Testimony for the U.S.-China Economic and Security Review Commission Hearing on *China's Emergent Military Aerospace and Commercial Aviation Capabilities,* May 20, 2010

China's Aviation Sector: Building Toward World Class Capabilities

By Richard D. Fisher, Jr., Senior Fellow, International Assessment and Strategy Center

Introduction

Since the beginning of the latest phase of China's military modernization following the 1989 Tiananmen Massacre, the Chinese Communist Party leadership has striven to build a world class aerospace sector as a major element of increasing China's comprehensive national power. This goal has been pursued through enormous targeted investments in technology, design expertise, materials, and education, with successive sectoral reorganizations. A broad acquisition of foreign technology has used to accelerate modernization and has been critical in all areas of success. Having set a goal to become militarily dominant in the realms of air and space, this decade will see the emergence of a modern Chinese 4th to 5th generation air force, their first large cargo transport aircraft, and potentially, their first commercially viable transport aircraft. However, reaching this point has also been hugely difficult for China and especially for its aero engine sector where results are just beginning to be realized. Assuming continued heavy government support and success, by the 2020s these capabilities could form a core military and commercial air power projection capability for China. Absent appropriate U.S. government and commercial investments, by the 2020s the U.S. military and commercial aerospace sector will find itself in an increasingly heated competition with China, which will have significant security implications for the United States.

By 1989 China's aerospace sector had largely just started the painful process of emerging from decades of dependence on Soviet 1950s era combat aircraft designs, a limited ability to produce indigenous 3rd generation combat aircraft, an inability to produce competitive commercial transport aircraft and an inability to produce modern aircraft engines. The aerospace sector also was organized in geographic clusters of aircraft and equipment factories reflecting "People's War" strategies, but producing inefficiencies like one factory's fighters unable to another's engines. By 2010, after nearly three decades of investment, reorganization, and acquisition of broad foreign technology, China's aerospace sector is well on its way to making China one of the top two or three global air and space powers by the 2020s. China is now producing two 4th generation fighters which will soon be upgraded to 4+ generation capabilities, and a Chinese-made carrier-based fighter will soon emerge. These fighters are equipped with Chinese-made world-class precision air-to-air and ground attack weapons. China is now producing three types of airborne early warning and control (AWACS) aircraft and has one medium range tanker. China is also recapitalizing its trainer fleet with two new supersonic lead-in trainers, plus new jet and piston engine powered primary trainers. This decade will also see the emergence of a new C-17 size Chinese strategic transport aircraft.

It is increasingly apparent that since the early 1990s China has also been simultaneously developing a 5th generation combat aircraft, a prototype of which may fly in 2010 or 2011. Chinese aerospace officials hint it will be as capable as the U.S. Lockheed Martin F-22A. There are also hints of interest in smaller medium weight 5th generation fighters, raising the possibility

of a Hi-Lo 5th generation fighter mix. China can also be expected to soon field a new array of sophisticated unmanned aircraft for surveillance and then unmanned combat missions. China also has one of the world's leading research and development sectors devoted to hypersonic aircraft, which may yield new platforms this decade. China is also offering new capable and bargain-priced aircraft and systems for export and co-production, which could soon offer strong competition at the low end of the market.

China's previous attempts at commercial aircraft, such as its 1970s failed attempt to copy the Boeing B-707, and subsequent failed attempts to co-produce or develop airliners with dominant Western partners, have given way to a much more serious Chinese-led effort to develop its own airliner industry, starting in earnest during the 10th Five Year Plan (2001-2005). To accelerate results China is actively seeking key partnerships with Western companies. Airbus, Bombardier and Embraer hope to secure market share in China by shifting major elements of airliner production there, but are also helping to improve China's aerospace workforce. While the ARJ-21 regional airliner may only meet modest success, China hopes emerge this decade as a major market player with its larger C919 airliner. Though it enters a crowded narrow body airliner market, China is betting that its deep finances, captive market and access to state-of-the-art foreign technologies will allow the C919 to gain a market foothold before major rivals Boeing and Airbus are able to offer their next-generation narrow body airliner. There is also a less examined four-engine wide-body airliner program from the Xian Aircraft Company which likely aimed at filling military requirements. China's helicopter sector also has received much greater investment, is realizing more programs, but it has yet to break a significant dependence on foreign design assistance.

If there is an "Achilles Heel" it would be China's aeroengine sector, which after sustained investments since the mid-1980s, may only now be starting to produce a suitably reliable 4th generation fighter turbofan. This achievement, however, is already fueling the development of multiple high-bypass turbofan engines for large aircraft. At the same time China seeks foreign partnerships which it hopes will better assist its ability to remain abreast of regent engine technology developments. A 5th generation fighter turbofan with a 10-to-1 thrust-to-weight ratio is also expected to emerge within several years.

Caveats and Sources

In the main this paper seeks to assess the progress made by China's aircraft sector from a hardware perspective, though many conclusions must be tentative. This is due largely to China's intense effort to deny or restrict a detailed level of data and insight about its military, information that has long been taken for granted in the West. For example, despite its official "declassification" in 2006, the People's Liberation Army Air Force (PLAAF) has only allowed two semi public opportunities for foreign military officials to get close to the new Chengdu J-10 fighter (November 2009 and April 2010). Chinese aerospace officials have yet to release a brochure of basic performance data for the J-10. Journalists are simply denied the degree of access to mid and top level aerospace official, or to factories, such as is possible in the West. Western aerospace officials who work with Chinese companies also are often reluctant to comment on their future competitors, though China's Russian partners are sometimes more glib. China's major bi-annual airshow held near the city of Zhuhai has seen increasing restriction on

information by Chinese authorities over the last decade. That said, the year 2009 witnessed some important spikes in transparency by Chinese standards, especially regarding new strategies, the 5th generation fighter program and large aircraft programs.

Nevertheless it is possible to reasonably discern many ongoing trends. The Pentagon's annual China Military Power reports provide a useful measure of Chinese aerospace trends but could easily be used to provide much more useful detail. This author and many other journalists and analyst have been able to mine the global airshow and arms show network for much useful information on China's aerospace sector developments. As China seeks to compete in global military and commercial aircraft markets it seems to realize the necessity of providing more data about its products. Web sites like *Scramble,* using tools like *Google Earth* and Chinese sources are able to assemble useful order of battle data. Nevertheless data about advanced military programs like their 5th generation fighters, hypersonics, engines, future aircraft weapons and new strategic aircraft programs remains heavily guarded. But Chinese themselves are among the most interested in these programs and there is a vigorous vetting of new imagery and data, however scant, on numerous Chinese military issue web pages and blogs.

