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AIRCRAFT - FIXED-WING - MILITARY, China

Date Posted: 17-Jun-2003

Jane's All the World's Aircraft

CHENGDU AIRCRAFT INDUSTRY

CAC J-10

Chinese name: Jianjiji-10 (Fighter aircraft 10)
Westernised designation: F-10

Type

Multirole fighter.

Programme

Reports of the existence of this new Chinese fighter began to emerge in October 1994, following the detection by a US intelligence satellite of a prototype at Chengdu. Said to be in the weight and performance class of the Eurofighter Typhoon and Dassault Rafale, the J-10 bears a close external resemblance to the cancelled IAI Lavi (see 1988-89 *Jane's*), despite Israeli government statements that fears of unauthorised technology transfer are unfounded. A photograph, released in 1996 by the People's Liberation Army, of a wind tunnel model of the J-10 showed it to be outwardly identical to the Lavi in all essential respects, apart from slightly raised foreplanes and the addition of wingroot trailing-edge extensions.

This was confirmed in January 2001 when an unauthorised source posted a photograph of prototype 1001 on the Worldwide Web (although it was rapidly removed). The photograph showed the artist's impression first published in the 1997-98 *Jane's* to be accurate in all respects, except that it was larger, and fin chord was some 20 per cent greater from root to tip.

It now appears that go-ahead for what became the J-10 was given in September 1988, development by No. 611 Research Institute beginning in the following month. An all-metal mockup was completed by late 1993, but poor performance predictions, coupled with a requirement change from air superiority to multirole, caused some redesign and consequent delays in the programme.

In late 1995, Russian sources indicated that the first flight, then expected during the early part of 1996, would be powered by a single AL-31FN turbofan; first prototype 1001 is now thought to have achieved this milestone in mid-1996. Russian avionics manufacturer Phazotron offered its Zhuk (Beetle) radar (already selected for the F-8 IIM upgrade programme) and the more capable Zhemchug (Pearls) and RP-35 as alternatives to the Elta EL/M-2035 or a derivative.

In late 1997, the slightly modified prototype 1002 was lost in a fatal accident. Two further prototypes (1003 and 1004) had been completed, and designation J-10 bestowed, during that year; the officially announced `first' flight date of 23 March 1998 apparently referred to resumption of flight testing by one of these aircraft. According to China-based sources, 10 AL-31FN engines had been imported by end 1997 and four J-10 prototypes completed. An unofficial CAC source in mid-1999 stated that two prototypes (evidently 1001 and 1003) were then flying, with four others undergoing static test, still being assembled or only just completed; of these, 1004 and/or 1005 may have been static/fatigue test aircraft. Chinese sources at Zhuhai in November

2000 stated that between five and eight J-10s then built and more than 140 test flights made; nine aircraft identified by mid-2002, of which 1007 to 1009 may be preproduction or initial production aircraft, one of which reportedly having made a `first' flight on 28 June 2002. Service entry should be in about 2005 and some may be deployed in the two aircraft carriers that are due to be built by then. Meanwhile, unconfirmed reports in late 2002/early 2003 indicated that 10 J-10s had been deployed with the Nanjing Military Region in August 2002 for operational evaluation or familiarisation training; and that manufacture of the first two two-seat (J-10B?) examples would begin in 2003 and would have enhanced air-to-ground and maritime attack capability. The J-10 failed to make its widely predicted public debut at Zhuhai in November 2002, but it emerged shortly after the show that CAC and the No. 611 Institute had completed conceptual design work on two advanced variants of the J-10: one single- and one twin-engined, both having twin vertical tailfins and embodying stealth characteristics. Both also featured a redesigned and more angular nose section. It has also been noted that in 2002 the *China People's Daily* referred to the J-10 as *Qian Shi* (Attack 10), rather than the *Jian* (Fighter) title that might have been expected. This appears to support the suggestion in some quarters that the aircraft is viewed as a J-7/Q-5 replacement rather than a rival to the Su-27/J-11 to replace the Shenyang J-8.

Customers

Reports have suggested a PLAAF requirement for up to 300, but achievement of this may depend upon China's progress with licensed manufacture of the Sukhoi Su-27 (see entry for Shenyang (SAC) J-11).

Design Features

Tail-less delta wing and close-coupled foreplanes; single sweptback vertical tail with twin outward-canted ventral fins; single, rectangular ventral engine air intake.

Flying Controls

All-moving foreplanes; inboard and outboard elevons; single-piece rudder; wing leading-edge manoeuvring flaps.

Landing Gear

Retractable tricycle type. Main units retract forwards, twin-wheel nose unit rearwards.

Power Plant

One Saturn/Lyulka AL-31FN turbofan (79.4 kN; 17,857 lb st dry and 122.6 kN; 27,558 lb st with afterburning) in prototypes and initial production aircraft. Non-approval of manufacturing licence for this engine indicates possibility of change to domestic (WS10A?) power plant in later aircraft. Fuel capacity reported to be in region of 3,175 litres (839 US gallons; 698.5 Imp gallons) in wings and 1,775 litres (469 US gallons; 390.5 Imp gallons), giving total internal capacity of 4,950 litres (1,308 US gallons; 1,089 Imp gallons). Provision for auxiliary fuel tanks on centreline and inboard underwing stations.

Accommodation

Pilot only, on zero/zero ejection seat (apparently Martin-Baker in prototypes; possibly domestic Jianghan TY6 planned later).

Avionics

Reportedly equipped with quadruplex digital fly-by-wire FCS, GPS/INS navigation, HOTAS controls, a wide field of view HUD, one colour and two monochrome liquid crystal MFDs (weapons, RWR/navigation and radar information), air data computer, 1553B-standard databus and a helmet-mounted weapon sight. FCS based on active control technology developed in F-8 II ACT testbed. Pulse Doppler radar apparently yet to be selected; quoted candidates include Phazotron Zhuk or Zhemchug, domestic (LETRI) JL-10A, Elta EL/M-2035 and FIAR Grifo 2000.

Armament

Recently released photographs indicate 11 external stores points, including one on centreline, tandem pairs on fuselage sides and three under each wing, the outboard wing stations each carrying PL-8 (Python 3) or later AAMs such as PL-11 or PL-12. Other potential weapons could include Vympel R-73 and R-77 AAMs; C-801 or C-802 ASMs; YJ-8K (anti-ship) or YJ-9 (anti-radiation) missiles; and laser-guided or free-fall bombs. Internally mounted 23 mm cannon on port side of nosewheel; provision for a Chinese-developed (Luoyang Filat?) IR/laser navigation and targeting pod.

Following estimated data have not been confirmed.

Dimensions, External

Wing span	8.78 m (28 ft 9½ in)
Length overall	14.57 m (47 ft 9½ in)

Height overall	4.78 m (15 ft 8¼ in)

Areas

Wings, gross	33.1 m^2 (356.3 sq ft)
Foreplanes (total)	5.45 m^2 (58.66 sq ft)

Weights and Loadings

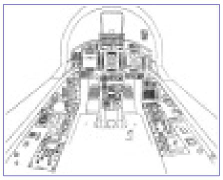
Weight empty	9,750 kg (21,495 lb)
Max internal fuel	4,500 kg (9,921 lb)
Max external stores load	4,500 kg (9,921 lb)
Max T-O weight with external stores	18,500 kg (40,785 lb)

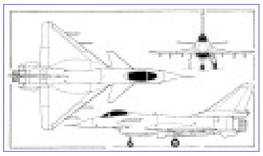
Performance

Max level speed: at altitude	M1.85
at S/L	M1.2
Service ceiling	18,000 m (59,050 ft)
T-O run	350 m (1,150 ft)
Combat radius	250-300 n miles (463-555 km; 287-345 miles)
Ferry range with max internal and external fuel	1,000 n miles (1,850 km; 1,150 miles)
g limits	+9/-3

UPDATED


Unpainted CAC J-10 with a full fit of external fuel tanks


Uncorroborated drawing depicting possible J-10 cockpit layout


Provisional general arrangement of J-10 fighter (Michael Badrocke)


Model of Chengdu's proposed twin-engined stealth development of the J-10 (AVIC I via Y Chang)

Height (m):	4.78
Length (m):	14.57
Max T-O Weight (kg):	18500
Service Ceiling (m):	18000
T-O Run (m):	350
Wing Span (m):	8.78

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ASIA PACIFIC

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JANE'S DEFENCE WEEKLY - MARCH 20, 2002

China to lift veil on its J-10

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Toronto

China could display its J-10 fighter aircraft for the first time at the Zhuhai airshow in November. Built by the Chengdu Aircraft Industrial Corporation, the J-10 attempts to rival current fourth-generation Western fighter aircraft.

China National Aero-Technology Import and Export Corporation (CATIC) officials revealed the news during the Asian Aerospace exhibition in Singapore early in March.

The appearance of an increasing number of images and documents relating to the new aircraft - which a CATIC spokesperson described as "still highly classified" - are providing Western analysts with increased insight into the capabilities expected of Beijing's equivalent to designs such as the Lockheed Martin F-16.

A single-engine, single-seat design, the multirole J-10 will represent a significant capability advance for the People's Liberation Army Air Force (PLAAF), which will operate the type alongside its future fleet of Russian-built and licence-manufactured Sukhoi Su-27SK (NATO reporting name: 'Flanker-B') interceptors. Estimated to have a maximum take-off weight of 18,400kg, the J-10 will likely be powered by a Lyulka Saturn AL-31FN turbofan with a maximum output of around 125.5kN (28,218 lb st). China late last year received its first of 54 AL-31FN engines, suggesting an initial production run of around 50 J-10 fighters.

The AL-31FN's performance approximately matches the 29,000 lb st-plus output of the General Electric/Pratt & Whitney engines that power the F-16 Block 50/52 fighter, although the US platform has a greater fully-laden weight of up to 19,187kg. There is no indication at this time that the PLAAF is interested in acquiring a thrust-vectoring capability from its AL-31-series engines.

An uncorroborated illustration posted on the Internet suggests that the J-10 will have 11 hard points, enabling the aircraft to carry a variety of short- and medium-range air-to-air missiles, air-to-surface weapons and long-range fuel tanks.

Likely armaments for the design include a number of systems from Israel and Russia, as well as licence-built Chinese weapons. If the aircraft's manufacturer were to follow Western companies and introduce conformal fuel tanks into the design, the type's operational range and flexibility could be further enhanced.

Documents supplied to *Jane's Defence Weekly* from a regional air force source (but also posted on the Internet) indicate that the

J-10 will have a western-style cockpit with a head-up display (HUD), up to three large-screen multifunction displays (MFDs) and hands-on throttle and stick controls. UK Royal Air Force (RAF) sources told JDW that the cockpit illustrated here appears well designed for single-seat operations, and that "depending on their computing power, it could be a very capable aircraft".

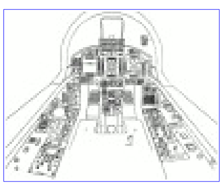
The cockpit is a typically "1980s-style" configuration, said an RAF official, adding credence to long-voiced suggestions that China has benefited from programmes including Israel's development of the indigenous Lavi fighter, which itself leveraged F-16 technologies.

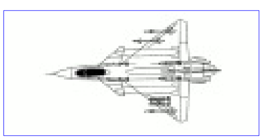
Development of the Lavi, which was in the same weight class and similar in configuration to the J-10, was abandoned in 1987 after 60-plus test flights; several years before the Chinese programme is acknowledged as having been launched. The MFDs illustrated in the J-10 diagram below provide (*left to right*) weapons; radar-warning receiver/navigation; and radar data, with the latter expected to be provided by a design such as the Phazotron-NIIR Sokol or Zhuk fire-control radars. These systems offer a respective detection capability of 180km and 80km in the frontal hemisphere, 80km and 40km in the rear hemisphere, track-while-scan against 24 targets and the simultaneous engagement of up to six and four targets. Another potential candidate for the J-10 is Phazotron's Zhemchug multifunction airborne radar - a further development of the Zhuk system, which has forward and rear hemisphere detection ranges of 120km and 50km respectively, track-while-scan of up to 20 targets and the ability to simultaneously engage up to four threats. A Russian industry official revealed that a 12-strong Chinese delegation visited Russia last October to observe tests of the Zhemchug system, and added that a production contract could be received this year for up to 20 radar sets for China.

Recently posted Internet photographs of the J-10 appear to show two aircraft in test markings. While it is unknown whether these are ground-test vehicles or airworthy platforms, a Taiwanese intelligence source told *JDW* that at least one of the pictures is of a real prototype.

For an aircraft believed to have been in development for almost a decade and well into its flight-test programme, hard facts about the J-10's capabilities remain sketchy.

The type will, however, provide a great capability advance over the PLAAF's current fighter assets, and this factor alone is certain to heighten awareness in the USA and Taiwan about China's ability to project air power within and potentially beyond its borders.


Documents obtained by JDW suggest that the J-10 will feature a Western-style cockpit


Documents obtained by JDW suggest that the J-10 will feature 11 hard points


Taiwanese intelligence sources say the J-10 prototype is genuine


Israel's two Lavi prototypes had conducted over 60 test flights - including in-flight refuelling by an A-4 Skyhawk - before the programme was scrapped in 1987
(Source: IAI-Bedek)


The J-10 programme is believed to have benefited from the abandoned development of Israel's Lavi fighter, the second prototype of which is pictured here at the Israel Air Force museum at Hatzerim airbase
(Source: C Hoyle/Jane's)

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10 Images

AERO-ENGINES - TURBOFAN, Russian Federation

Date Posted: 09-Oct-2003

Jane's Aero-Engines 15

LYUL'KA SATURN INC

LYUL'KA SATURN AL-31

Overview

Powerful fighter engine, one version being the first vectored-thrust supersonic engine in service in the world, and the latest being the engine of Russia's next-generation fighter

The basic design of the AL-31 was Arkhip Lyul'ka's last and greatest achievement. Intended for large supersonic fighters, design started in 1963, and the first prototype engine began testing in August 1974. Today a wide spectrum of advanced derivative engines, some having previously been known as the AL-35 and AL-37, have received AL-31 designations. Licence deals have been discussed, and one with CEC of China is believed to have been concluded. All Russian production, including export orders, is handled by the MMPP Salyut, and development of a major upgraded AL-31F is being carried out in partnership with that company and with Granit, as related under those names. In collaboration with Rolls-Royce, AL-31 gas-generators are used in ship propulsion and gas pumping.

AL-31F

First production engine, fitted with afterburner and matched to the Sukhoi Su-27. Service designation **R-32**, reported to the FAI as the power plant of the P-42 (modified Su-27 prototype) which set 32 time-to-height records in 1986. The AL-31F entered production in late 1981 and received final qualification in 1985. By 1993, about 1,500 had been delivered from MMPP Salyut and UMPO Ufa. In 1990 TBO was established at 900 hours, with a hot-section inspection at 300-hour intervals, but it has since been raised to the 1,000-hour level of the AL-31FP. According to Salyut (which see under that name) the immediate objective is to combine the increased thrust ratings with a TBO of 1,000 hours and 'expected life' of 2,000 hours. The engine is entirely modular, with the ability to replace the nozzle, afterburner, mixer, LP turbine, LP compressor and gearbox without removing the remainder from the aircraft. With the engine installed, it is also possible to replace the 1st LP compressor blades or all rotor stages of the HP spool. A high proportion of the construction is steel or titanium. A particular design feature was to achieve LP and HP compressors which would not surge no matter what might be happening in the sharp-edged aircraft inlet at extreme or even negative AOA, and to eliminate acoustic connection between the afterburner and the LP spool. In 2001 Salyut announced that it had completed the design and testing of an upgraded AL-31F. Its development of the AL-31F is now accelerating and is outlined in the entry on that organisation.

