Moshe Arens and General Dan Shomron, then head of Israel Military Industries and former chief-of-staff of the Israeli Defence Forces, visited Beijing to meet with Chinese counterparts. These visits occurred before China officially recognised Israel in 1992, and a major topic of discussion was reportedly Israel's concern over China's transfer of conventional and WMD-related weapons technology to Islamic states. Recently, there have been mixed signals as to whether Israel has been influential in stemming Chinese arms sales to Iran. Although it has sold ballistic missile systems to Arab nations such as Syria and Saudi Arabia, China may have also provided Israel with targeting information on a *quid pro quo* basis. This relationship, however, may have been altered with Israel's recent cancellation of the Phalcon AEW system for China due to pressure from the US.

Israeli Azimuth Technologies Ltd. and Israeli International Development Company Ltd. during December 1995 created a joint-venture/technology transfer partnership with the Beijing CATIC branch called the Beijing CATIC-Azimuth Electronics Company Ltd. Located in the Beijing Economic and Technological Development Zone, the firm specialises in satellite GPS applications such as navigation and automatic location systems. Modern GPS systems could provide accurate guidance systems for PLAAF aircraft and missiles but would probably be jammed during a major conflict. GPS systems help eliminate the tendency of inertial navigation systems to drift off course. China is believed to have refined widely available commercial GPS capabilities to provide an accuracy of within 10 m, compared to the normally available 100 m accuracy level.

In December 1991, a former Israeli senior missile scientist claimed that "Israel sold the PRC cruise missile technology and was of great help in developing the Chinese ballistic missile programme" (in other words, improved guidance systems for the DF-3 intermediate range ballistic missile, numbers of which were sold to Saudi Arabia, and the DF-15 (M-9) short range ballistic missile, which has been sold to various Islamic states).

3.5 Cruise Missiles TOP

3.5.1 Historical Development

Chinese cruise missile development has historically centred on tactical anti-ship systems with conventional warheads and limited ranges. However, these systems do have inherent land attack capabilities, as witnessed by Iran targeting Kuwaiti oil installations with coastal defence HY-2 missiles in 1987, the first recorded use of the Chinese 'Silkworm family' of cruise missiles against land targets. In addition, there is some speculation that a class of small nuclear warheads may have been developed, or is under development, for existing and future Chinese cruise missile systems. Also, various systems are considered to have the potential to be modified or upgraded into 'strategic' systems. One obvious measure of strategic potential is a nuclear, biological or chemical warhead capability. The guidelines originally developed for the MTCR relating to ballistic missiles, which have a capacity to deliver a minimum 500 kg warhead a distance of at least 300 km, could also be considered as a measure for strategic cruise missile systems. However, as nuclear warheads continue to be miniaturised, and as conventional explosives become more energetic and combined with highly accurate guidance systems permit strategic functions such as the pre-emptive attack of missile silos and hardened command centres, the distinctions between tactical and strategic cruise missile systems will become further blurred.

The Chinese systems with a growth potential are the 'Silkworm Family' et al, 'YJ-6, YJ-62, CAS-1, C-601, C-611, C-101, CSSC-X-5, HY-3, C-301, CSSC-X-6, HY-41, XW-41, C-201, CSSC-7, YJ-1,YJ-12, C-801, CSS-N-4 and YJ-2, C-802, CSSC-8 groupings of anti-ship cruise missiles. During the past several decades China has developed and modified these various groupings of anti-ship cruise missiles, incorporating features and upgrades such as digital controls, improved guidance and altitude control for low-level penetration, counter-ECM and anti-sea clutter performance, expanded range, sea-skimming capability, active acquisition radars, passive infrared sensors, radar altimeters, advanced ramjet engines, and anti-jamming systems.

National production and R&D organisations associated with Chinese cruise missile development have included the China Nanchang Aircraft Manufacturing Factory. Autopilot research is conducted by the Aeronautical Automatic Control Research Institute. While missile launchers and ground command systems have been developed by the Third Establishment of the Seventh Ministry of Machine Building. During the mid-1960s the China Nanchang Aircraft Manufacturing Factory began the copy production and reverse engineering of the Soviet derived SY-1 ship-to-ship missile and established the System Design and Research Institute of Coastal Defence Missiles. Some 40 factories throughout China provided subsystems and components for the SY-1; the autopilot was produced by the Beijing Aeronautical Instruments Factory. The engines for the SY-1 and other cruise missiles were developed at the so-called 'Rocket Engine Factory'. The WP-11 low-thrust aero-engine was developed for the WZ-5 high-altitude pilotless reconnaissance aircraft, other RPVs and short-range cruise missiles by the Beijing Institute of Aeronautics and Astronautics, and saw certification in 1980 according to Chinese references. It was subsequently produced in Hunan Province. Current R&D and production facilities include the Hai Ying Electro-Mechanical Technology Academy of China, Number 8359 Research Institute, Number 613 Institute, and a Cruise Missile Institute of China, Beijing.

3.5.2 The 'Silkworm Family' (SY-1, HY-1, HY-2, FL-1, FL-2, FL-7, CSS-N-1, CSS-N-2, CSSC-2, CSSC-3)

The Chinese were supplied with some P-15 (SS-N-2A 'Styx') anti-ship missiles in the late 1950s by the former Soviet Union, and these entered service in China as the SY-1 (NATO designation CSS-N-1 'Scrubbrush'). It is believed that the Chinese developed their own reverse engineered version in the 1960s, designated Hai Ying 1 (HY-1), which was used as a ship-launched and coastal defence missile entering service in 1974. NATO gave separate designations to these two missiles, the ship-launched version was designated CSS-N-2 'Safflower' and the coastal defence version CSSC-2 'Silkworm'. The name 'Silkworm' has been given to several Chinese, North Korean, Egyptian, Iranian and Iraqi made missile derivatives of this basic HY-1 design, which has caused some confusion.

Development of an improved version, the HY-2, started in China in 1970, and this version is similar to the Russian P-21 design (NATO SS-N-2C 'Styx'). The HY-2 has the NATO designation CSSC-3 'Seersucker' although this missile was used by the Chinese both for coastal defence and as a ship-launched missile. The HY-2 is believed to have entered service in 1978. An alternative design was also developed in parallel with HY-2, this was called Fei Long 1 (FL-1). This version is believed to have entered service in 1980 and to have had the NATO designation CSS-N-1 'Scrubbrush Mod 2'. A second Fei Long missile design, known as FL-2, was developed but probably did not enter service; this was fitted with a solid-propellant motor.

The HY-1 and HY-2 missiles have been marketed by the CPMIEC. FL-1 and FL-2 missiles have been marketed by CATIC but FL-2 was also offered for export by the China Nanchang Aircraft Manufacturing Company.

HY-2 missiles, described as 'Silkworms', were used by both Iran and Iraq during the 1980 to 1988 Gulf War against ship targets. In 1991 several HY-2 missiles were fired from Iraq at Coalition ships and one was intercepted by a Sea Dart missile from a UK vessel.

The HY-1 missile is the shape of a small aircraft, it is 5.8 m long, has a body diameter of 0.76 m, two delta wings with a span of 2.4 m, two tailplanes and a fin. The launch weight, including the boost motor is believed to be 2,300 kg. The missile has a single unitary high explosive warhead with a weight of 400 kg. A solid-propellant boost motor is fitted beneath the rear fuselage and is jettisoned after use. The sustainer motor is a liquid rocket motor, using TG02 (triethylamine and xylidine) and kerosene, pressurised by compressed air cylinders and fed via a turbopump to the motor chamber. The HY-1 has a maximum range of 85 km and a minimum range of 20 km. The missile is believed to cruise at M 0.7 (0.24 km/sec). Control is by conventional aircraft rudder and elevators. Guidance in mid-course uses a simple inertial system, with an X band (8 to 10 GHz) active radar terminal seeker that has six discrete frequencies of operation (the selected frequency is set before launch). The terminal phase is activated by a timer, that is also set before launch, so that the active radar seeker starts to search for the ship target at about 10 km range from the target. The accuracy of the mid-course guidance or terminal seeker are not known. HY-1 missiles can be launched from ship mounted canisters or from a simple four wheeled launch trailer.

The HY-2 is similar in shape to HY-1, but is 7.36 m long, has a body diameter of 0.76 m, and a launch weight including booster motor of 3,000 kg. The HY-2 has a larger 513 kg semi-armour piercing warhead, with a blast fragmentation charge, and has both electrical and mechanical impact fuzes. The HY-2 has improved liquid propellants in the sustainer motor, believed to be UDMH and kerosene, giving a cruise speed of M 0.9 (0.3 km/sec). The motor can operate at two thrust levels and these can be changed in flight. The HY-2 has an increased maximum range of 95 km. It cruises at an altitude of 100 m to 300 m, but the HY-2G version cruises at between 30 m and 50 m and then descends to around 8 m for the terminal phase and dives onto the target ship. The altitude is controlled by a radio altimeter, upgraded in HY-2G. There are at least three different terminal seekers fitted to HY-2 missiles; an improved X band (8 to 10 GHz) active radar similar to that used on HY-1, a passive infrared seeker on the HY-2A with a cooled detector, and a monopulse X band active radar seeker used on HY-2B and HY-2G versions. The accuracy of the mid-course guidance or terminal seekers are not known. HY-2 missiles can be launched from ship mounted canisters or launched from ground trailers. A coastal defence facility will have a target tracking radar and display vehicle, a command vehicle, four power generation vehicles, four cable carrying vehicles, two logistic support vehicles, four missile launch trailers, and eight transporter-loader vehicles with spare missiles. The command vehicle computers determine the pre-launch parameters set into the missiles to give the missiles the launch site and end of mid-course position co-ordinates allowing for target motion and wind conditions. Many improvements have been made to the ship and ground launch facilities since they first entered service, including the retrofitting of digital computers.

The FL-1 is similar in shape to HY-1 and HY-2, but between them in size, with a length of 6.42 m, a body diameter of 0.76 m and a launch weight of 2,000 kg including the solid boost motor assembly. The missile has a 513 kg warhead, believed to be the same as that used in HY-2, and uses a similar liquid propellant sustainer motor. The FL-1 has a maximum range of 45 km. Control and guidance are similar to HY-2 but the FL-1 appears to use the HY-2G standard radio altimeter and active radar seeker, with the capability to cruise in mid-course at either 100m to 300 m or at 30 m altitude, and then to dive down onto the target during the terminal phase. FL-1 can be launched from ships or from coastal defence trailers, similar to the HY-2.

The FL-2 is slightly smaller than FL-1, with a length of 6.0 m, a body diameter of 0.54 m and a wing span of 1.7 m. The weight at launch is 1,550 kg including the boost motor, and the bare missile weighs 1,300 kg. The missile has a smaller warhead with a weight of 365 kg. The major difference is that FL-2 has a solid-propellant sustainer motor, which gives the missile a maximum range of 50 km. It is believed that FL-2 uses the same control and guidance systems as FL-1 but can cruise at 20 m altitude at M 0.9 (0.3 km/sec). A supersonic version of FL-2, with the designator FL-7, was exhibited and offered for export in 1988. This missile had a length of 6.6 m, a body diameter of 0.54 m and a launch weight including booster of 1,800 kg, and a liquid propellant motor with a cruise speed M 1.4 (0.48 km/sec) and a range of about 30 km.

The 'Silkworm' family of missiles have been exported to Albania, Bangladesh, Egypt, Iran, Iraq, North Korea, Pakistan, Thailand and the UAE. It is difficult to identify each of the various missile types in the family, as they have similar shapes, but it is believed that the majority of exports have been of the HY-1 and

HY-2 missiles. The HY-1 and HY-2 are believed to have been built in Egypt, North Korea, Iran and Iraq, and exported to Albania, Bangladesh, Pakistan and UAE. FL-1 missiles are believed to have been exported to Bangladesh, Egypt, Pakistan and Thailand.

Due to the problems of identification it is difficult to estimate the probable number of missiles in service in China. It is believed that HY-2 missiles are carried on 15 Luda 1 and 2-class destroyers (type 051), on 26 Jianghu 1 and 2-class frigates (type 053), and on 1 Chengdu-class frigate (type 01). In addition there are probably 50 or so coastal defence installations and so the total number of HY-1 and HY-2 missiles in service by the late 1990s was probably between 600 and 1,000. The FL-1 missiles that were in service in China are thought to have been replaced with the longer-range HY-2 missiles and it is believed that neither FL-2 nor FL-7 entered service in China.

3.5.3 YJ-6, YJ-62, CAS-1, C-601, C-611

The development of the air-to-surface missile version of the HY-2 is believed to have taken place from 1975 to 1984 and to have entered service in China in 1985. The Chinese in service designation is Ying Ji 6 (YJ-6), the NATO designation is CAS-1 'Kraken' and the export version has the Chinese designation C-601. In 1990 an improved version, known as C-611, was offered for export, with improved liquid propellants and a range increase. It is believed that this version has the Chinese designation YJ-62. The C-601 has been marketed by CPMIEC.

The YJ-6 is similar in size and shape to the HY-2 missile, with a length of 7.36 m, a body diameter of 0.76 m and a wingspan of 2.4 m. The missile is shaped like a small aircraft, with two delta wings at mid-body, two tailplanes and a vertical fin. The YJ-6 weighs 2,440 kg at launch, and has a 513 kg high explosive semi-armour piercing warhead with impact fuzes. The missile has a liquid propellant motor that is believed to use UDMH and kerosene, pressurised by compressed air and fed through a turbopump. The motor has two thrust levels, the first accelerates the missile after launch from its carrying aircraft up to a speed of M 0.9 (0.3 km/sec), and then the second level maintains this speed up to impact. The YJ-6 has a maximum range of 110 km when launched from medium level (about 30,000 feet altitude), and a minimum range of about 25 km. The missile can be launched from altitudes between 1,000 m and 9,000 m (3,000 to 30,000 feet).

Control is by conventional aircraft rudder and elevators. Before launch the aircraft calculates the flight profile for the missile, and passes the launch and end of mid-course co-ordinates to the missile. The missile drops below the launch aircraft until it reaches an altitude of 850 m when the rocket motor ignites and the missile accelerates to cruising speed. It can cruise at several pre-selected altitudes, at 100, 70 or 50 m. The YJ-6 has an inertial platform for mid-course guidance and is believed to use the HY-2G radio altimeter supported by a doppler radar navigator located just forward of the tail fin. The missile has a monopulse X band (8 to 10 GHz) active radar terminal seeker, believed to be the seeker from the HY-2G. The accuracy of the mid-course and terminal seekers are not known. Two missiles can be carried on outboard wing pylons on the PLAAF's Xi'an H-6 aircraft, and the carrying aircraft have been modified with a distinctive cylindrical shaped target acquisition radar. The B-6D aircraft use the KS-6 digital computer and the ZJ-6W aircraft fire control unit for the YJ-6 missiles.

The YJ-62 version was reported in 1990 to use improved liquid propellant and to have a range increased to 200 km. It is believed that this version may have entered service in 1989.

There have been no confirmed exports of this missile, although reports in 1987 suggested that some missiles may have been sold to Iran and Iraq in the 1980s. China is believed to have 120 H-6 bombers in service but only a small number, probably 30, were modified to carry the YJ-6 missiles. Reports by the late 1990s suggested that most of the H-6 aircraft were not being flown due to difficulties in maintaining them and it seems unlikely that the heavy YJ-6 or YJ-62 missiles will be carried by the PLAAF's Su-27 'Flankers' (J-11s). It is believed that around 180 missiles may remain in storage for use in an emergency.

3.5.4 C-101, CSSC-X-5

The C-101 design and development programme probably started in the late 1970s and has been offered for export since 1986. The Chinese designation is not known but the Chinese export number is C-101 and the NATO designation is CSSC-X-5 'Saples'. The missile is advertised as being capable of ground, ship and air-launch. It is not known if C-101 is in service in China but flight trials were reported in 1989. This missile was probably the first Chinese ramjet powered missile and may have been used as a test bed for the development of the larger HY-3. The C-101 has been marketed by CPMIEC.

The C-101 appears to be a derivative of the smaller diameter FL-2 missile; the ground and ship-launched versions have a length of 6.5 m, a body diameter of 0.54 m and a launch weight of 1,850 kg, and have two solid-propellant boost motors strapped under the rear fuselage. The air-launched version has a length of 7.5 m, a body diameter of 0.54 m and a launch weight of 1,500 kg, and has a tandem boost motor. The C-101 has a 300 kg high explosive semi-armour piercing warhead, fitted with delayed impact fuzes. The solid-propellant boost motors (both the ground and air-launched variants) accelerate the missile to M 1.8, and are then jettisoned as the two side mounted kerosene fuelled ramjet engines take over. The missile cruises at M 2.0 (0.68 km/sec) at an altitude of 50 m, and reduces altitude at 3 km from the ship target to approach at 5 m above the sea. The C-101 carries 200 kg of kerosene fuel for the ramjet engines and the missile has a maximum range of 45 km, and a minimum range of 12 km. For control there are two small moving delta canards at the nose and upper and lower fins with rudders and a vee tail with elevators.

Guidance in mid-course is inertial and a radio altimeter maintains the height, the terminal phase homing uses an active radar believed to operate in J band (10 to 20 GHz). The radar seeker is programmed when to search for the ship target before launch and starts to search in azimuth some 20 km to 10 km from the target. The radio altimeter continues to determine the altitude of the missile during the terminal phase, reducing the altitude at 3 km from the target deliberately to make interception more difficult. The mid-course and terminal accuracy is not known. The ground and ship-launched versions are stored in canisters and the ground-launched missile uses a wheeled trailer as the launcher, believed to be similar to that used for the HY-2 'Silkworm' family. It is reported that C-101 can be carried by the Harbin H-5, Xi'an H-6 and probably the SH-5 amphibian.

There are no known exports of this missile. The NATO designation indicates that the primary role of this missile was to be ground launched for coastal defence and the only air-launched version shown appeared to be a very early prototype with bomb type suspension lugs. The C-101 has been offered for export every year from 1986 to 1996, and a 1998 report indicated that it was to be modernised for use on PLAN Houjian-, Huang-, and Hoku-class FAC. The reported use of a 300 kg semi-armour-piercing warhead with delayed action fuse, indicates that this high-velocity missile could possibly inflict significant damage even to large enemy ships such as aircraft carriers.

3.5.5 HY-3, C-301, CSSC-X-6

The Hai Ying 3 (HY-3) is a further development of the basic HY-2 airframe but follows the design layout of the C-101 missile, which was probably used as a prototype. Development of the HY-3 is believed to have started in the mid-1980s and the missile is believed to have entered service in 1995. The NATO designation is CSSC-X-6 'Sawhorse' and the Chinese export number is C-301. The missile is ground-launched but there are unconfirmed reports that it was also developed for ship-launch and that an increased range land attack missile was also developed. The missile is marketed by CPMIEC and it is reported that the guidance system upgrades are being developed by the Hai Ying Electro-Mechanical Technology Academy.

The HY-3 is 9.85 m long, has a body diameter of 0.76 m, and a span of 2.24 m. The launch weight of the missile including boosters is 4,600 kg. The missile has four wrap-around solid-propellant boost motors and two ramjet engines located each side of the rearbody. The warhead weighs 513 kg and is a high explosive blast fragmentation type, which relies upon kinetic energy to penetrate the ship target; impact fuzes with delays ensure that the warhead initiates after penetrating the ship's hull. There is also an active laser proximity fuze, to initiate the warhead if the missile should fail to achieve a direct hit. The four solid-propellant boost motors accelerate the missile from its zero length launcher up to M 1.8 and to an altitude of 300 m, and are then jettisoned. Two kerosene fuelled ramjets then take over and accelerate the missile to its cruising speed of M 2.0 (0.68 km/sec). There are two cruise options for the missile, at between 100 m and 300 m altitude, or at 6,000 m (20,000 feet). The HY-3 was initially reported to have a maximum range of 130 km but there is a second version now available with a range increased to 180 km. It is believed that the minimum range will be around 35 km.

The missile is controlled by two small canard fins at the nose and rudders on the two vertical fins (mounted top and bottom) at the rear. Guidance in mid-course is inertial with a radio altimeter, with a terminal phase active monopulse J band (10 to 20 GHz) radar seeker. The missile reduces altitude to around 50 m for the terminal phase and then dives down onto the target. The accuracy of the mid-course and terminal guidance is not known but reports suggest that an improved guidance system for land attack is being developed and it is assumed that this would be inertial with GPS updates. The HY-3 is launched from a towed four wheeled trailer, which has supporting jacks lowered and the wheels removed before launch. A standard fire unit comprises 8 to 12 missile launch trailers, four tractor vehicles, an acquisition and tracking radar, a command vehicle, a power supply vehicle and several logistics vehicles.

There are no known exports of the HY-3 (C-301) missile system, although the Chinese have been advertising it for export from 1988 through to 1996. It is believed that the missile entered service in 1995. This would indicate that around 30 to 50 missiles have recently been in service in China for coastal defence.

3.5.6 HY-41, XW-41, C-201, CSSC-7

The Hai Ying 4 (HY-4) is another HY-2 development programme, this time with a turbojet engine. Development of the HY-4 is believed to have started in the mid-1970s. It was probably related to the successful reverse engineering of small turbojet engines taken from US-built AQM/BQM-34 Firebee drones that had been recovered by the Chinese. The Chinese CH-1 drone, basically a copy of the Firebee design, first flew in 1972. It was fitted with a WP-11 turbojet that was based upon the Teledyne CAE J-69 engine in the Firebee. The HY-4 entered service in China as a coastal defence system in 1985 and an air-launched version is believed to have entered service in 1990. An improved version, given the Chinese designation XW-41, now the HY-41, was developed from 1987 but is believed to have been terminated in 1991 in favour of the smaller YJ-1 and YJ-2 programmes. HY-4 missiles have been offered for export, with the Chinese export numbers C-201 and C-201W. The NATO designation for this missile is CSSC-7 'Sadsack'. The missile is marketed by CPMIEC.

The HY-4 missile is similar to the HY-2G version of the 'Silkworm' family. It has a length of 7.36 m, a body diameter of 0.76 m and a wingspan of 2.4 m. The ground-launched coastal defence missile weighs 1,950 kg at launch including boost motor and the air-launched version weighs 1,740 kg. The warhead weight is 500 kg, and is a high explosive shaped-charge warhead. There is a single solid-propellant boost motor attached under the rearbody for the coastal defence missile that is jettisoned after use, and then a turbojet engine takes over for the rest of the flight. The missile carries up to 200 kg of kerosene fuel and has a maximum range of 135 km and a minimum range of 35 km. A later version, given the export number C-201W by the

Chinese (believed to be the HY-41), has a maximum range increased to 200 km. The missile is believed to cruise at M 0.8 (0.27 km/sec) and to have a cruise altitude that can be pre-programmed to be between 200 m and 70 m. The altitude is controlled by a radio altimeter and the missile dives down onto the target during the end phase. Flight control uses conventional aircraft rudder and elevators. Guidance in mid-course uses a simple inertial system, with a monopulse X band (8 to 10 GHz) active radar seeker for the terminal phase homing onto ship targets. The accuracy of the mid-course and terminal guidance systems are not known. The coastal defence missile is launched from an inclined 10 metre long ramp, mounted on an articulated wheeled trailer. A firing battery would have four launchers, an acquisition and tracking radar vehicle, a command vehicle and a power generation vehicle. The air-launched missile is believed to have been carried on the Xi'an H-6D bomber, with two missiles carried under each outer wing pylon.

There have been no reported exports of the HY-4 (C-201) missile. Although there are perhaps up to 120 Xi'an H-6 bombers in service, only a small number (about 30) are believed to have been modified to the H-6D standard to carry YJ-6 or HY-4 missiles. The HY-4 missiles are believed to be too heavy to be carried by the Su-27 'Flanker' aircraft and so it is believed that around 100 are probably held in storage for the air-to-surface role. In addition there are probably a further 250 missiles for use with coastal defence batteries.

3.5.7 YJ-1, YJ-12, C-801, CSS-N-4

The Ying Ji 1 (YJ-1) programme is believed to have started development in the mid-1970s, initially as a ground and ship launched anti-ship missile but then also as a submarine and air-launched weapon. The missile is similar to the French Aerospatiale designed Exocet missile but both China and France deny any links between the programmes. The YJ-1 entered service in 1984 and there is believed to be a development programme for an improved version YJ-12, with an increased range, which entered service in 1998. The YJ-1 missile system is marketed for export as the C-801 and the NATO designation is CSS-N-4 'Sardine'. The missile is marketed by CPMIEC.

The YJ-1 is similar in appearance to the French MM38 Exocet but is heavier. The missile is fitted with a tandem boost motor for launch from the ground, ship or submarine and is 5.81 m long, has a body diameter of 0.36 m and a wingspan of 1.18 m. This version of the missile weighs 815 kg including the boost motor. The air-launched missile does not have a tandem boost motor and is 4.65 m long and weighs 655 kg. The warhead weighs 165 kg and is a high explosive semi-armour piercing warhead with contact fuzes and a delay to explode inside the target ship after piercing the hull armour. The YJ-1 has a solid-propellant rocket motor, giving the missile a maximum range of 50 km when released from an aircraft at medium level (30,000 feet), a maximum range of 40 km when released from the surface and a minimum range of 8 km. The missile has a cruise speed of M 0.9 (0.3 km/sec). The missile is believed to cruise at 20 m altitude in mid-course, followed by a descent to 5 m for the terminal phase. The altitude is controlled by a radio altimeter. Control of the missile is by four moving fins at the rear of the missile. Guidance in mid-course is inertial, with a monopulse active J band (10 to 20 GHz) radar for the terminal phase. The accuracy of the mid-course and terminal guidance is not known. YJ-1 missiles have been reported to be carried on Nanchang Q-5 and Xi'an JH-7 aircraft and to have been cleared for carriage on the CHAIC Z-8 helicopter. The YJ-1 may be used for coastal defence in China and two canisters are carried on a 6 X 6 wheeled transporter-launcher vehicle.

YJ-1s are fitted to Luhu (type 052)-class destroyers, Luda-class destroyer with eight launch canisters per ship, Jiangwei-class frigates with six launchers per ship, to Jianghu 3 and 4 class (type 053HT) frigates with eight launch canisters, and to Houjian, Houxin, Huangfen, Hegu, Hema and Hainan-class FAC. In addition, the Chinese modified one Romeo-class (type 033) submarine to carry six YJ-1 launch canisters externally either side of the fin, with the submarine having to surface before launching the missiles. It is possible that more Romeo-class submarines may have been modified.

YJ-1 missiles, such as the C-801, have been exported to Thailand and it is believed to Iran, North Korea and Yemen. Some of these missiles may be used for coastal defence. An unconfirmed report in 1996 suggested that Iran was being assisted by China to assemble and later to build YJ-1 (C-801) missiles, to be called Karus in Iran. It is not known how many YJ-1 missiles have been built but it is estimated that 200 to 300 may be in service with the PLAAF, 300 with the PLAN and 100 for coastal defence. The YJ-12 development programme is most probably designed to increase the range, improve the accuracy and enhance the electronic-counter-counter-measures (ECCM) of the missile system.

3.5.8 YJ-2, C-802, CSSC-8

The Ying Ji 2 (YJ-2) development programme is believed to have started in 1985, with the first test flight reported in 1990, and the missile is believed to have entered service in 1994. The YJ-2 missile is based upon the YJ-1 but the missile body has been lengthened to replace the solid-propellant motor with a small turbojet engine to reduce the weight and increase the range. Small turbojet engine technology was initially developed in China from recovered US AQM/BQM-34 Firebee drones but supplemented by auxiliary power unit technology imported for civil airliners. WP 11 turbojet engines and the HY-4 missile engine programme formed a good base from which to develop a third generation of small turbojet engines for the YJ-2. The Chinese use the export number C-802 for the YJ-2 missile and have also used the number C-802K when referring to the air-launched version. The NATO designation is CSSC-8 'Saccade'. In 1994 the Chinese stated that an upgraded version of YJ-2 was in development. The YJ-2 is marketed by CPMIEC.

The YJ-2 is fitted with a tandem boost motor when launched from the ground or from ships. This version has a length of 6.39 m, a body diameter of 0.36 m, and a wingspan of 1.18 m. The launch weight, including the boost motor, is 715 kg. The air-launched version has no tandem boost motor and this version has a length of 5.3 m and a launch weight of 555 kg. The YJ-2 has the same warhead as the YJ-1, a semi-armour piercing high explosive warhead weighing 165 kg. The missile has an air inlet scoop under the centrebody, with a turbojet engine located in the rear. The ground and ship-launched missiles have a 160 kg tandem mounted solid-propellant boost motor, jettisoned after use. The YJ-2 has a maximum range of 130 km when launched from an aircraft at medium altitude (30,000 feet), 120 km when surface launched and a minimum range of 15k m. The Chinese stated in 1994 that an improved version of the YJ-2 was in development, with a maximum range increased to 180 km. The YJ-2 missile cruises at around M 0.85 (0.29 km/sec). The mid-course cruise altitude can be set at either 30 m or 20 m, and the terminal phase at either 7 m or 5 m; the altitude is maintained by a radio altimeter.

Control of the missile is from four moving fins located at the rear. Guidance in mid-course is inertial, with a monopulse active J band (10 to 20 GHz) radar, believed to be similar to that used in the YJ-1 missile, for the terminal phase. The accuracy of the mid-course and terminal guidance systems are not known. The YJ-2 is believed to be cleared for carriage on the Nanchang Q-5 and Xi'an JH-7 aircraft, and the CHAIC Z-8 helicopter, with two missiles carried on each. The YJ-2 is used as a coastal defence missile; a typical battery would consist of an acquisition/tracking radar on a command vehicle, four transporter-launcher 6 x 6 wheeled vehicles, and a power generating vehicle. The transporter-launcher vehicles carry three missiles in their canisters, and the canisters are raised to about 30 degrees for launch. There are no confirmed reports of YJ-2 missiles onboard Chinese ships or submarines but it must be expected that the YJ-1 launch canisters will be modified to fire these longer-range missiles in the near future. The upgraded YJ-2 can be expected to be one of the first Chinese cruise missiles to incorporate a combined inertial and GPS mid-course guidance system, giving the missile a genuine current land attack capability.

YJ-2 (C-802) missiles have been exported to Iran, with 100 missiles reported on order in 1995. Up to 10 Hudong-class FAC were ordered by Iran, each fitted with four YJ-1/YJ-2 launch canisters. Trials launches of YJ-2 missiles from coastal defence sites in Iran were reported in 1996. It is not known if the export sales of YJ-1 missiles to North Korea and Yemen also included later YJ-2 exports.

3.5.9 YJ-9, YJ-91

There were reports in 1995 that TAAS Israel Industries had developed and sold some STAR-1 anti-radar missiles to China. It is believed that this missile has the Chinese designation Ying Ji 9 (YJ-9). The Israeli design is based upon the earlier US BQM/MQM-74 Northrop Chukar unmanned air vehicle (drone/target), which first entered service in the USA in 1965 and was widely exported. TAAS developed an air and ground-launched radar decoy from the basic Chukar design, called Delilah, and this was offered for export in 1991. It is believed that STAR-1 is a modified Delilah with a passive radar seeker and a warhead for attacking ground or ship radar antenna. STAR-1 was first offered for export in 1995 but was probably initially developed for the Chinese.

The YJ-9 is believed to be the same as STAR-1; if this is correct then it is 2.71 m long, has a body diameter of 0.33 m, and a wing span of 1.15 m. The anti-radar missile version has a launch weight of 190 kg. The missile probably has a blast fragmentation warhead and this might weigh around 30 kg. The maximum range, when launched from medium altitude (30,000 feet), is believed to be 100 km and the minimum range about 10 km. The YJ-9 is believed to have the ability to loiter over the target area, waiting for radars to start transmitting. The missile has a small turbojet engine, believed to be the NPT-151.4 used in the Delilah unmanned aerial vehicle (UAV). The missile probably has a maximum speed of M 0.75 (0.26 km/sec). Guidance in mid-course could be programmed and use GPS updates, again as in the Delilah UAV, with a terminal passive broadband radar seeker reported to cover the frequency bands form 2 to 18 GHz (S, C and X bands). The YJ-9 can be both air and ground-launched and because of its light weight could be carried by a wide variety of aircraft or helicopters.

It is not known for certain if any YJ-9 missiles have been bought by China or if they are now being made under licence. The initial reports of the sale of STAR-1 to China were denied and the specifications above should not be interpreted as an implication that YJ-9 is definitely a Chinese built STAR-1 missile.

Reports in 1995 suggested that the Delilah UAV design was also being developed into a larger cruise missile by TAAS for China with a range of 400 km. It is believed that this programme has the Chinese designation YJ-91 but no details have been made available. If the reports are accurate, then it is possible that YJ-91 could be a version of the Delilah design with inertial and GPS mid-course guidance, an active radar or imaging infrared seeker for terminal guidance and a warhead weighing approximately 150 kg.

3.5.10 Advanced Systems (Hong Niao Series)

China is probably developing a series of new cruise missiles that could be deployed with conventional or nuclear warheads. Recent unconfirmed developments indicate that the rates of China's progress in this area may have been much faster than anticipated and that their missile design capabilities have significantly improved over the past decade. As outlined in section 3.6.1, significant Russian technology transfers since the mid-1990s may have accelerated these developments. It is increasingly likely that after 2000, China will have operational long-range cruise missiles with stealth characteristics (e.g. diffused/downward pointing exhausts, reduced radar cross sections, and low-altitude flight capabilities) capable of delivering nuclear, conventional, chemical and perhaps biological payloads with great precision through the use of advanced navigational and intelligent sensor systems.

Some recent Taiwanese reports indicate that China is developing a modern cruise missile force of up to

1,000 missiles. A long-range land-attack cruise missile series could now be operational, with some unconfirmed reports indicating that an operational unit has already been established in north-western China, possibly under the control of the Second Artillery. It is also possible, as an interim low-tech solution, that China may modify some of its obsolete aircraft (e.g. the large number of J-5 and J-6 fighter and training aircraft in the PLAAF's inventory) into unmanned cruise missiles. While technically unsophisticated, large numbers of these missiles could be used to overwhelm an enemy defence in support of more technically advanced systems.

A Number 8359 Research Institute was reportedly established by the 1990s for cruise missile R&D, assembly and testing. Another unconfirmed report refers to a Cruise Missile Institute of China located in Beijing involved with R&D such as the underwater launch of cruise missiles (at least one type of the latter system may now be deployed). China is now believed to possess up to six separate tactical missile systems that could be converted to cruise configurations with ranges of up to 600 km. The older generation XW-41 medium/long-range turbojet-powered cruise missile is reportedly available in ground and air-launched versions and can be used against ground and maritime targets. The C-802 (YJ-2/YJ-8A) anti-ship cruise missile could be converted to a ground-launched, land-attack version with significant accuracy, possibly equipped with GPS and ground terrain contour-matching (TERCOM) radar systems. Reportedly, accurate Chinese TERCOM guidance algorithms, a previous stumbling block, have now been indigenously developed after being studied since the late 1980s. The Hai Ying Electro-Mechanical Technology Academy of China (possibly also termed the Cruise Missile Institute of China) has recently made guidance and range improvements to the Hai Ying HY-1 and HY-2 'Silkworm' class, ramjet-powered HY-3, and turbojet-powered HY-4. It is also believed that China has developed a small tactical nuclear warhead for cruise missile deployment.

Some sources also indicate that Pakistan may have recovered a crashed but largely intact, errant US Tomahawk cruise missile used in the August 1998 attack against an Islamic terrorist base in Afghanistan. If so, technologies from this may have been passed on to China for both its own cruise missile and anti-cruise missile defence programmes (e.g. satellite GPS/INS/terminal guidance system, onboard computer software and hardware, other electronics, airframe and wing design, power supplies, furl system, warhead, and lightweight turbofan propulsion system components). In addition to direct reverse-engineering, the captured Tomahawk could prove useful for upgrading Chinese anti-missile defence systems through the study of its radar signature. A derivative Chinese cruise missile would not be an exact copy of the Tomahawk and would employ modified domestic software and other systems. Over 600 RGM/UGM-109 Tomahawk cruise missiles have been launched from ships and submarines against Iraq during 1991, 1993, 1996 and 1998, against Bosnia in 1995, against Sudan and Afghanistan in 1998, and against Serbia and Kosovo in 1999. Of these 600, there are at least six recorded instances where the missile went off course without the warhead exploding, and it is highly likely the remains have been examined by technical experts from nations such as China, Pakistan, Iran, and Iraq.

China has reportedly been investigating combined GPS/INS, passive imaging IR and TERCOM guidance systems to provide high accuracy for new cruise missiles, and some reports indicate breakthroughs since the mid-1990s in these areas as well as miniaturised turbofan propulsion systems. Elements of this guidance technology could have been obtained from the reverse-engineering of US Tomahawk cruise missiles, as well as Russian and Israeli technology transfers. Other terminal sensor technologies under development may include laser radar, SAR, and MMW systems, or composites of these and other systems.

China is also developing ramjet engine technologies to provide supersonic missile speeds to complicate enemy interceptions and increase the range of smaller missiles. China's earlier generation ramjet-powered missiles have been large and with limited ranges. The purchase of the Russian Raduga SS-N-22 ramjet-powered anti-ship missile could potentially provide a new source of cruise missile ramjet technology.

A major land-attack cruise missile programme designated X-600 or Hong Niao-1 (HN-1, or Red Bird-1) was believed to have started in 1977. A small turbofan engine was tested in 1985, with the first HN-1A and HN-B versions entering service for operational evaluation in 1992. Its appearance has two straight folding wings in mid-body and a folding aircraft tail and tailplane assembly at the rear. The HN-1A version may be based upon the Russian SSC-X-4 'Slingshot' and the SS-N-21 'Sampson' (RK-55) technologies. The HN-1B is probably based upon the Russian AS-15 'Kent' designed by Raduga NPO (similar to the SSC-X-4 and SS-N-21 systems but without the tandom booster assembly; Raduga NPO displayed a modified version of the AS-15 in 1992, designated the Kh-65SE, with the turbojet mounted below the fuselage on a fixed pylon, and with a range of 600 km). The aero-engine is mounted in the rear body of the missile, with an underbody air inlet.

The HN-1A has a length of 6.4 m, a diameter of 520 mm, a wing span of 3.0 m, and a launch weight of some 1,400 kg. Some unconfirmed reports indicate that the HN-1A conducted its first low-level flight in 1988, at speed of Mach 0.5 and a range of 500 km in the Kansu proving ground. The HN-1A is reportedly a ground-launched version with an operational range of 600 km, whereas the HN-1B is air-launched by the venerable H-6D bomber (2 missile capability), and has a launch weight of 1,200 kg and a range of 650 km when released from an altitude of 30,000 feet. Reported guidance systems are IN, GPS, TERCOM, and daylight TV for mid-course, and night time low-light TV and TERCOM for updates and terminal guidance. A warhead weight of 400 kg is possible for the HN-1A/B, which could be either a 90 kT nuclear or high-explosive submunition device. A radio altimeter is used to control the cruise altitude, which is reportedly 20 m. One report suggests an accuracy of 5 m CEP but this could be overly optimistic.

Reports suggest that an improved aero-engine became available in 1992 and that the follow-on HN-2 entered in-service operational evaluation in 1995 with range increased to some 1,800 km for the HN-2A/B versions. Other reports indicate that there were four HN-2 test launches between February 1995 and October 1997, with two successes and two partial failures. Three versions reportedly exist, the HN-2A and HN-2B, both of which are ground-launched, while the HN-2C is possibly submarine-launched with a 1,400 km range. The ground-launched versions are fitted with tandem mounted solid-propellant boost motor assemblies, which are jettisoned after use. Air-launched versions could be carried by aircraft such as the JH-7/FBC-1, J-8IIM, J-11/Su-27 or Su-30. The HN-2 series may have benefited from the incorporation of technologies derived from the reverse-engineering of downed US RGM/UGM-109 Tomahawk cruise missiles. The HN-2 series is also believed to have payloads and guidance systems similar to the HN-1 series.

The HN-3 with a 2,500 km range may have entered operational evaluation by 1998 and could still be under development. It may have a range of 2,000 km to 3,000 km, probably due to the use of conformal fuel tanks. The missile cruises at about Mach 0.9 and an altitude of 10 m to 20 m. While precise dimensions are unknown, the launch weight is possibly 1,800 kg. There are two versions, the ground-launched HN-3A, and the ship- or submarine-launched HN-3B.

A 'HN-2000' supersonic stealth cruise missile may currently be under development, with a maximum range of 4,000 km. The PLAN may design vertical launch systems (VLS) for this cruise missile series for the Song-class Type 039 submarine, probably based upon Russian technology transfers. It may also employ the latest cruise missiles with the new generation Type-093 SSNs, launched from a capsule from 533mm diameter torpedo tubes.

Recent reports from Taiwan claim that the PLA has already developed and operationally deployed cruise missiles with CEP of under 5 m, which seems to confirm the HN-1, HN-2 and HN-3 programme. In early

1980s, preparatory R&D work for an advanced cruise missile programme was undertaken that was to last for over a decade. A breakthrough in guidance technology was achieved by late 1980s, and simulated captive tests were flown on aircraft, and a small turbojet engine for the missile was also developed. The cruise missile programme entered full-scale engineering development phase by the early 1990s. Together with the Luhu/Luhai destroyers, J-10 fighters and the DF-31 ICBM, the cruise missile was considered one of the highest-priority defence projects during the sixth five-year plan, with Beijing having invested over 500 million Rmb yuan in upgrading the main production facility alone. Field trials were said to be successfully conducted in early and mid-1990s.

According to original plans, the design configuration was scheduled to be finalised in 1996-98, and a land-based version of the weapon is believed to already be in service. Ship- and submarine-launched variants are also said to be in the experimental stages. These Taiwanese reports also claim that the mainland cruise missile is similar in performance to the US Tomahawk, with maximum range of 2,000 km and employing DSMAC guidance (plus TERCOM and GPS updates). Minimum cruising altitude is claimed to be 15 m to 20 m. Payload is either a conventional or nuclear warhead. If the weapon has already entered operational service, it could be used in a war against Taiwan.

3.6 Cruise Missile Foreign Technology Transfers TOP

3.6.1 Former Soviet Union/Russia

It is believed that by 1994-95, China successfully transplanted an entire Russian cruise missile plant, complete with research and development team, to a location near Shanghai (probably based on either the Kh-15/AS-16 'Kickback' or more likely the Kh-55/AS-15 'Kent'). As Russian cruise missile technology now supports land-attack ranges of about 4,000 km, China's capabilities in this field could increase rapidly.

China is also believed to have acquired co-production rights for the Russian Kh-31/ AS-17 'Krypton' supersonic ramjet-powered missiles (the Mach-2, Zvezda Bureau's Kh-31P was designed to counter the radar of the US Patriot surface-to-air missile and the US Navy Aegis fleet defence radar), and is negotiating to licence produce an improved version of the KR-1 with a 400 km range, which could also be modified with wings to further increase its range. Some of these various types of cruise missiles could be armed with nuclear warheads. It is unclear whether all of this assistance has been directly sanctioned by the Russian government or conducted at an organisational level.

Taiwan reports claim that Russia has marketed the 360-mile range Kh-65SE cruise missile to China. The Kh-65SE has been displayed at air shows in Russia and abroad for sales promotion, although China has not reportedly displayed this missile. The Kh-65 is a short-range version of the Kh-55. The Kh-65SE and the Kh-55 are believed to have the same inertial and terrain-following guidance system, although the GLONASS precision satellite navigation system may now be incorporated in the most recent versions, as well as triangular fuselage attachments for increased fuel. Kh-65SE technologies could conceivably assist China in developing Tomahawk-like cruise missiles with advanced engine, fuel, and guidance technology features.

A 1995 report in connection with the alleged Russian cruise missile design team located in the Shanghai area also indicated the potential transfer of other cruise missiles such as the Yakhont 3,000 kg ramjet-powered, anti-ship cruise missile with a speed of Mach 2 to Mach 2.5, and a range of 72 miles to 180 miles. The Yakhont could transfer to China technology used for the development of compact long-range, vertical launch and relatively inexpensive ramjet cruise missiles that could have increased survivability against Western anti-missile systems. It is also conceivable that Russia could sell China its 270 mile range

SS-N-19 anti-ship cruise missile that has a 1,900 pound warhead, and Mach 1.6 speed, and has been deployed on Russian Kirov and Slava-class cruisers. China has received Raduga SS-N-22 'Sunburn' supersonic anti-ship cruise missiles as part of its recent purchase of Russian Sovremenny-class destroyers. It could also receive air-launched versions (3M-80EA version) with an increased engagement range of up to 250 km, which could be mated with Russian-exported Su-27 and Su-30 fighter aircraft. During 2000, China also engaged in negotiations to purchase variants of the Russian 3M54 (part of the Club-N system for launch from surface warships and the Club-S for submarine launch) supersonic anti-ship cruise missile (maximum range 220 km, with a 200 kg warhead). The variants are intended to upgrade the capabilities of the PLAN's two Kilo-class Project 877EKM submarines.

3.6.2 United States

The transfer of US Garrett TFE-731-2 aero-engine technologies for the K-8 military trainer aircraft programme during the early 1990s was potentially highly significant. Through reverse-engineering this has probably provided China with the capability to develop higher quality turbojet and turbofan aero-engines for use in cruise missiles and to extend the range of existing cruise missile designs. For example, the TFE-731-2 could fit into a Silkworm cruise missile if the fan section of the aero-engine was removed or the fan blades shortened, allowing the missile increased performance at speeds up to 1,000 kph and a range of 1,800 km (considerably improved performance over domestic power plants such as the WP-11 aero-engine, which is based upon technologies several decades old). The Zhuzhou South Motive Power and Machinery Complex (China National South Aero-Engine and Machinery Company) was the intended producer of the Garrett TFE-731-2 engine. Between 1992 and 1996, Allied Signal reportedly exported 59 TFE-731-2A-2A aero-engines to China, whose primary interest was in acquiring a production capability. China cancelled further orders when co-production plans were stopped by the US. The HY-4 cruise missile is reportedly now powered by a copy of a US turbojet aero-engine.

China may have also have benefited from the direct transfer of specialised US cruise missile technologies. Some reports indicate that China has examined a US Tomahawk cruise missile that was fired at a target in Afghanistan in 1998, but crashed en route in Pakistan. Reports indicate that an employee of the US Army's Army Research Laboratory, Aberdeen, Maryland, may have sold information during 1995 that was used to develop guidance systems for the C-802 anti-ship cruise missile.

3.6.3 Canada

In January 1997, a joint venture was established at Zhuzhou, Hunan Province, between Pratt and Whitney Canada and the China National South Aero-Engine and Machinery Company to produce components for small gas-turbine aero-engines and co-operatively develop commercial aero-engines for the Chinese and global market. However, defence analysts believe that the technologies transferred, including specialised five-axis milling machines, computerised engine control systems, and high-temperature resistant alloys, can be reverse-engineered and modified to be used for Chinese cruise missile propulsion systems.

The Zhuzhou plant currently manufactures the WP-11 aero-engine for older-generation Chinese cruise missiles, and was to have been the location for the similar failed attempt at co-operation with the US firm Allied Signal and Garrett (Williams International). Derivative aero-engines could have superior thrust-to-weight ratios, improved reliability, and emit less smoke than older Chinese designs.

Pratt and Whitney Canada's parent firm is the US company United Technologies. During 1999, the US imposed unprecedented restrictions on the transfer of defence and dual-use technologies to Canada that could be passed on to restricted national third parties such as China but these were subsequently somewhat relaxed.

3.6.4 Israel

Israel Military Industries and Chinese counterparts have co-operated financially and technically in the development of the Delilah 2 land-attack cruise missile (based upon the STAR-1/Delilah anti-radar drone used by Israel during the 1992 Lebanon War). This will incorporate sophisticated technical features such as GPS, INS, active radar and/or imaging infrared seeker mid-course and terminal guidance systems, with a 400 km range and a 150 kg to 450 kg payload (see section 3.5.9). Israel is also reportedly providing assistance for China's YJ-12A supersonic medium-range anti-ship sea-skimming cruise missile, the YJ-62 long-range anti-ship sea-skimming cruise missile, the YJ-9 air/ground-launched anti-radiation missile, and various satellite systems. Israel has also reportedly recently offered to sell China its Searcher, Hunter and Close-Range military RPVs. However, this close relationship may have soured in 2000 following intense US pressure on Israel to restrict military sales to China.

3.7 Air-to-Air Missiles TOP

During the late 1950s and early 1960s, two types of air-to-air missiles were originally produced under licence from the Soviet Union. They were designated the PL-1 (radar guided) and PL-2 (passive infrared guided) and later incorporated a number of local modifications. The PL-2 was a derivative of the Soviet AA-2 'Atoll' (which in turn was derived from an early US Sidewinder when an unexploded example was obtained in 1958 when a PLAAF MiG-15 returned to base with a dud lodged in its fuselage after a dogfight with Taiwanese fighters!). The Zhuzhou Aero-Engine Factory took the lead for the production of both missiles and in 1964 established a separate missile design institute and missile production subsidiary, which became China's first specialised air-to-air missile production and R&D centre. Also during the 1960s, the Aeronautical Armament Design and Research Institute was formed by the Chinese Aeronautical Establishment. The institute specialised in air-to-air missiles, airborne radars, optics and other armament systems, and was renamed the Air-to-Air Missile Research Institute/R&D Development Centre in 1984. The PLAAF Badanjilin Airbase in north-west China has recently been identified as connected with prototype air-to-air missile tests against unmanned drones, having been established in 1958 and conducting over 800 such tests over three decades.

Versions of the PL-1 and PL-2 are today still mainstays of the PLAAF, with the PL-2 having the largest production run of any Chinese tactical missile. The PL-2B incorporated improvements during the early 1980s such as an increased sensitivity of its sensor, greater detection range, increased anti-interference capability against background solar and other radiation, improved fuze detection, average higher missile velocity, and increased resistance at low altitude.

The PL-3 and PL-5B were independently designed successors to the PL-2 and were developed by the Air-to-Air Missile Research Institute and the Zhuzhou Aero-Engine Factory. As second-generation missiles, they incorporated improvements such as increased manoeuvrability (almost double the PL-2's acceleration) and range, improved target acquisition sensitivity and enlarged angular range, and were largely based on the US AIM-9 Sidewinder. Incorporating an 'infrared integrated circuit fuze', the PL-5B began production in 1986. The PL-5E is reportedly an improved export version with increased angle of attack capability.

During the late 1980s the PL-7 was developed by the Zhuzhou Aero-Engine Company as an 'infrared dogfight' system (derived from the French Magic missile), which can automatically search, acquire and track targets. Other reports have attributed this designation with a medium-range semi-active radar homing, all-aspect, all-azimuth attack capability. The development of the PL-7 brought China one step closer to reaching global standards for such weapons. The PL-9 and PL-10 are recent short-range air-to-air missile developments. The PL-9 is an infrared tracking, proportionally guided and canard configured air-to-air and ground-to-air missile, with an all aspect attack capability, apparently derived from the Israeli Python 3. The Luoyang Opto-Electro Technology Development Centre, Luoyang, Henan, is believed to have developed the IR guidance system for the PL-9 air-to-air missile.

Two other unnamed specialised air-to-air missile (PL-1) factories and research institutes were also established in the 'Third Front' hinterland region during the 1960s, and in the 1970s they also began production of the PL-2. The Pilotless Aircraft Research Institute of the Nanjing Aeronautical Institute and the Northwest Polytechnic University also conducted the research and production of air-to-air missile target drones.

China purchased some 200 Italian Aspide air-to-air missiles for a 1980s fighter upgrade programme. It has now developed its own shipborne and ground-based upgraded versions, the LY-60N and LY-60, with the technology also probably transferred to indigenous air-to-air designs (including the PL-10).

A next generation air-to-air missile for China's new fighters (J-10, Su-27), will require all-direction, all-altitude and all-weather performance, and Beijing can be expected to pursue such capabilities aggressively. Related R&D in China includes optimal guidance and correctional proportional guidance laws, banked turning controls, thrust vector controls, and millimetre wave active radar guidance systems. The Air-to-Air Missile Research Institute is conducting R&D on the application of modern control theory to non-linear control and filtering, compact combined guidance systems, active radar guidance, self-adaptive digital autopilots, digital information processing and controls, system emulation, infrared and radar background radiation, target characteristics, anti-jamming, television guidance, staring focal-plane array multi-element imaging, and anti-radiation and laser guidance systems.

The lack of an advanced all-weather beyond visual range missile, such as the US semi-active Sparrow has been a serious shortcoming of Chinese combat capabilities. Some reports indicate that the PL-10 medium range air-to-air missile is one solution but it may not have proven to be completely satisfactory in performance. A Chinese fire-and-forget version of the US advanced medium-range air-to-air missile (AMRAAM), the ARM-1 anti-radar missile (some reports indicate it as the AMR-1 or PL-11), is also believed to be under development by the China Leihua Electronic Technology Research Institute and the Number 607 Institute, Wuxi, in addition to advanced transferred foreign designs and assistance from Russian engineers under private contracts. The US has recently reported that it is doubtful that China is developing an air-to-air missile specifically designed to target specialised EW aircraft targets such as the USAF's AWACS and JSTARS platforms. Other sources indicate that such a project is underway for the J-10 and J-11 fighter aircraft programmes with Russian assistance. The ARM-1 could be deployed from 2001-2005, and is possibly related to the FT-2000 ground-launched anti-radiation missile programme. Qinghua University researchers have also recently proposed advanced beyond visual range air-to-air missile concepts. Table 3.3 summarises Chinese air-to-air missile developments.

Table 3.3 Chinese Air-to-Air Missiles

· PL-1 radar beam rider missile similar to AA-1 'Alkali'.

· PL-2 IR passive homing missile similar to AA-2b 'Atoll B'.

· PL-3 IR missile developed as improved PL-2.

· PL-4 IR missile developed as improved PL-3.

· PL-5 IR missile developed as improved PL-4.

· PL-6 IR missile developed as improved PL-5.

· PL-7 IR dogfight missile based on the French Magic 2.

· PL-8 IR dogfight missile based on the Israeli Python 3.

· PL-9 IR dogfight missile based on the US AIM-9L (exported to Pakistan with the F-16 programme), an advanced all-aspect IR dogfight missile.

· PL-10 medium range semi-active radar homing missile based on Italian Aspide, which in turn was developed from US AIM-7E Sparrow.

· ARM-1 anti-radar missile.

· RVV-AE-PD, a co-operatively developed Chinese-Russian advanced long-range ramjet powered air-to-air missile.

· R-129 (locally produced Russian R-77E).

· FT-2000 (modified, possibly related to ARM-1 project).

· TY-90 (helicopter-launched AAM).

The FT-2000 surface-to-air anti-radiation missile was displayed at the Zhuhai 'Air Show China '98' by CPMIEC. It reportedly has merged Chinese, US and Russian technology to produce an anti-AWACS/EW platform system, which may also have a low orbit ASAT capability in a boosted version. Some reports indicate an active radar guided version of FT-2000, as well as the FT-2000A version fitted with an active MMW proximity fuse passive guidance system. The FT-2000 and FT-2000A could conceivably be adapted for air-to-air anti-radiation deployment against enemy AWACS aircraft (such as the E-3A, the E-2C, or EA-6B). The basic FT-2000 system comprises a truck-mounted four-tube vertical launcher similar in appearance to the Russian Antey S-300/SA-10 'Grumble' SAM. It employs a passive anti-radiation missile with a slant range of 12 km to 100 km and an altitude of up to 20 km. Detection is in the 2 Ghz to 18 Ghz (S-Ku bands) range. The length of the missile is 6.8 m and it has a total weight of 1,300 kg. The FT-2000 surveillance and target acquisition radar is reportedly a new system with 3-D, non-phased-array radar combined with a main parabolic antenna and smaller dish antennas to handle higher frequencies. Following field trials during 1998, the PLA claimed the FT-2000 missiles 'hit their target every time'.

Luoyang Opto-Electronic Technology Development Centre's TY-90 helicopter-launched AAM was also revealed at the 1998 Zhuhai air show and is an IR-guided system with a 6 km range. It could be used to arm PLA helicopters such as the Z-9G and Z-11, or a future attack helicopters where the missile would be used in conjunction with a helmet sight.

The Su-27 (J-11) and Su-30 acquisitions have provided China with a wide variety of the most advanced Russian missiles, including the R-73/73M (AA-11 'Archer') and the R-74ME improved variant, the complete R-27 (AA-10 'Alamo') IR/semi-active/active family, and the R-77E (AA-12 'Adder') active seeker family. The R-73E provides the PLAAF the capability of an off-boresight, helmet-sighted air-to-air missile, capable of 12g manoeuvres via the use of thrust-vectoring vanes to direct engine exhaust. The R-73 is controlled by an Arsenel SHCH-3UM-1 helmet sight providing off-boresight targeting of 60 degrees and a field of fire of 120 degrees, with consequent significant reductions in the target acquisition and missile launch times. The Mach 3 R-77 system has a 56 mile range and 12g manoeuvrability, with a more advanced version, the R-77M-PD, reportedly having a ramjet motor and a range of about 100 miles, being designed to attack AWACS aircraft.

Recent reports indicate that China and Russia are co-operatively developing an advanced long-range ramjet powered air-to-air missile known as the RVV-AE-PD, also a R-77 variant. China's long-held interest in acquiring an export version of the 75 km-capable R-77 missile for its Sukhoi Su-30MKK fighters has apparently yet to be officially finalised, but is expected to lead to an initial order for around 100 missiles for evaluation purposes. Beijing plans to assemble and eventually manufacture the weapon, which is believed to have been designated the R-77E (local designation 'R-129') under a licence agreement with Russian prime contractor Vympel NPO.

Israeli technology has also probably provided the basis for advanced pilot helmet sight systems reportedly through its Israeli Rafael Python system acquired during the late 1980s when Israel is believed to have transferred to China its Python 3 infra-red guided air-to-air missile. The PL-9 helmet-mounted sight is believed to be used with J-7MG, J-8IIM and other PLAAF fighter aircraft. Israel has reportedly offered China its advanced Python 4 system with a wide 120-degree field of view, high acceleration and stress tolerance, possibly as well as the Elbit Helmet-Mounted Display for guidance.

3.8 Precision Guided Munitions (PGMs) TOP

The PLA is currently believed by some observers to have a serious shortage of precision-guided and smart air-to-ground and air-to-ship weapons. Its arsenal is thought by some to comprise mostly 250 kg and 500 kg gravity bombs and 80 mm, 130 mm and 250 mm unguided air-to-ground rockets, although it should be noted that by the mid-1980s NORINCO was commercially marketing sensor-fuzed cluster bombs that were capable of detecting and attacking individual vehicle targets. The development of laser, inertial, infrared, anti-radiation, GPS and TV guided bombs and other PGMs for China's most capable combat aircraft such as the FC-1, J-8IIM/J-8III, FBC-1/JH-7, Su-27 and J-10, will probably be a national priority.

The new Xi'an FBC-1/JH-7 fighter bomber is now reportedly equipped with domestically produced laser-guided munitions, as well as guided C-801 and C-802 anti-ship missiles. An associated navigation/targeting pod with radar and forward-looking infrared sensors (FLIR) and a laser designator pod, providing capabilities similar to the US Lantirn system, is believed to be operational and developed by the Number 613 Institute. Laser-guided bombs are now reportedly in the PLAAF/PLAN inventory but the designator(s) remain unknown.

The YJ-21, YJ-22, YJ-81, and YJ-91 are all recently noted Chinese land-attack air-to-surface missile programmes. The YJ-91 is an anti-radar missile (see section 3.5.9).

Other RMA-related priorities will be improved night attack capabilities and increased sortie rates, and the development of computer software systems to help integrate all of these new capabilities. System integration of these new generation weapons will present a major challenge for China's aerospace-defence industry. Israel has been a likely source of PGM technology and related advanced missile guidance systems, while the potential purchase of Russian Su-30MK attack aircraft will probably include a PGM package that can be reverse engineered. For its ground forces, the PLA is now being equipped with a new generation of PGMs such as manportable SAMs with a fire-and-forget and passive infrared tracking capability and ATGMs with digital guidance systems and thermal imagers.

China's lightweight C-701 TV-guided anti-ship missile was also initially exhibited at Air Show China '98, and was developed by the Number 613 Institute which is very active in PGM technology development. CPMIEC has recently released new photographs of the C-701 anti-ship missile, which is currently being offered for export in both air- and sea-launched configurations. The C-701's TV seeker can reportedly be used in other missiles or bombs for a PGM capability, and the C-701's modular design also could permit the use of laser, infrared seekers or millimetre-wave seekers. The air-launched version has a nose-mounted electro-optical TV-type seeker with the four fixed wings two-thirds of the way down the fuselage and with the four control fins at the rear. When air-launched from a helicopter, the C-701 has a maximum range of 15 km. The missile has an overall length of 2.507 m, diameter of 180 mm and a launch weight of 100 kg, and a cruise speed of Mach 0.8. No details of the conventional warhead have been revealed, although it is probably of the blast-fragmentation type with a weight of 30 kg to 50 kg activated by a proximity/impact fuze.

For shipborne applications, the C-701 is launched from a fully-enclosed square canister on a quadruple launcher, with the wing tips extending as the missile leaves the launcher. The guidance method for the ship-launched version is not known. However, most missiles of this type, for example the UK's Sea Skua and the French AS-15TT, use radar command guidance or have a nose-mounted semi-active radar seeker. In 1998 it was not yet deployed in significant numbers by the PLAN but this may have now changed. It is intended for use on helicopters and FACs to attack small naval targets and perhaps coastal ground targets, similar to the role of the US Maverick.

Some sources have indicated that any attempt to reverse engineer the recently procured Russian SS-N-22 'Sunburn' submarine and ship launched anti-ship cruise missile, produced by the Raduga Central Design Bureau in Dubna, could take at least a decade. However, such estimates could be pessimistic, particularly if transferred foreign subsystems are combined with indigenous systems such as the C-801 and C-802 series. The 3M-80EA is an air launched version of the SS-N-22. Since China has already ordered the shipboard version of the Sunburn with two Sovremenny-class destroyers the adoption of an air-launched PGM version is possible.

Russia has reportedly sold China Kitolov laser-guided artillery rounds. In 1997, Russia reportedly sold China 100 SP 2S23 Nona-SVK 120mm gun-mortar systems with laser-designated Kitolov-2 PGMs and Gran laser-designated mortar shells, and a number of 300mm Smerch MLRS (multiple-launch rocket systems). A 1999 report indicated that China had started the licensed production of Russian-designed Krasnopol 152mm 9K25 and 155mm M cannon-launched laser-designated guided-projectiles. It is high likely that these items will be reverse-engineered and mass-produced by China, and attempts have been made to maintain secrecy around such transactions. Israel is another likely source of PGM technology and advanced missile guidance systems. It is well within the capabilities of the Chinese defence industry to reverse-engineer and mass copy-produce such tactical PGM systems. It is highly likely that laser-guided munitions are a part of the PLA's current inventory.

3.9 Surface-to-Air Missiles (SAMs) TOP

China's first surface-to-air missile was the two-stage Hong Qi HQ-1 (solid-propellant booster, liquid upper stage), and was produced under licence from the Soviet Union (SA-2) as a combined effort of over 20 factories during the early 1960s. An upgraded version was designated the HQ-2, with increased range and altitude. The HQ-2B is a high and intermediate altitude air defence weapon featuring a claimed high anti-jamming (ECM) capability, and is mobile on a lengthened version of Type 63 AFV chassis. The HQ/RF-61 is a semi-active homing, intermediate and low altitude air defence missile in ground and ship-based versions. The 50th Research Institute, Shanghai Institute of Microwave Technology is reportedly active in developing automated command systems for SAM units.

Other air defence missiles include the recently identified HHQ-7 and HQ-28A. The former is probably an upgraded version of the HQ-7 (FM-80 version of the French Crotale system) short-range, solid-propellant theatre defence missile, and the latter a variant of the HQ-2 low-to-high altitude SAM. At Farnborough-2000 Chinese air defence systems displayed reportedly included the LY-60, FM-80, FM-90, FT-2000, KS-1/KS-2, HQ-2A, and HQ-2J. These missiles are mostly derived from existing systems. As discussed previously, the HQ-2 is a modernised copy of the Russian SA-2, from which the KS-1 was also developed by CPMIEC during the early 1990s with a phased array radar system and associated ECM systems. The KS-2 is a further refinement of the system for use against a wide variety of targets including high-altitude reconnaissance aircraft, UAVs, helicopters, and air-to-surface missiles. The FM-90 is a naval SAM first displayed at Farnborough '98 by CPMIEC and is an advanced 15 km range derivative of the FM-80, which is in turn a version of the French Crotale R400 missile. It is not known what China's SAM force levels are but one recent unconfirmed estimate indicated an annual indigenous production rate of 5,000 missiles and a stockpiled inventory of over 30,000.

In naval systems, the LY-60 is derived from the Italian Aspide and the FM-80 from the older version of the French Crotale (not the newer Crotale NG). In 1999, the PLAN reportedly began replacing the HQ-61 SAM used in Jiangwei-class frigates with the new LY-60N SAM system developed by the Shanghai Academy of Spaceflight Technology. The LY-60N has improved range and targeting capabilities. The missile is applicable to use with a vertical launch system (VLS), and reportedly can be used against aircraft, helicopters and missiles, including sea-skimming types. An airborne version, the FD-60, is reportedly a semi-active radar guided air-to-air missile similar to the Italian Aspide. The portable ground-based version is the FY-60. The LY-60N may be exported to Pakistan.

By 1994 Russia had also transferred to China the technology for the production of S-300 SAM (reportedly comparable to the US Patriot in performance). Some four batteries totalling 100 missiles were believed to be directly purchased and deployed around Beijing (similar to the inner ballistic missile defence system ringing Moscow), and Su-27 airbases at Wuhu and Suixi. China purchased two or more regiments of the S-300PMU-1 during 1991 and 1994 and there are at least discussions about doubling this inventory. China has also shown interest in the S-300PMU-2 Favorit improved version, which can engage aircraft, strategic cruise missiles, ballistic missiles and PGM air-attack weapons. Recently, additional S-300-type missiles have been deployed at military bases and cities opposite Taiwan. Derivative S-300s (HQ-9 or HQ-11 according to varying reports, and also probably closely related to the FT-2000 missile programme), incorporating Patriot-derived countermeasures, have now reportedly been developed for export by China. The HQ-9 began development from mid-1996 and has been associated with the CAIC's 4th Research Institute.

Some versions of the PL-9D air-to-air missile are also believed to have been produced in a mobile form of ground-to-air system for several years, possibly as a component of the Type 90 2x35mm AAA 'Sky Shield' gun-missile field air defence system mounted on a WZ523 or WZ551K armoured vehicle chassis linked with the AF902 radar/TV van.

China has undertaken the licensed production of up to 160 Russian Tor M1/SA-15 'Gauntlet' SAM launchers that would be used to equip 10 air-defence regiments assigned to PLA group armies, possibly indigenously produced as the HQ-10. Some 120 PLA specialists have been trained in Russia on their operation. Chinese production has reportedly been slow due to problems encountered in manufacturing the system's phased array radar. China has already bought up to 35 systems directly from Russia, 15 in the first batch delivered before 1997, and 20 in the second batch early in 2000. The Tor-M1 self-propelled system is reportedly capable of intercepting at low to medium altitudes MLRS rockets, cruise missiles and guided bombs, and track targets while on the move, and supposedly outclasses domestic systems such as the HQ7, HQ61, and LY60. It carries eight 9M334 vertically launched missiles that can engage targets to a maximum range of 12 km and a maximum altitude of 6,000 m. However, the new Chinese PGZ-95 with an advanced radar/fire control system would also make a formidable and complementary anti-aircraft system. Another programme is the HQ-16 SAM, which reportedly uses Russian SA-11 technology.

CPMIEC is now marketing the new 'fire and forget' FN-6 manportable 72mm SAM, which has a reported operational altitude of from 15 m to 3,500 m and is also in service with the PLA. A single-shot kill probability of 70 per cent is claimed for targets manoeuvring up to 4 g. An IR seeker system includes capabilities to jam IR and modulated jamming and artificial IR jamming. Optional equipment includes an optical sight and IFF system. The FN-6 can also be mounted on vehicles, helicopters and small naval vessels, with the naval version having four missiles in a ready-to-launch position with the operator positioned below deck.

Other manportable systems include the Qianwei QW-1 'Vanguard' passive IR homing missile that is touted as China's equivalent to the US Raytheon Systems Company Stinger or the Russian SA-18, and was initially revealed in 1994; the Honying HY-5 (similar to the Russian Strela-2/SA-7 'Grail'); and the 72mm QW-2 (similar to the Russian Kolomna KBM Igla-1/SA-16 'Gimlet'). Pakistan's Anza Mk-1 SAM may be based upon the HY-5, and the Anza Mk-2 upon the QW-1. The CPMIEC QW-2 entered service in 1998 and has a fire-and-forget passive IR homing capability, effective altitude from 10 m to 3,500 m, and a maximum slant range of 6,000 m. The QW-2 weighs 11.32 kg, of which 1.42 kg is HE warhead, has four unfolding fins at the rear and two movable control surfaces at the front, just behind the seeker, and a two-stage motor with the first stage ejecting the missile from its launching tube and the second accelerating it to a maximum speed of 600 m per second. Helicopter and shipborne versions of the QW-1 were reportedly developed and could also conceivably be developed from the QW-2 model.

3.10 Ballistic Missile Defence (BMD), Anti-Satellite (ASAT), and Offensive Space Systems TOP

The official Chinese position on BMD, theatre missile defence (TMD), and ASAT systems is that "all countries should undertake neither to experiment with, produce or deploy outer space weapons, nor to utilise outer space to seek strategic advantages on the ground, for example, using disposition of the important parts of ground anti-missile systems in outer space for the purpose of developing strategic defensive weapons." This position in practise also includes ground-based ABM systems. The Chinese make the point that the USA, with the most sophisticated military offensive 'spear' in the world, now also wants to create an invincible 'shield' to protect itself and its forces abroad from attack, which will also increase American offensive capabilities.

However, it is likely that the PLA itself has been supporting at least limited research on such systems for many decades and may consider the deployment of more advanced systems a future option. The PLA General Staff Research Institute recently reported that 'controlling space and seizing air and space superiority will be important contributing factors in seizing the war initiative'. In 1999, the official *Xinhua* news agency reported that the PLAAF Surface to Air Missile Corps, originally established in 1958, was now forming an air defence network capable of intercepting short and medium range missiles (i.e. TMD), stealth bombers, cruise missiles and anti-radiation missiles, and that this air defence network would include the launch of early warning satellites within the next decade. Other recent probably inaccurate reports from the Shanghai-based *Liberation Daily*, have suggested the developed of multiple-warhead ABM missiles and national BMD systems. Russian and China have also recently discussed the development of a joint regional BMD system if the US should proceed with its own. However, this would appear increasingly unlikely following outgoing President Bill Clinton's decision to leave US BMD in the R&D rather than deployment stage and not violate the spirit of the 1972 ABM Treaty between the US and former Soviet Union, which China has recently vigorously defended.

During March 1992 there were unconfirmed reports that in exchange for technical information on the Chinese DF-15 and DF-11 short-range ballistic missiles, Israel had transferred US Patriot anti-aircraft/BMD guidance and propulsion technology (possibly documents, hardware and software) to China through the sale of systems supplied by the US during the Gulf War and related Israeli Arrow air defence missile technology. The Patriot missile system is a battle-proven BMD system that China could either directly reverse-engineer, incorporate technologies into Russian derived and indigenous BMD systems, or study to develop countermeasures to increase the effectiveness of its own export-oriented ballistic missile systems. Defence penetration capabilities derived from this information and developed by the Chinese could include electronic and sensor jamming, and the provision of an auxiliary propulsion system for warhead manoeuvring. Recent sources have indicated that the new Chinese HQ-9 long-range SAM would use the same guidance frequencies as the Patriot and could also employ technology from Patriot missile guidance systems combined with a domestically designed propulsion system, and search and guidance equipment derived from the Russian S-300PMU-1 SAM system. The HQ-9 is claimed to have capabilities similar to those of the US Patriot, such as a limited anti-tactical ballistic missile capability, and may have been tested against Scud-type missiles. China is developing various indigenous SAMs, including the HQ-9 advanced long-range system intended to counter high-performance aircraft, cruise missiles and tactical ballistic missiles, and the HQ-7 (FM-80) short-range tactical SAM for both land and naval applications. An active-guidance version of the FT-2000, similar to the Russian S-300PMU, could conceivably be developed for TMD applications (the so-called FD-2000 version, which has not been confirmed to date).

In regards to countering an enemy BMD/TMD system, a likely Second Artillery response would be the expansion of its overall ballistic missile force to increase the chances that some of its nuclear warheads would overcome such a defence. In August, a CIA report claimed that China could expand its ICBM force up to 10 times to some 200 missiles in response to the development of a US national BMD and regional TMD systems. This would be a relatively expensive option requiring increased production of significant additional missiles and infrastructure but China has this capability. A cheaper BMD response could be the further development of so-called ballistic missile penetration aids (PENAIDS) that include those summarised in Table 3.4.