Goals and Trends

China's leadership has set a national goal of creating a world class aerospace sector to fulfill both the requirements of dominating modern air and space combat and for creating competitive commercial aerospace companies capable of meeting Chinese civil transport needs and for competing in the global marketplace. In November 2009 People's Liberation Army Air Force (PLAAF) commander General Xu Xiliang described a new strategy for the PLAAF as building "an integrated air and space force capable of offensive and defensive actions." The emphasis on the Air Force building capabilities for space warfare was a new emphasis subsequently explained in Chinese state media as necessary for China to win future wars. This will require that China's aerospace sector is able to master 5th generation and 6th generation levels of military capability. Also, beginning in earnest during the 10th Five Year Plan (2001-2005), China has started the difficult and expensive task of building a commercially viable "civil" large aircraft manufacturing sector. Industry spokesmen have repeatedly stated that China must meet this goal if it is to be able to emerge as a leading global power later in this century.

Reorganization In the 1950s, consistent with People's War strategies that envisioned long guerrilla wars against invaders, China created an aerospace sector characterized by regional redundancy in order to ensure production of military aircraft. Major aircraft centers such as in Shenyang, Chengdu and Xian produced their own aircraft, engines and components but often one center's aircraft could not use another's engine. Due to the isolation of the Cultural Revolution and the 1960s Sino-Soviet split, China's aerospace sector remained relatively static due to political chaos, underfunding and lack of contact with new foreign technology. But these redundant centers also built political patronage networks to help ensure continued business.

Since the early 1990s it has been apparent that China's party and military leadership has been unhappy with the aerospace sector's inability to produce world-class products. There has been a pursuit of at times of the contradictory goals of achieving greater rationalization while also seeking to promote competition and innovation, which would require redundancy. In 1999

China organized its then about 440,000 aircraft sector employees into two large corporate conglomerates, placing most military and large aircraft concerns in Aviation Industries of China (AVIC) one and then putting trainers and helicopters in AVIC Two, with the goal of spurring greater domestic competition. AVIC, however, was a bureaucracy that exercised control over still existing aircraft and component companies. The AVIC 1 Commercial Aircraft Corporation was an early attempt to combine distributed government and private factories and institutes toward the goal of making an airliner, the ARJ-21. Then in 2008 and 2009 there was a re-merging of AVIC 1 and 2, with a reported 420,000 employees and 100 companies, with some talk of the need to build new globally competitive "integrated companies."

New organizations have emerged apparently to create a divide between military and civil products, but such separation does not seem practically or politically possible for China. In early 2009 AVIC Defense emerged, with a reported 60,000 employees, but with a new organization focused on advancing mastery of new technology but with apparent greater autonomy from the AVIC bureaucracy. However, AVIC Defense is also marketing the U.S. designed Cessna C-162 small civil trainer, which is co-produced by the Shenyang Aircraft Co. after a 2008 agreement. In early 2008 the Commercial Aircraft Corporation of China (COMAC) emerged, combining the former AVIC 1 Commercial Aircraft, Shanghai Aircraft Corporation and the First Design Institute for the goal of building competitive commercial airliners. However, a 2008 U.S. Institute for Defense Analysis study of a 2007 visit to the ARJ-21 airliner plant concluded that the former AVIC 1 Commercial Aircraft Co. was ultimately responsible to the Central Military Commission of the PLA. There are reports that individual aircraft companies like Chengdu and Shenyang have split into "military" and "civil" branches, but these companies remain united by a single leadership, and military and civilian assembly lines remain co-located, to ease the sharing of skills and technology. COMAC's First Design Institute may also contribute to the design of China's new large military transport aircraft. These reorganizations also will not change existing Chinese policies of "combining the military and civilian" to ensure maximum mutual benefit.

In early 2009 the AVIC Commercial Aircraft Engine Co. was announced with the initial goal of completing a large high bypass turbofan by 2016, currently called the "SF-A" first displayed in late 2009. It is now building a 30 hectare research and development facility in Shanghai, which indicates there is a potential for this new organization to actually relocate existing large aircraft engine expertise from major engine development centers in Chengdu and Shenyang, or to build a new engineer cadre. Military turbofan research and production remain at Chengdu and Shenyang, which likely have had longstanding large high-bypass turbofan programs. When put into production, the SF-A can be expected to enable military versions of new civil airliners, plus new large military transports and perhaps bombers.

Another organizational trend worth monitoring is an upgrading of commercial relationships between Chinese aerospace universities and aerospace companies. In early May 2010 it was announced that the Harbin Institute of Technology, famous for its contributions to China's manned space program and for aircraft carrier design, signed an agreement to help the China Aerospace Science and Industry Corporation (CASIC) with five new laboratories to conduct rapid research. CASIC makes precision guided bombs, short range ballistic missiles and unmanned aerial vehicles (UAVs). While most Chinese aerospace universities and departments are heavily involved in government funded research for military programs, movement into

formal military-corporate relationships may be a new trend. A more widespread teaming of universities and aerospace corporations may rebound to make both the universities and the companies far more competitive.

China's aircraft sector has also been aided by a number of other trends:

Better design methods: In the early 1990s Chengdu and Shenyang benefitted from the hiring of Russian design consultants, whereas Chengdu had already benefitted from hiring Israeli design assistance for the J-10 program. Russian design assistance is still sought for various programs, to include engine design, though Russia has managed to protect its engine intellectual property better than for airframes. The Ukraine has been a source of consulting on large aircraft design and turbofan engine design. But China received a real boost in the late 1980s when its aircraft companies started using CAD-CAM (computer aided design, computer aided manufacturing) and CATIA (computer aided three dimensional application) programs, at first from France. A Chinese source has noted that computer design programs accelerated the design of Chengdu's FC-1, which provided experience needed to radically reduce the development time for the twin-seat J-10S. Such programs are essential for China's distributed aerospace concerns to jointly develop and produce new aircraft, engines and other products.

New materials: Following global trends China has invested heavily in new materials to enable lighter stronger airframes and that allow higher temperatures needed for high performance engines. A recently released biography of a Chengdu Aircraft Co. designer explained how they developed initial composite materials for use in the J-10 and how they managed to hire a California-based laboratory to test their product. Composite material fabrication has also been an increasing part of the airline component production work that Airbus and Boeing have given to China. In early October 2009 X'ian Aircraft International acquired Austria's Fischer Advanced Composite Components, a major supplier of airframe and interior composite-based components. An ability to build large composite material airframes and skin of sufficient strength would contribute greatly improve China's ability to produce stealthy 5th generation aircraft designs, as well as modern, efficient civil and military transports.