AL-31A

In December 1999, the Russian arms-exporting organisation Rosvoorouzheniye said it was ``establishing a facility in China for the production of spares and repair of AL-31A engines which power Chinese fighters." The factory is managed by LM (see under China). By late 2002 Chinese purchases of Sukhoi fighters and trainers had amounted to 30 Su-27SK, 40 Su-27UBK, and 38 Su-30MKK, all of which had been delivered. Despite the designation Su-30MKK, the Editor understands that these aircraft have fixed-axis nozzles. AL-31A engines modified for single-engined application power the prototypes of the indigenous Chengdu J-10 (F-10). The first prototype underwent taxi trials in late 1997, but the first flight was reportedly `delayed by a major engine malfunction' until 24 March 1998. At that time 10 engines had been ordered for this programme, to power prototypes, and in 2001 a further 54 engines, of the upgraded AL-31FN type (described below) were ordered for production aircraft. Western analysts have suggested that J-10 production for China's PLAAF would probably total about 300. The Editor knows nothing of any plans to produce the J-10 engine under licence, but LM's big contract to maintain similar engines would put them in a strong position should such a decision be taken, and one also cannot ignore India's big purchases of AL-31-engined aircraft (see next).

AL-31FP

Developed from 1988, with features noted in description below. Fitted with definitive thrust-vector control with AL-100 nozzle. The first AL-31 TVC nozzle was tested in 1986. This was then fitted to one engine of Su-27 development prototype No 07-02, flown with this nozzle from 21 March 1989. On 12 April 1996 Su-27 No 711 began testing with two TVC engines linked to the aircraft's FBW flight-control system. All of these early nozzles had ±15º movement in the vertical plane only, driven by the aircraft's hydraulic system. The AL-31FP has the refined AL-100 nozzle with an axis inclined at 32º (handed left/right in the aircraft) to give direct control in both transverse planes and facilitate single-engined flight. The nozzle is driven by two pairs of rams in a kerosene-operating system independent of the aircraft hydraulic system. This engine went into low-rate production in 2000, to power the Su-30MK. Formal service entry, with 20 Sqn, Indian Air Force, took place on 27 September 2002. The IAF expects the 40 (also reported as 32) Irkutsk-built aircraft to be in service by January 2004, following which an additional 140 or 150 aircraft are intended to be built under licence by HAL at Bangalore. It has not been disclosed whether HAL Koraput Division will manufacture the engines for these aircraft but, in July 2002 at the Farnborough Air Show, Sukhoi Director-General Mikhail Pogosian said that Indian production would "allow for joint marketing to other countries." Production rate could be increased following the signing of further Indian or Chinese export orders. It appears to have shocked the US Air Force that, in classified simulations, the Su-30MK consistently mastered the F-15C in a diverse range of engagements. Nozzle TBO is 250 hours, that of the remainder of the engine being 1,000 hours. The AL-100 nozzle has now been integrated with the more powerful AL-37, described separately.

AL-31FN

Developed 1992-94. Increased thrust (maximum 125.5 kN, 28,218 lb st), Fadec control with hydraulic (fuel pressure activation) back-up, and improved fuel economy. Fitted to Su-32 (previously designated Su-27IB), Su-27SM (Su-35) and Su-32FN, all of which have a range of 4,000 km (2,485 miles) on internal fuel. The Su-27SM is expected to be the only multirole single-seat fighter in production for the Russian air force throughout the immediate future. Whilst producing these aircraft, the main production factories at Komsomolsk and Novosibirsk are likely to be heavily engaged in updating earlier Su-27s. Despite tight funding, five SM fighters are scheduled for delivery before the end of 2003. The AL-31FN is probably also the engine fitted to all four fighters (two Su-27s and two dual-control Su-30s, sub-types unspecified) supplied to Indonesia on 27 August 2003 as part of an order much delayed for financial reasons. Eventually the AURI (Indonesian air force) is expected to find money for more.

An AL-31FN version with rearranged accessories (and probably with a different designation) is being supplied to China to power the J-10 single-engined fighter. Powered by a prototype version of this engine, the first of several J-10 development aircraft began its flight-test programme in 1996. An initial batch of 54 production engines was delivered in 2001-2002. Though the prototype J-10 had a fixed-axis nozzle, production aircraft may use thrust-vectoring.

AL-31F/VCN

Refined VCN (vector-controlled nozzle) version, cleared for flat, straight and inverted spins and to airspeed of minus 200 km/h (124 mph). Available in standard or tropical versions.

AL-31F-M1

So-called 'fifth-generation' engine for the upgraded Su-27 derivatives and for the PAK-FA, the next-generation fighter for the Russian Air Force. It is expected that this aircraft will be derived from the Sukhoi S-37/Su-47, with two engines with vectoring nozzles. Brief further details appear in the entry on NPO Saturn.

AL-31ST

Industrial (ST = shaft turbine) engine, developed and marketed in partnership with Rolls-Royce Industrial and Marine Division, see company introduction and UMPO entry.
Except where otherwise stated, the following description applies to the AL-31F:

Type

Two-shaft augmented turbofan.

Intake

Fabricated with 23 solid guide vanes hydraulically driven with 30º movement.

LP Compressor

Four stages slotted into discs (see section drawing). Mass flow 110 kg (243 lb)/s. According to the Salyut motor-building enterprise, a major upgrade on the next-generation AL-31F is a three-stage LP spool, handling a considerably greater airflow.

HP Compressor

Variable inlet guide vanes followed by nine-stage spool with first three stators variable. Easy field replacement of damaged blades. Overall pressure ratio 23. Bypass ratio, AL-31 0.6, AL-31F 0.571.

Combustion Chamber

Annular, with 28 downstream burners fed from inner manifold. Auto continuous ignition during missile launch. AL-31FP, machined chamber with welded fuel burners.

HP Turbine

Single-stage with cooled blades, using air/air heat exchanger in bypass duct. Entry gas temperature up to 1,427ºC. AL-31FP has rotor blades with an advanced coating, and upgraded rear turbine bearings.

LP Turbine

Two-stage with cooled blades. Both turbines have active tip clearance control. AL-31FP, strengthened disc.

Jetpipe

Short mixer section to merge the core and bypass flows upstream of the afterburner.

Afterburner

Two flame-holder rings downstream of multiple radial spray bars. Inter-linked primary and secondary multi-flap nozzles are angled about 5º downwards.

Accessories

Grouped above engine, with main banana gearbox ahead of inlet.

Control System

Hydro-mechanical full-regime control giving smooth variation in power from flight idle to maximum afterburner, even in extreme (for example, negative-airspeed) manoeuvres. Automatic elimination of surge `at Mach numbers 2 to 2.5 when normal, flat and inverted spins occur'. Linked via software to Su-27 fly-by-wire flight-control system.

Dimensions

Length	
AL-31F	4,950 mm (195 in)

AL-31FP, F/VCN	4,990 mm (196.5 in)
AL-31FN	5,000 mm (196.9 in)
Maximum diameter	1,277 mm (50.27 in)
AL-31F	1,240 mm (48.82 in)
AL-31FP, F/VCN	1,277 mm (50.28 in)
AL-31FN	1,180 mm (46.46 in)
Inlet diameter	910 mm (35.8 in)

Weight, Dry

AL-31F	1,530 kg (3,373 lb)
AL-31FP, F/VCN	1,570 kg (3,461 lb)
AL-31FN	1,538 kg (3,391 lb)

Performance Ratings

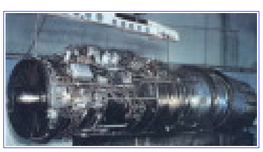
Maximum augmented	122.6 kN (27,560 lb st)
Maximum dry	79.43 kN (17,857 lb st)

Specific Fuel Consumption

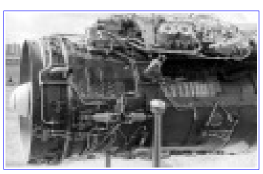
Maximum augmented (typical)	55.52 mg/Ns (1.96 lb/h/lb st)
Maximum dry:	
AL-31F	18.87 mg/Ns (0.666 lb/h/lb st)
AL-31FP	18.98 mg/Ns (0.67 lb/h/lb st)
AL-31FN	19.97 mg/Ns (0.705 lb/h/lb st)

UPDATED

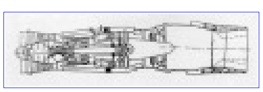
AL-31F showing top-mounted aircraft accessory gearbox, as on all Su-27 variants (Nigel Eastaway)



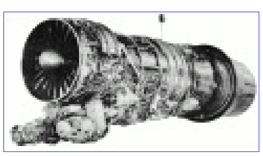
AL-31F, without accessory gearbox



Cutaway AL-31F



Longitudinal section through AL-31F (fixed nozzle)



AL-31FN configured for J-10


AL-31FN for Chinese J-10


AL-31FP showing vectoring nozzle (Yefim Gordon)


Cutaway AL-31FP (Yefim Gordon)


The completely new AL-100 nozzle, ±15º pitch, ±12º yaw (Yefim Gordon)


AL-31F/VCN

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CHAPTER 7 - RUSSIA'S PARTNERSHIP PROGRAMMES

Date Posted: 24-May-2000

Russia's Aerospace Industry - November 1999

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RUSSIA'S PARTNERSHIP PROGRAMMES

Louis Bleriot flew his little monoplane across the English Channel 90 years ago, and in so doing, bravely demonstrated the inherent transnational personality possessed by even the earliest and smallest aircraft. The character of the aerospace industry globally has always been extrovert, and aviation personalities have always been inclined to be daring. Pilots too, the world over, civil and military alike, simply love showing off in front of a crowd. From the earliest days these tendencies have brought both rewards and dramatic reverses - who will ever forget the words of the Airbus test pilot as he ploughed his prototype into the trees at the Paris Air Show a few years ago, "this should make X (an important aviation official watching the display) sh*t his pants" - a foolish, and fatal, act of bravado. However the industry has long required of its test pilots the skill and daring to push technology to its structural limits, and sometimes the temptation to go beyond these limits has brought disaster.

Conforming to the global pattern, the Russian aerospace industry has a tradition of international partnership, back to the earliest years. In the 1930s, the little Polikarpov-designed I-16 fighter gave the Soviet Air Force a technological lead, due in part to the power and reliability of its licence-built Wright Cyclone radial engine. During the Second World War, the UK and USA provided, under the Lend-Lease scheme, vast quantities of military aircraft and aviation technology to aid the Soviet Union's war effort. However, with the ending of the anti-Nazi alliance and the start of the Cold War, technology transfer from west to east featured a new element. When the Soviets assessed an item of western technology to be superior to its home-bred equivalent, the niceties of licence-production would be disregarded, and any means would be employed to bring it to Soviet service. There are some classic examples.

In 1945 the fastest and highest-flying bomber in the world, with the longest range and the biggest bomb load, was the Boeing 'Superfortress', the B-29. Not only was the B-29 far ahead of world competition simply as a flying machine. Its on-board systems included electrical, electronic and mechanical innovations including a complete defensive suite of remotely-controlled gun barbettes. Following the forced landing - or shooting down - of several American B-29 bombers over Soviet territory at the end of the war, the Soviet aviation industry performed a stupendous 'reverse engineering' job, and remade the B-29 as the Tu-4. The work involved more than 900 factories and research institutes, taking more than two years. The Tu-4 eventually had a production run of more than 1,000, and became the USSR's principal strategic bomber until the jet-propelled Tu-16 gradually took over from the mid 1950s. As a footnote, the biter was bit in his turn. The Chinese then reverse-engineered the Tu-4.

In 1947 the most powerful jet engine in the world was the Rolls-Royce 'Nene'. It was so new, and so powerful, that it was not installed on any British service aircraft at the time. A batch of 25 'Nene' and 30 Rolls-Royce 'Derwent' were sold to the USSR, by a decision of the British Labour government which has never really been explained; Stalin allegedly nearly fell out of his chair in surprise when he heard the news. The 'Nene' was quickly remade by the Klimov concern as the RD45/VK1, and put into production. Installed in the then brand-new MiG-15 fighter, the reliable engine with its durable Whittle-designed centrifugal compressor gave this aircraft a performance superior in many respects to its only world rival, the American F-86 'Sabre', demonstrated in combat during the subsequent war in Korea. There is a footnote to this story, too. Extraordinarily, the RD45/VK1 is still serving the Russians today; truck-mounted variants can be seen on airfields as snowclearers, and another version powers the TMS-65, a projector of nuclear, bological and chemical decontaminant for the ground forces in Russian and former Warsaw Pact armies.

Post-Cold War, the Russian aerospace industry has adopted more conventional and acceptable methods of international partnerships, against the backgound of a stagnant domestic economy and derisory Russian MoD orders. In this decade, projects have been developed for joint exploitation of space equipment. Civil airliners made by famous names - Tupolev and Ilyushin- are offered for sale with imported western engines. Military aircraft are offered with western electronics. Licence-production of Russian military aircraft is undertaken, predominantly in India. Russian research establishments, formerly secret and closed to foreign visitors, engage in joint experiments with their former professional opponents. The Russian Government has correctly identified the potential of the aerospace industry to generate income, through sales and international financial support for partnesrhip projects. It is through partnerships in the competitive international aerospace market that quality, intellectual brilliance and innovation will secure a future for the Russian industry.

7.1 India TOP

India is an established military market for Russia but one which Rosvooruzheniye is working hard to develop further. The long-term programme for military and logistic co-operation between Russia and India up to 2000 is estimated to be worth more than US$7 billion. India accounts for about 40 per cent of Russia's foreign military co-operation activities. Within the framework of this programme India has already received MiG-29 aircraft, Tunguska anti-aircraft complexes, rockets and ammunition, and has modernised its MiG-21bis fighters. Rosvooruzheniye delegations regularly fly to Delhi to take part in sessions of the Russian-Indian working group on military and logistic co-operation.

It has recently been announced that India is to lease an unspecified number of Beriev A-50 AEW&C aircraft, acquire nuclear capable Tupolev Tu-22M 'Backfire' bombers and finalise details on the purchase of the aircraft carrier *Admiral Gorshkov*, together with MiG-29K fighters to form its air group. Indian efforts to build an indigenous AEW&C aircraft suffered a setback after the Hindustan Aeronautics Ltd Airborne Surveillance Platform prototype crashed earlier this year. Officials said India required a minimum of three AEW&C aircraft. The purchase of the S-300V SAM has also been discussed, together with the upgrading of Indian Army SA-3s. Licensed production of the Sukhoi Su-30 is due to begin during 2000. *7.1.1 MiG-AT trainer offer*

MAPO is offering India two versions of the MiG-AT trainer with either French (Sextant Avionique) or Russian avionics. Both would have the French Turbomeca Larzac 04R20 engines and both could be capable of carrier operations. According to MAPO's general designer, Vasili Shtykalo, the MiG-AT has a reconfigurable fly-by-wire control system, which is designed to be able to simulate any current combat aircraft in the Indian Air Force. "Our air force is testing the trainer," explained Shtykalo, "orders are confirmed and a contract will be signed as soon as funding is available." The MiG-AT will replace Russia's primary, basic, intermediate and advanced training aircraft with one type, but in India, it is proposed to be the advanced trainer only. MAPO director-general Vladimir Kouzmin confirmed a price of between US$12-13 million for each MiG-AT, depending on configuration and equipment fit. "We will complete development flying in six to seven months, that means full flight development and certification," he said. By Aero India 98, the MiG-AT had flown exactly 400 sorties in 210 hours. The MAPO-MiG factory in Moscow has currently made 16 complete sets of parts for production aircraft with seven of them in final assembly.

7.1.2 MiG-29 offer

MAPO-MiG has also offered to upgrade the India's MiG-29 combat jets to SMT standard. The Indian Air Force currently operates about 60 MiG-29A and UMs. According to MiG estimates the proposals will enhance the combat effectiveness of the MiG-29 by up to four times in the air-to-air role and at least six, possibly eight times in the air-to-surface role. Indian reports

quote the flyaway cost of the Su-30 as US$20 million each, plus US$8 million to integrate the Indian Air Force requirements.
7.1.3 Russia-India LCA partnership

The first test flight of the Indian Air Force's Light Combat Aircraft (LCA) Technology Demonstrator has been re-scheduled, according to Indian Defence Minister George Fernandes. Although it is set to take place by July 1999, military sources remain sceptical. They say it is more likely to be pushed back even further because of technical problems made worse by sanctions imposed by the USA. The LCA project is likely to look to Russia for its development after US involvement ended following Washington's recent economic sanctions and an embargo on exporting military equipment. Official sources have said the LCA's Kaveri engine is likely to be tested in Russia.