Apparently, an ASAT (*fanweixing*) R&D programme during the early 1980s was halted due to technical limitations such as satellite tracking capabilities but a ground-based laser system is now reportedly operational (see Chapter Eight). ASAT and BMD related R&D, which probably began during the 1960s, may now be supported through the 863 Programme. China has reportedly shown a greater recent interest in nuclear and conventional space-based missile defence systems. The China Chang Feng Mechanics and Electronics Technology Academy (or the 2nd Academy) is apparently conducting ASAT and BMD related research such as space interceptor terminal homing guidance and control. One cancelled 2nd Academy ASAT project was reportedly termed the 'Red Guard Programme' or '640 Programme', and consisted of proposed kinetic kill vehicles, high-powered lasers, and space-based detection and tracking components. It produced a database of experimental results that could be applied to a new programme. The Harbin Institute of Technology and the Beijing University of Astronautics and Aeronautics are also believed to conduct research related to ASAT development. Solid-propellant ballistic missiles such as the DF-21 and DF-31 have the potential to be used as direct-ascent ASAT weapons with nuclear, kinetic or RF warheads. The Cox Report claimed that China has the technical capability to develop direct ascent anti-satellite weapons, where the existing older DF-3 ballistic missile could be modified for use in this role, in an approach similar to that taken by former Soviet SS-9 ASAT system.

Table 3.4 Potential Areas of Chinese Strategic Warhead Penetration Aid Development

· Decoys that create multiple radar targets, which must be tracked until discrimination of the actual nuclear warhead can be accomplished. · Simple decoys that are effective during exo-atmospheric flight of the nuclear warhead but burn up during re-entry into the atmosphere. · Chaff consisting of aluminium strips that are designed to reflect radar beams, thereby confusing a radar as to the location of the PLA warhead. · Jammers used to jam the radar system during the flight of the PLA nuclear warhead. · Radar absorbing materials, which can also be used to reduce the radar cross-section of the PLA nuclear warhead. · The PLA nuclear warhead itself could be reoriented to present the lowest radar cross-section. · The development of improved manoeuvring re-entry vehicle (MARV), the technology for which has been demonstrated by China's development of the Shenzhou man-rated spacecraft, MIRV or MRV platforms. This would effectively increase the size of the PLA's nuclear force without the full expense required to deploy additional missiles, and in the case of MARVs, could be used to complicate hit-to-kill or conventional warhead ballistic missile defence systems.

The FSW recoverable satellite series has the technical potential to be used as an offensive Soviet-type fractional orbit bombardment system (FOBS) for nuclear weapon attack from space, although there are no indications that China is currently developing such a capability. However, during 1965 the First Academy *(*Carrier Rocket Research Academy*)* reportedly proposed a programme to develop FOBS based upon reports of the period that the Soviet Union was developing similar systems. The Chinese FOBS system would have been a three-stage DF-6, thereby adding a third stage to the DF-5 ICBM, and was to have become operational by 1974. However, it was probably cancelled in 1973 due to technical problems. The advantage of orbital weapons over ballistic systems could include 'surprise attacks' and unusual flight paths to targets (e.g. a southerly approach to the continental US over the Antarctic). Indeed, an 'orbital basing mode' was at one time briefly considered for US MX-Peacekeeper ICBM MIRV warheads. Large solid-propellant ICBMs such as the DF-31 and DF-41 are also probably capable of deploying such orbital weapons, although there are no current indications that China has such a programme.

Increased benefits from China's civil space programme activities could provide capabilities for future activities in space warfare areas. For example, the Xi'an Satellite Monitoring and Control Centre, operated by COSTIND, has reportedly practised real-time orbital control of satellites since the early 1990s. China operates large phased-array and over-the-horizon (OTH) radar early warning systems in such locations as Xinjiang and Shanxi Provinces. China officially opposes the use of all weapons in space.

3.11 Anti-Tank Missiles   TOP

PLA anti-tank guided missiles (ATGMs) have included the Russian AT-3 Sagger, designated the Red Arrow HJ-73, the first generation indigenous Red Arrow HJ-3, the second-generation Red Arrow HJ-8, and the modern Red Arrow HJ-9. The Red Arrow series has seen PLA service for some years, and has also been exported to other nations such as Bosnia-Herzegovina and Pakistan (where earlier versions are co-produced). All Chinese ATGMs are developed and produced by NORINCO and its subsidiaries.

The PLA's second-generation anti-tank missile Hongjian (Red Arrow) HJ-8 was reportedly deployed during the late 1980s with the capability of piercing some 80mm of armour in its 8A high explosive anti-tank (HEAT) warhead and 8C models. The latter had an additional nose-mounted precursor HEAT charge that clears away explosive reactive armour (ERA) to allow the main charge to penetrate the steel armour of the vehicle. The 8A/C had a maximum range of 3 km. In addition to standard tripod-mounted infantry versions, which weigh 89.2 kg, there are other launch platforms such as the BJ 2023 C 4 x 4 light combat vehicle weighing 2.3 tons, a full-tracked carrier with four missiles in the ready-to-launch position and another eight rounds in reserve, and a WZ-551 4 x 4 LAV with a similar mounting, and a helicopter mounting where the gunner has a roof-mounted stabilised sighting system.

The Red Arrow HJ-8E was ready for production in the mid-1990, and has a range of 4 km, an increased range of 1 km, and an estimated hit accuracy of over 90 per cent, with its tandem/HEAT warhead providing an anti-reactive armour capability of over 100 mm. The Red Arrow 8E is infantry portable or mounted on various types of vehicles and helicopters. The structure of the missile was simplified and a new digital guidance system employed. Overall it has a performance similar to the Tube-launched, Optically-tracked, Wire-guided (TOW) anti-tank missiles developed by the US, Germany and France. It can be fitted with a PTI-32 thermal imager to detect targets at a range of 4,000 m and identify then at 2,000 m. The Red Arrow 8 has been extensively used to arm PLA helicopters such as the Z-11 and Z-9. Pakistan may have produced a version of the Red Arrow 8.

Details of the new generation Red Arrow HJ-9 ATGM were first made by NORINCO at a public appearance during a major parade held in Beijing during 1999. The first application for the Red Arrow 9 is on a 4 x 4 variant of NORINCO's WZ 551 6 x 6 armoured personnel carrier. This chassis is also used as the basis for the older Red Arrow 8 ATGM system that has been in service with the PLA for a number of years. The new Red Arrow 9 is of a different design and apart from its warhead is very similar to the US Raytheon Systems Company 3,750m range TOW ATGM. The major difference is that the Red Arrow 9 is laser guided, with the laser having a range of over 5.5 km and operating in the 0.9 µm waveband. The 4 x 4 Red Arrow 9 system has a combat weight of 13.75 tons with the commander and driver in the front, power pack in the middle on the left side and the missile system at the rear. On the roof is a raised plinth that houses the retractable missile launcher. This has four missiles in the ready-to-launch position, two either side, with the electro-optical package in the centre. The launcher can be traversed 200 degrees left and right with elevation and depression being 10 degrees. Another eight missiles are carried in the hull which can be loaded on to the retracted launcher automatically or manually.

The method of guidance is command-to-line of sight. There are at least two versions of Red Arrow HJ-9, the Red Arrow 9A millimetre wave command guidance version and the Red Arrow 9B laser beam riding version. In addition to the standard two field of view day sighting system, a thermal sight is also fitted to enable targets to be engaged under conditions of smoke and fog. This operates in the 8 to 12 µm range and can

detect a target at a range of 4,000 m and recognise a target at a range of 2,500 m. The 152 mm missile and its launch tube weigh 37 kg. It has four fins at the rear that unfold after launch with the four control surfaces almost two thirds down the missile. Maximum rate of fire is quoted as two missiles per minute when engaging targets at maximum range. The missile has a minimum range of 100 m and a maximum range of 5,000 m. The main HEAT warhead will penetrate 320 mm of rolled homogenous armour at an angle of 68 degrees protected by ERA. The nose mounted HEAT precursor charge activates the ERA allowing the main charge to penetrate the armour. The Red Arrow HJ-9 can be installed on a number of other platforms including full tracked armoured vehicles, trucks, helicopters and coastal craft. NORINCO is also marketing a training and support package with the missile.

There are recent unconfirmed reports of a 'Red Arrow 3000' fire-and-forget ATGM that employs state-of-the-art technologies such as fibre optics, automatic target-recognition and line-matching algorithms, and millimetre-wave seekers. In addition to being able to engage tanks it can also attack low-flying helicopters. These reports may be referring to versions of the HJ-9.

NORINCO has also reportedly developed a new shoulder launched anti-tank system called the 'Queen Bee' (PF-98), that has a calibre of 120mm, with HEAT tandem warhead and other types of multipurpose warheads, tripod or bipod mounts, and optical and thermal sights. It is also reported to have an effective range of 800 m with HEAT against NATO standard triple armour, or 1,800 m with multipurpose warheads against light armour.

Some reports indicate that the Russian gun-launched ATGM AT-11 'Stabbler' is currently under licensed production in China.

3.12 Chinese Missile Proliferation TOP

3.12.1 Overview

The proliferation of Chinese missile technologies to second parties is also important for domestic missile development programmes because this provides opportunities to obtain related foreign technology transfers in hardware and materials from third parties through technical interactions. For example, Russian and North Korean technical assistance has also been provided for the Iranian ballistic missile development programme, in addition to Chinese technology transfers. Despite consistent statements by Chinese leaders that they are willing to co-operate with international efforts to curb ballistic missile proliferation, there are indications that China continues to sell missile technologies, if not complete systems, to nations such as Pakistan and Syria. Most proliferation has taken the form of short to intermediate range ballistic missiles, anti-ship cruise missiles and tactical MLRS of a variety of types for the armed forces of developing countries.

During October 1994, the US negotiated with China a joint statement on missile non-proliferation in which Beijing reaffirmed its 1991 commitment to observe the guidelines and parameters of the MTCR. China agreed to ban all exports of MTCR-class ground-to-ground ballistic missiles, not as a full member but as an adherent to the regime. MTCR guidelines basically specify that missile supplier nations are forbidden to export complete missile systems, components or technologies that are directly related to ballistic missiles and have a capacity to deliver a minimum 500 kg warhead a distance of at least 300 km. China's past and recent exports of missile systems to various Middle Eastern nations has also placed its commitment to the MTCR in doubt. During August 1999, the Chinese Ministry of Foreign Affairs' director-general of the arms control and disarmament department, Sha Zukang, indicated that following worsening Chinese-American relations in the wake of the Kosovo crisis, and Taiwan's continued move towards independence with the support of continued US arms sales, China has 'stopped studying the MTCR... we are not in a mood to study the MTCR any further...the Kosovo crisis served as an excellent advertisement for missiles'.

Specifically, the US has failed in its attempt to convince China to abide by the annex of the MTCR, which has the objective of halting transfers of missile-related technologies and materials to other nations who often have political agendas hostile to those of the West. Furthermore, China has increasingly insisted on a merger of offensive MTCR and defensive BMD controls in the wake of US efforts to establish a regional BMD system that could include the participation of Japan, Taiwan and South Korea, and the potential networking of such theatre BMD systems to create a regional system that could undertake the boost-phase intercept of Chinese missiles. During October 1999, China, Russia and Belarus introduced a joint resolution at the United Nations aimed at putting pressure on the US to stop its current efforts at amending the 1972 Anti-Ballistic Missile (ABM) Treaty. The ABM Treaty between the US and former Soviet Union limits the missile defence systems that the US and Russia are able to deploy, and Beijing indicated that its amendment would 'tip the global strategic balance, trigger a new arms race and put the world and regional stability in jeopardy'.

During their June 1998 summit in Beijing, President Jiang Zemin had indicated to his US counterpart Bill Clinton that China would consider fully joining the MTCR and end missile-related sales to nations such as Pakistan and Iran. In practice it will be difficult for the central government to control such missile technology sales under the terms of the MTCR because of perceived inequities (notably the sale of advanced Western and Russian combat aircraft that deliver heavier ordnance payloads at greater ranges than the banned Chinese missile types), the financial profitability of such sales, and the reportedly increasingly autonomous export actions of Chinese defence firms. Rather than simply directly selling integrated missile systems, China is now transferring associated missile subsystem and production technologies to client nations under the guise of other types of technical assistance. Along with North Korea and probably Russia, China remains a major missile technology exporter. In many cases, however, China is believed to be transferring dual-use technologies, sub-systems, and technical expertise that are not explicitly covered by these multilateral control regimes. Major Chinese exporting agencies may have undertaken such sales with little or no direction from higher policy-co-ordinating central government bodies such as the Central Military Commission and COSTIND.

Specifically, there are some indications that Chinese export firms may have recently exported missiles and other WMD-related systems to Middle Eastern clients via North Korean ports. Chinese defence firms have also apparently implemented a 'bill-to-order' programme for current-generation short and medium range ballistic missiles, such as the M-9 and M-11, in which client nations such as Iran, Syria and Pakistan are thought to have been charged up-front for missile exports in order to financially support the considerable R&D costs of such systems. In order to circumvent further MTCR guidelines, China may also be using the 'slow dribble method' of transferring these missiles to customers as components, sub-components and production techniques, rather than as complete systems.

The CIA has recently claimed that Chinese firms had increased missile-related sales to Pakistan, a claim denied by Pakistan, despite reports that Chinese experts had been sighted near a Pakistani factory. The report also accuses the Chinese of continuing missile-related assistance to several other countries not on good terms with the US such as Iran, North Korea and Libya.

3.12.2 Iran

A 1995 classified CIA report is thought to have concluded that China is providing Iran with a broad level of missile-related technical co-operation that exceeds MTCR guidelines and will eventually permit the development of an indigenous Iranian ballistic and cruise missile production capability. CPMIEC reportedly sold missile-related equipment including gyroscopes, accelerometers and other guidance technologies, upgrade kits for previously purchased Chinese anti-ship cruise missiles, and computerised machine tools to Iran's Defence Industries Organisation (DIO) during 1995-96 . CPMIEC is also probably the export agent for recent C-801/802 anti-ship cruise missile sales; some 100 C-802/YJ-2 missiles were reported on order during 1995. Recently, another Chinese defence exporter, China Great Wall Industry Corporation (CGWIC), best known for the commercial marketing of the Long March series of satellite launch vehicles, has been accused by the US of selling Iran missile-testing technologies for the development of Scud-type missiles. An unconfirmed 1996 report suggested that China assisted Iran to initially kit assemble, and later completely manufacture, the newer C-801/YJ-1 anti-ship cruise missile, known as the Karus in Iran. Chinese, or other foreign, technical assistance is probably required for all of these projects. A 1999 US intelligence report claimed that China has recently supplied Iran with missile telemetry equipment and trained Iranian engineers in China on inertial guidance systems.

Table 3.5 provides a summary of the type and major characteristics of Chinese missiles and missile sub-systems believed to have been sold and transferred to Iran until recently. The Iran-130, Iran 700, Karus, Mushak series, Nazeat, Oghab, Shahin-2, Tondar 68, and Zelzal-3 are all domestic Iranian programmes; where appropriate these are listed together with comparable Chinese or related domestic systems. 'C' and 'CSS' are NATO designations for 'Chinese' and 'Chinese surface-to-surface' missiles; 'M' is the Chinese designation for missile export versions; DF, HY, HQ, YJ, FL, and SY are acronyms for Chinese language missile designations.

Table 3.5 Major China-Iran Missile Programmes

· C-801/YJ-1, Karus and C-802/YJ-2 - Karus is reportedly the Iranian-produced version of the C-801/YJ-1.

· CSS-6/DF-15/M-9 - see section 3.3.4.

· CSS-7/DF-11/M-11, Tondar 68 - see section 3.3.3.

· CSS-8/M-7/Project 8610, Mushak 120/160/200 - domestic Mushak missile programmes are probably closely related to an indigenous M-7 production capability (see section 3.3.2).

· HY-1/SY-1, HY-2, HY-4, C-601 'Silkworm' series - see section 3.5.2, etc.

· Iran-130, Nazeat, Shahin-2 - all approximately 130 km-range ballistic missiles, possibly the same or interrelated programmes, or related to the Mushak series; solid fuel.

· M-18, Iran 700 - possible Iranian involvement with this programme (see section 3.3.10).

· North Korean Scud-B/C and Nodong missiles - includes various ongoing Chinese technical assistance, such as upgrading Scud Bs to 500 km range.

· Oghab, Type-83 - 40 km range unguided artillery rocket with a 300 kg payload; 1,000 m CEP.

· Zelzal-3 - domestic programme based on a combination of Chinese, Russian, North Korean and German technologies; possible range of up to 1,500 km; possibly also technically linked to Chinese M-18 programme.

· FL-10 - most recent anti-ship system based upon Chinese technologies.

3.12.3 Iraq

China possibly provided some technical assistance for Iraq's Al Aabed ('The Worshipper')/Tamouz-1 long-range (2,500+km) missile/space launch vehicle that reached the test stage in December 1989.

The now deceased Canadian Dr. Gerald Bull's Brussels-based Space Research Corporation provided assistance to Iraq prior to the Gulf War to develop extremely long-range artillery systems such as the 'Babylon' and 'Baby Babylon' projects. Such systems could conceivably have been used for long-range bombardments with both conventional or WMD rounds, and to place payloads into space orbit. Dr. Bull also provided R&D assistance to China for similar projects, which NORINCO has reportedly applied both to conventional artillery systems and an experimental long-range 'supergun', so technical crossovers between China and Iraq in this area were quite possible.

China has sold HY-2 Silkworm anti-ship cruise missiles to Iraq, as well as H-6 bomber/C-601 Silkworm missile integrated airborne systems, but the latter were believed to have been destroyed during the Gulf War. During the Gulf War several HY-2s were fired against Coalition force ships, and one was intercepted by a Royal Navy Sea Dart missile. The longer-range Iraqi FAW-70/150/200 km anti-ship cruise missile series is derived from the Chinese Silkworm system through the addition of an improved delta-wing, and are produced at the Nasr missile factory. Iraq is now believed to have Chinese C-801/YJ-1 anti-ship cruise missiles in its inventory and M-7 ballistic missiles may have been exported as well.

In a reverse technology transfer-type deal of note, Poly Technologies officials have reportedly purchased unexploded US Tomahawk cruise missile components from Iraq to assist China's advanced cruise missile development programme. Similar reports have been circulated concerning unexploded US cruise missiles used in 1998 attacks against the forces of terrorist Osama bin Laden in the Sudan and Afghanistan, as well as subsequent vehicles recovered in Yugoslavia, being delivered into Chinese hands.

3.12.4 Saudi Arabia

Poly Technologies organised the 1987-88 sale of 36 to 60 DF-3 missiles, 10 to 15 missile transport vehicles (the DF-3 is transportable but not launch mobile; see section 3.3.7), and related technical support services, to Saudi Arabia in a deal that was reportedly worth up to US$3.5 billion. The US reportedly had previously refused to sell Saudi Arabia Pershing missiles. The supposedly conventional warhead equipped DF-3 intermediate-range ballistic missiles have a total coverage of Israel. However, China may have also provided Israel with the locations of DF-3 deployment sites. During March 1988 Israel had hinted that it might bomb the new missile sites as a pre-emptive measure similar to its destruction of an Iraqi nuclear facility.

The sale resulted in Saudi Arabia breaking off relations with Taiwan. While this arms transfer could have caused a further destabilisation of the fragile Middle East balance of power, the US was assured by both China and Saudi Arabia that nuclear warheads would not be provided for the missiles, and China indicated that it would not provide further intermediate-range ballistic missiles to any other nations. Saudi Arabia's ostensible rationale for this missile procurement was as a deterrence against Iran and it denied that the force represented 'Islamic missiles'.

The Saudi DF-3s are reportedly maintained and operated by up to 300 Chinese technical personnel at isolated locations. Possible basing sites are: As-Sulayyil, some 500 km south of Riyadh; near Al-Leel or the Al Kharj military complex, both some 100 km south of Riyadh and in the centrally located Empty Quarter desert; or more unlikely at the King Khaled Military City complex 400 km north of Riyadh. Remote As-Sulayyil is the most likely known basing location, although the force is believed to be based at two sites with at least four to six launch pads per site.

Reports in March 1997 indicated that the Saudis are considering options for the replacement or modernisation of its now ageing DF-3 force. Modernisation is unlikely because China is moving towards retiring its own DF-3 force (although its domestically deployed upgraded DF-3A is technically more advanced), while the design employs a corrosive liquid fuel that makes refuelling hazardous and degrades launch readiness efficiency. The US believes that the purchase of a comparable-range newer-generation missile would undermine MTCR restrictions, and could further motivate similar developments by other Middle Eastern nations such as Iran. However, various delegations from China's aerospace industry and strategic missile force, the Second Artillery Corps, have reportedly recently visited Saudi Arabia to discuss replacement options. Prince Khaled bin Sultan, who is believed to have negotiated the original DF-3 purchase, has visited both China and Russia several times to discuss such issues within the past few years.

Chinese solid fuel replacement missiles could conceivably include systems such as the DF-21A (China is reportedly considering the use of the DF-21A as an eventual replacement for its own DF-3A force; see section 3.3.5), and possibly the DF-25 (see section 3.3.11; some sources have indicated that the DF-25 programme, formerly thought cancelled, has currently been revived). Solid fuel systems would decrease maintenance requirements, be more mobile, and allow prompter launching times, but there have been no recent reports on specific sales to Saudi Arabia.

3.12.5 Egypt

During the early 1990s Egypt reportedly was undertaking the development of an improved range 'Scud 100' missile programme with technical assistance from China and North Korea. Some recent reports have indicated that China is to assist in the modernisation of the Egyptian Sakr missile factory, which currently produces a derivative of the Russian FROG artillery rocket known as the Sakr-80. If confirmed this will permit the production and reverse-engineering of Russian SAMs, Silkworm anti-ship cruise missiles, Scud-Bs, and perhaps the improved range Scud (450 km), which is now reportedly known as 'Project-T'. Egypt has the FL-1 and HY-2 versions of the Silkworm in its inventory and unconfirmed reports indicate that M-9 ballistic missile systems may also have been provided.

3.12.6 Libya

Libya has reportedly unsuccessfully attempted to obtain Chinese long-range missiles such as the DF-3 but has possibly acquired shorter-range M-9s. Unconfirmed reports have indicated that Libya purchased 140 M-9 missiles in 1989, passing on some 80 to Syria. Chinese technical experts are believed to have provided some assistance since at least 1998 for the domestic Al Fatah/Ittisslat programme, which is reportedly an ongoing effort to produce a missile with a 950 km range and 500 kg payload capability.

US reports in April 2000 claim that China has recently undertaken ballistic missile technology transfers to Libya, including a hypersonic wind tunnel. CPMIEC is reportedly assisting the ongoing Al Fatah programme, and Chinese technicians may be providing possible technical training for the use of North

Korean-provided ballistic missiles that could include Scud, No Dong or Taepo Dong types.

3.12.7 Syria

During 1996, US intelligence sources reportedly discovered that Chinese military exports to Syria included M-11 missile guidance systems and technical assistance for an underground chemical/biological weapons factory outside of Damascus similar to one under construction in Libya. Nuclear-related technology and technical training has also reportedly been supplied but such co-operation is still believed to be at an embryonic stage. Syria probably does not have a full-scale nuclear programme. Some Chinese ballistic missile-related transfers to Syria are believed to have been co-ordinated with those for Iran.

Poly Technologies has reportedly been key in brokering the sale of M-9 and M-11 missile technologies to Syria, which may have provided funding for their development. Conflicting reports indicate that M-9 missile sales to Syria were cancelled during 1991-92 due to pressure from the US. Syria reportedly entered into a 1988 agreement with CPMIEC to fund the M-9's development, and transfer it to Syria. Some 24 M-9 mobile TELs were possibly delivered by 1991-92.

During 1996, CPMIEC reportedly transferred missile components for Syria's North Korean Scud-C programme, in addition to technical assistance for a Syrian solid rocket motor propellant programme for domestic ballistic missiles. Such assistance has reportedly included the export of 30 tons of solid rocket propellant chemicals, with a 1992 order for an additional 60 tons. CPMIEC may also have directly transferred M-11 technologies. Further unconfirmed reports have indicated that China helped establish a Syrian missile production capability in 1992, and that Chinese technical specialists are working at the underground Scud-B/C Hamah and Aleppo production facilities to produce missile guidance systems, and at the Scientific Studies and Research Centre. It is uncertain whether these same plants will produce M-9 and M-11 missiles. As with Saudi Arabia, China may have also provided Israel with targeting information on Syrian missile locations on a *quid pro quo* basis. However, China's current co-operation with Israel may deteriorate as a result of the recent Phalcon AEW cancellation, while its collaboration with 'rogue' Middle Eastern states such as Iran, Iraq, Libya and Syria may increase.

3.12.8 Yemen

Yemen has reportedly received C-801/YJ-1 and possibly C-802/YJ-2 anti-ship cruise missiles from China.

3.12.9 Pakistan

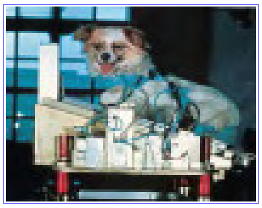
A Chinese M-11 SRBM production facility was discovered by the US in 1995 and is reportedly located at the National Development Complex at Fatehgarh near Rawalpindi, where Chinese technicians helped develop an extended range version of the missile. Pakistan has now probably developed nuclear warheads for the M-11; 34 Chinese supplied M-11s are believed deployed at the Sargodha air base.

In 2000, the CIA reported that Pakistan's new Shaheen II nuclear-capable medium range ballistic missile incorporates Chinese solid fuel technology. US intelligence officials maintained that China continues to transfer missiles technologies such as special steels needed to produce missile engines, guidance systems, and design information.

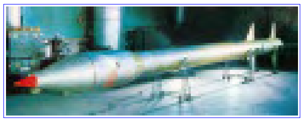
3.12.10 North Korea

China has provided North Korea with various ballistic and cruise missile, nuclear and other WMD-related technologies, which in turn are believed to have been transferred to various Middle Eastern nations including Egypt, Iran, Libya and Syria.

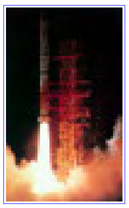
During June 1999, Chinese firms reportedly transferred missile components to North Korea in retaliation for the US bombing of the Chinese embassy in Belgrade. The transferred technologies included accelerometers, gyroscopes and special high-speed grinding missile production machinery. The transfers may have been undertaken as commercial sales without the direct approval of Beijing. A US Defense Intelligence Agency report is believed to have indicated that the origins of the transferred technologies included China, Russia and the US, all funnelled through China. During 1998, other missile-related transfers from China allegedly included specialised steel alloys. The Chinese Academy of Launch Technology (CALT) is reportedly co-operating with North Korea on space programme activities also possibly related to ballistic missile developments.



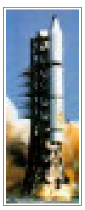
The Chinese Academy of Space Technology (CAST) claim they conducted a successful biological experiment by sending a small dog into orbit with a biological sounding rocket in 1960.
(Source: CAST)



A T-7A Biological Sounding Rocket.
(Source: CAST)



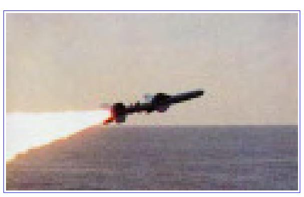
On May 12, 1997, a CZ-3A space launch vehicle successfully launched the DFH-3 large volume telecommunications satellite with state-of-the-art technologies for domestic telephone, fax, data and video broadcast services.



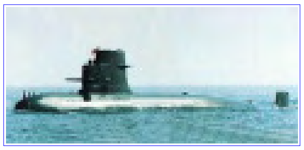
Launch of the Long March 2C SLV

The X-600 or Hong Niao-1 (HN-1, or Red Bird-1, including HN-2, HN-3, and other versions) series of advanced air, land, and sea (surface and submarine) launched land attack cruise missiles are reportedly deployed and under development with advanced guidance systems. This represents a new level of sophisticated capability for China.

The DF-21A, DF-31 (shown above with its TEL), and the DF-41 represent the most modern solid propellant mobile ballistic missile technology in the PLA inventory. The DF-21A is depolyed and may have extremely accurate terminal guidance systems. Deployment of the DF-31 has begun, and the DF-41 is believed to be at the test stage. Both are thought to be capable of carrying MIRV warheads.
(Source: A. Pinkov)



The Ying Ji YJ-2 (C-802) is one of the most capable anti-ship cruise missiles in the PLA inventory, and has been widely exported to nations such as Iran. China has a wide variety and large inventory of anti-ship cruise missiles, some of which could be adapted for a land-attack role.
(Source: CPMIEC)



The 1,700 ton Type 039 Song-class SSK (shown above) is the double-hulled construction follow-on to the Type 035 Ming-class SSK, but it may need some design modifications before final acceptance by the PLAN.
(Source: PLAN)

Shown above from top to bottom is the Red Arrow 8A, 8C, and the 8E. Details of the new generation Red Arrow HJ-9 ATGM were first made by NORINCO at a public appearance during a major parade held in Beijing during 1999.
(Source: NORINCO)

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Ben Sheppard; Dr Howard DeVore

CHAPTER 4 - SPACE SYSTEMS

Date Posted: 05-Dec-2000

China's Aerospace And Defence Industry - December 2000

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SPACE SYSTEMS

4.1 R&D and Production Infrastructure TOP

Today, China has a complete space programme infrastructure for the R&D and production of strategic and tactical missiles, satellites, launch vehicles, and advanced technology support systems. China launches and operates geostationary communications and broadcast, recoverable photographic and scientific, navigation, and science satellites. Some estimates place the total number of workers in the missile and space sector at approximately 800,000 within over 300 enterprises, institutes and other research and training establishments. However, such a large total would probably include military personnel (from COSTIND launch and tracking, telemetry and control operations, the Second Artillery Strategic Missile Force, and missile R&D centres for all the branches of the PLA) and industrial sub-contractors with dual-use applications. Table 4.1 summarises some of the key space and missile sector manufacturing and

R&D centres in China by province and city.

Table 4.1 Current Chinese Space and Missile Sector Geographical Clusters

· **Beijing**

- Beijing Centre of Space Science and Technical Information
- Beijing Institute of Control Engineering (Instrumentation)
- Beijing Institute of Environmental (and Structural) Test Engineering
- Beijing Institute of Material Technology
- Beijing Institute of Remote Sensing
- Beijing Institute of Satellite Environmental Engineering
- Beijing Institute of Satellite Information Engineering
- Beijing Institute of Space Automation Control
- Beijing Institute of Spacecraft Systems Engineering
- Beijing Institute of Space Machinery and Electronics
- Beijing Orient Institute of Measurement
- Beijing Satellite Manufacturing Factory
- Beijing Shibao Satellite Image Company
- Beijing Space Technology Development and Application Corporation
- Beijing Special Engineering and Design Institute
- Beijing Spot Image Company
- Beijing Tongha Measuring Instruments Corporation
- Beijing Wan Yuan Industry Corporation
- China Academy of Launch Vehicle Technology
- China Academy of Space Electronics Technology
- China Aerospace International Holding Ltd.
- China Great Wall Industry Corporation
- China National Space Administration/China Aerospace Industry Corporation
- China North Industries Corporation (NORINCO)
- China Precision Machinery Import and Export Corporation

- China Space Technology Research Institute

- China Orient Telecomm Satellite Company Limited

- China Telecommunications Broadcast Satellite Corporation

- Chinese Academy of Space Sciences

- Chinese Academy of Space Technology

- Chinese Society of Astronautics

- Chinese Society of Space Research

- COSTIND (China Satellite Launch and TT&C General; Astronautical Engineering Institute)

- General Establishment of Space Science and Application, CAS

- Institute for Astronautics Information

- Nanyuan ICBM production facility

- National Remote Sensing Centre of China

- National Satellite Meteorological Centre

- Poly Technologies Inc.

- Research Centre for Space Science and Applications

- Space Centre for Payloads and Applications

- Wuzhai Missile and Space Test Centre

· **Gansu Province**

- Lanzhou Institute of Physics, Lanzhou

· **Guangdong Province**

- Shantou Institute of Electronic Technology Equipment, Shantou

· **Guizhou Province**

- China Jiangnan Space Industry Company Group, Zunyi

· **Henan Province**

- Luoyang Institute of Tracking, Telecommunications and Technology

· **Heilongjiang Province**

- Harbin Fenghua Machine Factory

- Harbin Institute of Technology, Harbin

· **Hong Kong**

- AsiaSat Inc.

- APT Satellite Holdings Ltd.

· **Hubei Province**

- Sanjiang Space Group, Wuhan

· **Hunan Province**

- National University of Defence Technology, Changsha

· **Jiangsu Province**

- Nanjing Chenguang Machinery Manufacturer, Nanjing

· **Jiangxi Province**

- Nanchang Aircraft Manufacturing Company, Nanchang

· **Liaoning Province**

- Dalian Haiyang Chemical Technology Company, Dalian
- Shenyang Xinle Precision Machinery Company, Shenyang

· **Shaanxi Province**

- Shaanxi Lingnan Machinery Company
- Xi'an Institute of Space Radio Technology, Xi'an

· **Shandong**

- Yantai Institute of Telemetry Technology, Yantai

· **Shanghai**

- Number 809 Institute of the Shanghai Space Bureau
- Shanghai Academy of Spaceflight Technology
- Shanghai Astronautics Bureau, and Systems Laboratory
- Shanghai Huayin Machinery Plant
- Shanghai Institute of Power Machinery
- Shanghai Institute of Satellite Engineering
- Shanghai Institute of Space Power Source
- Shanghai Institute of Spacecraft Engineering
- Shanghai Institute of Spaceflight Automatic Control Equipment
- Shanghai Institute of TT&C and Telecommunication
- Shanghai Scientific Instruments and Materials Corporation
- Shanghai Xinxin Machinery Plant
- Shanghai Xin Zhong Hua Machinery Factory

· **Shanxi Province**

- Shanxi Institute of Power Machinery

- Shanxi Taihua Institute of Electronic Machinery Equipment

· **Sichuan Province**

- Sichuan Space Industry Corporation/Chengdu Space Technology Development Company, Chengdu

· **Yunnan Province**

- Yunnan Space Industry Corporation

In 1993, the now defunct Ministry of Aerospace Industry's space responsibilities were transferred to the newly created China National Space Administration (CNSA) and the China Aerospace Industry Corporation (CAIC, or China Aerospace Corporation), which also report to the State Council in co-ordination with the MOST. During 1998-99, the CAIC was restructured under COSTIND. The two new units created as part of the restructuring were the China Aerospace Technology Group and the China Aerospace Machinery and Electrical Group but details remain unclear. The overall organisation of the CAIC's subordinate units is believed to remain valid and the space and missile role continues. Table 4.2 outlines some of the key organisations now under the authority of the CAIC and a summary of activity areas. Also see Appendix A for a detailed listing of subordinate organisations. The CAIC President organisationally has also been the CNSA Administrator but this may have been effected by the 1998-99 reorganisation of the aerospace-defence sector.

The CNSA is China's formal national space agency, with a mandate from the State Council for co-ordinating international collaboration and concluding co-operation agreements with foreign partners and governments. Its activities are all outwardly of a civil and scientific nature. Apparently, the CNSA eventually hopes to become a true national space agency patterned after NASA and removed from direct industrial and military undertakings. The CAIC controls the vast majority of China's space and missile industry from research to commercialisation, with the implementation of space and defence projects in co-ordination with COSTIND. It is key for the positioning and sub-contracting of subsidiary firms and R&D centres in such major projects. The total number of employees in its subsidiary firms and research organisations is estimated to be over 270,000, with perhaps 60,000 of this total consisting of engineers and scientists.

Table 4.2 Key Organisations Under the Authority of the China Aerospace Industry Corporation

· Chinese Academy of Launch Vehicle Technology (CALT, or the 1st Academy or the Beijing Wanyuan Industry Corporation) produces launch vehicles, ballistic missiles such as the DF-15, mission analysis, and interface co-ordination. Reportedly China's primary ICBM production facility at Wanyuan was shut down and relocated to a plant near Chengdu during 1998. The Wanyuan production complex was believed to include 13 research institutes and seven factories, and employed 27,000 engineers and technicians, and also manufactured Long March satellite launchers.

· China Chang Feng Mechanics and Electronics Technology Academy (or the 2nd Academy) produces spacecraft and components, military space system R&D related to ASAT and BMD systems.

· Hai Ying (Sea Eagle) Electro-Mechanical Technology Academy of China (or the 3rd Academy or Yunnan Space Group) employs about 3,500 personnel. R&D activities include cruise missile guidance systems.

· Hexi Chemical Corporation (or the 4th Academy) conducts R&D on solid rocket boosters and composite materials.

· Chinese Academy of Space Technology (CAST, or the 5th Academy) specialises in satellites and recoverable payload R&D.

· China Space Civil and Building Engineering Design and Research Institute (or the 7th Academy).

· Shanghai Bureau of Astronautics (or the 8th Academy, or the Shanghai Academy of Spaceflight Technology) produces launch vehicle first and second stages, and altitude-control, guidance and stabilisation system R&D.

· China Academy of Basic Technology for Space Electronics (or the 9th Academy).

· Beijing Tongha Measuring Instruments Corporation.

· China Astronautics Industrial Supply and Marketing Corporation.

· China Great Wall Industry Corporation (CGWIC) and China Great Wall Industry Group (space launch services, space technology and systems, and prime contractor for space services).

· China Jiangnan Space Industry Company Group.

· China National Precision Machinery Import and Export Corporation (CPMIEC) develops and produces various missile types, rocket engines, radars, precision machinery, optics, etc.

· China Sanjiang Space Group.

· Feihuan Corporation.

· Harbin Institute of Technology.

· Shaanxi Lingnan Machinery Company.

· Sichuan Space Industry Corporation.

· Yunnan Space Industry Corporation.

The Chinese Academy of Space Technology (CAST) is an organisation of over 10,000 employees, including 6,000 engineers. It concentrates on spacecraft development but is also involved with missile R&D and has at least 16 research institutes and factories. Up to 1995, CAST had organised the development of 35 satellites in the areas of science research (microgravity), low earth orbit and geosynchronous earth orbit remote sensing and communications. Its responsibilities do not directly include meteorology. CAST faces a challenge in maintaining its traditional predominant role of developing Chinese communications satellites because this area is becoming increasingly commercialised and integrated with foreign sources of financing, manufacturing, and technology. It is also leading China's efforts to design and build a set of standardised spacecraft that could be used for multi-role payload applications. Table 4.3 summarises the various research and manufacturing organisations under the authority of CAST.

Table 4.3 Key Organisations Under the Authority of the Chinese Academy of Space Technology

· Beijing Centre of Space Science and Technical Information · Beijing Institute of Control Engineering · Beijing Institute of Environmental Test Engineering · Beijing Institute of Satellite Environmental Engineering · Beijing Institute of Satellite Information Engineering · Beijing Institute of Spacecraft Systems Engineering · Beijing Institute of Space Machinery and Electronics · Beijing Orient Institute of Measurement · Beijing Satellite Manufacturing Factory · Beijing Space Technology Development and Application Corporation · Lanzhou Institute of Physics · Shanghai Institute of Spacecraft Engineering (also linked to CALT) · Shanghai Scientific Instrument Factory · Shanxi Taihua Institute of Electronic Machinery Equipment · Shantou Institute of Electronic Technology Equipment · Xi'an Institute of Space Radio Technology Engineering · Yantai Institute of Telemetry Technology

In June 2000, the Hong Kong firm Asian Star Development Inc. was appointed as a business agent for

CAST, introducing and promoting on an international basis various commercial products, such as satellite communication networks, global positioning systems and other commercial products developed by the academy. The global mandate includes developing programmes of cultural and technological exchanges, contacting potential technology partners and clients, and co-ordinating international joint ventures and alliances. Asian Star Development's holdings and products reportedly encompass an extensive and interconnected global range of ventures, including advanced technologies, manufacturing, Internet, entertainment, real estate, leisure, sports, retail and infrastructure projects.

The China Academy of Launch Vehicle Technology (CALT) is the leading organisation responsible for the development, production, and support of the Long March family of launchers and military missiles. CALT has some 27,000 employees and 20 R&D institutes, in addition to various related production organisations. It is also involved with the development of other defence and dual-use systems such as the FSW reconnaissance satellite series. Primary production sites are located at Beijing and Shanghai. CALT's Academy of Rocket Motors Technology (or 4th Academy) is responsible for the R&D and production of solid rocket motors, as well as designing composite materials, chemicals, electronic instruments, power machinery, and pressure vessels. Formed in 1962, it employs some 12,000 personnel. Recent products have included the FG-23 solid-propellant motors for the reconnaissance satellites, and the Earth Perigee Kick Motor for telecommunications satellites, and motors for the LM-1 launcher (GF-02 third stage), the tactical ballistic missiles, the JL-1 SLBM, and others. Subordinate entities include the 401st Institute (SLBM solid rocket motors), China Hexi Chemistry and Machinery Company, and the Shanxi Institute of Power Machinery. The China Hexi Chemistry and Machinery Company has developed and manufactured various solid rocket motors since 1965, and has facilities that include advanced production systems, test equipment, and precision analytical apparatus for rapid data acquisition. The Shanxi Institute of Power Machinery conducts R&D on aerospace power devices, including solid rocket motor designs for current generation ballistic missiles.

Foreign technologies obtained through commercial contracts (for example, US and European built communications satellite guidance and attitude control systems, coupling load analysis, integration systems, encryption devices, and upper stage orbital 'kick' motors), are believed to be routinely transferred to military applications despite safeguards intended to prevent this from occurring. Western assistance in developing reliable, integrated commercial satellite launcher upper stage control systems could be directly applied to MIRV modernisation programmes.

The National Remote Sensing Centre of China (NRSCC) is a 'virtual' organisation, responsible for the co-ordination of various remote sensing activities throughout China. These include the Remote Sensing Ground Station (RSGS), the Chinese Academy of Sciences, the Ministry of Posts and Telecommunications, and the CNSA. This is in addition to the approximately 460 earth observation institutes and organisations in China with some 10,000 engineers and technicians, including the Institute of Remote Sensing Applications (IRSA). The NRSCC is also involved in technology development activities for such areas as advanced supercomputing technologies, digital SAR signal processing, telephony and data transmission, and software development. The Institute of Electronics is an R&D component of the MOST that has been active in airborne and space-based SAR technology research and instrument development.

The CAS is responsible for the Centre for Space Science and Applied Research (Chinese sub-orbital sounding rocket programme), the IRSA, and the National Laboratory for Resources and Environment Information System, which together include more than 50 research institutes. The RSGS, Beijing, subordinate to the CAS, operates China's major dedicated earth observation ground station, which is responsible for the reception, archiving, processing and distribution of earth observation data. It currently receives LandSat, ERS and JERS data, in addition to domestic satellite information. Some sources state that US Landsat ground station equipment was originally provided to China during the early 1980s for the surveillance of the Sino-Soviet border.

The Xi'an Institute of Space Radio Technology (XISRT) is one of the key organisations in China responsible for the design and manufacture of dual-use earth observation and communications satellite sub-systems such as antennas, transponders, tracking, telemetry and communications repeaters, charged coupled device (CCD) cameras, switches and other microwave components. It has payload integration and testing facilities but those of CAST are reportedly more extensive.

Education and training facilities such as the Beijing Institute of Aeronautics and Astronautics and the Northwest Polytechnic University have R&D facilities such as ramjet and liquid rocket test stands, and various computational and measurement facilities.

The Chinese Society of Astronautics, Beijing, organises national/international co-operation and exchanges in aerospace-related technical and academic areas, as well as annual symposia, technical conferences, and workshops across the country through local branches. Its professional committees include the areas of tactical missile system engineering, quality and reliability, robotics, computer applications, space medicine, materials technology, structural strength and environmental engineering, measurement and tests, launch engineering and ground equipment, recovery and re-entry, telemetry, solid rocket propulsion, liquid rocket propulsion, space electronics, space power, space remote sensing, space control technology, aerodynamics and flight mechanics, spacecraft manufacturing technology, spacecraft inertial devices, spacecraft measurement and controls, spacecraft systems engineering, and launch vehicle systems.

The Chinese Society of Space Research, Beijing, was founded in September 1980 and is a non-governmental organisation with a membership of over 2,000. The society is attached to the Chinese Association for Science and Technology but its activities are closely related to those of CAS establishments. It promotes international scientific exchanges, provides technical advice to Chinese government organisations, presents awards for scientific excellence, publishes technical journals, and encourages an interest in space science amongst the general public. Technical committees include the areas of space astronomy (Purple Mountain Observatory), space physics (Centre for Space Science and Research), space chemistry and geology (Guyang Institute of Geology and Chemistry), space life sciences (Institute of Space Medical Engineering), space materials sciences (Shanghai Institute of Ceramics), space mechanical technology (Changchun Institute of Optics Mechanics), space exploration (Centre for Space Science and Applied Research and the Beijing Institute of Space Machine and Electricity), space remote-sensing (Shanghai Institute of Technical Physics), and the National Society of Microgravity Science and Application (Institute of Mechanics).

4.2 Space Programme Objectives TOP

China is pursuing space projects for a variety of reasons related to national defence, scientific exploration, economic development, and national prestige. It has national priorities in environmental and resource management and communications because of its large landmass and huge, widely dispersed population. It needs the hard currency generated through activities such as commercial Long March launch services. New technologies developed through the space programme can be applicable to other industry sectors. Military activities remain an integral, driving component of China's space activities. Space accomplishments also project a 'high-tech' image of a modern China to the international community as a very visible indication of its level of achievement in science and technology. A strategic space plan, the 'National Mid- and Long-Term Programme for Scientific and Technological Development for 2000-2020', will reportedly emphasise such areas as in-orbit propulsion, satellite tracking and control, and manned astronaut programmes. The US Department of Defense has recently claimed that in times of crisis or war the PLA could exploit its capabilities for space control through denying the enemy access and by use of military and commercial space systems (e.g. ASAT lasers).

There have been some 62 launches since 1970, using five basic families of launch vehicles from the three principal launch sites at Jiuquan, Xichang and Taiyuan. Since October 1996, China has made 18 successful launches in a row following three launch mishaps that occurred in 1995 and 1996. Since 1970 to 1996 China had a total of seven reported Long March launch failures out of a total of 45 launches. As of January 2000, China claimed to have 68 operational satellites of all types in orbit (perhaps only a third of which have fully functioning payloads - for example in 1997, the US Space Command indicated that China had 16 payloads in orbit, not including non-functioning satellites with decayed orbits and space debris). A fourth major launch site may be under consideration for the southern island province of Hainan, requiring an initial investment of up to US$250 million but offering increased payload advantages and a location allowing safer launches over the largely uninhabited ocean. By the mid-1990s, China's reported space budget was approximately US$1.5 billion but today it is probably considerably higher and not officially included in the defence budget.

Chinese space technology has gone through five major transformations during the past three decades, according to Xu Fuxiang, the current Director of CAST. These stages were:

· 'Satellite models evolving from a single model to a variety of models;'

· 'Satellite research and manufacturing technologies moving from exploratory to maturity;'

· 'Satellite use widening from scientific research to broad service applications uses in mainstream society;'

· 'Satellite research and manufacturing operations changing from a small scale experimental nature to a modernised and scientific approach;' and

· 'Pace technologies development opening up from a closed system'.

CAST reports that to date China has made or participated with other international partners in developing over 40 types of satellites and spacecraft, which include vehicles that travel in low-earth, medium and high orbits. During November 1999 China took the initial step in its manned space programme after the successful launch of the Shenzhou (christened by President Jiang Zemin, and variously translated as 'Magic Vessel', 'God Ship' and 'Heavenly Vessel') prototype man-rated capsule. CAST, the largest satellite manufacturer in China, currently has four different series of space platforms available: medium capacity communications satellite; re-entry satellite; Earth observation satellite; and 'mini-satellite'. CAST reports the increasing reliability and maturity in the development of Chinese space technologies as evidenced by recent successful launches, which include the May 1999 Shijian-5 ('Practice') micro-gravity fluid and space physics spacecraft, the joint Brazil-China Ziyuan-1 ('Resource') remote sensing satellite, and the maiden flight of the Shenzhou man-rated capsule.

In June 2000, Wang Yongzhi, chief designer for manned space projects for the China Engineering Academy, articulated at a Beijing space conference the long-range planning goals for China's space programme.

· The launching of unmanned and manned spacecraft - one or two more tests of the Shenzhou series will be required before manned flight will occur.

· Astronauts will conduct space walks and extra-vehicular activities (EVAs).

· Experiments will be conducted with multi-section space dockings.

· A man-tended space laboratory will initially be launched for short visits.

· Professor Sun Jiadong, head of the China Space Technology Research Institute, indicated that the ultimate objective of the programme is to establish colonies on other planets.

CAST is now reportedly undertaking R&D to develop satellites in large capacity communications, navigation and positioning, and applications such as disaster mitigation. The new research is anticipated by China to result in breakthroughs in communications speed and bandwidth, reception techniques and reliability. By 2010 China conceivably could have two or three integrated space-terrestrial satellite applications networks. In addition to satellite technologies R&D, CAST is the lead organisation in manned spaceflight technologies. CAST's future foreign collaboration programmes will probably include the joint research and fabrication of satellites; the supply of complete satellites or components; the piggyback delivery of payload on CAST satellites or 'retrieving satellite service'; testing spacecraft in simulated space environments; and the design, development and manufacture of satellite ground networks.

Military space activities have traditionally been a distinct COSTIND responsibility, although aspects are also related to the Strategic Missile Force (also note section 3.10's related discussion on BMD and ASAT systems and Chapter Eight's review of Chinese DEW developments). For example, the so-called 'Costind Industries' of Beijing is believed to have developed an advanced Dong Than Hong military reconnaissance imaging satellite. However, China's civilian and military space and missile programmes are also directly integrated in function and practice. The Chinese civilian technical launch authority, CALT, is also responsible for the development of military missiles such as the 'M' series through its military subsidiary, the Beijing Wan Yuan Industry Corporation. In July 1999, the US DIA and CIA accused CALT of supplying North Korea with advanced ballistic missile systems, probably in reaction to the May 1999 US bombing of the Chinese Embassy in Belgrade.

Military and dual-use applications probably account for approximately 60 per cent of China's total space programme activities under COSTIND. While China's space programme is outwardly commercially oriented, many of its activities have a direct relationship to military R&D and operations related to strategic and tactical missile development. All Chinese launch vehicles are spin-off derivatives of military missiles, and improved technologies from these launchers have been spun-back for the development of improved missiles and sub-systems. For example, the Long March (CZ) series of launchers have demonstrated a multiple satellite launch capability that is directly applicable to the development of MIRV warheads. Furthermore, satellites such as the Fengyun weather satellite series provide the Second Artillery with improved operational capabilities. In April 1985, a nationwide integration of space and missile units was reportedly undertaken to enable the Second Artillery to monitor all test sites and satellites in orbit. Other PLA facilities play important roles in China's space effort, such as the use of underground nuclear explosions at the Lop Nor (Lop Nur) nuclear test site to harden missile and spacecraft electronic systems to harsh radiation environments. Military satellite launch is usually from the Xichang Space Centre, and telemetry, tracking and control is provided by the Xi'an Satellite Monitoring Centre. COSTIND operates a total of about seven primary space tracking and control and signals intelligence stations spread across the country under its China Launch and Tracking Control General (*Weixing Fashe Cekong Xitong Zongbu*). The latter also has responsibility for all launch centres and the related Luoyang Institute of Tracking, Telecommunications and Technology, and the Beijing Special Engineering and Design Research Institute (launch and tracking facility development), with a total staff of some 5,000 engineers and technicians. In January 2000, the 'PLA Daily' announced the creation of a 'military space research centre' at the PLA 'Arm and Command Technologies College' that will research space launch control and space warfare, including the use of various simulation facilities.

4.3 Launch Vehicles TOP

4.3.1 CZ-1 (LM-1)

The first Chinese satellite was launched in 1970 using a Chang Zheng 1 (CZ-1) or Long March 1 (LM-1) satellite launch vehicle (SLV). The DFH-1 satellite weighed 173 kg and was placed into a low earth orbit (LEO) varying between 440 km and 2,400 km altitude. The original CZ-1 SLV was only launched twice, in 1970 and 1971, but in 1985 the Chinese started advertising a CZ-1C (LM-1C). The Chinese have designed missiles specifically for the export market, holding development until export orders have been placed, and the same approach has been pursued in the satellite launch vehicle business. The CZ-1C was to have been a three stage liquid propellant SLV with a launch weight of 88,000 kg with the capability of putting around 600 kg into LEO. There were no orders for the CZ-1C and it is presumed that the project has been terminated. In 1987 a CZ-1M version was offered. This was a three stage SLV with two liquid propellant stages and a third solid-propellant stage, which could use either Italian or American solid motors. This SLV proposal had a launch weight of 85,000 kg and the capability to put a 900 kg payload into LEO. The CZ-1M proposal is also believed to have been terminated. In 1988 the Chinese proposed a third version, CZ-1D, that has two liquid propellant stages and a solid-propellant third stage, but using a Chinese solid-propellant motor. The first launch was planned for 1992. The CZ-1D is being marketed by the CGWIC and is believed to be designed and developed by the CALT.

The CZ-1D has a total length of 28.02 m, a body diameter of 2.25 m and a launch weight of 81,000 kg. The first stage has a length of 17.84 m, a body diameter of 2.25 m, an empty weight of 4,100 kg, a propellant weight of 60,000 kg and a total launch weight of 64,100 kg. There are four YF-2A motors using UDMH and nitric acid with a maximum burn time of 130 seconds and a sea level thrust of 28.1 t each. Each of the YF-2A motors have moving vanes in the exhaust nozzles for control. The second stage has a length of 5.35 m, a body diameter of 2.25 m, an empty weight of 2,540 kg, a propellant weight of 12,200 kg and a total weight of 14,740 kg. There is a single YF-3A motor, but with two combustion chambers, both now gimballed for control. The YF-3A uses UDMH and nitrogen tetroxide, has a maximum burn time of 120 seconds and a vacuum thrust of 30 t. The third stage has a length of 2.2 m, a body diameter of 2.0 m, an empty weight of 250 kg, a propellant weight of 625 kg and a total weight of 875 kg. The single solid-propellant motor is believed to have a thrust of about 3 t but there are no details available. It is reported that control for the third stage uses a cold gas nitrogen system but this has not been confirmed by the Chinese. It is believed that the guidance system is inertial with an onboard digital computer, similar to that used for CZ-3. The payload section has a length of 2.63 m, a body diameter of 2.05 m and a capability to place 750 kg into LEO.

4.3.2 CZ-2C (LM-2C)

The CZ-2 development programme was initiated in 1966, using design and technologies from the DF-5 ballistic missile project, by the Beijing Wan Yuan Industrial Corporation. The first launch of a CZ-2A was attempted in November 1974 but this was unsuccessful. A modified version CZ-2C was successfully launched a year later in November 1975 with the first recoverable Chinese satellite. All the CZ-2C launches have been made from the Jiuquan (Shuang Cheng Tzu) launch site. It is believed that the DF-5 intercontinental range ballistic missile programme was slowed down during the early 1970s to enable the design effort to be concentrated on the CZ-2 SLV, as the Chinese felt that it was more important to have military space-based electronic monitoring and surveillance (camera) assets. The objective was to have an SLV that could place a 2,000 kg payload into LEO. There were considerable similarities between the FB-1 and CZ-2 designs, as both came from the DF-5, and this caused some confusion during the 1970s. However, it is known that the FB-1 had four failures out of eight launches and carried a considerably smaller payload. The CZ-2 is marketed by the CGWIC and it is believed that the CZ-2C is manufactured by the CALT.

The CZ-2C (LM-2C) is a two stage liquid propellant SLV, with a total length of 32.57 m, a body diameter of 3.35 m, and a launch weight of 192,000 kg. Later versions have an increased length to 35.15 m (due to a longer payload section) and a launch weight believed to be around 194,000 kg. The first stage has a length of 20.52 m, a body diameter of 3.35 m, a dry weight of 9,000 kg, a propellant weight of 142,000 kg and a total launch weight of 151,000 kg. There are four YF-20 motors using UDMH and nitrogen tetroxide with a maximum burn time of 130 seconds and a sea level thrust of 71 t each. Each of the YF-20 motors are gimballed for control. The second stage has a length of 7.5 m, a body diameter of 3.35 m, a dry weight of 4,000 kg, a propellant weight of 35,000 kg and a total launch weight of 39,000 kg. There is a single YF-22 motor using UDMH and nitrogen tetroxide with a maximum burn time of 110 seconds and a vacuum thrust of 73 t. The YF-22 motor is simply a modified YF-20 but control for the second stage uses four YF-23 gimballed vernier motors each with a vacuum thrust of 1.1 t. The YF-23 vernier motors continue on after the shut down of the YF-22 second stage motor, to provide guidance and orbit adjustment, with a total burn time of 300 seconds. The payload section of the earlier CZ-2C had a length of 4.55 m, a body diameter of 3.35 m, an empty weight of 300 kg and a payload weight of 1,800 kg.

Guidance for the CZ-2C is inertial with on-board computer control, believed to have been designed by the Micro-Electronic Research Institute. The early CZ-2C SLV had a payload capability of 1,800 kg into LEO, with orbits typically in the 160 km to 400 km altitude bracket. Later versions, from 1987 onwards, had a payload capability of 2,100 kg into LEO with orbits between 200 km and 300 km altitude. The length of the payload section on the later SLV is increased to 7.13 m, the propellant weight in the first stage is increased to 144,000 kg and the thrust of the second stage motor is increased to 77 t.

4.3.3 CZ-2C/SD (LM-2C/SD)

In 1986 the Chinese proposed seven versions of the CZ-2C SLV for possible use but this figure appears to have now been reduced to one, known as the CZ-2C/SD. The CZ-2C/SD (smart dispenser) version is believed to have a total length of 40.0 m, a body diameter of 3.35 m and a total launch weight of 213,000 kg. The changes from the standard CZ-2C versions are reported to be an increased length stage 2, with an additional 20,000 kg of propellant carried, and the use of the smart dispenser with an orbit transfer stage to release two satellites and a commercial perigee kick motor (CPKM). This should provide a payload capability into LEO increased to 3,500 kg. It is believed that a HEXI Corporation CPKM with a 1.2 m diameter solid-propellant motor was used, with the first launch of a CZ-2C/SD undertaken in 1997.

4.3.4 CZ-2D (LM-2D)

The CZ-2D version was first launched in August 1992. Despite plans to develop a modified CZ-2C using an American payload assist module, the CZ-2D actually used developments from the CZ-2E, CZ-3 and CZ-4 programmes. There had been 3 CZ-2D launches, all from the Jiuquan launch site by the mid-1990s. The CZ-2D is marketed by the CGWIC and it is believed that it is manufactured by the Shanghai Academy of Spaceflight Technology (SAST).

The CZ-2D (LM-2D) is a two stage liquid propellant SLV, with a total length of 38.3 m, a body diameter of 3.35 m and a launch weight of 232,000 kg. The first stage is similar to that used for the CZ-4 and CZ-2E SLVs, and the second stage is believed to be the same as the second stage of CZ-4. The first stage has a length of 24.66 m, a body diameter of 3.35 m, a dry weight of 9,500 kg, a propellant weight of 183,200 kg and a total launch weight of 192,700 kg. There are four YF-20B motors using UDMH and nitrogen tetroxide with a maximum burn time of 156 seconds and a sea level thrust of 76 t each. Each of the YF-20B motors are gimballed for control. The second stage has a length of 10.41 m, a body diameter of 3.35 m, a dry weight of 4,000 kg, a propellant weight of 35,550 kg and a total launch weight of 39,550 kg. There is one YF-22B motor using UDMH and nitrogen tetroxide with a maximum burn time of 127 seconds and a vacuum thrust of 73.6 t. Control of the second stage uses four YF-23B gimballed vernier motors each with a vacuum thrust of 1.2 t and these burn for 136 seconds. Guidance for the CZ-2D is inertial with on-board computer control. The payload section has a length of 3.23 m, a body diameter of 3.35 m and a capability of placing 2,600 kg into LEO with orbits in the 170 km to 350 km altitude bracket. It is possible that with a longer payload section then the payload could be increased.

4.3.5 CZ-2E (LM-2E)

The first launch of a CZ-2E was in July 1990. CZ-2E are launched from the Xichang launch site. This SLV is marketed by the CGWIC and it is believed to be manufactured by the CALT.

The CZ-2E (LM-2E) is a two stage liquid propellant SLV with four liquid propellant strap-on boosters attached to the first stage. It has a total length of 51.17 m, a body diameter of 3.35 m and a launch weight of 464,000 kg. The strap-on boosters have a length of 16.02 m, a body diameter of 2.25 m, an empty weight of 3,000 kg, a propellant weight of 38,000 kg and a total launch weight of 41,000 kg each. Each booster has a single YF-20B motor using UDMH and nitrogen tetroxide with a maximum burn time of 125 seconds and a sea level thrust of 76 t. The first stage has a length of 23.7 m, a body diameter of 3.35 m, an empty weight of 9,500 kg, a propellant weight of 187,000 kg and a total launch weight of 196,500 kg. There are four YF-20B motors using UDMH and nitrogen tetroxide with a maximum burn time of 160 seconds and a sea level thrust of 76 t each. Each of the YF-20B motors are gimballed for control. The second stage has a length of 15.52 m, a body diameter of 3.35 m, an empty weight of 5,500 kg, a propellant weight of 86,000 kg and a total weight of 91,500 kg. There is a single YF-22B motor using UDMH and nitrogen tetroxide with a maximum burn time of 300 seconds and a vacuum thrust of 76 t. Control for the second stage uses a hydrazine monopropellant with four pitch motors, four roll motors and two yaw motors (common to the CZ-3 third stage). Small solid motors spin-up the second stage and payload sections just prior to separation, and then tumble the empty second stage after separation using 12 springs. Guidance for the CZ-2E is inertial with an on-board digital computer. There are radio command and self-destruct systems, a 380 to 400 MHz telemetry system with two 15 W transmitters, and radar transponders to assist in tracking each of the stages. The payload section has two length options, 10.5 or 11.95 m, a body diameter of 4.2 m and a capability of placing up to 9,000 kg into LEO, 3,100 kg into geostationary transfer orbit (GTO), or 1,700 kg into geostationary orbit (GEO). Chinese diagrams show that a liquid or solid-propellant perigee kick motor has been fitted to the CZ-2E payload section but there are no details available.

4.3.6 CZ-2E/TS (LM-2E/TS)/ CZ-2F (LM-2F)

There have been several reports concerning improved CZ-2E versions. Reports in 1996 suggested that a twin satellite version (CZ-2E/TS) was being offered by the Chinese. It is believed that the larger HEXI Corporation CPKM (designated FG-46) might be used for the CZ-2E/TS. The FG-46 is a solid-propellant 1.7 m diameter motor that is 2.5 m long. It uses the HTPB propellant with a weight of 5,445 kg in a fibre glass motor case, with a total weight of 5,980 kg. The CPKM could increase the payload by some 10 per cent. The Chinese are to undertake manned spaceflight during the upcoming decade (see section 4.5), and the CZ-2E/TS's follow-on CZ-2F will be used as it has the capability to put around 10,000 kg-12,000 kg into LOE.

At the 1998 Zhuhai Air Show, CALT introduced models of the CZ-2EA that will perform the function of a launcher for new manned capsules (i.e. CZ-2F). The CZ-2F stands some 50 m tall with a two-stage core with four liquid strap-on first stage boosters. It has a total of eight first stage YF-20 engines (four in the core and one each on the strap-on boosters), and a single YF-22 engine in the second stage, all using nitrogen tetroxide and UDMH liquid propellants. The CZ-2F also has a Soyuz-like emergency escape rocket system for the manned capsule.

4.3.7 CZ-3 (LM-3)

It is believed that the requirement for CZ-3 was to place a 1,400 kg payload into geosynchronous transfer orbit (GTO), and to achieve this the Chinese developed a cryogenic third stage motor system. Work on the cryogenic motor started at the Liquid Fuel Engine Research Institute around 1965, a first combustion test was made in 1971 and complete motor tests started in 1975. Re-ignition tests were started in 1979 but a series of development problems delayed successful long burn and re-ignition tests until 1983. The first launch of the CZ-3 SLV was made in January 1984. The CZ-3 is launched from the Xichang launch site. It is marketed by the CGWIC and is believed to be manufactured by the CALT for the third stage and payload and by the SAST for the first and second stages.

The CZ-3 (LM-3) is a three stage liquid propellant SLV, basically using the two stages of the CZ-2C with a cryogenic third stage added. The total length is 43.85 m, the body diameter 3.35 m and the total launch weight is 202,000 kg. The first stage has a length of 20.22 m, a body diameter of 3.35 m, an empty weight of 9,000 kg, a propellant weight of 142,000 kg and a total launch weight of 151,000 kg. There are four YF-20 motors using UDMH and nitrogen tetroxide with a maximum burn time of 130 seconds and a sea level thrust of 71 t each. Each of the first stage YF-20 motors are gimballed for control. The second stage has a length of 9.71 m, a body diameter of 3.35 m, an empty weight of 4,000 kg, a propellant weight of 35,000 kg and a total launch weight of 39,000 kg. There is a single YF-22 motor using UDMH and nitrogen tetroxide with a maximum burn time of 110 seconds and a vacuum thrust of 73 t. Control for the second stage uses four YF-23 gimballed vernier motors each with a vacuum thrust of 1.1 t that burn for up to 300 seconds. The third stage has a length of 7.48 m, a body diameter of 2.25 m, an empty weight of 2,000 kg, a propellant weight of 8,500 kg and a total weight of 10,500 kg. There is a single YF-73 cryogenic motor using liquid oxygen and liquid hydrogen with a total burn time of 800 seconds and a vacuum thrust of 4.5 t. The YF-73 motor uses a single turbopump assembly feeding four gimballed combustion chambers, and this motor can be stopped and restarted once in flight. Stability control is provided for the third stage by a hydrazine monopropellant system with four roll, four pitch and two yaw motors.

Guidance for the CZ-3 is inertial with on-board computer control, and there are three telemetry channels operating on 400 MHz, 3 GHz and 5 GHz. There is no telemetry on the first stage but data recorders are recovered from the down-range wreckage. The payload section has a length of 6.44 m, a body diameter of either 2.32 m or 2.72 m, and an empty weight of 500 kg. The payload fairings are fibre glass and in two halves, these are jettisoned in space by either explosive bolts with springs or by an explosive cutting chord. It is believed that the jettison is made during boost at around 120 km altitude. The CZ-3 capability has been demonstrated with payloads of up to 1,400 kg into GEO and it is expected to be able to place payloads up to 4,500 kg into LEO.

4.3.8 CZ-3A (LM-3A)

The first launch of a CZ-3A was made in February 1994 from the Xichang launch site. The CZ-3A is marketed by the CGWIC and is believed to be manufactured by the CALT. As of January 2000, the CZ-3A has been launched four times since 1994 for telecommunications satellites and an experimental scientific capsule missions.

The CZ-3A (LM-3A) is a three stage liquid propellant SLV, with a total length of 52.33 m, a body diameter of 3.35 m, and a launch weight of 240,000 kg. The first stage has a length of 23.08 m, a body diameter of 3.35 m, an empty weight of 9,500 kg, a propellant weight of 170,000 kg and a total launch weight of 179,500 kg. There are four YF-20B motors using UDMH and nitrogen tetroxide with a maximum burn time of 130 seconds and a sea level thrust of 76 t each. Each of the YF-20B motors are gimballed for control. The second stage has a length of 11.53 m, a body diameter of 3.35 m, an empty weight of 4,000 kg, a propellant weight of 29,600 kg and a total weight of 33,600 kg. There is one YF-22B motor using UDMH and nitrogen tetroxide with a maximum burn time of 110 seconds and a vacuum thrust of 73.6 t. Control of the second stage uses four YF-23B gimballed vernier motors each with a vacuum thrust of 1.2 t, and these burn for up to 300 seconds. The third stage has a length of 8.84 m, a body diameter of 3.0 m, an empty weight of 3,000 kg, a propellant weight of 17,600 kg and a total weight of 20,600 kg. There are two YF-75 cryogenic motors using liquid oxygen and liquid hydrogen with a maximum burn time of 470 seconds and a single restart capability, each motor has a vacuum thrust of 8 t. Control of the third stage uses a hydrazine monopropellant system with four roll, four pitch and two yaw motors. Guidance for the CZ-3A is inertial with an on-board digital computer, and it is believed to use a strap-down inertial platform. The payload section has a length of 8.89 m, a body diameter of 3.35 m and the capability to place a 2,500 kg payload into a geostationary transfer orbit. About 8,500 kg payload could be placed into LEO.

4.3.9 CZ-3B (LM-3B)

It is believed that the CZ-3B is a CZ-3A SLV with the addition of the four liquid strap-on boosters developed for the CZ-2E. The requirement appears to have been to double the payload of the CZ-3A into geostationary transfer orbit to 5,000 kg. The first launch of the CZ-3B took place in February 1996 but was a failure. However, all subsequent CZ launches have proved successful. On 20 August 1997, a LM-3B SLV successfully launched a Philippine telecommunications satellite. Launches are made from the Xichang launch site. The CZ-3B is marketed by the CGWIC and manufactured by the CALT.

The CZ-3B (LM-3B) is a three stage liquid propellant SLV with four liquid propellant strap-on boosters attached to the first stage. The CZ-3B has a total length of 54.8 m, a body diameter of 3.35 m, and a launch weight of 426,000 kg. The strap-on boosters have a length of 16.02 m, a body diameter of 2.25 m, an empty weight of 3,000 kg, a propellant weight of 38,000 kg and a total launch weight of 41,000 kg each. Each booster has a single YF-20B motor using UDMH and nitrogen tetroxide with a maximum burn time of 125 seconds and a sea level thrust of 76 t. There are no confirmed details of the three stages of the CZ-3B but it is believed that these are similar to the three stages of the CZ-3A. However, if the reported total launch weight of 426,000 kg is correct then CZ-3B would probably have one or more lengthened stages compared to CZ-3A. One report suggests that the second stage has been lengthened but this has not been confirmed. The payload section of CZ-3B is reported to have a body diameter of 4.2 m and the capability to place 4,850 kg into GTO and up to 12,000 kg into LEO.

4.3.10 CZ-3C (LM-3C)

It is believed that the CZ-3C is similar to the CZ-3B but with only two strap-on liquid propellant boosters attached to the first stage. This would give the CZ-3C a total length of 54.8 m, a body diameter of 3.35 m and a launch weight of 344,000 kg. This could probably place around 10,000 kg into LEO and presumably might also be considered for the manned spaceflight/space station programme in some capacity.

4.3.11 CZ-4 (LM-4)

It is believed that the CZ-4 was originally intended as a launcher for Chinese geostationary satellites but that when the payload was found to be insufficient it was adapted for launching polar orbiting meteorological satellites. The first and second stages appear to be identical to those used in the CZ-2D, with a third stage added. The first launch was made in September 1988 and a second in September 1990, both of which were successful. The launches were made from the Taiyuan (Wuzhai) launch site. The first CZ-4 SLV was shown in photographs by the Chinese marked as LM-4A, although the Chinese specifications simply refer to the CZ-4 (LM-4). It is not known if there is any significance in this difference but as the follow-on launcher is designated CZ-4B then presumably the references to CZ-4 in the specifications actually refer to the CZ-4A. The CZ-4 is marketed by the CGWIC and has been manufactured by the SAST.

The CZ-4 (LM-4) is a three stage liquid propellant SLV, with a total length of 41.88 m, a body diameter of 3.35 m and a total launch weight of 249,000 kg. The first stage has a length of 24.66 m, a body diameter of 3.35 m, an empty weight of 9,500 kg, a propellant weight of 183,200 kg and a total launch weight of

192,700 kg. There are four YF-20B motors using UDMH and nitrogen tetroxide with a maximum burn time of 156 seconds and a sea level thrust of 76 t each. Each of the YF-20B motors are gimballed for control.

The second stage has a length of 10.41 m, a body diameter of 3.35 m, an empty weight of 4,000 kg, a propellant weight of 35,550 kg and a total weight of 39,550 kg. There is one YF-22B motor using UDMH and nitrogen tetroxide with a maximum burn time of 127 seconds and a vacuum thrust of 73.6 t. Control of the second stage uses four YF-23B gimballed vernier motors each with a vacuum thrust of 1.2 t and these burn for 136 seconds.

The third stage has a length of 1.92 m, a body diameter of 2.90 m, an empty weight of 1,000 kg, a propellant weight of 14,150 kg and a total weight of 15,150 kg. There are two YF-40 motors using UDMH and nitrogen tetroxide with a maximum burn time of 321 seconds and a vacuum thrust of 5.1 t each. Control of the third stage is by gimballing the two YF-40 motors, and during the coast and final trim before payload separation a set of 14 hydrazine monopropellant thrusters are used to control roll, pitch and yaw (similar to the CZ-2E second and CZ-3 third stage systems).

Guidance for the CZ-4 is inertial, with on-board computer control. The payload section is 4.91 m long, has a body diameter of 2.90 m and an empty weight of 800 kg. The CZ-4 is reported to be capable of launching a 1,500 kg payload into a sun synchronous polar orbit at around 900 km altitude and a 4,000 kg payload into LEO. A second payload fairing offered for use has a length of 8.48 m and a diameter of 3.35 m.

4.3.12 CZ-4B (LM-4B)

An upgraded CZ-4 version, known as CZ-4B, was first reported in 1994. It is believed that the CZ-4B has an improved third stage, using YF-40B motors. The CZ-4B has a total length of 43.01 m, a body diameter of 3.35 m and a total launch weight of 254,500 kg. The improved third stage has a length of 6.24 m, a body diameter of 2.90 m and a total weight of 16,700 kg. The two gimballed YF-40B motors use UDMH and nitrogen tetroxide, with a maximum burn time of 412 seconds and a vacuum thrust of 5.2 t each. These motors are able to restart once. The payload capability is expected to increase to 2,800kg into a sun synchronous orbit at 900 km altitude or to 4,200 kg in LEO. In 1999, a CZ-4B conducted the successful simultaneous launch of two satellites.