Advanced electronics: The last decade has seen Chinese electronics companies absorb significant foreign technology which has aided their development of new advanced electronic components. In the 1990s the PLA was able to have some access to Israeli and Russian designs for radar for 4th generation fighters, which has aided the development of new Chinese radar for the J-10 and J-11 fighters. Access to Russian and Israeli active electronically scanned array (AESA) technology has likely accelerated China development of this critical technology for 4+ and 5th generation fighters and new radar aircraft. China has also quickly adopted technologies needed to create new digital cockpits that ease pilot workload and allow for better information networking. At the 2008 Zhuhai show China revealed a new large "data fusion" digital display similar to that used by the new Lockheed-Martin F-35 fighter. With Russian and perhaps some Israeli assistance China has also produced new optical/low-light/laser targeting pods to better use their new precision guided munitions.

Growing Engine Progress

Perhaps one of the most serious barriers to China's ability to build a world-class aerospace sector has been its heretofore inability to produce modern and reliable high-power turbofan engines for military and civil aircraft. That said, it is possible to detect that an enormous effort is underway and while China has experienced considerable difficulties along the way, it is a fact that progress is being made. However, as with so many other advanced military programs, China does not allow the dissemination of sufficient data about specific engine programs to make clear determinations regarding their progress.

Military Turbofans Without an indigenous high-power turbofan China cannot enter into sufficient fighter production rates needed to rapidly recapitalize it fighter force to the 4th generation. Furthermore, it cannot sufficiently enable the sale of its 4th generation aircraft. As such, a great deal is resting on the success of the WS-10A or FWS-10 *Taihang*, China's first indigenously designed 4th (called 3rd) generation fighter turbofan, a product of the 606 Shenyang Aeroengine Research Institute (SARI) and the Shenyang Liming Aero Engine Group. A program reportedly started in 1986 by Deng Xiaoping, the goal of the WS-10A program was to produce a turbofan competitive with the Russian Saturn AL-31F and comparable U.S. engines to power new 4th generation fighters like the Shenyang J-11 and Chengdu J-10. It reportedly began flight testing on a J-11 fighter in 2002 and may have started low-rate production in 2006. A picture of the *Taihang* was revealed at the 2006 Zhuhai show, and a full scale engine was finally displayed at the 2008 Zhuhai show, though a full engine complete with exhaust nozzle was not displayed until the recent PLAAF 60th Anniversary.

Since the early 1990s Russian sources have disclosed to the author that Shenyang was experiencing great difficulties in meeting planned thrust goals, while there have been reports and rumors of other specific problems. In August 2009 a Chinese AVIC official admitted there were many problems facing the *Taihang* but declined to elaborate. Other possible issues include incidents of shedding turbine blades, oil leakage issues, and even one unconfirmed rumor of a new J-11BS fighter disintegrating in flight due to a *Taihang* engine failure. To be sure, U.S. engine makers were very challenged to make the leap from 3rd to 4th generation fighter engines, though at the recent November 2009 Dubai Airshow Russian officials conceded that given their large investment and commitment that China would eventually make the *Taihang* work.

While having kept a much lower profile, it is increasingly clear that the 624 Engine Design Institute, or the China Gas Turbine Establishment (GTE), and its related Chengdu Engine Group, may have competing advanced fighter turbofan engine programs. This was revealed with some surprise at the 2008 Zhuhai Airshow, when GTE revealed models of new fighter and trainer turbofans. One is a 9,500kg maximum thrust class engine, the other a 4,200kg maximum thrust class engine, and both appeared equipped with axisymetric thrust vector control nozzles. These enhance extreme post-stall maneuverability and can improve short take-off and landing performance. This engine may be related to the more well known WS-13 program, or what is sometimes called the *Taishan*, which is ostensibly based on the Russian Klimov RD-93 turbofan that powers the MiG-29 and the Chengdu FC-1.

There are other indicators that Chengdu may have a large fighter turbofan development program. At the 2009 Moscow Airshow a Chinese AVIC official demurred when asked whether the Taihang would power the J-10 fighter. Then at the same show, Ukrainian officials explained to

the author their hope to work with China, first to coproduce the Progress AI-222-25F turbofan for the Hongdu L-15 trainer, but then to co-develop a 9,500kg thrust engine and then a 15-ton thrust fighter engine. A Chinese source then suggested the AI-222-25F coproduction venture would fall under the Chengdu Engine Group.

It is also likely that there are programs underway at Shenyang and Chengdu to develop more powerful turbofans for 5th generation fighters. Chinese professional engineering journals show an interest in engines with a 10 to 1 thrust to weight ratio, thought to be a requirement for advance 15+ ton thrust engines needed for next generation fighters. One program is called WS-15 and is likely a program of the Chengdu Engine Group, though some Chinese sources say it is a Shenyang program. In mid-December 2009 an internet-source image of the WS-15 engine core appears, at least confirming this program's existence. A wall chart from the 2006 Zhuhai show illustrating China's fighter engine history noted the "4th Generation Aero-engine" to be a product of the "AVIC-1 Power Systems." In 2008-2009 AVIC was further reorganized resulting in the "AVIC Engine Group," which may promote greater cooperation among formerly competing engine groups. A Russian source recently stated that China is also developing a 18-ton thrust engine, which would exceed 40,000 lbs. of thrust and approach the 19.5-ton thrust Pratt and Whitney F135 engine of the F-35. China is unlikely to stop there. At the 2008 Zhuhai show a GTE official gave a rare interview in which he noted that the U.S. may be developing future engines with 16 to 1 thrust-to-weight ratios, implying they had to follow suit.

While having resisted the sale of its current advanced turbofan technology to China, Russia hopes to remain a source for completed advanced turbofans. In late 2009 a Russian source told the author that China is interested in the improved more powerful versions of the AL-31. For example, the AL-31F-M1 adds 1,000kg of thrust for a total maximum thrust of 13,500kg, and Russian officials note that future versions could achieve 15-tons of thrust. The PLA may make additional purchases of the AL-31FN if Shenyang's and Chengdu's engine programs remain problematic. In addition the PLA is purchasing more Russian Klimov RD-93 engines to support the FC-1/JF-17 program with Pakistan. The more interesting possibility is that the PLA will continue to purchase Russian military turbofans as its indigenous engines come on line so as to sustain a higher rate of fighter production.