7.1.4 Indo-Russian Aviation PVT

After early problems with the supply of spares for India's MiG-29s, this joint venture between MiG-MAPO and Hindustan Aircraft Ltd (India) was established to cover spares and maintenance for the Indian MiG fleets and assume a limited regional service centre role, providing spares and maintenance for Malaysia's MiG-29s (purchased direct from Russia). The MiG plant also undertakes the modernisation of early MiG models.

There are currently a number of programmes underway for the modernisation of MiG aircraft. The programmes that have the highest industrial profiles are:

MiG-21 Upgrade. The MiG-21-93 'Fishbed' was Russia's first pure export modernisation programme, which started as early as September 1991 for India. The contract to modernise 125 Indian MiG-2lbis fighters to MiG-21-93 standard was signed on 1 March 1996 (the initial agreement was concluded as early as April 1993, but the final negotiation of financial conditions went on for some time). The first flight of a Russian MiG-21 modernised to the MiG-21-93 standard was made on 25 May 1995. The first two Indian aircraft were also modernised at Nizhnyi Novgorod. The remaining aircraft are being modernised at Nasik, India. Some elements of MiG-21-93 equipment, such as the radio communications, will be of Indian manufacture. The inertial navigation system, as well as part of the cockpit suite, will be of French manufacture. The service life of the airframe will be prolonged to 4,000 hours (or 40 years). In May 1997, Hindustan Aeronautics signed a contract to upgrade 29 Laotian MiG-21s. Other countries are also interested in this MiG-21 upgrade programme, including Vietnam (about 130 aircraft) and Syria (about 170 aircraft).

MiG-23 Upgrades. The first stage module of the MiG-23-98 upgrade replaces the original avionics with a system on the model of the MiG-29SMT (Mil Std 1553 databus, central onboard computer and 'glass' cockpit). It also provides for the upgrading of the aircraft's radar and weapons. The second upgrade module prolongs the aircraft's service life by up to 2,500 hours. The third module introduces new EW systems, radio communications, and navigation systems. The final module involves updating the ground service as well as improving flight preparation and combat mission planning. A modernisation offer has also been prepared for the MiG-23BN attack aircraft.

MiG-27 Upgrade. With 165 MiG-27L 'Flogger-J' aircraft made between 1986 and 1996, India is currently the world's sole user of this aircraft (Ukraine has several dozen MiG-27s but intends to delete them). An initial agreement between India and Russia on modernising MiG-23s and MiG-27s was signed on 27 September 1994. The scope of upgrade planned for the MiG-27 is similar to that of the MiG-23B98. A modernised MiG-27 with new avionics and 'glass' cockpit was shown in India during the Bangalore exposition of December 1996. Resumption of the MiG-27's production in India is being considered.

7.1.5 Major Russian Aerospace Exports to India

Type	Designation	Units	Ordered	Delivered	Comments
AAM	AA-10a Alamo/ T-27R	(720)	1996	1997	For 40 Su-630MK/ MKI FGA
AAM	AA-11 Archer/ R-73M1	(720)	(1996)	1997	For 40 Su-30MK/ MKI FGA
FGA	MiG-21	125	1996	1997	Fr and II avionics upgrades
FGA	Su-30M Flanker	40	1996	1997	Deal worth US$1.8b; incl 12 Su-30MKI and 20 other version
FGA	MiG-27L Flogger-J	165	1983	1994-97	Indian designation Bahadur (licensed construction)
Hel	KA-31	3	1997	2000	

SAM	S-300	24	1998	1998	24-36 launchers
SAM	SA-N-4	3	(1989)	1997	For 3 Brahmaptura-Class frigates
SAM	SA-N-4 Gecko/ Osa-M	(60)	(1989)	1997	For 3 Brahmaptura-Class frigates
SAM	SA-N-7 Gadfly/ Smerch	(66)	(1986)	1997	For 3 Delhi-Class destroyers
SAM	SA-N-5 Grail/ Strela-2M	(320)	(1983)	1989-97	For 8 Khukri-Class corvettes
ShShM	SS-N-25	16	1996	1997	More for delivery 1998
ShShM	SS-N-25	3	(1997)		On 3 Krivak-4
ShShM	SS-N-25/ X-35	(96)	(1997)		For 3 Krivak-4
ShShM	SS-N-2	3	1993	1997	For 3 Brahmaptura-Class frigates
ShShM	SS-N-2e Styx/ P-27	(24)	1993	1997	For 3 Brahmaptura-Class frigates
ShShM	SS-N-25	3	1992	1997	For 3 Delhi-Class destroyers
ShShM	SS-N-25/ X-35	(96)	1992	1997	For 3 Delhi-Class destroyers
ShShM	SA-N-7 ShAM/ Shtil	3	(1986)	1997	For 3 Delhi-Class destroyers
ShShM	SS-N-2	8	1983	1989-97	For 8 Khukri-Class corvettes
ShShM	SS-N-2d Styx/ P-21	(64)	1983	1989-97	For 8 Khukri-Class corvettes
ShShM	SS-N-2	7	1987	1991-97	For 7 Tarantul-1-Class FAC
ShShM	SS-N-2d Styx/ P-21	(56)	1987	1991-97	For 7 Tarantul-1-Class FAC
ShShM	SA-N-5 Grail/ Strela-2M	(280)	1987	1991-97	For 7 Tarantul-1-Class FAC
Tanker	IL-78	6	1996	1998	First 2 delivered early 1998

7.2 China TOP

7.2.0 Introduction

Recently the international significance of Russian partnerships with the Chinese aerospace industry has come to the fore. Particularly brought into focus has been co-operation in fighter design and, now, production. This co-operation is interesting especially to India in view of the heightened tension and indeed current armed conflict with Pakistan. China is the traditional supplier of war materiel to Pakistan, and it must be assumed that any technological advances gained by China will eventually be passed on in some form to the Pakistan military. As has been already covered above, India is Russia's most important military technology client.

7.2.1 Principal Sino-Russian fighter projects

The FC-1 light multirole fighter. Revealed at the Paris Air Show in 1995, this single-engined aircraft is set to fly this year, after extensive design assistance from Russia. Its rationale is not entirely clear, since it appears to sit in a similar weight class to the

J-10. It could end up for export only. Pakistan has been identified as a possible first customer.

The J-10. It is billed by the US Office for Naval Information (ONI) as "China's first indigenous design of a fourth-generation fighter". It is the most controversial of all China's new military aircraft projects due to the US assertion that it is derived from Israel's cancelled Lavi fighter - a US government-funded aircraft development programme. The J-10 is intended to reach squadron service by 2005, although this may depend on the veracity of reports that the aircraft is suffering development difficulties, including a prototype crash. "Access to Western technology will mean the J-10 will enter service with more sophisticated onboard systems than the Su-27SK," the ONI reported. The USN also believes that a naval derivative, perhaps twin-engined, will embark aboard China's first aircraft carrier, which will enter service in the "2010 timeframe". It is reported that a helmet-mounted sight and new dogfight missile, possibly based on the highly advanced Israeli Rafael Python 4, could be in development in China alongside the J-10. Beijing-based sources sya that by the end of 1998 Moscow had sold China 10 AL-31 engines. Incorporation of the AL-31 into the J-10 airframe has proved difficult

The J-11 programme. Reports suggested China has also ordered a third batch of Su-27s from Russia, including a combination of Su-27SMKs and twin-seat Su-30MKs. The Su-27SMK is a multirole version of the basic Su-27 interceptor, featuring air-to-surface weaponry, in-flight refuelling probe, a multitarget tracking and engagement radar compatible with the Russian R-77 medium-range fire-and-forget AAM (known to NATO as AA-12). The Su-30MK is broadly comparable to the multirole US F-15E. The Su-27 deal also paved the way for contracts between China and Russia for air-launched missiles, including the R-73 (AA-11) short-range IR dogfight weapon, the R-77 and Kh-31 (AS-17) anti-ship missile. The latter may also be fielded as a co-developed anti-radiation weapon.

7.2.2 Other projects in progress and payment problems

At the end of 1998, Beijing was believed to be in debt to the Russian aerospace industry for the recent orders for more than 70 Su-27 combat aircraft and four Il-78 in-flight refuelling tankers, the latter aircraft alone costing US$1 billion. Another US$250 million is being spent on an AEW version of the Il-76. Reports at Singapore's Asian Aerospace '98 suggested that Russia has developed an advanced interceptor version of the Su-27 for China for eventual production at Shenyang. CATIC is also fronting the export drive for the low-cost FC-1 multirole light fighter unveiled in 1995 but not due to make its first flight until 2000. China hopes to attract a launch customer discouraged by the price of F-16A/B, Gripen or Mirage 2000-5. MAPO-MiG is thought to be the development partner. Chengdu is also working on the J-10 advanced multirole aircraft, another project requiring continued R&D cash.

China's People's Liberation Army Air Force plans to field a fleet of AEW&C aircraft - to meet this requirement, the UK's GEC-Marconi (now part of BAE) and Israel Aircraft Industries have been competing to integrate radars on a Russian platform based on the Il-76. Supporting Il-78 tankers may be procured from Russia.

7.2.3 Major Russian Aerospace Exports to China

Type	Designation	Units	Ordered	Delivered	Comments
FGA	Su-27	50	1992	1993	Deliveries to 1996
FGA	Su-27S	24	1995	1996-97	Deal worth US$2.2b inc 6 Su-27B trainer
FGA	Su-27SK Flanker-B	(200)	1996	1997	Incl assembly from kits. Chinese designation J-11
FGA	Su-27	150	1997	1999	Licensed production. PRC designation J-11
SAM	Tor-MI	15	1995	1997	SA-15
SAM	SA-10c/S-300PMU	(4)	1992	1993-97	
SAM	SA-10 Grumble/ 5V55R	(144)	1992	1993-97	For 4 SA-10c/S-300PMU SAM systems

SAM	SA-15 Gauntlet/ 9M330	(255)	(1996)	1997	For 15 SA-15 SAM
ShAM system	SA-N-7 ShAMS/ Shtil	4	1996		On 2 Sovremenny.
ShAM	SA-N-7 Gadfly/ Smerch	(88)	1996		For 2 Sovremenny.
ShShM	SS-N-22 ShShMS	2	1996		On 2 Sovremenny.
ShShM	SS-N-22 Sunburn/P-80	(32)	1996		For 2 Sovremenny.
Hel	Ka-28	8	1998	1999	Original deal in 1996
ASSM	SS-N-22		1998	2000	
Hel	Mi-17	35	1995	1997	30 delivered by 1997
RL	Shmel		1997		Licensed production
AAV(M)	SA-15 SAM	15	(1996)	1997	

7.3 United States of America TOP

7.3.1 Tests of Russian Equipment and Technology

In 1994 no fewer than 30 items of non-US defense equipment were selected by the Pentagon for evaluation under the FY94 Foreign Comparative Testing (FCT) programme, including items from Russia, Ukraine and Kazakhstan. The FCT funds the testing and evaluation of selected defense equipment, either in production or in the late stages of development. Testing procedures are designed to determine whether an item meets US service requirements. The DoD maintains that the FCT programme stimulates competition and does not put US defense manufacturers at a disadvantage. The FY97 programme included selected programmes from Russia. Advanced aircraft fabrication technologies developed by the All Russian Institute of Aviation (VIAM) were evaluated by the DoD for potential use in the JSF. The structural integrity, affordability and supportability of the advanced metallic technologies used in a centre fuselage section developed by VIAM will also be part of the review. Two other Russian systems evaluated under the FY97 FCT initiative were the MA-31 supersonic sea-skimming extended-range target developed by the Zvezda Design and Experiment Bureau and titanium nitride coatings for aircraft engine compressor blades developed by PRAD. Lockheed Martin has subcontracted studies on VSTOL technology to Yakovlev, to make use of the latter's experience in designing and operating vectored-thrust aircraft.

7.3.2 Russia-US simulation partnership

Two of the most enthusiastic supporters of blending defense and entertainment requirements for simulation are Martin Marietta and GreyStone Technology, both of which have traded developments back and forth between the two customer communities. According to a Greystone spokesman, the company's involvement covers artificial intelligence, advanced visualization, realtime man-in-the-loop simulation and advanced mission planning. Greystone have three forums: US government, commercial and international, which is primarily training. Greystone has a partnership arrangement with the Gromov Flight Research Institute.

7.3.3 Russia-US partnership in rockets and Space Launch vehicles

US decision-makers have adopted a two-track approach to making sense of the country's space-launch system. One track could lead to a truly re-usable launch vehicle (RLV), hitherto stalled by the inability of the Pentagon and the National Aeronautics and Space Administration (NASA) to agree on a common, practical set of requirements. On the other track, US military spacecraft in the next century could be launched routinely by second-hand rocket engines acquired from Russia. The US military uses three expendable launch vehicles (ELVs): the Martin Marietta Atlas and Titan, and the McDonnell Douglas Delta. This is costly, because of the duplication of facilities and low-rate production of three different systems; and cost is one of the reasons why Atlas and Delta are losing ground in the commercial market to competition from Europe, China, Japan and Russia.

One Russian design bureau, NPO Energomash, has developed 53 rocket engines - almost twice as many as the entire US industry. One US executive, returning from his first visit to the new Russia, reported that "the good news is that we're 20 years ahead in gas turbines, and the bad news is that we're 20 years behind in rockets." In the US, P&W has teamed with NPO Energomash (formerly known as Glushko); Aerojet has concluded agreements with Samara (Kuznetsov), Saturn (Lyulka) and CADB.

The Russian rockets would be built in the US if they were selected for ELV. A P&W spokesman remarked that NPO Energomash leads the US producers in both performance and reliability. Chamber pressure is an important indicator of liquid rocket performance: the higher the pressure, the more compact the propulsion package. In the mid-1960s, when the US ran the Rocketdyne F-1 LOX/kerosene rocket for the Saturn booster at 5,500kPa (800lb/sq in), Energomash flew the RD-235 at more than 13,790kPa (2000lb/ sq in). Six RD-235s power the Proton booster.

The RD-170, said the spokesman, is Energomash's "crowning achievement." Fitted to the Energia and Zenit boosters, the RD-170 runs at some 24,000kPa (3500lb/sq in). Even though it is used on ELVs, the RD-170 is designed for at least 10 missions. Energomash engineers have developed flexible joints for hot-gas ducts, so they can gimbal the engine's thrust chamber rather than the entire engine, as is done in US engines. Most of the high-pressure components of the engine remain fixed. Flanges are spherical, not flat, with a separate ring to hold the flange in tension; even if the structure deflects, the flange will not leak. P&W/Energomash are proposing a two-chamber derivative of the four-chamber RD-170 for Atlas. Designated RD-180, the engine would have a thrust of 4,000kN. A three-chamber engine is also a possibility.

7.3.4 USA-Russia partnership in pulsed power

In its 1990 'Science and Technology Program', the USAF highlighted areas of basic military/aerospace research in which other nations eclipsed the USA. The few fields in which it admitted it had fallen behind were: semiconductor materials and microelectronic circuits (Japan), machine intelligence and robotics (Japan), photonics (Japan), superconductivity (Japan), biotechnology materials and processes (Japan) and pulsed power (Soviet Union). Though the results of US attempts to woo Japan into quid pro quo research programmes in these areas have been slow in coming, initiatives in Russia have been successful. Thanks to a concerted bid to buy into certain Russian research programmes, for example, USAF has acquired a new order of understanding into pulsed power and its off-shoot, microwave weaponry, enabling the USA to wrest back a world lead in this field.

7.3.5 US Air Force Moscow office

The USAF Materiel Command's European Office of Aerospace Research and Development (EOARD) arranged in 1993 to open a Moscow-based office to support its primary operation in the UK. For the previous two years, EOARD officials conducted research- gathering missions to Russia and other states of the former Soviet Union to establish links with the many research institutes and facilities there, including those involved in ballistic-missile defense. The establishment of a satellite Moscow bureau, staffed by a Russian-speaker, was intended to facilitate development of these contacts. EOARD supports air-force efforts by identifying and evaluating foreign technological capabilities and accomplishments, including theoretical expertise, that can be applied to US requirements. The office liaises between scientists and engineers of both countries with the goal of establishing technology exchanges in specific areas.