4.3.13 Other SLV Developments

Since 1970, China has developed various SLV technologies that are summarised in Table 4.4.

Table 4.4 Chinese Satellite Launch Vehicle Technologies

· multi-stage rockets

· flight trajectory optimisation

· stage separation and high-altitude ignition systems

· satellite fairings and large payload fairings

· lightning protection systems

· nitric acid/UDMH liquid propellant rocket engines

· LH2/LOX cryogenic engines

· rocket engine clustering technology

· connection, unlock and separation of liquid propellant boosters

· optimum propellant utilisation

· engine bi-directional gimballing and related control technology

· SLV spin-up and lateral manoeuvres

· hydrogen operated bi-directional gimballing servo-mechanisms

· nozzle extension made of section-variable helical tubes

· high-speed cryogenic dynamic seals

· prevention of subsynchronous vibration of high-speed cryogenic turbopumps

· engine restart under low-temperature, high-vacuum and low-gravity conditions

· cryogenic propellant tank and vacuum common bulkhead of tanks

· thermal insulation of cryogenic propellant tanks

· cryogenic valves and propellant safety

· cryogenic propellant management in a low-gravity environment

· POGO attenuation

· low-frequency vibration control technology for entire SLVs

· cold helium pressurisation

· surface tension tanks

· polysulfide rubber solid-propellant rocket motors

· solid-propellant supper stage motors

· aluminium-magnesium alloy thin-wall tank and common bulkhead storage tanks

· pressure-fed tank pressurisation

· hydrostatic gas bearing inertial instruments and platforms

· hydrodynamic gas-supported inertial instruments

· dynamic tuned inertial instruments

· high-accuracy four-gimbal inertial platforms

· all-inertial strap-down compensated guidance systems

· onboard computers

· high-accuracy fully-compensated platform-computer guidance systems

· altitude control for multi-stage SLVs

· attitude control motors and related technologies (e.g. analogue /digital attitude control)

· thrust vector control and electromechanical hydraulic servo-mechanisms

· vertical takeoff lateral shift controls

· rocket transverse bending vibration controls

· propellant sloshing/anti-vortex controls

· jet vane and vane actuating mechanisms

· automatic self-destruct software

· use of NASA-standard ISO-9000 technical quality assurance guidelines following launch accidents in 1994, 1995 and 1996, as well as improved launch and range safety regulations

Reports dating from 1996 suggest that the Chinese are developing a first stage cryogenic propellant motor system that would provide the capability to put 20,000 kg payloads into LEO. It has also been reported that Zenit SLV kerosene-oxygen engine technology from Russia has recently been made available to China, though it is possible that such technology may have come from the Ukraine as well. A report from June 2000, indicated that a new kerosene-oxygen engine was successfully tested at the Fengzhou Test Centre. China is also believed to have the technology required to develop an oxygen-hydrogen engine comparable to the European Vulcain used for the Ariane-5 heavy SLV and the Japanese LE-7 used for the H-2 heavy SLV.

A report in 1994 suggested that Chinese solid-propellant booster technology had matured so that solid strap-on boosters might be offered in future alternatives for the CZ-2E, CZ-3B, CZ-3C liquid strap-on booster motors, or as additions to the CZ-4A or CZ-4B SLVs. The solid-propellant booster motors are believed to be 7.0 m long, with a body diameter of 1.4 m and a sea level thrust of 57.5 t each. Clusters of six or eight have been proposed for heavy launch vehicles. The DF-31 and DF-41 solid-propellant ICBMs would also appear to have a SLV potential and are indicative of China's maturing technology in this propulsion area.

In 1999, CALT announced the development of two new SLVs: the CZ-1D for launching small satellites of under 1,000 kg to LEO; and the CZ-3C with two additional first stage boosters for launching satellites of up to 3,700 kg to earth-synchronous transfer orbits. Larger SLVs with capacities of up to 15 tons to low earth orbit and 7 tons to geosynchronous orbit are also to make their appearance soon, according to CALT.

Since the mid-1980s there have also been speculative reports of China's intent to develop a heavy Saturn-1 class or Ariane-5 class launcher (20-70 ton payload to LEO). This might be an upgraded derivative of the current CZ-3B or CZ-2E launch vehicles, China's most powerful operational launchers, to support a manned space programme at the Jiuquan launch site. Recent reports have indicated the possible development of a CZ-5 series that could deliver a 20 ton payload to LEO, a first step to a true heavy launch capability that could be used for the transport of space station component modules. Any near-term Chinese manned mission, and a possible unmanned probe to the moon in the next decade, would be primarily motivated by considerations of global political prestige. However, manned space efforts over the next two decades could increasingly improve China's military space capabilities (e.g. construction of large space-based anti-satellite and anti-missile systems). Such major space developments could also lay the groundwork for increased space exploration with the other major space powers, particularly the US.

4.4 Satellite Programmes TOP

4.4.1 Telecommunications

China has identified telecommunications as one of 12 priority fields of foreign high technologies targeted for import, and has specified areas such as direct broad educational systems, small satellite telecommunications systems, and the integration of telecommunications and remote sensing systems for natural disaster monitoring. A domestic satellite system with 55 earth stations has been established. International satellite earth stations include five Intelsat (four Pacific Ocean and one Indian Ocean), one Intersputnik (Indian Ocean Region) and one Inmarsat (Pacific and Indian Ocean Regions). International fibre-optic links have also been established to Japan, South Korea, and Hong Kong.

The key organisations for the ownership and operation of space communications infrastructures have until recently been the China Telecommunications Broadcasting Company (ChinaSat), part of the Ministry Information Industry, and the competing China Unicom ('the Second Carrier') controlled by the Ministry of Information Industry and the Ministry of Railways and Electric Power. ChinaSat developed and managed the communication infrastructure linked to the domestic space segment and very small aperture satellite terminals (VSAT) services. China Unicom participated in local and long distance fixed, mobile, satellite and cellular communications traffic. However, during July 2000 China's central government State Council approved the break up of the market monopoly of the national telecommunications sector. China Telecom was divided into two parts: China Telecom and China Mobile. Major competitors now include China Unicom, China Netcom, and China Jitong. China Orient Telecomm Satellite Company Limited, Beijing, was established in 1995 to provide satellite services for China Telecom, and operates the US-manufactured Chinastar-1 telecommunications satellite, which according to some US claims may be used for PLA communications in addition to commercial applications.

APT Satellite Company Ltd., Hong Kong, provides the mainland telecommunications services via its Apstar-*1A* satellites that were built by Hughes Space and Communications Company. The Ministry of Information Industry also promulgated Telecommunications Service Standards to urge telecoms operators to improve service quality. The PLA and China Telecom are also divesting their shares of Great Wall Telecommunications Company to China Unicom, although the military has been reluctant to depart completely from the lucrative urban second generation CDMA technology mobile-phone market and its associated technological spin-offs (see Chapter Nine, section 9.4.4). China APMT, established in April 1998, is participating in the Asia-Pacific Mobile Telecommunications Satellite systems programme, together with Singapore, Thailand, Malaysia, Japan and Indonesia. China APMT represents COSTIND, the Ministry of Information Industry, CAIC, and the China Resources (Holding) Company, Ltd.

In September 2000, Singapore Telecommunications announced the formation of a strategic alliance with China Netcom to provide corporate communications services between China and international cities. In the same month, China Unicom, the Hong Kong-listed vehicle of China United Telecommunications, the mainland's second-largest telecommunications operator, announced that it would sign a joint-venture agreement with Hutchison Telecommunications (Hong Kong), the telecommunications arm of multi-billionaire Li Ka-shing's conglomerate Hutchison Whampoa. China Unicom stressed it would emphasise mobile network optimisation, sales and marketing, telecoms-related consultancy and training in the mainland. It will have a majority control in the joint venture, Great Wall Telecom Networks, due to mainland regulations limiting foreign investors holding a minority stake in Chinese telecommunications SOEs. However, the organisational structure of China's rapidly developing telecommunications sector is changing on an almost weekly basis and further significant developments are anticipated.

The Number 54 Research Institute is a key developer of mobile satellite communications earth stations, satellite TV receivers, and narrow-band small-capacity over-the-horizon microwave communications systems. The Telecommunications, Telemetry and Telecontrol Research Institute, the China Academy of Engineering Physics and the Nanjing Research Institute of Electronics Technology have developed Ku-band direct broadcast satellite communications systems. Vehicle mounted and dual polarisation satellite earth stations have been developed by the Shijiazhuang Number 54 Research Institute and the Nanjing Research Institute of Electronics Technology. Satellite TV receiving stations have been developed by the China Jiangnan Space Industry Group Corporation. A mini meteorological satellite image/data receiving system has been developed by the High and New Technology for Peace and Development Company Ltd.

The DAMA communication system developed in Beijing is the fundamental technology for the widely used VSAT system network. The widespread utilisation of DAMA technology is expected to significantly enhance the development of China's satellite telecommunication technology. China is expected to have over 8,000 two-way VSAT systems by 2002, the largest user in Asia Pacific. Over 80 per cent of China's population is currently able to receive television satellite broadcasts.

While China has been launching geostationary communications satellites since 1984, previous domestic Chinese communications technology (DFH-1, DFH-2) was believed by many to have been below international standards. In November, 1994, China launched and lost its next generation Dongfanghong ('the East is Red') DFH satellite, built by CAST with Ku-band technology, antennae reflectors, momentum wheels and wave tube amplifiers supplied by Daimler-Benz Aerospace AG (DBA, formerly Deutsche Aerospace). This German firm and the CAIC had agreed in 1993 to establish the 'EurasSpas' joint-venture to develop the next generation of 'Hughes 601-class' domestically produced Chinese communications satellite series. On 12 May 1997, a CZ-3A successfully launched the follow-on DFH-3 large volume telecommunications satellite with start-of-the-art technologies for domestic telephone, fax, data and video broadcast services.

A CZ-3B, one of China's most powerful SLVs, launched the French-made Sinosat-1 telecommunications satellite to geosynchronous orbit (24 C-band and 14 KU-band transponders that cover the entire Asia-Pacific region) from Xichang on July 18, 1998. Sinosat-1 was manufactured by Aerospatiale and supplied by the Chinese-German joint-venture EurosSpace GmbH, and owned and operated by the domestically owned Sino Satellite Communications Company Ltd. of China. With an intended 15 year lifespan it will provide multiple services including data transfer and ATC functions. A similar system termed Zhongxing (China Star) 22/ChinaSat-22 was launched into geosynchronous orbit on 25 January 1999 on a CZ-3A from the Xichang launch centre. There have been US claims that ChinaSat-22, or UHF

C-band Feng Huo-1, is a military telecommunications satellite that will be the first of several satellite components for a secure Qu Dian C^4I, high-capacity automated data-link, tactical battle management information system, which will integrate and distribute data from air, land and naval units in real-time. The 2,300 kg Zhongxing-22 has a projected lifespan of eight years.

Spar Aerospace Ltd. of Canada has supplied satellite communications and data-broadcast technology linked to the Asiasat and ChinaSat satellite network systems, which will interconnect more than 70 Chinese transportation centres in such cities as Beijing, Shanghai, Chengdu, and throughout the western region of the country. The Asiasat-1 and Asiasat-2 geosynchronous telecommunications satellites operated from Hong Kong, but with substantial investment by the Chinese defence-related conglomerate CITIC, provide Chinese telecommunication services including voice, data, direct broadcast TV, and VSAT networks. In July 2000, the Space and Technology Group of EMS Technologies Canada Ltd. agreed to supply CAST repointable, lightweight Ku-band antennas, pointing mechanisms and related electronics for the DFH-3 series of communications satellites. Italy is also to co-develop a new telecommunications satellite with China. In 1999 Alenia Aerospazio announced that it had received a contract from CAIC to design a data-relay satellite that could be used with Chinese reconnaissance/remote-sensing satellites and a potential future manned space station to permit non-line-of-sight communications with ground stations.

As the US increasingly restricts its advanced dual-use space technologies to China as a result of the Cox Report and related investigations, Beijing will probably turn to sources such as Europe and Canada for telecommunications and remote sensing systems it has difficulty developing domestically. While US satellite manufacturers oppose such restrictions, US commercial launch service providers also fear 'below market cost' Chinese launch services and have sought restrictions in this area. Nevertheless, there were discussions by senior corporate executives from around the world, including CGWIC, during 1998 about forming a global cartel for the provision of commercial space launch services.

Recent reports have suggested that China intends to develop new telecommunications satellite frequency bands (such as Ku, Ka UHF, L, S, and X) by 2010 to supplement the C band system currently in use, and to expand the C band system from 500Mhz to 800Mhz. The development of a national information highway with broad capability space-based components will include multi-user time sharing facilities of 60-120 megabyte per second transmission capacities, together with 100 megabyte per second communications satellite performance. VSAT development for voice, data, graphics, characters and TV broadcasts is a national priority. Inter-communications between different satellite systems, automated Internet/satellite control and security systems, and improved production and processing technologies related to satellite communications systems, are other national priorities.

It seems probable that the PLA has greatly increased its command, control and communications and targeting capabilities through the use of civil telecommunications and US GPS and Russian GLONASS satellite positioning systems. China's national time authorisation centre at the Shanxi Astronomical Station is co-ordinated with the US GPS network. During 2000, China and Russian moved towards an agreement for China's use of the GLONASS GPS system, probably in exchange for Chinese financial support to upgrade the system. The 'Twin Star Programme' is reportedly a domestic effort to develop a Chinese GPS system of two to four navigation satellites at geosynchronous orbit after 2000 (prototype navigation satellites were apparently developed by the early 1980s but have not been launched to date). China Aerospace International Holdings Ltd. (CASIL) is reportedly marketing a Mobile Object Tracking Control System that uses GPS and geographic information systems (GIS) to provide location data for moving objects. In November 1999, MOST claimed that Chinese GIS software (five basic software platforms, two application and development platforms, and 33 dedicated and application platforms) had made major breakthroughs for military, space, aviation and civil applications, and was at an advanced international level. In January 2000, China claimed that it had sufficient original digital data to develop digital topographic global maps to the 1:50,000 level. There are believed to be over 400 organisations in China developing GIS technologies and applications. China has recently employed a combination of GIS, GPS and remote sensing technologies for such civil applications as the precise surveying, measurement, mapping and database development of national railway systems. It is quite likely that similar military applications are also underway. GPS and GIS type systems could have military applications such as TERCOM and DSMAC missile guidance systems.

Russia and China could sign documents on co-operation regarding the use and advancement of GLONASS by late October or early November 2000. GLONASS is reportedly able to determine the exact position and speed of an object anywhere on the globe, while checking time with an error of as little as one millionth of a second. The system has important military applications and is especially important in delivering precise military strikes. The US NAVSTAR GPS system is currently the most popular of this kind, and is used for military and civilian purposes throughout the world, but the American government restricts the use and accuracy of the signal and reserves the right to cut off its availability if dictated by national security interests. China has showed interest in having GLONASS terminals installed at airports and on aircraft. Russia has also invited China to participate in financing a group of new GLONASS satellites, with the entire system eventually incorporating 24 satellites, compared to the just 14 satellites currently available, of which only nine are fully operational.

4.4.2 Remote Sensing and Reconnaissance

Various Chinese technical organisations are involved with remote sensing activities that have dual-use applications: NRSCC; RSGS; MOST; Ministry Information Industry; CNSA; and the IRSA. The CAS's IRSA was founded in 1980, and in 1981 the former State Science and Technology Commission established the NRSCC, incorporating the IRSA as a department. IRSA research staff number some 220 people. The CAS also established a related Joint Centre for Remote Sensing in Beijing during 1989 that has some 8,000 square metres of floor space, which includes a computer centre and centralised photograph processing laboratory.

These organisations are involved with the R&D and application of remote sensing in such areas as geoscience, agriculture, biology, natural disasters and environmental science. Specific research areas include radiation features of remote sensing, high spectrum remote sensing, microwave remote sensing, GIS and image processing techniques. Charged-couple device (CCD) multi-spectrum and infrared sensors have also been developed. NRSCC R&D activities include the application of supercomputers and associated advanced computing technologies, digital SAR signal processing, telephony and data transmission, and software development.

Equipment includes high-altitude aircraft and satellites equipped with high-resolution cameras (RC-10A and RC-10), multi-spectrum scanners, infrared and thermal infrared scanners, spectrum imagers, and SAR systems. The IRSA also operates aircraft, such as specially modified Cessna Citation S2 light business jets, to monitor natural disasters and assist in natural resource development. China has developed its own technologies for airborne image transmission, SAR, airborne imaging spectrometers, and multispectral scanners. During 1997, China announced the development of an 'all-weather real-time aviation remote sensing system' as a key national scientific accomplishment. China has had an airborne SAR system for a number of years with the payload designed by the Institute of Electronics of Academia Sinica (IEAS).

For ground segment operations, NRSCC manages the dedicated Chinese Remote Sensing Ground Station, Beijing, that provides coverage of about 85 per cent of mainland China, and all of the Koreas, Taiwan and Japan. For space applications, there are some 350 earth observation institutes, with several thousand scientists and researchers under the mandate of NRSCC. Meteorological satellite data collection platforms and ground receiving stations have been developed by the 10th Research Institute and the Nanjing Da Qiao Machine Factory.

The first generation of military recoverable Fanhui Shi Weixing ('Return Test Satellite') FSW-1 photographic intelligence satellites was initiated in 1966 but were largely replaced by the larger, improved FSW-2 series. China's early series reconnaissance satellites usually lasted only up to seven to 10 days in orbit before the sensor payload returned to earth, although the FSW-2 series initiated in 1994 apparently can remain orbit for up to 16 to 18 days. According to some US sources, the footprint of early generation Chinese reconnaissance satellites was very small. These satellite systems were also relatively heavy (over 2,500 kg because of the heavy armour required to withstand re-entry, although China has also reportedly developed lightweight wooden ablative shielding), and equipped with optical cameras, opto-electronic imagers, radars, and infrared scanners. However, all-weather capabilities were believed to be limited due to a lack of SAR technology, which is now being developed domestically and possibly assisted through technology transfers from nations such as Canada, Russia, Germany and the UK.

FSW-type satellites are launched from the Jiuquan Launch Centre in the Gobi Desert and the Xichang Launch Centre in Gansu Province by CZ-2C launchers. They are monitored by the Xi'an Satellite Monitoring and Control Centre, operated by COSTIND, which has reportedly practised real-time orbital control of satellites since the early 1990s. Payload retrieval is believed to be undertaken by PLA helicopter units and specialists from the PLA Second and Third Military Intelligence Departments. As of 1999, China is believed to have successfully recovered 16 of its 17 launched recoverable remote sensing satellites.

It is likely that the FSW-2, with a modest 10 m ground resolution, has now been surpassed by a more advanced FSW-3 type with a resolution of from 1 m to 4 m, which would be useful for military intelligence operations such as distinguishing between different parked aircraft types. There has been a report of 'Costind Industries' of Beijing having developed an advanced Dong Than Hong military reconnaissance imaging satellite but no supporting details are available (this report may have been referring to the FSW-3 series).

Some sources indicate that China does not possess a real-time photo-reconnaissance capability and the associated technologies, while others indicate that this has been accomplished or is currently under development with CCD, CMOS, optical, electro-optical, SAR, infrared and other multispectral sensors, and with digital spread-spectrum communications to download images to centres equipped with data-fusion and GIS for precise target identification and location. China's CCDs may in fact now be third or fourth generation systems. The 509th Institute of the CAIC's 8th Academy is reportedly active in SAR satellite R&D, while CCD, infrared focal plane arrays, and fibre optics research is being undertaken by the 44th Institute of the Ministry of Information Technology, Chongqing Institute of Optoelectronics. The Beijing Institute of Control Engineering is a known centre of excellence for satellite infrared detection systems that probably have dual-use civil-military applications. While some dual-use foreign assistance has been received, the majority of China's R&D efforts in space-based reconnaissance, surveillance, and targeting are apparently domestic, and its infrared and focal array R&D programmes are believed to still significantly lag behind state-of-the-art Western systems. However, in November 1998, the CAS and Chinese Academy of Engineering announced a breakthrough in Chinese-developed output equipment for high-resolution digital imaging techniques, which had reached international calibres, and could be used for "space and remote sensing" and "the modernisation of military forces".

China has sought foreign remote sensing data from US Landsat, Japanese MOS and ETS-1 and French SPOT satellite systems. The development of geographic information systems (GIS) is a priority area. Italy's Telespazio provided, from 1992 to 1995, training, personal computers and software to the NRSCC to assist in Landsat data interpretation. The Beijing Shibao Satellite Image Company (Beijing Spot Image

Company) was established in 1998 at Miyun some 100 km from Beijing as a joint venture between the CAS Remote Sensing Ground Station and the French Space Agency and Spot Image. Its purpose is to provide high-ground resolution (full colour resolution of at least 10 m) SPOT remote sensing satellite data to Chinese users, including stated military applications. In 1997, China and Israel were discussing co-operation in the area of remote sensing, as well as smallsat systems.

China has plans to develop an L-Band SAR satellite, as verified by reports concerning Chinese space co-operation with Canadian organisations since the mid-1990s. Payload design for this SAR satellite is headed by IAES, in co-operation with CAST, with R&D support having been provided by the '863' research programme since 1988. However, CAIC has also examined the possible development of a C-band SAR satellite, also involving CAST. Applications for SAR systems could include sea and land monitoring, environmental and disaster conservation and warning, and natural resource exploration. SAR systems also have various potential military reconnaissance and observation applications.

China is also known to be interested in obtaining foreign SAR satellite technology from Canada's RADARSAT series. A space co-operation memorandum of understanding (MoU) was signed between the CNSA and the Canadian Space Agency in 1995, with RADARSAT data applications, L-Band SAR, geomatics, communications systems, and space robotics technologies being the likely areas of technology transfer to China. In 1996, another co-operative MoU was signed between the Canadian Space Agency and COSTIND 'on space collaboration for peaceful purposes' in such areas as remote sensing, satellite communications and space robotics. A RADARSAT-1 ground station is now located at the Remote Sensing Satellite Ground Station, Beijing. In 1997, Canada's MacDonald, Dettwiler and Associates supplied elements of its Fast TRACS transportable satellite earth station to China, to allow the reception and processing of SAR and optical satellite imagery from the Canadian RADARSAT-1 and French SPOT remote-sensing satellites. During 1996 Canada's Com Dev International and the Xi'an Institute of Space Radio Technology moved towards establishing the Com Dev Xi'an joint venture to produce components and electrical subsystems for Chinese communications, remote sensing and meteorological satellite systems into the next century. Such components will include space microwave filters, antennas, and ground station wave guide switches. The agreement also includes significant advanced technology transfer benefits for China.

Some sources have indicated that it is very likely that Russia has sold China data on radar satellites from its NPO Vega-M corporation, which manufactures the Russian Almaz SAR satellite series. NPO Vega-M is building a 2 m to 7 m resolution SAR that can be used as a payload in light satellites developed by the NPO Machinostroyenia and NPO Khrunichev bureaus. Russian expertise includes the integration of SAR satellite capabilities with targeting requirements. During October 1996, China announced a project for the development of a radar satellite for military and civilian missions with a projected launch by 2002 and a cost of some US$250 million. Reportedly, the British company GEC-Marconi and Germany's DASA also expressed interest in participating in this project (but China's relationship with DASA soured in 1999 after the firm sought to obtain regulatory approval to build the high-resolution Rocsat II earth observation satellite for Taiwan). Information from a secret US-UK project headquartered at the Lawrence Livermore National Laboratory to develop a satellite radar signal processing system capable of detecting the wake of a submerged submarines, is believed to have been compromised to the Chinese by Chinese-American operative Dr. Peter Lee in Beijing during May 1997. This information could be integrated with a future Chinese SAR satellite system. In July 2000, the British government rejected, under European Union export laws, a British firm's request to provide technologies for a medium-resolution radar Earth observation satellite.

Some recent reports indicate that China will establish, beginning after 2000, a six satellite global reconnaissance network, ostensibly for disaster and environmental monitoring, with four sensor imaging satellites and two SAR satellites (some sources indicate an eight satellite system split between optical and SAR systems). The optical satellite will weigh only 400 kg and the SAR satellites 700 kg and each will have three years of operational life. A new ELINT satellite system may also be under development. This follows Japan's recent announcement to field a similar constellation in response to the North Korean ballistic missile threat. Reports indicate that China's next-generation reconnaissance satellites may also have a manoeuvrability capability and stealth characteristics to counter ASAT attacks. A Chinese SAR sensor capability will also be significant as it could provide a means to detect submerged enemy submarines and underground targets such as ICBM facilities. The new Chinese reconnaissance satellite network would be capable of monitoring US, Taiwanese and Japanese military activities in the Asia-Pacific region, and is likely be deployed within the decade.

On October 14, 1999, a Long March 4B successfully launched the joint China-Brazil Earth Resources Satellite Ziyuan-1 ('Resource' or CBERS-1, which received some 70 per cent funding from China and relies primarily on Chinese technology) remote sensing satellite "with an integrated performance reaching an internationally advanced level", and a 10 m resolution multispectral imaging capability. The 1,540 kg ER-1 satellite is in a 778 km sun-synchronous orbit and will provide real-time optical, CCD, wide field imaging, IR multiple spectrum, short-wave IR and thermal IR data over a two year projected lifetime. It reportedly has advanced attitude and orbital triaxial stability control systems. However, the experimental satellite may have encountered technical difficulties in early May 2000 with the loss of 1.5 per cent of data-transmission capability (but with other systems such as its high-resolution CCD camera continuing to work normally). Nevertheless, at least one more is planned in the series which may have an improved 3 m or better resolution capability. CBERS-2 began assembly in Brazil during June 2000, and is to be launched by mid-2001. Chinese has also recently signed remote-sensing co-operation agreements with South Korea and Italy. The oceanographic research satellite Haiyang (Ocean)-1 is to be launched in 2001.

The Chinese satellite Tsinghua-1 was launched from a Russian launch vehicle to low earth orbit from Plesetsk on June 29, 2000. It is the first demonstrator for a planned 'Disaster Monitoring Constellation', carrying a multispectral Earth imaging camera providing 39 m nadir ground resolution in 3 spectral bands, digital store-and-forward communications systems, a digital signal processing signal experiment, a British-built GPS space receiver and a new 3-axis microsat attitude control experiment. A co-operative programme between Tsinghua University and the University of Surrey, UK, the so-called 'Tsinghua System' could eventually comprise a constellation of seven microsats for remote sensing applications. Follow-on satellites could have improved resolutions.

China launched the multipurpose observation 'China Resource 2' (ZY-2) satellite into orbit during August 2000 aboard a CZ 4-B rocket from the Taiyuan launch centre. The satellite is reportedly designed to conduct scientific experiments and to gather and send back pictures and other data that can be used to survey land, plan cities, monitor crops, and survey disasters. According to a Xinhua report, the satellite is a data-transmission type imaging satellite and also probably represents an improved military reconnaissance capability.

Polar orbiting remote sensing weather satellites were launched in 1988 and 1990 (FY-1A and FY-1B), along with the establishment of a compatible ground receiving network, to provide complete global coverage. *Feng Yun* ('Wind and Cloud') FY-1C was launched in orbit in January 1996. The FY-2-1R, which as launched on June 10, 1997, is China's first geosynchronous orbit meteorological satellite. The FY-1-3 was launched on May 10, 1999 with the maiden launch of the CZ-4B vehicle. China's third geostationary meteorological satellite, the FY-2B, was successfully launched from Xichang on June 25, 2000. The original FY-2 was believed to have been destroyed in April 1994 during spacecraft propellant loading in an accident at Xichang that resulted in a number of human casualties. The FY-1 type is equipped with 10 visible channels and an IR radiometre capable of sending realtime meteorological images to ground stations, and making sea water colour soundings and marine remote sensing. The FY-2-1R can cover some 100 million square kilometres of earth surface, providing meteorological data such as cloud images, temperatures and wind movements. The FY spin-stabilised series has been developed by the Shanghai Academy of Spaceflight Technology (Shanghai Aerospace Technology Research Institute), and uses control systems based on the DFH-2 communications satellite series. Imaging and data transmission are expected to be comparable to advanced US, Japanese and European systems. Visual, water vapour and infrared data will be provided. A common satellite bus associated with the programme, the Shi Jian SJ-5 is expected to be used for various future satellites. An in-orbit lifetime of three years is expected. China plans to develop and launch 10 more meteorological satellites over the next decade.

Electronic signals intelligence is probably carried out both by dedicated military satellites, civil telecommunications satellite systems and ground survey (geodetic) experimental satellites. China is reportedly developing new space-based ELINT systems that could detect active enemy radar systems and communications emissions. The PLA Fourth Department probably leads all of these efforts through specialised units.

4.4.3 Space Science and Technology

China has an active space science programme but traditionally budget restraints in this area has resulted in some limitations. The return payload test satellite FSW series has been marketed since 1987 by the CGWIC for microgravity experiment space leasing and remote sensing applications, and are built by CAST. FSW-1's have been launched by CZ-2s since 26 November 1975 (China being the third nation after the US and Soviet Union to develop recoverable satellite technology) for such applications as microgravity experiments, earth resource missions and military photographic reconnaissance. The FSW-2 series has a module that remains in orbit to conduct experiments after the re-entry vehicle returns to earth and can return a payload of 300 kg to earth after a stay in orbit of up to two weeks.

Possible future R&D areas include Long March recoverable free flyer satellites and microgravity containerless processing. CAS has indicated that China is planning to send a satellite probe to orbit the moon after 2000 and that optical and microwave remote sensing earth orbit satellites will be used as precursors to this mission. The Robot and Automation Research Institute, also part of CAIC, and CAST both share a mandate to develop a space robotics strategy and hardware. Space power systems and silicon solar cells have been developed by the Tianjin Power Institute. Interest has been displayed for other space science projects such as generating power with tethered satellites and planetary exploration missions to Mars and deep space. The PLA and CNNC have proposed using nuclear reactors for satellite power generation since the mid-1990s but no actual Chinese developments are known in this controversial area. By the mid-1980s, China's clean room facilities had reached international standards, limiting dust particle diameter contamination to less than 0.5 micro metre.

CAIC has announced plans to develop small (mini and micro) satellites, with keen interest evident in related foreign programmes. China and South Korea have discussed the development of low earth orbit micro-satellites for environmental monitoring and communications applications, based upon technologies South Korea has obtained through research co-operation with the United Kingdom. 'Smallsats' or 'lightsats' of 100 kg or less could have military applications such as communications and data-link. They could also have remote sensing applications, notably electro-optical imaging and SAR surveillance. Active Chinese smallsat programmes include Tsinghua-1, CAS's Chuang Xing-1, CAST's 968 satellite bus (used for SJ-5 and Haiyang-1, or Ocean-1, meteorological satellite in 2001), and a smallsat being developed by the Harbin Institute of Technology called Tansuo (Exploration) 1, which is a high-resolution imaging satellite scheduled for launch in 2001. Tsinghua University is also developing China's first nano-satellite, the THNS-1. This earth observation satellite reportedly weighs less than 10 kg and is to be launched as a piggyback payload by the end of 2001. Smallsats have potential military utility for rapidly replenished communications and reconnaissance systems, and could be launched to orbit aboard derivative solid-propellant ballistic missiles such as the DF-21, DF-31 and DF-41. China has recent plans to develop 250 kg smallsats with CCD imaging systems with a resolution of 1.5 m from an altitude of 630 km.

4.5 Manned Space Programmes TOP

The CNSA has undertaken as part of its 1996-2000 plan a so-called 'Project 921' for a Soyuz or Gemini class two-to-four-man capsule that can be launched on a CZ-2F booster (larger fuel tanks, strap-on rocket boosters and larger diameter payload fairing) from a new dedicated launch pad at the Jiuquan Space Centre, which includes extensive facilities such as a vertical vehicle assembly building and a large SLV mobile transporter. This programme has taken a major step forward with the successful launch from Jiuquan of China's man-rated spacecraft prototype Shenzhou, built by CALT, on 19 November 1999, followed by its successful recovery the next day. The development of the manned spacecraft prototype was a joint effort of CAST, CGWIC, Shanghai Academy of Spaceflight Technology (Shanghai Research Institute of Aeronautics and Space Technology), CALT's Carrier Rocket Research Institute (China Research Institute of Carrier Rocket Technology), CAS, Beijing University of Aeronautics and Astronautics' Spacecraft Design Group, and the Ministry of Information Industry. The PLA Second Artillery Strategic Missile Force has also probably been active in the programme for spin-off benefits such as improved ballistic missile targeting accuracy. The final testing, launching and retrieval operations were conducted through remote control systems and constituted a technological breakthrough for China. Tracking and control was undertaken by COSTIND's Beijing Space Command and Control Centre.

Chinese experts were particularly pleased with the successful retrieval of the unmanned 8,400 kg capsule from the grasslands of Inner Mongolia. China claims that the programme to send three to four astronauts (or 'taikonauts') into space at a time is the largest, most complicated and technically most difficult project the country has undertaken, and has only been previously accomplished by Russia and the US. Approximately 10 Chinese astronauts have been chosen from the ranks of their top fighter pilots and have received extensive training in Russia since the mid-1990s. An astronaut training centre with gravity acceleration machines, weightlessness simulators, vacuum chamber, and other equipment has apparently been established near Beijing. China will probably first attempt to send astronauts into low orbit, where they would eventually conduct space walks and experiments such as space dockings and the construction of a space laboratory. The project is also seen by PLA military experts as instrumental in enhancing China's space surveillance and ballistic missile technologies. While the military importance of Shenzhou have been doubted by some experts, the ability to manoeuvre and rapidly change orbits with low-thrust propulsion systems is an important aspect of space warfare and BMD countermeasures capability.

The initial development of human rated spacecraft and life support systems represents a major departure for Chinese space activities. The programme's dual objectives would be to provide platforms to perform space science and as a major stimulus to develop China's advanced technology industrial base (similar to the results of the US Apollo programme). Major contractors are probably CALT for the launcher and CAST for the capsule, with the Shanghai Academy of Spaceflight Technology providing the subsystems. The Russian Rocket System Corporation Energia is believed to have provided major foreign technical input. While Chinese astronauts are believed to be receiving training in Russia, domestic facilities including the Chinese Institute of Space Medicine (or Space Flight Medical Research Centre which was according to some accounts established by Qian Xuesheng as early as 1968) have also been established.

Animals such as dogs are believed to have been successfully launched in Chinese recoverable spacecraft since the 1980s and serious manned system R&D has been conducted at least since the early 1990s. In November 1999, the CAST's Beijing Institute of Satellite Environmental Engineering announced the establishment of an "exceptionally large space environment experimental unit of internationally advanced quality" to be used for the development of manned spacecraft and space stations through simulating the vacuum, radiation, light and thermal conditions of space.

Some reports now indicate that China is planning to have a manned flight in orbit by 2001 and perhaps a manned space station by 2020 or earlier. Chinese media reports in September 2000 indicated that Chinese astronauts are in Russia for training for China's first manned spacecraft mission during 2001. The 'Project 921', elements of which have been ongoing since the 1980s, are based upon recoverable satellite systems, including concepts for reusable space shuttles, recoverable manned capsules, and, eventually, an inhabited space station. Significant space technology transfer (e.g. the tried and trusted Soyuz spacecraft system) and cosmonaut training at Star City's Gagarin Cosmonaut Training Centre are believed to have been provided by Russia for the Chinese manned space programme. Since at least 1996 Chinese astronauts have participated in cosmonaut training with Soyuz manned spacecraft technology such as docking, navigation, and life support systems, which the Shenzhou appears to be largely based upon. However, Chinese space experts are also aware that the level of technical sophistication of Russian space technology is well below that available in the West and that Soyuz essentially represents 1960s-level expendable capsule technology. More advanced follow-on systems will have to be developed indigenously or with technology transfers from the West.

China's interest in manned spaceflight perhaps extends back to the 1960s but progress was almost certainly disrupted by the Cultural Revolution, although some efforts extended into the next two decades. However, unconfirmed reports indicate that it was not until April 1992 that the Chinese political leadership decided that an independent manned space programme was technically and economically feasible. The State Council reportedly directed that a manned spacecraft prototype be launched before the new millennium to firmly establish China as a 'Great Power'. The national manned space programme was given the designation Project 921: the initial stage, 921-1, will be a manned space capsule; the second stage, 921-2, will be a manned space station; and the third stage, 921-3, a modern space transportation system comprised of a delta winged space shuttle, operational by 2020. A new booster rocket using liquid oxygen and kerosene was proposed that would eliminate the toxic propellants used in the existing CZ-2 family of rockets. Clustering of identical first stages would permit heavier payloads, such as space station components, to be launched into orbit. The original 921-2 space station module concept reportedly had a total mass of 20 t, a length of 15 m, and a diameter of 4.2 m. Span across the solar panels was 22 m. It is to be equipped with a Mir-like five-port docking section at the forward end that would allow many such units to be assembled into a large space station complex.

The original Project 921 proposal was issued by the Shanghai Astronautics Bureau in October 1993 for inclusion in the Eight and Ninth Five Year Economic Plans. However, the development of the new liquid oxygen and kerosene rockets was reportedly not approved, with resources instead allocated for the development of large solid motors for military use (the heavy booster programme may now be again active). The 921-1 spacecraft was approved for immediate development, to be launched on a man-rated modification of the CZ-2E, the CZ-2F. The 921-2 space station module would be launched by an uprated CZ-2E, the CZ-2E(A), and the module could only have a mass of 12 t to 14 t, rather than the 20 t originally planned. A first generation Chinese space station, however, could also be as simple as docking two Shenzhou modules together. Some circulated drawings of the CZ-2E(A) indicate that a smaller space station module could have a length of 10 m and a diameter of 4.2 m. Authorisation to proceed with the 921-2 space station was reportedly provided in February 1999, with the first design review in May of that year. A vacuum chamber with a diameter of 7 m and a height of 12 m had reportedly been built to test the station. First launch could be by 2002, with a slow rate of assembly of the space station thereafter.

China has also suggested participation in the US-led International Space Station programme in the form of ground-based monitoring stations, returning equipment and products from orbit in recoverable satellites, and Long March deliveries to orbit. Although such international participation has been suggested as recently as January 2000 by MOST, to date China has not been invited to play a role, and in the short-term this appears politically unlikely.

Unconfirmed reports over the past several years, and as recent as February 2000, have linked Russia's ongoing decision to extend the operational life of the Mir space station with major financial backing provided by China. The decision is opposed by the US who want Russia's manned space effort focused on the new International Space Station, which China has not been allowed to participate in. If these reports are true, Mir could see further expansion with Chinese modules. Mir could be used as a base for the Chinese manned space effort, thus providing a radical increase in capability for China's space programme over a short period of time. The outright purchase and rehabilitation of Mir could cost in access of US$1 billion but would provide China a quick foothold in space with the old space station's working life perhaps extended for another decade or more following extensive repairs to modules and onboard computers.

4.6 Aerospacecraft Projects TOP

There are various unconfirmed reports of Chinese aerospace plane (*kongtian feiji*) and space shuttle (*hangtian feiji*) research developments. Wind tunnel models of a craft similar to the proposed US Boeing X-20 Dynasoar spaceplane in the 1960s (the development of which Chinese rocket expert Qian Xuesen had reportedly been involved with before leaving the US to return to China, along with his knowledge of the German wartime 'Project Sanger' transatmospheric skip-bomber project) may represent the orbiter stage of the 921-3 reusable spacecraft (or the so-called 'Zing Jian-15').

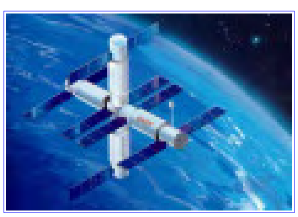
China published photographs of a two-seat spaceplane simulator as early as 1980, possibly a test cockpit in an aircraft that flew parabolic trajectories to provide brief periods of zero-G. This project is probably at an early stage of development, if it actually exists at this time. An advanced aerospacecraft such as this would provide independent manned access to space, reduce the cost of launching payloads into orbit, and assist future high-speed commercial transport aircraft programmes. A hypersonic cruise airplane, derived from aerospacecraft technologies, with a sustained cruise capability of between Mach 5 and 14 could provide various military capabilities including interdiction, reconnaissance, surveillance, precision targeting and weapons guidance, strategic bombing, and strategic airlift. Orbital military aerospacecraft could provide these functions plus enhanced ASAT and BMD 'space control' functions through the use of coplanar orbital transfer techniques which Chinese scientists have evidenced some recent interest in.

Other recent US reports have also indicated that China is researching a small aerospacecraft, perhaps a quarter the size of US space shuttle. Reportedly, the Chinese system could have an advanced radar system which could detect small objects in low earth orbit within a 200 km radius, and an ASAT weapons capability. Other recent speculative reports have indicated a KongZhen-4 (Sky Recon-4) programme by an 'Institute 626' to develop a Mach 10-class aerospacecraft similar in concept to the supposed US 'Aurora' reconnaissance vehicle. Other unconfirmed, possibly erroneous, reports link Chinese R&D in this area with Germany's cancelled 1980s 'Project Sanger-2' manned space shuttle and France's abandoned 1980s Hermes space shuttle, and various domestic initiatives such as the 'Project 863-204' group's research on 'air turbo rockets', 'Project 863-221-3' group's research on turbojet/ramjet propulsion systems, and 'Project 10.5' pulse-detonation propulsion R&D. Russian information from such Soviet-era programmes as the late-1950s Myasishchev VKA-23 Design 2 space shuttle test concept may also have now reached Chinese hands. The Beijing Institute of Systems Engineering, Shanghai Academy of Space Technology, and the Beijing University of Aeronautics and Astronautics have evidenced interest in advanced single-stage-to-orbit (SSTO) concepts that use propulsion systems such as scramjets. The Aerodynamic Research and Development Centre at Mianyang, near Chengdu, Sichuan Province, has wind tunnel facilities for testing vehicles that can travel at speeds from Mach 5 to 10.

CAST may also have national long-range plans (over the next two decades) for the indigenous development of advanced launch vehicles such as a 100 metric ton horizontal takeoff and landing, two-stage-to-orbit (TSTO) space transportation system capable of carrying a four metric ton payload to LEO. However, these concepts also appear at present to be rather speculative and have probably only reached the concept definition and feasibility study phase. The TSTO proposal has reportedly been centred around airframe and propulsion teams in Shenyang, and various research institutes specialising in gas-turbine, ramjet and scramjet rocket air-breathing combined cycle propulsion systems throughout China. Follow-on technologies would include advanced materials, engine compressors and a hydrogen fuel combustion system. The Jiuquan Space Centre has also been linked in some unconfirmed reports to the development of a manned space shuttle, with first stage development to be completed by 2000 and with flight test and operations past 2003. The National University of Defence Technology reported development of liquid bipropellant variable thrust rocket engines in 1991.

In March 1998, Zhang Heqi, Chief Scientist of the '863' Programme and a former Director General of the CAS Zijinshan Observatory, predicted that China would launch a 'space shuttle' unmanned prototype within two years and launch a manned space shuttle to orbit several years later. He predicted this would be China's greatest scientific achievement since their first atomic bomb, hydrogen bomb and artificial satellite. The estimated weight of the vehicle would be 10 tons. This undetailed description, however, may in fact be of China's prototype manned capsule-type spacecraft rather than a winged aerospacecraft.

China-Brazil Earth Resources ER-1 Satellite. China has recently made significant improvements to its satellite remote-sensing/reconnaissance capabilities.



An artist's impression of China's proposed manned space station. (Source: CAST)

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Ben Sheppard; Dr Howard DeVore

CHAPTER 5 - NAVAL SYSTEMS

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NAVAL SYSTEMS

5.1 R&D and Production Infrastructure TOP

While perhaps being the largest navy in the world in overall numbers of vessels of all classes, the PLA Chinese Navy (PLAN) lags technologically behind other regional forces such as the US Navy and the Japanese Maritime Self-Defence Force. It may also be inferior, in some respects, to elements of the Indian, Taiwanese and ASEAN (Association of South East Asian Nations) navies. The majority of its vessels are modestly equipped with modern weapons and electronics systems - according to some sources by as much as three decades behind the most technologically advanced ships. Particular areas the PLAN is said to be deficient in are air defence, surveillance, and command, control, communications, computers and intelligence systems. However, some significant modernisation efforts are in process or planned, and the PLAN's warship construction programme is believed to be second to only that of the US Navy in numbers of major ships and submarines under construction.

Recent reports have the PLAN's strength at 96 attack submarines (including some 69 of the old Romeo-class; some reports indicate that the PLAN also has over 100 old submarines in storage that could be reactivated), 55 destroyers and frigates, and at least 87 missile-armed fast attack craft (FAC) and 250 gun/torpedo FAC (some of the smaller surface vessels would qualify as corvette class). It operates some 300 support ships of various types, including approximately 120 mine warfare vessels, 49 replenishment ships, and various survey, research and other support vessels such as intelligence and degaussing ships. Some sources indicate a PLAN strength of over 1,100 ships of all types, over three times that of the US Navy. China's merchant fleet is growing at over 1,500 national-flagged vessels and several hundred more under flags of other nations. The PLAN personnel strength is 268,000 officers and men. Operationally the navy is divided into three fleets: the North Sea Fleet on the Yellow Sea; the East Sea Fleet on the East China Sea and the Taiwan Straits; and the South Sea Fleet on the South China Sea, including Hainan Island. It has a naval air arm of some 800 shore-based combat aircraft and shipborne helicopters, now including JH-7 fighter-bombers.

PLAN shortcomings include its HQ-61 and HQ-7 surface-to-air missile (SAM) systems, which are based upon the French Crotale. These SAM systems are generally thought not to provide an effective area-defence capability, increasing their vulnerability to air and missile attack. Anti-submarine warfare (ASW) technology is generally considered modest, employing towed-array sonar and sonobuoy systems over two decades old. Over the horizon (OTH) targeting is not considered effective, nor is co-ordinated targeting tactics. Damage-control and anti-contamination systems also require improvement by Western standards. Mine-hunting and sweeping technology is basic. Underway replenishment capabilities are considered limited.

On the positive side, the PLAN's effectiveness in all of these areas of deficiency is improving. In addition to the ships reviewed in this chapter, Chinese naval modernisation also includes the acquisition for its naval aviation arm of new aircraft such as the JH-7 and J-8D that are capable of aerial refuelling. It has excellent anti-ship missile and sophisticated offensive mine technology, including underwater-launched systems in both areas. A large number of older systems are being decommissioned and replaced by newer systems. Technical training is becoming increasingly sophisticated for officers and enlisted ranks in various aspects of surface, submarine and aerial warfare, as is joint-service combat exercises that are being conducted increasingly further from China's shores. Various Western military observers have reported that PLAN personnel are currently extremely well trained and make the best use of available equipment which is very well maintained.

There are indications that the PLAN is currently undertaking an operational, technological and ship construction renaissance. Major PLAN warships will in the near future be equipped with missile vertical launch system (VLS) technology and integrated tactical data systems, as well as improved ASW helicopters and gas-turbine propulsion systems. The PLAN has increasingly been conducting activities designed to extend its reach. During 1988 the PLAN's East China Sea Fleet under Vice-Admiral Zhang Lianzhong (who subsequently was promoted to Admiral and Commander of the PLAN) reached a strategic milestone after completing a major 120-day exercise that encompassed a 57,000 nautical mile voyage. The March 1997 voyage of a PLAN task force, comprising two Luhu-class destroyers and a Dayun-class supply ship, to Honolulu and San Diego in the US and on to Mexico, Chile and Peru, was the longest voyage undertaken by Chinese warships in over 500 years. On 14 July 14 1999, the research vessel 'Snow Dragon', was the first Chinese scientific expedition vessel to have entered the Arctic Ocean and North Polar area. In November 1998, the Snow Dragon began China's 15th Antarctic expedition. After a 600-year hiatus, Chinese naval vessels returned to the African coast during July 2000. Two PLAN warships, the guided missile destroyer *Shenzhen* and the supply ship *Nancang*, led by Rear Admiral Huang

Jiang, chief of staff of the South China Fleet, berthed at Tanzania's Dar es Salaam for a two-day port visit. This was the first time Chinese naval ships have reached African soil since the eunuch Admiral Zheng, who led a huge Chinese fleet to Africa's east coast in the early 15th century. In the past, the PLAN had rarely ventured far from home coastal waters, lacking adequate logistic capabilities for extended 'blue water' deployments.

A PLAN Naval Weaponry and Research Centre was reportedly established in 1978 to undertake naval R&D. The Northwest Integrated Missile Test Range in the Liaoxi region has reportedly been used by the PLAN and COSTIND to test ASMs, underwater ordnance, ship-gun weapons systems, submarine-launched missiles, navigation, and electronic countermeasure systems.

The PLAN has some 13 schools for sailors and officers, various masters degree training centres, and four doctoral programmes, including opportunities to study technical subjects abroad. By the 1990s, over 84 per cent of PLAN officers in naval vessel units had reported receiving college education or higher. All officers at or above combat vessel department heads and pilots in aviation units are reportedly college graduates, developing a young generation of 'scholar-type' and 'knowledge-type' officers. Technical subjects include advanced project management systems (PERT/CPM), microelectronics including all-function automatic electronic control systems, navigation, dynamics, telemetering and remote-control, aviation, missile control and guidance systems, satellite navigation and astro-navigation. PLAN educational, training and R&D institutes include:

· Navy Command Academy, Nanjing

· Dalian Shipping Academy, Dalian

· Naval Engineering Academy, Dalian

· Dalian Warship Institute (First Surface Vessel Academy; established prior to the 1949 founding of the PRC, in 1946)

· Naval Aeronautical Engineering Academy Yantai, Shandong (missiles and aircraft)

· Guangzhou Shipping Academy, Guangzhou

· Guangzhou Warship Academy (Second Surface Vessel Academy)

· Navy Submarine Academy, Qingdao (established in 1953, and with over 2,000 students studying some 40 courses)

· Navy Political Academy, Qingdao

· Aviation School, Qingdao

· Navy Electronic Engineering Academy, Nanjing

· Navy Cadets School, Bengbu, Anhui

· Wuhan Engineering College

· Yantai Aviation Engineering College, Shandong.

During the 1990s the PLAN convinced the leadership of the Chinese Communist Party (CCP) to modernise the country's naval forces for future warfare, including consequent reforms for the R&D establishment, production, and equipment acquisition processes. Such reforms have reportedly included the 1995 'technical guarantee service' pact agreed between the PLAN's Shanghai Military Representative Bureau, which represents some 100 naval production and research facilities, and the East Sea Fleet. The purpose of the agreement is to transform new technology into operational equipment as soon as possible. It is also intended to encourage an integrated approach to weapons development via what has been termed the 'five systems principle' - in other words to analyse and study as a complete system; design as a complete system; product certification as a complete system; production as a complete system; and delivery as a complete system. Future PLAN R&D interests include:

· Stealth ship designs

· Breakthroughs in the size and characteristics of aerial vehicles

· Stealth tactical submarines

· Improved long-range observation and reconnaissance systems integrated with weapons guidance systems for the precise target delivery of weapons

· Improved electronic warfare (EW), electronic countermeasures (ECM), and electronic intelligence (ELINT), etc.

· Bringing 'all-dimensional' 3-D space to naval operations.

China is also planning to better utilise its untapped marine resources for economic development. It is exploring the possibility of developing potential marine industries such as deep-water mining, comprehensive utilisation of seawater and power generation with marine energy. China also plans to double its offshore oil and gas output to 40 million tons by 2005. The country's offshore waters have an estimated 25 billion tons of oil resources and 8.4 trillion cubic metres (294 trillion cubic feet) of natural gas. Output value from the marine industry is expected to make up at least 5 per cent of the China's GDP during 2000. China has an 18,000 km (11,178 mile) mainland coastline and more than 5,000 islands, each with an area of more than 500 square metres and the islands' coastlines total more than 14,000 km. China is planning to become a modern marine power during the 21st century, according to a national marine conference held recently in Beijing. Wang Shuguang, director of the State Bureau of Oceanography, said China would work out a comprehensive marine development strategy, a marine development and utilisation plan, a marine biological environment protection plan and plans for the development of other specific projects. China is to develop a new marine law system, including laws on the right of marine resources, marine resource development and utilisation law and marine environment protection law. China's marine industry has realised 327 billion Rmb yuan in output value in 1998 against less than 10 billion Rmb yuan in the early 1980s.

Also related to this strategic naval doctrine is the concept of a so-called 'Greater China', which is often used to describe interconnected ethnic-Chinese economic activities throughout mainland China, Hong Kong, Taiwan and Singapore, plus regional nations such as Malaysia, Indonesia, Vietnam, Myanmar, Cambodia and the Philippines, where numerically Chinese are a minority but comprise the majority of the business class. At some future date, Greater China's economic power could see a consolidation into a single political base, although most overseas Chinese prefer to keep their distance from Beijing's political reach. However, this process has already begun with Hong Kong's and Macao's reunification with the mainland. Beijing also has a firm agenda for Taiwan and the disputed South China Sea Territories, which could also have implications for persecuted Chinese minorities throughout the region. Aircraft carriers could be useful for enforcing regional territorial claims and during an invasion or blockade of Taiwan. China has recently been unable to directly apply military pressure to cease repeated atrocities against ethnic Chinese in nations such as Indonesia. An aircraft carrier task group and related amphibious assault capabilities also would provide a highly visible power projection solution for this problem area.

China now has nearly 200 shipbuilders, together with 600 related research institutes and auxiliary equipment manufacturers. The China State Shipbuilding Corporation (CSSC) is a national industrial complex under COSTIND, operating some 27 large and medium-sized shipyards, 67 manufacturers of maritime equipment, and some 40 R&D and technical training organisations. CSSC has a total workforce of 300,000 people, including 80,000 engineers and technicians.

The China Overseas Shipping Company (COSCO) is the world's largest commercial merchant marine. Some sources have charged that COSCO operates vessels equipped with ELINT, COMINT and other electronic systems that monitor foreign telecommunications, and is involved in illegal arms smuggling operations. COSCO is also believed to be involved in the deployment of Chinese intelligence operatives around the world, and has reportedly delivered various weapons-related technologies to states such as Pakistan, North Korea, and Iran.

The China Shipbuilding Trading Company Limited is a subsidiary of the CSSC that undertakes the export of naval ships and craft and marine equipment, the construction and control of all shipyards, shipbuilding and related marine equipment facilities, and the import of naval materials and expertise. Import and export activities are controlled by the Xinshidai Group. Products include submarines, guided missile destroyers and frigates, anti-submarine vessels, guided missile boats, landing craft, pontoon bridges, rapid-fire naval guns, torpedoes, mines, anti-ship missiles and electronic systems.

The China Ship Research and Development Academy is a major national organisation with over 10,000 technical and engineering personnel and extensive national R&D facilities related to all aspects of ship building and ocean engineering. It conducts R&D and product development in the areas of special crafts (air-cushion vehicles, hydrofoils, ground-effect machines, small waterline plane craft), submarines and submersibles, diving robots, diving apparatus, surface warships, power generating installations (nuclear, internal combustion, steam turbines, boilers, gas turbines, generators, and various combined systems), new and special materials for shipbuilding, and high-precision gyros. The academy also conducts R&D and product development in stable platforms, computer systems, wire and wireless communications and navigation systems, analogue simulation systems, noise reduction engineering, fibre optics and hydro-acoustics engineering, and CAD/CAM (computer aided design/manufacturing).

The Shanghai Merchant Ship Design and Research Institute, Shanghai, is active in the R&D of new ships, marine machinery, electrical products, and software applications. The Shipbuilding Technology Research Institute, Shanghai, is China's primary research institute for applied shipbuilding technology, and specialised research offices and the Applied Software Development Centre of the CSSC. R&D areas include ship construction and technology, ship machinery installation, electricity and pipe systems, welding and cutting technology, non-destructive testing, coatings, automatic equipment, materials, and computer systems.

The China Ship Sciences Research Centre, Wuxi, Jiangsu is a major CSSC R&D centre with research installations such as water pools, wind and water ducts for fluid dynamics experiments. R&D areas include fluid dynamics, structural dynamics, vibration, noise, impact, anti-explosion, instrumentation, and computational mathematics. It has developed atmospheric diving suits, energy efficient devices for retrieving energy from propeller wakes, the *Dongfang* series of high-speed boats, cavitation propeller systems, double duct propellers, ship's propellers software, Z-type counter-rotation propulsion device, intelligent sensors, hydrofoils, and submersible devices and structures.

The CSSC's Marine Design and Research Institute of China, Shanghai, is a major R&D centre that include a ship resistance and propulsion test pool, a manoeuvring test pool, a sea keeping test pool, a laboratory for testing propeller cavitation, a wind tunnel, and a hydraulic propelling laboratory. This institute has designed and developed warships, roll on/roll off ships, ocean-going survey and scientific survey vessels, space tracking ships, double-hulled hovercraft and other hovercraft platforms, hydraulic jet-propulsion technology, and 20-seat amphibious augmented RAM wing craft.

The Special Vehicles Research Institute, Jingmen, Hubei, was founded in 1961, and is China's main centre for the development of special vehicles such as unique water-based vehicles, airships and surface-effect and wing-in-ground (WIG) effect vehicles. The institute has over 1,300 employees and its facilities include the only high-speed hydrodynamic test water tank in Asia. It conducts R&D on aerodynamic surface effect, longitudinal dynamic stability of water-based vehicles, spray and drag characteristics of water-based vehicles, water impact load of three-dimensional flying bodies, take-off and landing of amphibian aircraft, manned helium airships (FK-4, FK-100) and remote-controlled airships (FK-6, FK-11, FK-12), seaworthiness and model test techniques for surface effect vehicles. It developed the large SH-5 seaplane during the 1970s and the follow-on SH-5B version.

The Hangzhou Applied Acoustics Research Institute, Hangzhou, Zhejiang is a major CSSC R&D subsidiary that was China's first, and now largest, research establishment engaged in the study of applied acoustics. The institute has nine R&D offices for acoustics, electronics, systems engineering, and energy exchange materials, in addition to a computer centre, measurement centre, quality control centre, and a trial production factory. Major R&D activity areas include sonar, magnetic anomaly detection, echo sounders, infrared systems, digital display instrumentation, various piezoelectric materials and elements, and various transducers.

The Nanjing Maritime Radar Research Institute, Nanjing, Jiangsu, conducts CSSC R&D in such areas as radar engineering, radar systems, combat command and control systems, navigation radar, navigation and positioning systems, structures, foreign technology transfer, electronics and power sources, quality control, measurement, and computers.

The Tianjin Navigation Instruments Research Institute, Xinqiao, Tianjin, is a major CSSC institute conducting R&D in areas that include radio communications, navigation equipment, platform gyro compasses, computers, motors and electrical devices, automatic steering control and logs, precision machinery, information systems, standards and measurement. The institute manufactures precision radio positioning systems, various radio, infrared, laser and radar warning systems, gyro compasses and gyro theodolites, and other electronic equipment.

The Shanghai Marine Electronic Equipment Research Institute (formerly Shanghai Number 22 Radio Factory) has undertaken extensive R&D for the CSSC on underwater sound electronics (sonar) and 'supersonic technology', radio, marine electronics, echo sounding apparatus for shallow/medium/deep waters, CRT multi-functional shoal detectors, sound correlated rangers, various underwater 'sound and supersonic energy exchangers', sea bottom geomorphographs, multi-functional cloud chart facsimiles, marine radio receiving and transmitting systems.

The CSSC's Zhengzhou Mechanical and Electrical Engineering Institute, Zhengzhou

Henan, specialises in the R&D of mechanical engineering, automatic control, hydraulic technology, chemicals, electronic equipment, servo-mechanisms, microcomputers, and servo systems.

The Wuhan Maritime Communications Research Institute, Wuhan, Hubei, is a CSSC research institute and also a member of the China Giant Panda Electronic Group. R&D areas include ship and land-based communications, inter-communications, mobile communications networks, personal communications systems, antennas, transmitters and receivers, high-frequency series parallel modulation-demodulation terminals, very-low frequency communications channels and demodulation terminals, regional communications networks, telegraph exchange and processing, communications control, data-collecting and processing, secure communications, computer applications, communications systems engineering, signal processing, and self-adapting communications technology.

The CSSC's Yangzhou Marine Electronic Instruments Research Institute, Yangzhou,

Jiangsu, undertakes R&D and product development in the areas of electronic technology, instrumentation, computer software, communications satellite equipment, and microwave technology applications. It has also developed power sources for satellite ground station transmitters.

The Harbin Marine Boilers and Turbine Research Institute, Harbin, Heilongjiang, is a major CSSC institute that has the largest gas-fired turbine and combined power equipment test stand in China. R&D areas include steam turbines, boilers, gas-fired turbines, combined cyclic power plants, nuclear power plants and thermonuclear projects (double-loop circulation systems), mechanical transmissions, thermodynamic computer controls and automatic controls.

The Shanghai Marine Diesel Engine Research Institute under the Administration of the Number Seven Institute of the CSSC, conducts R&D in diesel engine and power devices, high-speed marine engines, China's first water-free cold ceramic motor, electronics and electrical systems, and computer systems applications. It has developed the aspherical holographic polariscope for COSTIND, a non-spherical holographic photo-elastic device that is used for aerospace, nuclear, radar, communications and other applications.

The Sichuan Gear Box Plant, Jiangjin, Sichuan, is a subsidiary of the CSSC and a specialised producer of gear boxes, couplings and vibration reducers.

The Huazhong Electro-Optical Technology Research Institute, Wuhan, Hubei, is a major CSSC institute conducting R&D in areas that include large precision optical instruments, electro-optical automatic control systems, astronomical navigation systems, special purpose TV monitoring systems, low-light level night vision systems (e.g. BY-I and TY-I portable low-light level night vision telescopes), laser and infrared systems, various precision static angle and length testing instruments, integration of electronic devices and machinery, and computer development. The institute has also developed various types of electro-optical detection/tracking systems, periscopes, special colour CCTV systems for high-pressure oxygen cabins, and other related products. Advanced R&D interests include infrared-thermal imaging systems, laser technologies, signal detection and digital image processing systems.

The CSSC's Zhongnan Optical Instruments Factory, Zhicheng, Hubei, undertakes R&D and production in areas that include optics, liquid crystal display optical material such as composite polarisation discs, and barium fluoride crystal processing.

The Jiangsu Automation Research Institute, Lianyungang, Jiangsu, is a CSSC institute with R&D units for automatic controls systems engineering and devices, fibre optics data buses, simulation, shallow gauging technology, display technology and computer systems and software engineering, and a trial production factory with more than 200 pieces of equipment. The Jiangsu Leisheng Electronic Equipment Plant, Wuxi, Jiangsu, is a major CSSC plant that is China's largest research and production enterprise specialising in underwater sound equipment. The Kunming Ship Equipment Group Corporation, Kunming, Yunnan, is a CSSC conglomerate of seven large and medium-sized production enterprises, six R&D institutes, one material supply company, and one education and training centre. It engages in R&D in areas such computer technology and software, microcomputer control of industrial production processes, underwater salvaging and sounding, noise monitoring and analysis, precision plastic injection moulds, production technology, and precision machining.

The Luoyang Ship Material Research Institute, Luoyang, Henan, is a CSSC centre conducting R&D on metallic and composite materials and manufacturing techniques.

The Dalian Marine Propeller Plant, Dalian, Liaoning, is a CSSC specialist propeller and bronze alloy casting plant. The Dalian Shipbuilding Industry Corporation (Group) and related Dalian Shipyard are major CSSC shipyard establishments with three shipbuilding slipways for ships of up to 80,000 tons and other major facilities. Organisation includes a shipbuilding technology research institute and an explosives processing research institute. R&D from the explosive processing research unit has been applied to projects in the shipbuilding, nuclear, space, electronics and other sectors.

The Donghai Shipyard, Shanghai is a major CSSC ship repair subsidiary. Hudong Shipyard, Shanghai is a major CSSC shipyard that employs 12,000 workers, and can build ships up to 70,000 tons, medium and low speed high-powered marine diesel engines, and large steel structures. Shanghai's Jiangnan Shipyard was founded in 1865, and is one of the largest shipyards in China capable of the manufacture of ships up to 80,000 tons. Jiangnan operates a design technology institute, a materials testing institute, a welding institute, computer and information centres, and has CAD/CAM and management information system technologies. The Quixin Shipyard, Shanghai, designs, builds, repairs and refits military and civilian craft, and has also acquired US processing technology for the Boeing hydrofoil craft Type 929-115. Shanghai's Zhonghua Shipyard builds, repairs and refits major surface combat and auxiliary ships, including guide-missile destroyers and new scientific research ships, and has also manufactured the research ship 'Kancha 3' and a 258-seat sidewall hovercraft.

The Guangzhou Shipyard International Company Ltd., Guangzhou, Guangdong, is the largest modern shipbuilder in South China, and produces products such as systems for Boeing hydrofoil craft.

The Wuchang Shipyard, Wuhan, Hubei, specialises in custom shipbuilding, large steel structures, pressure containers and machinery manufacture. It has developed the launch vehicle tower for the Xichang space launch centre (96 m high, 5,000 tons in weight and used for launching the Long March 2 rocket).

China is one of the largest producers of naval equipment in the world today, having progressed from a very limited capability prior to 1949, to progressively building large and more complex vessels over the next five decades. In the past warships were produced by reverse-engineering or licensed blueprint, but are now increasingly being developed with selective foreign technology transfers and indigenous efforts. China today has over 20 major naval R&D institutes, production facilities and testing sites across the nation that undertake the development of warships, other platforms, communications and transport systems, and the design, trial and production of various military ships and equipment. The most important naval shipyards are located at Dalian, Jiangnan and Wuhan. Key current clusters of maritime manufacturing and R&D in China by city and province are summarised in Table 5.1.

Table 5.1 Current Chinese Maritime/Naval Industry Geographical Clusters

· Xinhai Corporation (PLAN)

· Beijing Marine Communications and Navigation, Beijing

· China National Shipbuilding Equipment and Materials Corporation, Beijing

· China Shipbuilding Trading Company Limited, Beijing

· China Ship Research and Development Academy, Beijing

· China State Shipbuilding Corporation, Beijing

· Huludao Shipyard

· Anhui Shipbuilding Industry Company, Dadongmen, Anhui

· Anqing Marine Diesel Engine Plant, Anqing, Anhui

· Fujian Shipbuilding Industry Corporation, Fuzhou, Fujian

· Guangdong Shipbuilding Industry, Guangzhou, Guangdong

· Guangzhou Shipbuilding Company Ltd., Guangzhou, Guangdong

· Guangzhou Shipyard International Company Ltd., Guangzhou, Guangdong

· Huangpu Shipyard, Guangzhou, Guangdong

· Shenzhen Shipbuilding Trading Company Ltd., Shenzhen, Guangdong

· Zhanjiang Shipyard, Guangdong

· Behai Shipyard, Behai, Guangxi

· Harbin Engineering University, Harbin, Heilongjiang

· Harbin Marine Boilers and Turbine Research Institute, Harbin, Heilongjiang

· Luoyang Ship Material Research Institute, Luoyang, Henan

· Zhengzhou Mechanical and Electrical Engineering Institute, Zhengzhou, Henan

· Cheoy Lee Shipyards, Hong Kong

· China Shipbuilding Industry Corporation, Wuhan State Shipbuilding Special Equipment Factory, Wuhan, Hubei

· Special Vehicles Research Institute, Jingmen, Hubei

· Wuchang Shipyard, Wuhan, Hubei

· Wuhan Heavy-Duty Casting and Forging Plant, Wuhan, Hubei

· Wuhan Maritime Communications Research Institute, Wuhan, Hubei

· Wuhan Shipbuilding Industry Corporation, Wuhan, Hubei

· Zhongnan Optical Instruments Factory, Zhicheng, Hubei

· China Ship Sciences Research Centre, Wuxi, Jiangsu

· Jiangsu Automation Research Institute, Lianyungang, Jiangsu

· Jiangsu Leisheng Electronic Equipment Plant, Wuxi, Jiangsu

· Jiangsu Shipbuilding Industry Corporation, Nanjing, Jiangsu

· Nanjing Maritime Radar Research Institute, Nanjing, Jiangsu

· Yangzhou Marine Electronic Instruments Research Institute, Yangzhou, Jiangsu

· Zhenjiang Marine Diesel Works, Zhenjiang, Jiangsu

· Jiujiang Shipbuilding Industry Corporation, Nanchang, Jiangxi

· Dalian Marine Propeller Plant, Dalian, Liaoning

· Dalian Shipbuilding Industry Corporation (Group), Dalian, Liaoning

· Dalian Shipyard, Xigang

· Dalian, Liaoning

· China State Shipbuilding Corporation, Qingdao Beihai Shipyard, Shandong

· China State Shipbuilding Corporation, Quixin Shipyard, Shanghai

· Donghai Shipyard, Shanghai

· Hudong Shipyard, Shanghai

· Jiangnan Shipyard, Shanghai

· Marine Design and Research Institute of China, Shanghai

· Quixin Shipyard, Shanghai

· Shanghai Marine Diesel Engine Research Institute, Shanghai

· Shanghai Marine Electronic Equipment Research Institute, (Shanghai Number 22 Radio Factory), Shanghai

· Shanghai Marine Equipment Research Institute, Shanghai

· Shanghai Merchant Ship Design and Research Institute, Shanghai

· Shanghai Navigation Aids Factory, Shanghai

· Shanghai Navigation Instrument Plant, Shanghai

· Shanghai Shipyard, Pudong, Shanghai

· Shipbuilding Technology Research Institute, Shanghai

· Zhonghua Shipyard, Shanghai

· Chongqing Shipbuilding Industry Corporation, Chongqing, Sichuan

· Sichuan Gear Box Plant, Jiangjin, Sichuan

· Tianjin Navigation Instruments Research Institute, Xinqiao, Tianjin

· Kunming Ship Equipment Group Corporation, Kunming, Yunnan

· Hangzhou Applied Acoustics Research Institute, Hangzhou, Zhejiang

· Zhejiang Shipbuilding Industry Corporation, Hangzhou, Zhejiang

Currently, CSSC claims that 80 per cent of its product output value is civilian and 50 per cent of its tonnage is exported. Ships up to 150,000 tons are constructed, such as Chinese designed cargo ship built at Dalian Shipyard. Technical co-operation agreements have been signed with Japanese shipbuilding organisations on ship design, shipbuilding technology, production organisation, management, technical innovation, and new product development. CSSC has, over the past decade, organised over 2,000 people to go abroad for technical training and investigations, and some 1,000 foreign experts to provide lectures in China. CSSC has cumulative foreign investments of over US$200 million and some 150 direct foreign investment projects. Over one-third of CSSC affiliated enterprises have initiated foreign joint-ventures with firms from Hong Kong, US, Singapore, Thailand, Belgium, United Arab Emirates, etc. It had a total of over 68 foreign joint enterprises by the early 1990s.

During 1998-99, the CSSC undertook a major reorganisation under COSTIND into two major, and apparently competitive, conglomerate SOEs: the China Shipbuilding Industries Group and the China Shipbuilding Heavy Industries Group. Details remain unclear at this time but the overall structure of subordinate CSSC organisations is believed to remain valid.

5.2 Surface Combatants TOP

The PLAN has approximately 55 frigates and destroyers, including two Type 052 Luhu-class and 15 Type 051 Luda I/II-class destroyers, plus at least five under construction. Only two Luhu-class ships were built because of concerns over the use of key foreign equipment, such as US gas-turbine engines. Since the early 1980s to the mid-1990s, some estimates placed Chinese destroyer and frigate annual production at a rate of one to two destroyers and two to four frigates per year. However, current estimates place the PLAN's naval construction build-up only behind that of the US Navy. This is probably a low percentage of actual inherent production capacity that could be increased during a crisis.

The Luda-class was China's first indigenous destroyer design but is largely similar to the Soviet Kotlin-class. The steam-powered Luda-class is equipped with twin 57 mm guns or Breda 40/70 guns, two Z-9A helicopters, CY-1 ASW missiles (comparable to anti-submarine rockets) fired from box launchers originally developed for SY-3 (C-801) cruise missiles, triple lightweight torpedo tubes to fire Italian-type A244S torpedoes, and ESM that allows over-the-horizon attacks by its FL-2 anti-ship missile.

Two new 6,600-8,000 ton Luhai-class destroyers are being completed at the Dalian Shipyard and equipped with a new vertical launch missile system. This class is some 2,000 tons heavier than the earlier Luhu-class and is China's most modern warship design. The first of the Luhai-class, the *Shenzhen*, began sea trials during 1999 and was assigned to the South Sea Fleet. The second of the class is due to be completed by 2001. Up to four of the class may be produced. The main armament is the C-802 anti-ship cruise missile but it apparently has sufficient space for additional weapons, such as the Russian Raduga Design Bureau's Moskit/SS-N-22 'Sunburn' supersonic surface-to-surface missile (SSM), to be added in the future. Compared to the Luhu-class, the Luhai destroyers have double the number of C-802 fixed launchers amidships (16) and are equipped with a Sea Eagle (Rice Field) and Type 363 radar systems. The HQ-7 point air defence system used on the first of the class is considered by some to be inadequate and a more advanced indigenous or Russian system may be integrated into the Luhai design, as well as Luhu and Luda-class destroyers. The Luhai-class represents the PLAN's largest indigenous surface combatant to date, perhaps a major step towards the development of a 'blue water' fleet. The rumours of a larger, 11,000 ton follow-on to the Luhai-class is probably a hoax but could point to future intentions to develop cruiser size vessels.