High Bypass Turbofans China is also apparently making progress in developing its own high-bypass turbofans for use in new large civil and military transport aircraft. At the 2008 Zhuhai show a mockup of the 3,200kg thrust "Minjiang" high-bypass turbofan, with potential application for business jets or UAVs, was displayed for the first time. It was reported to be a joint program of the GTE and the Shenyang Liming Aeroengine Company, another potential indicator of cooperation between the otherwise rival aeroengine groups. This engine may be used by business jet size aircraft. Then at the early November 2009 Shanghai Industry Fair the AVIC Commercial Engine Corporation made a surprise revelation of its new "SF-A" 12,000 to 13,000kg (@30,000lbs) thrust high-bypass turbofan, which one Chinese report noted had been developed in "secret" since about 2001. This engine may be ready for use by 2016 and is intended for use by the new COMAC C919 regional airliner.

The Chinese companies responsible for the SF-A have not yet been revealed. However, it has been oft reported that SARI was developing a high-bypass turbofan based on the engine core

developed for the WS-10A. The prototype for this engine may be known as the FWS10-118, which also may be known as the WS-10D, a 12+ton thrust engine. This engine, or a purchased Russian Dvigatel D30-KP turbofan, or a co-produced model known as the WS-18, may power the new X'ian H-6K bomber. GTE's work on the Minjiang is a potential indicator that Chengdu may also be working on larger high-bypass turbofans. With the SF-A engine China hopes eventually to compete with the Safran/General Electric CFM-56 high-bypass turbofan family, one of the most popular regional jet turbofan engines with over 14,000 in service. This is a very ambitious objective, as China would also have to compete with the global sales and service infrastructures of well established turbofan makes CFM, GE, Pratt Whitney and Rolls Royce. But China is also planning to support the long-term development of its advanced high-bypass turbofan sector by developing several types of large aircraft that will provide a growing domestic market for its engines.

China is also going to try to keep abreast of continuous foreign turbofan developments. In 2002 AVIC chose the U.S. General Electric Company to produce a version of its CF-34 turbofan for the ARJ-21 regional airliner. But in late 2009 the new COMAC changed horses, selecting the CFM/Safan Leap-X turbofan for its C919 airliner, because it promised advances in fuel efficiency over the market-dominant CFM-56 turbofan and CFM agreed to accelerate its development schedule to fit the C919's timetable.

Military Programs

4th Generation Fighters China is now producing single and twin-seat versions of two 4th generation fighters for its air forces and now has over 500 4th generation and 3+ generation fighters and strike fighters. With a successful indigenous high power turbofan the PLA could likely double this number within this decade, but with improved 4th generation fighters. This represents a major achievement for China's combat aircraft sector despite the fact that both required major inputs of foreign technology and consulting, and both fighters currently rely on Russian-built turbofan engines. Both fighters employ modern effective weapons, use Chinese-built radar and may soon, if not already, start using a Chinese-built turbofan. Both fighters may also be upgraded with a Chinese-built active electronically scanned array (AESA) radar which would elevate them to a 4+ generation level. When so upgraded, they will likely be competitive with U.S. 4+ gen fighters like the Boeing F/A-18E/F *Super Hornet*, the Lockheed-Martin F-16 Block 60 *Falcon* and AESA radar equipped variants of the Boeing F-15C *Eagle.*

Though it took over 20 years of formal development the Chengdu Aircraft Corporation's canard-configuration (horizontal stabilizer in front) J-10 has emerged as China's first "indigenous" 4th generation fighter. In 2010 over 150 are estimated to be serving in about seven units. The single seat J-10A and twin-seat J-10S are comparable in size and performance to the F-16, which is not an accident as F-16 technology sold to aid Israel's *Lavi* fighter program of the 1980s, migrated to Chengdu when Israel was hired to provide consulting assistance on the J-10 program. A recently revealed early mockup of the J-10 built in 1991 shows it had the engine air intake of the Lavi/F-16. This was changed, however, when Russian consultants joined the mix in the early 1990s to integrate the Russian Saturn AL-31FN turbofan engine. The radar of the J-10 is assessed to have been influence by Israeli and Russian technology, while a Russian active seeker makes possible

the J-10's formidable PL-12 medium range AAMs. While there are few images of active J-10s carrying targeting pods and precision guided munitions, this capability is planned for the J-10.

At the end of 2008 Chinese reports emerged of a new variant of the J-10 testing at Chendgu, and images soon emerges of what is called the "J-10B," which has a redesigned engine air intake, a new infrared search and tracking (IRST) device and what may be a new AESA radar. Russian sources suggest that an early Russian Phazotron Corporation AESA radar sold to China in the mid-1990s may have formed the basis for the new Chinese radar. Some reports also suggest that the J-10B is primarily intended to meet a requirement from Pakistan. These modifications point to the J-10 having evolved rapidly toward a 4+ generation level of capability. In 2005 a Russian estimated for the author that China might build up to 1,200 J-10s over its lifetime, while in late 2009 another Russian source stated that so far 300-400 AL-31FN engines had been purchased to support J-10 production. It is expected that Chengdu will integrate a version of the WS-10A *Taihang* turbofan into the J-10, while Russia hopes to sell more powerful versions of the AL-31FN.

One of China's first major post-Tiananmen military purchases was its initial batch of 36 Sukhoi Su-27SK single-seat fighters delivered between 1992 and 1996. In the few times they have met in mock combat, the Su-27 and Su-30 have outperformed the U.S. Boeing F-15C, though the later has had advantages in electronics and weapons. Its first experience with a world-class 4th generation fighter, the PLAAF's absorption of this fighter was not without difficulty. However, by 1998 the PLA felt confident enough to secure a co-production agreement between Sukhoi and the Shenyang Aircraft Co. for up to 200 fighters from Sukhoi-built components, designated the J-11. However, Russian glee at having secured such a large customer started to change dramatically by 2004. In 2000 a high Shenyang official told the author that they might not build all 200 co-produced fighters, and it turns out that only about 100 kits were indeed acquired from Sukhoi.

To the Russian's then and ongoing dismay, the PLA's real goal was to appropriate the Su-27 design and with improvements put it into production. The J-11B emerged early in the last decade and reportedly started entering PLAAF units in 2007. In 2002 it was tested with the WS-10A *Taihang* turbofan but recent reporting and imagery suggests it may only by 2009 be equipped with this engine due to developmental difficulties. The J-11B improves upon the Su-27 design by using more composite materials to reduce airframe weight, a new digital cockpit and a better Chinese-made radar. In early 2010 a source suggested to the author that the J-11B is also being tested with an AESA radar, which would point to its quick evolution toward a 4+ generation capability. In 2008 it was revealed that the twin-seat J-11BS was in development and this is now in production. An estimated 140 Su-27s and J-11s serve in about seven PLAAF units. In mid-2010 internet source images of the Shenyang factory tarmac indicated that the PLA Navy Air Force (PLANAF) is now acquiring J-11B and J-11BS fighters for land-based units.