7.3.6 Russian-US co-operation on defeat of hard targets

Even as technologies mature, the see-saw between defense and offense continues; defenders can learn the limits of current bomb inventories and burrow a few metres deeper. Defense sources both in Europe and the US agree that at a certain point, hard-kill of buried targets becomes unfeasible. This has led to parallel efforts to develop means of isolating enemy bunkers by severing nodes of communication. One means of accomplishing this is by the use of conventional EMP weapons that would destroy communications and electronics. Both Russia and the US are believed to have active development programs in this field, but EMP power-generation and packaging requirements for air delivery vehicles are formidable. The Los Alamos National Lab is known to be working, with Russian help, on land-based pulse-power generators using explosives.

7.4 Western Europe TOP

7.4.1 Russian-UK partnership in plasma power

Russian scientists have stunned a select group of Western physicists by claiming they have stumbled on a breakthrough in plasma technology with the potential to reduce aircraft drag not merely by a few per cent but by as much as 30 per cent - maybe more. A plasma is an ionised gas. Run an electric current through a neon light tube, for example, and the end result is a plasma. Another common plasma is found in lightning. The claims are being publicised not by the Russians, but by BAe. Representatives from BAe have visited many previously uncharted former Soviet science establishments over the past five years in the search for innovative science and technology. Having 'found' the plasma research, BAe is seeking to validate the claims in laboratory experiments of its own. The experiments involve the introduction of a plasma or ionised gas into the airstream in front of an aircraft. If BAe can substantiate Russia's claims - and there is considerable scepticism that there is anything measurably real about the Russian work - it could lead to one of the biggest leaps in aircraft design since the coming of the jet age. According to the Russians, the potential advantages of 'plasma aerodynamics' are not even limited to drag reduction. Other spin-offs include: sonic boom attenuation - delaying the onset of an aircraft's supersonic shockwave; aerodynamic control through selective drag reduction - allowing an aircraft or missile to manoeuvre by applying the plasma effect to different parts of the airframe; and thermal protection through reduced air friction.

It could also herald a breakthrough in stealth, since plasma generation is claimed vastly to reduce radar cross-section. The absorption of radio waves by plasmas has been well-known since the early days of manned space flight. The communications black-out that a space vehicle encounters on re-entry is caused by the shielding effects of plasma. This builds naturally in front of the spacecraft as it hits the Earth's atmosphere and shocks the air to high temperature. The same principle applies to the absorption of radar energy. Although the aircraft would appear to glow like a lightbulb, with enough plasma generators to cover the entire airframe, it could be rendered totally invisible to radar. The story of how Russia's plasma research came to reside at BAe began in the early 1990s. For some years, the UK MoD and elements of the UK aerospace industry had been aware of the potentially beneficial effects of plasmas on airframe design; low-key experiments, indeed, had been conducted in the UK in the early 1980s. Following the collapse of the Soviet Union in 1991, BAe struck an agreement with a Russian government agency charged with realising commercial benefit from the sale or licensing of technology and products developed under former Soviet space, aerospace and defence programmes. The accord was supposed to lead to synergies that would benefit both parties.

The deal broke down as the Russians tried to sell everything "from night sights to jet engines", according to one UK official, and the Russian market was soon found to be almost worthless due to the dire state of the economy. However, the premise was deemed sound. All it needed, BAe officials concluded, was some focus. In 1993, BAe headquarters asked its Bristol-based Sowerby Research Centre (SRC) to lead the company's research-gathering project in Russia and other countries of the CIS. The SRC chose Professor Ron McEwen, executive scientist at the Bristol centre, to head the programme. He was familiar with aspects of Soviet fundamental science after visits to several recently opened 'science cities' in the Moscow area and contacts with Russian scientists at a high-technology exchange forum in Finland. The new, refocused BAe charter was now clear. One of its twofold aims was "to enable the acquisition of former Soviet technologies, materials, processes, products or facilities relevant to any aspect of BAe operations when this would be more cost-effective than by other means available to us". Among other potentially beneficial technologies, BAe has been looking at former Soviet techniques for welding aircraft primary structures, a technique scoffed at by the rest of the world, but for which the Russians are claiming weight savings of up to 40 per cent. With its partners, BAe is also evaluating new Russian-developed aluminium alloys. Russia developed the world's first aluminium-lithium alloys, a material that has contributed much to the aerospace industry. It was, however, the second aspect of the BAe charter that proved instrumental in the plasma discovery. This objective was "to investigate claims of hitherto unknown former Soviet capabilities where these appear to offer the possibility of technical advantage".

Prof McEwen began trawling Russia in 1994. He initially enquired about possible scientific breakthroughs at intermediate levels - university directors - descending deeper as his investigation went on into individual departments. "I became well-known within the Moscow region, so much so that people started coming to me," he said. He began to pick up rumours that the Russians had been conducting exotic experiments with plasmas in the aerospace field. "They're complicated, a bit difficult to control and understand, though a lot is understood, especially about relatively low-temperature plasmas," said Prof McEwen. Intriguingly, the Russians maintained they had developed "special plasmas" that behaved differently at high pressures, when they are normally difficult to sustain. To garner Prof McEwen's interest, a director of one particular institute demonstrated the effect with a portable, box-like device from which a jet of plasma would shoot out and punch a hole through a razor-blade. The Russians maintained that the technology was semi-secret and that it had potential applications in the anti-ballistic missile field and within supersonic combustion ramjets (scramjets) for hypersonic aircraft. Prof McEwen, however, was unimpressed. Besides the sideshow atmosphere, BAe had no interest in either application. The effect was sufficiently interesting, however, for him to commission a Russian scientist to write a review of all unclassified Soviet work in the plasma field. When complete, the company realised it possessed what was probably the first truly authoritative account of Russian work on plasmas. It documented papers that promised massive drag reductions by applying plasmas to flying vehicles.

"Normally, aerodynamicists can design the shape of a flying vehicle to suit the range of atmospheric conditions, speeds and so on that it will experience," Prof McEwen said. "They assume there is nothing they can do about the atmosphere itself. The Russian approach, on the other hand, seeks to alter the atmosphere through which the vehicle is flying." An important parameter is the speed of sound, which depends on the temperature and the specific heats of the gas. Specific heats are in turn related to the complexity of the molecules comprising the gas The gas laws themselves depend on the forces between the molecules. If some of the molecules are not just N2 and O2 - the usual constituents of air - but more complex ones, or if there are unusual forces between them, the result is an atmosphere modified from the norm and this will alter the aerodynamics of a body flying throug hit. The question, according to Prof McEwen, is: "What are the details and how can it be made to work to our advantage?" He returned to Russia in 1996 with academic and company aerodynamic experts. Mainly sceptical, they were keen to take a more in-depth look at the Russians' so-called 'special' plasmas.

Previous experiments conducted at TsAGI - the Central Aerodynamics and Hydrodynamics Institute outside Moscow - had shown drag reductions, but these had explored conditions not of immediate interest to BAe. A further set of experiments was set up under the auspices of BAe Military Aircraft, Sowerby Research Centre, the UK MoD and DERA. While BAe was mainly interested in plasma application to aircraft for high-subsonic/low-supersonic, medium-altitude flight - the regime in which most of its military and civil products fly - DERA was keen to evaluate its wider implications, and for hypersonic flight in particular. The Russians themselves were stressing the potential application of plasmas at high altitudes and speeds at, or in excess of, Mach 5.

In the series of UK-sponsored tests run at TsAGI at the end of 1996, drag reductions were again noted. About this time, BAe and DERA became aware of a growing interest in this topic in the USA and were invited to participate in an expert meeting in Colorado last June. Although many US delegates attended, little focused research had apparently been conducted in the USA until then. The work by BAe and DERA in collaboration with the Russians made the US community take notice. That the USA is interested in the potential of plasma aerodynamics is beyond doubt. US officials said that a "major meeting" on the subject has since been held at Princeton University, New Jersey, and more recently at Norfolk, Virginia. Furthermore, US plasma experiments have been carried out, some of them replicating the Russian tests. However, the conclusions drawn from their work so far are by no means clear. At NASA's Langley Research Center, the focus of renewed US hypersonic activity, scepticism about the value of plasma aerodynamics abounds. "There is no smoking gun," said Dennis Bushnell, senior scientist at the facility. "There is no phenomenon here. What we have are experimental observations only. If there's anything in it, then there's no defensible theory."

Bushnell conceded that US experiments have recorded an effect - a drop in drag - and that the Russian work is "worth investigating and running to ground". He is dismissive, however, of the measurement techniques that the Russians have used to analyse this "plasma magic", as he calls it. "Besides, even if there is an effect, what do you do with it?" he asked. "Is there any new physics here? Even if there is, there's the whole issue of how you make use of it." One concern is that the energy needed to generate a sufficiently workable plasma may out weigh the energy savings that may accrue from a few percentage points in drag reduction. US experiments into plasma aerodynamics are likely to continue for at least another 18 months, according to US officials, under the aegis of the USAF's Wright Laboratory at Wright-Patterson AFB, Ohio, at NASA and within the Air Force Office of Scientific Research.

Part of the rationale for BAe's decision to go public on its plasma co-operation with the Russians is borne of the desire to do more work with the USA. The nightmare scenario for any sophisticated aerospace nation, the UK included, is that a breakthrough in this field by another country could render its current technology obsolete. A number of plasma experiments, heavily based on Russian work, are continuing at BAe's Warton facility in Lancashire. BAe's Prof McEwen is philosophical about all that he has observed to date. "Are the Russians achieving anything other than dumping heat into the airstream?" he asked. "There certainly are effects we just can't explain at the moment and we have to continue our investigations until things become clearer. No-one, not even the Russians, has successfully exploited the technology. Yet it does seem to have the potential to yield aerodynamic advantage." *7.4.2 Proposed partnership with UK on new naval CIWS for export*

Russia's Altair State Research and Development Corporation is seeking sponsors for the Trezubets (Trident) rocket-based close-in weapon system that it has under development. According to Altair officials, the organization has approached both BAe Defence and GEC-Marconi concerning possible collaboration, with particular reference to potential Far East markets. Trezubets would marry a novel dual-frequency I/J-band (2/3cm) radar with a total weight of 5,000kg, with one or more 10-round trainable launchers, which also weigh 5,000kg each. These are automatically reloaded with replacement five-round rocket pods mounted on below-deck carousels. System power consumption is 20kW.The launchers fire proximity-fuzed unguided rockets having a maximum range of 1,500m. System reaction time is 2s. Altair has been developing a prototype of the mechanically scanned radar for the past two years. The scan rate of one sweep per second during surveillance rises to six per second in tracking mode, which is said to make the design the fastest of its kind. The radar is claimed to be capable of tracking 16 air targets simultaneously, even in the presence of intensive jamming (ECM suppression 80dB). Coverage in elevation is -5º to +70º, and detection range is 30km against a 1m2 target. No Trezubets launcher has yet been constructed, but the folding-fin rockets are based on an existing design. These have a nominal velocity of 1,000m/s, resulting in a flight time of 1.5s to intercept range. Each of the 220mm-calibre rockets weighs 60kg, is 1.7m long and carries a heavy (25kg) warhead. Company literature indicates that a single Trezubets launcher would provide a kill probability of 0.9 or greater at a range of 1,500m against each of four missiles in a wave, assuming that the incoming weapons are flying along the same axis at intervals of 2s. Altair representatives state that a kill against a Harpoon or anti-radiation missile could be virtually guaranteed by ripple-firing six rockets in a controlled-dispersion pattern.

7.4.3 Russia-Austria partnership with MiG-110 transport

The Russian aerospace company MIG MAPO and Austrian company ANL Handels-gesellschaft have signed a letter of intent to create a joint venture to build and sell MiG-110 light transport aircraft. Although the MiG-110 is designed as a civil transport, it is among the candidates to replace the widely used obsolescent An-26 twin-engined multi-role family. The agreement was signed on 27 October 1998 during a one-day visit to Vienna by then Russian Prime Minister Evgeniy Primakov. The Russia-Austrian industrial group will comprise representatives from both companies, as well as government officials. According to preliminary agreements, ANL will finance the completion of the aircraft's design and initial production. Final assembly will be carried out in Austria from parts delivered by MAPO MiG in Moscow. The version assembled in Austria will be designated MiG-110A. MiG-110 is a twin-engined, twin-beam high-wing monoplane powered by two Klimov/St Petersburg TV7-11SV turboprops. The maximum take-off weight will be 18,000kg including 5,500kg of cargo (or 48 passengers) carried in a pressurised cabin with built-in ramp in the hinged lower section of its beaver-tail rear fuselage. The cruising speed will be 500km/h, range 1,680km with a 4,500kg payload or 3,775km with full fuel and 2,660kg payload.

Russia's armed forces may well support the MiG-110 as a light transport aircraft replacement for the An-26. There are four other aircraft of this type being designed in the CIS including the MiG-110, Tu-130, Sukhoi S-80 and An-142. Although the most advanced aircraft are the An-142 and S-80, they do not meet armed forces requirements for the type of cargo carried. For example, they cannot carry UAZ-452 trucks. The third design, the Tu-130, meets these requirements, but is in a very early stage of development. CIS market demand for transports with a capacity of 5,000kg is estimated to be more than 1,000 aircraft for civil operators and over 300 for the armed forces. It has also been claimed that a military version of the existing Il-112 civil transport is the favoured An-26 replacement, but firm orders remains to be seen.

MiG-110 design work began in February 1992. Last year, the design work accelerated when Mikoyan completed the main development on the MiG-AT airframe and the design group was moved to the MiG-110. At present, the full-scale mock-up of the MiG-110 is ready, as well as a 33 per cent of the construction documentation.

7.4.4 France's role in the MiG-AT programme

French industry has recently increased its involvement in the MiG-AT programme. Sextant Avionique will supply its Topflight suite for the aircraft, and act as systems integrator for both the on-board avionics and the associated ground-based equipment. Mikoyan vice-president Anatoliy Belosvet says that his organization - which is financing MiG-AT development and flight trials - selected the French solution because it provided a combination of advanced technology, low cost and little or no risk.

Sextant will provide a "smart" head-up display, head-down displays using active-matrix liquid-crystal (AMLCD) technology, an inertial navigation system based on ring laser gyros, mission and symbol-generation computers, communication and navigation equipment, and electromechanical back-up instruments. The present arrangement covers the supply of units from France; licence production in Russia would require a further agreement. GosNIIAS (the Russian State Research Institute of Aviation Systems), which has developed software for all Soviet combat aircraft over the past 40 years, will perform a similar role for the MiG-AT.

Mikoyan had earlier selected Snecma and Turbomeca to provide the Larzac 04-R20 turbofans for the twin-engined MiG-AT. The twin-Larzac installation has, according to Mikoyan, half the specific fuel consumption of the L-39's single engine, and 40 per cent longer life. Snecma and Turbomeca have granted a full licence for production of engines to power the MiG-AT. Russian industry could also participate in development of the projected 04-Y3 variant, which would use a new low-pressure compressor to raise its maximum thrust from 14.1kN to 16.2kN. Other French companies, including Auxilec and Messier-Bugatti, are possible participators in the MiG-AT. The Russian air force requires about 500 aircraft, of which some 200 would be delivered during the first five years of the programme. The MiG-AT team sees a potential export market for at least 600, and possibly double this number. Mikoyan plans to market the design internationally, even if it loses the UTK competition. The organisation has also talked to Yakovlev about possible future collaboration on a Snecma powered trainer.

7.4.5 Proposed partnership with France for Sukhoi Su-20/22 upgrades

Although France is not an operator of this type, the French firms of Thomson-CSF and Sextant Avionique have revealed a joint proposal to offer an avionics upgrade for the Sukhoi Su-22 Fitter strike aircraft. The proposal involves the fitting of the new Phathom radar, based on the Russian Phazotron Kopyo using Thomson data and signal processors plus a joint Thomson/Phazotron analogue processor. System flexibility is the key to this upgrade and, among the various equipments proposed, are the Sherlock RWR, Barem self-protection jammer, the SMART HUD and OTAL-200-1300 HUD camera, LCD multifunction cockpit displays, an RLG INS, mission computer, NSS100-P GPS/Navstar receiver, the AHV6 radar altimeter, TMV 630 laser rangefinder, the Rubis nav/attack pod, the Convertible Laser Designation Pod (CLDP), a helmet-mounted display and the CINNA 3PN mission-planning system.