The PLAN has four basic categories of frigates, the most recent being the Jiangwei-class, the Jianghu III/IV-class, the Jianghu II-class, and the Jianghu I-class. These are all armed with either YJ-1 or HY-2 SSMs and are currently undergoing extensive upgrades and modifications. In 1999-99, China undertook construction of two additional Jiangwei II-class guided missile frigates at the Huangpu Shipyard, Guangzhou, to supplement four Jiangwei IIs recently procured at Shanghai's Hudong Shipyard as a follow-on to the Jiangwei I-class. Two of the original four Jiangwei IIs may have been intended for export to Pakistan but this deal did not materialise (there have been recent reports that Pakistan may renew a four frigate purchase). Armament on the Jiangwei II includes two twin 37 mm guns and the new navalised LY-60 SAM. The Jiangwei-class also carries the CY-1 ASW missile in a sextuple launcher forward of the bridge. The class is reportedly deficient in long-range SAMs, sensor and EW systems, and ASW systems.

The second and third Jiangwei II-class frigates (Project 055), equipped with the Chinese version of the French Crotale Modulaire point defence SAM system, were completed during 1999, at Hudong Shipyard, with a number of modifications compared to earlier members of the 377 foot class. The awkward HQ-61 SAM sextuple launcher abaft the twin 100mm gunmount on the foredeck was omitted. The superstructure beneath the forward pair of twin 37 mm Model 76A gunmounts was extended toward the bow and the *Wok Wan* manned director for the 100 mm guns (based upon a 1940s Soviet 'Wasp Head' system) was deleted. A two-level deckhouse was added atop the pilothouse to support twin radar directors and the aft pair of 37 mm gun mounts flanking the helicopter hanger was raised one deck. Finally, the antenna for an air early warning system was fitted on a mast abaft the funnel for the 21,460 brake horsepower SEMT Pielstick 12 PA68 BTC dual diesel propulsion system built under licence. In general, by Western standards the class is still outdated and has limited ASW capability.

At the 1999 IDEX defence exhibition, a model design for a 1,600 tonne multipurpose guided missile frigate for export known as the F16U was revealed by the CSSC. Probably intended for export to Pakistan or Thailand, it includes many Western, Russian and Chinese weapons and sensor system options. These include Harpoon, MM 40 Block II Exocet, SS-N-25 Uran, 76mm OTOBreda main gun, twin Chinese 37 mm gun mounts on port and starboard, the Signaal 30 mm Goalkeeper close-in weapon system, twin decoy launchers, possible Thomson-CSF sensor suite with Jupiter-type long-range surveillance radar, Signaal STING-like fire-control and tracking radar, Signaal SIRIUS-like IR search and track sensor, 3-D missile designation radar (possibly Thomson-CSF's Arabel or Alenia's EMPAR), Eurosam Aster missile system, bow dome for medium frequency passive/active sonar, two five-bladed propellers and a French Dauphin or Chinese Z-9 shipboard helicopter. The frigate has a 32 cell VLS. It is rumoured that 3,100 ton 'stealth escort vessels' are now also under development.

The Luhu and Luhai-class destroyers operate two Z-9A Haitun helicopters and single Z-9As from the Jiangwei-class and some Jianghu-class frigates. The PLAN's helicopter-based ASW and anti-surface vessel capability remains at a developmental level. New PLAN ships are air-conditioned and sealed against nuclear, biological or chemical warfare attack.

Beijing's decision to purchase the 7,700 ton Sovremenny-class destroyers from Russia for US$800 million may have been a result of its perceived inadequate measures to counter the US deployment of carrier battle groups in response to China's 1996 military exercises in proximity to Taiwan. The 1996 Sovremenny purchase under 'Project 956E' will provide the PLAN with a modern, multipurpose surface combatant with significant anti-ship, anti-air, and anti-submarine capabilities integrated into a single platform (i.e. eight Mach 4.5 SS-N-22 'Sunburn'/3M-80E 'Moskit' 160 km range supersonic anti-ship missiles, Mach 3 SA-N-7 'Gadfly'/Shtil anti-aircraft missiles with a 25 km range, torpedo tubes, rocket launchers, bow-mounted sonar, and a Ka-28 Helix ASW helicopter), with some 44 missiles in all per ship. Derived Russian ship and combat system architectures will conceivably be applied to future indigenous Chinese ship designs. The first two of the class were constructed for the PLAN at the St. Petersburg's Severnaya Verf shipyard.

During February 2000, the first Sovremenny, the *Hangzhou*, was delivered to China, with a second scheduled for later the same year along with a reportedly large supply of Sunburn cruise missiles. In July 2000 it was reported that the second ship of the class had began sea trials in preparation for delivery to China by November 2000. Discussions are underway on the sale of two or more additional ships of the class, which may be vessels withdrawn from the Russian Navy and refitted for the PLAN by the Severnoye Design Bureau. The Sovremenny-class is the largest and most sophisticated combat ship type the PLAN has operated to date, and the service arm will require significant improvement in such areas as training, doctrine, logistics, maintenance and joint operations to be successfully deployed. Some have compared it to the US Aegis Ticonderoga-class or Japanese Kongo-class in complexity and capability.

An innovative alternative, or supplement, to aircraft carriers that reportedly has seen some recent Chinese interest, is the development of a large surface combatant class, similar to the Russian nuclear-powered Kirov battle cruiser class or the proposed US 'Arsenal Ship'. Such a class would be heavily armed with a variety of vertically launched defensive and offensive missiles, which could be used for sea-control, ASW, land-attack and anti-air and anti-missile operations. There have been some recent reports of the development of a larger, cruiser class vessel, with extensive VLS missile armaments and modern electronics, as a follow-on to the Luhai-class, but these are generally regarded as misinformation.

Other major PLAN surface ships include the training ship *Shichang* and the supply ship *Nanchang*. The 37,000 ton underway replenishment oiler *Nanchang* was originally built in Russia but was sold to China for a reported US$10 million. It had a final fitting out at Dalian in 1993 and was commissioned in 1996. The PLAN is also credited with having some 100 minesweepers (active and reserve), 44 mine warfare remote-controlled drones (active and reserve) for sweeping acoustic and magnetic mines, 1 minelayer, 6 troop transports (AP/AH), 5 submarine support ships, 3 salvage and repair ships, over 23 supply ships, 88 tankers, 4 icebreakers and 3 degaussing ships. The PLAN operates two 11,000 ton Dayun-class logistical replenishment ships.

PLA military intelligence has established 'communications stations' on numerous boats and ships (Dadi, Singfengshan and Xiangyanghong classes, almost 40 major units in all) for this purpose in co-operation with PLAAF and PLAN SIGINT units. Surveillance vessels are active in the South China Sea, Sea of Japan and Indian Ocean in monitoring the radio traffic of US, Japanese, Taiwanese, Russian, Indian, South Korean, Vietnamese and other military forces in the region. The *Shiyan 970* (weighing up to 2,000 ton), launched in 1998 from Shanghai's Zhonghua Shipyard, is believed to be China's most advanced intelligence-gathering auxiliary ship, and is now reported to be fully operational and concentrating on work with the PLAN North Fleet in the area of Japan and Russia.

China has recently developed realtime integrated meteorological information system for the PLAN's fleet of space launch tracking ships. The 'three oceans realtime integrated meteorological protection system', is a project linked to Chinese manned and unmanned space programmes and missile tests that employs four

Yuanwang-class space tracking vessels, which are routinely sent to the Pacific, Atlantic and Indian Oceans to track orbital and ballistic missions. The Yuanwang-class vessels have reportedly completed 31 Pacific expeditions of a cumulative 500,000 miles over the past two decades, and fulfilled over 34 measuring and navigating missions for major national scientific experiments and international commercial space activities with a full success rate. A new 4,600 ton missile-range tracking ship was completed during 1999.

The PLAN has large numbers of FAC of the Hoku, Hegu, Shanghai and other types, as well as large numbers of small patrol craft, gunboats, hydrofoils, and torpedo boats (perhaps 1,000 or more small armed craft altogether, if older designs are included). The PLAN is reportedly fielding a new missile-armed fast patrol boat believed to be designated the P-29, possibly modified from the Hegu export class, which has been sold to Pakistan armed with C-802 ASMs. In 1999, the Huangpu Shipyard completed two 542 ton Type 037/2 Houjian-class missile FACs to be deployed with the South Sea Fleet. New 478 ton Haiqing-class FACs were also delivered. The Shanghai Quixin Shipyard produces the 478 ton Houxin-class FAC, the Luxin-class missile FAC (at least four in 1999), and the Huangfen-class missile FAC for the PLAN. The Zhanjiang Shipyard produces the Hudong-class FAC.

The PLAN is building up to 26 of the Houxin-class each armed with four C-801/C-802 ASMs. The 10 Hudong-class FAC exported to Iran (first batch of five in September 1994 and the remainder in March 1996) mounts four C-801/C-802 ASMs on a 38 m hull derived from that of the 1960s vintage Osa-class. Self-defence capability is limited to a single AK-230 twin 30 mm mounting and possibly a MANPADS missile system but many of these smaller PLAN craft have ECM systems and radar-controlled anti-air attack guns. Houxin-class, Houjian-class (Project 520T) and Huang-class FACs are each armed with four to eight C-801/C-802 ASMs, as well as 30 mm, 37 mm and 14.5 mm guns, and weapons radar systems. Four Houjian-class FACs are stationed at Hong Kong.

During August 2000, the Australian Submarine Corporation and Hong Kong company Cheoy Lee Shipyards won a US$33.72 million contract to construct six Hong Kong 30 m police patrol craft. The Keka-class is believed to be heavily armed and was recently designed for the Royal Thai Navy. The major vessel replacement programme for up to 30 patrol boats for Hong Kong police could conceivably have technical benefits for the PLAN. In 1999, Hong Kong naval reservists were reported undertaking mobilisation exercises with the PLAN.

Elements of the large PLAN fleet of light vessels (FACs, escort vessels, torpedo boats, submarine chasers, corvettes, etc.) have recently been observed conducting exercises in conjunction with large surface combatants as far as 250 nautical miles from the coast. The exercises apparently had two objectives: the development of innovative new tactics to employ against a technically superior foe such as the US Navy; and enhancing the PLAN's ability to secure China's major sea lines of communications. The US Navy has recently conducted computer simulations where a large fleet of enemy light vessels and submarines armed with advanced cruise missiles was able to conduct serious damage to its carrier battle groups in a form of naval guerrilla warfare. The use of state sponsored, or at least condoned, piracy in the intense commercial shipping lanes of the South China Sea region, is another small vessel tactic that some have suggested is a possible wartime option for China. However, Beijing has recently implemented a severe crackdown aimed at piracy in the region.

5.3 Submarines TOP

China probably possesses the world's largest number of conventional submarines and a small force of nuclear-powered boats but many of these boats are facing obsolescence. The PLAN is believed to have approximately 96 operational or semi-operational submarines; only one of these is currently a SSBN and five or six are SSNs, although new classes of these types are now becoming operational. For example, the numerous Type 035 Romeo-class SSKs believed to be in PLAN operation are based upon a Soviet design dating from the late 1950s, which in turn had been based upon the Second World War German U-boat concepts (84 were built with about 30 still believed to be operational and over 50 in reserve). The Type 035 Ming-class is a follow-on design built by the Wuhan Shipyard. During 1999, two more Ming-class submarines were reportedly delivered bringing the total number to 19. The new Mings are of the modified ES5E model first launched in 1997, possibly due to problems with the Song-class development programme. Some estimates have suggested that China was producing at about one submarine every two years during the 1980s and one per year by the mid-1990s. In recent years this rate of production appears to have increased to two or more submarines per year. This is probably a low percentage of actual inherent production capacity that could be increased during a crisis. The China Steel Corporation reportedly provides HY-80/110 and better grade steel to the CSSC for submarine construction.

China has developed a first-generation nuclear powered Xia-class SSBN (Type 092) that carries 12 JL-1 SLBMs. The Julong *(*Giant Wave)-1 (JL-1, or CSS-N-3) is the navalised version of the DF-21. The first generation Xia submarine was reportedly very noisy and thus easily detectable. The JL-1 has a range of 2,150 km, carries a single 250 kT warhead, with 12 SLBMs per Xia submarine and three to 10 missiles in reserve. China has devoted considerable resources over several decades, spanning the harsh political and economic climate of the 1960s and 1970s, to develop the Xia-class and nuclear attack SSN Type 091 Han-class submarines, along with JL-1 SLBMs. These persistent efforts stand as a marked testimony of China's ability to co-ordinate the vast resources required for a complicated indigenous defence R&D and production programme, with little, if any, help from foreign sources and limited computer capabilities. This effort, while lagging behind the West and Russia technologically, also included the development of an instrumented fleet of specialised ships to monitor and analyse data during SLBM launches.

Reportedly, at least six specialised R&D institutes were established for this effort, dating back to the late-1950s. While the official organisation and communications structure of these institutes was vertically-oriented, in practice many unofficial, lateral ties were formed between the various dispersed members of the project team. Such a structure probably persists to this day in China's defence industry. China succeeded in developing a limited SSBN capability (most sources indicate a single operational *Xia*) but it was not clear how this technological capacity had been integrated within China's overall strategic deterrence posture and whether this will change with the acquisition of more modern and numerous boats and SLBMs. However, retired PLAN commander and vice-chairman of the Central Military Commission, Admiral Liu Huaqing, clearly designated the requirement for a survivable nuclear retaliatory force through the deployment of a credible submarine-based deterrent fleet, most likely as a long-term goal with a minimum four boat SSBN operational force.

The PLAN operates five Han-class SSNs but their overall operational status is uncertain. The first was laid down around 1968 and began trials in 1974, the second in the class was commissioned in 1980, with three more entering service between 1984 and 1991. All five submarines are assigned to the North Sea Fleet.

The Xia-class was laid down in 1978 and launched in 1981 but did not attain operational status until 1987. Displacing an estimated 7,000 t submerged, the design is essentially a lengthened Han with a missile compartment inserted aft of the fin to accommodate 12 JL-1 two-stage SLBMs. The Xia successfully launched a JL-1 some 1,400 km during trials in September 1988 to a target area in the East China Sea that was 400 km south-east of Shanghai (the PLAN's usual target area for SLBM tests is an area focusing on 123.53 degrees North and 28.13 degrees East, with a 35 nautical mile, or 65 km, radius).

Historically, China overcame the negative effects of the withdrawal of Soviet technical assistance by, in 1964, successfully assembling a single, diesel electric-powered, Golf-class submarine from parts earlier supplied by the Soviets. It appears likely that the Chinese used it as the test platform for their initial SLBM test in October 1982. Subsequently two Xia-class nuclear powered submarines (some sources have indicated more) were reportedly constructed, each equipped with 12 ballistic missile tubes, but it is uncertain if the second Xia can be considered fully operational. The operational Xia began a major technical upgrade in 1995 that has reportedly included a JL-2 capability; the single Golf-class submarine may also have been retrofitted with the JL-2. Reportedly, a Chinese nuclear submarine during 1985 to early 1986 navigated some 20,000 nautical miles (37,000 km), and broke a previous 84-day continuous underwater navigation record set by a US submarine.

The 1,700 ton Type 039 Song-class SSK is the double-hulled construction follow-on to the Type 035 Ming-class SSK. The first *Song* (320) was launched from the Wuhan Shipyard in May 1994, with two or more expected to be constructed. Sea trials began during 1995 but acoustic signature and other problems were apparent, and the second in the class, which was completed at the Wuhan Shipyard in 1999, is believed to be substantially modified. The Song is China's first new diesel-electric submarine design for over two decades and has a hydrodynamically efficient 'teardrop' type hullform. It has a stair-stepped sail with dive planes mounted on the lower forward section, and houses integrated spherical bow sonar, and also has a large upper rudder, and one highly skewed seven-bladed centreline propeller.

The Song-class is reportedly armed with a new submerged-launch anti-ship cruise missile designated YJ-8Q, which is a derivative from the ship-launched YJ-8, in addition to a variety of torpedoes and mines. It may be equipped with a licensed version of the French DUUX-5 Fenelon sonar, known as the Type 256, which has advanced features that permit the simultaneous detection/tracking of four targets at ranges of 200 km or more. Maximum speeds are 5 kt surfaced and 22 kt dived, with a maximum diving depth of 300 m. Russian technology is believed to have been used for the design of the submarine and perhaps German MTUE2V493 diesel engines (while MTU denies supplying the Song programme, it has in the past licensed the CSSC to manufacture MTU 1163 TB82 diesels for surface vessels). If the Song-class ultimately proves inadequate a new class of SKK, utilising air-independent propulsion (AIP) could be developed for improved submerged endurance.

Current naval nuclear projects include the closely related new generation Type 093 SSN (perhaps similar to the Russian Victor-III class) and the Type 094 SSBN (capable of carrying 16 new generation JL-2 SLBMs). Up to four Type 094 SSBNs may be developed, with one or more possibly under construction. Up to seven Type 093 SSNs may be developed, with the first now possibly undergoing testing and two more under construction. Some unconfirmed sources have indicated the Chinese designation '*Da Bie* Mountain' for this new SSN class, which reportedly has the capability to use vertically launched supersonic anti-ship and land-attack cruise missiles and possibly anti-air missiles.

New generation nuclear submarines will probably include significantly improved nuclear propulsion development compared to the older Han and Xia class submarines, which are reportedly unreliable, noisy and unsafe. Some unconfirmed reports indicate that these new nuclear submarine classes could be extremely fast (40 kt range), with noise levels comparable to current US designs, and will use high-temperature gas-cooled reactors such as those being developed by Tsinghua University's Institute of Nuclear Energy Technology. A military Submarine Institute is located at Qingdao. The Huludao Shipyard is reportedly China's major nuclear submarine shipyard (and indeed, the only one in Asia), and has previously produced the Han-class.

Construction of a hardened base for China's nuclear-powered submarines reportedly commenced in 1968 at an inlet near Qingdao on the Shandong Peninsula coastline of the Yellow Sea. The project included the removal of 810,000 cubic metres of rock and the pouring 200,000 cubic metres of concrete. An underground shelter system was camouflaged and hardened against attack by the mid-1970s, and includes multiple shelters with equipment for servicing nuclear propulsion systems and loading JL-1 missiles.

Some other reports indicate that the PLAN's Xia SSBN and JL-1 SLBMs are deployed at the Jianggezhuang Submarine Base. During the late 1980s, its is believed that an improved global VLF communications station at Chagde was developed to provide secure communications with submerged submarines.

New submarines and submarine technology is being obtained largely from Russia. The development of new Chinese submarine propulsion reactors has reportedly also been assisted by Russian specialists but possibly only under private contracts; Moscow has strongly denied direct involvement. Some reports indicate that the Russian Rubin Bureau began to provide assistance in 1995 for the design of China's next class of SSN in the areas of hull and machinery quieting, hull coatings, combat control, sonar, weapons (torpedoes and sub-launched cruise missiles, wake-homing and wire-guided torpedoes, the Yakhont supersonic anti-ship missile, etc.), and countermeasures. Other reports have claimed that Russia sold China hull coating technology to reduce radiated sound. During September 1999, unconfirmed reports indicated that China was prepared to purchase up to two Russian Typhoon SSBNs, amongst the world's largest submarines, each equipped with 20 SSN-20 SLBMs, each with 10 MIRV warheads and a range of over 8,000 km. These reports were denied by senior Russian officials but could be indicative of a potential major arms transfer in this area that would radically improve Chinese capabilities. Other speculative reports indicated that advanced Russian Project 971 Akula-class SSNs could be purchased by China, perhaps within four years. Russia is also expected to market its new Project 677 *Lada/Amur Type-1650* fourth-generation SSK to China, which would provide a very fast and stealthy capability with considerable range for the PLAN if equipped with AIP.

To date Russia has sold four Kilo-class SSKs to China. The second of the Type 636 Kilo-class SSKs arrived from Russia to China during 1999, the first having arrived in January 1998. The first two Type 866 Kilo-class hulls were delivered to the PLAN in February 1995 and November 1996, and were previously designed for another customer from the former Warsaw Pact. The third and fourth Kilos are the more advanced Type 636 SSKs that were built specifically for China. Based upon an old design, the most recent version of the Type 636 was developed by the Rubin Design Bureau and manufactured by the Admiralty Yard, St. Petersburg.

China was the first foreign customer for the fourth generation Type 636, although other less sophisticated versions of the Kilo have been obtained or ordered by India, Iran, Algeria, Poland and Romania. According to some sources, the PLAN Kilos could be retrofitted with compact nuclear propulsion and/or AIP systems. Increased training and maintenance is also required as components of Russian arms transfers because of incidents of unreliability. In one example, two of the PLAN's Kilos became inoperative for long periods due to engine and electrical system problems reportedly caused by faulty maintenance. An unconfirmed April 2000 report indicated that China may have already domestically produced a reverse-engineered version of the Kilo-class submarine.

The '863' Programme is funding the Special Ocean High-Tech Programme, which includes R&D in marine investigation, exploration and utilisation, particularly marine oil and gas prospecting technologies of the type required to exploit offshore South China Sea resources. The CR-01 cable-free automated underwater robot, developed by the Shenyang Institute of Automation (National Engineering Research Centre for Robot Technology) and the CAS Beijing Institute of Acoustics, was announced in 1997. Capable of diving as deep as 6,000 m, it represents technology that could also be applied to military submarines (acoustics systems, automatic control systems, propulsion and energy systems, and vehicle recovery methods). Technologies for the project, such as acoustics sensors, were reportedly obtained from Russia's Institute of Maritime Technology Problems.

The Type 312 is a small, remotely controlled underwater mine countermeasures system believed to be for use in harbours and estuaries. It uses a 20.94 m long drone with a displacement of 39 t, which is controlled by radio signals from a shore station or mother ship up to 3 nautical miles (5.55 km) away. During transit the drone is powered by a 12V 150C 500 hp supercharged diesel engine, giving a maximum speed of 11.6 kt. During minesweeping operations the drone is powered by an electric motor. It has a range of 108 nautical miles at 9 kt. Acoustic and magnetic sensors are used but it is not clear how located mines are destroyed.

5.4 Amphibious Assault Capabilities TOP

The PLAN's amphibious assault capabilities are currently estimated to provides sealift sufficient to transport approximately one to two infantry divisions. It also has access to hundreds, if not thousands, of smaller landing craft, barges, and troop transports, civilian fishing boats and trawlers, and a large number of civilian merchant ships (China's merchant marine - COSCO - is the world's largest) to augment military transport. For example, in 1997, the 10,000 ton *Huayuankou* roll-on/roll-off cargo ship was refitted for the wartime deployment of troops and helicopters, under a non-defence budget project jointly funded by the State Planning Commission, the CSSC's Number 708 Research Institute and the PLAN. The PLA also has shortcomings in military long-range airlift, logistics, and air support, but again has access to large numbers of civilian air transport aircraft for logistical support for amphibious operations. A recent Taiwanese estimate indicated that the PLAN could deploy some '300-plus landing craft', including commercial fishing vessels, for an invasion operation.

Air-cushion vehicles are reportedly being developed to increase amphibious assault capabilities. Newer designs include the '*BeiXing'* all aluminium and alloy hydrofoil that operates between Hong Kong and Macao. A new high-speed hydrofoil craft being developed at Huangpu Shipyard is believed to be a priority project. The Special Vehicles Research Institute reports that it has conducted R&D on surface effect vehicles and wing-in-ground (WIG) effect vessels. During 1998 tests were conducted on the prototype 'White Swan' (DXF-100 designation according to some reports) WIG effect ship at Dianshan Lake, Shanghai. The Swan is reportedly designed by the CSSC's Shanghai Number 708 Research Institute and constructed at the Quixin Shipyards. Composite materials were used extensively in its design, which integrates the technologies of hovercraft and ground-effect aircraft, and is probably based upon a large amount of Russian Volga II passenger ferry and military 'ekranoplan' research in this area. It can carry 15 to 20 passengers at speeds of up to 130 km per hour; a follow-on model will reach speeds of up to 250 km per hour. A 1999 report indicated that an apparent follow-up design capable of carrying 100 lightly armed troops was being developed at Quixin. Larger versions could be used for ASW, anti-ship, and amphibious assault and rapid troop transport.

A June 2000 report indicates that the PLAN has recently revived a production programme for the Yuting (Type 074)-class landing ship-tank (LST), with four platforms built over the past year and more probably on order. Of the four Yutings recently completed, two are operationally deployed and two are in the final stages of fitting at Zhonghua. Six of the class were produced at the Zhonghua shipyard in Shanghai from 1991 to 1996 in order to augment amphibious lift capabilities and helicopter deployment. These ships have a full-load displacement of 4,800 tons and can carry 250 troops along with 10 main battle tanks and four landing craft, as well as a platform to accommodate two medium helicopters. While it was believed that the series had been completed when the last of these was commissioned in January 1997, the resumption of production at Zhonghua appears to have been prompted by PLAN concerns over its reportedly limited maritime lift capabilities given heightened tensions with Taiwan.

The PLAN operates Yuting, Yukan and other tank landing ships, and has recently deployed Jingsah-class air-cushion vehicles. The PLAN's regular inventory of amphibious ships includes some 16-21 LSTs (plus those on order) such as the Yuting-class, Yukan-class, and Shan-class; 43-44 medium landing ships (LSMs) such as the Yudao and Yuliang classes; and 44 medium/utility landing craft (LCM/LCU) - but with perhaps 230 or more old vessels in reserve. All of which are currently considered insufficient by some analysts to mount a major assault on Taiwan. New models of troop transports have recently been developed such as the Zhousan-class Type 072 LST and the Qiongsha-class assault ship that can carry over 400 troops or 350 tons of equipment. Numerous hovercraft-type assault ships are probably being developed. The new Yuting-class procurement programme may also be outside the current five-year defence modernisation plan, which indicates increased flexibility in equipment modernisation . PLA Factory 781 reportedly manufactures amphibious landing craft. There have also been unconfirmed reports that the PLAN is developing a new 18,000 ton-class LST (Project 9885) with an unknown date of service entry.

Some reports indicate that the PLA marine corps may have up to three or more divisions, each with over 5,000 men. Other reports estimate that it only has a one or two brigade strength of between 6,000 to 8,000 men with an attached tank battalion, all stationed at Hainan Island. Discrepancies in the actual strength estimates could be the result of confusion caused by regular PLA units being trained for amphibious warfare operations which may number up to 100,000 men, particularly units of the 31st Group Army in Fujian, part of the Nanjing Military Region. Primary heavy equipment includes Type 63 amphibious tanks and Type 77 amphibious armoured personnel carriers. The Type 99 is the most recent amphibious light tank in PLA service.

5.5 Aircraft Carrier Development Programme TOP

Since at least 1992 there have been reports that China's Central Military Commission had decided in principle to support the development of a blue water fleet that would include up to three aircraft carriers as early as the end of the decade. Evidence of support for this position was provided by strategic assessments attributed to Chinese military thinkers. Notable examples include: *Can the Chinese Army Win the Next War?* (1993); *A New Scramble for Soft Frontiers* (1995); and the article *The Dream of the Chinese Aircraft Carriers* (published in *Modern Ships*, January 1995). China's military establishment is reportedly concerned over the lack of a power projection capability for operations directed against US and Japanese regional forces, Taiwan, the South China Sea and the Strait of Malacca and beyond to the Indian Ocean.

Various actions have seemingly supported this assessment. A simulated flight deck with catapult and arrester wires is said to have been copied from the decommissioned Australian light aircraft carrier HMAS *Melbourne*, which China supposedly bought for scrap during 1984 and rebuilt at a northern Chinese air base (some reports indicate that the bulk of the ship was scrapped by 1994 after a thorough analysis by naval experts). The ex-Soviet era aircraft carriers *Varyag* and *Minsk* were reportedly purchased by Chinese proxy organisations to be closely examined for reverse-engineering in addition to being used for commercial projects. The PLAN had access to US aircraft carriers on numerous occasions prior to 1989 and reportedly observed the scrapping of the 51,000 ton *USS Franklin D. Roosevelt* (CVA-42). Some claim that an operational Russian aircraft carrier was not purchased by 1993 largely due to cost considerations, but that Russian knowledge in such areas as ski-jump aircraft launch systems, ASW helicopters, and naval airborne warning and control system (AWACS) aircraft would be made available on demand.

The 40,000 ton 'aviation cruiser' *Minsk* was reportedly purchased in 1998 for just several million dollars by a Chinese commercial enterprise, the Guangdong Ship Dismantling Company, through a South Korean intermediary. It is now believed to be used as a tourist attraction by the Shenzhen Ming Si Ke Investment

Company Ltd. at the small port of Shatian in Guangdong Province after having been stripped down to little more than an unpowered, corroded hulk, bereft of all electronic and weapon systems, by Russia. However, design drawings of the *Minsk* were also probably part of the deal and could have more utility than the actual ship.

China's interest in the *Varyag* is believed to date back to at least 1992 (erroneous reports during that year indicate that it had already purchased the ship and a complement of Su-27K carrier aircraft). A May 1998 report cast doubt that the US$20 million sale of the *Varyag* (one of two Kuznetsov-class carriers dating back to the early 1980s, originally planned for the former Soviet Navy and about 70-80 per cent complete) would proceed with the Macao firm Agencia Turistica e Diversoes Chong Lot Limitada (registered in August 1997 under an apparently fictitious local address, and controlled by Hong Kong residents Cheng Zhen-shu and Chong Lap-cheung, reportedly with strong connections to PLAN shipbuilding interests). Furthermore, the contract with the Russian arms export agency Rosvoorouzhenie was to have prohibited the use of the vessel for direct military purposes, although studying the ship's design and technology would be difficult to prevent (as it would also be for the *Minsk* in terms of naval design and construction). Chong Lot had applied to the Macao government within a month of its formation for permission to dock the carrier in local waters to serve as a floating hotel or casino but this proposal was at least initially rejected. In any event, the 67,000 ton *Varyag*, which was actually owned by the Ukraine as part of the Russian-Ukraine Black Sea Fleet, is believed to be in poor, stripped-down condition and would apparently be difficult to renovate to an operational status (costing upwards of US$2 billion).

However, the UK's Marconi Electronic Systems and France's Thomson-CSF have according to some accounts jointly offered to refit the *Varyag* for flight operations, navigation, testing and logistics, all co-ordinated through Paris-based trading agent P.J. Masson's firm IBC 500 and perhaps funded through a barter arrangement with Chinese state-owned enterprises. While Marconi and Thomson have denied this allegation, they are prime candidates for providing sophisticated technical systems for an indigenous Chinese aircraft carrier programme. Both companies are currently thought to be supplying the PLA with other advanced defence technologies ranging from naval destroyer upgrades and AWACS systems to fighter aircraft fly-by-wire, avionics and radar systems. Reports during 1998 and 1999 indicated that some type of commercial deal was apparently proceeding and that the *Varyag* would be more likely to compete with the *Minsk* as commercial family amusement centres or aircraft carrier theme parks rather than an operational combatant.

It was thought that a light helicopter carrier programme would probably precede a full fixed-wing or vertical/short take-off and landing (V/STOL) aircraft carrier. The latter was predicted to be in the 40,000-plus ton range with an envisaged launch date of 2010. Russia, Spain and France have reportedly offered to construct aircraft carriers for China, regardless of US objections. For example, in 1995 the Spanish shipbuilder Empresa Nacional Bazan reportedly made such an offer for a light 'AC200' 25,000 ton or a medium 40,000 ton design for an estimated US$400 million. This did not result in a construction contract although it is possible a design was purchased by China. The Chinese may have also acquired design information on France's new nuclear-powered carrier the *Charles De Gaulle*. By 1996, the PLAN had reportedly discussed the direct purchase of the carrier *Clemenceau* but had missed an opportunity with the 37-year old *Foch*, which was sold to Brazil in August 2000.

China has also reportedly obtained the detailed plans for the Russian Kiev-class helicopter and V/STOL aircraft carrier as part of the *Minsk* purchase (or, according to other reports, obtained them from the Nevskoye construction bureau for under US$1 million without official approval from Moscow during the early 1990s). Nevertheless, the ASW emphasis of the design, which is over three decades old, has limitations that are probably unsuitable for PLAN requirements, which are believed to emphasise a conventional take-off and landing (CTOL) platform with ski-jump. Some unconfirmed reports have claimed that China has acquired four Yak-36 V/STOL fighter aircraft from Russia, which could be reverse-engineered and technically upgraded. The Russian 80,000 ton Ul'Yanovsk-class nuclear-powered aircraft carrier design, which was never completed, could perhaps better meet China's long-term requirements. However, Russia's continuing decline as a major naval power would also make the choice of its carrier technologies by China somewhat questionable other than as an interim measure until it could perfect domestic designs.

Reports from 1997 indicated that President Jiang Zemin wished to accelerate the Chinese aircraft carrier programme. Other reports during the same year indicated that a light helicopter carrier would precede the development of a true aircraft carrier. However, conflicting, pessimistic reports by June 1998 forecast that China would wait until 2020 to fully deploy an aircraft carrier because of a lack of programme funding estimated to be some US$500 million for domestic construction and foreign equipment imports. Another concern was the lack of trained flight crews, although PLAN officers had since the late- 1980s been receiving training in large ship handling and flight deck operations on mock-up facilities. The lack of suitable carrier-borne aircraft was another possible stumbling block. Some discussions were reported with the Royal Thai Navy on V/STOL aircraft operations on their light aircraft carrier (just purchased in 1997 before the crash of the south-east Asian economy), the Spanish-built 11,500 ton *Chakkrinareubet*, which operates a ski-jump flight deck, two aircraft elevators, and four helicopters and six Harriers. Another potential obstacle was international condemnation of the development of an offensive power-projection capability, particularly by smaller neighbours (in the current strategic environment this concern appears increasingly unlikely). A 24-month feasibility study on design concepts was to be conducted by Beijing-based defence institutes.

Arguments frequently cited against China acquiring or developing an aircraft carrier capability include: the high cost; a lack of complementary escort and supply vessels; alternative means (e.g. shore-based long-range aviation, nuclear submarines, and advanced conventional-warhead cruise and ballistic missiles) of achieving similar military results in the region; and the vulnerability of such ships to missile and submarine attack (particularly to the US Navy). Many would argue that China simply lacks, for the foreseeable future, the expertise and trained personnel to develop and operate such large capital ships with complementary naval aviation capabilities.

However, recent reports indicate that China's aircraft carrier programme may have gained new life. While some defence analysts continue to deny the existence of a Chinese aircraft carrier programme, or an initial deployment until about 2020, international developments and regional challenges to the PLAN, particularly by the US and Japan, also reinforce the likelihood, and urgency, of such a programme from Beijing's perspective.

Recent unconfirmed reports have claimed that a 48,000 ton PLAN CV aircraft carrier is under construction at Shanghai's Hudong Shipyard (Zhaochuanchang), as part of a co-operative design and development effort between the Wuhan Ship Design Institute and other naval institutes in Shanghai (including the Jiangnan Shipbuilding Company) and Dalian. The aircraft carrier programme is reportedly classified as the 'National Defence 9985 Project' and has seen several major redesigns during the past several years. It will reportedly be powered by gas-turbines with a capability of up to 30 kt, although follow-on versions of a projected class of three may be nuclear-powered. Funding for two has been approved but the PLAN requires three. Nuclear propulsion systems could be the same as those used for the newest generation of Chinese nuclear submarines. The design has undergone various revisions during the past four years but has now been frozen with shipbuilding underway at an early stage. A modularised design is to be employed. The cost of each ship is an estimated 3 billion to 19 billion Rmb yuan, according to varying reports (this is cheaper than Western carriers but China has low labour and overhead costs, as well as superior purchasing power parity). Long-term spending of some 1 billion renminbi has already been approved.

With a conventional angled flight deck, its aircraft complement is expected to include 24 (one squadron) to 36 of the new J-10 indigenous fighter, which has seen numerous programme delays over the past several years but is now believed to be in the flight test stage. The navalised version of the J-10 (twin-engined) reportedly does not require a steam catapult launching system because of the possible use of a ski-jump system or an innovative electromagnetic system China is believed to have developed. Russian-derived, domestically manufactured 'Top Plate' 3-D radar and propulsion systems (TB-15 steam turbines; gas-turbine technology has also been transferred from the Ukraine, and some reports indicate that combined diesel and gas, or CODAG, systems may be used) are to be employed, and two 6x4 (or 6x2) vertical-launch missile systems (fore and aft) for various missile types (anti-ship, anti-air, anti-submarine), as well as automated 37 mm cannon. The extensive array of defensive and offensive systems could be intended to lessen the needs for extensive escorts. Other carrier aircraft could include AWACS, ASW and utility helicopters/aircraft (perhaps 10 to 13 of these various types), or as alternatives to the J-10, shipborne advanced derivatives of Russian Su-27 (Chinese designation J-11) and Su-30 fighter-aircraft. The PLA Navy Aviation Technology Academy is reportedly undertaking research on shipborne aircraft flight safety, operations and flight dynamics. Persistent reports indicate that the first hull was put into dry dock during July-August 1999 but there is at present no publicly available satellite imagery to confirm such construction claims.

An August 1999 report carried by *Agence France Presse* cited Beijing's approval for the construction of two aircraft carriers, one of which would displace a massive 250,000 metric tons, and a smaller one of 30,000 tons, both of which are to be completed by 2009. Such claims for a Chinese super carrier might easily be totally dismissed as mistaken or misleading information (certainly, this would represent the largest warship in history, dwarfing even current US super carriers). Nevertheless, immediately following the US attack on the Chinese Embassy in Belgrade, public support for an aircraft carrier programme was reportedly orchestrated by a former PLA female soldier with the surname Li (writing under the pen-name *Bingmeizi*, or 'Sister Soldier') on Chinese Internet sites. The author called for 'Chinese around the world to unite and contribute to the construction of the world's largest and most advanced aircraft carrier to enhance our country's defence capability'. The plea was reportedly taken up by the Chinese media and thousands of supporters and millions of yuan were donated to the cause.

During May 1999, the China Science and Technology Association issued a statement that indicated: 'The fact that China is the only permanent UN Security Council member with no aircraft carrier battle group is a handicap which fails to match China's status.' It also published a book entitled *The 21st Century: China's Super Aircraft Carrier*, with the thesis that the PLA should be modernised through domestic ingenuity and not simply procuring foreign systems.

A January 2000 report, carried by the Chinese daily newspaper *Ming Pao* and citing an unspecified source, indicated that a 48,000 ton carrier would begin construction during 2000, be in the water by 2003, and be operational by 2005. The carrier would have a complement of 24 fighter aircraft and would cost some 4.8 billion renminbi yuan. Additional aircraft carriers would be reportedly constructed every three years.

Chinese shipyards with a large ship construction capability include: Shanghai's Hudong Shipyard (100,000+ ton capacity) and Jiangnan Shipyard (80,000+ ton capacity); and the Dalian Shipyard (80,000 ton capacity). Related naval R&D centres include the Shanghai Merchant Ship Design and Research Institute, Shanghai's Marine Design and Research Institute, Shanghai's Shipbuilding Technology Research Institute, the Shanghai Marine Diesel Engine Research Institute, Beijing's China Ship Research and Development Academy, the Harbin Marine Boiler and Turbine Research Institute, and the Wuhan Ship Design Institute. A huge new 4.7 billion Rmb yuan shipyard is currently under construction in Shanghai's eastern Pudong district at Waigaoqiao. Some reports indicate that the Shanghai Jiangnan Shipbuilding Company has constructed facilities that could be used for the simultaneous construction of three 60,000 ton aircraft carriers (the US can only construct two carriers simultaneously).

The Dalian ('Red Flag Number Seven') Shipyard has reportedly been upgraded along the lines of the Newport News Shipbuilding facilities where US Navy aircraft carriers are constructed. This includes a 300,000 ton dry dock facility that has been linked to aircraft carrier construction (if based at Dalian, the initial carrier would be part of the PLA Navy's North Fleet), but which apparently only has a single carrier construction capability at a time. Admittedly, the construction of large commercial vessels lacks the complexity of specialised aircraft carrier naval architecture requirements, although modern modular techniques have dual-use applications. With its lack of experience in large warship construction, the R&D, systems engineering and integration of an aircraft carrier will be major, but not insurmountable, challenges for China.

As previously discussed, various programmes are believed to be underway that could potentially complement the carrier programme. New generation Type 093 nuclear attack submarines and rumoured 3,100 ton 'stealth escort vessels' could be used as components of a PLAN carrier group. New generation improved surface vessels are indeed becoming operational and a programme to develop operational support capabilities for a carrier group could be developed in parallel to the carrier programme. Various missile, gun and torpedo systems, towed-array sonars, phased-array radars, and combat control systems have now been developed or acquired by China for potential use in a carrier group. The aircraft carrier programme could result in a major restructuring and technological upgrading of the entire PLAN. It could also encourage other advanced technology commercial spin-offs of value to China's entire economy and stimulate innovation in state-owned defence enterprises.

An innovative alternative, or supplement, to aircraft carriers that reportedly has seen some recent Chinese interest, is the development of a large surface combatant class, similar to the Russian nuclear-powered Kirov battle cruiser class or the proposed US 'arsenal ship', which would be heavily armed with a variety of vertically launched defensive and offensive missiles that could be used for sea-control, ASW, land-attack and anti-air and anti-missile operations (and perhaps heavily armoured and semi-submersible to enhance survivability). Given China's growing sophistication in advanced ballistic and cruise missile technology, the former Soviet design approach of integrating long-range ship-to-ship, anti-submarine and anti-aircraft/missile missiles within aircraft carrier designs could also be adopted as a compromise solution. A PLAN officer has reportedly recently advocated the construction of a light aircraft carrier equipped with aircraft, automated heavy and light cannon, advanced command, control and communications and EW systems, as well as ship-to-ship and ship-to-air missiles. It is also useful to note that while in the US Navy the US$5 billion USS Nimitz-class (CVN-68) nuclear-powered super carrier faction still predominates (derivatives of which now have a displacement of over 100,000 tons), plans are increasingly being discussed for a new class of conventionally-powered (direct electric drive), smaller carriers with stealth features and equipped with V/STOL aircraft.

However, a complete Chinese aircraft carrier programme, including R&D and design, shipbuilding and equipment installation, sea trials and operational training and support, in addition to the procurement of appropriate aircraft, could take a decade or more to achieve (some reports indicate as long as 18 years). If recent reports prove accurate, China's aircraft carrier programme could, however, be well into an accelerated development cycle.

The training ship/helicopter carrier *Shichang* was completed at Shanghai's Quixin Shipyard in December 1996 and deployed during 1998. At an estimated 12,000 tons full-load, it provides a limited naval aviation capability with a complement of 4 Z-9W helicopters (similar to a scaled-down version of the Royal Navy's Argus-class multi-role support ship). It has been described by the PLAN as a 'national defence mobilisation ship' and can be used for cadet navigational training or disaster relief. The *Shichang* can also be used as a helicopter training ship (modules can be stacked to form a helicopter hanger and flight control station in addition to the two spot helicopter deck), a hospital ship or a container ship capable of transporting 300 twenty foot equivalent cargo containers on its deck. It has crew accommodations for some 200 personnel and is believed to be unarmed.

With its straight deck, it could arguably represent a type of first-generation Chinese light helicopter carrier to provide the PLAN with some naval aviation experience beyond simply operating helicopters from the flight decks of destroyers and frigates. The development of a light helicopter carrier prior to a true aircraft carrier would provide the PLAN with valuable experience in naval aviation, carrier group operations and the defence of high-value targets. Such vessels would also provide greatly improved power projection capabilities for amphibious warfare operations. However, some recent reports indicate that China has bypassed light carrier development and is proceeding directly to full aircraft carrier operations.

5.6 Naval Systems TOP

5.6.1 Weapons

A priority for current PLAN weapons programmes is the detection, tracking and targeting of US carrier battle groups at as great a range as possible in the event of a conflict involving Taiwan. In order to achieve this objective China will use aircraft, air, sea (surface and submarine) and ground-launched cruise missiles, mine-warfare systems, and some IW efforts.

Indigenous naval missile systems include the 'cumbersome' and 'unreliable' short-range HQ-61 SAM and the fourth generation C-101, C-301, C-801 and C-802 anti-ship cruise missiles. The HQ-61M version reportedly has a range of 3 km to 10 km. In 1999, the PLAN reportedly began replacing the HQ-61 SAM used in Jiangwei-class frigates with the new LY-60N SAM system developed by the Shanghai Academy of Spaceflight Technology. The LY-60N has improved range and targeting capabilities. The missile is applicable to use with VLS.

The indigenous CSA-NX-2 SAM, fitted to two Jiangdong-class frigates during the 1970s, was considered to be a failure. The FM-80/HQ-7 short-range ground and ship-based solid propellant theatre defence missile is reverse-engineered Russian technology and mounted on the Luhu-class destroyer. To enhance its relatively poor air defence capability the PLAN has also started using shipborne versions of the NORINCO PL-9C missile-gun integrated weapon system, which includes 37 mm guns. Jianghu-class frigates and Luhu-class destroyers are among the ship types believed to be equipped with this system. An effort is reportedly underway to modify the HQ-9 Patriot-like SAM system for shipborne use. Shipborne laser defence systems are also reportedly under examination.

A submarine-launched anti-ship cruise missile programme is believed to be underway based upon the C-802 (the so-called Ying Ji YJ-8-2). By the early 1990s OTH anti-ship targeting methods were in use by the PLAN.

The YJ-83 is the latest version of the YJ-8 (CY-1) anti-submarine missile, encapsulated for underwater launch from torpedo tubes, and the Zhuhai-class may be armed with this system. Modified Romeo-class submarines reportedly carry six YJ-1 SSMs.

R&D and procurement is being conducted on advanced sea mines reportedly incorporating rocket propulsion (e.g. the EM-52 type), advanced propelled-warheads, mobile stand-off capabilities, microprocessor and remote-control radio/acoustic detonation technologies, to increase PLAN capabilities for denial of sea control to superior naval forces through an asymmetrical warfare strategy. China currently produces the EM-11 bottom influence mine, the EM-31 moored mine, the EM-32 moored influence mine, the EM-52 rocket-propelled rising mine, and the EM-53 remotely controlled, acoustically activated, ship-laid bottom influence mine, as well as new generations of mobile, submarine launched mobile bottom mines, propelled-warhead mines and Russian designed systems. The PLAN probably has the capability to lay entire dormant patterns of various types of mines that can be activated and deactivated at will prior to a conflict. However, the PLAN is believed to be deficient in mine countermeasures.

The US was supporting the transfer of Honeywell Mk46 Mod 2 anti-submarine acoustically-homing torpedoes to the PLAN prior to 1989. The Ming-class SSK is armed with indigenous Yu-4 (SAET-60) torpedoes, with hull-mounted sonars that have active and passive search and attack modes. The Whitehead A244S anti-submarine torpedo is in the PLAN inventory. A Yu-5 torpedo has also been developed. An indigenous Type C43 heavy torpedo may have been developed in the early 1990s with wire mid-course guidance and active/passive terminal homing systems for launch from surface ships and submarines. Another reported system is the 324 mm Mk32 ASW torpedo. FQ 2500 ASW 26-barrelled mortars probably originate from a 1950s Soviet design. PLAN systems include the SRBOC Mk33 six-barrel chaff launchers

Naval gun developments include:

· AK-130 130 mm/70 DP;

· Type 60 130 mm;

· Type 76 130 mm/58 DP (on the Luda-class destroyer);

· Type 79 100 mm/56 DP (on the *Chengdu*, *Jiangnan*, *Jiangdong*, *Jianghu*, *Jiangwei* I frigates);

· Creuset-Loire 100 mm/55 compact;

· The new 100 mm/56 DP (on the Luhai, Luhu, Jiangwei II classes);

· Type 76 57 mm/70;

· Type 76A 37 mm/63;

· Type 66 57 mm/70 (on the *Zheng He* training ship);

· Type 61 37 mm/67 (USSR Model 1939);

· The new rapid-fire 37 mm gun;

· AK-630 30 mm/65;

· Type 69 30 mm/65 (USSR AK-230) (small patrol craft);

· Type 61 25 mm/60 (USSR Model 1940);

· 4.5 mm MG;

· 2.7 mm MG.

5.6.2 Electronics

Increasingly sophisticated EW and ECM systems are being developed for major PLAN warships, including automated data exchange and passive and active intercept and countermeasure capabilities against radar (fire control and missile seekers), communications, data signals, and electro-optical and infrared threats. The 'Sea Guard' shipborne ECM system was displayed at CIDEX '98 and is applicable for small-to-medium sized vessels to counter dual-mode (radar/IR) guided anti-ship missiles (a similar system has reportedly been developed for ground use that also includes smoke grenades to counter laser and TV-guided PGMs). Domestic decoy launch systems (for example the ECR-1) and anti-sonar and anti-torpedo ECM systems have also reportedly been developed by CSSC research establishments (notably the EAJ-1). French Thomson-CSF Sea Tiger surveillance radars and TAVITAC 2000 command systems were initially obtained in the early 1990s for a Luda-class modernisation programme, and are now produced as an uprated unlicensed version, the CSS-3 combat data-system.

The PLAN data-link system, 'Link W', is reportedly an unlicensed version of the US Link 11 system. Russian command systems are quite different in concept (and in some respects more primitive than comparable Chinese systems), and may cause difficulties for integrating various ships into the overall fleet. The first indigenous PLAN combat data system was reportedly developed during the late 1980s. Other naval electronics includes the BM-8610 ESM system and the Type 945 GPJ ECM.

Information on radars used by the PLAN continues to be limited. Identified Chinese naval air/surface search radars comprise the I-band (8 to 10 GHz) ESR-1 surface search/fire-control radar; the G-band (4 to 6 GHz) Hai Ying air search radar; the three-dimensional G-band 'Rice Screen' air search radar; the I-band Type 352 surface search/fire-control radar; the G/H-band (4 to 8 GHz) Type 354 (NATO reporting name 'Eye Shield') air/surface search radar; and the E/F-band (2 to 4 GHz) Type 360 surface search radar. Of these, the ESR-1 is reported to be installed aboard Chinese Luhu-class destroyers while the three-dimensional 'Rice Screen' radar is noted as being installed aboard Jianghu I/III/IV-class frigates.

The Type 352 radar appears to be a Chinese variant of the Russian 'Square Tie' system and is described as being fitted to: PLAN Luda I/II-class destroyers; Jianghu I/III/IV-class frigates; and Huangfen/Hegu/Hoko/Hema/Houijan/Houxin-class guided-missile FACs. The remaining cited system - the Type 360 surface search radar - has been noted as being installed aboard Thai Naresuan-class frigates. It is also likely that Jiangwei-class frigates and Houijan-class guided missile FACs are fitted with a derivative of the Russian A-band (70 to 73 MHz) P-8 (NATO reporting name 'Knife Rest') air search radar, which may be designated as the Type 765 in Chinese service.

Outside mainland China and aside from the already noted Thai use of the Type 360 equipment, the Type 352 radar is probably installed aboard. Examples include the Bangladesh single Jianghu I-class frigate and five Durdarasha-class guided-missile FACs; the Egyptian pair of Jianghu Is; the North Korean four Huangfen-class guided-missile FAC; the Pakistani four Huangfens and four Haibat-class guided-missile FACs; and the Thai four Chao Phraya-class frigates. The Type 765 radar is noted as being fitted to the Egyptian pair of Jianghu Is. Sources suggest that China has developed a series of I-band (8 to 10 GHz) navigation/surface search radars (said to include the Types 752, 753, 756 and 757), which are suitable for installation aboard destroyers, escorts, FAC and submarines. Identified applications include the Houxin-class guided-missile FAC (Type 756) and the Bangladesh Jianghu I (Type 753 - surface search role).

The PLAN has supported towed-array sonar research since the mid-1970s and a number of domestic systems have been developed, as have underwater sonar stations. Chinese engineers developed a copy of the French DUBV-43 variable depth sonar, which incorporates some US technology, during the 1990s. The PLAN had obtained two DUBV-43s for the *Harbing* and *Qingdao* Luhu Type-053 class destroyers, which were commissioned in 1994 and 1996 respectively. The PLAN had also purchased French DUUX-5 sonar equipment by the early 1990s. An indigenous sonar system that was reverse-engineered, and reportedly incorporates US technical innovations, is believed to be deployed on the Zhuhai-class destroyer. In 1999, Harbin Engineering University announced a breakthrough in the development of the 'phase coincidence of underwater multi-channel holographic hydrophone measuring system, including system shock, noise absorption, and other problems', which has applications for national defence and maritime resources. The Hangzhou Applied Acoustics Research Institute is active in the development of defence acoustics technologies and the linkage of them to space-based systems. The institute is believed to have co-operated with Canadian research establishments in this area, ostensibly for civilian maritime natural resource applications.

5.6.3 Propulsion

As discussed in section 2.3.7, the Zhuzhou Aero-Engine Company and the Harbin Marine Boiler and Turbine Research Institute have developed a marine power plant for hovercraft through modifying the WJ6 gas-turbine. The Xi'an Aero-Engine Factory has converted the WS9 into a 11,000 kW (15,000 hp) industrial power plant. Research is under way on a 22,000 kW (30,000 hp) marine system that would be suitable as a naval power plant.

In August 1986, CATIC licensed the technology for the US Pratt and Whitney FT8 gas turbine engine, including joint development, production and international marketing rights for 25 years. The FT8 is a development of the JT8D-219 aero-engine (used to power Boeing 727, Boeing 737, and MD-82 aircraft) and can produce 24,000 kW (33,000 hp). This represents another significant technical leap for China's gas turbine capability, with potential naval applications, and operations began in 1996.

There are unconfirmed reports that the PLAN is developing an 'all electric direct drive' test platform, which could use electric power generated from diesel generators not only for ship propulsion but also for powering energy-intensive sensor and weapon systems. Similar research is underway in the US and other nations.

5.6.4 Other Foreign Technology Transfers

Significant surface vessel and submarine technologies have been transferred from Russia. These include the four Kilo submarines; TEST-71ME wire-guided acoustic homing ASW and 53-65KE wake-homing anti-surface vessel torpedoes for the Kilos; ASW systems such as the Kamov Ka-28 or Ka-30 shipborne helicopters, and possibly the (supposedly suspended) Yak-44 naval AWACS aircraft; and Sovremenny-class destroyers with advanced sea denial weapons systems such as the SS-N-22 'Sunburn' anti-ship cruise missile.

There are unconfirmed reports of a Chinese purchase of the Russian Shkval (Squall)-E rocket-powered torpedo that travels at up to 200 kt, with improved guidance systems permitting the use of a conventional warhead. Other reports indicate that about 40 units of the Shkval-VA-111 version were obtained from Kazakhstan (which inherited a production facility from the Soviet Union) in 1997, apparently without fire-control systems. The Shkval has an effective range of 6 km to 12 km, a length of 8.2 m and a diameter of 533 mm. When in Soviet service it employed a tactical nuclear warhead.

France is also believed to have supplied current sonar systems that employ US technologies for China's surface and submarine fleet since the mid-1990s, perhaps up to 45 Crotale ship-based defence systems (two had been sold in 1988), and possibly systems for the Song-class submarine. In 1999, Thomson-CSF was approached to undertake an upgrade of the electronic systems for the PLAN's Crotale low-altitude SAM system.

Other unconfirmed reports indicate the use of German diesel engine technology for the Song-class SSK. AIP and signature reduction systems for SSKs is another likely current Chinese R&D and foreign technology transfer priority. In 1998, the PLAN held discussions with France on the possible purchase of used French Navy vessels but with an emphasis on transferring new technologies that can be used for indigenous shipbuilding. China had also considered the licensed production of the French Agosta-class SSK prior to its purchase of Russian Kilos.

China's indigenous Luhu-class destroyer design had utilised various foreign systems, which have presented a major systems integration, logistics and maintenance challenge. The first two of the class are fitted with US gas-turbine engines, French fire-control, SAM and associated tracking radars, Italian-derived close-in weapon systems, Dutch-derived electronic intelligence and warfare systems, and Italian ASW torpedoes. Future members of the class could be powered by Ukrainian designed naval gas turbines. This trend has continued with the Luhai-class, which is believed fitted with gas-turbine engines from the Ukraine, German electrical systems and Italian torpedoes, as well as two Russian Kamov Ka-28 ASW helicopters.

One related area that has recently been a focus of Chinese nationalism is the 'concept of sea as national territory' (*haiyang guotu guan*). This concept stresses the historical loss of great areas of Chinese maritime territory, such as those claimed in the South and East China Seas. The PLAN's inner zone of responsibility includes a chain comprising the Yellow Sea, passing beyond Taiwan and including the South China Sea. The outer chain is believed to extend as far as the Marshal Islands. Apparently, the PLAN has recently surveyed and prepared for the eventual deployment of naval forces, including ballistic missile and cruise missile submarines, outward to the South Pacific and Indian Ocean. On 26 February 1992, the Chinese National People's Congress passed the Territorial Waters Law, claiming these and other disputed island groups as Chinese territory and reserving the use of military force to secure them. On May 15 1996, China ratified the 1982 United Nations Law of the Sea Convention, under which nations may declare an exclusive 200 nautical mile offshore zone from the mainland. China is now using the convention to reinforce its various South and East China Seas claims based upon historical linkages. Additionally, Chinese strategists now refer to the need for 'survival space' (*shengcun kongjian*) for strategic frontiers extending horizontally into the Indian Ocean, South and East China Seas, and vertically into space. On these doctrinal grounds China is now developing a blue water naval capability. Figure 5.1 illustrates China's first and second chain of island defence boundries and 5.2 China's vital regional strategic interests.

Figure 5.1 China's First and Second Chain of Island Defence Boundaries

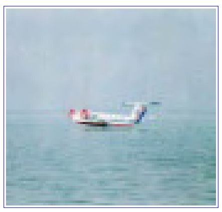
Figure 5.2 China's Vital Regional Strategic Interests

The Jianghu IV-class is China's most current frigate class, although more modern stealth classes may be under development.
(Source: Van Ginderen Collection)

China's space and missile programmes employ four Yuanwang-class tracking vessels which are routinely sent to the Pacific, Atlantic and Indian Oceans on space tracking missions.
(Source: Robert Pabst)

To date Russia has sold four Kilo-class SSKs to China, two each of the Type 636 (shown above) and Type 866. It is possible that more advanced diesel-electric and nuclear powered types may be obtained in the future.
(Source: V Osintsev)

The CR-01 cable-free 6000m automated underwater robot.



During 1998 tests were conducted of the prototype "White Swan" DXF-100 ground-in-wing effect ship at Dianshan Lake, Shanghai, that has the potential to be developed into a larger amphibious warcraft.

China will be obtaining Russian SS-N-22 "Sunburn" cruise missiles (shown above) as part of it's recent purchase of Sovremenny-class destroyers, and is obtaining various other precision-guided munition systems from Russia.
(Source: Richard Scott)

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CHAPTER 6 - GROUND FORCE SYSTEMS

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GROUND FORCE SYSTEMS

6.1 R&D and Production Infrastructure TOP

China has a vast land forces defence production and R&D establishment, most of it reporting to NORINCO, and much it also simultaneously involved with dual-use and non-defence commercial production. Its potential 'surge capacity' for wartime production is truly vast and probably beyond precise estimation. Much of its activities, like those of the overall aerospace-defence sector, are secretive and conducted under tight security measures. Many of the military equipment manufacturing firms are also inconspicuous small to medium sized enterprises. Small firms such as the Changchun Great Wall Uniform Company, Changchun, Jilin, produce military uniforms and the various other standard equipment and kit requirements of the PLA, in addition to export products. However, in addition to the large PLA standing force and primary reserve structure, some estimates have suggested that the ultimate troop reserve capacity of the PLA militia is in the tens of millions. All of these troops would have to be supplied with equipment during a conflict.

During 1998-99, NORINCO undertook a major reorganisation under COSTIND with new spin-off groups emerging, the China Ordnance Industries Group and the China Ordnance Equipment Group. Details remain unclear on these two apparently competing major SOE conglomerates but the overall structure of NORINCO subordinate organisations is believed to remain valid.

Beijing North Vehicle Works is an enterprise under NORINCO specialising in the production of special purpose military vehicles. It has over 7,000 workers, including 700 technical staff, over 2,800 pieces of equipment, and production space totalling 300,000 square metres. Equipment includes advanced NC processing centres, floor boring-milling machines, and high-precision tri-co-ordinate measuring machines. It has five R&D institutes responsible for military and civilian vehicle technologies. Beijing North Vehicle Works has reportedly developed over 40 models of military vehicles such as tanks, command, missile-launching, reconnaissance and recovery vehicles, ambulances, and self-propelled howitzers.

The related China North Vehicles Research Institute is a military industry research facility that conducts R&D into special purpose vehicles. It specialises in the design, testing, inspection, structural analysis and strength testing of wheeled and tracked armoured fighting vehicles (AFV). Particular areas of research include dynamic force, gear-drive equipment, electric control, liquid control electricity and computer software.

The Dingyuan Motor Vehicle Proving Ground, Anhui, provides the PLA General Logistics Department with a major vehicle R&D facility. This includes testing and proving grounds, and cross country and high-speed testing roads, that total some 33.8 km in length. It has also been designated a national motor vehicle testing and proving unit by the China National Automotive Industry Corporation.

The Inner Mongolia Number One Machinery Plant (NeiMeng), Qingshan, Baotou, Nei Mongol, is a major subsidiary of NORINCO, with its plant occupying an area of 18.2 million square metres and building floor space totalling 1.43 million square metres. Workers number 25,500, including 5,592 technical personnel. Some 700 pieces of new equipment have recently been imported from the US, Germany and Japan. The plant produces and undertakes R&D on 'third generation of tracked vehicles' (for example, AFVs). Unconfirmed sources indicate it can produce 300 main battle tanks (MBTs) per year.

The probably associated Inner Mongolia Number Two Machinery Plant, Baotou, specialises in steel alloy production, casting, forging, production of engineering machinery, various kinds of heavy trucks, and hydraulic transmissions. It operates research institutes (defence and civilian), and metallurgical, technology and quality control departments.

The Baotou facility reportedly produces the Type 85, T-90 and follow-on MBT series, possibly with German, Austrian, Swiss and Czech technical assistance. An automotive apprenticeship programme at Baotou was reportedly jointly funded by NORINCO and Daimler Benz (MTU Division). Other German tank design assistance may have been obtained from Krauss-Maffei and Rheinmetall but that are no confirmed examples of Leopard II technologies being provided to China as of this time.

Chang'an Machinery Plant (Chan'gan Automobile Co. Ltd.), Chongqing, Sichuan, is a major NORINCO plant undertaking military R&D and production including armaments, as is the Changfeng Machinery Plant, Chongqing, Sichuan. The China Munitions Industry General Company, Beijing, develops defence ordnance, machine tools and machinery. The China National Machinery and Equipment Import and Export Corporation is a major national trade SOE that imports and exports defence products such as AFVs, trucks and special use vehicles. The China Xinxing Corporation (Group) is a national SOE that provides PLA logistical requirements for food, clothing, construction materials, fuels, vehicles, boats, etc., and reports to the PLA General Logistics Department although recent reports indicate it may have been spun-off as a commercial venture.

Jialing Industry Co. Ltd., Chongqing, Sichuan, is a large NORINCO plant that probably has a major ordnance production capability, as does the Jiangling Machinery Plant located in the same city. Jianshe Machine Tool Works (Jianshe Industries Group Corporation, Jianshe Motorcycles), also located in Chongqing, is a major NORINCO plant. It is the largest automotive plant in China, although it now claims most of its production is of civilian products.

The ANDA Forging Plant, Anshun, Guizhou, while an AVIC plant in the aerospace sector, probably has a specialised AFV armour R&D and production capability.

The Shandong Chemical Plant, Jinan, Shandong, is an arms production facility that is over 100 years old, and is now an affiliate of NORINCO. The Shandong Machinery Plant conducts 'physio-chemical testing for arms production' for NORINCO. The Shandong Non-Metallic Materials Research Institute provides defence industry R&D and product development in areas related to advanced composite materials. The Shandong Optoelectronic Instruments Plant produces incandescent, infrared and laser finder optics for military use.

The Jidong Chemical Plant, Yangquan, Shanxi, is a subsidiary of the China Weaponry Industrial Corporation and is a major producer of explosives and pyrotechnics such as detonating cords and fuses. The Liaoning Qingyang Chemical Industrial Corporation, Liaoyang, Liaoning, is a major NORINCO producer of explosives and related devices, as is the Liaoning Xiangdong Chemical Plant, Lingyuan, Liaoning. The Yunan Packaging Factory of the Dadong Chemical Industrial Group Corporation, Luliang, Yunan, also produces explosives.

The Shaanxi Institute of Applied Physics and Chemistry, Xi'an, Shaanxi, specialises in defence-related R&D concerning the chemistry and physics of explosives, pyrotechnics, electronics instruments and precision machinery.

The Northeast Machinery Plant, Shenyang, Liaoning is the standardisation centre for the NORINCO Group, a 'new technology popularisation station', a precision machine tool repair and welding centre. It is also the location of the Northeast China regional measuring station. NORINCO's Shenyang Industrial Institute, Shenyang, Liaoning, is also involved with the development of advanced manufacturing technologies.

NORINCO also conducts various electronics, sensor and directed energy weapon R&D (see Chapter Eight). For example, its Nanjing Xuguang Instruments Plant, Nanjing, Jiangsu has research institutes specialising in product design, NC machine tools, precision instruments, fibre optics and optical technologies.

The PLA Armour Engineering College is reportedly located in Beijing. A PLA National Training Centre reportedly exists in Fujian Province. COSTIND operates the 'Base 31' Baicheng Conventional Weapons Testing Centre but little is known of this secretive facility.

The PLA College of Military Machinery conducts R&D on the prevention of accidental explosions, fires and unwanted electromagnetism for military equipment.

The PLA's National University of Defence Sciences and Technology, Changsha, Hunan, is a major national education and R&D centre established in 1954. It conducts R&D in such areas as parallel supercomputers, digital simulation/emulation computers, sounding rockets, walking robots, magnetic suspension train prototype, photo-electronics, modulating broadcasting systems, large-screen display systems, high-speed data collecting and processing systems, and precision machine tools control and image monitoring systems. It has 10 departments, 12 research centres and eight research institutes. The university offers bother graduate and undergraduate degrees in a variety of technical disciplines. It has a faculty of 1,600 full and part-time members, of whom 208 hold professorships and 630 are senior engineers and associate professors. Major recent multi-disciplinary defence R&D efforts have included:

· Yinhe (YH)-1 Supercomputer (100 million calculations/second)

· YH-2 Supercomputer (1 billion calculations/second)

· YH Full Digital Emulation Computer, Series I/II (leading-edge emulation system, used for LM-2 rocket launcher development)

· YH Intelligent Computer (supporting high-speed logical and numerical calculation, multiple AI languages)

· 'Weaver' series meteorological rockets (Weaver Number One manufactured in 1987 and world-class Weaver Number Three in 1991)

· Liquid bipropellant variable thrust rocket engine

· Cerenkov free-electron laser device

· Laser Gyroscope

· Micro-Aperture Diameter Laser Measurement Device

· Maglev Prototype

· Walking Robot

· Robot Force-position Mixed Control System

· Automobile Computer-Controlled system

· X500 Display Processing System

· Automatic Intelligent Target Recognition System

· Hypermedia System HWS

· Simulation System of System Engineering Instruction

· High-Precision Turning Dimension Accuracy Control System.

Key current clusters of ground force system manufacturing and R&D in China by city and province are summarised in Table 6.1.

Table 6.1 Current Chinese Ground Force Industry Geographical Clusters

· Beijing Fengtai Engineering Machine Company, Beijing

· Beijing Jeep Company Ltd., Beijing

· Beijing North Vehicle Works, Beijing

· China Munitions Industry General Company, Beijing

· China National Automotive Industry Corporation, Beijing

· China National Machine Tool Corporation, Beijing

· China National Machinery and Equipment Import and Export Corporation, Beijing

· China North Vehicles Research Institute, Beijing

· China PLA General Logistics Department, Military Supplies Technical Institute, Beijing

· China Xinxing Corporation (Group), Beijing

· PLA College of Military Machinery

· PLA Armour Engineering College

· PLA Science and Technology Exchange Centre, Beijing

· Research Institute of Production Technology for Military Supplies, General Logistics, Beijing

· Dingyuan Motor Vehicle Proving Ground, Dingyuan, Anhui

· Ma'anshan Iron and Steel Company Ltd., Ma'anshan, Anhui

· PLA National Training Centre, Fujian

· China Munitions Industry General Company, Guangdong Weiguo Machinery Factory, Guangdong

· Guangdong Lingnan Industrial Corporation, Shenzhen Company, Shenzhen, Guangdong

· Shenzhen Hwardar Power Systems Supply Company Ltd., Shenzhen, Guangdong

· ANDA Forging Plant, Anshun, Guizhou

· Hebei Yanxing Machinery Plant, Zhangjiakou, Hebei

· Heilongjiang Military and Technology, Industrial Trading Company, Harbin, Heilongjiang

· Henan Honyu Machinery Factory, Yunyang, Henan

· Henan Qinghua Machinery Plant, Xuchang, Henan

· Henan Xiangdong Machinery Plant, Yunyang, Henan

· Nanyang Explosion-Proof Motor Plant, Nanyang, Henan

· Huazhong Pharmaceutical Plant, Xiangfan, Hubei

· Hubei Dongfang Chemical Plant, Yicheng, Hubei

· Hubei Jiangshan Machinery Plant, Laohekou, Hubei

· Hunan Shaoyang Auto-Parts Factory, Shaoyang, Hunan

· Jiangnan Machinery Plant, Xiangtan Hunan

· National University of Defence Sciences and Technology, Changsha, Hunan

· Jiangsu Shugang Opto-Electronics Instrument Factory, Yangzhou, Jiangsu

· Jiangsu Xingsu Machinery Plant, Wuxi, Jiangsu

· Nanjing Defence Industry, People's Products Industrial Company, Nanjing, Jiangsu

· Nanjing Xuguang Instruments Plant, Nanjing, Jiangsu

· Yuhe Machinery Plant, Nanjing, Jiangsu

· Benxi Precision Machinery Plant, Benxi, Liaoning

· Liaoning Qingyang Chemical Industrial Corporation, Liaoyang, Liaoning

· Liaoning Xiangdong Chemical Plant, Lingyuan, Liaoning

· Northeast Machinery Plant, Shenyang, Liaoning

· Shenyang Industrial Institute, Shenyang, Liaoning

· Shenyang Wusan Complex, Shenyang, Liaoning

· Inner Mongolia Number One Machinery Plant, Baotou, Nei Mongol

· Inner Mongolia Number Two Machinery Plant, Baotou, Nei Mongol

· PLA Factory Number 3530, Xianyang Zhongxing Printing and Dyeing Mill, Xi'an, Shaanxi

· Shaanxi Institute of Applied Physics and Chemistry, Xi'an, Shaanxi

· Xi'an Huian Chemical Plant, Xi'an, Shaanxi

· Xi'an Kunlun Machinery Plant, Xi'an, Shaanxi

· Xi'an Northwest Optical and Electrical Instruments Plant, Xi'an, Shaanxi

· Xi'an Qinchuan Machinery Plant, Xi'an, Shaanxi

· Shandong Chemical Plant, Jinan, Shandong

· Shandong Machinery Plant, Zibo, Shandong

· Shandong Non-Metallic Materials Research Institute, Jinan, Shandong

· Shandong Optoelectronic Instruments Plant, Tai'an, Shandong

· Jidong Chemical Plant, Yangquan, Shanxi

· Shanxi Qiyi Precision Machinery Plant, Taiyuan, Shanxi

· Chang'an Machinery Plant (Chan'gan Automobile Co. Ltd.), Chongqing, Sichuan

· Changfeng Machinery Plant, Chongqing, Sichuan

· Chongqing Jinguan Protective Material Research Institute, Chongqing, Sichuan

· China Ordnance Materials Corporation, Chongqing, Sichuan

· China PLA Factory 7322, Baiyao Chang, Chengdu, Sichuan

· Chongqing Huachuan Machinery Plant, Chengdu, Sichuan

· Jialing Industry Co. Ltd., Chongqing, Sichuan

· Jiangling Machinery Plant, Chongqing, Sichuan

· Jianshe Machine Tool Works (Jianshe Industries Group Corporation, Jianshe Motorcycles), Chongqing, Sichuan

· Sichuan Nanshan Machinery Plant, Nanxi, Sichuan

· Wangjiang Machinery Plant, Chongqing, Sichuan

· China PLA Factory 3522, Nankaiqu, Tianjin

· China PLA Factory 7438, Branch Number One, Wulumuqi, Xinjiang

· Yunan Packaging Factory, Dadong Chemical Industrial Group Corporation, Luliang, Yunan

6.2 Armoured Fighting Vehicles (AFVs) TOP

During the past two decades estimates of Chinese MBT production have ranged from 100 to 700 vehicles per year. The most intense phase of production covered the period 1981-1985. A peak was reached in 1984 with the production of 600 to 700 MBTs before a decline to about 100 to 200 vehicles per year by the mid-1990s. Approximately one-half of production is believed to be exported. This is probably a low percentage of actual inherent production capacity that could be increased during a crisis. MBTs in the PLA inventory reportedly include the T-34/85 (obsolete and probably in storage), the T-54/55 (obsolete and probably in storage), the T-59, the T-69, the T-79, the T-80, the T-85II, the T-88, the T-90 and the T-98. Light amphibious tanks include the T-62, T-63 and, most recently, the T-99. The PLA has approximately 7,500-8,000 MBTs, mostly Type-59s and Type-69s, but with increasing numbers of the newer models (perhaps 1,000 or more). The production of the T-80 and earlier types is believed to have ceased.