Chengdu's FC-1 lightwight fighter program is another important "4th gen" achievement for China's combat aircraft sector. It started in the 1980s as a Grumman-led program to radically upgrade Chengdu's J-7 (MiG-21) fighter, which ended after Tiananmen, and was picked up by Russia's MiG in the early 1990s. The upgraded FC-1 design was revealed in 1995 and soon became a co-development program with Pakistan where it is called JF-17. It made its first flight

in 2003 and an upgraded version entered Pakistan Air Force service in early 2010. The FC-1's main attraction is that if offers about 80 –to-90 percent of the F-16's performance for about a quarter to one-third the price. It also features a useful radar, digital cockpit and can use 4th generation AAMs and precision guided ground attack munitions. Pakistan may build up to 250 and many countries are interested in buying or co-producing this fighter, which has no real market competitor from Russia or the West. The PLA, however, has not yet purchased the FC-1.

5th Generation Fighters On July 16, 2009 Secretary of Defense Robert Gates told a Chicago audience that China "is projected to have no 5th generation aircraft by 2020," and only a "handful" by 2025. This argument was used to help convince the U.S. Congress to end production of the Lockheed-Martin F-22 *Raptor* 5th generation fighter at 187 aircraft. So it was a surprise when on the November 8, 2009 edition of CCTV's program "Face to Face," PLAAF, Deputy Commander General He Weirong stated that China's 4th generation fighter would fly "soon" and that this fighter could enter service in "about eight to ten years," or between 2017 and 2019. General He is also reported to have said the planes in development "will match or exceed the capability of similar jets in existence today." As this was the first detailed statement made by any Chinese official about its 5th generation fighter program, it has to be assumed that the PLA at least has confidence in General He's statement.

Just before General He's statement a widely cited but not confirmable Chinese Internet source stated that a prototype of the 5th generation fighter could start flying in 2010, albeit with a version of the 12-13-ton thrust WS-10A turbo fan in lieu of the not yet ready 15-ton thrust engine. This source also noted that China could acquire up to 300 of these fighters. Reportedly these fighters will have a "4 S" capabilities: stealth, super cruise, super maneuverability and short take off. After the March 2010 National People's Consultative Congress, Chinese aerospace officials were cited in some Chinese reports noting the goal is to make China's 5th generation fighter as capable as the U.S. Lockheed-Martin F-22.

China's 5th generation fighter program may already be twenty years old. According to the apparent memoir of a former 611 Aero Design Institute member, in 1989 China started organizing conceptual studies for its "next generation" fighter. Both the Shenyang Aircraft Co. 601 Aero Design Institute and the Chengdu Aircraft Co. 611 Aero Design Institute were then appropriated work in the "2-03" Program.

Beyond this public data about the 5th generation programs at Shenyang and Chengdu is unsatisfactory. Both are thought to have been working on "heavy" twin-engine stealthy and highly maneuverable designs to compete with U.S. and Russian 5th generation fighters. However, Chinese internet sources, again unconfirmable, have suggested that in the PLA decided in favor of Chengdu's 5th generation design, giving Shenyang a subcontractor role. Both companies are thought to have at various times tended toward a "canard delta," with Shenyang first thought to be favoring a "triplane" design and perhaps later a triplane-forward swept wing. Chengdu has usually been associated with a twin-engine canard-delta design. A Chengdu 611 Institute brochure obtained around the November 2002 Zhuhai Airshow included a computer simulation design for an apparent heavy twin-engine canard-delta design which bore some resemblance to the aborted Mikoyan MiG 1.44 5th generation fighter prototype. Reporting from the time of this aircraft's unveiling in 1999 indicated some Russian interest in selling it to

China, but there has been no subsequent reporting to that effect. There have been more recent indicators that both Chengdu and Shenyang have worked with 5th generation concept that starts with a flat delta shaped airframe core, to which are attached canard controls, wings and stabilizers.

There is also a possibility that China could have a program for other 5th generation fighters, perhaps to include a medium-weight fighter to compliment its reported heavyweight fighter program. In early 2005 a Chinese industry source told the author that the Chengdu Aircraft Co. was considering a "F-35 like" fighter program. That would have been a period during which Chinese defense concerns were finalizing their programs for the next Five-Year Plan to begin in 2006, but it is not known whether such a medium-weight fighter program was approved. However, at the November 2006 Zhuhai Airshow the Shenyang Aircraft Co. revealed a radical canard-triplane forward swept wing fighter design. But its compelling feature was that it had one engine, an indication that there may be a medium-weight 5th generation fighter program as well. By mentioning the Lockheed-Martin F-35, there is at least the implication that a potential Chinese medium-weight fighter could be built in multiple versions, to include a short-take off and vertical landing model (STOVL), much like the F-35B.

Aircraft Carrier combat aircraft Fairly soon China is likely to reveal its first fighter designed for its new aircraft carrier, now entering its final stages of refurbishment in Dalian. In 2009 Chinese sources indicated China may build four to six carriers. Since 2005 Russian sources have reported on discussions with China over reviving production of an improved version of the Sukhoi Su-33 to meet PLANAF carrier requirements. But in 2009 a Russian source disclosed to the author that discussions had not progressed due to China's refusal to buy a profitable number of fighters. Since about 2005 Russia has been concerned over Shenyang's effort to build its own carrier version of the J-11B, having obtained an early Su-33 prototype from the Ukraine in the late 1990s. At the end of August 2009 there was a spate of Chinese internet sourced reports, albeit unconfirmable, that a naval variant of the J-11B had started testing. With an AESA radar a naval J-11B would be very competitive with the F/A-18E/F, expected to remain the most important U.S. carrier fighter. It should also be expected that China will develop a carrier-based variant of its 5th generation fighter by the early 2020s.

Strike Fighters From 2000 to 2004 the PLA took delivery of 100 Russian Sukhoi Su-30MKK and MKK2 strike fighters for the PLAAF (76) and the PLANAF (24). This potent strike fighter gives the PLA a powerful multi-role fighter with an 8,000kg payload that in some air-to-air combat parameters is superior to the comparable U.S. Boeing F-15E *Strike Eagle.* Along with the Su-30 the PLA purchased many capable air-to-air and ground attack weapons, like the Vympel R-77 self-guided AAM and the Kh-59 medium range precision strike attack missile.