The Sukhoi Design Bureau has offered the modernisation of equipment and armament to foreign users of Su-20 and Su-22 Fitter (although these aircraft are no longer in active service in Russia). The total number of Su-20/22 Fitters used by the Czech Republic, Yemen, North Korea, Peru, Syria, Hungary and other countries is more than 300. The modernisation variant has not been precisely detailed as yet, being dependant on the individual needs of aircraft users. One of the tenders includes installing Kopyo radar, new boards for the computer, a new avionics system with liquid crystal displays, etc. The Kopyo radar may be used not only against the air targets beyond visual range, but also for mapping the terrain. The aircraft weapon system can be expanded by Kh-31P anti-radiation missiles as well as by Kh-31A and Kh-35 anti-ship missiles. Mikhail Simonov, Sukhoi's general designer announced during ILA'94 that a modernised Su-22 would be shown the following year.

7.4.6 German/Russian MiG-29 modernisation

Formed by DaimlerChrysler Aerospace (DASA), MIG MAPO and Rosvoorouzheniye in 1993, MiG Aircraft Product Support (MAPS) has provided upgrades incorporating NATO standard equipment (based on those undertaken for the Luftwaffe following German reunification) for MiG-29s operated by Hungary and Poland. Similar offers have been made to Bulgaria, Romania and Slovakia. However, the company is set to expand its operations beyond Central and Eastern Europe following an agreement announced at MAKS'99, seeking markets further afield for its 'Fulcrum' modernisation and support services. Propects include the Peruvian Air Force, thought to have acquired up to 18 surplus aircraft from Belarus in late 1996 and a further three from Russia in 1998. It will also augment the proposed sale of new-build aircraft for the first time, with an offer likely to be made to potential customers including the Austrian Air Force, which requires up to 20 multi-role fighters to replace its Saab J 35 Drakens.

7.5 Multinational links in the jet trainer market TOP

Companies in France, Russia, the Republic of Korea, the UK and the US are involved in a complicated series of international efforts to develop a new generation of advanced jet trainers and light combat aircraft. Mikoyan and Yakovlev, which are promoting the MiG-AT and Yak-130 to meet the Russian air force's UTK requirement to replace its Czech-built Aero L-39s, have established technical links with South Korean companies Daewoo and Hyundai respectively (together with Italian firm Aermacchi in the lattercase). Daewoo would build wings from composite materials for production MiG-ATs, although the prototypes will employ metal construction.

Both aircraft are potential contenders for selection by the Republic of Korea Air Force (ROKAF) as its KTX-II advanced trainer, for which Samsung Aerospace will act as systems integrator. Samsung has been working with Northrop - and possibly also with Russian companies - on its own KTX-II proposals and is additionally being wooed by BAe, which is offering co-development of a Hawk derivative. The ROKAF already operates 20 Hawk Mk67s and is considering further purchases.

7.6 Russkii Faktor TOP

Readers with practical experience of the Russian market will have learned to cope with many of its special features. There is more than just the *razgil'dyaistvo;* there are some traditional and by no means negative characteristics that have a charm all of their own. Together they form what we shall call *Russkii Faktor,* or RF for short. One learns to accept these special aspects of life and work in Russia, and, over the years, they keep one up to the mark.

7.6.1 Letnii Rezhim - a sociological speciality

First example - *letnii rexhim* (= summer timetable). *Letnii rezhim* can afflict an organisation from June to October. During this period, a large proportion of the management and staff will be absent from the workplace. In the 'good old, bad old days' firms provided free summer holiday camps for the children of the workers for the bulk of this time. The hard-pressed parents then had the chance, at last, for an extended spell at the dacha, or at a holiday resort in the countryside or on the Black Sea. Today, the tradition of *letnii rezhim* persists, albeit in modified form due to the general state of the nation. Organisations have reduced or closed down their sponsored camps, so the *dachniki* parents are now often accompanied by their offspring; at the dacha, the cultivation of food has become an essential for family economic survival. So, when you fail to receive a fax from your Russian export partner, check the calendar. You might then forgive his reticence. He and his family may well be on *letnii rezhim,* their annual life-saver.

Postscript. *Letnii rezhim* notwithstanding, it is worth remembering that some rather crucial historical events have taken place in the period 18-21 August: construction of the Berlin Wall (1961); Russian-led invasion of Czechoslovakia (1968); the August Coup in Moscow in 1991. RF did not run to type in those particular years. *7.6.2 Ekranoplan to the rescue?*

Russia's strategic aims, perhaps inherited from the Soviet past, sometimes do combine with RF and the state's geophysical characteristics to produce a real technological oddity. Possibly the oddest, and ever-so-Russian example, of the *genre* has been the series of Ekranoplan flyingboat craft that are based on the 'Wing in Ground Effect' (WIG) principle. The Russians built the first large-scale WIG craft in the 1960s. The 500-tonne displacement and appropriately nicknamed 'Caspian Sea Monster' remained secret to the West until the late 1980s. There have been at least eight modifications to the single craft built, the number on the tail indicating the modification number. The original Caspian Monster prototype is reported to have crashed and sunk in the Caspian Sea in 1980 after 14 years of service. Conceived as a vehicle for rapid seaborne assault, such as a possible Warsaw Pact invasion of Denmark, the Ekranoplan craft design is ideally suited for high speed transportation of forces, thanks to its greater payload capacity, greater range and less fuel consumption than conventional aircraft, whilst operating at a comparable speed. It flies at a height of a few meters above the sea, on the compressed cushion of air created between the surface and its specially contoured wing.

Humanitarian Conversion

The 'Caspian Sea Monster' has been succeeded by a slightly less grandiose craft propelled by eight NK-87 turbofan engines and called 'Lun', which weighs a mere 400 tonnes. These are built at Nizhny Novgorod. With a range of 4,500km and a cruising speed of 450-550km/h, a version of Lun called Spasatel-2 (='Saviour') is being proposed as one component in a rescue sytem for coping with maritime disasters, including one of special Russian concern, accidents involving submarines. Spasatel can carry up to 600 passengers, or cargo including surface or submersible rescue craft and special equipment. A Russian proposal includes stationing a team (internationally funded, naturally!) of 5 Spasatels at key waterborne locations around the globe, with the necessary crews and materiel at readiness for callout on all types of emergency seaborne rescue. Such a scheme would include a universal international emergency radio frequency to notify 'SUBSMASH' or other disasters, and a co-ordinated rescue management organisation. The organisation would have at its disposal a fleet of Spasatel-portable miniature rescue submarines based on the USN's one example. Such niceties as getting first the agreement, and then the compliance, of all submarine-owning states to fund such a project is just the first of many problems. Then, equipment such as submarine emergency access hatches would have to be standardised worldwide, and everyone would have to agree on, and then purchase and install, the appropriate communications equipment.

An Ekranoplan Piggy-back!

There is another proposal from Nizhny Novgorod for employing their (smaller) 140-tonne Ekranoplan named 'Orlyonok' in a similarly-conceived international rescue scheme. Under this version, 5 composite or 'piggy-back' combinations of giant 6-engined Antonov An-225 'Mriya' transports, each with an 'Orlyonok' mounted on its back, would be stationed around the globe at key landborne locations. The enormous combination would take to the air and head for the disaster scene. On arrival above the area, or at another point designated by distance, 'Orlyonok' would separate from its mother-ship, and, carrying the necessary rescue equipment, would glide down to water-level and then cruise to provide a moored seaborne base of operations. The idea of composite aircraft is itself not new. In the late 1930s, Britain developed the Short Maia-Mercury seaborne combination of a 4-engined Short 'Empire' flying boat, which took off carrying on its back a mail-carrying floatplane, which in turn was air-launched at a suitable range to complete the then problematic transatlantic trip. During the final year of the Second World War, Germany developed and successfully used the landborne 'Mistel' composite bombing system. A piloted single-seat fighter (Me 109 or Fw 190) was strapped on top of an explosive-packed unmanned Ju 88. The combination took off and flew the mission, controlled by the fighter pilot. The fighter separated in the target area, and then radio-controlled the Ju 88 'cruise missile' onto its objective. However, the present Russian proposal dwarfs all previous concepts in its sheer scale and expense. The landborne sites would really have to be very special airfields, as the takeoff weight of the composite craft would be not less than 610 tonnes.

Despite the daunting scale and other improbable aspects of these two Ekranoplan schemes, the need for an international quick-reacting submarine or other maritime rescue scheme is arguably apparent. The *Komsomolets* disaster and the sinking of the ferry *Estonia* come immediately to mind. Other relevant factors are the increase in size and numbers of holiday cruise ships carrying very large numbers of often elderly and infirm passengers, and lately, the development of 'tourist submarines'. How marvellous, to create one day a life-saving system based on technology designed originally for a massive military invasion.

The MiG AT Advanced Jet Trainer
(Photo: MiG MAPO/Artur Sarkisyan)

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Roy Giles

AIR-TO-AIR MISSILES, China

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Jane's Air-Launched Weapons 42

SD-10 (PL-12)

Type

Active-radar guided beyond-visual range air-to-air missile.

Development

The SD-10 active-radar BVR air-to-air missile is now the highest priority air-to-air weapons programme for China's military industry, and has supplanted several previous developmental projects (such as the PL-10 and PL-11) in terms of effort and importance. When, and if, it enters service, it should provide the People's Liberation Army Air Force with a sophisticated, indigenous airborne weapon that will complement, to some degree the Russian-supplied R-27/R-77 missiles that equip the PLAAF's Sukhoi Su-27 and Su-30 force.

The SD-10 (perhaps known also as the PL-12) is evolving under aegis of the Beijing-based China National Aero Technology Import & Export Corporation (CATIC), while work on various aspects of the programme is underway at a number of different technical centres around the country. The SD-10 is listed as part of CATIC's current 'Thunder-Lightning' family of air-to-air missiles, that includes the PL-5E, PL-9C and TY-90 systems (all developed by the Luoyang Electro-Optical Technology Development Center). However, confusion surrounds the provenance, and even the designation, of the SD-10 programme. 'SD-10' is the export designation of a national programme that may, or may not be, the PL-12.

The PL-12 designation has also been associated with a notional air-to-air development of China's LY-60 surface-to-air missile, but the actual status of this development effort is unclear. The SD-10 on the other hand is a very real programme.

Prior to the emergence of the SD-10, China's active radar seeker AAM development programme was sometimes identified as the 'AMR-1'. During Air Show China 1996, held during November in Zhuhai, the China Leihua Electronic Technology Research Institute/No 607 Research Institute exhibited a newly-developed active radar seeker, the AMR-1. This seeker was, in turn, believed to have been applied to a new air-to-air missile design, derived from the LY-60 surface-to-air missile, and dubbed the 'PL-12'. This active radar missile, and the earlier semi-active radar homing PL-11, seemed to have a common design heritage with the Italian Aspide missile, supplied to China during the late 1980s. The status of the PL-11 and 'LY-60/PL-12' development programmes is unclear, but sources within CATIC say these earlier programmes have all been abandoned in favour of the SD-10.

The existence of the SD-10 programme was acknowledged by Chinese officials for the first time in early 2002 (the first pictures of the new missile appeared from Chinese sources during 2001). According to CATIC sources the missile has a range of 80 km. Earlier speculation around the AMR-1/LY-60 programme suggested that a ramjet engine was being developed for it, and such a powerplant would allow a missile to be effective at such long ranges. All available models and artist's impressions of the SD-10 released to date clearly show a rocket-powered missile with a conventional airframe configuration. However, unidentified models of a notional ramjet-powered air-to-air missile have been shown in China and so an enhanced propulsion solution may be under consideration, or even under development, for the SD-10. According to a CATIC engineer, speaking in February 2002, several SD-10 test firings have already been undertaken, and most of the SD-10's subsystems testing had been completed (although the missile was not yet ready for service).

Description

The SD-10 is outwardly very similar to the US-designed AIM-120 AMRAAM. The two share a comparable aerodynamic configuration, although with a length of 3.85m, a diameter of 20.3 cm and a weight of 180 kg the SD-10 is a little longer, wider and heavier than the AMRAAM. The SD-10 has four rear-mounted control fins that each have a very distinctive notch cut into their base. These fins are longer and more prominent than those of the AMRAAM and are cropped at an angle (rather than in line with the missile body). Four larger triangular fins are fixed to the mid-section of the missile. Internally, the leading edge of the centrebody fins is in line with the start of the missile's rocket motor. That motor is a variable-thrust sold rocket booster, that offers two levels of motive power for different sections of the flight envelope.
CATIC is known to be developing X-band and Ku-band active radar seekers, which may be intended for the SD-10. However the latest reports confirm that China has been co-operating closely with Russia's AGAT Research Institute, based in Moscow, and that AGAT is the source of the SD-10's essential active seeker. This joint development effort (perhaps with the name 'Project 129') has reportedly seen the supply of AGAT's 9B-1348 active-radar seeker (developed for the Vympel R-77, AA-12 'Adder') to China for integration with a Chinese-developed missile, the SD-10. Alternatively, technology from AGAT's 9B-1103M seeker family may be offered to China. Russia is also the source for the missile's inertial navigation system and datalink.
The SD-10 has four engagement modes. To take the greatest advantage of its maximum range it will use a mix of command guidance (via a datalink) plus its own inertial guidance before entering the active radar terminal guidance phase. The missile can also be launched to a pre-selected point, using its strap-down inertial system, before switching on its own seeker for a terminal search. Over short ranges the missile can be launched in a 'fire-and-forget' mode using its own active seeker from the outset. Finally, the SD-10 has a 'home-on-jam' mode that allows it to passively track and engage an emitting target, without ever using its own active radar or a radar from the launch aircraft. The seeker is connected to a digital flight control system that uses signal processing techniques to track a target. The missile's warhead is linked to a laser proximity fuse.
The SD-10 is claimed to have an operational ceiling of 20 km, with a maximum effective range of 70 km and a minimum engagement range of 1,000 m. The missile has a 40 g manoeuvring limit and, according to CATIC, it has been tested for a 100-hour captive 'live flight' life.

Operational status

The SD-10 is not yet believed to be in PLAAF service, but is in an advanced stage of development and may have been released for operational test and evaluation with the air force. According to CATIC, the SD-10 can be carried by a range of aircraft including the J-7 (F-7), J-8 (F-8) and MiG-series fighters, or any Western aircraft that have been fitted with the missile's PF95 launcher and pylon. The obvious radar limitations of these aircraft make it clear that they will probably never be fitted with the SD-10, at least in Chinese service. While trials firings have probably been conducted using Shenyang J-8 testbeds, it is believed that the SD-10/PL-12 programme is intended, initially, to equip China's fleet of Su-27 (J-11) 'Flankers' as part of a wider nationally-sourced capability enhancement for the PLAAF's 'Flanker' force.
The other potential applications for the SD-10/PL-12 in Chinese service are on the Chengdu J-10 next-generation combat aircraft now under development, perhaps the upgraded Shenyang J-8M 'Finback' and the CATIC FC-1/Super 7 lightweight multirole combat aircraft being developed jointly by China and Pakistan. During 2001 officials at Pakistan's National Development Complex confirmed that the NDC was conducting study/development work on a new active-radar missile programme, a possible reference to the SD-10. Certainly the most prominent 'public appearance' of the SD-10 to date has been on the full-size mock-up of the FC-1/Super 7. Pakistan has established a national production line for the Italian Galileo Avionica (formerly FIAR) Grifo 7 multimode fire-control radar at its Kamra Avionics and Radar Facility. A version of the Grifo radar (Grifo S7) is being developed for the FC-1/Super 7, and the Grifo is already fitted to Pakistan's Chengdu F-7PGs. In July 2002 Galileo Avionica confirmed that it would be offering the latest development of the Grifo radar, the Grifo 2000/16, as a candidate radar for the J-10 once its entered the production phase. Galileo Avionics describes the Grifo 2000/16 (originally designed as a radar for F-16 upgrades) as a modern, modular, multimode radar with enhanced air-to-air capabilities that is compatible with modern BVR missiles.

Specifications

Length: 3.85 m
Body diameter: 203 mm
Wing span: n/k
Launch weight: 180 kg
Warhead: HE fragmentation

Fuze: Active proximity fuse
Guidance: Inertial mid-course and /or datalink updates, with active radar terminal homing
Propulsion: Solid dual-thrust rocket motor
Range: 70 km (in a head on engagement)

Contractor

China National Aero Technology Import & Export Corp (CATIC), Beijing.