NORINCO's 122 medium tank, said to be armed with anti-tank guided weapons (ATGW), and twin anti-aircraft machine guns, apparently never entered service during the 1960s. The PLA may have also had examples of the Soviet Joseph Stalin III (T-10) heavy tank, originally developed to counter the German Tiger and Panther tank series during the Second World War.

The first Chinese mass-produced MBT was the Type-59, basically a copy of the 1950-1960s era Soviet T-54A. China is believed to have manufactured some 10,000 T-59 MBTs and it remains the backbone of the PLA's armour formations. During the 1960s and 1970s, the Type-62 light tank (a scaled-down version of the T-59) and the Type-63 amphibious light tank (based upon the Soviet PT-76) were also developed. Border clashes with Russia during the 1960s helped accelerate Chinese armour and anti-tank weapons development. This included the Type-69 MBT, the Type-73 100mm anti-tank (AT) gun, the Type-69 rocket propelled grenade (RPG) and the HJ-73 anti-tank guided missile (ATGM). Large numbers of the T-59 and T-69 were sold by China to both Iran and Iraq during their 1980s war.

The development of the T-69 MBT began by 1969, with production initiated by

1974. The T-69 is essentially an improved T-59 with a 100 mm smoothbore main gun optimised for firing a new long rod sabot ammunition, engine horsepower increased from 520 to 580, active IR night vision, two axial stabilisers and automatic fire control systems. Over 1,000 T-69 MBTs were believed to be produced, providing important manufacturing and R&D experience and technical personnel for follow-on development projects. Following the successful development of the long rod sabot for rifle guns in the 1980s, the T-69 was re-equipped with 100 mm rifled guns because of the PLA's dissatisfaction with the smoothbore version. With an improved fire control system, the resulting modified tank was designated the T-69II. The T-69III, also called the T-79, uses a British-style 105 mm rifled gun (possibly developed with technology transferred from Austria) and an imported British Marconi fire control system. Chinese 105 mm gun technology may also have been provided by Israel as early as 1984. Older tanks in PLA service such as the T-59 and T-69 have been upgraded with the addition of reactive armour and improved laser range finders, IR night vision systems, etc.

During the late 1970s and early 1980s, with inputs of imported Western technologies,

China began the development of its second generation of MBTs (its first indigenously designed models), particularly the well-known Type-80 MBT. The T-80 employs six small road-wheels, torsion bar suspension, a 105 mm rifle main gun, an improved fire control system and a turbo-charged diesel engine with 730 hp output. Two versions were developed: the T-80I; and the T-80II an independent thermal charged sight with integrated laser range finder and extra carrying rails around the turret. The T-80 entered PLA service in 1988 and was designated the Type-88. It included the option of adding extra composite armour on the front arc. However, T-80/T-88 was largely obsolete by Western and Russian standards of the period, which included 120 mm to 125 mm smoothbore guns, composite armour, high power diesel or gas-turbine engine and sophisticated stabilised fire control systems.

The Type-85/88C is an improved T-80; the T-88B/C began serial production and PLA deployment in 1999. The various models of the T-85 family include the T-85II (a T-80 with composite armour, stabilised fire control system and a welded turret); the T-85IIA with an increased length calibre 105 mm rifled gun; the T-85IIM added a 125 mm smoothbore gun with autoloader; the T-85IIP is a Pakistani export version of the T-85IIM; and the T-85III has improved mobility through an engine rated at 1,000 hp compared to the original 730 hp. Some reports indicate that NORINCO attempted to develop a high-power diesel engine in the 1000-1,500 hp range during the 1980s, perhaps for the T-85. While this venture was unsuccessful an 900 hp diesel engine for MBTs was apparently developed. The NORINCO X-150-906 is another V-12 960 hp diesel engine that could have MBT applications. In 1999, Yugoslavia offered to upgrade the T-85II with a MPP 1000 modular power pack and a new fire-control system.

The T-85III reportedly incorporates many of the features of the T-90 such as modular composite (and perhaps reactive) armour. Stabilised image intensification sights allow the engagement of enemy targets while in motion. The T-90 incorporates innovations such as modular composite armour, stabilised turret, slaved targeting of sight and gun, passive thermal imaging, improved day/night laser range-finder and crosswind sensor. It also has an auto-loading 125 mm smoothbore gun capable of firing APFSDS (armour-piercing, fin-stabilised, discarding sabot), HEAT (high explosive anti-tank), and HEAT-FRAG. The T-90II reportedly has reactive armour to counter advanced anti-tank mines (ATMs). The T-80 and early T-85 versions had a four man crew but the T-85IIM and T-90II and follow-ons have all had a three man crew with a 125 mm gun fed by an automatic loader.

By the late 1980s and early 1990s, China began development of its third generation MBT but this process was complicated by competing design schools. One faction wanted to implement Western designs but the other wished to continue Russian-style MBT developments. This resulted in a compromise design, the Type-90II, which employs a Russian T-72 style layout with Western advance fire control systems and a high-power diesel engine with 1,200 hp output, possibly an improved German commercial WD396 engine derivative. (Some sources argue that a Perkins engine was used coupled to a French SESM ESM 500 automatic transmission for export versions to Pakistan as the MBT-2000 and other sources a Ukrainian Kharkov 6TD-2 1,200 hp engine and transmission). A Russian-style 125 mm smoothbore main gun with autoloader was employed, probably with high-performance tungsten and/or depleted uranium (DU) core sabots. DU ammunition has reportedly been tested for various Chinese artillery and MBT applications. Indeed, some sources claim it had been introduced in the PLA inventory by the 1990s for 105 mm, 120 mm and 125 mm weapons, with a second generation of the rounds having also been developed. Tungsten alloy rounds are probably standard for most units. Having both 120 mm and 125 mm tank calibres results in obvious logistics disadvantages.

A joint Chinese-Pakistani MBT project is also believed to use T-90II technology, the MBT-2000/P-90 'Al Khalid'. Improved versions were evident by 1999. The T90II is also closely linked to the Russian T-80 design. However, it uses a welded steel turret, integral modular composite armour, diesel rather than a gas-turbine engine, indigenous fire-control systems and cannot fire a Russian gun-launched missile. All Chinese MBTs from modernised T-69s onwards are believed to have automatic fire-detection and suppression systems and full nuclear, biological and chemical (NBC) warfare environmental protection. IF reflective coatings have reportedly recently been applied to Chinese MBTs for stealth protection. NORINCO reportedly claims that the T-90's engine package can be replaced in just 40 minutes.

A 48 ton MBT-2000/P-90 'Al Khalid' was exhibited in 1999 by NORINCO and is possibly an upgraded T-90IIM intended for export and joint production with Pakistan. Reports suggest it is equipped with a Ukrainian Kharkov 6TD-2 1,200 hp engine and transmission, and new indigenous thermal sights developed by the Luoyang Opto-Electro Technology Development Centre. Primary armament is a 125 mm smoothbore gun with automatic loader. Speeds of up to 70 km per hour and a range of 400 km are claimed, with 85 per cent of hits made against mobile targets at ranges of 2 km. Production of the Al Khalid in Pakistan is believed to have started in 1999.

Reports by July 2000 had indicated that the PLA had begun fielding the T-98 MBT, the most advanced tank to enter PLA service to date, with significant improvements in the key areas of armour, mobility and firepower. The T-98 is also referred to as the WZ123 MBT and the T-96A by some sources, and is probably a further refinement of the T-90II MBT series that was jointly developed with Pakistan. It is armed with a 125 mm smoothbore gun fed by an automatic loader and a computerised fire control system has been installed. Both the commander and gunner have stabilised day/thermal sights, with the gunner's incorporating a laser range finder. Hence, the T-98 is capable of conducting 'hunter killer'-type target engagements. Some sources indicate that it must be stationary in order to engage the auto tracking mode of its fire control system, and that this could be a serious limitation compared to that of Western MBTs, but this may be misinformation.

The main gun may also be able to fire the Russian-derived AT-11 ATM. The two-person turret is a new design with the sides sloping slightly inwards and is well protected over the frontal arc. The frontal armour package is a modular design that can be replaced if damaged. A pole-type laser detector is mounted on the right side of the turret and on the left what is reportedly a lazer dazzler system to neutralise enemy ground or helicopter based electro-optical sighting systems. The T-98's secondary armament includes a coaxial

7.62 mm machine-gun and a heavy 12.7 mm machine-gun mounted on the turret roof, as well as banks of five electrically-operated smoke grenade launchers on either side of the turret.

The chassis resembles that of the Russian T-72 MBT with a well sloped glacis plate with V type splash board, horizontal ribs and a dozer/entrenching blade mounted under the nose of the vehicle. Unlike earlier Russian-influenced designs, the T-98 does not have the characteristic exhaust outlet on the left side of the hull, leading to speculation that a new power pack may be employed that is of not of domestic design. A torsion bar suspension is probably used, with either side consisting of six large dual rubber-tired road wheels with the drive sprockets at the front, idler wheels at the rear, and track return rollers on top.

Unconfirmed sources indicate that the tank's total weight is 52 tons but with explosive reactive armour (ERA) or type-681 composite armour, the weight increases to 54 tons. Type 98 armour may be all welded with ceramics and DU armour according to PLA and Hong Kong newspaper sources. Advanced armoured skirts would probably be fitted for combat. Russian 'Dronz-type' active-defence explosive armour technologies may have been transferred. The Ukraine may be providing various new tank technologies through its Morozov Machinery Complex.

The 'T-2000' is reportedly an experimental 48-50 ton Chinese tank, with external gun mount. Other reports indicate that China may be developing a new generation 50 ton tank similar to the Russian T-95 and 'Black Eagle' designs, and may be receiving design assistance from the Ukrainian Karkov Tank Design Bureau. This latter design could possibly be armed with a 152 mm smoothbore main gun developed by Russia and financed by China. There has also been some speculation on the use of liquid propellant gun technology, possibly transferred from Germany or Israel.

China had reportedly taken delivery of some 200 Russian T-80U MBTs by 1995, which should help raise the overall sophistication of the PLA's AFV technology. NORINCO obtained the series production capability for the Russian BMP-1 infantry fighting vehicle during 1994-96, reportedly without a production license agreement from Moscow, and is now exporting it abroad. It is also reportedly now obtaining the design for the more advanced BMP-3 (some reports indicate that the PLA may have directly acquired 300 BMP-3s from Russia).

During 1997, NORINCO announced the development of a family of ERA systems for integration into new and older MBTs, perhaps up to 32 mm outer plate. Other sources indicate NORINCO's Type-1 ERA has a 13 mm plate and reduces HEAT penetration by 70 per cent. Type-2 ERA has a 26 mm plate and reduces HEAT penetration by 70 per cent and 30 per cent for a kinetic round. Type-3 ERA has a 32.5 mm plate and reduces HEAT penetration by 70 per cent, including tandem HEAT warhead, but no data is available for kinetic rounds. ERA armour is only initiated by HEAT warheads or large calibre kinetic projectiles. It is not initiated by fire, gas cutting, or sympathetic detonation. NORINCO summarises the advantages of their ERA armour as follows: high level of protection; light weight; simple structure and manufacturing technology; low cost; easy installation; and ease of replacement under combat conditions.

Chinese composite armour developed by the mid-1980s for the T-85 and follow-on MBTs is cited by some sources as being of 'Type 681' and 'Type 683'. DU MBT armour technology is also probably available to the PLA based upon China's extensive dual-use nuclear programme. Some reports indicate that T-85-98 tanks use HY-80 RHA (rolled homogenous armour) steel (~ 240BHN). The T-85 reportedly uses alumina oxide ceramic plus layer of high hardness steel, while the T-98 employs alumina oxide ceramic, kevlar and DU armour. Rubber side-skirts and turret storage racks are standard equipment on all PLA MBTs since the late model Type-69s, and while having little effect on KE rounds, could offer some degree of stand-off protection against HEAT warheads. Kevlar liners are reportedly available on the latest model Chinese tanks. Gun barrels for 125 mm guns use electro-slag manufacturing techniques (ESR).

Some view China as eventually being capable of capturing a significant share of the global MBT market share, perhaps up to 20 per cent by the end of the decade. Figure 6.1 is an attempt to organise the confusing pedigree of Chinese MBTs. NORINCO remains China's primary MBT and AFV manufacturer. China's new domestically developed series of MBTs exhibit various Western design influences, which may indicate a trend of moving away from the traditional reliance on Soviet/Russian AFV design derivatives.

A wide variety of other AFVs are produced by NORINCO for the PLA and export customers. Chinese armoured personnel carriers (APCs) and infantry fighting vehicles (IFVs) include the K-63, the WZ-501, the WZ-523, the WZ-551, the WZ-553, the YW-531, the YW-534, the W-701, the YW-307, the YW-309, the T-55, the T-56, the T-63, the T-77I/II, the T-85, the T-501, and the T-531A.

WZ-523 wheeled APCs are in use by the PLA's Hong Kong and Macao Garrisons. However, a modern type based upon the Russian BMP-3, the most heavily armed IFV in the world with a 100 mm main gun and 30mm automatic cannon, is likely to be developed. During 1999, China is believed to have received production rights for the BMP-3 fire control system and associated 9M117 Bastion/AT-12 'Stabber' laser-guided missile (which could also be used with the main guns of older MBTs).

The Type 90/WZ-501 IFV is an improved domestic design based upon the Russian BMP-1. Variants of this mobile, low-profile and well-powered design include command vehicles, missile launch platform, artillery support vehicle and armoured scout. The YW-534 is an indigenous APC that has been continuously upgraded and converted into various multi-mission variants. The WZ-553 is one of the newest wheeled light armoured vehicles (LAVs) in the PLA inventory. The Type-92 (WZ-551) is an indigenous wheeled IFV similar to a Western LAV-type. However, there have been no indications to date of the PLA showing an interest in the growing Western trend towards substituting wheeled LAVs for MBTs in the creation of mobile crisis reaction forces (a trend which could prove dangerous in the future if such light forces, even if equipped with advanced technology weapons, sensors and communications equipment, were pitted against equally sophisticated enemy heavy armour units with sufficient air and missile support).

NORINCO has developed at least two self-propelled anti-aircraft artillery guns (SPAAG), the Type-80 twin 57 mm (similar to the older Russian ZSU-57-2) and several versions of a 37 mm system. All of these are based on a modified tank chassis. As of 1997 there were no known exports. The WZ-551 6x6 APC chassis has been proposed as the basis for the HN-5C and PL-9 fire-and-forget SAM systems but the production level is not known.

NORINCO and the Beijing Jeep Company Ltd. manufacture for the PLA a 4 x 4 jeep military utility vehicle that employs lightweight construction materials such as composite armour. It comes armed with a wide-range of ATGWs, SAMs, recoilless rifles, grenade launchers, heavy machine-guns.

A comprehensive, computerised and highly automated tracked minesweeping system has reportedly been developed by a Beijing R&D institute and State Factory Number 541 to clear minefields for attacking armoured forces.

Electric motor vehicle development was prioritised for national development by the MOST and Ministry of Machinery Industry in 1994, and could have applications for the propulsion of future advanced AFVs. During 1998, the Beijing Pan Asia-Pacific Scientific and Technological Development Company and Shanghai research institutes announced breakthroughs in multi-fuel automotive technologies, which include permanent magnets, rare earth materials for storing hydrogen, and powerful nickel-hydrogen batteries. Chinese firms now have the capability to mass-produce motorbikes powered by electricity. Sino Design is reportedly a joint venture between Daimler Benz and the PLA College of Armoured Warfare

(PLA Armour Engineering College), which is designing a turbine electric drive engine for military applications. Research is also being conducted on the use of gas-turbine engines to power MBTs and other AFVs, and potentially suitable gas-turbines in the range of 600 to 2,000 hp are being developed.

The National University of Defence Technology has been developing 'advanced world level' walking robot, robotic control system, and 'automatic intelligent target recognition system' R&D programmes since the early 1990s (funded through the '863' Programme), which could also have future autonomous AFV applications. Unmanned radio-controlled and robotic tracked AFVs have reportedly been developed for tasks such as working in hazardous (e.g. radioactive) environments and sentry duties.

6.3 Artillery TOP

PLA artillery types still reportedly include some 15,000 towed and self-propelled (SP) pieces. Some of the types in service are listed below.

· Type 54 122 mm SP

· Type 54 122 mm

· Type 54 152 mm field howitzer

· Type 59 130 mm field howitzer

· Type 59 100 mm ATG

· Type 60 122 mm field howitzer

· Type 66 152 mm field howitzer

· Type 60 122 mm field howitzer

· Type 59 130 mm

· Type 66 152 mm

· Type 83 152 mm SP

· Type 83 152mm field howitzer

· T-86 100 mm ATG

· D-30 122 mm field howitzer

· WAC-21 155 mm field howitzer

· 155 mm SP guns

· Type 55 120 mm SP mortar

· Type 53 82 mm SP mortar

· Type 56 160 mm mortar

· Type 55 120mm mortar

Most of the older equipment is in fact now probably scrapped or stored in inventory. In addition, as with other gun systems, efforts must be underway to streamline the training and logistics requirements for parts and ammunition.

During the period covering the early 1980s to the mid-1990s, some estimates placed Chinese artillery production of calibres over 100 mm at about 175 to 300 guns per year, with perhaps about half of this production being used for export. This is probably a low percentage of actual inherent production capacity that could be increased during a crisis. In general, new-generation indigenously-designed 155 mm howitzers are now replacing older generation 152 mm Russian designs in the PLA to improve performance and to standardise logistics. The US was supporting a PLA 155 mm ammunition facility upgrade programme prior to 1989. Russian-designed Krasnopol 152 mm 9K25 and 155 mm M cannon-launched laser-designated guided-projectiles can be fired from NORINCO 155 mm 45 calibre PLZ-45 SP howitzers and towed howitzers in PLA service such as the Type WA 021, XP52, and Type GM-45.

There have been some past concerns over the quality of Chinese munitions. For example, in 1997 the Royal Thai Army was forced to destroy some 10,000 Chinese-made 120 mm mortar bomb rounds because of concerns over defects that may have been responsible for an explosion that caused the death of a soldier.

Recent NORINCO artillery developments include the Type 89 SPATG, the BLZ-45 155 mm SP howitzer, and the 203 mm SP howitzer (which reportedly closely resembles the US M110). The new 203 mm SP howitzer is reportedly called Type 99 and entered production in 1999. It is 52 calibres long, has a range of 30 km for conventional high explosive shells and 55 km for rocket-assisted projectiles, is mounted on a Type 89 chassis, and can fire up to eight rounds per minute.

The Type 83 is a second generation SP gun armed with a 152 mm main gun/howitzer in an enclosed fixed turret, and is based upon the T-69 tank chassis. The Type 85 SP gun is an improved version of the Type 54 SP gun. It features a 122 mm main gun and is based upon the chassis of the YW-531H APC.

In 1997, Kuwait purchased 27 PLZ-45 155 mm 45 calibre SP artillery/howitzers from China in a US$186 million deal that also attracted competition from US, South African and UK firms. The Kuwait deal also included the export of an ammunition resupply vehicle based on a common tracked chassis, a forward observation vehicle on a tracked or wheeled chassis, a battery/battalion command post vehicle on a YW 534 full-tracked APC chassis, artillery location and fire-correction and meteorological radars on a 6x6 chassis, and a Type 653 armoured recovery vehicle based on a T-69 MBT chassis, with the crane uprated to 20 tones.

The PLZ-45 has a maximum range of 39 km, firing an extended range full bore base bleed (ERFB-BB) projectile, or 30 km firing a standard ERFB projectile. The on-board fire-control system includes an automatic gun-laying system, optical sights, navigation system, and GPS receiver. The ammunition supply vehicle is almost identical in design to the United Defense LP M992 Field Artillery Support Vehicle that has been in service with the US Army for some years. The PLA versions carries 90 rounds and associated charges, which are fed to the PLZ-45 via a conveyor belt at a rate of eight rounds per minute. Standard equipment includes an APU and a crane for loading pallets of ammunition through the roof. The system's 155 mm/45 calibre gun is based upon the Type WAC-21 towed system with a 39 km range that was based upon a design of the late Dr. Gerald Bull.

In 1997, NORINCO began marketing a 105 mm portable light howitzer that appears to be based upon the Italian OTO-Breda 105 mm Pack Howitzer. Two examples of the Italian gun had previously been supplied to the PLA. The NORINCO 105 mm gun can be used as a howitzer or an anti-tank weapon firing HEAT shells, with a range of 10,222 m being achieved with a US M1 HE-type shell.

The recent development of China's 120 mm gun was reportedly very successful, perhaps close to that of the German 120 mm smoothbore. However rather than arming a MBT, the new 120 mm smoothbore was used for the Type 89 SPATG, also referred to as the PTZ89, and believed to have been introduced into

PLA service by the late 1980s. The NORINCO 120mm SPATG is based on chassis of the 152 mm Type 83 SP gun but with a new all-welded steel turret positioned further forward with an extended bustle likely for an automatic loader. Its 120 mm smoothbore gun has a thermal sleeve and fume extractor, and fires an APFSDS projectile weighing 23 kg, with claimed muzzle velocity of 1,725 m per second, and penetration of 550 mm-600 mm of rolled homogeneous steel armour at 2,000 m (the 120-II APFSDS-T round). Various types of ammunition are fired with semi-combustible cartridge cases, including Western types. A primary role would be to destroy advanced Western tanks such as the US M-1 series and Japanese Type-90 series. The PLA's 120 mm tank destroyer concept apparently stems from similar German concepts used during the Second World War, which involved mounting a powerful AT gun on a chassis that was more economical to produce than that of a MBT.

During 1995, the PLA reported the development of a 21 m long 'supergun' capable of directly attacking Taiwan, and probably based upon technology provided by the infamous and deceased Canadian Dr. Gerald Bull during the 1980s. In 1999 reports indicated that NORINCO may have developed a 'super range rocket gun' system, with a range of 360 km. An earlier Chinese system had a range of 180 km. Since the 1980s, China has developed 155 mm and 203 mm gun technologies based upon the research of Dr. Bull. The new system may be a 6x406 mm rocket system with an automatic loading system mounted on a modified ballistic missile mobile launch system, and as such would probably not be a true gun-type system but a type of multiple launch rocket system (MLRS). A 'rocket gun' battery would consist of six launchers (i.e. 36 tubes), a command vehicle, communications vehicle and a ballistic correction radar. Warhead types could include high-explosives, incendiary, ground penetration, cluster and anti-armour submunitions.

China had reportedly claimed that each rocket would be equipped with a GPS, TV, IF or laser sensors for ballistic corrections to increase accuracy. Such an accurate, long-range and high rate of fire system, could prove ideal for offensive operations against Taiwan. Each rocket is reportedly capable of striking any part of Taiwan if deployed in Fujian Province because the strait that separates Taiwan from the mainland has an average width of 200 km, being 130 km wide at its narrowest point and 250 km wide at its maximum. It could be difficult to develop effective countermeasures against such a system. A September 2000 Chinese report indicated that China had developed a new rocket launcher, the WS-1B, which reportedly has the longest range in the world at 360 km and a lethal radius of 450 m. Apparently upgraded from an earlier WS-1 model with a range of 180 km, the WS-1B incorporates GPS, TV guidance, and a 'laser curve-adjusting system', and may well be the same 'super range rocket gun' system announced in 1999. Laser guidance would require target designation, possibly by personnel near the target area. The WS-1B has reportedly recently undertaken tests at Fuzhou, Fujian, where targets were hit within a circular error of probability (CEP) of several hundred metres.

PLA MLRS (over 3,500 of all types) have included the 8 x 300 mm Angel-120 (120 km maximum range), the Type 83 273 mm, the 140 mm BM-14, the 140 mm BM-16, the Type 70 130 mm, the Type 82 130 mm, the Type 85 130 mm, the Type 81 122 mm, the Type 83 122 mm, the Type 90A 122 mm, the Type 63 130 mm and the Type 63 107 mm towed MLRS, the Type 762 425 mm mine disposal MLRS, and the Type 74 284 mm minelaying MLRS.

Indonesia is one of various nations that operates versions of NORINCO MLRSs such as the Type 63 12x107 mm. The earlier MLRS fired unguided rockets with simple warheads but the latest models (the Angel-120,WS-1B, A100) probably incorporate PGM technologies and various submunitions. Advanced systems such as the Type 90A incorporate GPS, panoramic sights, increased automation for reloads, 40 km+ range, and a variety of munition types including mines. China has recently developed a 10 tube version, the A-100, of the Russian 12 tube 300 mm BM 9A52 Smerch MLRS, which has the longest range of unguided Russian ballistic missiles (100 km maximum range). It can also fire high-explosive fragmentation sub-munitions, top-attack submunitions, conventional high-explosives, anti-tank mines, and FAEs.

AAA guns include an estimated 10,000 of all types in the PLA inventory. These include: the 23 mm; the Type 55 37 mm; the Type 56 85 mm; the Type 65 37 mm twin; the Type 59 57 mm; the Type 59 100 mm; the Type 74 37 mm; the Type 80 57 mm SP; and the Type 63 37 mm SP. It is quite likely that the obsolete models have been stored in inventory.

Chinese AT guns have included the Type 51 90 mm anti-tank rocket launcher, the Type 52/56 75 mm recoilless rifle, the Type 55 57 mm, the Type 54 76 mm, the Type 56 85 mm, the Type 59 100 mm, the Type 65 82 mm recoilless rifle, the Type 73 100 mm, the Type 75 105 SP, and the Type 86 100 mm. Again, the more obsolete types are probably in storage and intended for use by the PLA's massive secondary reserves during a crisis.

Unconfirmed sources have indicated that China has recently developed a rocket artillery round that is identical to the Russian 122 mm BM-21. China has also recently announced a new guided rocket round call the SAL-GP that carries four pop-out fins, similar in concept to the Russian SA-7 for flight stabilisation. The rocket reportedly has a tandem warhead with a diameter of some 110 mm and can penetrate 830 mm of armour at up to 20 km. Other modern ordnance systems believed to have been obtained from Russia include the 9M330 Tor (SA-15 Gauntlet) tracked SAM system, several examples of the Splav 300 mm Smerch MLRS with PGMs in 1996 (that were subsequently reverse-engineered), 45 2S23 120 mm Nona-SVK SP mortars in 1997, in addition to man-portable FAE systems.

6.4 Small Arms and Infantry Equipment TOP

China produces a wide variety of small arms to equip the PLA and for export. These range from small arms, heavy and light machine guns, grenades and grenade launchers of various types, and a variety of high explosives. This equipment is now also increasing in sophistication to match the increasing requirements of the PLA. Some reports indicate that the PLA may have up to 15,000 special-forces type soldiers, who receive top priority in training and new equipment. Often used for helicopter-borne reconnaissance roles and attacks on enemy key facilities such as command posts, missile sites and airfields, each PLA group army or brigade equivalent is probably equipped with a special forces unit ('special penetration groups'). A PLAN naval reconnaissance school may be located at Xiamen. The PAP also reportedly has SWAT-like units for anti-terrorist and other special operations duties. During 1998, China participated in an Asia-Pacific special forces annual conference for the first time.

The elite 15th Airborne Army was reportedly the first large PLA unit after the Hong Kong Garrison to be equipped with the new Type 95 SLAR. It is also reportedly equipped with a special lightweight version of the Type 71 100 mm mortar, the Type 80, which is made from titanium parts, and a lightweight version of the 82 mm mortar, the Type 83-1, the Type 75 105 mm recoilless rifle mounted on BJ-212 jeeps, and possibly Russian BMD-3 airborne armoured assault vehicles.

The PLA has recently established its first permanent combined forces 'Blue Army' in its north-eastern Shenyang military region in order to play the enemy role during combat exercises. It is reportedly equipped with air defence and EW systems, in a further move towards increased modernisation and professionalism.

The PLA's NORINCO 5.8 mm automatic assault QBZ (*Qing Buqiang Zu*, or 'light rifle family') Type 95 (some sources state Type 87) bullpup rifle is reportedly a fully modern design, with telescopic and night sights and grenade launcher. PLA Hong Kong Garrison troops have recently been issued this rifle in addition to Kevlar-type helmets, leather combat boots (rather than the PLA's traditional green canvas running shoes), camouflage uniforms, and body armour. This equipment, plus mobile digital communications equipment, will probably set a standard for the PLA 'future infantryman'. The PLA is now rapidly adopting a series of Type-97 uniforms that have Western design elements and are of higher quality than previous issue, and were first issued to the PLA Hong Kong Garrison. Indigenously produced Kevlar-type ballistic helmets are also in widespread use, as was displayed by various units participating in the PRC 50th Anniversary parade on 1 October 1999.

The T-95 rifle replaces the T-56 and T-81 used by the PLA. T-95 development was initiated in 1991 and the design finalised by NORINCO in 1995, although it may still be undergoing some refinements. Assault rifle, LMG and sniper models have been developed at facilities in Beijing and southern China. The assault rifle weighs 3.35 kg and is 758 mm in length, the LMG version weighs 3.95 kg and measures 840 mm in length, having an integral bipod and drum-shaped magazine, and effective range of up to 600 m. Some experts who have handled the weapon claim it is butt-heavy but well-machined. The fire-selector is located well behind the magazine at the very butt end of the rifle on the left side.

A NORINCO 5.56 mm bullpup automatic assault rifle, the Type 97, has been offered to the export market. It is based upon the 5.8 mm Type 95 that first saw service with the PLA Hong Kong Garrison in 1997. The T-95 is intended to become the PLA's standard assault rifle and like the T-97 is a gas-operated selected fire weapon with rotating bolt locking and is fed from a standard 30 round magazine. The T-97 has a cyclic rate of fire of 650 rounds per minute and effective range of up to some 400 m. The cocking lever is mounted below the integral carrying handle, with cartridge case extraction on the right. Overall the T-97 weighs 3.35 kg with an empty 30 round magazine and has an overall length of 758 mm, including a barrel length of 490 mm. It can reportedly be fitted with a barrel with one turn in 7 inches for the NATO standard SS109 ball round (muzzle velocity of 920 m per second) or with one turn in 12 inches for the US M193 ball round (muzzle velocity of 980 m per second). Other versions of the T-97 include a LMG which has a barrel life of 15,000 rounds, compared to 10,000 rounds for the assault version. The T-97 can be fitted with a multi-purpose bayonet and can fire rifle grenades, with the top of the carrying handle being equipped with a mounting rail for a telescopic or night vision sight; a 35 mm grenade launcher can be mounted under the forward section of the barrel. Basic unit cost is approximately US$500, or about double the production cost.

NORINCO markets the 7.62 mm Type 81 assault rifle in various configurations, as well as the 5.56 mm CQ automatic rifle which is based upon the US 5.56 mm M16 design. The NORINCO Type 81 7.62x39 mm LMG was derived from the Type 81 Assault Rifle,

which was in turn derived from two earlier weapons, the indigenous Type 68 rifle and the Type 56 rifle, a copy of the Russian AK-47. The Type 81 is produced primarily for export. The NORINCO Type 67 7.62x54 mm GPMG has been in production since the early 1970s and has a reputation as a robust and reliable weapon. It is a composite of earlier designs such as the Czech ZB26, French Maxim, and Russian SG43 and RPD. Both the Type 67 and 81 have cyclic rates of fire of some 650 rounds per minute.

PLA infantry support weapons over the years have included the 35 mm W87 grenade launcher, the 30 mm AGS-17 grenade launcher, the 160 mm M43 mortar, the Type 53 120 mm mortar, the 75 mm and 60 mm mortars, and the 75 mm recoilless rifle. By the 1970s China had reportedly developed six-barrelled 23 mm and 30 mm Gatling-type guns for airborne weapons applications. It is not believed that these systems were applied in an actual aircraft but they have the potential to be revived for anti-tank applications. Some 30 mm Gatlings may now be in use with vehicle-mounted SAM/AAA systems.

Chinese infantry rocket propelled grenade (RPG) launchers are mostly modified copies of the Russian

RPG-7. However, new systems are appearing such as the PF-89 light one-shot RPG (similar to an improved LAW-72) and a new double tube RPG (designator unknown) that may be intended for bunker-busting. The PLA still routinely deploys recoilless rifles at the squad and platoon level.

A new type of bullet-proof material was recently developed by the Chongqing Jinguan Protective Material Research Institute, which is designed to replace traditional body armour plate, porcelain products and other bullet-proof materials. Compared with equivalent existing products, the new material is reportedly more flexible, lighter and can prevent internal injury. Vests made of this kind of material weigh only 1.3 kg each.

In 1999, the PLA began replacing its 1960s-era GK80 *gang kuei* 'steel combat helmet' with a redesigned synthetic fibre 'ballistic' model that was tested for a year by its Hong Kong Garrison. The new QGF02 (*qing gang fang*, or 'light steel composite') helmet is reportedly lighter than its steel predecessor while providing 16 per cent more coverage and extending protection to the ears and upper neck. Its weight is 1,450 g and it is claimed that the composite material helmet was successful at defeating a 7.62 mm round fired at 128 m to 137 m per second from a Type 54 weapon. It design is based upon those in modern use by Germany, US, and Japan, all of which closely resemble Second World War German Army helmet designs.

PLA infantry are now equipped with new systems such as IR night vision systems and the Russian Shmel FAE flame-thrower (being co-produced by China), which may have the destructive power (heat and pressure) of a small tactical nuclear weapon. The PLA has acquired or developed various types of specialised air-drop equipment ranging from a Russian-designed paratroop combat vehicle with AT weapons, large calibre artillery, high-altitude oxygen devices and desalination machines for converting seawater to fresh.

The PLA has insisted on the massive use of landmines as an option to protect frontiers, although efforts have recently been made to clear them from China's border with Vietnam. China has not signed the 1997 Ottawa Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction, and reportedly has a massive stockpile of anti-vehicle and anti-personnel landmines (some 110 million of the latter type, the most in the world), but claims it has not exported anti-personnel mines since 1994. Chinese-produced anti-personnel landmines reportedly include the Type 72B, which is specifically designed to thwart de-mining efforts because if it is tilted more than 10 degrees while it is being removed from the ground it detonates.

Specialised equipment under production for the PLA includes its recently announced first 'field mobile trestle bridge' deploying a span measuring 30 m long by 4 m wide in 25 minutes. The bridge was jointly developed by the Chang Jiang Shipping Company and Number 466 Plant. In 1998, a mobile field hospital was introduced for the PLA, which is containerised and can be transported on short notice. It serves as a complete facility for up to several hundred patients and includes operating theatres, headquarters, communications, medical supplies and equipment stores units. During the same year, a new set of survival equipment for downed pilots was introduced for various geographical conditions.

Appendix D provides a technical summary of many of the wide variety of major Chinese manufactured small arms. China has also recently suffered a large number of cases of illegal arms trafficking, such as in 1995 when PAP security forces seized large caches of weapons and explosives in Mongolia including 500,000 detonators, 144,500 kg of dynamite and 1,751 illegal firearms. 'Arms bazaars' for illegal weapons and other military equipment are routinely held in locations such as the market town of Baigou. Poly Technologies was reportedly involved in a scheme to illegally sell 2,000 NORINCO AK-47 semi-automatic rifles to the US after legal Chinese small arms imports to the US were banned in 1994. Beijing is also often not particular with whom it conducts legal small arms related sales. For example, in

1997 China sold the Indonesian security forces a consignment of non-lethal riot-control equipment, which included Type 54 7.62 mm teargas grenade pistols, reinforced clear plastic helmets with visors, body length shields for individual soldiers, and low-voltage electric wands.

The joint Chinese-Pakistani MBT-2000/P-90 "Al Khalid" project is believed to use technology from the Chinese T-90II MBT (shown above).
(Source: NORINCO)

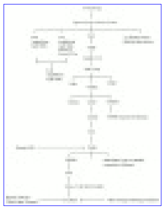

Figure 6.1 Development Linkages of Chinese MBTs

The WA-021 155mm gun howitzer.
(Source: NORINCO)

The 273 mm long-range rocket launcher system.
(Source: NORINCO)

The new PF-89 anti-tank rocket.
(Source: NORINCO)

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CHAPTER 7 - NUCLEAR AND WEAPONS OF MASS DESTRUCTION

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NUCLEAR AND WEAPONS OF MASS DESTRUCTION

7.1 Historical Nuclear Developments TOP

Qian Sanqiang, a physicist who conducted nuclear research at France's National Centre for Scientific Research during the 1930s and 1940s, is considered by many to have been the 'father of the Chinese nuclear bomb'. Qian's key assistant was Wang Ganzhang, who remained a special advisor to the China National Nuclear Corporation (CNNC) until at least the late-1980s. A state Nuclear Council under the chairmanship of the President of the Chinese Academy of Sciences, Guo Moro, was founded in 1949, the same year as the establishment of the PRC, to begin the development of nuclear weapons. A policy was developed for the repatriation of Chinese atomic scientists from the West and the identification of geological regions with fissionable materials. As previously discussed, significant Soviet assistance was initially supplied for this programme but aid from Moscow was terminated after the Sino-Soviet split. Foreign-trained Chinese scientists who participated in the nuclear programme included: Wang Ganshang, physicist, Berlin University and the University of California; Hua Luogeng, mathematician, Cambridge University and the University of Illinois; and Zhao Zhongyao, physicist, California Institute of Technology. Qian Xuesen's key role in China's strategic weapons programmes was previously discussed in section 3.1.

The Chinese nuclear weapons programme was established in 1955, initially with the help of the Soviet Union. Notable examples included the formation of the Sino-Soviet Nonferrous and Rare Metals Company in March 1950 to locate and mine radioactive materials in Xinjiang Province, and the March 1953 donation of a Soviet 'atom smasher' to China, plus assistance in the organisation of a number of research facilities leading to a August 1954 agreement to conduct joint research on nuclear military applications. The programme was also strengthened by support from indigenous talent including repatriated Chinese scientists trained earlier in the US and Europe. By 1960 the Central Military Commission had decided to weaponise (*wuqihua*) the nuclear programme, that is to move beyond R&D and test devices and produce operational bombs and warheads through the Beijing Nuclear Weapons Research Institute. Chinese leaders incorporated nuclear weapons development into the second five-year economic plan with a consistently high priority. Beijing had probably concluded by as early as 1958 that the only path to an independent nuclear weapons capability, with or without Soviet assistance, was to develop a broadly-based indigenous materials and development programme. In retrospect, China's reluctance to rely upon a Soviet strategic umbrella and the subsequent Sino-Soviet split, was almost inevitable given historical geopolitical enmities between the two powers.

Despite the sudden Soviet withdrawal of aid in June 1959, China exploded its first atomic bomb (U-235 implosion fission device weighing 1,550 kg code-named '596' with a yield of 22 kT to 25 kT) on 16 October 1964, at Lop Nor. China's first thermonuclear hydrogen (fusion) bomb was exploded two and a half years later on June 17, 1967 (its sixth nuclear test, a full-scale radiation implosion Teller-Ulam U-235, U-238 and lithium-6 deuteride device with a yield of 3.3 MT). The original Chinese fission bomb design used a bomb fuelled by enriched uranium and detonated by the advanced implosive detonation technique originally designed for plutonium-fuelled weapons. The time period between the first fission and first thermonuclear fusion explosions was 32 months, the shortest elapsed time for any nuclear weapons state. This was less than half the time taken by the United Kingdom, the second fast amongst the original five nuclear powers at 66 months (the Soviet Union 75 months, the US 87 months, and France 103 months).

Initial weapons were made with uranium, later versions were also made with plutonium. Series production of fission weapons began by 1968 and fusion weapons by 1974, and, in general, estimated warhead weight was miniaturised from about 2,200 kg to some 700 kg to permit delivery by ballistic missiles. During this early period, China had several plutonium production reactors, a plutonium reprocessing facility and a uranium enrichment facility (gaseous diffusion separation plant in Lanzhou in north-west China). Adequate uranium supplies were assured because China has extensive if unquantified uranium deposits. China's first uranium mine was located at Chenxian in Hunan Province, beginning in 1958; at least 26 other mines were subsequently developed in provinces such as Hunan, Zhejiang and Jiangxi. A weapons-grade nuclear production capability was achieved with the completion of two plutonium production reactors near Baotou, Inner Mongolia.

China is one of the five declared nuclear weapons states under the Nuclear Non-Proliferation Treaty (NPT). From 1964 to the end of 1996, China had conducted 45 verified nuclear weapons tests (23 atmospheric and 22 underground), all at its Lop Nor testing site, located about 2,300 km west of Beijing in Xinjiang Province. Despite international pressure, China continued atmospheric bomb tests until 1980, long after the last atmospheric tests by France had ended in 1974. Beijing also conducted the world's only, and extremely dangerous, reported test of a ballistic missile armed with a live nuclear warhead. In 1966 a DF-2 (CSS-1) IRBM with a 15 kT to 25 kT warhead was successfully fired and detonated 800 km into the Lop Nor test range (some reports indicate it was fired 1,750 km from Shuangchengzi to Lop Nor). The largest Chinese nuclear test, carried out in 1976, had a yield of about 4 MT. China's first underground test took place in 1969 and from 1981 all subsequent tests were conducted underground.

In September 1992, the United States, Britain, Russia and France joined together for a moratorium on nuclear weapons testing. Immediately before the testing halt, eight tests were conducted in 1992; six by the US and two by China. On 5 October 1993, just 12 days after losing its bid to host the 2000 Olympic games, China conducted an underground nuclear explosion at the Lop Nor test site, its 39th since 1964. In January 1996, Chinese Foreign Ministry spokesperson Chen Jian vowed that his country would press on with its nuclear weapons tests in defiance of the ban by Russia, US, the UK, and following six more tests in the South Pacific, France. On 8 June 1996, China conducted another test at Lop Nor, its 44th, and was condemned around the world. China muted some of the criticism by stating that it would end testing after exploding one more nuclear bomb. China exploded its 45th and last official nuclear bomb on 29 July 1996. The Cox Report makes the interesting observation related to allegedly stolen US nuclear weapons designs by China:

'*While it is sometimes argued that eventually the PRC might have been able to produce and test an advanced and modern thermonuclear weapon on its own, the PRC had conducted only 45 nuclear tests in the more than 30 years from 1964 to 1996 (when the PRC signed the Comprehensive Test Ban Treaty), which would have been insufficient for the PRC to have developed advanced thermonuclear warheads on its own. This compares to the approximately 1,030 tests by the United States, 715 tests by the Soviet Union, and 210 by France.*'

Through the United Nations Conference on Disarmament and the Test Ban Amendment Conference, attempts to transform the 1963 Partial Test Ban Treaty into a comprehensive treaty culminated in 1996. To modernise its capabilities, only China among the five recognised nuclear powers (with the short-lived exception of France) disregarded the post-Cold War moratorium on nuclear testing that had been in effect since October 1992. China continued nuclear tests until Foreign Minister Qian Qichen signed the Comprehensive Test Ban Treaty (CTBT) on 24 September 1996 at the United Nations. The CTBT has now been signed by 154 states, including the five original nuclear powers, but has continuing problems with interpretation and verification. Beijing has not yet fully ratified the treaty.

China has also recently developed (and acquired from abroad) various supercomputers capable of simulating nuclear explosions, as well as the reported acquisition of advanced US laser nuclear simulation ('fermi-second' or 'fast-electron' technology) knowledge. These latter capabilities could also result in a capability for 'micro nuclear explosion' tests that would be virtually impossible to detect by national means, or the future development of small, pure fusion weapons (that is without the uranium or plutonium fission trigger used in current thermonuclear devices).

China claimed that its nuclear bomb tests were needed to confirm the safety and reliability of its weapons. It also maintained that these tests were required prior to the probable implementation of the CTBT in 1996. However, the final Chinese nuclear tests were probably designed to investigate warhead miniaturisation and better yield-to-weight ratios in addition to improved safety features. The Cox Report claims that 'even after signing the CTBT, the PRC may be testing sub-critical or low yield nuclear explosive devices underground at its Lop Nor test site'.

During October 1999, the Senate rejected ratification of the CTBT, opening the potential for resumed US tests and possible resumption by other nuclear states such as China. Earlier during the same month, China and Russia rejected the use of seismic monitoring stations near their nuclear tests sites to help resolve CTBT verification problems. China and Russia also refused the use of small conventional explosions to calibrate the monitoring stations that would be deployed on their territories under the CTBT (two primary posts and four secondary sites in China but none in close proximity to the key Lop Nor area). US intelligence agencies have reportedly claimed that both China and Russia have recently conducted covert small nuclear test explosions (that is low or sub-kiloton), including one at Lop Nor on 12 June 1999 possibly related to advanced MIRV warhead development. Some experts also claim that larger nuclear explosions could be conducted underground in an 'evasive' manner to avoid international detection. China has long maintained, prior to ratifying the CTBT, that it should be allowed to undertake 'peaceful nuclear explosions' for scientific purposes and industries such as mining. So-called laboratory 'hydro-nuclear' tests produce yields of only a few pounds but are sufficient for developing new nuclear weapons designs, and are virtually impossible to detect. 'Cold tests' (*leng shiyan*) involve the physical testing of weapons components without fissile material.

7.2 Deployed Nuclear Arsenal TOP

Various estimates have been made as to the actual total number of operational Chinese strategic and tactical nuclear warheads, and there are no official Chinese confirmations. Most reports have indicated anywhere from 145 to 300 strategic warheads and between 80 to 150 tactical warheads, for a total of up to 450 nuclear weapons. However, the actual numbers could be considerably higher as China has published very little concerning its nuclear weapon stockpile. Together, these may have a cumulative yield of 250 MT. China's largest warhead type is 3 MT to 5 MT in yield. All of China's first generation nuclear weapons were of domestic design, although there is now some evidence that current generation lightweight designs may have transferred US design features. China's nuclear arsenal may be deployed in at least 20 locations throughout the nation.

In addition, the dividing line between 'strategic' and 'tactical' systems is not always clear and there may be some overlap between the two areas. China has produced at least five different types of fission and fusion weapons of varying yields and design features. The Chinese are believed to have in service two types of tactical nuclear ballistic missiles, aircraft bombs, and some atomic demolition charges (potentially used as nuclear land mines on Chinese territory to disrupt an invading army). Such tactical weapons were probably built during the 1960s and early 1970s and may very well be approaching the end of their operational lives according to some sources. However, China is believed to have tested more recent neutron enhanced radiation tactical weapons with yields between 1 kT to 5 kT during the 1980s. During July 1999, Beijing formally announced that China possessed neutron weapon technology, probably as both an indirect threat against secessionist-minded Taiwan and to discredit espionage allegations of the US Cox Report. The PLA has conducted various defensive and offensive exercises simulating the use of tactical nuclear weapons since the early 1980s.

The use of neutron and electromagnetic pulse (EMP) tactical weapons has recently been linked to potential PLA Taiwan invasion scenarios, the former to destroy military forces but maintain vital economic infrastructure, and the latter to paralyse telecommunication, computer, avionics and other military electronics systems. Persistent reports indicate that Taiwan had a significant nuclear weapons programme underway by the late-1980s (China claims this was initiated in 1966) but these efforts were halted due to US pressure. Following mainland missile tests near Taiwan in 1995, Taiwan's former President Lee Teng-hui suggested to the National Assembly that the issue of a nuclear capability should be revisited. Current unverified reports indicate that Taiwan's Nuclear Energy Research Institute recently approached Israel with regard to possible joint nuclear weapons development programmes. Taiwan could probably develop such weapons within a relatively short period of time under a crash programme. Computer simulations of nuclear explosions may have been undertaken and Taiwan may have stockpiled weapons-grade fissionable material.

Much of the information associated with China's nuclear force and capabilities remains shrouded in secrecy. A number of experts believe that it is possible that China's nuclear stockpile could be two or three times larger than previously estimated. Even if this is accurate China's stockpile would still be much smaller than operational US and potential Russian stockpiles even after current nuclear disarmament programmes are considered.

China's aircraft-delivered nuclear bombs are usually considered tactical and may be carried on a relatively small number of H-5 and H-6 bombers and A-5 'Fantan' and Su-27 (J-11) fighter-bombers. Tactical weapons could also be delivered by 203 mm (8 inch) artillery and 273 mm and 425 mm multiple rocket launchers in PLA service.

It is extremely difficult to estimate the actual structure of China strategic forces because of the PLA's tight security policies, misinformation and disinformation factors, and the secretive and misleading nature of strategic force deployments. To increase the survivability of its missile forces, China has made vast efforts to hide its missile capabilities through employing dummy missile silos, camouflaging missiles under civilian buildings with removable roofs, placing missiles in mineshafts, mountain caves and tunnels. The Chinese have reportedly considered deploying the DF-5 ICBM inside of fake bridge towers and on rail cars.

It is unlikely that the US or any other potential opponent has identified all of China's missile sites and force levels due to its high levels of concealment and secrecy. For example, many sources credited China as having only four DF-5 missiles on alert, two of which are known to be deployed in silos in Central China, where they could be destroyed by a pre-emptive strike. Yet, other sources have indicated that since 1978 China has been producing 10 to 12 Long March missiles per year, with the LM-2C vehicle frame being used by both the DF-5 ICBM and the space launch vehicle. There are published photos that show at least nine of these types of missile on an assembly line at a single time. Some calculations would indicate that over 200 of these missiles could have been produced between 1978 and 1996 alone. Yet, according to recent US statements, China is only credited with having a force of an estimated 17 to 20 DF-5s and DF-5As, which raises the question as to the location of the remaining missiles.

It is possible that China may have successfully duped the world as to the size of its ICBM force, given its concern over having its retaliatory missile force pre-empted and its superior capabilities at maintaining secrecy, combined with a military doctrine that places much importance on the value of deception operations. For example, this is an argument advanced by Yang Zheng of the National University of Singapore. Yang asserts that China actually has an inventory of 2,350 nuclear warheads; among these are some 550 tactical nuclear weapons and 1,800 strategic nuclear weapons. China's annual production, in this scenario, of warheads was about 110 to 120 during the 1980s, and about 140 to 150 during the 1990s. With an average annual production as low as 75 warheads during the 1980s, another estimate suggested that China's possessed by the mid-1990s up to 2,000 nuclear weapons of all types. Other US intelligence estimates during the mid-1980s had forecast that China's nuclear warhead inventory by 1996 would be as high as 700 devices.

At least one report projects that China could produce 3,000 to 5,000 nuclear warheads by 2010 if it so desired. Other reports indicated that during 1998, China produced six to eight new ICBMs, a supposed unprecedented rate of production. It can safely be concluded that the PLA has the technical capability (and China has the economic capacity) to increase its strategic nuclear forces by a factor of two to three times, and to improve their operational flexibility. The collapse or weakening of the ABM Treaty and CTBT, along with the deployment of theatre missile defence systems in Asia by the US and its allies could heighten such developments.

7.3 Development Programmes TOP

The 1999 US Cox Report charges that:

· China is likely to continue to work on small thermonuclear warheads based on stolen US design information.

· China has the infrastructure and ability to produce such warheads, including warheads based on elements of the stolen US W-88 Trident D5 design information.

· China could begin serial production of small thermonuclear warheads during the next decade in conjunction with its new generation of road-mobile missiles.

· The introduction of small warheads into PLA service could coincide with the initial operational capability of the DF-31 ICBM, which could be ready for deployment in 2002.

· These small warhead designs will make it possible for China to develop and deploy missiles with multiple re-entry vehicles (MRVs or independently targetable MIRVs).

· Multiple re-entry vehicles increase the effectiveness of a ballistic missile force by multiplying the number of warheads a single missile can carry as many as ten-fold.

· Multiple re-entry vehicles also can help to counter missile defences. For example, multiple re-entry vehicles make it easier for China to deploy penetration aids with its ICBM warheads in order to defeat BMD systems.

The US Department of Energy has identified two general design paths to the development of modern thermonuclear warheads: the Russian practice of simplicity and reliability in design; the US practice of implementing innovative designs and lighter-weight warheads. The Cox Report has suggested that China will emulate the US design path for the development of its next generation of thermonuclear warheads but it has already begun the development of smaller thermonuclear warheads. China worked to complete the testing of its modern thermonuclear weapons before it signed the CTBT through a series of nuclear tests from 1992 to 1996 to develop small, light warheads for the next generation of its nuclear forces.

The Cox Report claims that China is developing smaller, more compact thermonuclear warheads, which exploit elements of stolen US design information, for its next generation of road-mobile ICBMs. This includes the stolen design information from the US W-70 Lance warhead or the W-88 Trident D-5 warhead. According to the Cox Report, 'these warheads give the PRC small, modern thermonuclear warheads roughly equivalent to current US warhead yields'.

W-88 type warheads could also be used for improved tactical ballistic and cruise missile systems. While China may not currently be able to match precisely the exact explosive power and other features of modern US nuclear weapons, it is probably working toward this goal. The difficulties it faces are surmountable through the use of modern aerospace and defence industry capabilities that China already has in place. The Cox Report's allegations are not new to the Western intelligence community. In fact, a 1984 US Defense Intelligence Agency (DIA) report had predicted that Chinese strategic weapons programmes would benefit from 'overt contact with US scientists' as well as 'covert acquisition of US technology'.

The Cox Report also most interestingly claimed:

'*The full extent of US information that the PRC acquired and the sophistication of the PRC's indigenous design capabilities are unclear. Moreover, there is the possibility of third country assistance to the PRC's* *nuclear weapons programme, which could also assist the PRC's exploitation of the stolen US nuclear weapons information.*'

This 'third country' could be Russia, another former Soviet state such as the Ukraine, or Israel. Other sources indicate that the new generation lightweight Chinese nuclear warheads for the new DF-31 and DF-41 ICBMs are in fact longer and heavier that the W-88, with the W-88 having a smaller trigger design. Critics of the Cox Report charge that China undertook its own warhead miniaturisation programme for at least 13 years, from 1979 to 1992, and that actual development challenges are not in design but in the actual manufacturing process because plutonium is one of the most complex metals known to science and is highly reactive with other metals and materials. China succeeded in exploding its miniature warhead on 25 September 1992, with an advanced ovoid core design and atomic trigger similar to the W-88 design. However, the warhead was also possibly the product of a parallel logical engineering design evolution, which has been followed by Russia, France and the United Kingdom related perhaps more to the laws of physics than espionage (in other words narrow nose cone designs of about 16º wide).

7.4 R&D and Production Infrastructure TOP

China has been developing its nuclear infrastructure for many decades. Some sources indicate that China began start-up programmes for nuclear weapons (1955), strategic ballistic missiles (1956) and nuclear-powered submarines (1959) and submarine-launched ballistic missiles (1958) even before a uranium mining infrastructure had been fully developed, and when domestic applied and theoretical physics capabilities were still rudimentary and consisted of a small core of senior Chinese physicists and scientists (*daoshi*) trained abroad (e.g. Qian Sanqiang and his wife He Zehui, Wang Ganchang, and Peng Huanwu).

The original nuclear weapons design institute was code-named the Ninth Academy, and also conducted pioneering Chinese basic R&D on cosmic rays, bubble chambers, particles and high-energy physics. Most Chinese senior research scientists and engineers from the Chinese Academy of Sciences (CAS) in fields such as physics, electronics, and aerospace were, and continue to be, deeply involved with strategic programmes. Interdisciplinary defence work is co-ordinated by the CAS Department of Technical Sciences. Marshal Nie Rongzhen and his PLA staff deserve the most credit for initially mobilising and organising China's strategic technologies R&D base, while often being opposed by an entrenched civilian-party bureaucracy. In some respects the missile and submarine programmes were more complex than the nuclear weapon programme, because of the former's requirements for sophisticated inertial guidance systems, accelerometers, solid rocket propellants (for SLBMs) and advanced metallurgy and reactor propulsion systems. CAS institutes in such fields as optics, mechanics and chemistry also played an important role in missile/space and nuclear submarine programmes. These developments were also, in the views of some, accomplished without any overall strategic concept for their military employment.

Even today, much of the key R&D infrastructure of Chinese universities and research institutes can be traced back to the original strategic weapons programmes. Jiatong and Qinhua Universities were specifically established to work on such programmes, as was the Dalian Institute of Technology. These educational centres also award advanced degrees at the Masters and PhD level for strategic weapons related research. The Ninth Academy continues to play a leading role in R&D on fluid dynamics, gas dynamics, condensed state physics, pressure physics, shock wave and detonation physics, nuclear physics, inertial confinement fusion, engineering and material science, radiochemistry, computational mathematics, chemical engineering, laser research, and opto-electronics. It also maintains National Keypoint Laboratories in such fields as high-temperature and density plasma physics, and shock wave and detonation physics.

China's first nuclear strategic region identified with uranium and thorium deposits was in Xinjiang Province, where a research centre was established at Alashan Kou, Dzungarian Gate, on the border with Kazakhstan (where units of China's nuclear forces are still believed to be located). The triangular area between Lake Lop Nor, the town of Yuli and the Turfan Depression became the Lop Nor Nuclear Weapons Test Base. Lop Nor's first commander was Zhang Yunyu. Much of the original Chinese nuclear development infrastructure was constructed in regions near the Soviet border. After relations between the two countries deteriorated, new and often duplicative and redundant facilities were dispersed throughout China to lessen their overall vulnerability to attack.

Organisations that were key to the development of China's original nuclear weapons included:

· the Lop Nor (Nur) Nuclear Weapons Test Base;

· the Ninth Bureau or Nuclear Weapons Bureau (including the Beijing Nuclear Weapons Research Institute, the Northwest Nuclear Weapons Research and Design Academy (Ninth Academy) at Qinghai, and the Nuclear Component Manufacturing Plant at Jiuquan, responsible for weapon R&D and production of actual devices;

· the Geological Bureau (Third Bureau of the Ministry of Geology), responsible for uranium prospecting;

· the Mining and Metallurgy Bureau (Third Department of the Ministry of Metallurgy, or Twelfth Bureau), responsible for the control of mines and facilities for processing uranium concentrates and uranium oxides;

· the Fuel Production Bureau (including the facilities at the Lanzhou Gaseous Diffusion Plant - or Fifteenth Bureau or Plant 504 - and Baotou Nuclear Fuel Component Plant), with responsibilities for uranium tetrafluoride, uranium hexafluoride and plutonium;

· the Construction Bureau or Design Academy, with responsibility for the design of nuclear plants and other facilities;

· the Equipment Manufacturing Bureau, established in 1961, with responsibilities for manufacturing materials, instruments, and equipment;

· the Sixth Bureau, established in 1961 to control equipment and materials supply, and the overall transportation system for the programme;

· the Science and Technology Bureau; Information Bureau or Institute (Eleventh Bureau), responsible for technical information collection and analysis from foreign sources;

· the Security and Protection Bureau, responsible for safety, health and environmental protection;

· the Planning Bureau;

· the Finance Bureau;

· the Cadres Bureau (personnel);

· the Institute of Atomic Energy; and

· the Design Bureau.

Thermonuclear facilities included the Qinghai Ninth Academy (hydrogen bomb igniter experiments and design); the Nuclear Fuel Component Plant, Baotou, Nei Mongol, responsible for Lithium-6 Deuteride isotope separation, production and compound synthesis; the Ministry of Chemical Industry, responsible for heavy water production; the Ministry of Metallurgical Industry, responsible for minerals containing lithium; and a self-design tritium plant. Most of these organisations and facilities were eventually merged into the overall China National Nuclear Corporation (CNNC), COSTIND and CAS structures that exist today, some with differing names and responsibilities that now also include nuclear power projects.

Until the early 1980s China's nuclear industry was focused on military production and weapons development. Only relatively recently has the development of a commercial nuclear power industry been sanctioned by Beijing and this remains of secondary importance to defence requirements. China's national nuclear infrastructure (also see section 7.5 on the CNNC) includes the following elements:

· power and research reactors;

· uranium mines and mills;

· uranium refining and conversion facilities;

· fuel fabrication facilities;

· heavy water production plants;

· particle accelerators;

· radioactive waste management facilities;

· radioisotope sources;

· weapons development, integration and test facilities;

· delivery vehicle development, integration and test facilities; and

· electronics and other sub-systems development, integration and test facilities.

Tasks undertaken in these facilities include R&D, engineering, manufacturing, operations and maintenance, mining, and construction. An Atomic Research Centre is located at Tarim Pendi, Xinjiang Province. Other nuclear-related organisations include COSTIND's Military Scientific Councils and the Nuclear Safety Administration. A State Bureau of Nuclear Security has also been associated with the Ministry of Defence. The National Nuclear Safety Administration is China's nuclear power plant regulatory agency. The Chinese Academy of Sciences (Academica Sinica) conducts nuclear-related basic R&D; the CNNC has the applied R&D role.

China is believed to have widely dispersed facilities for the production of nuclear weapons-grade materials. Nuclear weapons and/or materials are estimated to be present in at least 11 of China's provinces. The geopolitical implication of this is that if China's central government weakened and the nation fragmented along provincial or military district lines, it is possible that nuclear armed 'warlords' could emerge and that states such as North Korea and Iran could more readily obtain Chinese nuclear weapons.

The existence of nuclear bases and nuclear weapon manufacturing centres in the Tibetan Autonomous Region has also been reported but not verified, with China possibly having such facilities at Haiyan in the Haibei Tibetan Autonomous Prefecture and Huangyuan in Amdo. An important nuclear weapon research and design facility in Dhashu was believed to be constructed in the early 1960s. Some unconfirmed reports indicate the facility is based near Lake Kokonor and is known as the Northwest Nuclear Weapons Research and Design Academy, or the Ninth Academy under the jurisdiction of the Ninth Bureau (described by some as 'China's Los Alamos'). The facility is reportedly a highly secretive research centre for such areas as detonation development, radio-chemistry and many other nuclear weapons related activities, and has also possibly assembled components of nuclear weapons. A 1993 report from the International Campaign for Tibet also suggested that a 'nuclear city' had been established on the Tibetan plateau. The report suggested that a nuclear reactor was built at the 'city', which is protected by missiles (including nuclear weapons) and is a major employer of prison labour. Other reports suggest that it haphazardly dumped nuclear waste and that 35 of the 500 inhabitants of a 'town' near a mine in the N'gaba area died from drinking contaminated water.

The Cox Report reports that Qinghua University Nuclear Research Institute has claimed success in the development of high-temperature, gas-cooled reactors, projects that could assist the development of nuclear weapons. Qinghua has in fact played an important role in the weapons-grade plutonium processing programme and also submitted an unsuccessful competing design for the first nuclear submarine propulsion reactor. The China Academy of Engineering Physics (CAEP), under COSTIND and the CNNC, is in overall charge of Chinese nuclear weapons programmes. This includes responsibility for the R&D, testing and production of all of China's nuclear weapons. It is claimed that the CAEP has pursued a very close relationship with US national weapons laboratories, sending scientists and senior management to Los Alamos and Lawrence Livermore during the mid-to-late 1990s to 'acquire information and collect intelligence'.

China's nuclear weapons testing facility is located in a remote part of Xinjiang autonomous region, called Lop Nor (Lop Nur). The facility has two principal testing regions: in the west the tests were typically undertaken in horizontal tunnels, while in the east or south they were conducted in vertical shafts. The Lop Nor test site reportedly extends over an area of 100,000 square kilometres and is said to comprise three distinct elements, including the 'nuclear city' of Malan (not normally shown on maps) reportedly on the road between Uxxatal and Yushgou. A research institute is located less than 100 km north-west of Malan. (42 º 24 minutes N 87 º 20 minutes E).

The nuclear testing site is around 260 km south-east of Malan. The central area of the test site is divided into three underground test facilities (which may have been used for tests in horizontal tunnels), including the western test area which may have been used for testing tactical warheads and the southern zone which was used for tests in vertical shafts. Underground nuclear explosions at the Lop Nor nuclear test site were until 1996 used to test new weapons designs and to harden missile and spacecraft electronic systems against harsh radiation environments and EMP. In 1996, Xu Zhilei was described as being China's 'senior expert on nuclear weaponry'.

The Chinese capability to produce enriched uranium was initially confined to a single enriched uranium production facility, the Lanzhou Gaseous Diffusion Plant. Construction of the plant probably began in 1957, with operations commencing by 1963. This facility was estimated to produce weapons grade U-235 at a rate of 150 kg to 330 kg per year during the 1960s. Modifications during the early 1970s reportedly increased the plant's capacity. During 1992, the Russian Zheleznogorsk Mining and Chemical Combine (Krasnoyarsk-26), a centre of excellence for plutonium processing and spent nuclear fuel reprocessing, reportedly privately offered assistance to the Lanzhou Gaseous Diffusion Plant to upgrade its uranium enrichment facilities. The Lanzhou complex consists of at least three facilities:

· the Lanzhou Gaseous Diffusion Plant, producing 375 kg of U-235 annually in the mid-1970s.

· the Helanshan Centre Number One gas centrifuge plant, producing 80 to 90 per cent enriched U-235, and entered service in 1969.

· the Helanshan Centre Number Two gas centrifuge plant, which entered service during the mid-1970s.

The Haiyan (Hai-yen) or Koko Nor complex in Qinghai (Tsinghai) Province was China's first major nuclear weapons R&D centre, and up to the early 1970s was also a major weapons fabrication centre. A large nuclear stockpile site and weapons development complex included facilities for high explosive and fissile component production, general component (e.g. cases and electrical systems) production, final weapons assembly, high explosives component testing, and environment testing. Located near Qinghai Lake in Haiyan County, the facility was built in 1958, and given the formal designation of State Plant 221, or the Qinghai Provincial Mining Zone. Under Marshal Nie Rongzhen, from 1958 to 1964, the facility reportedly developed China's first atomic bomb, and two years later China's first hydrogen bomb (leading to the local nickname the 'two-bomb base.')

The 1,100 square kilometre base, which was actually a closed self-contained city, included 560,000 square metres of building plants, 330,000 square metres of production buildings, over 40 km of special railway lines that converged with the Qinghai- Tibet Railway Line, some 80 km of standard highways, 1,000 six-digit computer-controlled telephones, and one thermal power plant with an annual generating capacity of 110 million kWh. However, in 1987 the State Council approved the closure and radioactive clean-up of the facility and personnel were reportedly gradually shifted to other facilities. Tourist sightseeing visits are now apparently available for the facility, which is maintained by the provincial government.

Construction of China's original plutonium production complex at Jiuquan (Yumen), Gansu Province, began in 1958-59. A graphite-moderated water-cooled reactor at this site was reportedly photographed by US intelligence satellites in 1962 and February 1964. During 1964 the reactor apparently was not operational, perhaps shut down for a change of fuel elements. Construction continued over the next decade and operation of the large plutonium chemical separations plant began during 1970. In addition to the original plutonium production reactor at Jiuquan, China built a second, very similar, plutonium reactor and chemical separation plant at Guangyuan (Kuangyuan), Sichuan Province, which began production during mid-1973, with approximately the same plutonium production capacity as the Jiuquan reactor of 300 kg to 400 kg per annum.

A gaseous diffusion plant at Heiping (Chinkouko) facilitated a significant increase in U-235 production, commencing with construction in the early 1970s. The plant was probably fully operational by late 1974. Heiping produces an estimated 750 kg to 2,450 kg of U-235 per year. A reprocessing plant in Xinjiang is co-located with waste disposal facilities associated with the nuclear weapons programme and was said in the mid-1990s to have the capacity to extract 14 kg of plutonium per year. Fuel elements are fabricated at: the CNNC Ybin Nuclear Fuel Element Plant (Plant 812),Ybin, Sichuan; the CNNC Nuclear Fuel Complex, Lanzhou; and the CNNC Plant 202 (Nuclear Materials) Baotou, Inner Mongolia.

The materials and component production facility at Baotou includes a small air-cooled reactor with capacity to produce about 10 kg of plutonium per year. During late 1964, US intelligence estimated that the reactor had recently become operational. Initially US intelligence estimated that the first Chinese nuclear weapons test in October 1964 used plutonium from this facility. However, subsequent analysis of the debris from the test immediately demonstrated that the first Chinese nuclear weapon used uranium, which led US intelligence to conclude that the U-235 plant at Lanzhou had become operational.

In April 2000, China began construction of its first nuclear fuel element plant at Baotou, which is expected to produce 200 tons of nuclear fuel elements annually following a trial period from September 2001 until March 2003. According to the new China Nuclear Industrial Group (resulting from the 1999 restructuring of the CNNC), output from the plant will eventually replace Canadian fuel imports for two 700,000 kW heavy water reactors (HWR) being built at Qingshan, Zhejiang Province. Some 200 million Rmb yuan is to be invested in the plant.

US intelligence is believed to have initially identified the Mianyang (Tzu-t'ung) nuclear weapons fabrication centre because of the presence of numerous revested buildings and three high explosives test points similar to those at Koko Nor, as well as the overall size of the installation and its pattern of facilities dispersal. It was probably operational by the late 1960s or early 1970s and was believed to have represented a major increase in China's nuclear weapons fabrication capabilities. The Mianyang complex provides strategic duplication and dispersal for nuclear weapons R&D and production. It also incorporates attack countermeasures such as situating buildings along narrow valleys and carefully minimising the disturbance of local terrain features and agricultural patterns (Koko Nor is highly visible).

The Beijing Institute of Nuclear Engineering was founded in 1958 and is China's largest comprehensive institute for nuclear industrial engineering R&D. It also serves as a national nuclear engineering and construction general contracting unit. The institute's staff complement includes over 2,000 engineers and technicians, equipped with extensive computer-aided design and engineering systems. Projects have included 'nuclear factories', R&D test facilities and bases, and the transfer of dual-use military technologies to civilian applications. R&D fields include reactor physics, thermohydraulics, radiation protection, and isotopic applications. It also operates the Shenzhen Design Branch, Hainan Design Branch, Nanjing Irradiation Centre, and the Changshu Irradiation Station, Jiangsu.

The institute was a prime contractor for the Qinshan Nuclear Power Plant project, China's first indigenously designed and constructed nuclear power plant. It has conducted technical exchange and co-operation programmes with organisations from the US, Japan, Germany, France, Canada, Sweden, Russia, Czechoslovakia, Pakistan, Thailand, Algeria, United Kingdom, Australia, Belgium, Spain, Iran, Korea, Malaysia, India, Jordan, Denmark, Switzerland, Holland, Austria, Italy, Yugoslavia, New Zealand, Hong Kong and Macao.

The '863' Programme is currently funding R&D in fast neutron breeder reactors and high-temperature gas-cooled reactors at Tsinghua University's Institute of Nuclear Energy Technology (reportedly applicable to new generation nuclear submarine propulsion systems because of intrinsic low noise levels), 'as well as fission/fusion reactors based on existing fusion technology, so as to develop safe and economical reactors that will greatly increase the nuclear fuel ratio'.

During 1998, China began construction of its first 'fast neutron power station' prototype in Beijing, which is scheduled to enter trials by 2003. The CAS's Institute of Plasma Physics, Hefei, has a major controlled nuclear fusion facility, first developed in 1994. It is now conducting 'breakthrough' research with its HT-7 TOKAMAK superconductivity device in steady-state magnetically confined fusion, computer precision-controlled current feedback, plasma displacement feedback control, reactor wall handling, and long pulse discharging conditions. The Southwestern Institute of Physics, Chengdu, Sichuan, has also undertaken fusion R&D, with various facilities including the major TOKAMAK Huan Liu HL-1M fusion reactor. In 1998, the Beijing General Academy of Non-Ferrous Metal, the Northwest Academy of Non-Ferrous Metal and the CAS Institute of Electronic Engineering developed China's first power transmission cable made of high-temperature bismuth/strontium/calcium/copper/oxygen superconductivity materials, and is conducting related magnetic levitation experiments, under the sponsorship of the '863' Programme.

The Shenyang Institute of Metals Research and the Chinese Northwest Institute are reportedly involved with next generation warhead miniaturisation efforts. During 1997 they attempted to obtain advanced US high-temperature furnace technology for this application.

From 1979 to 1990, US scientists and officials made extensive visits to Lop Nor and other Chinese facilities, and concluded that Chinese nuclear technologies, including weapons programmes, were 'quite advanced'. A past director of the US Los Alamos nuclear weapons laboratory, Dr. Harold Agnew, recently stated: 'They don't need help from us...they're just curious, as we are curious about them...they have excellent facilities, *some better than ours*' (emphasis added). A particular example of superior Chinese technology sited by Agnew is an advanced camera known as a pinex, used for warhead development, which in the US version has one axis and the Chinese version two, doubling its usefulness.

7.5 China National Nuclear Corporation (CNNC) TOP

As part of a move to increase the efficiency of China's domestic nuclear capability, the China National Nuclear Corporation (CNNC) was established in 1986 through a restructuring of the former Ministry of Nuclear Industry. CNNC is a legal corporate entity with government administrative functions. It is currently undergoing another restructuring and has reportedly been placed under the authority of COSTIND (traditionally, its presidents and vice-presidents have been appointed by the State Council). The new entities spun-off from the CNNC during 1998 are believed to be the China Nuclear Group and the China Nuclear Construction Group but details remain unclear and the CNNC's overall organisational structure is believed to remain valid.

The CNNC has overall responsibility for both civilian and military nuclear activities at all levels of the nuclear fuel chain. It is a national industrial conglomerate integrating all aspects of nuclear science, technology, industry (equipment and weapons production, management, and site construction), and foreign trade and technology transfer. It has over 200 subsidiary organisations and an estimated 300,000 employees (of which 70,000 are scientists and engineers), including a significant world-class R&D capability. The CNNC probably funds portions of PLA capabilities outside of the official defence budget. Today it is emphasising a dual-use role that was highlighted in an October 1989 speech by the then CNNC President Jiang Xinxiong:

'*To strengthen China's national defence, the (nuclear) industry has successfully developed various types of nuclear weapons, attracting worldwide attention. In view of the strategic shift that has taken place in China's national construction since 1979, the industry has turned its emphasis to serving the national economy, thus ushering in a new historical period for the development of China's nuclear industry. The primary task for the nuclear industry in shifting from military to civilian production is the vigorous development of nuclear power...*'.