In 1998 the PLA was able to revive the X'ian Aircraft Corporation JH-7 strike fighter program, which dated back to the 1970s, when after the second effort, the PLA purchased full co-production rights for the British Rolls Royce *Spey* turbofan, now called the *Qinling*. A slightly improved version of the *Spey* was soon seen on upgraded JH-7A, which began to emerge in 2002. There are now about 180 JH-7As and earlier JH-7s serving in the PLANAF (five regiments) and the PLAAF (three regiments). The JH-7 carries the C-803 anti-ship missile, the KD-88 medium-range ground attack missile and with new Chinese-made targeting pods can use

a range of Chinese-made laser and navigation satellite-guided bombs. While aerodynamically comparable to a larger 1960s vintage European Septcat *Jaguar* strike fighter, China now markets the JH-7A as a much less expensive alternative to the Su-30 and the F-15E. There are reports and some imagery that suggests X'ian is developing a stealthy JH-7B powered by a further improved *Qinling* engine.

China has yet to develop a new dedicated tactical close support fighter to succeed the 1970s vintage Hongdu Q-5, a radical development of the J-6, a copied Russian MiG-19. However, at the 2004 Zhuhai show it revealed the Q-5J, the first twin-seat version of the Q-5 for training, which heralded a major upgrade for a new single-seat Q-5 that can carry modern targeting pods for use of laser and navigation satellite guided munitions. Reports suggest that only 120 Q-5s remain in the PLAAF, which would be able to perform useful close air-support for possible conflicts over Taiwan or Korea.

Bombers Much like the continually modified U.S. Boeing B-52, China continues to develop new versions of the X'ian H-6 medium bomber, a copy of the venerable Russian Tupolev Tu-16 that first flew in 1952. This path was likely chosen in the early 1990s after Russia rebuffed early PLA attempts to purchase the supersonic Tupolev Tu-22M *Backfire*. The latest H-6K emerged in 2007, featuring a yet unknown but more powerful new turbofan engine that confers greater range. It also makes increased use of composite materials, has a new electro-optic targeting systems and a new digital cockpit. Most important it was configured to carry six new land attack cruise missiles on its wings, and possibly six more in its bomb bay. The H-6K is also likely be able to deliver new satellite-guided and laser-guided bombs. With its new engines the H-6K can likely reach Guam. Though subsonic and unstealthy, like the B-52, the H-6K's cruise missiles would pose a considerable threat to U.S. and allied forces and it could be used as aerial precision artillery after the suppression of enemy air defenses.

There is much speculation that X'ian is working on a new strategic bomber program, though there is no official confirmation of such. Apparently in connection with the November 2009 PLAAF Anniversary an internet image was released of what apparently was a model of a new large delta flying-wing four-engine bomber. It appears to be powered by four large high-bypass turbofans mounted external to the delta wing, which appears to be larger than the U.S. B-2 *Spirit* flying-wing bomber. It appears this design would not be as stealthy as the B-2 but it might have greater range and carry a larger payload. That said it cannot be verified from existing sources that this is a real PLA program. Nevertheless, its revelation during the PLAAF anniversary points to the prospect of a future high-tech PLA bomber program. If real, such a delta flying-wing bomber would give the PLA an intercontinental range nuclear delivery vehicle, or the third element of a nuclear triad along with land and sea-based nuclear missiles.

Advanced Weapons Following quickly from their stunning use during the 1991 Gulf War and then subsequent U.S. engagements in Kosovo and Iraq, the PLA has now developed its own advanced air-to-air weapons and has developed two families of indigenously designed precision-guided weapons.

In the 1990s the PLAAF acquired modern Russian aircraft weapons, and in 1993 was the first to introduce a helmet-sighted short-range air-to-air missiles (AAM) on the Taiwan Strait in the

form of the Vympel R-73. Taiwan still lacks a helmet-sighted AAM, meaning PLA pilots can fire their missile well before non helmet sighted AAMs, basically guaranteeing victory. The U.S. Raytheon AIM-9X helmet display-sighted AAM was not deployed to U.S. Pacific-based squadrons until 2003. China's main AAM maker Luoyang is now developing a new next-generation highly maneuverable helmet display-sighted short-range AAM influenced by the South African Denel A-Darter short-range AAM. In late 2009 South African sources told the author that Denel did investigate cooperation with Luoyang but decided it would not be profitable and ended talks.

Russia has had a decisive influence on Luoyang's new PL-12/SD-10 self-guided medium-range AAM. As the PLAAF purchased Vympel's 75-km range R-77 self-guided AAM for its Su-30 strike fighters, it also managed to purchase an advanced AGAT missile guidance radar to form the basis for what quickly emerged as the PL-12. With new "lofting" programs, Western AAM experts estimate the PL-12's range may exceed 100km, which may make it very competitive with early models of the U.S. Raytheon AIM-120 AMRAAM. In 2008 internet imagery suggested that Luoyang may be developing a ramjet engine powered AAM, perhaps having purchased assistance from Vympel, which had an unrealized ramjet powered AAM program in the 1990s. If realized, such a ramjet-powered PLA AAM might be able to exceed 150km in range, which would allow the interception aircraft flying over Taiwan from well within the protective cover of Mainland-based SAMs. Such a ramjet-powered AAM would also present a great threat to critical U.S. AWACS and tanker support aircraft. The PLA also has the option of purchasing the 300km range Russian Novator A100 AAM now in development.

Beginning at the 2006 Zhuhai Airshow, missile makers Luoyang and CASIC have progressively revealed two new families of precision guided weapons. Both are offering laser-guided and navigation satellite guided bombs. The later likely can use U.S. GPS or Russian GLONASS navigation satellite signals, but soon will be using signals from China's COMPASS navigation satellite constellation. CASIC's "FT" series now includes the 100kg FT-5, which is analogous to the most recent U.S. Small Diameter Bomb (SDB) development of the revolutionary JDAM navsat guided weapons. Luoyang and CASIS bombs can also be fitted with strap-on wings to give them extended range. With their Su-30s the PLAAF also purchased several new Russian ground attack weapons like the Molniya Kh-29 short-range attack missile, the Raduga Kh-59 medium-range attack missile and the KAB series of optically-guided bombs.

Of some importance, Russia also sold the PLA the Raduga Kh-31A, a formidable ramjet-powered anti-radiation missile designed to target radar and other electronic emitters, like AWACS. Early in the last decade reports and images emerged of a Chinese copy of the Kh-31, called the YJ-91. Raduga officials, however, consistently denied selling co-production rights. An Asian military source explained to the author that the YJ-91 takes the engine of the Kh-31 and adds a more effective Israeli aided seeker.

China has developed a new strategic air-launched land attack cruise missile, derivative of either the land-based DH-10 of the Second Artillery or the PLA Navy's YJ-62. Initially arming the new H-6K bomber this cruise missile likely will arm future bombers. Since the 1998 Zhuhai Airshow China has shown models of a new ramjet-powered anti-ship missile, similar in configuration to the French ASMP, but there was no confirmation of this program until mid 2009

when an Asian military source told the author it is in PLA service. If true this means the PLA now has a supersonic anti-ship missile with a possible range greater than 200km.