UPDATED

China's SD-10 active-radar air-to-air missile has been prominently displayed on the full-size mockup of the CATIC FC-1 (Super 7) lightweight fighter

A full-size mockup of the SD-10 missile

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4 Images

AIR-TO-AIR MISSILES, China

Date Posted: 23-Jul-2003

Jane's Air-Launched Weapons 42

PL-9

Type

Short-range, IR missile.

Development

The PL-9 is China's very latest short-range air-to-air missile and represents the synthesis of China's experience with all previous indigenous and foreign-sourced AAM programmes. The PL-9 is described by CATIC as a 'third-generation' weapon and, given China's existing experience with the PL-8 (Python 3), the PL-9 should have a combat capability that exceeds that of the AIM-9L/M Sidewinder. The PL-9 still has a conventional aerodynamic configuration, so it is not a super-agile missile in the class of the Python 4, ASRAAM or AIM-9X, but its large size, wide control surfaces, all-aspect seeker and laser proximity fuse put it in a class above any previous Chinese-sourced AAM.

The PL-9 was first shown in model form in 1989, as a mobile surface-to-air missile with the capability for air-to-air use also. The airborne version of the weapon was first shown in public during the mid-1990s, so it is clear that the programme was launched at least 10 years earlier. The PL-9 has been mated with a Chinese-developed helmet-mounted sight system, first shown during Air Show China 1996, at Zhuhai, and produced by the Luoyang Electro-Optical Equipment Research Institute (LOEC). LOEC also led the development of the new IR seeker for the PL-9, and may even be the design and development authority for the entire missile system (LOEC advertisements show the PL-9 as a company product, though the firm does not claim to produce missile themselves). The missile group of the China National Aero Technology Import & Export Corporation (CATIC) has overall responsibility for the PL-9 programme, and it is listed as one of the four in-production missiles of CATIC's 'Thunder-Lightning' air-to-air family (along with the PL-5E, SD-10 and TY-90).

At the 2002 Asian Aerospace exhibition, held during February in Singapore, CATIC displayed an enhanced version of the PL-9, the PL-9C. This version had first been reported in 1999, when it was described as an export-oriented programme. Key changes over the earlier version are the PL-9C's new InSb (indium antimonide) multi-element seeker (functioning in the 3-5µ band) with digital signal processing. According to CATIC, the PL-9C has significantly improved IRCCM capabilities, putting it in a class above the PL-8. Also according to CATIC, the PL-9C is intended for use on the PLAAF's J-8 and J-10 fighters.

Shown in parallel with the PL-9C was the DK-9C air defence system, a ground-based SAM system using the PL-9C missile. The DK-9C uses a wheeled, four-shot launcher, with the capability to integrate an air defence radar, or rely on the missiles' own seekers for a passive engagement capability. The system is claimed to have an effective range of 8 to 10 km (4.97 to 6.2 miles).

Description

The basic design of the PL-9 owes a debt to the PL-8, and the PL-9 missile body is almost identical to the PL-8 in terms of size and shape. The PL-9 (and the PL-8) share almost the same body diameter as the PL-7 also, showing that China's missile designers appreciate the benefits of a larger rocket motor for endurance and manoeuvrability. The fin configuration of the PL-9 is very different to either of its immediate predecessors however, and returns to the conventional 'Sidewinder model' of the PL-5.
The PL-9's seeker assembly and associated electronics are all mounted forward of the primary control fins, in front of the servo-actuators. Immediately behind the forward fins is the laser-proximity fuse, clearly identifiable by the laser's optical apertures. Behind the fuse is the relatively compact warhead, which extends back to the first of the launcher attachment points on the missile body. The rest of the PL-9 airframe is given over to the rocket motor (about 55 per cent of the total volume). The missile has wide, cropped double-delta forward fins and a large rear tail unit, with rolleron controls.
The missile is 2.90 m long, has a body diameter of 157 mm, a wing span of 0.81 m and weighs 115 kg at launch. The missile front fins have a diameter of 641 mm, while the rear fins span 816 mm. Despite the relatively large size of the missile, the HE warhead is understood to weigh only 10 kg, but it has a kill radius of 13 m. The PL-9 has a cooled all-aspect IR seeker, with IRCCM capability, and a maximum detection range of 30 km. The seeker can track targets at up to ±30º off-boresight, with an angular tracking rate of 28º/s. The missile has an active laser fuze, a maximum velocity of M3.5, and a peak manoeuvrability of 40 *g*. The minimum engagement range is 500 m, and the maximum range 15 km. The PL-9 missile is reported to have a high-altitude capability up to 21 km (69,000 ft).
The PL-9C retains the same airframe configuration as the PL-9, but with a new multi-element seeker and digital signal processing for improved anti-countermeasures performance. According to CATIC the PL-9C has twice the head-on detection range of the PL-9 at 8 km. The IR seeker itself has a field of view of ±1.5º and will lock on to a target in >0.3 of a second. The maximum firing range against a frontal hemisphere target is 22 km. The minimum range in the rear hemisphere is 500 m. CATIC claims a single-shot Pk rate of 90 per cent.

Operational status

It is believed that PL-9 entered development in the mid- to late-1980s, and entered Chinese service in the early 1990s. A naval surface-to-air missile variant, designated PL-9N, with a four-missile launcher similar to that used with the PL-8, has been offered for export since 1993. The ground-based DK-9C system is also available. Unofficial sources state that the PL-9 is in service with the Pakistan Air Force (equipping its F-7 aircraft). It is possible that the PL-9 may also have been exported to Iran. The PL-9C version was first offered for export in 1999. According to CATIC the PL-9/C is compatible with the J-7/F-7, J-8/F-8, 'MiG fighter families and other Western fighters'. Several Chinese sources still maintain that the PL-9 has not entered PLAAF service.

Specifications

Length: 2.9 m
Body diameter: 157 mm
Wing span: 0.816 m
Launch weight: 115 kg
Warhead: 10 kg HE
Fuze: Active laser
Guidance: IR
Propulsion: Solid propellant
Range: 15 km (PL-9), 22 km (PL-9C)

Contractors

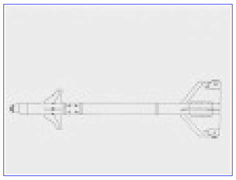
China National Aero Technology Import & Export Corporation (CATIC), Beijing.
Luoyang Electro-Optical Equipment Research Institute (Luoyang Optoelectro Technology Development Centre), Luoyang, Henan Province (seeker).

UPDATED

Seeker head of the PL-9C variant (Robert Hewson)

 *A PL-9 missile carried by a Shenyang J-8IIM (Robert Hewson)*

 *A PL-9 missile fitted to a J-7 (MiG-21 `Fishbed') aircraft (CATIC)*

 *PL-9 diagram*

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CHAPTER 3 - MISSILE SYSTEMS

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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 tandem 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.

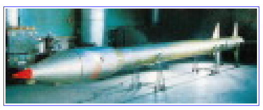
In 2000, the CIA reported that Pakistan's new Shaheen II nuclear-capable medium range ballistic missile incorporates Chinese solid fuel technology. US intelligence officials maintained that China continues to transfer missiles technologies such as special steels needed to produce missile engines, guidance systems, and design information.

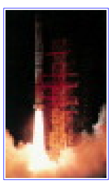
3.12.10 North Korea

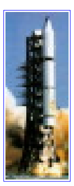
China has provided North Korea with various ballistic and cruise missile, nuclear and other WMD-related technologies, which in turn are believed to have been transferred to various Middle Eastern nations including Egypt, Iran, Libya and Syria.

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)

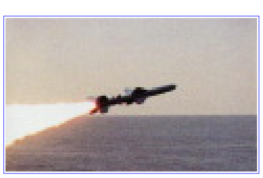

A T-7A Biological Sounding Rocket.
(Source: CAST)

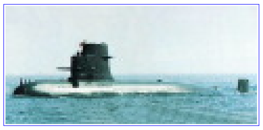

On May 12, 1997, a CZ-3A space launch vehicle successfully launched the DFH-3 large volume telecommunications satellite with state-of-the-art technologies for domestic telephone, fax, data and video broadcast services.


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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CHAPTER 9 - INFORMATION TECHNOLOGIES

Date Posted: 05-Dec-2000

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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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PROCUREMENT, China

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JANE'S SENTINEL SECURITY ASSESSMENT - CHINA AND NORTHEAST ASIA - 12

PROCUREMENT

DEFENCE EQUIPMENT REQUIREMENTS TOP

The 1995 Chinese parliament agreed to the spending of US$18 billion on new military equipment for the PLA over a five-year period, including submarines and a number of advanced attack aircraft.
However, funding restrictions were re-introduced in 1995 and, with the exception of the Russian submarine deal, equipment procurement was reduced. The `Kilo' class submarines were acquired on a 50:50 barter/cash deal which, unlike the Iranian `Kilo' programme, was not believed to include a specialist Russian training team resident in China.
China also completed negotiations for the licensed production of a range of Russian high-technology systems, including combat aircraft, air-to-air and air-to-surface missiles, battlefield anti-tank missiles, air defence systems and conventional submarines.
At an enlarged meeting of the CMC which followed the 15th Party Congress, the decision was made to reduce the Chinese armed forces by 500,000 personnel. The reduction in troop strength will be mainly targeted at the army. Funds saved by the cuts will be re-allocated for the purchase of high-technology naval and air force weapons.

Land Forces Requirements TOP

New tanks and armoured fighting vehicles are being developed and, according to US Defense Intelligence Agency data, there are two new main battle tanks and at least one new infantry combat vehicle undergoing trials in China.
Reports of recent acquisitions of air defence systems from Israel have been denied, despite the fact that certain ground-based

SAM systems bear a striking resemblance to the IAI Python.

Over the next 20 years, according to a number of Chinese assessments, the deployment of new tanks (such as the T-80-II and T-90-II) and armoured personnel carriers (BMP-3s) will lead to the development of an increasingly more mechanised and modern force. But it should be pointed out that the PLA is projected to have only four mechanised divisions and five high-quality tank divisions by 2015. These units will serve as the basis for any cross-border projection force, along with the designated rapid-reaction divisions of the 15th Airborne Army.

Although rapidly deployable, the three airborne divisions will continue to be restrained by an inadequate lift capability. Other stumbling blocks for the RRUs (rapid response units) are the lack of logistical supply capability, AWACS for battle management, air-refuelling capability for fighter support and other equipment, backward technology and training and doctrinal deficiencies. Despite these shortcomings, the mechanised force will serve as the backbone of any cross-border force, supported by the infantry divisions.

Land Forces Modernisation TOP

Many of the army's battlefield direct fire and mobility systems are being improved with the addition of night vision equipment, air defence missiles and nuclear, biological and chemical (NBC) equipment.

The lessening tensions along the Russian and Indian borders have meant a corresponding reduction in procurement funds for the PLA. What funds have been made available have been applied to improving its main battle tank fleet with the purchase of Russian-built T-80s and series production of the T-85M. Serial production of the T-85M, which will replace the ageing Type 59 and Type 69 tanks, is underway at the Norinco plant in Beijing.

The deployment of the LY-60 medium altitude SAM system, which is expected to become operational with ground units in the near future, is expected to enhance Chinese anti-aircraft defences. Composed of a surveillance radar, tracking/illuminating radar and launch vehicle, the LY-60 is based on the Italian-built Aspide air-to-air missile, which China received prior to the 1989 Tiananmen crisis.

In December 2000, a rocket gun unit of the Nanjing Military Region test-fired a new generation of WS-1B rocket guns, which have been put into mass production in China. These 406 mm super-range rocket guns have a range of 360 km - the longest range for conventional guns in the world.

A Chinese military specialist disclosed that the WS-1B super-range rocket gun was developed on the basis of a conventional rocket gun with a range of 180 km by the China North Industries Group Corp. The gun was designed for the military struggle against Taiwan.

The Central Military Commission stipulated that since the average distance between the coasts on the two sides of the Taiwan Strait is about 200 km, and the widest part from the east coast to the west coast of Taiwan Island is about 160 km, the range of this guns should be set at about 360 km so that they can cover the entire Taiwan Island.

Air Force Requirements TOP

Of all the armed services, the PLAAF has been the slowest to modernise. In many respects, this is linked to political reasons. The air force's close identification with Minister of Defence Lin Biao and leftist radicals during the Cultural Revolution left it politically suspect afterwards. China's domestic turmoil shredded the PLAAF officer corps and severely disrupted the country's aviation manufacturing infrastructure. In essence, the Cultural Revolution cost the PLAAF almost two decades of development and sharply diminished its political influence.

This lack of political clout severely hampered the PLAAF's technological development. The equipment flown by both the PLAAF and the PLAN Air Force is composed almost entirely of Soviet designs from the 1950s and 1960s. The fighter force is composed of the J-5, J-6/Q-5 and J-7, which are Chinese designs of the MiG-17, 19 and 21, respectively. While the inventory of interceptors exceeds 4,000, they are antiquated and far inferior to other regional assets, namely the F-15, F-16, Su-27 and Mirage 2000. Its bomber force, which numbers between 400 and 500 H-5s and H-6s (based on the Soviet Il-28 and Tu-16) is equally slow and vulnerable. More importantly, the PLAAF lacks aerial refuelling capabilities and Airborne Warning and Control System (AWACS) aircraft. Without rectifying these shortcomings, Chinese air power cannot be used in a power projection capacity.

Following the strategic decisions taken as a result of studying conflicts in the Middle East, the CCP allowed the PLAAF to develop key technologies. Much of the original development was based on the quick and relatively easy acquisition of Western technology but the post-Tiananmen boycotts have thwarted that process.

In March 1999 President Jiang Zemin called on the PLAAF to step up its offensive and defensive capabilities through high-technology development. Speaking at the air force's Ninth Communist Party Congress, Jiang said, ``We should build an air force capable of both offensive and defensive operations with Chinese characteristics." As regards weaponry development, the president stressed the need to ``revitalise the PLA through science and technology", adding that ``speedier development of hi-tech weapons is needed while preparing to fight a battle with present weapons."

New Aircraft

According to senior Chinese officials, there are at least three types of aircraft being prepared for operational service:

- Upgraded F-7 (a license-built MiG-21) airframe;
- J-8III;
- J-9.

The last is thought to have involved the adaptation of technology from the Israeli Lavi programme. Photographs were shown at the Paris Air Show in June 1995, where the aircraft was designated FC-1. It was described as a single-seat, single-engined, air-superiority fighter optimised for interception and ground attack missions. No first flight data was revealed and the aircraft's illustration was clearly a photo-montage.

New Technologies

Priority is also being given to the development of in-flight refuelling technologies. Equipment in this regard was procured from overseas, some of it from Israel. EW systems are also in demand for new aircraft types, including long-range fighters and maritime patrol aircraft (MPA). Two Tu-154M airliners have been modified to carry a very basic electronic warfare (EW) suite at the PLAAF research institute at Beijing-Nan Yuan. Further negotiations with Israel for electronic intelligence technology and with Russia for the A-50 airborne early warning and control aircraft may be continuing.

Foreign Military Sales

According to informed sources, China is planning an upgrade of the J-8IIM fighter design to increase its export potential. The upgrades are focused in two areas: a digital fly-by-wire (FBW) flight-control system and the addition of operational pods for targeting and electronic warfare. These improvements will allegedly put the J-8IIM on a par with the JH-7 in terms of air-to-ground capability. The J-8IIM aircraft, however, will exceed the JH-7 in terms of aerial combat capability. It should be noted that the foreign market for the J-8IIM is limited, since Pakistan has already joined the FC1 multi-role fighter project and the only other obvious buyers are Myanmar, Bangladesh and Sri Lanka.

Flying Panther

The Fighter-Bomber China 1 (FBC-1 or Flying Panther) that the China Aviation Industrial Corporation exhibited at the 1998 Zhuhai Air Show represented `the military supporting itself'. It is understood that the Flying Panther fighter is made by the Xian Aircraft Company and was successfully test-flown at the end of the 1980s. It has 10 external weapon racks and a maximum weapon mount capacity of five tons.

The Flying Panther fighter's key technology is its engines. While the overseas media had previously claimed that the Flying Panther would have upgraded Russian AL-31SM turbofan engines, the Flying Panther that was shown at the Zhuhai Aerospace Show had two British Spey MK-202 turbofan engines. The turbofan engine is a bottleneck technology for the Chinese aircraft industry which, from the 1960s to the present, has never been made in China, with its past most advanced J-8II fighter using turbojet engines.