The CNNC orchestrates R&D on nuclear energy and technologies, advanced reactor and nuclear fuel technology R&D, and the transfer of nuclear technologies and consulting services domestically and abroad. It is in charge of the specialised education, training and exchange of personnel in nuclear science, technologies and management. The CNNC has authority for: conducting economic and technical co-operation and trade with foreign nations through direct negotiation and the signing of contracts; the import and export of complete sets of equipment for nuclear power plants, uranium series products and isotopic products; contracting for foreign construction projects; and the export of technology and labour services. It is responsible for the exploration, assessment, mining and extraction of radioactive mineral resources in China. CNNC's Bureau of Nuclear Fuel provides industrial production systems for uranium conversion and enrichment, fuel manufacture, spent fuel reprocessing, and the recycling of uranium and plutonium, including expertise in the separation of uranium isotopes by means of gas-centrifuge and laser techniques. It also has 'a dozen large nuclear fuel plants and research and/or design institutes' (including uranium hexafluoride production plants) located in the provinces of Sichuan, Gansu, Shaanxi, Inner Mongolia, and the cities of Tianjin, Taiyuan, Shanghai and Zhengzhou.

Specific CNNC R&D areas include controlled nuclear fusion (for example, the TOKAMAK HL-1 research reactor), laser fusion, a high-flux testing reactor, miniature neutron source testing reactors, intense pulsed electron accelerators, and Nd-glass lasers. Facilities include 15 research organisations and six research and design institutes with a total staff of 25,000, including some 8,000 senior research fellows. The CNNC provides a National Atomic Energy Authority function for China's co-operation with the International Atomic Energy Agency (IAEA). It has a basic policy of promoting the self-reliant development of nuclear technologies, while simultaneously seeking advanced expertise and technologies abroad and 'using China's nuclear imports only for peaceful purposes'.

The CNNC's China Nuclear Equipment and Materials Corporation supplies materials and equipment products for both military and civilian applications and has subsidiaries in Beijing, Shenyang, Shanghai, Wuhan, Guangzhou, Xi'an, Chengdu, Tianjin, Harbin, and Zhengzhou. The CNNC's China Nuclear Information Centre collects and disseminates nuclear-related scientific and technical information through foreign information networks. It also operates the International Nuclear Information System and the *CNNC Atomic Energy Press*, the *Nuclear Industry Audio-Video Press*, and the *Nuclear Industry Information* newspaper. The China Nuclear Energy Industry Corporation is the CNNC's main foreign trade organisation.

The China Nuclear Instrumentation and Equipment Corporation produces defence products such as fire-control systems and precision instrumentation. It has 13 organisations specifically engaged in the R&D and production of nuclear instruments and equipment (e.g. nuclear radioactive detectors, laboratory systems, isotope systems, radiation protection systems, and nuclear reactor systems) in Beijing, Shanghai, Wuhan, Xi'an, Dalian, Suzhou, Emei and Shenzhen. The CNNC's export and import activities are co-ordinated through the Xinshidai Group conglomerate. Export and import activities include all dual-use aspects of nuclear energy and related equipment and systems. It has established trading relationships with over 100 companies in some 40 nations. CNNC has a large number of subordinate or affiliated organisations and R&D facilities that are summarised in Table 7.1.

Table 7.1 CNNC Subordinate and Affiliated Nuclear Organisations

· Airborne Survey and Remote Sensing Centre of Nuclear Industry, Hebei.

· Artificial Diamond Factory, CNNC.

· Asia Simulation Control System Engineering Ltd., Zhuhai - nuclear reactor simulation control systems.

· Bantou Breeder Reactor.

· Baotou (Pao-t'ou) Nuclear Material Plant 202 (40º38'N 109º59'E) - materials and components.

· Beijing Geological Research Institute, CNNC.

· Beijing Positron-Electron Collider, CAS.

· Beijing Institute of Nuclear Research (Institute of Nuclear Engineering).

· Beijing Institute of Modern Physics.

· Beijing Nuclear Instrument Factory.

· Beijing Research Institute of Chemical Engineering and Metallurgy.

· Beijing Research Institute of Radiation Protection.

· Beijing Research Institute of Uranium Geology.

· Beijing Synchrotron Radiation Facility.

· Beijing University, Department of (Technical) Physics.

· Beijing Vacuum Electronic Research Institute - large power pulse magnetrons for linear accelerators.

· Central-South Bureau of Geologic Exploration of Nuclear Industry.

· Chengdu - gas centrifuge enrichment.

· Chengxian (Ch'eng-hsien) (33º42'N 105º36'E) - uranium mine.

· Chenzhou Uranium Mine.

· China Academy (Institute) of Engineering Physics (Ninth Academy), Beijing (believed by some to be the core R&D centre of China's nuclear weapons complex; recent head is Hu Side, with deputy Du

Xiangwan).

· China Air Dynamics Research and Development Centre, Mianyang, Sichuan.

· China Baoyuan Development Corporation - civilian and non-nuclear spin-off developments.

· China Centre for Nuclear Industry Economics.

· China Chongqing 3rd Veteran Research University.

· China Institute for Radiation Protection.

· China Institute of Atomic Energy.

· China Institute of Engineering Physics.

· China Isotope Corporation.

· China National Nonferrous Industry Corporation, Shaanxi.

· CNNC Bureau of Geology.

· CNNC Bureau of Nuclear Fuel.

· CNNC Bureau of Uranium Mining and Metallurgy.

· CNNC Electronic Instrument Factory, Shanghai.

· CNNC Factory 720, Nanchang, Jiangxi.

· CNNC Nuclear Equipment Factory, Dalian.

· CNNC Nuclear Equipment Factory, Xi'an.

· CNNC Nuclear Instrument Factory, Beijing.

· CNNC Nuclear Instrument Factory, Shanghai.

· CNNC Nuclear Instrument Factory, Xi'an.

· CNNC Optical Instrument Factory, Suzhou.

· CNNC Plant (Atomic Complex), Lanzhou, Gansu.

· CNNC Plant 276, Xileng, Guizhou.

· CNNC Synthetic Diamond Factory, Suzhou.

· CNNC Valve Factory, Suzhou.

· China Nuclear Energy Industry Corporation (CNEIC) Daya Bay Nuclear Power Company (Guangdong Nuclear Power Joint Venture Company, Ltd., near Hong Kong).

· CNEIC Qinshan Nuclear Power Company, Shanghai.

· China Nuclear Engineering Corporation.

· China Nuclear Equipment and Materials Corporation.

· China Nuclear Industry Materials and Equipment Huadong Corporation, Shanghai.

· China Nuclear Industry Number 5 Installation Company, Shanghai.

· China Nuclear Industry 24th Construction Company, Chengdu, Sichuan.

· China Nuclear Industry 25th Construction Company, Hengyang, Hunan.

· China Nuclear Information Centre.

· China Nuclear Instrumentation and Equipment Corporation, Beijing.

· China Nuclear Power Research Institute (Wuhan Heat and Power Research Institute), Chengdu, Sichuan (President Jiang Zemin is a former director of this institute).

· China Rainbow Development Corporation (China Rainbow International Corporation).

· China Zhongyuan Engineering Corporation - international nuclear co-operation and contracts in areas such as nuclear fuel development and accelerator and reactor developments.

· Chinese Mechanical Engineering Society, Beijing.

· Chinese Nuclear Society, Beijing.

· Chongqing (Ch'ung-ch'ing) (30º38'N 103º40'E) - experimental nuclear reactor.

· Design and Research Institute of Uranium Mining and Metallurgy.

· Donghuangyuan (Tung-hua-Yuan) (40º22'N 115º50'E) - conventional explosives testing related to nuclear programme.

· East China Bureau (Institute) of Geologic Exploration of Nuclear Industry.

· Eighth Research Institute CNNC.

· Engineering Physical Research Institute, Sichuan.

· Fuzhou Uranium Mine (27º59'N 116º21'E) - mining and metallurgy.

· 210 Factory CNNC, Northwest Geologic Survey Bureau.

· Guangyuan Breeder Reactor (Kuang-yuan) Plant 821 (32º26'N 105º52'E) - plutonium production reactor.

· Haiyan (Hai-yen/Koko Nor) 9th Academy (36º58'N 100º50'E) - design, testing and fabrication of nuclear weapons and components; central nuclear weapons stockpile.

· Hebei Company, China Nuclear Instrumentation and Equipment Corporation - micro-gamma cameras.

· Hefei Tokamak Facility (Hefei Superconduction Tokamak Facility under development).

· Heiping (Chin-k'ou-ho/Chinkouko) (29º18'N 103º04'E) - uranium gaseous diffusion plant.

· Helanshan Centrifuge (1 and 2).

· Hengyang Institute of Technology - nuclear power plant engineering.

· Hengyang Uranium Processing Mill (26º54'N 112º36'E) - uranium oxide production.

· Huachang Construction Company (22nd Construction Company).

· Huakang Construction Company (21st Construction Company).

· Huatai Construction Company.

· Huaxia Installation Company, Sanhe, Hebei.

· Huaxin Biochemical Products Factory CNNC.

· Huaxing Construction Company, Xupu, Jiangsu.

· Huayang Construction Company.

· Hunan Research Institute of Uranium Mining.

· Institute of Applied Physics and Computational Mathematics, Beijing (basic research in such areas as computational physics and the hydrodynamics of explosions).

· Institute of Engineering Physics of China.

· Institute of High Energy Physics, CAS, Beijing.

· Institute of Nuclear Energy Technology, Tsinghua University, Beijing.

· Institute of Modern Physics, CAS.

· Institute of Plasma Physics, CAS, Hefei.

· Institute of Solid State Physics, Beijing.

· Institute of Systems Engineering.

· Institute of Theoretical Physics, Beijing.

· Jian Zhong Chemicals Corporation.

· Jiangsu 7th Institute - nuclear design institute.

· Jiang Xi Changhua Chemical and Metallurgical Company.

· Jiuquan (Yumen/Subei) Plant *404* (40º15'N 97º21'E) - plutonium production reactor

· Kaili Industry Development Corporation.

· Lanzhou Gaseous Diffusion Plant (Lan-chou) Plant 504 (Nuclear Fuel Complex; Uranium Enrichment Plant) (36º09'N 103º29'E) - gaseous diffusion plant.

· Lanzhou Heavy Ion Accelerator (cooling storage ring under development).

· Lanzhou Institute of Modern Physics.

· Lianxian (Lin-hsien) - uranium mine.

· Lop Nor Nuclear Test Site, Xinjiang (41º30'N 88º30'E).

· Mianyang/Zitong (Mien-yang/Tzu-t'ung) Ninth Academy CAEP (31º28'N 104º46'E) - nuclear weapons design.

· Nanchang Heli Machinery Works.

· Nanfang Machinery Works, (Number 260 Factory) CNNC.

· Nanjing Green Hydrotreater Works.

· National Key Laboratory for Artificial Microstructure and Mesoscopic Physics, Beijing.

· National Synchrotron Radiation Laboratory, Hefei.

· Ninth Academy, Lake Kokonor, Tibet.

· Northeast Bureau of Geologic Exploration of Nuclear Industry.

· Northwest Bureau of Geologic Exploration of Nuclear Industry.

· Northwest Institute.

· Northwest Nuclear Weapons Research and Design Academy (Ninth Academy).

· Northwest Nuclear Weapons Design Centre, Qinghai (fission and fusion weapons R&D centre termed the 'Nuclear City').

· Nuclear Power Institute of China.

· Qinghua University - Qinghua Low-Temperature Nuclear Reactor.

· Research Institute of Physical and Chemical Engineering of Nuclear Industry.

· 716 CNNC Mining Company.

· Shan Dong Geology Bureau.

· Shanghai Boiler Factory.

· Shanghai Dynamic Equipment Company.

· Shanghai Electronic Instrument Factory, CNNC.

· Shanghai Guanghua Instrument Factory.

· Shanghai Kexing Pharmaceutical Corporation - radio-pharmaceutical production using cyclotrons.

· Shanghai Nuclear Engineering Research and Design Institute (undertakes major domestic and foreign export projects).

· Shanghai Number One Machine Tool Plant.

· Shanghai Synchrotron Radiation Facility.

· Shanghai Yue Long Chemical Plant.

· Shangrao (28º28'N 117º58'E) - uranium mine.

· Shenyang Institute of Metals Research.

· Shenzhen University.

· Sichuan Orient Boiler (Group) Company, Ltd. - nuclear power plant components manufacture.

· Sichuan Province Institute of Nuclear Technology Applications, Chengdu.

· South China Bureau of Geologic Exploration of Nuclear Industry.

· Sixth Research Institute, CNNC - plasma technologies.

· Southwest Bureau of Geologic Exploration of Nuclear Industry.

· Southwest Institutes (Ninth Academy and Chinese Academy of Engineering Physics) of: Applied Electronics, Chemical Materials, Electronic Engineering, Explosives and Chemical Engineering, Environmental Testing, Fluid Physics, General Designing and Assembly, Machining Technology, Materials, Nuclear Physics and Chemistry, Structural Mechanics, Research and Applications of Special Materials Factory, and the Southwest Computing Centre, all located near Mianyang, Sichuan Province.

· Southwest Research and Design Institute of Reactor Engineering, Sichuan.

· Southwestern Institute of Physics, Sichuan Province.

· State-Owned Number 202 Plant, CNNC.

· State-Owned Number 245 Factory, CNNC.

· State-Owned Number 267 Factory, CNNC.

· State-Owned Number 404 Factory, CNNC.

· State-Owned Number 523 Factory, CNNC.

· State-Owned Number 813 Factory, CNNC.

· Suzhou Valve Factory.

· Tianjin Synthetic Diamond Plant.

· Technique Development Corporation, CNNC.

· Tongxian (T'ung-hsien) Plants 2 and 4 (39º55'N 116º39'E) - uranium mine.

· Tuoli Plants 601/401 (39º48'N 116º03'E) - research and development.

· Tzu-t'ung complex, Sichuan Province - nuclear fabrication centre.

· Uranium mining facilities at some 18 CNEIC sites, uranium milling operations at five CNEIC sites, uranium enrichment at a Lanzhou facility (perhaps up to 200 kg of enriched uranium per year - China claimed in 1989 to have halted uranium enrichment for military purposes), and a reprocessing plant in Xinjiang, co-located with a nuclear weapons waste disposal facility, believed to be capable of extracting 14 kg of plutonium per year. Nuclear fuel elements are fabricated at the CNNC Ybin Nuclear Fuel Element Plant (Plant 812), Ybin City, Sichuan; CNNC Nuclear Fuel Complex, Lanzhou; and CNNC Plant 202 (Nuclear Materials), Baotou, Inner Mongolia. Five CNNC geological exploration units cover all of China to search for radioactive materials.

· Wu-shiht'ala installation north of Lop Nor in Xinjiang Province - nuclear R&D.

· Xi'an (Sian/Hsi-an*)* (34º16'N 108º54'E) - nuclear test support.

· Yibin (I-pan) Nuclear Fuel Element Plant 812 (28º46'N 104º34'E) - plutonium processing.

· Yin Chuan 217 Active Carbon Plant.

· Yumen Breeder Reactor.

· Zhengzhou Fifth Research and Design Institute of Nuclear Industry.

7.6 **China** Institute of Atomic Energy (CIAE) TOP

The CIAE, which is key to China's nuclear efforts, is a multidisciplinary institute reporting both to the CNNC and the Chinese Academy of Science. Its predecessor, the Institute of Modern Physics, Academica Sinica, was founded in 1950 and renamed the Institute of Atomic Energy in 1958 after constructing a heavy water research reactor and cyclotron. The Institute of Atomic Energy was renamed as the CIAE in 1984 and restructured. The predecessors of the CIAE played a key role in military physics research prior to the first fission bomb test in 1964 and the first thermonuclear test in 1967. Notable nuclear scientists who served as CIAE president have included Wu Youshun, Qian Sanqiang, Wang Ganchang, Dai Chuanzhen and Sun Zuxun. The CIAE employs some 4,500 scientists, engineers and technicians and is located in the Fang Shan District of Beijing.

Technical and R&D activities include fundamental nuclear physics, reactor engineering and technology (including fast-breeder reactor and neutron source reactor designs), radiochemistry, nuclear techniques, isotopes, computer applications, health physics, radiation metrology, computerised databases and technical information, and related education and training, complete with internal electronic instrument factories and machine shops. The China Nuclear Data Centre, the Tandem Accelerator Nuclear Physics Laboratory, the CNNC Radiometrological Centre, and the CNNC Nuclear Power Software Centre are attached to the CIAE. Major facilities include three research reactors (10 MW heavy water reactor, 3.5 MW light water swimming pool reactor, and a 27 kW mini-reactor), one cold neutron source system installed in the heavy water research reactor, 10 accelerators of various types, two electromagnetic isotope separators, extensive computer systems (mainframe and networked personal), four zero-power facilities, high-level hot cells and other facilities for reactor engineering, radiochemistry and isotope R&D and production.

The major R&D fields of the CIAE's Department of Nuclear Physics include theoretical and experimental physics, nuclear data measurement and evaluation, condensed matter physics with thermal neutron scattering, and intense particle beam and laser physics with facilities such as an Intense Electron Beam Laser Laboratory. Fundamental physics activities include research on high-temperature superconductors and the technology of high-power electric pulses, the production of intense particle beams for transmission and interaction with matter, an Excimer laser pumped by intense electron beams, and free-electron laser research.

The CIAE's Department of Reactor Engineering and Technology is responsible for the construction of commercially exported reactors, nuclear materials and nuclear fuel elements (assembly and material testing of hot cells). It conducts fast-breeder reactor R&D. The Department of Radiochemistry includes work in the areas of nuclear fuel reprocessing systems such as centrifugal extractors and transplutonium chemistry. CIAE reportedly supplies radioisotope products to over 2,000 customers domestically and abroad. The Division of Health Physics is responsible for radiation and environmental protection R&D and the engineering of relevant technologies and methods, while the Division of Radiation Metrology is the metrological centre for the Chinese nuclear industry. The Department of Nuclear Techniques undertakes R&D on accelerator and irradiation applications involving electron and ion accelerators and Cobalt-60 source irradiation.

The CIAE has a key nuclear technology transfer function for China. The CIAE's Centre for Scientific and Technological Information has established technical information exchanges with over 189 organisations in some 28 nations, including the mutual staff exchanges of thousands of Chinese and foreign personnel to attend conferences, conduct 'fact-finding missions', and study and conduct R&D as visiting scholars. Publications include *Science and Technology of Atomic Energy*, *Chinese Journal of Nuclear Physics*, *Nuclear Chemistry and Radiochemistry*, *Isotopes*, etc. Specific projects have included a CIAE Miniature Neutron Source Reactor built in Pinstech, Pakistan, in 1989. Various other bilateral co-operation agreements are being conducted, as well as foreign contract research, engineering projects, and the import and export of various nuclear-related facilities and technologies. It also operates training facilities such as the CNNC Graduate School and the Beijing Nuclear Industry School.

7.7 Nuclear Civilian-Military Programme Interactions TOP

7.7.1 Reactor Programmes

China's 'Outline of the Ninth Five-Year Plan and Long-Term Goal for the Year 2010 for National Economic and Social Development' highlighted the peaceful use of nuclear energy through 'vigorously promoting the peaceful uses of nuclear technology with the emphasis on the development of nuclear power and the corresponding construction of the system of nuclear fuel cycle'. However, as China's nuclear fuel cycle for reactor power systems will be provided almost totally by domestic suppliers, it will also provide dual-use military applications. For example, various experts acknowledge that nuclear power reactor waste such as the man-made elements neptunium 237 and americium 241 (which are not subject to IAEA safeguards) can be used to make nuclear weapons after a partitioning and transmutation process.

While nuclear power in a relatively new source of energy for China (in 1995 supplying less than 1 per cent of the nation's hydroelectricity and currently about 1 per cent), both domestic and foreign-assisted systems are being developed. The current capacity of 2.1 gigawatts is planned to increase to 40 to 50 gigawatts by 2020 (over 5 per cent of total energy needs), necessitating the approval of dozens of new plants (at least four new plants have been approved). China has been aiming to generate 3 per cent of its power from nuclear facilities by 2006, rising to 5 per cent in 2020. According to the Uranium Institute, by 1997, China had three nuclear power reactors in operation, with another four under construction (eight 'reactor units' in four project sites were to be constructed from 1996 to 2000, with six being imported from Canada, France and Russia but this schedule now appears to be sliding into the next five year plan). Future construction is possibly to occur in Shandong, Jiangsu, Fujian, Jiangxi and Hunan Provinces. China also currently has some 12 research reactors, plus various military nuclear production sites (operational or potentially operational, although China claims to have ceased military nuclear production). Data from the mid-1990s indicates that nuclear research reactors are operated by:

· South West Research and Design Institute of Reactor Design, Sichuan

· China Institute of Atomic Energy

· Shan Dong Geology Bureau

· Shenzen University.

The Qinshan Phase I nuclear power plant in Zhejiang Province was domestically developed, construction commencing in March 1985 by the CNNC 22nd and 23 Construction Companies, with the design by the Shanghai Nuclear Engineering Research and Design Institute. It started generating power in December 1991 (Qinshan was shut down for a long period during 1999 to effect repairs and safety checks, although its overall load factor from 1993 to 1997 was some 77 per cent). The Daya Bay (Dayawan) nuclear plant in Guangdong has been developed as a joint venture with Hong Kong (construction commenced in August 1987).

China has nuclear power co-operation programmes with Canada (the Atomic Energy of Canada Ltd.'s CANDU heavy water reactors), France (the Daya Bay Nuclear Power Plant and the Ling'ao Nuclear Power

Plant) and Russia. Firms from the US (e.g. Westinghouse Electric Corporation, General Electric and ABB Fuel Engineering), South Korea and Japan (Hitachi and Toshiba) have also shown interest in entering the nation's rapidly expanding nuclear power market, particularly through the provision of Advanced Boiling Water Reactor technologies which are not yet used by operational Chinese reactors. The US had recently lifted restrictions on the export of nuclear power systems to China, which has long desired to obtain advanced American reactor technologies. However, this level of technology transfer may have been effected by the deterioration in bilateral relations stemming from the Kosovo conflict in 1999 and US hesitation to fully support China's entry into the World Trade Organisation. Westinghouse and the CNNC had signed a memorandum of understanding during 1998 on technical co-operation in the areas of advanced non-dynamic pressurised water reactors and advanced light water reactors. In April 2000, a senior official of the US nuclear power association stated that American firms are ready to co-operate with Chinese manufacturing and R&D counterparts in establishing a 'technology base' in Shanghai.

Nuclear power facilities have been constructed that include the 300 MW pressurised water reactor (PWR) at Qinshan, and two French designed 900 MW PWRs at Daya Bay in Guangdong Province (Guangdong-1). Further developments are underway at Lingao near Daya Bay (another two 900 MW PWRs) and at Liaoning with Russian assistance. Qinshan's components were reportedly 70 per cent Chinese in origin and 30 per cent foreign imports. CNNC has received internal reactor systems and instrumentation from the French reactor builder, Framatome, while South Korea has provided pressure vessels.

Daya Bay, on the coast 52 km north-east of Hong Kong, was a joint Anglo-French venture between GEC and Framatome, made possible because of a deal to sell electricity to nearby Hong Kong. An earlier commercial partnership between GEC and CNNC had collapsed when the US refused to allow CNNC to use the Westinghouse PWR licence because of Chinese aid for the Pakistani nuclear weapons programme. The first unit was connected to the grid in 1993 and the second in 1994. Daya Bay is 75 per cent owned by CNNC and 25 per cent by China Light and Power, a Hong Kong utility. In October 1995, China signed another deal with Framatome and GEC-Alsthom for two 900 MW reactors at Ling'ao, a replica of the Daya Bay plant, just a few kilometres away.

China has proceeded with two indigenously-designed 600 MW PWR reactors at Qinshan (AC-600 series with enhanced passive safety features), albeit with Western assistance. The reactors are known as Qinshan Phase II and are intended for completion by 2001. This will be followed by Qinshan Phase III, which is scheduled to be completed by 2002 and involves the construction of two 720 MW PWR reactors. In December 1995, CNNC signed a contract with the French reactor company Framatome for 'reactor internals and instrumentation'. South Korea will probably provide reactor vessels and various other components will also be imported. China has negotiated with Russia since 1996 for construction of two Atomenergoprojekt VVER-1000 reactors, the Russian version of a PWR, at Liaoning. Another nuclear power project is currently underway at Qiaxima. Other potential PWR-type reactor sites include: Hiayang in Shandong Province; Lianyungang (Russian reactor project now underway at this location) in Jiangsu Province; Sanmen in Zhejiang Province; and Hui'an in Fujian Province. This indicates that China has diversified its options with regard to foreign providers of nuclear technology.

With the construction of the Qinshan and Daya Bay projects, the resulting foreign technology transfers and the strengthening of the domestic industrial base, China is now one of only seven nations that can independently design, construct and manage nuclear power plants of 300 MW, 600 MW or 900 MW capacities. Chinese PWR technology is a combination of domestic developments and transferred French technology. All Chinese reactors are equipped with three protective levels of safety features: fuel element cap; pressure container; and reactor containment chamber. Much of China's reactor production capabilities are centred around four major machinery bases in Shanghai, central, north-east, and south-west regions. While it has a full nuclear production capacity, weaknesses are evident in advanced manufacturing systems, quality control, and production management, and foreign assistance in these areas is being sought. The State Nuclear Security Bureau is now requiring all domestic nuclear technicians to pass examinations and receive certification before being allowed to work at a nuclear power plant.

Framatome completed the construction of the core for a 1,000 MW nuclear reactor during August 2000, which is destined for use at the Ling'ao nuclear power station in Guangdong province, along with the Shanghai Number 1 Machine Tool Works. The reactor core was shipped to Ling'ao by the end of August 2000. Ling'ao was also built by Electricite de France and Alstom, and is linked to the 2000 MW Daya Bay nuclear plant in the port of Hong Kong. These firms are now working on a 600 MW reactor core for the second stage of the Qinshan Nuclear Power Station, Zhejiang, which should be completed by the end of 2000. Qinshan is to be linked to Ling'ao on a power grid in 2002.

China has conducted R&D on magnetically-controlled nuclear fusion reactors since 1958, developing at least 10 small and medium related research facilities. Currently, a large facility is centred around the HL-1M TOKAMAK device, and a HL-2A TOKAMAK device is planned.

However, like the rest of the world, the future of commercial nuclear power in China is not ensured for at least the short-term. Recently, amid various announcements of new hydroelectric power schemes to be built in western provinces, the state media has not disclosed official plans to build new nuclear power stations. Industry sources say Beijing may be responding to market forces because during the first half of the 1990s energy prices were high and the mainland was experiencing a shortage. International energy prices subsequently dropped sharply and although foreign oil prices have risen again China still has an energy surplus. Hence, in April 1999, Beijing announced a three-year moratorium on new nuclear plants in the midst of a major review of China's long-term energy strategy up to 2010 and beyond.

Nevertheless, during 1999 progress continued on the development of the Qinshan Phase II and III, Lingao, Lianyungang, and Qiaxima nuclear power projects that have already been approved. Premier Zhu has reportedly supported a policy of accepting increasing oil and gas imports in preference to the atmospheric pollution caused by coal, and has ordered many collective coal mines and small coal-fired generating plants to cease operations. However, as China's economic growth revives coastal provinces are now lobbying for new nuclear power projects that are competitive with coal-burning plants in the next five-year plan to 2005. In its report 'Medium and Long Term Energy Strategies for China', the State Development and Planning Commission recently argued that "over the medium and long-term, nuclear power will become one of China's main energy sources".

7.7.2 Nuclear Fuel Production, Waste Disposal, and Reprocessing

After more than three decades of development, China has a range of facilities under the CNNC for uranium ore prospecting and processing, uranium enrichment, fuel fabrication and reprocessing. These geological prospecting, isotope separation, processing, enrichment, nuclear fuel fabrication, spent fuel storage/disposal and reprocessing capabilities form the main elements of the dual-use nuclear fuel cycle and supply system that China has developed.

Annual processed uranium production capacity in China is an estimated 150 tons and above. China claims to have verified estimated uranium ore reserves of over 1.7 million tons. China became a nuclear fuel exporter, mostly to developing countries, during the early 1980s. Uranium geological exploration methods include the use of remote sensing and airborne surveying/radiometry and engineering by the CNNC Bureau of Geology. The CNNC Bureau of Uranium Mining and Metallurgy operates 'dozens of institutes and enterprise including uranium mines, uranium mills, uranium mining and metallurgy complexes, as well as research and design institutes, machine-building factories and construction companies'. The major processes involved with the production of plutonium-239 involve uranium mining and milling, uranium processing, plutonium production, chemical processing of irradiated fuel elements, plutonium processing, and weapon assembly, with the primary materials required being uranium, graphite, aluminium, ferrous products, chemicals, etc. Uranium for the military and civil nuclear fuel cycles is produced at mines located at:

· CNEIC Anshun, Guizhou

· CNEIC Chanziping, Guangxi

· CNEIC Chenzhou, Hunan

· CNEIC Daladi, Xinjiang

· CNEIC Dianxi, Yunnan

· CNEIC Dongkeng, HunanlJiangxi

· CAEIC Dapu, Hunan

· CNEIC Fuzhou, Jiangxi

· CNEIC Guidong, Guangdong

· CNEIC Jianchang, Liaoning

· CNEIC Kaiyang, Guizhou

· CNEIC Kashi, Zinjiang

· CNEIC Lanhe, HunanlViangxi

· CNEIC Lianxian, Guangdong

· CNEIC Quzhou, Zhejiang

· CNEIC Xianshan, Zhejiang

· CNEIC Xunwu, Jiangxi

· CNEIC Zolge, Sichuan.

Uranium milling operations are undertaken at:

· CNEIC Plant 272 (formerly Plant 414), Hengyang, Hunan

· CNEIC, Shanrao, Jiangxi

· CNEIC Quzhou, Zhejiang

· CNEIC Fuzhou, Jiangxi

· CNEIC Xifeng, Guizhou.

Some reports indicate that China ceased the production of enriched weapons grade uranium for military purposes in 1989 and plutonium in 1991. However, such production could easily be continued if indeed it has ever completely ceased. In addition, it is difficult to completely separate the production of nuclear power plant fuels and weapons grade materials production. China is reportedly suspicious of any proposed international fissile material control regime, although it has co-operated with IAEA controls on foreign technology transfers such as Canadian CANDU reactors. Beijing rejected proposals for tighter international regulation of how nations store nuclear materials at an IAEA conference in Vienna during September 2000.

China is also developing fast breeder reactor systems (a pilot reprocessing plant capable of reprocessing 100 tons of spent fuel annually was announced by CNNC in 1995) to ensure its long-term supply of nuclear fuel. It employs isotope separation and thermal and gaseous diffusion fuel production methods to enrich U-235 for weapon and reactor applications. The CNNC is believed to have implemented an advanced fuel reprocessing cycle which extracts plutonium from spent reactor fuel. Construction reportedly began on a 25 ton per year reprocessing facility at Lanzhou (in the north-west province of Gansu) in 1970 and this facility has probably been operational for some time. Another two full-scale reprocessing plants are reportedly planned: one to service the Qinshan and Guangdong (Daya Bay) civilian nuclear power reactors recently purchased from Canada; and the other near the PLA's nuclear weapons test and R&D site at Lop Nor.

China produces the six essential materials for fission, boosted fission and true thermonuclear weapons, and operates powerful fission reactors to produce plutonium and tritium. The CNNC claims to produce and supply over 800 types of isotopic products through 24 manufacturers under the China Isotope Corporation. These include cobalt-60 sources, tritium-titanium targets, tritium-scandium targets, uranium reagents, and depleted uranium products (possibly including tank armours and armour-piercing munitions). One source indicates that by the end of 1994, China's total residual fissile material stockpile was as high as 4 metric tons of plutonium and 23 metric tons of highly enriched uranium - reportedly sufficient fissile material for some 2,700 nuclear weapons. During 1999, the preliminary design for a new nuclear fuel element assembly line for heavy water type reactors passed the review stage.

There are currently some 50,000 to 100,000 cubic metres of low and intermediate level waste (L/ILW) in store at Chinese nuclear power plants and research facilities. Several disposal methods are being developed for these wastes. CNNC has established a separate body to undertake this, the 'Ever Clean Environmental Engineering Corporation'. For liquid ILW wastes from existing nuclear sites, *in situ* solidification of a waste/grout mix has been proposed, with underground 'pools' formed about 7 m below the surface. Recent plans have designated an area in north-west China in the Gobi Desert for such a facility, where the water table is approximately 40 m below the ground surface. Demonstration projects for handling nuclear waste tailing ponds and uranium waste have been developed at Jiangxi and Hunan Provinces respectively. China announced in 1997 its intention to develop four radioactive waste disposal facilities to treat L/ILW 'produced by nuclear power plants, ordnance factories and other institutions actively using nuclear technology', and 'is currently conducting research in using the glass solidification technology to treat high-level radioactive liquids, and plans to introduce the technology firstly to the ordnance industry'. During 1999, the initial stage construction of a nuclear waste disposal site north-west China was completed as passed official inspection.

Deep-well injection into clay strata at approximately 150 m to 500 m depth has also been investigated. Tests were carried out in 1983, at the Sichuan Nuclear Fuel Plant, which was selected for development on an industrial scale. At Sichuan, disposal will be into a stratum some 1,000 m below the surface, with the waste added to cement and other materials to form a grout. Liquid LLW is conditioned with either bitumen or cement at an on-site facilities at the nuclear power plants. For disposal of the conditioned and solid waste, up to four regional disposal sites have been proposed, using near-surface vault technology. Two sites are believed to have been selected to date. The first, the so-called Northwest Repository, with an initial capacity of 60,000 cubic metres is to be located at the Lanzhou Nuclear Fuel Complex. The second site, the South Repository with a capacity of 80,000 cubic metres, is at Changwan, near to the Daya Bay reactor, in Guangdong Province, where construction began in late 1995.

Plans exist for the reprocessing of spent fuel in China, with vitrification of the resultant liquid waste. China currently operates a reprocessing plant for defence plutonium production at Lanzhou. It is also planning to develop a pilot-scale plant using the Belgian PAMELA-type technology, at the Sichuan Nuclear Fuel Plant, which probably began operation in 1996. Until a commercial reprocessing capability exists, spent fuel will be stored on-site at the nuclear power plants. There are two pools at Qinshan, and one at Daya Bay. In addition, a Centralised Storage Facility has been built at Lanzhou and is used to store material for reprocessing.

Until recently, no particular concept, other than deep disposal, has been adopted by China for the disposal of the vitrified wastes. A long-term programme known as 'SDC - *Shen Di Chu'* (or Deep Geological Disposal) has been conducted on R&D towards high-level radioactive waste (HLW) disposal. Geological HLW disposal is China's preferred option and research in this area began in 1985. In 1996 a Co-ordinated Research Group was established, which is responsible for related planning, programming, R&D and technical support. The Group is supervised by the CNNC's Bureau of Science and Technology, with participation by the Beijing Institute of Nuclear Engineering, the Beijing Research Institute of Uranium Geology, the China Institute of Atomic Energy, and the China Institute for Radiation Protection. Activities fall into two main parts, site screening and technical development. Granite has been selected as candidate rock type. Geological studies are scheduled for between 1995 and 2010, followed by operation of a underground research laboratory, most likely in the Beijing area.

Two candidate sites have been identified, one at Yangfang and another in an abandoned molybdenum mine at Shihuyu. The latest date for repository construction is now being given as 2050. The site selection studies for a repository, which began in 1985, were also broken down into four stages: nationwide screening (1985 to 1986); regional screening (1986 to 1988); district screening (1988 to present) and site screening. In the regional screening stage, some 21 districts were selected for investigation. In the district screening stage since 1989, work has concentrated in north-west China, where the fourth stage, site characterisation, is believed to have recently begun with the drilling of boreholes and extensive geophysics. A second site is also planned for study for inter-comparison purposes.

7.7.3 High-Energy Physics

Under its Beijing Institute of High-Energy Physics, China operates various R&D facilities. These include:

· the Beijing Electron-Positron Collider National Laboratory (its 5.8 GeV electron positron collider was China's first high-energy particle accelerator, which reportedly obtained the world's most precise measurements of the tau lepton particle);

· the Beijing Spectrometer;

· the SG-1 Intense Pulsed Electron Accelerator;

· the Heavy Ion Research Facility in Lanzhou;

· the Hefei National Synchrotron Radiation Laboratory;

· the Beijing Synchrotron Radiation Facility (see Appendix D); and

· the HWRR-II neutron source reactor.

The Department of Physics, Beijing University, has facilities that include an Institute of Solid State Physics, an Institute of Theoretical Physics, the Beijing Institute of Modern Physics, and the National Key Laboratory for Artificial Microstructure and Mesoscopic Physics. R&D activities include:

· condensed matter physics (e.g. high-temperature superconductor materials, films and devices);

· theoretical physics (e.g. particle theory, nuclear theory, medium-high energy physics, quantum field theory, quantum optics theory, theoretical condensed matter physics and statistical mechanics, relativity theory and astrophysics, non-linear science, plasma physics, mathematical physics); and

· optical and laser physics (e.g. optoelectronics, laser devices and materials of new wavelengths, and non-linear optics and spectroscopy).

The CNNC operates laser fusion devices, tandem electrostatic accelerators, and intense-pulsed electron accelerators. At the end of 1998, some 45 industrial electronic radiation accelerators and 123 gamma radiation devices were in operation in China, mostly of domestic manufacture, for various applications including medicine and agriculture. The Lanzhou Institute of Modern Physics has developed has developed a major heavy ion circular accelerator.

During July 2000, China's State Council approved plans for the development of advanced particle accelerator and high-energy physics submitted by CAS at the seventh meeting of the Science and Technology Leading Group of the State Council chaired by Premier Zhu Rongji. A State Council official reiterated that the development of advanced particle accelerator and high-energy physics is vital for raising the level of science and technology in China.

Planned facilities for the early 21st century include a high-energy Tau-Charm Factory in Beijing (a double-ring collider to study tau-charmed particles obtained through an upgrade to the existing electron positron collider), a Beijing Light Source (electron energy at the 2.2-2.5 GeV range, full injection magnetic focusing structure, superconductive bending magnet to extract hard x-rays, 12 to 19 beamlines, etc., with a condensed matter physics, molecular atomic physics, and other applications area focus), and the Shanghai Synchrotron Radiation Facility (to study soft x-rays, and high ultra-violet light sources), which reportedly is to be China's major scientific research project for the next decade.

These seemingly esoteric basic research activities in fields such as astrophysics, nuclear physics, and the physics of the elementary particles of matter that are devoted to understanding extreme states of matter (e.g. very high pressures, energies, high-energy densities, etc.) also have very definite, but little discussed, military applications (also see Chapter Eight on DEWs such as high-energy lasers, particle beams, and radio frequency/microwave systems). Such research has allowed China to develop leading-edge technologies in the areas of superconducting magnets, Klystrons, microelectronics, high-vacuum systems for integrated circuit manufacturing, and radiation-resistant materials. A related area is 'virtual nuclear testing' through the use of supercomputers and elaborate three-dimensional software simulations for the development of new generations of nuclear weapons. During 1998, China announced the establishment of an all-aspect radiation simulation laboratory co-operatively developed by the CNNC and Beijing University.

Attention is also centred on the possible development of pure fusion weapons, which do not use fission triggers and will produce no significant undesired radioactive side-effects with yields of about 1 kT (i.e. 'mini-nukes' that could be delivered with precise guidance systems to destroy almost any military target). These fusion weapons will use advanced systems of conventional energetic high-explosives (for example shock-sensitive HMX Cyclotetramethylenetetranitramine, nuclear isomers such as the isotope hafnium-178, or metallic hydrogen compounds), lasers or anti-matter (anti-proton) systems as trigger mechanisms. Some believe that the US has an insurmountable lead in such basic research fields (with future corresponding geopolitical advantages or monopolies) through facilities such as the National Ignition Facility at the Lawrence Livermore Laboratory in California. Nevertheless, recent nuclear-related espionage activities conducted in these same facilities, reportedly on behalf of Chinese intelligence services, has demonstrated the difficulty in containing secrets in the modern world.

7.8 Nuclear Foreign Technology Transfers TOP

7.8.1 United States

The release of the controversial Cox Report has brought to a climax growing US national security concerns over a reportedly massive Chinese intelligence operation to acquire advanced American defence technologies. Such technologies have included space and missile systems, nuclear warheads, supercomputers, and other sensitive defence-related areas. China's efforts to acquire such technology have been linked to specific espionage cases involving the infiltration of US nuclear facilities, alleged bribes of US politicians, and lucrative commercial contracts with major US aerospace and telecommunications corporations. These security concerns, steadily growing over the past several years, have also come to the fore at time of worsening US-China political relations, heightened by the US bombing of the Chinese embassy in Belgrade which occurred almost simultaneously with the release of the Cox Report.

China regards the US as a key source for advanced defence, dual-use and commercial technologies. Until quite recently most US technologies targeted by China were of medium-level sophistication but there are now indications that Chinese intelligence operations are focusing on leading-edge developments from a variety of disciplines. The Cox Report charges that China's military modernisation efforts are specifically being aided by Chinese intelligence agents and operatives obtaining classified and sensitive US defence technologies, and that China has "stolen" more US technology than any other nation. However, the report is also linked to opposing factions in the US Congress who have different positions on whether China should be granted most favoured nation trading status and allowed entry into the World Trade Organisation. The US role in defence of Taiwan and concerns over China's maturation as a regional power in Asia are equally important considerations.

Critics charge that the Clinton administration's loosening of federal Commerce Department export restrictions to China has allowed the transfer of a broad array of dual-use US technologies to Chinese companies that are now being applied to PLA modernisation. Restrictions on the exports of systems such as supercomputers were changed without a rigorous review by US national security and intelligence experts. US businesses were allowed to export products on an 'honour system' with special licences only required if a military end-use was suspected. The Clinton administration has indicated that it supports the majority of the Cox Report's recommendations, except the recommendation for a greater Pentagon role in approving business licenses for the export of dual-use technologies.

Critics have charged that much of the report's other information is probably anecdotal in nature and according to some interpretations alarmist in tone and presenting worse-case scenarios. The report has been criticised for numerous factual errors related to technical details covering areas such as missile and spacecraft specifications, which calls into question the level of understanding of underlying issues. Actual W-88 information obtained by China is probably restricted to details of the warhead's weight, size, explosive power, and internal configuration that allows optimal explosive power with minimal size and weight, rather than detailed blueprint designs, although some sources indicate that China may have knowledge of W-88 key measurements to within four-hundredths of an inch. Such information alone is unlikely to have enabled China to develop a new generation of lightweight nuclear warheads suitable for MIRV applications.

The Cox Report specifically charges that China has been obtaining sensitive US nuclear information "for at least the past several decades" and despite this knowledge security at US nuclear weapons laboratories such as Los Alamos, Lawrence Livermore, Oak Ridge and Sandia "does not meet even minimal standards." Intelligence leaks continue although steps are currently being taken to increase security. In addition to their nuclear research, these national laboratories have now expanded R&D activities to includes aspects of lasers, high-performance computers, microelectronics, global climate change and biotechnology.

This information was reportedly obtained through a complex information-gathering matrix, which includes direct espionage, the use of "front companies" (over 3,000 Chinese corporations are located in the US, some with links to the PLA and Chinese intelligence organisations, and with technology "targeting and acquisition roles"), and "a network of individuals and organisations that engage in a vast array of contacts with scientists, business people and academics". China has also used joint ventures with US firms and attempts at controlling direct interests in US firms for intelligence purposes. The US is now undertaking increased security measures in its national nuclear laboratories, which include polygraph tests for personnel, additional security guards, on-site counter-intelligence offices, and a restructuring of both classified and unclassified computer networks with increased firewalls preventing the illegal transfer of files and increased access checks. Visiting researchers from 'sensitive' nations such as China, Russia and India are to be restricted, or perhaps eliminated.

A declassified DIA estimates brief in 1984, "Nuclear Weapon Systems in China", indicated that the Reagan administration was aware of Chinese efforts to obtain US nuclear secrets both through overt co-operative scientific exchanges and covert technology acquisitions. It was also aware that these activities would lead to qualitative improvements in Chinese nuclear weapons by the early 1990s. Specific improvements to Chinese nuclear weapons resulting from the assimilation of US technologies could include increased reliability and confidence (accuracy), more compact warheads for tactical and MIRV applications, increased hardening for a ballistic missile defence environment, and tailored output devices related to enhanced radiation, plus improved warhead safety, storage and logistics procedures.

While US technology transfers of various types may have accelerated PLA modernisation, these do not provide its total basis. Naturally, China has refuted the charges of the Cox Report. For example, China has stated that the concept of simulated nuclear explosions via lasers was developed on the basis of "inertial confinement fusion by laser" research, which was originally advanced by Wang Ganchang of the CAS in 1964! Furthermore, China claims that:

'*The Cox report also alleges China 'stole' the secrets of the nuclear explosion tests of miniature fusion and the anti-submarine microwave technology. This is sheer nonsense. People with even slight scientific and technical knowledge know that, as early as 1964, when China successfully exploded its first atom bomb, Wang Ganchang, noted Chinese physicist and academician of the Chinese Academy of Sciences (CAS), initially advanced the concept of laser-based nuclear fusion. He is considered one of the earliest scientists in the world who independently put forward the concept. Following this, China began its systematic research on the technology of laser-based nuclear fusion. In 1973, the one-beam laser was used to drive deuteron ice and a neutron was observed in the experiment. In 1974, a nuclear reaction took place through the use of one-beam laser on a drive target of deuteron polymer, and a D-D reaction to produce a neutron was observed. In 1986, China adopted the direct driving method to produce a neutron from a glass target capsule filled with D-T gas. Between 1990-92, through experimentation, thermonuclear fusion reaction was achieved through the method of indirect driving, and a thermonuclear neutron was observed.*

In the mid-1970s, renowned Chinese theoretical physicist, CAS academician Yu Min and a batch of Chinese scientists under his leadership advanced the concept of achieving laser fusion through the method of the X-ray radiation for driving a shooting laser into a heavy metal shelled cavity through the entrance, and put forward the structural design of placing target pellets at the centre of the columnar hollow cavity. Between the late 1970s and the 1980s, China manufactured its own laser device - Shen Guang (magical light) - for research into laser-based nuclear fusion. Later, it was discovered through US declassified documents that Chinese and US scientists almost simultaneously advanced a similar concept in their respective research. This fully indicates that the law governing science exists objectively, and people all over the world can access it sooner or later, no matter what method is used.'

The Cox Report claims that China conducted some half-dozen neutron bomb tests during the mid-1980s. The last test probably occurred on 29 September 1988 (some reports indicate that it was unsuccessful), based upon technology obtained from the US (i.e. W-70 enhanced radiation nuclear warhead), and it can be assumed that this weapon has been deployed in the PLA arsenal if it has indeed been perfected. Further more the report states that 'In the late 1970s, the PRC stole design information on the US W-70 warhead from Lawrence Livermore Laboratory. The US government first learned of this theft several months after it took place. The PRC subsequently tested a neutron bomb in 1988.'

China may have obtained further US intelligence in 1995 to improve its neutron bomb design. In July 1999, Zhao Qizheng, Director of the Information Office of the State Council, claimed, referencing a State Council report entitled *Facts Speak Louder Than Words and Lies Will Collapse By Themselves - Further Refutation of the Cox Report*, that during the 1970s and 1980s, China independently mastered neutron bomb and nuclear warhead miniaturisation technologies. Although the US originally developed the neutron bomb it is not believed to have tested it, although some sources indicate that is was deployed on the former US Sprint missile defence system as the W-66 warhead and as an 8-inch artillery shell version for use against Soviet tank formations in Europe. However, US physicist Sam Cohen, the 'father of the neutron bomb', has recently indicated that Washington secretly provided China with information on neutron bomb technology. He maintains that while by 1990 Washington was aware that Beijing had used US technology, no Chinese agents were charged or arrested and no US officials or scientists were punished. An unconfirmed scenario is that the Reagan-Bush administrations clandestinely transferred the capability to China to help deter a ground invitation from the then Soviet Union, when the US played the 'China Card' informal alliance. President George Bush was both a former director of the Central Intelligence Agency (CIA) and US Ambassador to China, and could have had a direct involvement with such an operation.

The Cox Report asserts that Chinese intelligence activities have resulted in China obtaining sensitive design and test information on virtually every deployed US thermonuclear weapon design from the US Department of Energy (including the W-88 Trident D-5 warhead, the W-56 Minuteman 2 warhead, the W-62 Minuteman 3 Mark 12 warhead, the W-76 Trident C-4 warhead, the W-78 Minuteman 3 Mark 12A warhead, the W-87 Peacekeeper warhead, the neutron bomb W-70 Lance warhead, and the MIRV warhead technologies). The miniaturised W-88 is thought to be the most sophisticated warhead developed by the US.

The Cox Report states:

'*The PRC may have acquired detailed documents and blueprints from the US national weapons laboratories... With the stolen US technology, the PRC has leaped, in a handful of years, from 1950s-era strategic nuclear capabilities to the more modern thermonuclear weapons designs. These modern thermonuclear weapons took the United States decades of effort, hundreds of millions of dollars, and numerous nuclear tests to achieve.*'

It also indicated that during the mid-1990s 'the PRC stole, possibly from a US national weapons laboratory, classified thermonuclear weapons information that cannot be identified'. It is hypothesised that these technology transfers will allow China to technically upgrade its nuclear arsenal to a level approaching that of the US in a much shorter time-span that it would have been able to achieve on its own:

'*The PRC has an ongoing programme to use these modern thermonuclear warheads on its next generation of ICBMs, currently in development. Without the nuclear secrets stolen from the United States, it would have been virtually impossible for the PRC to fabricate and test successfully small nuclear warheads prior to its 1996 pledge to adhere to the Comprehensive Test Ban Treaty*.'

The new generation Dong Feng DF-31 ICBM may employ compact MIRV warhead designs that may have benefited from US technology. The Dong Feng DF-31 could be deployed by 2002. The report's assertion, however, that the transfer of US technology by itself has permitted a leap in Chinese capabilities from 1950s-era strategic capabilities to modern thermonuclear designs is perhaps unfair. It discounts China's massive domestic nuclear R&D infrastructure and development programmes.

7.8.2 Former Soviet Union/Russia

Pre-1960 Soviet support for China's nuclear programme was extensive and reportedly included the construction of a 6,500 kW heavy water reactor in Beijing, a 2,500 electron-volt cyclotron, a betatron, and help with the construction of atomic reactors in Lanzhou, Baotou and other locations. Russia provided various related scientific and engineering training, and reportedly even the planned provision of a sample nuclear device and technical assistance in the manufacture of nuclear weapons. These latter areas of assistance were probably not provided before the Soviets abrogated their agreements and may have been a major reason for the split between the two nations.

By 1992, reports were indicating that China was recruiting nuclear experts from the former Soviet Union and had established related offices in Russia and Ukraine. Some former Soviet scientists and engineers have probably been recruited to assist in upgrading Chinese nuclear R&D and production facilities. This is most likely in the nuclear reactor and nuclear materials field, and less likely in the direct nuclear weapons area. This 'brain-drain' is being encouraged by the continuing economic deterioration of former Soviet state. Proliferation could be encouraged through a lack of domestic government support to maintain R&D operations (with the resulting unemployment or underemployment of thousands of scientists, engineers and technicians), weak personnel and material monitoring mechanisms, an increased openness of formerly secret nuclear facilities, a growing black market and criminal organisations reportedly undertaking trade in contraband nuclear materials.

Up to 3,000 former Soviet nuclear scientists are believed to have comprehensive knowledge of nuclear weapons design and production. This is in addition to experts in additional delivery systems and scientists and engineers in related weapons of mass destruction (WMD) fields (up to 30,000 from the aerospace sector, 20,000 from the nuclear industry, and 10,000 from the chemical and biological weapons industries). Reportedly, non-proliferation safeguards and physical security systems are currently very weak in the large number of Russian nuclear facilities. Russia has the largest number of such facilities compared to any former Soviet state, about 60 per cent. Various Soviet-era top-secret 'nuclear cities' and other R&D establishments, with numerous Minatom (Russian Ministry of Atomic Energy) industrial enterprises, a large amount of nuclear materials and infrastructure, and thousands of consequently unemployed personnel, are now in a state of economic disarray. Many have been at least partially deactivated as summarised in Table 7.2.

During 1992, the Krasnoyarsk-26, Zheleznogorsk Mining and Chemical Combine reportedly made an offer through private channels to provide nuclear scientists to upgrade the CNNC uranium enrichment facility at Lanzhou. The outcome of this offer is unknown.

Reports from Moscow and Hong Kong during late 1995 to early 1996 indicated an agreement between the Minatom and the CNNC for establishing advanced nuclear facilities at Shenzhen in the areas of controlled thermonuclear fusion and radioisotopes for medical and agricultural applications. The Russians have also reportedly constructed a centrifuge for enriching uranium in China but it is unclear whether Russian nuclear weapons researchers are involved in these programmes. In December 1997, China and Russia signed a US$3 billion agreement to construct a Russian-designed nuclear power facility in the eastern province of Jiangsu, specifically up to four 1,000 MW reactors at the port city of Lianyungang. Work reportedly commenced during October 1999, with scheduled first phase reactor operations for 2004-2005. The project had the strong personal endorsement of the then Russian President Boris Yeltsin.

Chinese reports indicated that a Sino-Russian symposium on nuclear research for peaceful purposes was held in Chengdu in April 1993 and a Sino-Russian symposium on peaceful nuclear explosions was held at a China Academy of Engineering Physics Institute in Beijing during late 1995. The first symposium probably involved nuclear weapon researchers but primarily dealt with civilian nuclear applications. The latter conference undoubtedly involved mainly nuclear weapon researchers from both countries and dealt with such civilian applications of nuclear explosives as changing the course of rivers and creating electrical power (applications that have never been attempted in practice). Russian reports in April 1996, indicated that the deputy minister of Minatom stated that Russians involved with defence-related nuclear technologies cannot travel abroad unless given permission by Minatom. Therefore, it can be assumed that direct Russian assistance provided to the Chinese nuclear weapons programme may have been approved at the ministerial level, although much related activity appears to occur at the commercial enterprise level, with Chinese representation through the CNNC or other COSTIND defence industry organisations, or possibly Chinese intelligence organisation front companies.

Table 7.2 At-Risk Russian Nuclear Establishments

· Aktau Nuclear Power Plant, Aktau, Kazakhstan - nuclear power generation ('dozens' of personnel losses between 1992 to 1996).

· Arzamas-16, All-Russian Scientific Research Institute of Experimental Physics, Sarov - nuclear weapon R&D and design, assembly and disassembly (some 5,000 personnel losses from 1991 to 1996).

· Chelyabinsk-70, Snezhinsk - premier nuclear weapon design laboratory.

· Chelyabinsk-65, Ozersk, Mayak - plutonium production, tritium production, weapon component fabrication.

· Impuls Scientific Production Organisation, Moscow - production of guidance systems, electro-optics, civilian electronic equipment (some 1,800 personnel losses between 1992 to 1993).

· Institute of Physics and Power Engineering, Obinsk - weapons grade nuclear material and nuclear reactor R&D (some 4,000 personnel losses from 1988 to 1996).

· Institute of Power Engineering Problems, Sosny, Belarus - power plant and mobile nuclear reactor R&D (100 personnel losses between 1992 to 1996).

· Krasnoyarsk-26, Zheleznogorsk Mining and Chemical Combine - plutonium production (reportedly houses enough plutonium 'for hundreds or thousands of bombs').

· Krasnoyarsk-45, Zelenogorsk - uranium enrichment.

· Penza-19, Zarechnyy - nuclear weapon assembly and disassembly.

· Physical Engineering Institute, Moscow - mathematics, engineering and physics research (over 1,100 personnel losses between 1991 to 1995).

· Southern Machine Building Plant (Yuzhmash), Dnepropetrovsk, Ukraine - SS-18 ICBM and space booster production and R&D (some 5,000 personnel loss between 1991 to 1996).

· Sverdlovsk-44, Novoural'sk - uranium enrichment.

· Sverdlovsk-45, Lesnoy - nuclear weapon assembly and disassembly, weapon component fabrication.

· Tomsk-7, Seversk - plutonium production, uranium enrichment.

· Zlatoust-36, Trekhgornyy - nuclear weapon assembly and disassembly.

The Cox Report stated in regards to potential Russian connections:

'*After the fall of the Soviet Union, the PRC and Russian scientists became increasingly co-operative in civilian nuclear technology, and apparently, military technology. The Select Committee is concerned that the growing co-operation between Russia and the PRC is an indication of current or future nuclear weapons co-operation. The Select Committee judges that Russia's nuclear weapons testing technology and experience could significantly assist the PRC with its nuclear weapons programme under the Comprehensive Test Ban Treaty, which does not permit physical testing.*

While the PRC could share its knowledge of US advanced thermonuclear warhead designs with Russia, Russia may not be interested in deviating from its past developmental path, since existing Russian warhead designs are apparently simple and reliable. The large throw-weight of Russian ballistic missiles has given them less cause for concern about the size and weight of their warheads. Russia's nuclear stockpile maintenance requirements under a Comprehensive Test Ban Treaty are thus very different than those of the United States.

The prospect of PRC-Russian co-operation, if that were to include military co-operation, would give rise to concerns in several areas, including nuclear weapons development and nuclear stockpile maintenance, nuclear weapons modelling and simulation, and nuclear weapons testing data.'

7.8.3 Canada

Chinese intelligence organisations have often used Canadian businesses and government organisations as a convenient conduit for advanced Western technologies that may not be so easily available elsewhere. A June 1999 report by the Canadian Security Intelligence Service (CSIS) warns that Canada is a frequent target for 'clandestine and illicit procurement activities by countries of proliferation concerns', including dual-use systems with potential weapons of mass destruction applications. The CSIS recommended that Canadian businesses should take caution over international dual-use technology contracts where the client cannot clearly explain the final destination or application of the product, when unusually favourable terms of payment are offered, when performance guarantees are waived, or unusual shipping or labelling instructions are used. During 1999, the US undertook unprecedented restrictions on the transfer of defence and dual-used technologies to Canada, which could be passed on to restricted national third parties such as China.

On 8 November 1994, Atomic Energy of Canada Ltd. (AECL) signed a Memorandum of Understanding (MoU) with the China National Nuclear Corporation (CNNC) to begin negotiations on the sale of two CANDU-6 700 MW reactors for the Qinshan site some 125 km south of Shanghai. On 12 July 1996, a 'Project Award Agreement' was signed by President Jiang Xinxiong of CNNC, and Reid Morden, President of AECL, followed by the formal awarding of the contract on 26 November 1996 for C$4 billion. Construction will take some six years. As part of the project, Hitachi Ltd. and the Itochu Corporation of Japan, and the US Bechtel Power Corporation, are to provide engineering and equipment for nuclear station subsystems. AECL also provided a letter of intent to Korea Heavy Industries and Construction Company (Hanjung) to provide heavy components such as steam generators, pressurisers, heat exchangers, and feed header assemblies, South Korea's first major nuclear export order. Hanjung is a subsidiary of the Korea Electric Power Company (KEPCO). Japan's Advisory Committee on Energy has reportedly described CANDU (Canada Deuterium Uranium) technology as 'the world's most efficient of all existing reactors in utilising uranium resources'.

Under the 1974 Nuclear Co-operation Agreement, Canada will not directly support defence-related nuclear technology proliferation, and enrichment of Canadian-supplied uranium beyond 20 per cent is prohibited (China is self-sufficient in uranium production). However, the CANDU programme reportedly includes significant technology transfers, potentially dual-use, to China in such areas as component manufacturing capabilities, fuel fabrication, and waste management technology. The primary technical advantages of

CANDU reactor technology compared to domestic Chinese reactor technology are that the CANDU system can burn natural uranium without extensive enrichment and employs on-line refuelling systems that do not require a reactor shut-down. The CANDU system is a heavy water and deuterium moderator system with relatively high capital costs, while Chinese reactors employ standard 'light' water. The CANDU system employs pressure tube systems, while light water reactors used pressurised vessels. All spent CANDU fuel would theoretically be subject to IAEA monitoring to prevent weapons applications. However, the CANDU system, reportedly produces large amounts of plutonium and could conceivably be modified to produce near weapons-grade plutonium, as well as converting U-238 to U-235 fission bomb material.

It has been unclear whether the Chinese will purchase heavy water or fabricated fuel bundles for the CANDU reactors, because China has its own nuclear fuel fabrication and heavy water production capability. It is virtually certain that AECL has agreed to some degree of technology transfer in order to promote a sale. CANDU technology transfer (unlike the transfer of other reactor designs, which are controlled by large, integrated private sector corporations such as General Electric, Westinghouse or Siemens) is reportedly in the hands of a number of private sector component manufacturers as well as AECL. The question of CANDU technology transfer raises the issue of China's notorious disregard for copyright and licensing agreements.

The Canadian nuclear industry has previously reportedly been the victim of Chinese nuclear espionage. In the early 1980s, the Chinese nuclear establishment approached AECL to express interest in the purchase of a SLOWPOKE (Safe Low Power Critical Experiment) miniature reactor, developed by Canada since the late 1960s. AECL obligingly provided them with detailed information on the reactor. Chinese scientists had previously worked with a SLOWPOKE reactor at the University of Toronto. During a trip to China in 1985 by Canadian researchers, it was discovered that the Chinese had apparently stolen and duplicated the SLOWPOKE reactor system. It has been reported that the Chinese have succeeded in selling their SLOWPOKE derivatives to Iran, Ghana, Pakistan, Syria, and Nigeria. The IAEA lists China with at least three 'MNSR' reactors (that is SLOWPOKE derivatives).

The uranium-fuelled (U-235), low-operating temperature SLOWPOKE energy system is designed to be housed in pool of water about 6 m in diameter and 13 m deep, in a building 20 m by 15 m. It can produce up to 10 MW of power per unit. While designed to heat large building complexes and to operate on an unmanned basis, it could conceivably have military applications (as a DEW power source for example) because of the system's compact size and high power output. During 1996, the Institute of Nuclear Energy Technology of Tsinghua completed development of a 'low temperature nuclear district heating technology.' This is a National Key Technology R&D Project under the 8th Five Year Plan that appears very similar to the SLOWPOKE concept.

7.8.4 France

France has been an early partner with China in the development of nuclear power reactors and continues to play an active role. During President Jacques Chirac's June 1997 visit to China an agreement was signed that covered reactor technology, R&D, and industrial applications in the nuclear cycle and safety fields. France has co-operated on the Daya Bay and the Ling'ao nuclear power plants since May 1997.

7.9 Chinese Nuclear Foreign Proliferation TOP

7.9.1 Overview

Like missile proliferation, the proliferation of Chinese nuclear technologies to second parties is also important for domestic nuclear development programmes. Such transfers provide interactive opportunities for Chinese researchers to obtain related foreign technology transfers in hardware and materials from third parties. For example both Iran's and Iraq's nuclear power and weapons programmes have reportedly received assistance from various other nuclear-capable nations in addition to China. US-led efforts to halt the international production and proliferation of fissile materials have been countered to a large extent by China's large capacity to produce fissile material and record of exporting reactors and nuclear technology to states suspected of using such equipment and technology to produce fissile material, and in the case of Pakistan, actual nuclear weapons.

While China claims to abide by the terms of the NPT, it is widely believed that it will supply on demand missile and nuclear-related strategic systems, or at least system components, to almost any hard cash-paying customers. China does maintain export bans and restrictive licensing procedures on various products including the export of copper, platinum, specified chemical compounds, and, theoretically, export products banned under international treaties; dual-use chemicals, chemical precursors, and heavy water are examples of products subject to strict licensing controls. However, a foreign firm conducting business dealings with a Chinese partner thought to be involved with restricted defence exports could cause penalties from the foreign firm's host government or a third party such as the USA.

China, until recently, has done the basic minimum necessary to facilitate its lawful entry into the international commercial nuclear technology export market. It joined the IAEA in 1984, signed some voluntary safeguard measures in 1988 and signed the NPT in 1992. In 1996 it ratified the nuclear CTBT and ceased nuclear weapons tests (its final and 45th nuclear test was detonated on 29 July 1996, just hours before it began negotiations to ratify the treaty). China has been invited to join the Nuclear Suppliers' Group, the so-called 'London Club' that implements strict controls on the export of dual-use nuclear technologies, but is not yet a member. During May 1997, China indicated it would join the so-called 'Zangger Nuclear Exporters' Committee.' The international committee meets biannually to develop a 'trigger list' of items that are subject to IAEA inspection if exported by a NPT signatory (e.g. heavy water, plutonium reprocessing plants, uranium enrichment equipment, beryllium, and zirconium).

Despite these measures it should be noted that China has since the 1960s traditionally supported nuclear weapons proliferation as a method of 'breaking the hegemony of the superpowers'. China has also more recently linked its proliferation of WMD-related technologies to states such as Iran and Pakistan as specific countermeasures to such actions as the US sale of advanced weapons systems to Taiwan. China's strategy to weaken past US nuclear technology boycotts has been to establish solid nuclear trade relations with companies from other western countries such as Framatome from France and AECL from Canada. It is believed that until about 1997 China was assisting South Africa's clandestine nuclear programme.

There are some current positive signs of a potentially more responsible Chinese WMD-related proliferation behaviour. US State Department officials recently indicated that China had complied with a 1996 agreement not to provide technical assistance to foreign non-safeguarded nuclear facilities, was strengthening internal review procedures, and was developing centralised export control regulations to govern all dual-use nuclear, missile, chemical and biological related exports. Towards this end, on 11 September 1997, China's State Council implemented regulations to specifically restrict the export of nuclear weapons and technology, and pledged not to transfer such materials to nations opposed to international safeguards. However, an apparent underlying motivation for this move is to meet a key US condition for ending a ban on the transfer of US commercial nuclear power technologies to China, and to alleviate international fears concerning China's proliferation of nuclear technology to Iran and Pakistan. A cynical interpretation of this recent action could view it simply as a restatement of China's original IAEA obligations agreed to in 1984 that were often ignored when convenient. The recent regulations specifically indicate:

· China does not advocate, encourage or engage in the proliferation of nuclear weapons, nor does it help other countries develop nuclear weapons.

· Nuclear exports will be subject to the supervision of international nuclear agencies.

· Without Chinese central government approval, recipients of Chinese nuclear technology may not transfer nuclear materials to third countries operating outside international supervision.

· The Chinese central government prohibits providing help to nuclear facilities not subject to the supervision of the International Atomic Energy Agency and will not provide exports, personnel, technical exchanges or co-operation with those facilities.

This policy was further detailed in some 23 clauses during June 1998, just prior to a Jiang-Clinton summit in Beijing, which specified regulations controlling the export of dual-use nuclear equipment and technology. However, the CIA claimed in 1999 that China and Russia remain the top suppliers of weapons of mass destruction technology, including nuclear, and that China's recent restructuring of its defence industry sector creates the potential for confusion and increased unauthorised transfers conducted at the enterprise level.

7.9.2 Pakistan

China's nuclear assistance to Pakistan began during the 1970s, beginning with the training of scientists and help with the establishment of R&D facilities. In 1991 the China Nuclear Energy Industry Corporation (CNEIC, a subsidiary of the CNNC) sold a 300 MW PWR based on Qinshan-1 to Pakistan. Construction began in August 1993 at the Chasma (or 'Chashma') site, 200 km south-west of Islamabad. By 1996, China had supplied the turbine-generator and the 60 m concrete dome had been completed. A primary issue with Chinese/Pakistan nuclear dealings was the fact that Pakistan has been actively pursuing a nuclear weapons capability for many years. This programme culminated in May 1998 when Pakistan tested six nuclear weapons, following India's test of five devices (it is unclear if all of these tests for both nations were totally successful). A small Pakistani nuclear arsenal may have been developed as early as 1993 according to some reports.

Pakistan has been identified as a centre for 'Islamic nuclear bomb' development and is believed to have received considerable covert nuclear and missile technology transfers from its close ally, China. CNNC co-ordinates nuclear technology transfers with the Pakistan Institute of Physics. This has included M-11 missile subsystems and perhaps up to 30 complete missiles, possibly complete nuclear weapon designs (an actual Pakistani 40 kT nuclear device was rumoured to have been successfully tested at Lop Nor during October 1994 and Pakistani scientists had observed Chinese nuclear tests by 1989), tritium for increasing the yield of nuclear weapons, and numerous ring magnets that are used in gas ultracentrifuges for enriching nuclear weapons-grade uranium. Some reports indicate that China supplied Pakistan with the same fission bomb design and trigger mechanism that it perfected in its 1966 live test on an IRBM. Reportedly, Chinese nuclear scientists visited the Pakistani nuclear weapons development facility at Wah during the early 1980s to assist with the weapon development and supply sufficient uranium hexafluoride feedstock to begin the operation of Pakistan's centrifuges for the production of weapons-grade uranium.

There have also been allegations that China assisted Pakistan in building a plutonium production reactor at Khusab and an associated plutonium separation facility. In January 1996, evidence collected by the CIA was released that indicated Chinese aid for Pakistan's uranium enrichment centrifuge programme at Kahuta. Similar allegations had been made in the mid-1980s. China reportedly sold 5,000 magnetic bearing assemblies to Pakistan for use in gas centrifuges used to enrich uranium for nuclear bombs. Heavy water sold by China to Pakistan for its civilian nuclear programme could also have been diverted to military applications. Some sources claim that the Kahuta complex was originally built using technology stolen from the Urenco corporation in the mid-1970s. This illicit trade was clearly a violation by China of the NPT, which only permits trade of such technology to states which have full-scope safeguards under the IAEA (Pakistan is not an NPT signatory). Clearly, regardless of the specifics of China's assistance, it has been crucial for Pakistan becoming a nuclear weapons state. Table 7.3 provides a chronology of suspected covert nuclear co-operation between China and Pakistan.

Table 7.3 Chinese-Pakistani Nuclear Co-operation

· 1974 **-** China assigns 12 scientists to assist Pakistan develop a nuclear device.

· 1975 **-** China helps Pakistan develop nuclear weapon research centres.

· 1977 **-** China and Pakistan plan to build and test Pakistan's first nuclear weapon but the operation is suspended because of the fall of Pakistan's government.

· 1983 **-** China provides Pakistan with the complete design for a nuclear weapon and sufficient uranium for perhaps two devices.

· 1986 **-** China provides Pakistan with sufficient tritium gas for up to 10 nuclear weapons and additional enriched uranium.

· 1989 **-** China allows Pakistani scientists to observe a nuclear test at Lop Nor.

· 1994 to 1996 **-** China helps build a 300 MW nuclear power plant at Chasma and a tritium gas purification plant at Khushab.

· 1995 **-** A Chinese state enterprise sells 5,000 ring magnets used to manufacture weapons-grade uranium to a nuclear research laboratory at Kahuta.

· 1996 **-** China pledges not to provide assistance to Pakistani nuclear facilities without safeguards, to avoid US sanctions, and also signs the Comprehensive Test Ban Treaty.

· 1998 **-** Pakistan conducts its first nuclear tests.

In June 2000, the 300 MW Chasma Nuclear Power Station, China's largest nuclear civil export project to date, began the generation of electricity. Reportedly, China's experience with the construction of the Qinshan Nuclear Power station was crucial for its successful development. Chinese technicians had installed the first nuclear fuel charge by November 1999.

7.9.3 Iran

It is widely suspected that Iran continues to seek from China and other countries nuclear power, research reactors, and other nuclear-fuel-cycle facilities that could potentially support a nuclear-weapons programme. China has played a particularly active role in Iran's civil nuclear programme since the 1980s through a number of co-operative projects. Some US reports have claimed that China has provided Iran with up to 10 nuclear reactors 'capable of making weapons and fuel', possibly at least partially in exchange for key military aircraft types that were flown by Iraq to Iran during the Gulf War. However, Chinese sales of nuclear facilities to Iran, such as small research reactors and related systems, including reactor fuel production technologies that conceivably could be used for extracting bomb-grade materials, have reportedly been made pursuant to IAEA safeguards. China had planned to sell Iran two 300 MW nuclear power reactors in 1992 but by 1995 indicated that the deal was suspended due to difficulties in site selection, as well as Iran's competing contract with Russia to purchase at least one large nuclear power reactor. In addition to US political and economic pressure, other factors leading to this decision may have included uncertainties over Iran's ability to finance the large cost of the programme, and possibly a cultural backlash by Iran against China's increasingly harsh treatment of its own domestic Islamic fundamentalist movement.

Overall, while it is considered unlikely that China would directly provide Iran with nuclear weapon systems (although it is believed that it provided Pakistan with a complete nuclear weapons design and this design was subsequently passed on to Iraq), it often does not exercise sufficient safeguards against military spin-offs from its exported commercial and experimental reactor programmes. Many would argue that China is probably complaisant concerning nuclear weapons developments it is aware of in Iran. The US has repeatedly urged China, as well as all other potential nuclear suppliers, to refrain from any nuclear co-operation with Iran. Washington believes that any nuclear collaboration, even that which has no apparent direct military application, could potentially enhance Iran's relatively limited nuclear capabilities. Many believe that Iran cannot actually be trusted to abide by its commitments under the NPT into the foreseeable future.