Trainer Recapitalization By early in the last decade the PLA embarked on a path to recapitalize its training fleet, concluding from hard experience gained during the 1990s that it required modern training platforms to prepare its pilots for new 4th generation fighters and all new aircraft dominated by digital cockpits. For trainers, new digital cockpits allow for rapid transitions to different training missions and greater scope for mission simulation. In 2010 the first CJ-7 piston engine primary trainer is expected to fly, the product of a 2006 agreement with Russia's Yakovlev to co-produce a version of the Yak-152K piston trainer. While the PLA reportedly will purchase 300, they will replace over 1,000 CJ-6 trainers. The Hongdu K-8 primary training jet was designed in the 1980s as a cooperative effort with Pakistan and U.S. engine maker Allied Signal, but the Tiananmen embargo forced adoption of the Ukrainian Ivchenko AI-25TLK turbofan, now co-produced as the WS-11. At first rejected by the PLA, after 2000 it was purchased to replace twin-seat JJ-5 trainers; about 400 are expected to be acquired for the PLAAF and PLANAF.

The PLA is also funding the development of up to five supersonic speed capable lead-in trainers. The PLAAF and PLANAF are buying the Guizhou JL-9, a less expensive turbojet powered trainer which takes the front end of Chengdu's FC-1, with a digital cockpit, but the back end of the old JJ-7 trainer, but with a new wing. Not yet ready for production is the Hongdu L-15, a twin turbofan powered trainer which likely must wait until its Ukrainian Ivchencho AI-225 engine enters co-production before being acquired by the PLA. Designed with assistance from Russia's Yakovlev, the L-15 appears well suited for development into a carrier trainer. The PLA also puts twin seat version of the Chengdu J-10 (J-10S), and soon, the Shenyang J-11B (J-11BS) into operational units to reduce the cost of training. Finally, in late 2009 a Pakistani source told the author that Chengdu will soon build a twin-seat version of the low cost FC-1 combat jet. In contrast the U.S. likely will not build twin-seat versions of the F-22 or F-35 fighters, relying instead on simulators for training, while struggling to commence a program to replace its continually upgraded 1950s vintage Northrop T-38 supersonic trainers.

Simulators are gaining increased usage throughout the PLA, and the PLAAF has long understood their value. The PLA has long been capable of producing modern full motion aircraft simulators and has also purchased simulator technology from abroad. Simpler desk-top simulators are also in widespread use in the PLA air forces. It should be expected that following on the U.S. example of increasingly networking military simulators to allow training by far-flung units about to be deployed, the PLA will make increasing use of similar simulator networking technology.

AWACs and EW Platforms China's ability to produce world-class electronic support platforms has come a long way from its first attempt in the 1960s to build an AWACs aircraft, the KongJing-1 (KJ-1), which sought to place a rotating radar on a copy of a Russian Tupolev Tu-2, itself a copy of the Boeing B-29 bomber. There are now about five AWACS programs alone plus multiple other electronic support aircraft programs underway. China has apparently masters critical large active electronically scanned array (AESA) radar technology for AWACS, meaning they are a generation ahead of the technology used on U.S. Northrop-Grumman E-2 and Boeing E-3 AWACS.

During the 1980s and 1990s there were multiple attempts to acquire foreign AWACS technology. Britain's Marconi apparently sold at least one example of its *Argus* radar from the cancelled *Nimrod AEW* program, which China placed on a modified Russian Ilyushin Il-76 transport. Then in the mid-1990s Britain's Racal Co. sold six of its *Skymaster* lightweight naval airborne early warning (AEW) radar, which still fly on the PLA Navy Air Force's Y-8J aircraft. Ostensibly sold to help China "combat piracy," by 1999 the Y-8J was observed in exercises providing long-distance cuing for ship-launched anti-ship missiles.

Perhaps the most well known foreign influenced AWACS program is the KongJing-2000 (KJ-2000), which placed the Elta/Israeli Aircraft Industries *Phalcon* fixed active electronically scanned array (AESA) radar on a Russian Beriev A-50, itself a highly modified Il-76. Even though by mid-2000 President Bill Clinton had personally intervened with Israeli Prime Minister Ehud Barak to cancel this sale, the PLA Air Force now flies four KJ-2000s. An Asian military source disclosed to the author that KJ-2000's radar signature is the same as the *Phalcon*, an indication that despite U.S. intervention, China found alternate means to complete this program. Part of the U.S. alarm at the *Phalcon* sale was the transfer of then state-of-the-art AESA technology which the U.S. was just discovering could be used as a weapon by focusing intense electronic radiation on vulnerable electronic components. In addition, AESA radar are highly difficult to jam and can passively monitor electronic intelligence at ranges greater than active detection.

A second less expensive Chinese AESA AWACS platform is the Shaanxi KJ-200/Y-8W, which uses a "balance beam" AESA radar very similar in configuration to the Swedish Ericsson PS-890 radar. Swedish officials have repeatedly told the author that there was no sale to China. Mounted on an improved Shaanxi Y-8 platform, the Y-8W operates at a lower altitude than the KJ-2000 but has a potential 300km detection range. In April 2010 Japanese Air Force fighters intercepted a Y-8W operating over the East China Sea. There are about five Y-8Ws in the PLAAF and the PLANAF reportedly will purchase this AWACS to replace or supplement the Y-8J.

A third AWACS program is called by some sources the ZDK-03, uses a rotating radar array and is due to be delivered to Pakistan's Air Force in 2010. There may also be multiple airborne radar programs underway for the PLA Navy Air Force. In late 2009 internet sources revealed that a version of the Change Z-8 helicopter was being tested with a retractable radar that in flight rotates below the fuselage. There is speculation this will be the first AWACS support platform for the PLA's first aircraft carrier. In 2005 a Chinese magazine carried a photo of a politician visiting an aircraft design bureau and also seen was the partial image of an apparent fixed-wing turboprop powered AWACS aircraft similar in size to the U.S. Grumman E-1 *Tracer*. Then a 2009 journal article from China's Northwestern University featured a wind tunnel study of a Russian Sukhoi S-80 twin-boom turboprop with "saucer" and "beam" radar configurations, suggesting an alternate future AWACS for Chinese aircraft carriers.