The Flying Panther is the first Chinese fighter model with a foreign turbofan engine, with China's export of that model clearly being a major breakthrough in China's weaponry development. Previously, the China Aircraft Industrial Corporation had exported in the 1990s the J-7M and J-7P, boldly importing electronics systems from abroad used for their weapons control, as well as undertaking some domestic upgrading based on imports. That included the J-7P fighter that was developed for export to Pakistan which, according to Pakistan's demands, had over 20 Chinese improvements.

China's announcement that it was exporting the Flying Panther fighter with its foreign engines showed that China's fighter manufacturing technology had changed from the completely self-developed model to one that fully used advanced overseas technology.

Air Force Modernisation TOP

Since the end of the Cold War, there has been more fighter development activities in China than anywhere else in the world. Most notable are the J-10 and J-11 (Su-27) projects, which suggest the PLAAF is adopting a `high-low' two-fighter doctrine. In addition, two more fighters (the F-8IIM and FC-1) are also being developed. While both are expected to be stop-gap measures, the latter (FC-1) is more likely to be made only for export. However, the future of these new fighter projects is far from certain (except the Su-27 perhaps, which is too `hot' to be shelved), as the PLAAF may not need or be able to afford all four of them.

In July 1998 Russian and Chinese defence officials agreed to co-operate in the joint research, development and production of military equipment. At the leading edge of this agreement is the Su-30. In August 1999 both countries clinched a deal whereby

Russia will sell 60 Su-30 fighter-bombers to China. The deal illustrated the PLAAF's aim to enhance its ground and ship-attack capability, as well as improve its all-weather strike capability. Russia may also transfer Su-30 production technology as China has repeatedly stressed its refusal to buy large quantities of weapons without the subsequent transfer of corresponding technology.

In terms of attack aircraft, development is much less impressive. The 30-year old Q-5 (a MiG-19 derivative) badly needs replacement, as does the obsolete H-6 (Tu-16) bomber. Yet the new HJ-7, its intended replacement, has not met expectations. Despite expected improvements, which will include a nose-mounted twin 23 mm cannon, two stores pylons under each wing, wing-tip air-to-air missile rails and terrain-following radar, the HJ-7 is hampered by an under-powered engine.

The lack of tankers, airborne warning and control systems (AWACS) and precision-guided weapons (especially TV or laser-guided missiles and bombs) remains the PLAAF's biggest problem. These deficiencies prevent the PLAAF from launching any effective air strike beyond its traditional territory (such as possible actions against Taiwan or over the Spratlys).

Russia has sold 72 **Su-27s** to China in three separate deals since 1996. Whereas the first 24 were basic models, later shipments included improved variants with both attack and multi-role capability. The supersonic AS-17 Krypton (Kh-31) anti-radiation missile and a number of AA-10 `Alamo' (R-27) air-to-missiles were sold to China over that period.

At the end of 1996 Chinese and Russian authorities concluded a co-production agreement for at least 100 additional Su-27s. Designated the J-11, they are intended for construction at the Shentang Aircraft Corporation's facilities.

A second aircraft being developed is the **FC-1 lightweight fighter**, based on the design for the MiG-33 rejected by the Soviet air force. Israel and several European countries are being considered as suppliers for the plane's avionics.

A third aircraft, the **J-10 (F-10) multi-role fighter**, is based on technology developed for the US-financed Lavi fighter programme, which was cancelled in 1987. In May 2002, the Chengdu Aircraft Corporation [CAC] delivered to the PLAAF the first batch of four "J-10" fighters. The CAC has decided to build 45 more "J-10" fighters as part of the first group of the newest model aircraft developed indigenously by China. Various military web sites quoted an air force officer as claiming that by 2005, "J-10" fighters will have replaced "J-8 III" fighters as the air force's main fighter.

According to sources, CAC is going to build the first group of 50 "J-10" fighters at its various plants. In view of the inadequacies of "Su-series" heavy fighters, the CAC is also going to supply the air force with new-type China-made heavy fighters, in light of the latter's needs. With blueprints finalised, the CAC will be able to test-fly the new-type heavy fighters during the first half of 2003. The PLAAF believes that with "J-10" fighters deployed, it will be able to significantly upgrade its offensive capabilities by a large margin.

The air force revealed that the four "J-10" fighters entering the inventory will not be deployed at coastal air bases for the time being. However, upon the completion of tactical training, "J-10" fighters will be deployed in coastal areas.

Missile developments

At November 2000's Zhuhai aviation show, the Chinese-made ``Flying Midge'' surface-to-air guided missile system and the new antiship, antiradar guided missile which can equip a new ``Flying Leopard'' fighter-bomber (FBC1) attracted attention.

The greatest changes to the latest model of the ``Flying Midge'' were in the improvement of its navigation and targeting systems and the addition of another infra red tracking system to the radar truck which will continue to track and anchor an object when the radar breaks down, and lead the guided missile in bringing down the object.

In another development, the Chinese put on display for the first time an advanced guided missile whose name remains unknown. Though it was only a model and was attached to the model of the ``Qianhong 7'' aircraft (namely, the ``Flying Leopard'' heavy bomber especially manufactured for its naval air force), it attracted the attention of foreign military experts.

A US military expert believed that it was a new supersonic anti-radar, anti-ship guided missile developed by the CPC military. The missile has equipped CPC troops in Fujian's front and could pose a serious threat to Taiwan's defense system, especially their navy. It is believed that China hoped that the new missile would break into foreign markets.

Operation problems

There is a tendency to overstate what this means for PLAAF combat capability. Whilst some analysts contend that `China's double-digit economic growth is funding three major combat aircraft development programmes at a time when the whole of Europe can barely afford two', other sources portray a far different situation.

A former air force attaché in Beijing points out that production of one of the three planes, the FC-1, is a joint project with Pakistan with the plane designed for export. He does not believe that China will be able to afford to procure both J-10s and Soviet aircraft and sees the J-10 as the more probable choice since it is more acceptable to the faction that favours indigenous development and production of weapons.

It may be a long time before the J-10 is operational. China's A-2 attack aircraft was not deployed until eight years after its initial test flight and there is no reason to think that the J-10 will enter service any faster. Problems have occurred which hamper

production, and the plane is unlikely to be deployed before 2004.
The Su-27 purchase was no bargain: at a cost of US$1 billion for 26 aircraft, this works out to nearly US$40 million per aircraft. Disagreements over price meant that the second batch of aircraft was left subject to the harsh Russian weather for more than two years, suffering significant deterioration. Metal fatigue has been a problem. The final batch will have suffered even more.
Chinese maintenance procedures are poor: of 24 Sikorsky helicopters purchased from the US a little over a decade ago, few are still in regular operation. PLAAF pilots train on average only about 80 hours a year. They almost never practise over water, a major deficiency in preparing for the type of missions they are likely to face in a confrontation involving disputed islands. The PRC's pilots are, moreover, reluctant to push an aircraft to the edge of its capabilities.
While Russian trainers complain about Chinese pilots, the Chinese note that the aircraft arrived without training manuals. They are also causing damage to Chinese runways, which were constructed for lighter airframes than the Su-27.
Taiwanese sources independently confirm these points, with one officer describing the aircraft as having ``a very low operational readiness capability due to poor logistics and maintenance. The number of take-offs and flights is not frequent." He was sceptical that the licensing agreement allowing the PRC to produce Su-27s would result in mass production of the aircraft, predicting that the Chinese would encounter real difficulties in providing the necessary logistical support and maintenance to ensure an acceptable operational readiness capability for the final product.
Even after lengthy training in Russia, the Chinese pilots designated to take over the Su-27s were so unskilled that Russian pilots had to deliver the aircraft to Chinese bases.
One problem that the PLAAF has been striving to overcome revolves around air transport and lift. To satisfy this requirement, China has looked to the former Soviet Union. In 1993 China ordered 10 **Il-76MD transport planes**. The following year, it purchased 15 Il-76Ms, significantly boosting the PLAAF's heavy-lift capabilities. China purchased an additional 10 Il-76MDs and discussions are underway with Russia regarding the procurement of up to four **An-124 transport planes**. In addition, China has approximately 300 civilian transport aircraft that could potentially be made available for military use.

Long-term prospects

In all probability the PLAAF will not look that much different in terms of capability in 10 years than it does today. Some important improvements could include the addition of airborne early warning (AEW) aircraft, aerial refuelling assets and a limited number of more modern aircraft.
Although the PLAAF has begun purchasing advanced Russian equipment and a limited number of Il-76 transports, it is unlikely that rapid modernisation using Russian-built systems will occur during the latter half of the 1990s. Such purchases would require major infusions of scarce financial resources.
China's defence purchasing power declined substantially during the 1980s and inflation combined with changes in currency-conversion practices have limited the impact of recent increases in defence budgets. However, the readiness of the Chinese leadership to allocate appreciable foreign exchange for these recent purchases demonstrates a growing realisation of the severity of the PLAAF's modernisation problems.
One possible solution to China's air power modernisation dilemmas would be a co-production agreement between China and such countries as Russia and Israel. An example of such trilateral co-operation centres on China's attempt to develop aerial refuelling and airborne control systems, necessary capabilities for power projection beyond the coastal mainland. A number of reports indicate China is seeking Russian and Israeli assistance in order to acquire these force multipliers.
China has, as mentioned above, purchased 10 Il-76 medium-to-long range transportation aircraft from Russia, ostensibly to improve the PLA's lift capability. However, some believe that some of these aircraft will be used as air-refuelling or AWACS platforms. In a reported US$250 million deal with China Israel will put its Phalcon 200 mile range airborne early warning radar on the Il-76.
The long-term prospects for success in any such undertaking, however, are fraught with uncertainties. These uncertainties include very long production lead times, the extent of China's budgetary commitment to any such project, the willingness of foreign suppliers to transfer the full spectrum of technologies involved in a modern combat aircraft, the prodigious development costs that would be associated with a full-scale programme between China and a foreign supplier and (perhaps most importantly) the ability of Chinese research and development personnel to assimilate and integrate newer technologies fully.
Even assuming that all these uncertainties can be satisfactorily resolved, there are the equally daunting tasks of maintaining high-technology systems that are well beyond the sophistication of aircraft in the present PLAAF inventory and of the air force being able to utilise such capabilities fully in training and in combat.
At the same time, to garner sufficient political and bureaucratic support within China, any such project must move from the co-assembly phase to production with full domestic content. As with numerous joint-venture projects in China, this would be a slow process and might not reach fruition. This would leave the air force unable to modernise its force structure for many years to come while facing serious problems of obsolescence.
If Chinese fighter and bomber production continues at its present rate, estimates indicate that the PLAAF will be roughly half its current size in 10 years' time. Moreover, except for a small number of advanced fighters procured from Russia, the

preponderance of China's force structure early in the next century will consist of fighters that today are already considered obsolescent.
It should be noted, however, that according to some intelligence reports China's major aircraft designers are competing to develop a large multi-role fighter that could enter service with the PLAAF and the PLAN Air Force around 2015. The XXJ fighter will emphasise air combat and a `reduced radar signature design'.

Naval Requirements TOP

Submarines

A key requirement for the PLAN is a second-generation nuclear-powered attack submarine. The acquisition from Russia of four `Kilo' class submarines at a cost of more than US$800 million has provided China with a proven platform and access to useful technology. But the PLAN has had trouble with the boats, largely because China has sought to trim training and maintenance costs. Two of the first three Chinese `Kilos' were seriously damaged through inadequate training but have since been repaired. The best of the crews on these three boats have been combined to crew the fourth vessel, whose performance shows significant improvement. Additional training is underway but there are reports that the PLAN will still not take the `Kilos' below a depth of 50 m. There are rumours that China may obtain a fifth `Kilo', but this is far from certain. An option on a further 18 `Kilo' submarines, making a total of 22, is understood to have been agreed between Beijing and Moscow.
According to Russian sources, China's President Jiang Zemin, during a visit to Russia in June 2002, reached an agreement with Russia on purchasing eight Type 636 "Kilo" class conventional submarines worth US$1.6 billion (about 13 billion yuan). The submarines will be delivered in five years. With the purchase, the number of the Kilo-class submarines that China has will increase to 12. According to one source, China’s significant purchase of the Kilo-class attack submarines is aimed politically at deterring Taiwan's independence forces, as well as making it operationally more difficult for US forces to come to the aid of Taiwan.
Jane's Defense Weekly, citing a Moscow source, reported that Russia's state-run arms exporting company will deliver the eight Kilo- class submarines to China in five years. It has been learned that after the US decided in April 2001 to sell eight diesel submarines to Taiwan, Beijing asked Russia to sell eight more Kilo-class submarines.
While attending a defence ministers' meeting of the member nations of the Shanghai Cooperation Organisation in Russia in mid-May 2002, Defence Minister Chi Haotian, Deputy Chief of Staff Xiong Guangkai, Director of Foreign Affairs Office under the Ministry of Defence Zhan Maohai, and other military officers discussed the arms purchase again with the Russian side.
The source pointed out that the reason for China's making additional purchases of the Kilo-class submarines is probably because the Chinese-made Song-class submarines had developed problems. China had spent several billion US dollars in developing the Song-class (Type 039) conventional submarines to replace the outdated R-class submarines. China's first sea test of the Song-class submarine in 1995 ended in failure. Another test in early 2000 still failed to solve the excessive noise problem. Western observers said the development of the Song-class submarines is way behind schedule. It is said that the construction of this type of submarine had still not been completed as of the end of 2001.
For several years China has been improving its conventional submarine fleet, based originally on a number of Soviet-supplied `Romeo' type patrol submarines. The first Song class conventional submarine was launched in early 1994 and it is thought that a number of recent Israeli developments have been incorporated in the design. In 1999 the second Song class submarine was launched from the Wuhan shipyard. Originally scheduled for completion in 1998, its timetable was upset when the first boat, fitted with a patchwork of systems and technologies, did not perform up to expectations. Whether the PLAN will proceed with series production will probably depend on results obtained from its subsequent sea trials. Song (Type 039) boats will eventually replace the `Romeos' (Type 033) in service and supplement the `Ming' class submarines in due course. The Song class submarine is supposedly based on the French Agosta class.
The delay in the Song programme has led the PLAN to resume the `Ming' class (Type 035) programme, previously thought to have ended with the launch of the 14th hull in mid-1996. Two `Mings' of the modified ES5E model were launched in 1997 and another has since been launched. At least two more modified `Mings' may be planned, to produce a total of 19 boats.
Domestic development of conventional submarines had been restricted by the lack of manpower and funding directed into the nuclear-powered fleet. This was particularly true of the PLAN's ballistic missile submarines, which although they have not been commissioned at a rate previously planned, have proved themselves reasonably successful. Construction of the nuclear-powered Han class attack submarine is continuing. It would appear that construction of the experimental Xia class has been stopped while the PLAN awaits the new Type 094 class. This new class is expected to arrive in the next few years and will carry 16 launch tubes for the new, longer range Julang-2 (CSS-NX-4) SLBM.
The South China Sea is not good submarine territory. It is unlikely that the PLAN would risk a nuclear-powered ballistic missile or even a nuclear-powered attack submarine in the relatively shallow waters of the continental shelf.

Aircraft Carriers

The embarked aviation debate is now raging throughout the Chinese military establishment and the issue probably will not be resolved until political consensus is reached. In 1985 the Chinese government bought the Royal Australian Navy's former aircraft carrier *Melbourne* for scrap. Instead of towing the carrier straight to the breaker's yard, the warship, originally built in the UK, was slowly taken to pieces for future back-engineering.

By 1987 the PLA Naval Air Arm had reconfigured part of an airfield, north of Beijing, to resemble the flight deck plan of the *Melbourne*. In the same year the first production F-8 combat aircraft was shot into flight from the re-constructed Lushun naval base near Dalian. This facility is not far from the Shenyang factory where the F-8 was developed from a previous Soviet design and where efforts are being made to adapt a version of the F-8-II for naval operations. Also in 1987 the PLAAF began a training programme for air force and naval personnel focusing on the operation of aircraft from sea-based platforms.