A recent CIA report indicated that China has restricted further nuclear technology transfers to Iran. However, an earlier 1999 US intelligence report had claimed that the China Non-Metallic Minerals Industrial Import and Export Corporation was discussing providing assistance to Iran for the construction of a nuclear-grade graphite production facility, as well as supplying Iran with titanium-stabilised duplex steel, components and materials for WMD during the same year.

7.9.4 Iraq

Past Chinese exports to Iraq have reportedly included, in violation of the UN and US embargoes, chemicals used for the manufacture of chemical weapons, missile fuel and nuclear systems. However, it is notable that the bulk of Iraq's technical assistance for its previously varied WMD programmes was not transferred from China. Indeed, chemical, biological and nuclear transfers were for the most part provided by Western firms.

However, China is believed to have provided some assistance for Iraq's formerly considerable nuclear weapons programme and may have benefited from Western technical expertise in return. There is also speculation that Pakistan transferred a proven Chinese nuclear weapon design to Iraq. Much of Iraq's 'yellowcake' concentrate containing 70 to 80 per cent uranium oxide needed to produce uranium hexafluoride prior to uranium enrichment is believed to have been imported from China and Brazil. It has also been reported that China and Pakistan assisted Iraq's gas ultracentrifuge uranium enrichment programme. In 1990, China's Wanbao Engineering Company (a NORINCO subsidiary) had reportedly agreed to supply Iraq with several tons of lithium hydride, a chemical used for the manufacture of nuclear weapons, missile propellants and chemical weapons, before the majority of the sale was apparently halted by the central government in Beijing. Iraq probably obtained plutonium reprocessing, uranium hexafluoride production and fuel fabrication technologies from a variety of other sources. While the physical infrastructure of Iraq's nuclear weapons programme was to a large extent dismantled following the Gulf War, key technical personnel and technical knowledge have probably been retained, and a nascent programme is still possible.

7.9.5 Algeria

China has reportedly supplied a 15 MW to 40 MW heavy water nuclear research reactor facility to Algeria at Oussera, 125 km south of Algiers. The project began in 1983, with development proceeding until the early 1990s under tight concealment, even after China joined the IAEA in 1984. If operated continuously, such a reactor could conceivably produce 3 kg to 8 kg of plutonium per year, which could be cumulatively sufficient for a nuclear fission weapon. The site's associated research facility could conceivably be used for plutonium extraction and fabrication for 'Islamic bomb' weapons applications. The higher ranges for reactor power and plutonium production are from CIA reconnaissance satellite estimates based upon the complex's cooling tower size, while the lower are from Algerian and Chinese publicly released information. The higher estimate would permit the development of perhaps one nuclear weapon per year.

Algeria is not an NPT signatory and is believed to have assisted Iraq's nuclear programme. However, the Oussera complex is now reportedly under the regular IAEA inspection of its reactor, nuclear fuel and heavy water components to ensure that these are not being used for nuclear weapons development. Full IAEA access to the complex has not been guaranteed and the final destination of all spent fuel remains an open question, although there are no recent reports of Algerian nuclear activities.

Like Libya and Syria, Algeria's nuclear programme is believed to be currently stymied because of a shortage of both technical and financial resources. China has no strong direct strategic or economic linkages with Algeria and its reactor sale was probably mostly profit-motivated.

7.9.6 Libya

Libya is believed to have received some nuclear programme support from China and is possibly capable of producing uranium hexafluoride, although there are no recent reports indicating such activities. During the early 1970s, Libya reportedly attempted to directly buy a tactical nuclear weapon from China but was informed by Premier Zhou Enlai 'that they were not for sale', although China agreed to provide some help with related Libyan R&D efforts.

7.9.7 North Korea

Beijing's co-operation with US and allied efforts to check North Korea's nascent nuclear weapons programme has been praised by some US officials and criticised by others. China played an active part in negotiations on the issue but Beijing's refusal to support sanctions against Pyongyang was seen by some as an attempt to limit international options to press North Korea to completely cease its nuclear programme.

Some sources have indicated a Chinese technical involvement with North Korea's nuclear programme but this is unconfirmed. A monazite-uranium refining plant at Hamhung, North Korea, was reportedly built with technology from the Shanghai Yue Long Chemical Plant.

7.10 Chemical and Biological Warfare TOP

Little is publicly known of the specifics concerning China's chemical and biological warfare capabilities but they are possibly substantial. For example, China's Academy of Military Medical Science reportedly has a large number of scientists that have conducted advanced R&D in such areas as anti-biological, anti-chemical and anti-nuclear warfare medicine. China officially denies the development of any chemical or biological weapons or components but its chemical warfare capability is believed by some observers to be mature and to have been underway since the 1950s. It may also have maintained a biological warfare programme, which began before China agreed to the Biological Weapons Convention in 1984. Some China experts believe that a wide variety of chemical agents have been produced and weaponised, and biological weapons may conceivably include manufactured infectious micro-organisms and toxins. Potential delivery systems include ballistic and cruise missiles, aircraft and artillery systems.

China is an original signatory state of the Chemical Weapons Convention (CWC), depositing the instruments of its ratification in April 1997. China is also the world's largest producer of many chemical products such as ammonia fertilizer and has large numbers of fertilizer, paint, herbicide and pesticide development and other industrial chemical production plants that could also be used for chemical weapons development.

In 1997, the US accused two Chinese and one Hong Kong firm of attempting to sell equipment and technology to Iran that could be used to produce chemical weapons. The substances involved were chemical precursors for tabun nerve gas, thionyl chloride and mustard. The Chinese firms implicated were the Nanjing Chemical Industries Group, the Jiangsu Yongli Chemical Engineering and Technology Import/Export Corporation, and Cheong Yee Limited of Hong Kong. Hong Kong firms often serve as entrepots for the export of dual chemicals and technologies. Other major potential suppliers include the Harbin Chemical Import and Export Corporation, the Hefei Chemical Works, the Jinling Petrochemical Company - Chemical Plant Number Two, the Shaanxi Chemical Import and Export Corporation, and the Taiyuan Chemical Plant Import and Export Corporation. Other unconfirmed reports have indicated that up to 400 tons of other 'chemical agents' (e.g. carbon sulfide, an ingredient of nerve gas) may have been sold by China to Iran.

During 1995 and 1996 the US made accusations that Chinese firms were assisting Iran to develop a chemical weapon infrastructure, which included chemical manufacturing plants and the precursors for developing chemical warfare agents. Such transfers were possibly of a dual-use nature and could have been provided by Chinese businesses without the full export control approval of the central government in Beijing. However, other US reports indicate that Iran's chemical weapons programme is one of the developing world's largest and that China has supported it with production technology and equipment, and perhaps even a complete chemical weapons factory. Other reports have also indicated that China has sold Iran de-toxicating agents to counter the lingering effects of Iraqi chemical weapons attacks during the last Iran-Iraq War. The strong possibility exists of some of this material being developed into chemical missile warheads, aircraft delivered bombs, and artillery shells.

During August 1993, the US had claimed that a Chinese containership, the *Yinhe*, was carrying chemicals forbidden under the CWC bound to Iran. These chemicals were specifically believed to be the precursors thiodiglycol used for blister agents (i.e. mustard gas), and thionyl chloride used for blister and nerve agents. However, after a reportedly thorough search of the ship's cargo by Chinese and Saudi officials (assisted by US technical advisors), the US subsequently withdrew this accusation. Some US reports maintain that the banned chemicals were somehow off-loaded before the inspection in Saudi Arabia.

In 1998, Beijing tightened controls, licenses and approvals over chemicals and chemical equipment imports and exports. This was an apparent response to foreign allegations of Chinese involvement in the proliferation of chemical weapons. China has recently expressed some discomfort with the CWC due to the creation of a small restrictive regime, the Australia Group, which Beijing claims is elitist in nature and responsible for splitting the CWC regime by seeking to impose unilateral standards. China allowed CWC inspections to occur in 1998 and some views are that PLA chemical weapons stockpiles have been destroyed. A 1999 US intelligence report claimed that China supplied Iraq with information on chemical warfare protective suits that could also be used for a covert chemical weapons programme. Table 7.4 summarises Chinese facilities that have a potential chemical weapons production capability.

China has an historical record of being a victim of biological and chemical warfare. The Imperial Japanese Army from 1937-45 had stockpiled some 700,000 to two million chemical shells in China (including mustard, lewisite, and phosgene), which are now abandoned and in many cases unstable, and Japanese efforts are still underway to remedy this unfortunate situation. Chemical weapons were used by the Japanese against Chinese military and civilian targets. Harbin, north of a currently suspected Chinese biological warfare site at Changchun in Manchuria, was the site of a Japanese biological weapon proving ground during the Second World War, which used human prisoners as subjects. China also claims that the US used biological weapons against the PLA during the Korean War.

In 1996 the CIA has reported that Iran had attempted to purchase dual-use biotechnology equipment from 'Europe and Asia', ostensibly for civilian applications but China's specific role in this remains unknown at this time.

Some Western experts rate China's biotechnology expertise as being of global calibre, while China is not being hindered in its related R&D efforts by the complicated bio-safety rules common in other major nations (there are reportedly routine widespread field testing of genetically altered organisms, and products made from such organisms are used in commercial food and medical products without labelling). Some also claim that China is implementing a human eugenics policy through the use of genetic engineering technologies to screen and prevent people with genetic defects from reproducing.

Table 7.4 Potential Chinese Chemical Weapons-Related Production Facilities

· 9074 Xuchang, Henan

· 9078 Xinxiang, Hunan

· 9510 Yunmeng, Hubei

· 9719 Dailan, Liaoning

· 9733 Penglai, Shandong

· 9734 Lianyungang, Jiangsu

· 9735 Kaifeng, Henan

· 9746 Putian, Fuijan

· 9846 Dachang Shanghai

· Beijing Chemical Experimental Plant, Chaoyang, Beijing

· Chemical Fertilizer Factory, Daqing, Petrochemical Works

· Chengdu Fertilizer Plant, Chengdu, Sichuan

· Cheong Yee Limited, Hong Kong

· Danyang Chemical Fertilizer Plant, Danyang, Jiangsu

· East China University of Science and Technology Huachang Polymer Company

· Fujian Yongchun Fertilizer Plant, Yongchun, Fujian

· Fuquan County Chemical Fertilizer Plant, Tuanyang

· Gansu Liujiaxia Fertilizer Plant, Liujiaxia Town

· Guangxi Liuzhou Fertilizers Plant, Liuzhou, Guangxi

· Guangdong Applied Institute of Si&F Fine Chemicals

· Guangzhou Nitrogen Fertilizer Plant, Chepo

· Hainan Fertilizer Plant, Gongye Shuiku

· Harbin Chemical Import and Export Corporation, Harbin

· Harbin Chemical Works, Taiping District Harbin

· Hebei Gaocheng Chemical Fertilizer Factory, Gaocheng

· Hebei Xuanhua Chemical Fertilizer Plant, Zhangjiakou City, Hebei

· Hefei Chemical Fertiliser Plant Hefei, Anhui

· Hefei Chemical Works, Anhui

· Henan Mengxian Number 2 Fertilizer Plant, Jinshansi

· Huadong Chemical College Chemical Plant

· Hubei Chemical Fertilizer Plant, Majiadain

· Huainan Chemical General Works, Huainan, Anhui

· Hutuohe Chemical Fertilizer Plant, Shijiazhuang Prefecture

· Huxian Chemical Fertilizer Plant, Huxian

· Inner Mongolia Speciality Fertilizer Plant, Zhuozi County

· IPLA Plant 5712, Changsa City, Hunan

· Jiangsu Yongli Chemical Engineering and Technology Import/Export Corporation

· Jiangxi Ammonia Plant, Jiangxi

· Jilin Chemical Industry Corporation, Fertilizer Factory, Jilin

· Jinling Petrochemical Company - Chemical Plant Number Two, Nanjing

· Jinling Petrochemical Corporation, SINOPEC, Nanjing

· Liaohe Chemical Fertilizer Plant, Panjin City (chemical complex)

· Liujiaxia Fertilizer Plant, Yongjing, Gansu

· MCI Nantong, Synthetic Materials Experiment Plant

· Nanjing Chemical Industry Group, Nanjing

· Qilu Petrochemical Corporation, Number 1 Chemical Fertilizer Plant, Ziho,

· Shandong

· Qinghai Chemical Plant, Xining

· Qinghai Potash Plant, Golmud City, Qinghai

· Quzhou Chemical Industry Corporation, Synthetic Ammonia Factory, Quzhou

· Shaanxi Chemical Import and Export Corporation

· Shaanxi Complex Fertilizer Plant, Xinlin Town

· Shandong, Feicheng Fertilizer Plant, Feicheng, Shandong

· Shandong Lunan Fertilizer Plant, Tengzhou

· Shandong Tancheng Chemical Fertilizer Plant, Tancheng

· Shanghai Fertilizer United Corporation, Shanghai

· Shanghai Jinsi Fine Chemicals Experimental Plant

· Shanghai Synthetic Resins Research Institute

· Shanghai Wujin Chemical General Works (chemical complex)

· Shanxi Chemical Fertilizer Plant, Chendong

· Shenyang Chemical Fertilizer Plant, Liguangbao

· Shijiazhuang Fertilizer Plant, Shijiazhouang, Hebei

· Sichuan Chemical General Works (chemical complex)

· Sino-Arab Chemical Fertilizers, Qinhuangdao City, Hebei

· SINOPEC Ningxia Chemical Works, Yinchuan, Ningxia

· Taiyuan Chemical Fertilizer Plant, Taiyuan, Shanxi

· Taiyuan Chemical Plant Import and Export Corporation, Shanxi

· Tianjin University Chemical Experimental Plant

· Wusong Fertilizer Plant, Wusong, Shanghai

· Wuzhi Chemical Fertilizer Plant, Wuzhi, Henan

· Xi'an Modern Chemical Research Institute

· Xinjiang Fertilizer Plant, Urumqi, Xinjiang

· Yunnan Guangming Phosphorous Fertilizer Plant, Anning County, Yunnan

· Yunnan Phosphate Fertilizer Plant, -Kunming, Yunnan

· Yuxi Phosphate Fertilizer Plant, Yuxi, Yunnan

· Zhenzhou Fertilizer Plant, Gangtie Road, Zhenzhou

A former Soviet biological warfare researcher has recently claimed that he had received two reports of serious haemorrhagic virus accidents and subsequent epidemics at Chinese biological warfare facilities in the area of the Lop Nor nuclear test site during the late 1980s. The Chinese R&D programme supposedly included the weaponisation of viral diseases and potent pathogens but specific details have remained fragmentary. In 1993, the Bush administration accused China of having an active biological warfare programme which it denied. Former Soviet military biotechnology researchers may now be active in China.

There have been some recent claims that the Changchun Biological Products Institute, Jilan, which borders North Korea, is involved with a PLA biological warfare programme involving pathogens and bacteria, and has attempted to import advanced production equipment from the US. The Wuhan Institute of Biological Products, Wuhan, is another suspected biological warfare centre.

Biotechnology is a priority strategic medium-to-long-range technology receiving considerable support from the MOST through national R&D support mechanisms such as the '863 Programme', which has recently funded projects in medicinal bio-products, bio-reactive engineering, product separation, purification engineering, and protein and genetic engineering. By the mid-1990s, some 20,000 Chinese scientists were engaged in high-level genetic research. The National Key Technologies R&D Programme has recently funded R&D projects in 'new materials for radioactive-proof and anti-biochemical pollution purposes', as well as biotechnology research in enzyme preparation, bio-chemical reagents, genetic engineering vaccines, active multi-peptides, amino acid products, and the large-scale cultivation of animal and plant cells. In 1997, China began the commercialisation of transgenic crops with such traits as insect, fungus and virus resistance, as well as nutritional enrichment and quality enhancement. Some one million acres of transgenic crops were planted, and advanced efforts made to develop edible oral vaccines and recombinant pharmaceuticals, making China a world leader in 'biopharming'. A five year (1996-2000) national biotechnology plan has accorded priority to the following R&D areas:

· Transgenic plants

· Molecular marker-aided plant breeding

· Recombinant microbiology

· New technology for plant genetic engineering

· Ggenetic engineering of animals

· Recombinant vaccines (e.g. For hepatitis b)

· Recombinant DNA polypeptide drugs

· Antibody engineering

· Genome research related to human diseases (e.g. the major national China Human Genome Programme initiated in 1994, which is collaborating with the International Human Genome Project, through centres such as the Shanghai Human Genome Research Centre and the HGP Centre, Beijing)

· New technologies for medical genetic engineering

· Protein engineering.

By 2000, the MOST plans to have built or upgraded some 20 to 30 key national biotechnology laboratories and 10 to 15 biotechnology engineering research centres. There are over 100 biotechnology laboratories across China. Specific key biotechnology related R&D centres are summarised in Table 7.5.

The Hangzhou Jiuyuan Genetic Engineering Company Ltd., is currently developing gene engineered drugs 'and major breakthroughs have been achieved in the structure of high expression engineered bacteria, high density fermentation and large scale property restoring and purification of restructured proteins'. The Hunan University of Medical Science during 1997 conducted China's initial research in the cloning of genetic diseases. In February 1998, researchers from the Shanghai Research Institute of Genetics announced a genetic engineering breakthrough with the breeding of transgenic goats capable of producing milk with a therapeutic human protein ('IX Factor' plasma thromboplastin component), with the project receiving funding from the '863' Programme. The CAS is undertaking a broad R&D programme through a number of its institutes of plant biotechnology and in 1998 announced that its transgenic research efforts had succeeded in transferring hepatitis B surface antigen and interferon genes into plants. Increased co-operation between mainland China research institutes and the Hong Kong bio-pharmaceutical industry and medical researchers is now underway. In August 2000 a new pesticide developed by Chinese scientists was announced that is allegedly capable of eliminating the most stubborn pests and was created by combining genetic elements of two viruses known to attack the insects.

Table 7.5 Major Chinese Biotechnology Research and Production Establishments

· Beijing University

· Beida (Beijing University) Bioengineering Valley, Shenzhen

· Bioengineering Development Centre, MOST

· Biotechnology Research Centre, Chinese Academy of Agricultural Sciences

· Changchun Biological Products Institute, Jilan

· China National Centre for Biotechnology Development (a key R&D and international collaboration organisation)

· Genetic Engineering Security Centre, Ministry of Agriculture

· Hangzhou Jiuyuan Genetic Engineering Company Ltd.

· Harbin University, Genetic Laboratory

· Hong Kong University of Sciences

· Huazhong Pharmaceutical Plant, Xiangfan, Hubei

· Huazhong University of Agriculture, Xiangfan, Hubei

· Human Genome Project (HGP) Centre, CAS, Beijing

· Hunan University of Medical Science

· Institute of Biochemistry, CAS

· Institute of Bioengineering of China, Jinan University

· Institute of Biology, CAS

· Institute of Botany, CAS

· Institute of Development Biology, CAS

· Institute of Genetics, CAS, Beijing

· Institute of Virology, Chinese Academy of Preventative Medicine

· Jiangmen Centre for Biotechnological Development, Guangdong

· Laboratory for Genetic Engineering, Fudan University, Shanghai

· Life Tech Asia Ltd., Hong Kong

· National Key Lab on Chinese Genetic Medical Science, Hunan University of Medical Science

· PLA General Logistics Department's 'Three Star Programme'

· PLA Number One Military Medical School

· Shanghai Human Genome Research Centre

· Shanghai Research Institute of Genetics

· Shenzhen Kaili Industrial Development Corporation, Shenzhen

· Shenzhen Kexing Biological Products Company, Ltd., Shenzhen

· Wuhan Institute of Biological Products, Wuhan

· Zhuhai Dongda Bioengineering Company Ltd., Guangdong.

Chinese scientists' successful involvement in the global Human Genome Project (HGP) is being supported through the HGP Centre under the Genetics Institute of the CAS. In the initial rough map of the HGP, Chinese scientists reportedly completed 1 per cent of the sequencing of the human genome. A HGP recent centre has been developed at Shunyi County, north of Beijing, on 3,800 square metres of land near the Capital International Airport.

In 1998, the National Key Laboratory on Chinese Genetic Medical Science of the Hunan University of Medical Science successfully cloned the world's first disease gene, specifically those triggering nerve deafness.

Construction of the largest bioengineering industrial base in Asia, the $US84.5 million Beida (Beijing University) Bioengineering Valley, is currently underway in Shenzhen,

Guangdong. The project is being undertaken by the Shenzhen Kexing Biological Products Company, Ltd., and is part of a key project being jointly developed by the Shenzhen City Government, Beijing University and the Hong Kong University of Sciences. Shenzhen Kexing is China's largest producer of biological products and specialises in the production of gene-engineered interferon, insulin, sinalbin, and human growth hormones.

While China's various biotechnology programmes are oriented towards civil agriculture-food and medical applications, the dual-use nature of such technologies and potential military applications cannot simply be ignored. The PLA is quite active in medical research through its military medical universities and such initiatives as the General Logistics Department's 'Three Star Programme' for the training of advanced scientific and technical personnel. PLA medical R&D establishment have undertaken advanced research in such areas as trauma, NBC warfare, and basic medical research. In April 2000, the PLA Number One Military Medical School developed China's first applied genetic chip, or 'biochip'. The Jiangmen Centre for Biotechnological Development, Guangdong, is believed to have defence links. The Huazhong Pharmaceutical Plant, Xiangfan, Hubei is a major NORINCO plant undertaking pharmaceutical production, as is COSTIND's Shenzhen Kaili Industrial Development Corporation.

While chemical and perhaps biological warfare capabilities may have been transferred to Middle Eastern client states, specific details remain scarce. An unconfirmed report references a biological warhead research programme in Beijing connected to China's advanced cruise missile development efforts. Another report indicates that China may have provide North Korea with smallpox cultures for its biological warfare programme. Interestingly, China's 27 July 1998, 'White Paper on China's National Defence' notes:

'*China holds, in view of the complexity of the problems relating to the verification mechanism (for the Biological Weapons Convention), that every country should, in a down-to-earth way, seek effective and feasible verification measures, and formulate concrete steps to prevent abuse of verification, and to protect the rightful commercial and security secrets of the states parties. China considers that, while improving the convention's verification mechanism, international co-operation and exchanges among states parties in the sphere of biotechnology for peaceful purposes should also be strengthened.*'

Qinshan Nuclear Power Plant, China's first indigenously designed and constructed nuclear power plant.

The Dayawan nuclear power plant.

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CHAPTER 8 - DIRECTED ENERGY WEAPONS AND SENSORS

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DIRECTED ENERGY WEAPONS AND SENSORS

8.1 R&D and Production Infrastructure TOP

While receiving some recent public attention, relatively little is know concerning the details of Chinese directed energy weapon (DEW, or *xin gainian wuqi*) systems development. Related R&D has probably been conducted since the 'Project 640' BMD and ASAT programme in the 1960s. Today support is probably provided through the 863 Programme of the MOST and managed by COSTIND. Other major DEW research is being undertaken as a broadening of the CNNC's traditional nuclear R&D activities and there does not appear to be any hesitation in the use of nuclear power sources for such weapons. China's broad laser R&D and production infrastructure appears to be formidable and it is quite possible that it has recently produced DEW breakthroughs. Reportedly, China has recruited significant Russian DEW expertise but large numbers of Chinese researchers also have a strong fascination and talent for this field.

While still probably trailing the expertise of the US in this field, China's DEW-related R&D and applications programmes are massive and sophisticated by any international standard. China is believed to be a world leader in various specific areas. Some estimates suggest that approximately 10,000 personnel, including 3,000 engineers, from 300 organisations are involved with China's laser programmes alone, with perhaps 40 per cent of related R&D being conducted for defence applications. Table 8.1 summarises China's key laser, optoelectronic and other potential DEW R&D and production centres.

The Southwest Research Institute of Technical Physics, Chengdu in Sichuan Province, conducts applied R&D on military lasers and photoelectric technology in such areas as laser crystals and components, laser photoelectric detectors, laser range-finders, laser control/guiding/tracking/'confrontation' systems, simulators, image processing, TV systems, and photoelectric systems. R&D is also conducted on 'plasma technology spin-offs', high current ion sources, cryogenic superconductors, and high field magnets. The military '493 High-Flux Reactor' Programme is believed to have been conducted at this institute.

The North China Research Institute of Electro-Optics has reportedly developed atmospheric laser radars (lidar), the 27th Research Institute laser range-finders, and the 41th Research Institute high-energy laser power sources. The North China Research Institute of Electro-Optics has also developed thermal imaging and slow-scan infrared imaging systems.

The National Engineering Research Centre for Solid State Lasers, Beijing, is conducting R&D on solid state lasers, multi-wavelength lasers, tunable lasers, diode-pump solid state lasers, and various industrial and medical laser applications. A large solid state laser, the LF-12 Shenguang-1 (Magic Light) began operations at the CAS Shanghai Institute of Optics and Fine Mechanics in 1986. The follow-on Shenguang-2 reportedly has a power output of two terrawatts and is a major facility for China's inertial confined fusion programme. This Shanghai R&D establishment has also developed a Nd:YAG laser with an output power of 62.5 MW, the Xingguang-2 Nd:Glass laser, and a tunable titanium-sapphire laser with an output power of 650 MW. Semiconductor optoelectronics devices and applications are a speciality of the 44th Research Institute of the former Ministry of Electronics Industry. The Tianjin Electronic Materials Research Institute conducts infrared technology R&D. The China Institute of Atomic Energy, Beijing, is a large research establishment that conducts R&D in such areas as strong current particle beam laser nuclear fusion, free electron lasers, quasi-molecular lasers, krypton-flouride excimer laser, and chemical lasers. The Southwest Institute of Nuclear Physics reportedly developed a fast breed reactor-pumped xenon laser.

Table 8.1 Likely Chinese Directed Energy Weapons-Related Organisations

· Anhui Institute of Optics and Fine Mechanics
· Beijing Aeronautical Manufacturing Technology Research Institute's Key Laboratory for High-Energy Density Beam Processing Technology
· Beijing Broadcasting Equipment Factory
· Beijing Electron Accelerator
· Beijing General Academy of Non-ferrous Metal
· Beijing Institute of Electronic Engineering
· Beijing Institute of Technology
· Beijing Light Source, CAS
· Beijing Polytechnic University
· Beijing Electron-Positron Collider, CAS

· Beijing Number Three Radio Equipment Factory

· Beijing University, Department of Physics

· Beijing Vacuum Electronics Research Institute

· Changchun College (Institute) of Optics and Fine Mechanics

· China Academy of Engineering Physics

· China Institute of Atomic Energy, Beijing

· China Science and Technology University

· Dalian Institute of Chemical Physics (Dalian Institute of Chemistry and Physics)

· Department of Radioisotope, Beijing

· East China Research Institute of Electronic Engineering, Hefei, Anhui

· Free Electron Laser Lab, Institute of High Energy Physics, Beijing

· 41st Research Institute

· 44th Research Institute of the Ministry of Electronics Industry.

· Guangdong Linnan Industries Company, Zhuhai Branch

· Guangzhou Institute of Laser Technology Applications, Guangzhou, Guangdong

· Hanguang Electronics Plant, Xiaogan Hubei

· Hangzhou Electronic Laser Technology Enterprises Inc.

· Hebei Academy of Sciences, Institute of Lasers, Shijiazhuang

· Hefei Cryoelectronics Institute, Hefei, Anhui

· High-Power Laser Laboratory, Shanghai

· Huadong Technology College

· Huazhong Electro-Optical Technology Research Institute, Wuhan, Hubei

· Huazhong Precision Instrument Factory

· HuaYe Optical Material Corporation, Jiangsu

· Institute of Applied Electronics

· Institute of Applied Physics and Computational Mathematics, Beijing

· Institute of Applied Infrared Technology, Liaoning

· Institute of Computer Applications

· Institute of Dynamics

· Institute of Electronic Engineering, CAS

· Institute of High Energy Physics, CAS, Beijing

· Institute of Ion Physics, CAS

· Institute of Nuclear Physics and Chemistry

· Institute of Optoelectronics, Beijing

· Institute of Particle Physics

· Institute of Physics, CAS, Beijing

· Institute of Plasma Physics, CAS

· Jiangsu Shugang Opto-Electronics Instrument Factory, Yangzhou, Jiangsu

· Kunming Research Institute of Physics

· Laboratory of Laser Cooling and Confined Atoms, Beijing University

· Lanzhou Institute of Modern Physics, CAS

· Laser Institute Academy of Sciences, Shandong Huada Machinery Works, Guangdong

· Laser Institute of Huazhong University of Science and Technology

· Laser Single Atom Detection Lab, Tsinghua University, Beijing

· Liuzhou Changhong Machinery Manufacturing Company, Liuzhou, Guangxi

· Luoyang Opto-Electro Technology Development Centre, Luoyang, Henan

· Luoyang Institute of Electro-Optical Equipment (Luoyang Electrical-Optical Equipment Research Institute), Luoyang, Henan

· Nanjing Aeronautics and Astronautics University

· Nantong Laser Hologram Company Ltd., Nantong, Jiangsu

· National Engineering Research Centre for Solid State Lasers, Beijing

· National Synchrotron Radiation Laboratory, Hefei

· National University of Defence Sciences and Technology (University of Science and Technology for National Defence), Changsha, Hunan

· North China Research Institute of Electro-Optics

· Northwest Academy of Non-ferrous Metal

· Northwest Institute of Nuclear Technology, Xi'an

· Nuclear Industry Physiochemical, Engineering Research Institute, Hedong, Tianjin

· Research Institute of Contemporary Physics, CAS, Gansu

· Shandong Optoelectronic Instruments Plant, Tai'an, Shandong

· Shanghai Institute of Laser Technology

· Shanghai Institute of Metallurgy, CAS, Shanghai

· Shanghai Institute of Optics and Fine Mechanics

· Shanghai Institute of Technical Physics

· Shanghai Laser Group Company Ltd., Shanghai

· Shanghai Leiou Laser Equipment Factory, Shanghai

· Shanghai Synchronised Radiation Unit, Shanghai

· Sichuan Space Industry Corporation, Baisha, Sichuan

· Southwest Institute of Applied Electronics

· Southwest Institute of Electronic Engineering

· Southwest Institute of Electronic Equipment

· Southwest Institute of Fluid Physics

· Southwest Institute of Nuclear Physics

· Southwest Research Institute of Technical Physics, Sichuan

· Synchrotron Radiation Laboratory (Beijing Synchrotron Radiation Facility)

· Tianjin Electronic Materials Research Institute

· Tianjin Institute of Laser Technology, Nankaiqu, Tianjin

· University of Electronic Science and Technology of China

· Ultrafast Laser Spectroscopy Lab, Zhongshan University

· Xi'an Northwest Optical and Electrical Instruments Plant, Xi'an, Shaanxi

· Zhang Yingxin Research Institute of TV and Electro-Acoustics, Beijing 27th Research Institute

· Zhongnan Optical Instruments Factory, Zhicheng, Hubei

The 11th and 13th Research Institutes of the China Academy of Electronics and Information Technology are also thought to be undertaking solid-state laser R&D. The China Academy of Engineering Physics has conducted chemical, solid-state, and free electron laser (Raman, Compton, Cherenkov, electromagnetic wave-pumped, etc.) research since the mid-1980s. Their initial free electron laser experimental system, Shuguang-1, began operation in 1993 with an output power of 140 MW (theoretical maximum output of 10 gigawatts) at the Southwest Institute of Fluid Physics. The Southwest Institute of Electronic Engineering is attempting to miniaturise the size of free electron lasers. Both the Institute of Applied Physics and Computational Mathematics and the Institute of High Energy Physics, CAS, Beijing, are also conducting free electron laser R&D. The Institute of Optoelectronics, Beijing, the Shanghai Institute of Optics and Fine Mechanics, the Institute of Applied Physics and Computational Mathematics, and the Anhui Institute of Optics and Fine Mechanics, are believed to be conducting R&D on adaptive optics and deformable mirrors, and other aspects of laser technologies. China considers itself a world leader in adaptive optics, following the US and Germany. Anhui is also active in the development of large-scale laser range-finders, lidar, excimer lasers, and the atmospheric effects on laser transmission.

NORINCO's Jiangsu Shugang Opto-Electronics Instrument Factory, Yangzhou, Jiangsu, undertakes the R&D, production and integration of lasers and optics, including products such as lightweight laser range-finders.

'Intelligent' coherent TV optoelectronic tracking systems have been developed by the 27th Research Institute and precision optics have been developed at the Guangdong Linnan Industries Company, Zhuhai Branch. The Zhang Yingxin Research Institute of TV and Electro-Acoustics, Beijing, has recently developed the Model 341TVT-B TV optical tracker and fire control system for acquiring and automatically tracking aerial targets in conjunction with the '341 radar servo system', which has a low-level target capability by improving radar angle tracking performance.

The Beijing Aeronautical Manufacturing Technology Research Institute currently operates the subsidiary Key Laboratory for High-Energy Density Beam Processing Technology (lasers, electron beams, plasmas).

Wuhan, capital city of the central province of Hubei, has recently announced its intention to establish itself as a centre of excellence in photoelectronic technologies, including laser devices, laser processing complete plants, and optical telecommunications equipment. To accomplish this it is seeking investment and technical expertise from Western firms such as Ericsson, ABB, Alcatel, and Siemens. Lucent Technologies of the US and 20 other multinational companies are reportedly helping Guangzhou, capital city of Guangdong Province, to establish itself as a 'photon valley' or electro-optical centre of excellence.

8.2 Development Programmes TOP

The PLA is currently devoting considerable discussion on the tactical and strategic use of DEWs for applications such as air defence, anti-personnel, communications, weapons guidance and fire control, sensors, space tracking, ASAT and BMD. It is likely that at least some of this interest is now being channelled into actual development programmes, probably supported through the national 863 programme for strategic R&D.

NORINCO has for a number of years openly marketed a portable offensive battlefield laser 'disturber,' the ZM-87, which has a flashblinding and damage range of up to 10 km depending upon weather conditions (a x7 magnifying optic option is available). The ZM-87 is designed to dazzle or blind enemy soldiers and optical sensors despite the UN's global ban on such systems. Indeed, such a system now appears to be mounted on the PLA's latest MBT, the Type-98, as a mast-mounted 'laser dazzler', and may also be mounted on PLAN ships. An upgraded version of the ZM-87 laser (*si guang pao*) is possibly under development and could have anti-aircraft applications with improved counter-countermeasures and automatic targeting systems.

China has developed various industrial (e.g. cutting, welding of special materials, annealing, material hardening and alloying) and medical laser applications using:

· high-energy helium-neon lasers

· C02 lasers

· titanium doped sapphire lasers (using a reportedly unique temperature gradient technique and induction thermal field up-shift method for atmospheric testing)

· pulsed YAG lasers

· continuous wave lasers

· solid-state lasers

· excimer lasers

· semiconductor lasers

· pulsed power supplies (e.g. 10 megawatt compensated pulsed alternator with high repetition rates),

· Nd:YAG laser crystal, innovative undoped YAG substrate (using a patented temperature gradient technique for ultraviolet and infrared optics)

· magneto-optic single crystal, and

· pyroelectric laser radiation detectors for the detection of pulsed laser radiation with a power density of up to 100 MW per square centimetre.

China claims that its quantum IR semiconductor laser technology developed by the CAS Shanghai Institute of Metallurgy is at an advanced level comparable only to efforts achieved by the US Luscent Bell Lab, and can be applied to such areas as telecommunications and 'national security'.

In recent years the China Science and Technology University and Nanjing Aeronautics and Astronautics University have developed high-power pulse laser impact-strengthening devices and applications for new materials surface modifications, including China's first practical neodymium glass laser impact strengthening device. The CAS's Institute of Physics, Beijing, during 1996 developed a laser molecular beam epitaxial system for the production of optical and superconductive films. It is claimed that only a few other nations such as Japan and France have developed similar systems. The HuaYe Optical Material Corporation is reportedly China's largest optical material supplier and produces laser and optoelectronic systems, as well as radiation-proof and radio-resistant glass. Such commercial laser and optical system developments probably provide a good technological base for DEW developments.

Sensors are another technical area closely related to DEW developments to which China has devoted considerable effort. For example, NORINCO's recent 'Sky Shield' is an electro-optical air defence fire-control system that is passive and difficult to detect. It can direct AAA and fire-and-forget SAMs at enemy combat aircraft and helicopters at low altitude under any lighting and weather conditions. Because it is passive and reportedly not susceptible to ECM, Sky Shield is vulnerable to anti-radiation missiles commonly used to home in on radar emissions from standard air defence fire-control systems. The electro-optical package includes a 8-12um common module thermal imager with Stirling close-cycle cooling, a 1.06um air-cooled laser range-finder, and a 0.4um to 1.0um linear zoom CCD TV camera. The thermal imager can reportedly acquire targets to a range of between 12 km to 15 km, the TV tracker 8 km to 10 km, and the laser range-finder at 8 km. Support systems in the truck-mounted system include an intelligent video image processor, tracking-control computer, tracking information processing computer, servo system, firing data processing computer, gun position computer for single-gun parallax correction, and the battery commander's control panel.

During 1996, China organised the 'Photonics China'96' conference in Beijing that brought together important laser and optoelectronic researchers from around the world, and covered sensitive topics that included military high-energy lasers, fibre optic sensors, detectors, focal plane arrays, microphotonics, and integrated optoelectronics systems.

The '863' Programme has recently funded laser research in pulse-power techniques, plasma technology, new materials and laser spectroscopy as well as coal-derived magnetohydrodynamic (MHD) high-energy systems. High-energy physics programmes at the Beijing Electron Accelerator facility, such as its intense-pulsed electron accelerator and Beijing Electron-Positron Collider, as well as high-temperature superconductivity research by the Institute of Electronic Engineering and the Northwest Academy of Non-ferrous Metal could have DEW power applications. So could research at the Beijing General Academy of Non-ferrous Metal, including a 1998 breakthrough in non-resistance power transmission cable constructed of high-temperature bismuth superconductivity material supported by the '863' Programme.

The National University of Defence Technology has had a Maglev research programme since 1989, which could have applications for 'mass-driver' electromagnetic gun type weapons. The National Key Technologies R&D Programme has recently funded research in electrical vehicle technologies, magnetic suspension (i.e. Maglev) trains, etc., that potentially could also be applicable to electromagnetic gun systems.

The state of China's high-energy particle beam weapons development is not known. However, advanced facilities such as the Beijing Electron-Positron Collider, the Synchrotron Radiation Laboratory, the Beijing Light Source, and the associated Institute of High Energy Physics, would probably provide some R&D capability in this area through fundamental physics exploration, in addition to potential but still very futuristic applications of anti-matter for weapons and space propulsion systems (see Chapter Seven, section 7.7.3). In 1999, the CAS Lanzhou Institute of Modern Physics developed China's first 14.5 GHz ECR ion gun as part of a heavy ion circular accelerator system, which will produce highly charged ion beams and metal ion beams. The CAS Institute of Ion Physics is developing various industrial applications for ion beams. The HT-7 Tokamak superconductivity device is operated by the CAS Institute of Plasma Physics, Hefei, and is amongst the largest such devices in the world. It specialises in plasma control research.

The HL-1M is another Chinese Tokamak steady-state magnetically confined fusion reactor. It is the largest such facility in China and was established in 1994. In 1999, the Shanghai Synchronised Radiation Unit, China's largest 'big science' project, started the development of injector, optical beam stations, storage ring, and synchronised radiation testing device units, with a total investment of some 1 billion Rmb yuan, and completion scheduled for 2004. The CAS Research Institute of Contemporary Physics, Gansu, is currently developing the HIRFL-CSR cooling storage ring project for 300 million Rmb yuan over five years. The HIRFL-CSR will provide conditions for stable nuclear beams, radioactive nuclear beams, highly ionised heavy ion beams, synchronised ion beams, and polarised beams of high quality and strength with different specifications and wide energy scopes.

The CAS's Institute of Plasma Physics is conducting R&D on plasma engineering applications and ion beams. In January 2000, China announced that scientists from the institute had achieved a nuclear fusion quasi-stable plasma capable of reproducing itself with a discharging duration as long as 10.71 seconds, a domestic record, using a super-conductivity Tokamak magnetically-confined nuclear fusion reactor. A YAG laser R&D, demonstration and diffusion centre was established at the Institute of Dynamics during 1997. In the same year, researchers from Beijing University's Department of Physics announced development of an ultraviolet He-Ne laser transmitter, a first for China. During the same year the MOST announced the development of 'quasi-molecules KrF lasers' as a major breakthrough by Chinese scientists. The China Academy of Engineering Physics has developed the Tianguang-1 excimer laser for its inertial confinement fusion programme. The Southwest Institute of Nuclear Physics and Chemistry has reportedly developed a fast breeder reactor-pumped xenon laser. The China Institute of Atomic Energy has developed a krypton-flouride excimer laser called 'Heaven' achieving output powers of up to 20 gigawatts since the mid-1980s and the Southwest Institute of Nuclear Physics and Chemistry has tested a nuclear-pumped helium-argon-xenon laser using its China Fast Breeder Reactor (potential peak power of almost one gigawatt).

In November 1999, the University of Science and Technology for National Defence announced the development of an atomic mercury laser generator. This university also developed China's first He-Ne laser in 1994, following only the US and Germany in mastering this technology. The CAS Dalian Institute of Chemistry and Physics is a world-class research centre for pulsed and continuous-wave chemical oxygen-iodine lasers since the 1980s under the 863 Programme. This research probably has DEW applications as military tests against targets have reportedly been conducted since the mid-1990s. In May 2000, the Laboratory of Laser Cooling and Confined Atoms, Beijing University, reported research on Bose condensation atomic cooling related to the development of 'atomic lasers'.

Recent US Department of Defense reports have indicated several specific Chinese DEW developments that are in at least the R&D stage and are summarised in Table 8.2.

The US had previously only specifically identified the former Soviet Union as a potential and credible military space threat. Other sources indicate that China's high-energy laser weapon programme is using high-energy deuterium fluoride lasers and may have used the US Mid-Infrared Advanced Chemical Laser (MIRACL) weapon design. The programme was declared operational during 1998 and is currently being upgraded or supplemented into a more powerful version capable of directly destroying satellites in low earth orbits. A possible basing location for the first generation ground-based ASAT laser system is central China, which could be co-ordinated with the new Chinese satellite tracking facility on the South Pacific Island of Kiribati. During 1998, a US Taiwanese-born nuclear physicist from the Los Alamos National Laboratory was convicted of providing secret military laser information (the laser simulation of nuclear explosions) to China via the CAS.

Table 8.2 Recent Chinese DEW Programmes

· Radio-frequency (RF) and high-powered microwave (HPM) sources for the basis of RF weapons are under development, as well as research on electronics susceptibility to HPM pulses and atmospheric propagation. · HPM warhead is in the research stage and could possibly be deployed by 2015. A conventional high-explosive powered RF system would be delivered near a target and detonated to focus an intense pulse of HPM to damage or disrupt electronics systems (i.e. similar to EMP effects of a nuclear detonation). · Long-range anti-aircraft and anti-missile RF continuous-flow beam systems are in the research stage, possibly deployed by 2015. · The near-term deployment of a RF countermine system mounted on a vehicle to destroy or neutralise enemy mines with electronic fuzes. · Electronic jammers to be used against GPS space systems are under development, as are RF systems to jam enemy satellite uplinks and downlinks. · Laser radars (lidar) used to track and image satellites are in advanced development or procurement stage. Satellite laser range-finders are located at space observatories in Wuhan, Nanjing, Beijing, Kunming, Lintong, and Shanghai. They have accuracies of up to 3 cm and are used for satellite orbital calculations and real-time space tracking activities as far as geosynchronous earth orbit. · Shipborne laser defence systems are reportedly under examination. · High-energy lasers used as a ground based anti-satellite (ASAT) weapon system are reportedly in research stage for satellite destruction, but with a current capability 'to damage, under specific conditions, optical sensors on satellites that are very vulnerable to damage by lasers'.

Unconfirmed reports specifies that the Dalian Institute of Chemical Physics has been engaged in military laser R&D since the 1960s. The National University of Defence Technology reported that it developed an 'advanced world level' Cerenkov free-electron laser device in 1990. The Southwest Institute of Fluid Physics and the China Academy of Engineering Physics and its Institute of Nuclear Physics and Chemistry are reportedly conducting x-ray laser research. This includes the Shenguang-1 prototype, which was tested in 1988, and a follow-on Xingguang-2 system. X-ray lasers, which can be nuclear or conventionally pumped, can be used for EW, ASAT and BMD applications.

Unconfirmed reports from 1999 indicate that the PLA shot down a target drone in flight using some type of DEW, possibly a vehicle-mounted chemically-pumped laser. Other reports have indicated research on large ground-based particle beam types weapons by the China Academy of Engineering Physics. A growing Chinese interest in airborne laser research is evident according to other reports. There has also been mention in the technical literature of Chinese interest in plasma weapons and high-energy ultrasonic and subsonic wave weapons for anti-personnel applications. However, it is not known if actual programmes exist for such devices.

Little specific information is available on HPM and RF programmes other than the possibility that they may include the development of nuclear reactor-pumped and conventionally-powered magnetic flux compression generators, backward wave oscillators, gyrotrons, klystrons, and vircators. Weapons applications could encompass directional air defence systems, a ASAT system warhead, and other types of warheads for use against enemy electronics systems such as avionics, radars and command and control systems. Some gigawatt level microwave radar systems may have been developed for counter-stealth applications. The CAS Institute of Electronics has undertaken research on broadband megawatt-range klystrons as HPM power sources since the early 1990s.

Other programmes associated with HPM weapon development are the China Academy of Engineering Physics' Flash-1 and Flash- 2 (Shanguang) vircator and electron beam accelerators at the Northwest Institute of Nuclear Technology, which have operated to power output levels of 1 terrawatt since research began during the mid-1970s. Other unconfirmed report indicates that the Southwest Research Institute of Technical Physics, the Southwest Institute of Applied Electronics, the Southwest Institute of Fluid Physics, the Southwest Institute of Electronic Equipment, the Northwest Institute of Nuclear Technology, Xi'an, the Institute of Applied Mathematics, the Institute of Applied Electronics, the National University of Defence Sciences and Technology, and the University of Electronic Science and Technology of China, are involved with HPM weapons R&D.

The China Academy of Engineering Physics and Institute of Particle Physics have reportedly undertaken electromagnetic and electrothermal railgun R&D since the mid-1980s. Nuclear EMP and neutron weapons have also been developed and it is possible that other advanced directional nuclear weapons are also under development (see Chapter Seven, section 7.7.3). The DM-140, DM-1200, and DMF-600 series of EMP simulators have reportedly been developed by researchers associated with the Beijing Institute of Electronic Engineering.

8.3 Foreign Technology Transfers TOP

A portion of the former Soviet Union's heavy investment in the DEW field may have been diffused to China through personnel and business transactions, as the Russian state S&T infrastructure continues to dissipate. Relevant Russian design bureaus include Antey, NPO Astrofizika, NPO Almaz, and OKB Vympel, which have conducted R&D on CO2, free-electron, and gas lasers, as well as HPM weapons and are familiar with current US developments in the field. The Institute of Applied Physics and the Lebedev Physics Institute may also have been at the cutting-edge of HPM and RF weapon research. Some reports indicate that Russia may have transferred the knowledge to develop a nuclear reactor-powered, ground-based laser with ASAT capabilities. The AGAT research establishment in Belarus may be providing assistance in laser optics to

China.

Recent reports attributed to the US Defense Intelligence Agency also indicate that Israeli Aircraft Industries may have transferred key high-energy laser technologies to China. The technology in question was originally provided by US firms (the TRW Space and Electronics Group, Ball Aerospace and Technology and Contraves Brashear Systems) for Israel's 'Tactical High Energy Laser Programme' or 'Nautilus Programme,' which was intended to provide a local defence against mortar, artillery and short-range rocket attacks. Chinese technicians were apparently observed working with an Israeli firm involved with the project but allegations of collusion have been denied by the Israelis. The Israeli programme has recently moved towards deployment along the border with Lebanon. Current generation multi-function optical sensor technology has also reportedly been transferred to Chinese firms by Tadiran Ltd. of Holon, Israel.

The Cox Report charges that during the late l990s, US R&D on electromagnetic weapons technology was illegally obtained through Chinese espionage efforts, and that such technology, once developed, can be used for space-based weapons to attack satellites and missiles. It also states:

'Based on the significant level of PRC-Russian co-operation on weapons development, it is possible that the PRC will be able to use nuclear reactors to pump lasers with pulse energies high enough to destroy satellites. In addition, Russian co-operation could help the PRC to develop an advanced radar system using lasers to track and image satellites.'

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INFORMATION TECHNOLOGIES

9.1 R&D and Production Infrastructure TOP

It is a commonly held assumption by many Western defence analysts that China will not be able to achieve a meaningful 'Revolution in Military Affairs' (RMA) for the foreseeable future because the country's information technology (IT) base is perceived as being generations behind that of the West. China also significantly lags in the development and production of defence-related microelectronics, system integration, networking, operating systems, and applications software. Advanced IT systems are at the heart of many modern RMA systems, and therefore, according to this viewpoint China will remain uncompetitive into the indefinite future. However, as reviewed in this report, China does in fact have an extensive civilian and dual-use IT infrastructure that is continuously improving. These advances are based upon China's own massive R&D efforts combined with large influxes of advanced foreign technology transfer.

There are currently some 200 research parks and advanced technology business incubators in China. Key high-tech issues these are now addressing include 'dot.com accelerators', cyber (virtual) incubators, seed funds and 'angel' investment networks, university-business linkages, and equity stakes in tenant firms. China's support for e-commerce business development and Web-based innovation is also matched with serious national security and cultural concerns linked to Internet access by the average citizen. For example, China's Digital Library project as a showcase of national and cultural participation on the Internet was created under the direction of the Propaganda Department of the Chinese Communist Party's Central Committee. As in most of the world, the Y2K scare was basically a non-event in China, with no known security lapses. Various advanced dual-use foreign IT is being transferred to China, particularly through Hong Kong and the surrounding Pearl Delta region with its various special economic zones (SEZ). It is prudent to anticipate that such IT innovations will be of benefit to China's aerospace-defence sector.

Various new R&D and procurement programmes are believed to be underway or have already been implemented in areas relating to modern communications, data-links and digitised systems throughout the PLA. The development of advanced electronic data-link systems would also be an evolutionary development of the Soviet doctrine of ground control assistance of air combat operations. In addition, the PLA has evidenced much recent interest (reflected by various articles in military journals and wargame and military exercise scenarios) in information warfare (IW) at the strategic, operational and tactical levels in relation to its current military modernisation efforts.

The former Ministry of Electronics Industry and its successor, the new Ministry of Information Industry, have reportedly accorded priority to the development of a modern national IT infrastructure as an integral element in China's economic and technological transformation through its so-called 'Five Goldens' and 'Three Golden Projects' initiatives. The Ministry of Information Industry's mandate includes the development of 'special-purpose communication networks for war industrial and other departments...and guarantee(ing) information security'. Emphasis is being placed on the establishment of foreign joint ventures and the transfer of leading-edge technology to China as market access concessions for foreign businesses seeking to penetrate the vast Chinese market. During 1998, over US$19 billion was allocated for IT infrastructure development. Much support is also provided to businesses through Chinese university R&D. China's total estimated IT market during 2000 will reportedly be worth some US$120 billion, much of it potentially for military applications.

Ministry of Information Industry statistics indicates that in 2000 China has more than 20 million computers and an electronic information network with a wideband that covers most Chinese cities. More than 34,000 Chinese companies have registered their domain names on the Internet, with more than 1,500 Chinese e-commerce websites by 1999. By the end of May 2000 the official number of Internet users in China had topped 10 million but the actual total is probably much higher and still growing. China is now second only to the US in absolute numbers. China now also has the world's second-largest fixed telephone network and the third-largest mobile telephone network. By the end of May 2000, China had 124 million users of fixed telephones (expected to grow to 180 million by year-end) and more than 56 million cellular phone users. China's telecommunications operation and service sectors saw over 27 per cent growth to reach 123.47 billion Rmb yuan in revenue in the first five months of 2000. During the same five-month period, the sales turnover of the manufacturing sector of IT products increased by 32.7 per cent to 200.7 billion Rmb yuan.

China's exports of IT products increased by 43.5 per cent on yearly basis to 59.94 billion Rmb yuan in 1999. In the same five-month period, China manufactured 2.08 million personal computers, more than doubling the figure for the same period of last year. During 1999, official statistics indicate that China produced 4.15 billion integrated circuits (IC) (a 12.6 per cent increase over 1998), 47.26 million programme controlled switchboards (a 53.6 per cent increase over 1998), and 32.03 million mobile telecommunications facilities (a 44.6 per cent increase over 1998). The Minister of Information Industry, Wu Jichuan, predicted in March 2000, that China's overall IT sector would have an annual growth rate of 20 per cent over the next decade, three times the projected growth rate for the national GDP. In 1999, the IT sector accounted for 3.4 per cent of China's GDP but contributed 10 percentage points to GDP growth. Such growth will be largely stimulated by large state procurement programmes, as well as a domestic and business demand for personal computers (PCs) - the world's second largest market following the US. Significant support is also provided to domestic IT businesses through Chinese government institute and university R&D.

The Ministry of Information Industry now controls over 70 R&D institutes formerly under the jurisdiction of the ex-Ministries of Electronics Industry and Posts and Telecommunications, with the goal of encouraging them to become increasingly financially independent and commercially-oriented. The first Chinese *minban* (i.e. non-governmental collective) IT firm was Cathay Silicon Valley founded in 1983. It was soon followed by others such as the Stone Group Corporation of Beijing, all linked to the Chinese Academy of Sciences (CAS). The Founder Group was linked to the former Ministry of Electronics, as are other major firms such as the Panda Electronics Group Company, the China Great Wall Computer Group, and the Taiji Computer Company. The Chinese Academy of Telecommunications Technology is also currently establishing a 'hi-tech enterprise group'. Also see Appendix A for a detailed listing of defence-related organisations subordinate to the Ministry of Information Industry.

The China National Electronics Import and Export Corporation is headquartered in Beijing but has a major presence across China. Controlled by the Ministry of Information Industry and ultimately managed by the Xinshidai Group under COSTIND, it is believed to be China's primary authorised organisation responsible for the export of military electronics systems. Products include air, naval and army radios and radars, air defence systems, navigation systems, optical systems, cryptographic equipment, mine detection equipment, fibre and laser optics, command, control and communications systems, electronic warfare systems, simulators, and Western and former-Eastern bloc components and spare parts.

The China National Instruments Import and Export Corporation is another major SOE involved with the import and export of computer equipment, satellites, ground stations, radar, telecommunications equipment, broadcasting equipment, remote sensing equipment, navigation, air surveillance and optical equipment, material testing machines, electronics, and related testing equipment.

The China Ping He Import and Export Corporation provides military electronics technology for the PLA General Staff's General Equipment Division. The China Xiaofeng Technology and Equipment Corporation is subordinate to COSTIND, with an advanced technology specialisation in computers, testing equipment and robotics, and an import and export co-ordinating role similar to that of the Xinshidai Group. The China Zhihua Corporation Ltd. reports to the Communications Department of the PLA General Staff. It specialises in communications, computer-image processing and navigation equipment. The Southwest Institute of Electronic Equipment is reportedly the PLA's primary electronic warfare (EW) and electronic countermeasures (ECM) research establishment.

The Guangzhou Communications Research Institute is directly subordinated to the Ministry of Information Industry. It is engaged in the R&D of mobile communications systems and networks, including digital multi-path radio relay systems, 'telemelring, telecontrol and telecomms (T3) systems', communications terminals, power supplies, antennas, security systems, piezoelectric devices, electronics ceramics and crystals.

The Shanghai Avionics Corporation is an AVIC firm based upon the former Chinese Aeronautical Radio Electronics Research Institute and the former Shanghai Aero-Electrical Appliance Plant. It has advanced facilities that include a system simulation laboratory, microwave anechoic chamber, environment test laboratory, computer centre, CAD laboratory, and an optical illumination laboratory. The corporation's main areas of R&D and product development include avionics and systems integration technologies, radio communications, radar, computer and software, display control, microwave test and measurement, electromagnetic compatibility, optical fibre data communications, and aeronautical illumination.

It should be noted that aerospace/defence-related electronics centres are apparently much more evenly distributed throughout China compared to the civil/consumer electronics-manufacturing sector. The overall IT sector is mostly concentrated in Guangdong, Jiangsu, Fujian, Zhejiang, Shandong, Beijing, Tianjin and Shanghai. In 1999, Guangdong became the first province to produce an annual IT output volume that exceeded 100 billion Rmb yuan.

The location of China's military-industrial complexes in the remote regions of central provinces to protect them from potential military threats (the so-called Maoist 'Third Front' strategy dating from the 1960s) has ensured their isolation from today's more prosperous coastal SEZs. This has made current efforts to modernise, relocate and diversify such plants very costly. Table 9.1 summarises some of the large numbers of current IT production and R&D clusters in China by province and city, with an emphasis on those that are probably aerospace and defence related.

Table 9.1 China's Information Technology Clusters

· **Beijing**

- Aviation Industries of China Corporation (AVIC)
- Beijing Broadcasting Equipment Factory
- Beijing Computer Technology and Application Institute
- Beijing Control Instrument Institute (33rd Institute)
- Beijing Guanqunjinchen Software Company Ltd.
- Beijing Institute for Telemetry (Technology)
- Beijing Institute of Radio (Metrology and) Measurement
- Beijing Lantong Electronics Company, Ltd.
- Beijing Institute of System Engineering
- Beijing Nonferrous Metal Institute
- Beijing Number Three Radio Equipment Factory
- Beijing Research Institute for Telemetry (703rd Institute of the First Academy)
- Beijing Ruixing Computer Technology Company
- Beijing Simulation Centre
- Beijing Stone Group Company
- Beijing University
- Beijing University Institute of Microelectronics

- China Aeronautical Computing Techniques Institute

- China Aerospace Industry Corporation (CAIC)

- China Electronics Corporation, Research Centre for Computer and Microelectronics Industrial Development

- China Carrie Enterprises Ltd. (Kaili Corporation)

- China Electronics Systems Engineering General Corporation

- China IC Design Centre, Tsinghua University

- China National Electronics Import and Export Corporation

- China National Instruments Import and Export Corporation

- China Ping He Import and Export Corporation

- China Xiaofeng Technology and Equipment Corporation

- China Zhihua Corporation Ltd.

- Chinese Academy of Surveying and Mapping

- Computer Research Institute of the National University of Defence Technology

- Dawning Group Corporation

- 1st Research Institute of the Ministry of Public Security

- Founder (HK) Ltd.

- Galaxy New Technology

- Hangwei Medical Systems Company, Ltd. (12th Institute)

- High and New Technology for Peace and Development Company Ltd.

- Intel China Research

- Intelligence Control Research Institute of Third Research Academy

- Intelligent Computer R&D Centre

- Institute of Computer Applications and Simulation Technology of the Second Research Academy

- Legend Computer Group Company/Institute of Computing Technology, CAS

- Microelectronics Research and Development Centre

- Ministry of Information Industry

- Ministry of Posts and Telecommunications

- National Engineering Research Centre for Application Specific Integrated Circuit (ASIC) Design

- National Engineering Research Centre for Data Communications

- National Engineering Research Centre for Parallel Computer

- National Research Centre for Intelligent Computing Systems

- National Semiconductor Material Engineering Research Centre of Beijing Non-ferrous Metal Research Institute

- Taiji Computer Company/Huabei Computer Technology Institute

- 3rd Research Institute of the Ministry of Public Security

- 35th Research Institute of the Third Research Academy

- Zhang Yingxin Research Institute of TV and Electro-Acoustics

· **Anhui Province**

- East China Research Institute of Electronic Engineering, Hefei

- Hefei Cryoelectronics Institute, Hefei

- Number 41 Research Institute, Bengfu

- Xun Fei Information Technologies of the University of Science and Technology of China, Hefei

· **Gansu Province**

- Lanzhou Physics Institute, Lanzhou

· **Guangdong Province**

- Guangzhou Communications Research Institute, Guangzhou

- Guangzhou HuaMei Communications Ltd., Guangzhou

- Shantou Institute of Electronics Technology, Shantou

- Shenzhen STS Microelectronics

- Shenzhen Super Computer Electronic Company Ltd., Shenzhen

- Zhuhai Kexing Development Company, Zhuhai

· **Hebei Province**

- Hebei Academy of Sciences, Institute of Lasers, Shijiazhuang

- Shijiazhuang Huawei Defence Electronic Engineering Company, Ltd., Shijiazhuang

· **Heilongjiang Province**

- Harbin Institute of Technology

- Research Group of Inertial Navigation, Harbin Shipbuilding Engineering Institute, Harbin

· **Henan Province**

- AVIC Research Institute Number 613, Luoyang

- China National Quality Supervision and Test Centre of Explosion-Proof Electrical Products, Nanyang

- Luoyang Optoelectro Technology Development Centre, Luoyang

- Luoyang Institute of Electro-Optical Equipment (Luoyang Electrical-Optical Equipment Research Institute), Luoyang

- Luoyang Institute of Tracking and Telecommunications Technology, Luoyang

- National Engineering Research Centre for Switching System, Zhengzhou

- 27th Research Institute, Ministry of Electronics Industry, Zhumadian

· **Hubei Province**

- Central-South China Company/China National Posts and Telecommunications Appliances Corporation

- Hanguang Electronics Plant, Xiaogan

- Wuhan Maritime Communications Research Institute, Wuhan

- Huazhong Electro-Optical Technology Research Institute, Wuhan

- Zhongnan Optical Instruments Factory, Zhicheng

· **Hunan Province**

- National University of Defence Technology, Changsha

· **Jiangsu Province**

- Jiangsu Huaning Electronics Group, Nanjing

- National Engineering Research Centre for ASIC System, Nanjing

- National Engineering Research Centre for Flat Panel Displays, Nanjing

- National Engineering Research Centre for Mobile Satellite Communication, Nanjing

- National Laboratory of Solid State Microstructures, Nanjing

- Nanjing Electronic Devices Institute, Nanjing

- Nanjing Marine Radar Institute, Nanjing

- Nanjing University, Nanjing

- Nanjing Xuguang Instruments Plant, Nanjing

- Panda Electronics Group Company, Nanjing

- Jiangsu Automation Research Institute, Lianyungang

- Jiangsu Shugang Optoelectronics Instrument Factory, Yangzhou

- Number 607 Institute, Wuxi

- Yangzhou Marine Electronic Instruments Research Institute, Yangzhou

· **Liaoning Province**

- Dalian Dongfu Colour LCD Screen Factory

- Dalian Marine University, Science and Technology Development General Company, Dalian

- Dalian Warship Academy Missile Department, Dalian

- Shenyang Polytechnical University, Shenyang

· **Shaanxi Province**

- Baocheng General Electronic Corporation, Baoji

- Changling (Group) Company Ltd., Baoji

- China Aeronautics Computing Technique Research Institute, Xi'an

- China Xi'an Botong Telecommunications Information Company, Xi'an Communication University, Xi'an

- Datang Telecommunications Corporation, Xi'an

- Flight Automatic Control Research Institute, Xi'an

- Hunan Electronic Device Plant, Luonan

- IBM-Botong (Xi'an) Software Development Centre, Xi'an

- National Speciality Laboratory of CAD/CAM [computer aided design/manufacture]

- Ordnance Industries of China, 206th Research Institute

- Qing'an Aerospace Equipment Corporation, Xi'an

- 39th Research Institute of Mechanical-Electrical Industry, Xi'an

- 210th Institute of the Second Academy, Xi'an

- Xi'an Electronic Engineering Research Institute, Xi'an

- Xi'an Intelligent Instrument Equipment Company, Xi'an

- Xi'an Research Institute of Navigation Technology (20th Institute of the Ministry of Electronics Industry), Xi'an

- Xi'an 613 Institute, Xi'an

- Xi'an Space Automation Company, Xi'an

· **Shandong Province**

- Shandong Optoelectronic Instruments Plant, Tai'an

· **Shanghai**

- Advanced Semiconductor Manufacturing Corporation

- China Huahong Microelectronic Ltd.

- Erasable Memory Device Packaging and Testing Factory (Intel)

- Fudan University

- Intel Structure Lab

- Shanghai Avionics Corporation

- Shanghai Institute of Laser Technology

- Shanghai Radio Equipment Research Institute (Shanghai Institute of Electronic Communication Equipment Engineering)

- Shanghai Scientific Instruments and Materials Corporation

- Shanghai Xinyue Instruments Factory

· **Sichuan Province**

- Chengdu Aero-instrument Company, Chengdu

- China Leihua Electronic Technology Research Institute, Neijiang

- China Southwest Electronic Equipment Research Institute, Chengdu

- Southwest Research Institute of Technical Physics, Chengdu

- Xinghua Instruments Plant, Qingshen

- Xinguang Electronics Devices Factory, Chengdu

· **Tianjin**

- Tianjin Electronic Materials Research Institute, Hexi

- Tianjin Institute of Laser Technology, Nankaiqu

- Tianjin Navigation Instruments Research Institute, Xinqiao

· **Zhejiang Province**

- Hangzhou Electrical Connector Factory/Institute, Hangzhou

- National Engineering Research Centre for Optical Instrumentation, Hangzhou

9.2 Hong Kong Connection TOP

The Hong Kong Industrial Technology Centre Corporation, formally established in March 1995 as a business incubator and technology transfer centre, has assisted with the formation of various leading-edge IT-based local businesses. It undertakes active co-operation with various Chinese central government and provincial science and technology agencies. The technology centre was established in collaboration with the Hong Kong Government's Industry Department, the Hong Kong Productivity Council, the Hong Kong Polytechnic Industrial Centre, and the Hong Kong University of Science and Technology. It is a key component of an underlying strategy to make Hong Kong and the surrounding Pearl River Delta region the future 'Silicon Valley of Asia' and plans are currently underway for its expansion (i.e. 'Tech Centre Two').

By the end of 1996, senior management at the centre had indicated that 'Chinese high-tech companies, for example in the aerospace industry, can take advantage of Hong Kong business expertise and gain better access to information and markets.' Meetings were held during 1997 and 1998 with mainland aerospace-defence organisations such as the Xi'an Aeronautics Computing Technique Research Institute, AVIC, and the China Aerospace International Holdings Ltd. In 1997, it was announced that 'the transfer of sovereignty to China will signal a more active position for the Tech Centre as a facilitator of technology exchange between Hong Kong and the mainland.'

The Industrial Technology Centre is now actively undertaking such collaboration with the MOST and its various provincial and municipal government level subsidiaries. During June-July 1997 a 'Technology for Tomorrow' high-tech exhibition was jointly organised by Hong Kong and mainland China, featuring superconductors, lasers, advanced materials, robotics, satellites and various ITs. The centre has continued to co-operate with various mainland advanced technology conferences and exhibitions. For example, it organised a technology study mission to Israel during June-July 2000 aimed at industry collaboration in such areas as IT, telecommunication, multimedia, software, semiconductors, electro-optics, and lasers. In 1999, a similar mission was sent to Silicon Valley in the US and resulted in various memorandums of technical co-operation.

Hong Kong remains a significant conduit to mainland China for advanced foreign dual-use IT. For example, after the United States imposed a ban on defence-related technology to China in 1989, Hong Kong firms supplied China with Vax computer systems, milspec versions of which are used for advanced military systems such as the US Joint Surveillance and Target Attack Radar System (JSTARS). Examples of Hong Kong firms, institutes, R&D and products that have potential enabling technologies with innovative aerospace-defence applications are summarised in Table 9.2. Of course, it is not implied that all such Hong Kong high-tech firms are supplying technology to the PLA but merely that such an important avenue exists and is possibly being employed.

Table 9.2 Hong Kong Based Advanced Information Technology Enterprises and Areas of Technical Expertise

· Asia Vision Technology Ltd. - computer vision, image processing systems and generalised alpha-numeric character recognition system.

· Asia Corporate Information Ltd. - intelligent document management systems.

· BYGS Systems Ltd. - CAD systems, formal description techniques technologies.

· Broadcast Design Group - satellite broadcasting equipment (for example, multiplexed serial digital facilities), project management, design and installation.

· Cellu Ware Research Technology Ltd. - geographic information systems (GIS), global positioning systems (GPS), cellular and non-cellular telecommunications systems (e.g. Mobile Radio Network Planner product for mobile radio communications).

· Centro Digital Pictures - advanced multimedia hardware and software.

· China Electronic Information Technology Ltd. - Chinese language interface/shell for popular computer user platforms and operating systems (e.g. Windows series) using multilingual processing systems that allows the input of Chinese characters using *Pinyin, Canjie, Jianyi* and *Wubi* phonetic systems.

· Cirkisys Technology Ltd. - radio frequency product design, mobile telecommunications, direct frequencer generators.

· Compass Technology - advanced integrated circuit packaging services.

· COSCOM RF - application oriented low voltage and power consumption hybrid RF devices and circuits, and novel radio architectures.

· Digital Research Laboratory - display technologies for computer platforms.

· Display Research Laboratory - video processors, infrared technologies.

· Ever Media International Ltd. - products and services related to digital video encoding and decoding, and digital compression (e.g. Internet/intranet Remote Monitoring System RealCam 5000 security product), Web-based remote video monitoring systems.

· Fucom Company Ltd. - shipping industry management systems, Internet infrastructure and software solutions.

· Fumiyama Corporation (H.K.) Ltd. - low-cost GPS navigation system development.

· FutureSoft Ltd. - CAD and computer-aided engineering (CAE) systems, including relational data-base management systems and intelligent graphic modelling.

· GPS Services Ltd. - customised development of satellite-based GPS for various applications including fleet management, security, navigation and surveying (for example, the GPS Mobile Targets Tracking System).

· Group Sense Ltd. - electronic data-base with voice output and speech recognition capability.

· Hi-Tech Workshop Ltd. - computer simulation systems for engineering and physical and material sciences systems.

· Integrated Solutions Ltd. - manufacturing information systems.

· Hong Kong Polytechnic Industrial Centre - image compression systems.

· Hong Kong University of Science and Technology, Technology Transfer Centre and Hong Kong Telecom Institute of Information - neural networks, pattern recognition, computer vision, machine intelligence, fuzzy logic, speech recognition, fibre optics, data transmission, and digital video signal processing.

· Infomaster Ltd. - developed a Chinese electronic data interchange (EDI) system in co-operation with China's Jiao Tong University to the international X.400 network standard.

· Information Technology Inc. - image compression systems.

· InfoTalk Corporation Ltd. - develops natural speech recognition in various languages and processing technologies for user-machine interfaces and telecommunications systems simultaneously for Chinese and English.

· Innovative Technologies Ltd. - electronic circuit high-current surge protection devices, resettable intelligent fuse systems to automatically protect electronics from over-current and over-temperature conditions.

· Intelligent CAD/CAM Technology Ltd. - CAD, manufacturing, engineering and product data management systems, parametric solid modelling and finite element analysis.

· Integra Antennas Ltd. - 900 MHz, 1.8GHz and 2.4GHz internal antennas for wireless communications systems, measurement and evaluation of radiation exposure.

· InterDigital Corporation/Hong Kong Productivity Council, Electronics Services Division - broadband Code Division Multiple Access digitisation technology used for military communications by modulating all channels with special codes over a broad spectrum, Time Division Multiple Access digitisation and multiplex technology, and CAD systems.

· LECCO Technology Ltd. - database application performance enhancement software.

· Legend Group/Beijing Legend Group - Hong Kong/mainland joint venture, production and technology transfer in electronics, computers and communications; has Silicon Valley office to obtain first hand information on leading-edge US technologies.

· MAT Technologies - electronics and telecommunications products including DES-based data security cards (operations in both Hong Kong and mainland China).

· Media60X - mobile wireless Internet applications.

· Mind Dynamic Technologies Ltd. - artificial intelligence (AI) and database applications for resource scheduling and timetabling applications.

· Motorola Asia-Pacific Division - semiconductors, custom transistors, 0.8 micron wide triple layer metal gate array transistors, etc. (has recently established a mainland manufacturing facility at Tianjin).

· Nivana Technology Company Ltd. - design of highly efficient video compression algorithms, with real-time monitoring and recording of remote images, for digital video surveillance systems.

· NUCO Automation Engineering Company Ltd. - microprocessor-based systems for precision control and process automation, intelligent controller cards, signal processing.

· PCS Technology Research Group Ltd. - R&D of protocols and systems for mobile communications, narrow-band, high-compression data transmission for time-sensitive information.

· PolyMedia Technology Company Ltd. - agent-based security and integrity management systems within a client-server framework in Internet/intranet environments, video-on-demand and other multimedia systems.

· Prima Design - CAD/CAM systems.

· Resource Technologies Ltd. - object-oriented AI systems, including a check-in counter allocation system for civil aviation, scheduling software for port operations (i.e. logistics), and potential network management and command and control applications.

· Rising More International Ltd. - GIS and computer-aided facility management custom software.

· Signal Communications (SiCOM) Inc. - full duplex compression digital voice and data transmission systems, state-of-the-art video and audio compression techniques and products, digital signal processing, video and speech encoder/decoder chip sets, remote video surveillance systems conducted over conventional telephone lines.

· Silicon Graphics Inc. (local office of US firm; other subsidiaries in Beijing, Shanghai and Guangzhou) - visual computing for technical and business applications, and supercomputers; conducts R&D at the Hong Kong Industrial Technology Centre Corporation.

· Sintek Semiconductor Ltd. - customised semiconductor devices to the one micron level, very large-scale integrated (VLSI) circuits, low-power operational amplifiers, mixed-signal products, reverse engineering of chips, single chip integrations of several smaller chips, re-layout and redesign of memory chips, and full capacity for the design of various CMOS (complementary metal-oxide semiconductors), SRAMS (static random access memories), ROMS (read only memories), and EPROMS (erasable programmable read only memories); offers consultancy services to mainland China.

· Spectra Technologies - infrared telecommunications, electronic business systems.

· Splineware Graphics Systems Ltd. - advanced CAD/CAM and automation technology.

· Sprint Technology Ltd. - encryption techniques.

· SunTEK Computer Systems Company - software development for major database management systems.

· SuperLogic Technology Ltd. - large data-base development and management.

· Tantulus Design Company - multi-functional programmable control boards with full multi-tasking and real-time performance for industrial, instrumentation and security applications.

· 303 Company Ltd. - integration of fingerprint recognition and smart card technologies.

· Universal Networks Company Ltd. - innovative network security server development for remote networking and dial-up networking applications.

· Valence Semiconductor Design Ltd. - design, development and manufacture of customised ASICS and other chips used for telecommunications, computer and other applications.

· Valery Ltd. - voice synthesis Voice Read Only Memory chips, EPROM technology, wafer fabrication, and design at the sub-micron level.

· Veridata Ltd. - development of advanced audio and video compression and encryption technologies for secure communications systems.

· Web Force Unlimited - Internet and intranet cross-platform communications.

9.3 Enabling Technologies TOP

The IT area includes a broad spectrum of inter-related technologies and applications areas. These include: avionics; instrumentation; computers; electronics and microelectronics; electrical systems; infrared and laser systems; radar; command, control, communications, computers and intelligence (C^4I) systems; identification and navigation systems; flight control; target acquisition; fire control; ECM; EW systems; IW; all-weather systems; fly-by-wire, fly-by-light and active controls; flight data recording; training simulation; and air traffic control (ATC).

China is moving towards being increasingly self-sufficient in many of these areas. While still seeking an influx of advanced foreign technology to fill technical gaps, China is now essentially self-sufficient in the basic IT building-block components of semiconductors and dielectric/magnetic devices, with numerous domestic organisations involved with their R&D and production. China reportedly has at least 330 semiconductor plants, 25 of which produce entire ICs; the Changhong Corporation and the Caihong Corporation are reportedly major defence electronics specialists. China's primary strategy is to import advanced IT technologies and products under license but with the underlying intent of gradually becoming self-reliant through the resulting upgraded domestic capabilities. R&D and design work is undertaken both at independent research institutes and research units at manufacturers. Specific areas of current Chinese technical emphasis for advanced manufacturing include CAD/CAM applications systems, industrial control computers, computer integrated manufacturing systems (CIMS), and industrial control systems. Simultaneously, the central government has recently tightened restrictions on the use of the Internet and other international computer networks by Chinese citizens for national security and ethical/cultural concerns.

In 1999, China consumed some 40 billion Rmb yuan of ICs but only 20 per cent of this supply was provided by domestic producers. The majority was provided under foreign licenses. However, in February 2000, it was announced that Shanghai's S&T Park would become a national base for the production of domestic IC designs.

The 863 R&D support programme is currently funding research for:

· the design, super-fine processing, packaging and testing of quantum-well semiconductors;

· intelligent computer systems and AI applications;

· optoelectronic components and integrating techniques for remote sensing, computing and communications applications;

· VLSI circuit applications; and

· information acquisition and processing technologies for intelligent automation systems, real-time satellite image processing, weather forecasting, and ocean surveillance.

Chinese laboratories are reportedly undertaking research on quantum logic devices that are miniaturised at the atomic level. In 1999, the China Science and Technology University established a laboratory devoted to quantum telecommunications research, including quantum code, quantum computation coding, quantum logic elements, and quantum computers. In 2000, the Bell Lab Chinese Academy of Basic Studies was established to undertake fundamental research on networking, telecommunications software, optical telecommunications, computational studies and applied mathematics. This is the first basic research laboratory founded by Bell outside of the USA.

Other recent IT R&D projects supported by the '863', Torch and National Key Technologies R&D Programmes have included manufacturing techniques for special purpose ICs, and submicron IC technology, 32 bit 'super microcomputers', high-speed parallel processing computer systems, and flat panel display systems. Flat television screens manufactured by the Xiahua Electronics Company reportedly reached international technical performance levels in 1999. The Beijing Lantong Electronics Company, Ltd. is currently developing ionic crystal display systems and large liquid crystal display screens with foreign investment support. Digital compression and transmission technology is being developed as part of national programmes for the R&D of digital high definition television (HDTV) and digital audio broadcasting being conducted by the MOST, Ministry of Information Industry and the Ministry of Radio, Film and Television. In 1998, China reportedly successfully developed digital HDTV systems and broadcasting, only following the US and some Western European nations in its implementation, after a two year development programme. China is believed to have developed its first military liquid crystal display (LCD) panel during the mid-1990s at the Ministry of Machine Building's Research Institute Number 55. In 1999, the Dalian Dongfu Colour LCD Screen Factory, began the mass production of colour LCD screens derived from Japanese and Taiwanese technology. China is today one of the world's largest manufacturers of colour LCD screens. It has also recently pioneered a video telephone system employing LCDs and regular telephone lines.

Digital telecommunications switching systems have been developed by the Ministry of Posts and Telecommunications, the PLA Information Engineering Institute, and the Xi'an-based Datang Telecommunications Corporation. The China Aeronautical Radio Electronics Research Institute is a key avionics R&D centre, while the China Aeronautics Computing Technique Research Institute is a key centre for the development of airborne computers and aerospace software. The Tianjin Electronic Materials Research Institute, Hexi, Tianjin, is a comprehensive research institute specialising in the R&D, testing, and production of specialised electronic materials including semiconductor materials, gallium arsenide, and fibre optics, as well as computer software, including AI systems.

A number of critics have doubted the PLA's ability to implement a RMA that emphasises IT/IW tactics due to both a shortage of modern hardware and an indigenous software development capability. A lack of sufficient applied software development has also recently proved to be a major constraint for the expansion of China's commercial IT sector. However, the Torch Programme has now established software development parks at: Chuangzhi Software Park in Hunan Province; Qilu Software Park in Shangdong Province; Dongda Software Park at the Northeast University, Harbin, in Heilongjiang Province; and the Tuopu Group's Western Software Park, Chengdu, in Sichuan Province. This is in addition to software development bases in Beijing, Tianjin, Hubei and Hangzhou. Recent software park developments have included systems for 'city public security comprehensive information'.

In 1998, IBM signed a series of major agreements with the Ministry of Information Industry, Systems Inc., the Great Wall Computer Company and CAS to develop various software applications. These were designed, *inter alia*, to overcome the then anticipated Year 2000 ('Y2K') computer systems problem, to develop Chinese language versions of the Java operating system and to provide an impetus to electronic-business. The Java application is intended to provide 'a breakthrough for China's software sector to bridge its gap with its international counterpart'. The 'Chinese Penguin 64', developed in 2000 by China's Institute of Software, is the world first 64-bit Chinese Linux operating system. This is a true Chinese operating system for Web and software development, and organisations with high-capacity needs (e.g. the PLA). IBM also established the IBM-Botong (Xi'an) Software Development Centre as a joint venture with the China Xi'an Botong Telecommunications Information Company, Xi'an Communication University.

Powerful anti-computer virus software has been developed by the Beijing Ruixing Computer Technology Company, which has reportedly seen application in Japanese Toshiba laptop computers as well as various domestic Chinese computer platforms. Beijing University spin-off Founder (HK) Ltd. is now reportedly one of China's major sources for electronic publishing software. GIS software is being produced by the China Geology University, the Shenzhen Yadu Graphic Software Company Ltd., the Founder Group, and the Wuhan Surveying and Mapping University.

In 1999, the US firm Radyne ComStream Inc. co-operated with the Beijing Aerospace Satellite Applications Company to provide high-speed corporate intranet and digital satellite communications earth station technology to the China Qingdao Haier Group to link its facilities throughout China. In September

2000, the Haier Group announced the establishment of a design company for integrated circuits and software located at the Beijing Zhongguancun Science and Technology Park. China has recently created a world standard in super video CD technologies.

The largest information network in the country, the China Public Multimedia Information Network (first established in 1995 as Chinanet and subsequently expanded), is projected to become the largest intranet in the world. In 1999, China announced a 'Government Online Project,' encompassing government websites and services from a number of ministries. These include a 'China 20,000 national defence research results' database and an online government procurement system.

In terms of hardware technical parameters such as circuit feature size and diameter of wafer substrate, in 1995 China was thought to be some five years behind the current state-of-the-art. However, by 2000 it can be expected that many of these problems will have been overcome due to the combination of China's own research activities (e.g. Fudan University in Shanghai has recently demonstrated research capabilities for VLSI chips and silicon-germanium devices) and the ongoing massive influx of foreign assistance. During 1995, 1 micron IC production technology was achieved by Chinese R&D centres. Most major IT production firms have now obtained ISO 9000 quality certification.

Motorola has been the largest foreign investor in China's electronics industry (some US$1 billion by 1997), and is actively transferring advanced semiconductor and software technology. Some recent unconfirmed reports indicate that Motorola semiconductor chips are being used in the latest PLA electronic anti-personnel mine systems. In 1998, Motorola and Nanjing University's National Laboratory of Solid State Microstructures established a joint venture for the R&D of the fundamental properties of ferroelectric thin film materials for advanced non-volatile low-power/low-voltage microcomputer memory applications.

The Mitsubishi-Stone Integrated Circuit Company Ltd. (a Chinese-Japanese joint venture between Mitsubishi Electric Corporation, Mitsui Company Ltd., and the Beijing Stone Group Company) is reportedly producing 20,000 eight inch silicon chips per month with a precision of 0.5 to 0.35 microns, and up to 210 million ICs of various kinds per year. The company will have the largest production base of its kind in China.

In 1997, China's former Ministry of Electronics Industry and the Japanese firm NEC announced the establishment of a nearly US$1.5 billion joint venture for an advanced IC and semiconductor VLSI circuit project to be located at Shanghai's Pudong New Area (China Huahong Microelectronic Ltd. or 'Project 909'). NEC, the world's second largest microchip maker after the Intel Corporation, announced in August 2000 that it will double its microchip output in China and invest US$339 billion to increase output at joint ventures in Shanghai and Beijing.

In 1997, the National Semiconductor Material Engineering Research Centre of Beijing Non-ferrous Metal Research Institute also announced the development of a 'vertically-pulled silicon single crystal of a diameter of 12 inches (300 mm), isolength 400 mm and weight of 81 k', and the implementation of China's first 200 mm polished chip production line in 1998, also part of the so-called '909 Project' for 0.35 to 0.5 sub-micron IC production with an annual capacity for 200,000 CZ silicon monocrystal wafers. China claims it is 'one of the few countries in the world who have mastered (this) technology'. China Huahong has also invested over US$30 million in California's Silicon Valley for joint venture and advanced technology transfer development.

A China-France joint venture, Shenzhen STS Microelectronics, located in Guangdong Province's Shenzhen SEZ, is reportedly currently annually producing and/or assembling over one billion application specific semiconductor ICs (e.g. telecommunications, computers, consumer electronics, automotive, and industrial automation and control systems). Production is expected to double to two billion during 2000.

In 1998, the US firm Intel announced that it would invest US$50 million to establish an IT R&D centre in Beijing. Intel China Research will undertake research activities related to Internet applications, phonetic identification, and Chinese applications software. Intel has also established an Erasable Memory Device Packaging and Testing Factory and the Intel Structure Laboratory, both located in Shanghai. In 2000, Intel Technology (China) Company, Ltd. launched its second phase US$200 million expansion project for a packing/testing factory for flash memory semiconductor chips in Shanghai's Pudong Waigaoqiao free trade zone.

During 1998, the Ministry of Information Industry predicted that by 2000 China would be capable of sealing and packaging three billion units of ICs annually, due to the application of new materials and new technological processes developed by some 13 research institutions, including Qinghua University. Western, South Korean and Japanese firms, such as Fujitsu, Panasonic, Alphatec, SGS, Hyundai, DuPont, AMD and Samsung, are all currently establishing joint venture and self-owned advanced IC packaging and test facilities in China that will probably spin-off and diffuse various innovative IT capabilities.

The Xi'an Space Automation Company was established in the Xi'an High and New Technology Industry Development Zone in north-west China's Shaanxi Province during July 2000. The new company was jointly organised by the Xi'an Changfeng Science and Technology Industries Group Company, the Beijing Space Petrochemical Technological Equipment and Engineering Company, and three other companies. It has a registered capital of over 53 million Rmb yuan. The founding of this company was a major initiative of the China National Space Machinery and Electronics Group Corporation to take part in the western China development drive. The new firm is to undertake the development of automation engineering and equipment, mechanic-electric integration engineering and equipment, computers, networks, intelligent metres and instruments, and technical services.

China has reached self-sufficiency in printed circuit board (PCB) production, and as of the mid-1990s had some 400 PCB manufacturing facilities. However, technically it recently still trailed the global leaders in this area, with miniaturisation usually not below the 0.5mm level, although prototype developments have recently been in the 0.1mm range. These facilities are located across China and are under the jurisdiction of various ministry-level organisations including the Ministry of Information Industry, AVIC, CAS, etc. China began domestic PCB production during the 1980s, but has benefited since from significant technology transfer activities from US firms such as DuPont, Japanese firms such as Panasonic, and various European companies. The coastal regions of Guangdong and Shanghai are areas of particular foreign joint venture and technology transfer activity.

Important recent PCB operations include:

· Baoji Number 4503 Factory (Jianguang Machine Factory), Baoji, Shanxi;

· the city of Baoding, Hebei, with three or four collective firms that reportedly produce good quality etching equipment;

· Wujing Special Equipment Factory, Changzhou, Jiangsu - a joint-venture with Hong Kong's Lida Company;

· Guizhou's Factory Number 4506, with technology transfer from Germany's Siemens, has a likely military production role, and is the site of a central government technology demonstrator model production line; and

· Chongqing University, Sichuan, and related factories (e.g. Factory Number 903 controlled by the China

National Nuclear Corporation) in the same province.

The University of Electronics Science and Technology of China, the Taiji Computer Corporation, and the 15th Research Institute are now active in the R&D of advanced microprocessor-based systems. The Taiji Computer Corporation's Huabei Computer Technology Institute participated in China's atomic and hydrogen bomb tests. It also completed the computer projects for the survey and control systems used for the launching of China's first satellite, the first ICBM launched to the South Pacific, SLBM launches, and geosynchronous satellites. The institute now conducts activities in basic research (e.g. large scale parallel processing technology, multimedia, AI, and mainframe/super-computers), software, and applied technology such as microcomputers and systems engineering for large state projects.

Precision alloys related to electronics such as magnetic, thermal bimetal, resistance, electric contact, etc., have been developed by the Aeronautical Materials Research Institute and the Kunming Noble Metal Research Institute. The Precision Machinery Research Institute has responsibility for associated advanced manufacturing techniques. In September 2000, the Qinghua Yinna High-Tech Development Company, Ltd. and the

Sumitomo Special Metals Co., Ltd. of Japan signed an agreement on the patent licensing of high functional rare earth neodymium-iron-boron permanent magnets used for computer drive mechanisms, high-grade audio components and aerospace electrical machinery. China produces 18 per cent of the world's annual output value of magnetic materials.

In 1996, the Beijing University Institute of Microelectronics developed deep-trench isolating, self-alignment and polycrystal silicon emitter advanced bipolar technologies, which are critical for supercomputer, telecommunications and fibre optic transmission systems. Advanced high-speed GaAs ICs and field effect transistors have also been developed by this institute. The Lanzhou Physics Institute has reportedly undertaken research on yttrium-barium-copper superconductor samples processed in microgravity on recoverable FSW-1 spacecraft, and related to advanced semiconductor development.

In 1997, CAS and the US firm Hewlett Packard established a memorandum of understanding for collaboration with CAS's Information Security Technology and Engineering Research Centre, which is undertaking the R&D and application of information security technology. During the same year, the CAIC and the US firm Digital moved towards establishing a joint venture for the development of a 'ARM chip based network computer'.

In 1997, the former Ministry of Post and Telecommunication's Wuhan Institute announced the development, under the '863' Programme, of synchronous digital hub and single-cell network telecommunications systems capable of data transmissions of 155 Mb/s, 622 Mb/s and 2.5 Gb/s, with a system of 2.5 Gb/s linking Haikou and Sanya over some 328 km. The Wuhan Institute is also active in the development of optical cable networks and during 1998 claimed that China has the largest optical cable network in the world.

In 1998, 'China's first large standard intelligent network, the advanced CIN system, reached its designed requirements since its coming into operation on the military network of the Beijing Garrison early this year'. The system was funded as a national priority for the development of 'the nation's intelligent network project' under the '863' Programme. It was developed by the National Centre of Digital Switching System Engineering of the Julong Corporation, the National Key Lab of Programmed Switching and Telecommunication Network of Beijing Post and Telecommunication University, and the National Computer Research Centre subordinated to CAS's Institute of Computation. During 1997, the Chinese Academy of Telecommunication Science and Technology announced the development of the SCDMA project for developing an intelligent antenna as part of a wireless communications system with synchronous Code Division Multiple Access (CDMA) technology of multiplex radio frequencies. The computer-based China Science and Technology Network had from 1994 to 1997 interconnected some 200 universities and 100 research institutes. Internet users in China are being supported with access through the Public Computer Internet Network and China Golden Bridge Information Network programmes linking together some 1,000 national computer networks.

China is undertaking R&D on micro-electro mechanical systems (MEMS) at various research institutes but until recently such research was said to lag behind the state-of-the-art efforts of the US, Japan and Europe by five years or more. China, however, has an active MEMS devices and related systems foreign technology transfer programme. In 1999, the world's lightest electromagnetic mini-motor with a weight of 12.5 mg. was developed by the Information Storage Research Centre of Shanghai Jiaotong University. It has a maximum rotation speed of 18,000 rpm and an output torque of 1.5 micro newton-metres, and is expected to have space, aviation and mini-robot applications. The integrated manufacturing technology used to develop the motor is believed to be of a world-class level.

Other areas of advanced IT enabling R&D where China is probably now starting to catch up with the West include silicon germanium semiconductors, E-beam lithography for the manufacture of sub-0.15 micron devices, mini-electronic displays, ASIC, copper interconnects for high-density semiconductors, digital cameras, reconfigurable computing, and the merging of logics and memories through embedded memories. Fudan University, Shanghai, is reportedly conducting ASIC and VLSI R&D.

China also has various avenues of foreign dual-use and defence electronics transfers to choose from. Foreign suppliers were well represented at a Chinese military-sponsored international defence electronics exhibition during June 2000 in Beijing. Major world military electronics developers such as Israel market advanced systems to the PLA, as well as major European manufacturers such as Acatel, Racal Electronics, Marconi and Thomson, and US firms, in the event of sanctions being lifted, such as Agilent Technologies, Tektronix and Teradyne.

9.4 Programme Applications TOP

9.4.1 Microelectronics and Avionics

If Hong Kong's semiconductor production is included with China's, China is now the world's third largest producer after the United States and Japan. During the 1970s China had a self-sufficiency policy for IC technology development but during the 1980s this changed to a policy to stimulate massive foreign advanced technology transfers and joint ventures. Foreign partners have included AT&T, Intel, Motorola, Mitsubishi, National Semiconductor, NEC, Philips, and Toshiba. Currently there are over 330 semiconductor plants in China, of which 25 produce ICs and the remainder discrete devices. The largest and most advanced producers include: the Shanghai Belling Microelectronics Manufacturing Company; the Advanced Semiconductor Manufacturing Corporation, Shanghai; the Hua Yue Microelectronics Company, Shaoxing; the Huajing Electronics Group Company, Wuxi; and the Shougang NEC, Beijing. In September 2000, the Philips Group's first joint venture semi-conductor production enterprise went into production at Dongguan City in Guangdong Province. It covers 15,000 square metres, with an investment of 1 billion Rmb yuab over the next two years.

The first Chinese designed and copyrighted 16-byte microprocessor chip was developed by Beijing University during early 2000 for applications such as palm computers, intelligently controlled equipment and telecommunications systems. In November 1999, the Tianyin Company of China Science and Technology University developed the first computer able to speak and understand Chinese (computer-based verbal interactive technology). The Data and Knowledge Engineering Institute (Jincang

Company) of the Chinese People's University, Legend, Hysense, and Sangxia are currently developing palm-sized mobile data-base systems through support from the '863 Programme'. Notebook-type computers, or *bijiben*, are particularly popular with the PLA.

Avionics integration technology was also made a priority during the late 1970s. The Avionics Research Institute developed an integrated system of aircraft communications, navigation and identification. Integrated head-up and head-down displays and related mission software were developed at the Aircraft Fire Control Research Institute and the Suzhou Aircraft Instrument Factory. By 1986, China had acquired an avionics test aircraft (American Citation II aircraft from the Cessna Aircraft Company) with an automatic data acquisition and real-time processing capability, in addition to French airborne equipment flight test data acquisition systems. The Flight Test Research Institute has operated various other avionics test aircraft for R&D on communications and navigation airborne equipment, radar and flight instrumentation.

The use of US Collins avionics systems has today become common by both large and small Chinese airlines and the company has subcontracted production to China since the late 1970s. In 1994, Collins signed a licensing and technical co-operation agreement with the Suzhou Instrument Factory for the EFIS-86T electronic, multifunction display, flight instrument system for the K-8 trainer/light attack aircraft, and the EFIS-85 for the Y-7 transport. Rockwell Collins has reportedly established avionics service centres in Shanghai and Beijing, to complement its Shanghai avionics distribution facility.

Recent unconfirmed reports have indicated that Israel has illegally transferred to China computer and avionics technologies that it jointly developed with the US during the 1980s and then abandoned. These systems could be used to upgrade the avionics levels of Chinese fighters to a level at least comparable to Taiwan's F-16s. Israel Aircraft Industries' avionics package for the J-10 could be similar to the Northrup F-5 Plus upgrade system, which comprised: an Elta El/M-2032 multimode, pulse-Doppler fighter/attack radar with look-up/look-down detection capabilities; 'hands-on-the-throttle-and-stick' systems; HUD; video recorder/camera; multifunctional displays; helmet-mounted sight; and an integrated EW suite.

A number of avionics-related joint ventures with Western firms have recently been established. Honeywell partnered Shanghai Avionics Company in 1995 to produce Mode S transponders for the domestic and global markets, including PLA aircraft. Honeywell air data computers for the Boeing MD-80 and MD-90 series are manufactured by the Chengdu Aero Instrument Company under a 1993 agreement. Collins Air Transport Division has teamed with the Leihua Electronic Technology Research Institute for the co-production of WXR-700 weather radar receiver-transmitter and TCAS-2 sub-assemblies. Collins has components built by the Chang Feng Machinery Plant in Suzhou and uses the China Aeronautical Radio Electronics Research Institute for product software verification. It is also pursuing GPS joint ventures in the Chinese market. Of course, specific direct PLA defence opportunities continue to be off limits to US firms.

9.4.2 Electronic and Information Warfare

Information warfare includes:

· intelligence-based warfare (i.e. 'cyberwar' where intelligence is electronically fed directly into operations such as targeting and battle damage assessment systems);

· cryptography;

· aspects of EW (e.g. network/electronic attacks on command, control and communications systems);

· electromagnetic and microwave weapons used to destroy or corrupt data;

· on-line defensive and offensive intelligence 'netwar' operations (disinformation, misdirection, agitation, deception, disruption, etc.);

· economic and cultural IW, 'spoofing' (i.e. substituting deceptive messages for real ones);

· computer and network viruses and 'logic bombs';

· psychological operations (PSYOP) concepts as 'hacker warfare' (intruding into victims' network systems via Internet links, often for the perpetrator's wanton enjoyment);

· 'information blockades';

· 'information terrorism';

· 'semantic attacks';

· 'intrusion' (intruding into victims' computer networks to directly cause economic losses); and

- 'cracking' (sharing of computer viruses through network files or those transmitted via e-mail, causing computer systems to crash or lose data).

The use of many of these concepts will be more closely related to intelligence operations rather than traditional military operations.

The PLA General Staff has reportedly established a high-level 'Leading Group of Information Warfare' to develop related strategies and tactics. Indeed, some recent reports have suggested that the PLA is to establish a dedicated IW service branch. However, according to some sources the PLA General Staff's Fourth Department (Electronic Resistance and Radar Department; Si Bu Tongxin Bu*)* has primary responsibility for EW R&D, and assists the PLA Third Department's foreign ELINT, COMINT and SIGINT collection and analysis activities. The Fourth Department is reportedly quite large, with thousands of staff and numerous monitoring stations established across China, and has been in a growth stage since the 1980s. It analyses satellite ELINT data, and co-ordinates PLA ELINT activities at the Military District, Group Army and Division levels, and is also probably highly involved with IW efforts.

Tactical EW efforts are a major part of the PLA's IW strategy, with the ongoing development of advanced intercept, direction-finding, active and passive jamming, other ECM and ESM (electronic support measures) systems for all services. Various Chinese military researchers have recently discussed such concepts as taking control of an enemy's information system without destroying it through 'technological and strategic means', the military consequences of deceptive electronic information and information overload, and IW training, doctrine and operations requirements. Discussions have also focused on seeking 'measures by which to launch vital strikes in future warfare, so as to damage the enemy's intelligence gathering and transmission facilities, and weaken the enemy's information warfare capacity'.

Exploiting the vulnerability of enemy military and commercial computer networks (i.e. 'cyber attacks') may be a specific focus of the PLA's IW and asymmetrical warfare efforts according to recent reports by the US Department of Defense's Office of Net Assessment and the Central Intelligence Agency. At least one source has claimed that China has the largest programme of this type in the world. Other recent US reports have claimed that Chinese 'hackers' have already penetrated Department of Defense computer networks and undertaken industrial espionage against US firms. The PLA's perspectives on IW have been detailed by various publications from organisations such as the Academy of Military Sciences but its overall practical challenge is to develop and procure the actual IT hardware and software to implement such theory. In 1985 a PLA officer called Shen Weiguang wrote a book called *Information Warfare* that delved into a theoretical analysis of the topic. In 1999, PLA Colonels Qiao Liang and Wang Xiangsui, published a book entitled *Unrestricted Warfare: Assumptions on War and Tactics in the Age of*

Globalisation, which openly advocates the use of IW, as well as terrorism, environmental degradation, narcotics trafficking, media and financial wars, as well as 18 other asymmetrical tactics and strategies, to create 'a war on many fronts...the war of the future' to blunt the Western edge in advanced conventional military technologies.

Senior Colonels Wang Bawarn and Li Fei, writing in the 13 June and 20 June 1995 issues of the *Liberation Army Daily*, provide an extensive theoretical basis for the PLA conception of IW:

"*Combat operations in a high-tech battlefield environment in which both sides use info-tech equipment or systems in a rivalry over the power to obtain, control and use information. Information warfare is a combat aimed at seizing the battlefield initiative with digitised units as its essential combat force.*"

Another recent PLA sponsored publication, *America, Russia and the Revolution in Military Affairs* has further warned:

'Those who believe that the current revolution in military affairs will be under the control of the United States or can develop only according to the speed and direction set by the United States are extremely wrong and quite dangerous.'

According to these views, the seizure, control and use of information is the essence of IW. This ranges from substantive destruction (the 'hard kill' of enemy headquarters, command posts and command control and intelligence centres) to EW (electronic jamming or use of electromagnetic devices to attack enemy information and intelligence collection systems such as communications and radar), military deception (operations such as tactical feints to shield or deceive enemy intelligence collection systems), operational secrecy, and psychological war (including the use of TV, radio, and printed materials to undermine enemy morale). The two general areas of IW are thought to be info-protection and info-attack through computer virus warfare, precision munitions warfare, and stealth warfare (all future war will be a struggle between stealth and detection). It is predicted that land, sea, air and space warfare will be highly integrated, and that the combat lines among service arms will be hard to distinguish.

The PLA's future RMA is being discussed in terms of long-range combat, outer space combat, 'paralysis combat', computer combat, and radiation combat. Major General Zheng Quishing specified in an article in the *Liberation Army Daily* of 16 July 1996, the requirements of local wars fought under high-tech conditions in terms of computer 'calculation capacities', the volume of telecommunications, the reliability of information, and improved real-time reconnaissance capabilities. 'Limited war under high technology conditions' (*jubu zhanzheng zai gaojishu tiaojian xia*), China's traditional strategy of "pitting the inferior against the superior" (*yilie shengyou*), striking a mortal blow with one massive pre-emptive strike (*yizhan ersheng*), and aiming for an opponent's weak point with so-called 'acupuncture warfare', are all also concepts within this rubric.

IW differs from the classic passive listening methods of ELINT, COMINT and SIGINT, in that it undertakes active measures to disrupt the enemy communications and electromagnetic-related capabilities. While much of the growing volume of PLA literature on IW and RMA are discussions on current and projected Western (particularly US) capabilities, and some Chinese concepts verge on science fiction, this line of military thought continues to impress foreign observers with its innovative approaches. For example, information is viewed as a weapon that can inflict injuries to enemy information systems (e.g. communications networks, news media, and computer hardware and software) through deception, occupation (or information overload), contamination, blockage and sabotage, and 'guidance' (or the transmission of misinformation). Direct IW attacks are intended to directly disrupt enemy command, control and communications capabilities, while indirect attacks are aimed at enemy morale and *esprit d'corp* (i.e. through combined IW and PSYOP techniques).

'Non-contact engagements' resulting from increased accuracies through the integration of reconnaissance, timeliness and precision, are intended to emphasise detecting the enemy first, anticipating actions, and emphasising manoeuvre, concealment and avoidance over firepower. This has led to notions of a new category of IW special forms, termed variously as 'network warriors', 'special warfare detachments', 'invisible forces', and 'information corps'.

Other recent innovative Chinese IW concepts have included 'virtual reality warfare' through the use of fabricated media propaganda and imagery, and the direct use of disinformation, disruption and deception methods in enemy command, control and communications systems to cause panic and confusion. A related concept is so-called 'information infiltration warfare', a PSYOP technique where military and civilian propaganda is directly disseminated to the enemy forces in the field to sap morale, as well as boosting the spirits of friendly forces and civilian populations.

The domestic Chinese IT industry is known to be developing IW-related tools, sometimes with foreign assistance. The Beijing Institute of System Engineering is believed to be active in IW development. In 1997, CAS and the US firm Hewlett Packard established a memorandum of understanding for collaboration with the Chinese Academy of Science's Information Security Technology and Engineering Research Centre, which is conducting the R&D and application of information security technology.

In 1998, the Beijing Guanqunjinchen Software Company Ltd. announced the development of an active inner-core anti-computer virus system, 'Kill '98'. It stated that the 'anti-computer virus authorities of the Chinese Ministry of Public Security believed that (this) new computer virus killer is the first of its kind in the world capable of killing viruses in the right moment just when viruses attempt to hurt computer software and hardware'. During the same year the MPS reportedly used 'destructive computer programmes' to disable the websites of Chinese dissident groups. The Beijing Ruixing Computer Technology Company has also recently been active in the development of anti-virus software that has been installed in domestic and foreign computer platforms in China. Xun Fei Information Technologies of the University of Science and Technology of China, Hefei, Anhui, has recently developed software to filter pornography from the Internet, CDs and other IT systems, which presumably could be modified to filter out other types of material deemed undesirable by the state.

In 1999, the Ministry of Science and Technology (MOST) announced that the Internet and Internet security were priority national research areas. The PLA, the Ministry of State Security and the Ministry of Public Security are known to be concerned with China's vulnerability to potential acts of IW sabotage during both peacetime and wartime. They have taken measures to remove 'hidden perils to hardware and software security' through the creation of security filters and specialised tests on all imported electronic equipment, as well as undertaking 'specialised research on computer viruses'. China's Founder Electronics Company has recently developed a new method of Internet security called 'Firebridge' and 'Sharks' that passed an evaluation by the Ministry of Public Security prior to production. 'Sharks' software is said to monitor and filter hacker attacks at any time and does not have an IP address, thereby making it impossible for hackers to detect it. The software can effectively filter distributed denial of service attacks.

A July 1999 report indicated that two Canadian Internet service providers were hit by denial of service attacks against Falun Gongdafa sect websites reportedly mounted by the Beijing Application Institute for Information Technology and the Information Centre of Xin An Beijing. The timing of the reported attacks coincided with Beijing's crackdown against the religious sect. Attacks were also reportedly made against US Federal Aviation Administration computer network servers so that these appeared to originate from Falun Gong site addresses.

During late July 1999, Taipei experienced an electrical blackout that was considered by some analysts to have been an IW attack by China in response to moves by Taiwan to move towards political independence. Taiwan has denied that such an attack occurred and attributed the blackout to a downed power line. By August 1999, hackers from mainland China and Taiwan were attacking each other's government, academic and business websites. However, Taiwan's defence ministry claimed that its military command and control network was protected against such cyberwar assaults. There were also reports in 1999 that in response to the US attack on the Chinese Embassy in Belgrade, Chinese hackers had attacked US government computer information systems that included websites at the White House, government departments, the Pentagon, and the US Embassy in Beijing.

China's EW interests are believed to include airborne early warning, the detection of stealth aircraft, airborne ECM, and anti-radar missile technology. An unconfirmed source indicates that at least six research institutes and four university research groups are conducting R&D on ECM in China. Russian ECM pods (perhaps the Sorbtsiya type) are believed to be a component of China's Su-27 fighter aircraft purchase and technology transfer programme. China reportedly has the most extensive SIGINT capability in the Asia-Pacific region, having developed its own systems with technology inputs from Russia, the US and Israel. SIGINT capabilities have also been strengthened by employing regional ground stations and intelligence gathering auxiliary ships within the context of an overall so-called 'Project 815,' which incorporates a wide range of intelligence systems. The China Southwest Electronic Equipment Research Institute reportedly developed new airborne ELINT systems (such as the BM/KZ 8608, which is thought to have been installed on PLAAF Y-8s) and is believed to be very active in EW research. The China National Electronics Import and Export Corporation has recently promoted the DZ9001 vehicle-mounted ELINT system and ZJ9301-1 manpack ESM suite that can handle three to five threat radars simultaneously. Other recent Chinese EW systems include the JD-1/JD-2/JD-3 anti-missile infrared jammers. Appendix C provides a comprehensive directory of important Chinese EW, sensor and communications systems.

9.4.3 Sensor Systems

China produces a wide variety of radar and other sensor systems for military and civil aviation applications. The 38th Research Institute has developed the JY-16 meteorological radar, while the Jinjiang Electric Machinery Factory produces the JLW-714 weather radar. CTL-88 digital weather radar series products have been produced by the Changhai Machinery Factory, meteorological radar automatic detection systems by the Chuanbei Electronics Industry Company, digital weather radar processing systems by the Nanjing Research Institute of Electronics Technology, and millimetre-wave (MMW) imaging radar by the University of Electronic Science and Technology. Radio telemetry, remote signal and remote control systems are a specialty of the Guangzhou Communications Institute. The 29th Research Institute, Southwest Institute of Electronic Engineering, Chengdu has developed radar reconnaissance and ECM systems. Uninterrupted power supplies for radar systems have been developed by the Hanjing Radio Factory and the Shenzhen Hwadar Computer Software Company.

The East China Research Institute of Electrical Engineering, Hefei in Anhui Province, is a national leader in the production of 3-D radar (JY-14 medium/long-range system), low-coverage radar (JY-9 low-altitude search radar), meteorological radar, digital signal and data processors, ship navigation and millimetre-wave communications systems, and ASIC design and application. Since the late 1970s it has developed the JY series of radars for export. These include the JY-8 3-D radar, the JY-9 low-coverage radar, the JY-10 radar information processing station, the JY-14 medium/long-range 3-D radar, and the JY-16 meteorological radar. It also produces integrated automatic air defence systems and air defence information radars, including the 141-1 solid-state 3-D target indication radar, which is in service with PLA SAM units for medium to high altitude coverage with multi-target tracking, real-time data processing and optimum target assessment and location.

The EFR-1 naval fire control radar is an I-band doppler system with moving target indication processing and cassegram antenna, and is reportedly linked to a TV tracker. The China National Electronics Import and Export Corporation claims it has a target acquisition and tracking capability out to over 30 km on a target of 2 m cross section. Recent Chinese military radars have reportedly included the ST-312 manportable battlefield surveillance radar, the REL-2 shipborne air warning radar, and a trailorborne 3-D radar. This is in addition to reports of a target acquisition radar on a tracked armoured fighting vehicle to operate with the quad-25mm SPAAG (self-propelled anti-aircraft gun) system, and a F30 fire-control radar system with a combined SAM/AAA system and TV/optical backup systems. Chinese radars displayed at the CIDEX-2000 defence exhibition reportedly included the CLC-1 search and track radar for the PZ-95 SPAAG system, the CLC-2 search and target acquisition radar, and the CLC-3 active/planar array radar.

Other current developments in this field include the JL-10A Shen Ying pulse-Doppler X-band fire control radar for the new Xi'an FBC-1/JH-7 fighter bomber. Produced by the Number 607 Institute, Wuxi, and the China Leihua Electronic Technology Research Institute, this radar probably incorporates technologies from the UK, Israel, Russia and Italy. A more advanced version of the JL-10A is believed to be under development, possibly for use on the J-10 fighter aircraft. This radar can simultaneously track 15 targets, compared to 11 for the earlier version, and attack between four to six targets simultaneously, compared to the maximum four in the earlier version. Detection range has been increased to 104 km from 80 km. Chinese terrain-following radar R&D reportedly dates back to the early 1970s when examples of downed US systems were obtained from North Vietnam and reverse-engineered. The systems were then flight-tested on H-5 bombers and installed variants of the Q-5 attack aircraft. A new generation terrain-following radar has been developed for the FBC-1/JH-7 fighter bomber.

The Chinese KLJ-1 radar system is believed to be a licensed copy of the Russian Phazotron Zhuk-27 multi-function fighter aircraft radar that Chinese Su-27s are equipped with. A 1999 report stated that the PLAAF was to receive the more advanced (slotted, flat-plate antenna, with a detection range of between 80 km to 140 km, and capable of engaging up to two aerial or ground-based targets simultaneously) Russian Phazotron Zhemchoug multifunction, fire-control radar for potential integration with the J-10 fighter aircraft. The report suggested that a licensing agreement had been reached for the indigenous manufacture of up to 200 units by 2015. Unconfirmed reports indicate that a domestic active phased-array radar system may also be under development for future versions of the J-10 fighter and the JXX stealth fighter (the so-called 'Project 225' radar). At the CIDEX-2000 defence exhibition in Beijing, literature depicting Chinese passive and active array antenna systems was reportedly available.

During 1996, a solid-state long-range radar warning system was developed by the Ministry of Electronics Industry's Number 14 Research Institute. A CAS electronics research institute has been conducting long-term R&D on synthetic aperture radar (SAR) technology for airborne and space applications. The CAIC has reportedly recently developed a new warning radar system, while the Chinese Academy of Engineering Sciences has developed an 'inverse SAR' technique that is claimed to have 'counterstealth' and 'strategic defence' applications. CAIC Institute 23 has recently reportedly developed the J-231 mid-range surveillance radar for the detection of anti-radiation missiles and stealth vehicles at ranges up to 260 km.

China is believed to have developed national air surveillance over-the-horizon (OTH) radar systems, which use pole antennas similar to those of the Australian Jindalee system since the 1980s. These systems can detect targets at ranges of up to 3,500 km over millions of square kilometres of territorial coverage at altitudes up to the ionosphere.

China is also believed to be conducting research in such areas as laser radar (lidar), ultra-wideband counter-stealth radar, and bistatic and multistatic counter-stealth radars. According to a recent US Congressional report, the PLAAF is developing an integrated national system comprised of 68 radar sites. In 1999, China announced that the China Defence Science and Technology University had developed an advanced system for instant radar wideband polarisation information processing that can improve military radar identification efficiency.

Reports from November 1999 indicated that China may be currently fielding a new revolutionary 'Passive Coherent Location' system, which utilises the pervasive signals generated by civilian radio and television broadcasts to detect aircraft and cruise missiles by analysing the minute turbulence and fluctuations caused by their flight to commercial wavelength signals. The system is passive and its receivers cannot be easily detected or jammed because no focused RF energy is transmitted to provide a signature. It could have important anti-stealth applications, conceivably making many expensive systems such as the USAF's F-117, B-2 and new generation F-22 stealth aircraft more vulnerable to detection.

Sophisticated computer analysis of data derived from an integrated network of inexpensive fixed and mobile antennas could provide specific sensor imagery of targets and three dimensional target trajectories. The US firm Lockheed Martin Mission Systems is said to have recently developed a similar 'multistatic illuminator surveillance' system called 'Silent Sentry' that is largely based upon sophisticated commercial technologies. A 'Tung-Nan' radar university research centre may have been involved with the development of the Chinese system but no other details are forthcoming.

China has also reportedly shown interest in purchasing high-resolution, long-distance ground-to-air radar systems from Russia, such as metre wave length systems that would have a range of up to 300 km and could be used to search for stealth targets. The acquisition of SA-10 BMD systems from Russia also included advanced phased-array 'Flap-Lid-B' radars that can be used to improve China's aerospace early-warning system.

A 1999 report indicated that Chinese front companies in the US had attempted to obtain detailed information on the US Navy's Aegis combat radar information system, which uses advanced phased-array technology. During the same year China announced the successful development of an advanced mobile PLA phased-array satellite communications antenna system developed by a research institute under the PLA General Staff Department. China has been conducting is own ground-based phased-array radar R&D since the mid-1980s.

The China Leihua Electronic Technology Research Institute is an important airborne radar specialist centre, and conducts R&D on firing and aiming radars, multifunction fire control radars, continuous wave radar for missile guidance, pulse Doppler radar, SAR, colour weather radar, and airborne phased-array radar. For the detection of stealth aircraft, it is believed that China is conducting R&D on metre-wave, millimetre-wave, infrared and laser radars and sensors. Some unconfirmed sources claim that China is now capable of producing onboard radar systems of the advanced US APG-68 phased-array class. The 14th Research Institute, Nanjing, is also developing early warning, phased array, HF, and space tracking radars. The 10th Research Institute, Southwest Institute of Electronics Technology, Chengdu, reportedly has defence-related programmes involving UHF, microwave, and millimetre communications and radar equipment. The Beijing Institute for Telemetry reportedly develops advanced guidance systems.

A US$62.5 million PLA procurement programme for Hughes AN/TPQ-37 artillery locating radars was not completed by the US in 1989, although two systems had been delivered to China during 1988. By 1994, the US Collins Air Transport Division had began the transfer of production technology for its WXR-270 (used for the Xi'an Y-7 transport) and WXR-700 commercial aircraft weather radars to a new facility at the Leihua Electronics Technology Institute, Wuxi, near Shanghai.

ATC systems comprise a rather broad area that includes radars, meteorology equipment, communications, navigation, landing aids, instrument landing systems, terminal area and control centre equipment, and related satellite information systems. The PLAAF continues to remain very reluctant to actually share

ATC duties with civilian authorities. It is likely that the majority of China's ATC systems will continue to be operated and purchased by the state for reasons of national defence, although the CAAC will have increasing civil ATC responsibilities.

The 28th Research Institute, Nanjing Research Institute of Electronics has developed ATC systems and ATC display consoles, as C^4I systems. The 38th Research Institute has produced S-band full solid-state primary surveillance ATC radars, intelligent terminals, microwave landing systems (MLS), while the Jinjiang Electric Machinery Factory produces the JLP-797 ATC primary radar. Full solid-state monopulse secondary surveillance ATC radars are a product of the Nanjing Research Institute of Electronics. The 20th Research Institute has developed MLS airborne receivers.

Chinatron markets domestic ATC systems but has limited experience in integrating modern systems. Most airports opt for the purchase of Western technology. Hence, Chinatron has in recent years actively searched for a US joint venture partner (perceived as having the best technology) to modernise its efforts. In 1995, the Japanese Overseas Economic Co-operation Fund provided a 640 million yen loan for the development of an indigenous ATC automated engineering project by the China Taiji Computer Company, the National Meteorology Centre and Sun Microsystems.

The now cancelled US-China Joint Defence Conversion Commission, conceived in March 1994, had planned a flagship project for the creation of a new ATC system that would have upgraded China's existing primarily military system for civilian use. Critics have claimed that this project, with direct co-operation between the US Air Force and PLAAF, would have provided China's with advanced dual-use technologies with military targeting capabilities. Proponents of the project believe that it could have shifted ATC influence from the PLA to the CAAC, improved air safety, and increased business opportunities for US advanced technology exporters.

Other recent US ATC contracts for China have been awarded to Hughes Aircraft (of Canada), Raytheon, and the Airspace Management Systems Division of Westinghouse Electronic Systems. CAAC's North China Regional Administration put Raytheon's Auto Trac ATC system into operation in Beijing during 1996. Raytheon ATC systems are also used at Zhuhai, Zhengzhou, Kunming, Nanchang, Xi'an, Taiyuan, and radar systems at Hong Kong's new Chek Lap Kok airport. The Intergraph Corporation has supplied an integrated digital ATC system. Unisys China (a joint venture between the Unisys Corporation of Canada and the China Meteorological Administration) have developed Doppler weather radar systems for Chinese and Asia-Pacific export applications. Rockwell has been providing products such as airborne weather radar systems and applications software to China since the mid-1970s.

Non-US firms active in the China ATC technology market have included Alenia, Thomson-CSF, Siemens, Marconi, Toshiba, Alcatel, NEC, Marubeni, and Plessey/Siemens. The Italian firm Alenia entered the market during the mid-1970s but did not obtain any major contracts until 1989. In 1994 Alenia received a CAAC contract to provide radar systems for some 33 airports. Thomson-CSF sold about five TSR systems to CAAC during the 1980s. Alenia is a current leader in air traffic management (ATM) systems in the Chinese market, as are Airsys ATM and Siemens.

China's ultimate ATC modernisation plans involve the future use of satellites and ground stations for ATM, specifically, 'Mode S' technology and satellite communications systems. As a experiment in this area, the CAAC is currently using six satellite ground stations to fill radar coverage gaps along several domestic air routes. As a first step towards these modernisation goals, since 1992, CAAC has integrated communication, navigation, surveillance (CNS) and ATM systems that employ satellite navigation and digital data communications technologies in a pilot project at its Beijing region in co-operation with Boeing. Systems used include an Air China GPS-equipped Boeing 737, Raytheon workstations, and SITA and ARINC data networks. Automatic dependent surveillance (ADS) trials and ADS-radar integration were undertaken during 1996. However, it is not known when controller-to-pilot data-link communications using direct VHF, HF and satellite communications systems will become fully operational. The first operational system will probably be used for the Beijing-Harbin-Russia air route region. In 1999, Lockheed Martin Air Traffic Management sold ATC automation systems for new airports at Nanching, Hangzhou, Shanghai and other cities.

During 1996, the 20th Research Institute of Navigation Technology, Xi'an, Shaanxi, collaborated with the CAAC, PLAAF, Daimler-Benz Aerospace, Westinghouse Electronic Systems, and Rockwell's Communications Systems Division, in a major GPS demonstration project for ATC applications such as satellite-based CNS/ATM. Trial systems included HF/VHF data-links, GPS receivers, VHF voice radio, and the Collins AVSAT avionics suite. The project demonstrated the feasibility of VHF data-links in China that provide three-dimensional position reports at two minute intervals out to 1,700 km. A possible method for funding Chinese satellite-based ATC modernisation would be to charge en route and overflight user fees. The Civil Aviation Department of Hong Kong is also currently trial testing future air navigation systems that integrate navigation satellites, avionics and data-link communications for ATC.

Beginning in 1998, China began the quiet development of the world's largest radio telescope (a 500 m spherical dish) in the Karst Valley, Guizhou Province, for astronomical observations. The 500 m FAST aperture-active spherical radio telescope, with a capacity 10 times that of the world's currently largest radio telescope, is to be built for deep space exploration, including the search for extra-terrestrial intelligence. The Xi'an University of Electronics Science and Technology has recently developed a new photo-mechanics electronics-integrated design scheme for new-generation large radio telescopes, reducing weight and cost, while improving tracking accuracy. The 1999 use of SIS receivers for the CAS Zijinshan Observatory's 13.7 m MMW radio telescope at Qinghai was said to be China's first practical breakthrough application of cryogenic superconductivity technology, and "laid a solid foundation for the extensive application of superconductive noise detection technology in national economy and defence".

Other facilities include a 2.16 m optical telescope and a new 4m Large Area Multi-Object Spectroscopy Telescope (or Large Area Multi-target Optical Fibre Spectroscopic Telescope) at the Xinglong Observation Station, Hebei, a new 3 m to -4 m optical telescope at Yunnan Observatory, a one metre optical telescope near Kunming, a 1.26 m IR telescope, a multichannel solar magnetic telescope near Beijing, and two 25 m radio telescopes at Shanghai and Xinjiang. Data from CAS astronomical observatories is reportedly used for China's orbital detection and tracking system comprised of high-resolution optical and radio telescopes and laser tracking devices, which may be able to detect objects in space as small as 10 inches in size and has an obvious military utility. China's major astronomical observatories are located at Beijing, Shanghai, Zijinshan, Yunnan, and Urumqi, as well as the Changchun Satellite Ground Station, the Xinglong Observation Station, Beijing University, the China Science and Technology University, Hefei, and the Nanjing Astronomical Instrument Research Centre.

9.4.4 Communications Systems

A PLA General Staff Department research institute has reportedly developed and implemented an army-wide on-line and general field communications network (a so-called 'Integrated Battlefield Area Communications System') within an advanced automated C^4I system. The PLAAF has also recently fielded a tactical Automated Air Defence Command and Control System. In 1999, it was reported that China is developing an automated command and control system for use at the army group level under a joint programme with Belarus, formerly a software centre of excellence for the Soviet Union. The recent Chinasat-22, or UHF C-band Feng Huo-1, is a military telecommunications satellite that will reportedly be the first of several satellite components for a secure Qu Dian C^4I, high-capacity automated data-link, tactical battle management information system, which will integrate and distribute data from air, land and naval units in real-time. The PLA has recently fielded a digital automatic mapping system for preparing maps in the field that was developed by the PLA Information Engineering University.

Xidian University's Institute of Information Science, reportedly China's most advanced military communications research institute, is conducting key related R&D in speech-signal processing, broadband integrated services digital networks (B-ISDN) and ASIC design. In December 1998, China announced the completion of testing of a new satellite antenna intended to provide real-time tactical battlefield communications for PLA ground forces. A PLA communication network has reportedly been developed in Tibet, based upon satellites and fibre optic systems that stresses survivability through multiple, portable and mobile field components. The China Electronics Systems Engineering General Corporation, Beijing, reports to the Communications Department of the PLA General Staff and specialises in communications and electronics technology and equipment. The 7th Research Institute, Guangzhou Communications Research Institute is also reportedly developing field mobile communications systems and digital mobile communications systems.

During 1998, China's first nationwide air-ground data-link network for civil aviation was implemented, with some 25 ground stations and a network management and data-processing centre, while the Central-South China Company under the China National Posts and Telecommunications Appliances Corporation was seeking foreign investors for the annual production of one million 'intelligent telephones'. China has developed commercially available super error controllers for data signal processing applications in low-data-rate transmission, telephone wire communications, short-wave radio communications, mobile communications and remote radio communications.

A 1996 General Accounting Office report for the House of Representatives on the transfer of US telecommunications equipment to China concluded that:

· numerous civil and military applications exist for broadband telecommunications equipment, such as video-conferencing, remote command and control, and telemedicine;

· specific military applications with encryption devices include the simultaneous sharing of intelligence, imagery, and video between several locations, command and control of military operations using video-conferencing, and medical support and telemedicine between the battlefield and remote hospitals;

· liberalised exports, resulting from the end of the Co-ordinating Committee for Multilateral Export Controls (COCOM) in 1994, of such advanced telecommunications equipment have now made it readily available throughout China;

· synchronous digital hierarchy (SDH) equipment is being manufactured and used to upgrade China's telecommunications networks to international broadband standards;

· the PLA is seeking the acquisition of asynchronous transfer mode (ATM) flexible switching systems and SDH broadband systems (voice, data, images and video, simultaneously at high rates of speed) that will benefit its command and control networks during the next decade; and

· significant ATM and SDH technologies have been exported to China by US firms (e.g. AT&T) and other foreign suppliers (e.g. from the Netherlands) to supposed civil end-users in the long-distance telecommunications market, which in fact have included firms such as COSTIND's Galaxy New Technology (through a joint venture, Guangzhou HuaMei Communications Ltd., made with the US firm SCM Brooks Telecommunications).

COSTIND and Galaxy New Technology have been active in space/missile-related intelligence activities. These reportedly include the transfer of advanced US fibre optics technology that has been used to develop a PLA communications network, which is secure, real-time and resistant to interference from a nuclear electromagnetic pulse (EMP). An encrypted Vsat ground station terminal system for a closed, mobile satellite data transmission network was sold by Hughes to another PLA-linked firm, China Electronics Systems Engineering Corporation, during 1996.

Such activities have shown no sign of abating. During May 1998, the Lockheed Martin built 'Chinastar-1' advanced telecommunications satellite (sold to the PLA-linked China Orient Telecomm Satellite Company Ltd. and COSTIND's Poly Technologies) was launched from the Xichang launch centre. It could provide some communications capabilities for the PLA. Teledesic Holdings Ltd., Seattle, has reportedly considered selling China access to its high-bandwidth satellite communications system, possibly for military applications. The US aerospace industry is pressing for the continuation of such projects because of competitive pressure from European aerospace firms (e.g. Aerospatiale and Matra from France, and DASA from Germany) in dual-use areas such as mobile telecommunications systems.

It was reported during July 2000 that China will probably develop its own CDMA standard. Aided by technology developed and handed over to civilian telecommunications companies by the PLA, the new standard could give China's networks access to additional bandwidth without reliance on foreign technology provided by US firms. The Wuhan Academy of Posts and Telecommunications is active in the development of ATM and optical technology and equipment related to high-speed Internet applications. The trade publication *ChinaByte* reported that China would develop its own third-generation mobile technology, probably time-synchronous CDMA (TS-CDMA) for use with wireless Internet. Chinese companies would develop and hold the intellectual property rights to the technology, which would also receive favourable treatment in China's telecom industry. From 1997 onwards, GSM 900, 1800, and CDMA systems have been developed by Datang Telecommunications, Huawei Techniques, Shenzhen, and Orient Telecommunications, as well as mobile telecommunications systems of their own intellectual property rights.

In November 1999, Zhongxing Telecommunications signed a contract with Yugoslavia's BK Group to provide mobile telecommunications equipment worth some US$225 million, the largest contract of its kind for China to date.

9.4.5 Navigation and Positioning Systems

In the early 1970s the Baoji Aeronautical Instruments Factory developed an advanced four-gimballed gyroscopic magnetic compass integrated with the horizon, which was designated the HZX Heading and Altitude Reference System. Various versions of this system have seen continued use for the J-7III, J-8, J-8II, Y-8, Y-10, H-6, SH-5, Z-8 and other Chinese aircraft.

Air data computers for the J-8 fighter and other aircraft have been developed by the Aeronautical Automatic Control Research Institute and the Chengdu Aeronautical Instruments Factory since the late 1960s. Since the mid-1970s, electro-mechanical analogue air data systems have been replaced by digital systems and new silicon-membrane and vibrating cylinder pressure transducers. These technologies were transferred from abroad to Chengdu and the Taiyuan Aeronautical Instruments Factory. Taiyuan has also developed air data navigation systems.

In the late 1970s the Aeronautical Electronics Research Institute began development of Doppler navigation systems, incorporating Doppler radar, digital computers, control displays, etc., and the VOR/ILS radio navigation receiver (ICAO certified).

The Aeronautical Automatic Control Research Institute initiated research on strapdown inertial navigation systems (INS) since the mid-1960s. By 1977 it had developed its first generation of fluid-floated inertial navigation systems, although with initial mixed technical success. The second generation INS developed in 1986 was the type 563 flexural system, and with its reduced size and the use of microprocessors brought domestic Chinese navigation technology to the global standards of the 1970s.

The Xinghua Instruments Plant, Qingshen, Sichuan Province, specialises in the R&D and production of "military radio time unified standard signalling equipment", radio time frequency measuring instruments, and intelligent mathematics measuring instruments. Systems developed by this firm have been applied to space launch vehicles in 1979-80, underwater nuclear tests, SLBM tests, ICBM tests during 1982-87, and various satellite launch, tracking and monitoring programmes. Current product and R&D areas include high-precision time-frequency timing equipment, Rubidium nuclear frequency standards, quartz frequency standards, automatic testing systems, intelligent digital frequency counters, AC/DC emergency power sources, voltage stabilisers, telecommunications and electronics.

During the early 1980s CATIC imported navigation systems from the Litton Industries Corporation and Collins Radio Company of the United States to modify the Y-8 transport, which resulted in a self-contained navigation capability for military sea patrol duties with an over the sea range of 2,000 km. By 1991 Litton had sold over 250 LTN211 and LTN 311 Omega/VLF navigation systems to China for use on Y-7s, Y-8s and Shanghai-assembled MD-82s.

The Zhuhai Kexing Development Company is reportedly developing command and control central and remote display systems using satellite GPS. The CAIC displayed a GPS system at an exhibition in Beijing during September 1996 that is advertised as having both a 12 channel GPS and a 12 channel GPS/GLONASS receiver. GPS systems are reportedly being configured into China's newest fighter aircraft and missile (ballistic and cruise) designs, with the Northwestern Polytechnical University and the Second Artillery Engineering College reportedly being active in this area. The Beijing Research Institute for Telemetry (703rd Institute of the First Academy) is also reportedly developing terminally-guided ballistic missile warheads for the DF-15 and DF-21 systems that exploit GPS technologies. The Flight Automatic Control Research Institute currently produces a 'Number 583 Inertial/GPS Navigation System' but only with a reported accuracy of 200 m circular error probable (CEP). The Shanghai Avionics Corporation has reportedly developed a satellite navigation landing system that employs a differential GPS receiver and ground station. The 'Change-2 Long-Range Radio Navigation and Positioning System' and other airborne GPS systems are believed to be in use by the PLAAF. China has developed commercially available global transport fleet dispatch systems that synthesise GPS, digital mobile multi-communications, GIS and 'an artificial intelligence database and multimedia system'. Loran-C and GPS have been developed by China's 20th Research Institute and Hwadar Electronics Company Ltd.

Israeli Azimuth Technologies Ltd. and Israeli International Development Company Ltd. during December 1995 created a joint-venture/technology transfer partnership with the Beijing CATIC branch called the Beijing CATIC-Azimuth Electronics Company Ltd. Located in the Beijing Economic and Technological Development Zone, the firm specialises in satellite GPS applications such as navigation and automatic location systems. Modern GPS systems could provide accurate guidance systems for PLAAF aircraft and missiles but could be jammed during a major conflict. GPS systems help eliminate the tendency of inertial navigation systems to drift off course. China is believed to have refined widely available commercial GPS capabilities to provide an accuracy of within 10 m, compared to the normally available 100 m accuracy level.

The new J-8IIM's 563B INS was designed by the Xi'an Number 613 Institute, and its air data computer at the '161 Factory'. Reportedly, Chinese navigation pods have also used French ATLAS pod technology that was sold to Pakistan for use on their F-16A/Bs for use with laser-guided bombs.

9.4.6 Simulation Systems

In 1983 the first Chinese designed computer-controlled panoramic flight simulator was developed for the J-6. Advances resulting from the project included computerised control technology, software, six degrees of freedom hydraulic simulation, and optoelectronic simulation. Emulation systems have been developed for such applications as the infrared control systems of air-to-air missiles. In general, China's aerospace simulator systems are several generations behind the most current level of technology, and are a priority for both civil and military modernisation and training efforts. Various efforts are being made at international co-operation and technology transfer. During 1999, Chief of the General Staff General Fu Quanyou called on the PLA to modernise training programmes through the use of virtual reality simulation technologies.

In 1997 Air China ordered a US$47 million purchase of Canadian CAE flight simulators for its Boeing 747, 737 and 767 aircraft. In 1995 Boeing donated two Boeing 737 CAE flight simulators to the CAAC Flight College, Sichuan Province, which has an extensive range of simulators including those for the Y-5, Y-7, TB-20/200, Bell 206, and Cheyenne 3A. Various Boeing 737, 757, 767 flight simulators are owned by China's major airlines. China Southern's Boeing 777 simulator is located at a new training facility at Zhuhai, south of Hong Kong. China Southern Airlines in 1998 purchased an Airbus A320 simulator training system and updates to existing Canadian CAE Electronics simulators for its Zhuhai training centre, by ordering new CAE Maxvue Plus Visual Systems. Taiwan had planned during 1998 to send commercial pilots to the mainland for training because "mainland China's airlines have the latest simulator models" but this plan apparently did not materialise because of regional tensions.

The Beijing Aviation Simulator Company currently manufactures aviation and space simulators and related subsystems. The Beijing Shu Guang Aeronautical Micro Motor Factory, China National Electronics Import and Export Corporation, and Shuguang Electrical Machinery Factory are also involved with aircraft simulator development and manufacture. An air combat simulator is reportedly under development by AVIC's 'Blue Sky Aviation Simulator Technology Development Centre'. The Dalian Warship Academy Missile Department has recently developed missile launch and fire control simulators for the Second Artillery strategic missile force. The Shenyang Polytechnical University has developed anti-aircraft system simulators. The Yuhe Machinery Plant, Nanjing, Jiangsu, has traditionally been an affiliate of the Headquarters of the General Staff Department of the PLA and specialises in the manufacture of mechanical and electronic military training equipment. In 1995, AVIC's Number 624 Research Institute developed an altitude simulation chamber for aero-engines. The Asia Simulation Control System Engineering Ltd., Zhuhai, developed an all-scale simulation control system for the Qinshan 300MW nuclear power generating unit.

The use of military tactical planning simulation techniques by nations such as the US motivated COSTIND and the former Ministry of Aerospace Industry to establish the Beijing Simulation Centre in 1984. Located at the Second Research Institute of the China Aerospace Industry Corporation, the centre has simulation system divisions for air defence missiles and satellite launch vehicles. It was apparently instrumental in the development of Chinese millimetre wave guidance systems. The PLA Academy of Military Science's Operations Institute is reportedly developing expert AI systems to assist military battlefield commanders. Various research institutes under the PLA General Staff Department, COSTIND, Second Artillery, and the CAIC are said to be jointly developing a ruggedized microcomputer for field use, with other reports indicating a successful testing of a real-time remote-sensing image processor. MBT training simulators are apparently in wide use and in 1999 the PLA's first logistics command simulation training system was announced.

During 1995 the PLA was interested in obtaining sophisticated US computerised war gaming simulation systems and apparently this technology transfer project was advocated by the US Joint Chiefs of Staff as a bilateral confidence-building measure. The status of the project is unclear but it was probably cancelled following China's aggressive stance towards Taiwan in March 1996.

The PLAAF Command College, Beijing, had by 1997 reportedly developed a new air-battle training simulator for defence, attack, support exercises, and combined force operations. Anti-aircraft artillery (AAA) fire-control and command simulators have been developed by the Shenyang Polytechnical University in co-operation with the PLA in 1997. The Zhengzhou Anti-aircraft Artillery Academy has developed simulators for ECM and attacks against helicopters, hovercraft, cruise missiles, etc. The Second Artillery has recently reported the further development of advanced ballistic missile simulation training systems. In 1998, Chinese scientists announced the development of simulations of space-based robotic repair systems for satellite repair and other missions.

During the 1998 Zhuhai Air Show an advanced domed virtual reality flight simulator developed by the Chuangchun Institute of Emulation Technology was displayed, indicating that the PLAAF is now probably using modern air combat manoeuvring instrumentation equipment and the use of simulators to practise aerial refuelling. During 1998, China unsuccessfully attempted to purchase an advanced air combat manoeuvring instrumentation system from the US but some reports indicate that the PLAAF has already established a comparable aggressor training system.

It is not clear if the PLA has training simulators for the Su-27; an unconfirmed report has indicated a domestic Su-27 simulator that is in service with six degree axis motion. It is likely, however, that Western civil aviation simulator technologies and training techniques will be spun-off to the PLAAF and PLAN given the current magnitude of such technical developments in China. Flight simulators have been developed for the J-6, J-7 and J-8 series of fighter aircraft and it may be assumed systems have been purchased from Russia or domestically developed for the Su-27/J-11.

9.4.7 Supercomputers

China is the third country, following the US and Japan, capable of manufacturing supercomputers. The National Research Centre for Intelligent Computing Systems was founded in March 1990 under the CAS's Institute of Computing Technology. As an R&D centre for advanced computer technology it is sponsored through the MOST's '863' R&D support programme. Particular areas of R&D include distributed artificial intelligence, parallel and distributed computer architectures, symmetric multiprocessors, and massively parallel processors. The centre also undertakes a technology transfer function for commercialising the results of its research activities and provides a co-ordinating function by networking researchers from across China and abroad.

The Dawning Group Corporation was spun-off from the centre in 1993 to commercialise the 'Dawning I' symmetrical multiprocessor parallel supercomputer, which can be used to manage very large systems, data processing and computation, scientific and engineering applications (e.g. plasma physics and controlled nuclear fusion) and simulation/emulation applications. The follow-on 'Dawning 1000' massively parallel computer was developed in May 1995 and the even more advanced 'Dawning 3000' (300 billion floating point operations per second) system has recently been developed. In 1997, Quadrics Supercomputer World, a subsidiary of the UK's Meiko and Italy's Alenia Aerospazio, entered a joint development with Dawning to develop new massively parallel supercomputers. In 1996 the US firm Motorola made significant equity contributions to the MOST's new Intelligent Computer R&D Centre. It placed emphasis on advanced computer systems based upon Motorola's semiconductor system structures, and the localisation of advanced Motorola computer software into the Chinese language.

Another massively parallel flexible computing system, the PAR95, was developed by the China Aeronautical Computing Techniques Institute during 1996. The Computer Research Institute of the National University of Defence Technology's 'Milky Way' or 'Galaxy' (Yinhe YH-1 Supercomputer at100 million calculations/second, and the YH-2 Supercomputer at 1 billion calculations/second) distributed client/server supercomputer systems also saw introduction by 1996. Integrated advanced technologies such as 'middleware', AI and multimedia co-processing reportedly have been used for applications that include emulation, space research and operations, defence systems, full digital simulation, and the control of intelligent tool machines. The YH-3 announced in 1997 is reportedly capable of 13 billion calculations per second and is much more compact compared to previous designs in the series. The National University of Defence Technology is also conducting R&D on parallel and distributed computer processing, which was initiated in 1994. In 1998 it established a parallel and distributed processing lab for supercomputer development. Other recent reports indicate the imminent development of a new generation of YH-4 supercomputers capable of performing 1 trillion operations per second.

In June 1999 it was announced that, under support from the '863' Programme, the Tsinghua Tongfang Company and the Computer Department of Tsinghua University had developed the 'Explorer 108.' This is an 'extendable parallel mass computer system' that is capable of 16 billion floating-point operations per second. A supercomputer reportedly capable of performing 384 billion floating-point calculations per second was revealed during July 2000 at the Beijing High-Speed Computer Application Centre. The new supercomputer is called Shenwei-1 ('invincible might") and reportedly ranks amongst the world's advanced supercomputers. In November 2000, another high-speed supercomputer centre is scheduled to begin operation in Shanghai. The Shanghai Super Computer Centre is situated at Zhangjiang High Tech Park in Pudong. It is said to be equipped with supercomputers with a floating computational speed of over 300 billion operations per second. They are being used for major national projects related to meteorological and climatic research, computer and aircraft design, biogenetics, naval engineering, nuclear technologies, etc.

Supercomputing capabilities, in general, are crucial for the development of sophisticated modern aerospace-defence technologies, encryption/decryption, and for strategic defence systems and nuclear weapons simulations. Chinese researchers are reportedly particularly capable in related algorithmic, AI and theoretical applications. Applications include weather forecasting, human gene cloning, image formation of earthquakes and oil exploration. Probable aerospace-defence applications are related to aircraft, space, missile, nuclear and DEW weapons designs. The Harbin Institute of Technology and the Nanjing Public Security Bureau are recently believed to have been provided assistance by Israel's Weizmann Institute in obtaining technologies for computers capable of up to five billion operations per second.

Supercomputers are also an important objective of China's recent foreign technology acquisition efforts. The Cox Report indicates that:

'*Since signing the Comprehensive Test Ban Treaty (CTBT) in 1996, the PRC has faced new challenges in maintaining its modern thermonuclear warheads without physical testing. Indeed, even after signing the CTBT, the PRC may be testing sub-critical or low yield nuclear explosive devices underground at its Lop Nur test site.*

The PRC likely does not need additional physical tests for its older thermonuclear warhead designs. But maintenance of the nuclear weapons stockpile for these weapons does require testing. The ban on physical testing to which the PRC agreed in 1996 has therefore increased the PRC's interest in high performance computing and access to sophisticated computer codes to simulate the explosion of nuclear weapons...

Given the limited number of nuclear tests that the PRC has conducted, the PRC likely needs additional empirical information about advanced thermonuclear weapon performance that it could obtain by stealing the US 'legacy' computer codes, such as those that were used by the Los Alamos National Laboratory to design the W-88 Trident D-5 warhead. The PRC may also need information about dynamic *three-dimensional data on warhead packaging, primary and secondary coupling, and the chemical interactions of materials inside the warhead over time.*

The Select Committee believes that the PRC will continue to target its collection efforts not only on Los Alamos National Laboratory, but also on the other US National Laboratories involved with the US nuclear stockpile maintenance programme.

The PRC may also seek to improve its hydrostatic testing capabilities by learning more about the Dual-Axis Radiographic Hydrotest (DARHT) facility at Los Alamos.'

Furthermore,

'*The PRC's use of high performance computers (HPCs) for its military modernisation poses risks to US national security. Significant improvements in PRC information warfare and military operations may increase the threat to US military systems and personnel in a way that cannot be easily countered. HPCs of varying capability could assist the PRC in this endeavour.*

Further, the PRC is likely to modernise its nuclear arsenal, with the help of HPCs. In this regard, it is believed that, if the PRC maintains its current path, it will still be a second-class nuclear power compared to the United States and Russia for the next several decades. However, if Washington and Moscow were to reduce their nuclear forces to about 1,000 warheads, as President Yeltsin has suggested, the PRC could conceivably expand its nuclear forces in an attempt to reach numerical parity.' *Advanced high-performance computers sold to China by the US and other Western nations are believed to be used for applications in nuclear weapons development, information warfare, cryptography, military command and control, intelligence collection, intelligence instrument R&D, development of high technology, ballistic and cruise missiles, BMD, mobile force development, designing submarine nuclear reactors, and combat simulations. Supercomputers could allow improvements to China's nuclear weapons designs by processing very large amounts of data from covert underground low or sub-kiloton nuclear tests, or by the complete simulation of nuclear tests. US reports during July 2000 indicated that China has been using supercomputers to simulate nuclear weapon explosions.*

China has developed or acquired advanced Computer Integrated Manufacturing Systems (CIMS) for aerospace production.

The latest versions of the J-8 fighter series are the J-8IIM (shown above) and the J-8D series, the latter capable of aerial refueling and is in service with the PLAN and PLAAF with significant upgrades in propulsion, weapons and avionics systems.
(Source: CATIC)

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Ben Sheppard; Dr Howard DeVore

FOREWORD

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China's Aerospace And Defence Industry - December 2000

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FOREWORD

The People's Republic of China's role and influence on the international stage looks set to increase with significant consequences for the region as well as for NATO and its allies. The author of this report, Dr Howard DeVore, believes that the People's Liberation Army (PLA) has different perceptions than that of the West, on overall US military effectiveness. This is particularly so, for US logistics capability, the view of the US as a superpower in decline, and the resulting effects of China adopting a more robust stance against the US and Japanese regional forces in scenarios involving, for instance, Taiwan, South China Sea territorial claims, and Korea.

There is therefore, an overwhelming need to understand the thinking behind, and the implications of the strategic developments and technological advances China makes over the coming years.

This report provides a comprehensive review and analysis of the current status of the People's Republic of China's aerospace and defence Industries. The report also examines the likely consequences for international trade resulting from technological advances being made in China as well as the implications political decisions made by the national government may have on the security and stability of Northeast Asia. The report complements an earlier publication, written by the same author, *China's Aerospace Industry Special Report* which was extensively referenced in the May 1999 Congressional Report, *US National Security and Military Concerns with the People's Republic of China*, sometimes referred to as the Cox Report .

China's Aerospace and Defence Industry provides a comprehensive background to foreign technology transfers, defence project management and key military and commercial programmes. The extent of foreign assistance China has received and the affect this has had on the People's Republic of China's technological developments is dealt with in depth. The report also examines current technological transformation and suggests that there could be a few surprises concerning significant defence programmes such as aircraft carriers and other military systems within the next few years.

This is followed by an examination of aircraft, propulsion, missile, naval, land and space systems technology and programmes as well as weapons of mass destruction, directed energy weapons, and information technologies. This Special Report then concludes with an analysis on the military and technological outlook for the People's Republic of China. The extensive appendices that follow provide an industry directory, including a list of electronic systems, small arms, explosive systems, and unmanned aerial vehicles. Throughout the report there are a series of tables detailing key civil and military R&D, production and storage facilities and programmes. The tables include lists of facilities related to strategic warhead penetration aid development, potential chemical weapons facilities, and possible military applications of US commercial space technology transfers.

This study builds upon and complements two highly successful China *Special Reports* recently written by Dr Howard O. DeVore: *China's Intelligence and Internal Security*, and *Technology, Trade and Investment - China*. These are also published by Jane's.

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