After initial flight training the selected personnel, all technical graduates, were transferred to the Guangzhou Naval Institute for command training aboard the PLAN's largest warships. Thus it was planned to create a stream of naval pilots with large ship command, exactly in the manner of the US Navy. In 1990-92 the PLAN sent its best engineers to view the various former Soviet navy aircraft carriers which had been laid up for scrap or for which there was no funding for completion.

At about this time various articles began to appear in the Chinese military press which talked about the future needs of full logistical support for `aircraft operated at sea' and about the building of sufficiently large berths for `power projection ships'. One article even talked wistfully of the day when every Chinese in Hong Kong could see the `silhouette of an aircraft carrier' laying off what would become a city within the PRC (albeit a special administrative region).

Further evidence of an interest in aircraft carriers was reported by the Russians. Chinese specialist naval engineering teams which visited Vladivostok and Nikolayev looked at redundant or half-built ships, took notes and returned to Beijing and Shanghai to compare findings.

By early 1993 it was obvious that to buy second-hand equipment from the Russian Federation or Ukraine would be too costly and limit the prospects for technology growth. The opportunity to see first-hand how things were developing in Russia was not missed, of course. In any case, the PLAN was uncertain of how best to proceed: the options being STOVL (short take-off/vertical landing) or catapult-assisted conventional carrier.

In March 1993 it was announced, with little publicity, that three `large aircraft-carrying ships' would be built. Building would begin as soon as possible, with hulls being laid at Dalian, Shanghai and Zhanjiang naval shipyards. Funding restrictions soon hit the planned aircraft carrier development programme, however.

In June 1998 sources reported that China was prepared to wait until 2020 to have a fully functioning aircraft carrier at sea. Senior Chinese naval sources stated that the carrier programme was approved at the 1997 15th Communist Party Congress. Previously, the programme was to have been included in the 1996-2000 Five-Year Plan, which would have produced a carrier between 2005 and 2015. The fact that the programme was moved to the next five-year plan indicates that funding was almost certainly an issue. Chinese officials have been discussing short take-off and vertical landing (STOVL) operations with the Royal Thai Navy, which received Southeast Asia's first aircraft carrier (*Chakri Naurebet*) in August 1997.

According to the Chinese military daily, *Ming Pao* (January 2000), China has dramatically shifted its aircraft carrier plans, speeding up the scheduled launch of its first light and conventionally powered aircraft carrier, which is estimated to cost 4.8 billion yen, to 2003. If this time frame is achieved, the first carrier could enter service around 2005. From then on, the report estimates, China will be able to build a new aircraft carrier every three years. This report followed one from August 1999 which stated that China had approved the construction of two aircraft carriers to be finished by 2009.

Although China has not yet built any aircraft carriers, *Ming Pao* reported that `classes for pilot captains' have been operated for quite some time. The students, who come from the airborne units of the navy and aviation institutes, all have a college education and three year of experience in flying jets. Most of them have assumed the post of team leaders. Reportedly, the two-year special and advanced training programme has turned out more than a hundred `outstanding pilots who can take off from an aircraft carrier'.

As reported above, it is said that a navy unit has built a simulated flying deck at its airport in northern China. It is understood that the PLANAF has used the deck to carry out numerous flying tests. The improved deck adopted the optical landing system designed and developed by China. Military analysts believe that this `is an important link for enhancing combat effectiveness'.

The feasibility study and draft design of China's aircraft carrier allegedly started in 1992. The final scheme (Plan 9985) was endorsed in 1999.

Although highly speculative, some sources contend that the displacement of China's first aircraft carrier, which will be built at the Shanghai Shipyard, will be 48,000 tons. According to these sources the aircraft carrier, which will use Russian TB12 technology for its steam turbine, will be able to navigate at a maximum speed of 30 knots and will be outfitted to embark 24 Su-30 aircraft, which China bought from Russia for US$2 billion. There are two sets of vertical 24-missile launchers on the decks at both the head and tail of the carrier. The devices, sources say, are likely to be equipped with cruise missiles. The 70 m long deck runway adopts advanced slant-line distribution, which saves the take-off distance. The jets can slide from the head of the carrier and take off. The carrier, sources say, will carry Russian radar (it must be noted, however, that none of these specifications conform to recent speculation about a Chinese carrier. Most experts believe that China's first carrier will be more modest, something akin to Thailand's *Chakrai Naurebet*).

Some Chinese analysts believe that there is an urgent need for the military to build aircraft carriers. They argue that the topography in the west of Taiwan facing the mainland coast is easy to defend but hard to attack, while the eastern coast is plain shoal. If China had an aircraft carrier deployed off the eastern coast, Taiwan's defensive forces would be forced to fight on two fronts. These analysts also argue that carriers could also be used to defend Chinese interests in the Spratly Islands, which are claimed by Taiwan, Vietnam, the Philippines, Malaysia and Brunei.

Surface Escorts

Since the late 1980s there have been the introduction of new generations of a Luhu class destroyer and Jiangwei class frigate. These provide the Chinese navy for the first time with much-needed anti-air warfare (AAW) and ASW capabilities. Both systems are equipped with short-range SAMs and shipborne helicopters carrying guided torpedoes. China's newest frigate class is the EF30 design, there being two under construction for the Thai Navy. The class may be procured later by the PLAN. The Houxin class (Type 030-11) guided missile ship was introduced in 1991. There are 20 such ships in the navy, dedicated to the South China Sea Fleet and another three are in different stages of construction. This class of missile boat is permitting the retirement of the obsolete Hegu and Huoku class missile boats.

In December 1996 Li Peng reached an agreement with Russia for the purchase of two Sovremenny class destroyers. The first ship was delivered in early 2000. The two destroyers are designed to enhance the PLAN's surface strike capabilities and its ability to deploy over long distances. It is expected to take two to three years to modify and fully fit the vessels. Some analysts are speculating that the Sovremennys could eventually form the core of a fourth fleet, which would serve as a task force with the flexibility to deploy more broadly. China's long-discussed aircraft carrier based battle group would have fulfilled this requirement, but it appears that plans for its creation have been shelved for the foreseeable future.

While payment may still be a problem, it has been reported that China is scheduled to receive two class 956 destroyers from Russia in a deal estimated to be worth US$800 million. Each destroyer will be outfitted with the Moskit anti-ship missile.

The growth of the surface navy, including the new destroyers which carry embarked helicopters, has paralleled the development of the submarine service. Diversion of effort to the building of warships for export is not thought to have caused a change in the naval procurement programme; Western sources believe that it is a lack of funds to buy foreign equipment, rather than technical or political problems, which have curtailed most of the destroyer/frigate programmes. It should be noted, however, that China has begun construction on two new Jiangwei II class guided missile frigates at the Huangpu shipyard. The first vessel (521) is undergoing sea trials; the second (522) has yet to be launched. The two 2,250-ton frigates will supplement the four Jiangwei IIs built as a follow-on from the original Jiangwei class. Two Type 037/2 Houjian fast attack craft (774 and 775) were also recently completed at the Huangpu shipyard.

Priority is being given to the acquisition of naval fire-control, EW and helicopter-handling systems from Western countries. Domestic industries are working on vertical-launch SAMs and phased-array radar for integration into warship command and control facilities.

Naval Aircraft

Besides increasing the number of ASW helicopters embarked in surface escorts, the PLAN is expected to acquire better, longer range land-based maritime patrol aircraft.

Plans to introduce a naval variant of the HJ-7 strike aircraft have probably been scrapped because of poor performance and obsolete avionics. Dropped by the air force in 1994, the navy will most likely follow suit in favour of continued procurement of the more advanced Su-27.

The naval version of the F-10 is the leading candidate for deployment on China's first aircraft carrier. China's first indigenous design of a fourth-generation aircraft, the F-10 is based heavily on the cancelled Israeli Lavi programme and its performance is expected to be equivalent of the F-16's. Because of the lack of access to Western technology, the F-10's deployment (land and sea versions) will probably occur no earlier than 2005.

Short Term Measures to Augment the Fleet

According to reports out of Hong Kong in November 1999, China is considering returning into active service some 50 decommissioned submarines currently languishing in a Shanghai military shipyard. The report went on to say that these submarines would be attached to the East Sea fleet.

In a similar vein, reports out of Hong Kong indicate that the Chinese Navy is stepping up efforts to refit a great number of merchant ships currently in reserve to make up for the shortage of naval landing vessels. In principle, the refitting effort is aimed at "using these ships both in peace time and war time." After being refitted, these merchant ships will be used for commercial purposes as usual, but in the event that landing operations against Taiwan are conducted, these ships may be used for carrying out military missions.

Naval Modernisation TOP

The current naval modernisation trend can be traced back to 1975 as China sought to deal with the growing Soviet threat to its shores. There was a need for the rapid development of the merchant marine and the consequent need to protect sea lanes. China also had a growing interest in offshore oil resources. To cope with these problems, the need for modernisation of the navy was recognised by the Chinese political leadership.

There are ambitious plans to upgrade the fleet in the following areas, which tend to mirror the planned development of newly built warships, facilities and aircraft:

- ASW systems and weapons;
- Close-in air defence systems;
- EW systems;
- Naval fire-control systems;
- Helicopter retrieval and deck handling equipment;
- Long-range missile tracking and illumination radar.

Submarine updates include the addition of new technologies from Israel, such as the developments gained from Israel's co-operation with the Germans on the Dolphin class. Israeli technicians arrived in Wuhan shipyard in early 1995 to work on improvements to the fleet.

In 1999 China took possession of its fourth Project 636 Kilo class submarine. The submarines, the first Project 636 models to be sold abroad, are reportedly fitted with automatic torpedo launching equipment and advanced noise reduction devices. According to some sources, the submarines are scheduled for deployment in the waters around Hong Kong.

Despite the qualitative improvement these submarines will mean for the PLAN, problems abound for China's submarine fleet. The Type 877EKM model submarines, which were obtained from Russia in 1995, are plagued with logistic support and maintenance problems and still do not have an operational capability. Several electric generators in one of the submarines allegedly broke, while the second submarine has serious problems with a water pump. Since much of China's military equipment dates from the 1950s and 1960s, its maintenance and technical knowledge are largely rooted in that era, thus slowing the repair on the two submarines. They are not expected to be operational until well into 1998.

Further problems are rooted in crew training for the `Kilo' class submarines. The first Chinese `Kilo' crew spent a year training in St Petersburg. The training programme for the Type 636 crew, however, has not been finalised. There are also rumours that money is scarce for further training abroad.

Work continues on an improved nuclear ballistic missile submarine programme, designated the Type-094. Reports suggest that four to eight Type-094s, essentially a modified Xia class submarine, will be built. Each will be fitted to carry 16 MIRVed JL-2-type (CSS-NX-4) submarine-launched ballistic missiles which have a range of 8,000 km (4,900 miles). Deployment of the first modified Xia class submarine is scheduled for some time after the turn of the century.

Chinese plans to augment its surface fleet with additional Luhu class destroyers is evidence of China's shift from coastal to ocean-going warship construction. Current PLAN orders call for at least one additional Luhu to be built. Luhu class destroyers are fitted with a French-built sonar, TAVITAC 2000 combat direction system, Crotale point-defence missiles and C801 surface-to-surface missiles; they also incorporate a helicopter deck and hanger. With regard to China's other major surface fleet plans there also appear to be problems. Construction of two additional Jiangwei class frigates has been delayed due to funding constraints. An in-service date of early in the 21st century is now planned. The Jiangweis carry CY-1 anti-submarine weapons, C801 anti-ship missiles and HQ-61 surface-to-air missiles, as well as a single Zhi-9 helicopter.

In 1999 the PLAN launched its largest, most advanced, and most powerful warship, the 6,600-ton *Shenzhen*, the first of the Luhai class DDGs. The Luhai class is the product of the Dalian shipyard, but most of its systems are imported. Each ship is propelled by gas turbines built in Ukraine and is outfitted with electrical systems from Germany and torpedoes from Italy. The destroyer is also expected to support two Kamov Ka-28 anti-submarine warfare helicopters. The ship's major armament comprises 16 C-802 (CSS N-4 `Sardine') anti-ship cruise missiles, as well as short-range SAMs for point defence. The HQ-7 air defence system has proven to be inadequate and will probably be replaced by the Russian SA-N-12 `Grizzly', reportedly the system being fitted on the Sovremenny class destroyers. The *Shenzhen* will be deployed with the South Sea Fleet and will support operations in the South China Sea. It was announced in August 1999 that China will evaluate the performance of *Shenzhen* before beginning construction of a second ship. Work on the second ship could begin within a year or two.

Shore facilities, including personnel accommodation and command and control centres, are being upgraded.

In June 1999 Cao Gangchuan, the director of the People's Liberation Army General Armaments Department, stressed that a priority and urgent modernisation task for the navy centred on the development of advanced weapons and equipment. Speaking at a conference on naval equipment, Cao said that naval construction must fulfill the requirements of potential regional high-tech wars. He stressed that the development of new weapons and equipment should focus on upgrading their combat effectiveness. In order to achieve this goal, he advocated the creation of a competitive system to spur the development of new weapons and systems.

At the meeting, Cao noted that the navy's rapid reaction capacity, emergency field repair ability and defence readiness must also be improved. He said the navy shoulders the responsibility for maintaining the security of territorial waters and the arduous task of developing weapons and equipment. The navy should therefore develop equipment to ensure that it remains as powerful comprehensive combat force.

Assessment TOP

The PLA's modernisation programme was endorsed by the CCP in 1992. As a result, in 1993-94 there was intense activity among Beijing's equipment staff to put the policy into action, but with little perceivable result. Most Western suppliers were unable to deliver equipment because of boycotts related to the Tiananmen Square demonstrations. Domestic industry will be encouraged to take up many of the projects but not all the ambitious plans will be successfully completed in time, unless Western equipment and aid is forthcoming.

Procurement History TOP

In the first few years of the its existence, China relied upon the Soviet Union for military assistance. In the 1970s a programme of domestic self-reliance was initiated following the political schism between the two communist powers. At the same time, European nations were invited to participate in Chinese military programmes, particularly in airframe technology, avionics and power plant provision. By the mid-1980s, the US and Canada were also systems and airframe providers. The Tiananmen Square incident in 1989 caused Western plans for aid and programmes like `Peace Pearl', to put US and Western European systems into a MiG-21 copy airframe, to be abandoned.

Following the end of the Cold War, and perhaps learning from the lessons of the Gulf conflict, Chinese military requirements turned to high technology. The West was slow to respond to Beijing's requests for information and samples, but the Russian Federation, keen for business, did supply equipment, leading to substantial orders and license production. The domination of the Republican Party in the US Congress, which dates from early 1995, means that it is unlikely that China will receive favourable terms on new technologies, but already there are signs that Southeast Asian nations like Indonesia, plus France and South Korea, might be willing to plug the gap. Pakistan is another developing country which is keen to share expertise and technology; China and Pakistan have jointly developed the K-8 training aircraft.

Major Conventional Military Procurement TOP

Designation	*Equipment Type*	*Quantity*	*Origin*	*Delivery*	*Manufacturer*
`Kilo'	Diesel Submarine	3	Russia	1995	Rubin
T-80	Main Battle Tank	6	Russia	1994	Russian Army
S-300	Air Defence System	2	Russia	1994	Antey
Su-27	Combat Aircraft	48	Russia	1993-	Sukhoi
Su-27UB	Combat Trainer	2	Russia	1993-	Sukhoi
Il-78	Tanker Aircraft	3	Russia	1993	Beriev
Mi-17	Helicopter	28	Russia	1993	Ulan Ude
Note The T-80 and S-300 imports were evaluation batches; the Su-27 fighters are thought to be the first of 70 on order and there are a number of `Kilo' class submarines said to be under construction for China.					

Main Foreign Suppliers TOP

	(US$ million)
France	130
US	84
USSR	1,286
Other	19
Total	1,519

Note
As a result of the Tiananmen Square incident, EU and US governments forbade the formation of new military and defence equipment contracts with China. Existing contracts and business relationships, including those of Aerospatiale/Eurocopter France and McDonnell Douglas, have continued, but the integration of Western equipment in the J-8II, for example, has ceased.

In July 2000 Israel cancelled a US$250 million contract to sell an airborne early-warning system (AWACS) system to China after pressure from the US, who expressed concerns that the equipment could be used to track US jets in the region.

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