The improved Y-8 also serves for other electronic warfare and support missions. In 2005 the Y-8G was revealed to feature two large cheek arrays on the forward fuselage, which could house a phased array antennae for electronic warfare or jamming missions. Soon after the Y-8T was

revealed as a dedicated airborne command and control aircraft, to serve as a supplementary command post. Earlier versions of the Y-8 serve as electronic warfare platforms for the PLAAF and the PLA Navy. In addition since 2007 the PLAAF has equipped some of its early Xian JH-7A strike fighters with dedicated electronic warfare pods, which likely allow it perform jamming escort missions similar to the U.S. Boeing EF-18F *Growler*.

Maritime patrol and anti-submarine (ASW) patrol aircraft are categories of combat aircraft in which the PLA remains lacking compared to other major air powers. In the middle of the last decade there were Russian reports of PLA interest in purchasing the very long range Tupolev Tu-142 strategic ASW aircraft but this has not been realized. The PLANAF relies on a small number of Shaanxi Y-8s modified for maritime patrol, while the PLA also sends electronic intelligence, and more recently, Y-8W AWACS on patrols over the East China Sea. At the 2000 Zhuhai airshow AVIC unveiled in model form its Y-7MPA, a dedicated maritime partrol version of this twin turboprop airliner, but there are no reports it was built. Earlier in the last decade Russian reports persisted of Chinese interest in purchasing or co-producing the Beriev Be-200 twin turbofan-powered flying boat. Instead, at the 2008 Zhuhai show it was revealed that China was going to build an updated version of its old Harbin SH-5 flying boat, called the JL-600. By late 2009 Chinese reports emerged that construction had started and a first flight was expected by 2013. It will be built in fire-fighting, and can be expected to be built in maritime patrol and anti-submarine versions. The JL-600 will also greatly improve Chinese logistic support for its far flung outposts in the South China Sea.

Unmanned Aircraft Development The PLA's interest in unmanned aerial vehicles (UAVs) dates back to the late 1950s and has been dominated by university-based programs until just this last decade. Chinese universities like Beijing University for Aeronautics and Astronautics, the Nanjing University for Aeronautics and Astronautics and Northwestern Polytechnical University still play a key role in unmanned aircraft research and development but mainline corporations have radically increased their investment in this sector since the 10th Five Year Plan. The PLA's investment in unmanned technologies is not limited to aircraft, but encompasses ground vehicles, surface ships, submarines and robots ranging from single-purpose tractors to humanoids. But by the time the first U.S. large unmanned combat aerial vehicle (UCAV) enters service, likely something based on the U.S. Navy's Northrop Grumman X-47B, similarly sized PLA UCAVs may not be far behind.

In the 1960s China was able to acquire Russian Lavochkin target drones and U.S. Ryan *Firebee* reconnaissance drones captured over North Vietnam and China, to form the early basis for its early unmanned aircraft effort. During the 1980s China was able to obtain its next major UAV technology boost from Israel, which at the time was a world leader in tactical UAVs. At the 2000 Zhuhai show the Guizhou WZ-2000 was revealed, a squat twin-jet powered delta winged high-altitude long-endurance UAV, which by the 2002 Zhuhai show evolved into a medium sized UAV, which by the 2008 Zhuhai show appeard to form the basis for an armed turbofan powered unmanned combat aerial vehicle (UCAV) similar in size to the U.S. General Atomics MQ-9 *Reaper*.

Since the 2006 Zhuhai show there appears to emerged a rough division of labor, in which Chengdu and Guizhou concentrate on medium and long range surveillance UAVs and medium

range UCAVs, while Shenyang appears to be concentrating on future long range subsonic and supersonic UCAVs. The 2006 Zhuhai show saw the revelation, in model form, of Chengdu's *Tian Yi*, which was revealed by internet sources in 2008 to have entered testing. While likely useful as a medium range UAV, the *Tian Yi* also serves to aid the development of Chengdu's *Long Haul Eagle,* which is close in size and configuration to the Northrop Grumman Global Hawk. In 2006 Guizhou revealed in model form its box-wing *Soar Dragon* UAV, credited with a 7,000km range, but there has been no subsequent information on this system.

At the 2006 Zhuhai airshow Shenyang created a stir by introducing in model form its *Dark Sword* supersonic UCAV, about which Shenyang has revealed very little. In 2006 it was described in a small plaque as a "fighter," which would have been an amazing accomplishment for a UCAV, though this mission was not mentioned in its plaque at the 2008 Zhuhai show. There has been some suggestion that this design may have been inspired by South African technical assistance. A new model of the *Dark Sword* was revealed as part of the 2009 PLAAF Anniversary, an indication that it remains an ongoing program. At the 2008 Zhuhai show the forward-swept wing subsonic *Warrior Eagle* was revealed, also likely a Shenyang program. This concept appears to be a more realistic goal technologically, if one considers it is well suited for attack and surveillance missions. Wall illustrations at the 2008 Zhuhai show suggested the *Warrior Eagle* would also be capable of cooperative "swarm" missions. There are also indications that the X'ian Aircraft Co. may be developing a strike UCAV.

PLAAF Space Warfare Potential While PLAAF leaders sought to justify active military space capabilities as part of their new strategy heralded as part of their 2009 anniversary, it is not clear that the Chinese leadership has chosen the PLAAF to be dominant "space combat' service for the PLA. Chinese source have occasionally referred to a debate over which service to take that lead, to include the Second Artillery or the General Armaments Department of the Central Military Commission, which currently controls China's manned and unmanned space program. However, there are likely multiple PLA programs underway to achieve military combat goals in space that most likely would be controlled by the PLAAF.

The 2006 Zhuhai show saw the revelation in model form of the Air Launched Launch Vehicle, a space-launch vehicle (SLV) launched from an H-6 bomber that looks similar to the U.S. Orbital Sciences *Pegasus* air-launched SLV. Such an SLV would be much more flexible than the PLA's current SC-19 anti-satellite (ASAT) rocket. However, it is not known whether the ASLV has been developed. At the end of 2007 Chinese internet sources depicted the *Shenlong,* an apparent unmanned space plane technology test vehicle seen suspended for launch by a H-6 bomber. This program apparently was led by the Chengdu Aircraft Corporation, which earlier had been involved briefly in the 1980s with France's *Hermes* small manned space plane program. The Shenlong could form the basis for a reusable unmanned military platform similar to the U.S. Air Force's recently launched X-37B space plane, or it could serve to validate technologies for larger manned space planes.

At the end of 2009 some Chinese media reports on the new PLAAF strategy mentioned "reports" that China was developing a sub-orbital bomber. This raises the issue of China's apparent heavy investments in hypersonic (5x or more times the speed of sound) propulsion technologies, with the apparent goal of producing hypersonic aircraft for military missions. In 2007 Chinese

engineers revealed that China has built a wind tunnel capable of Mach 5+ speeds that the Laboratory of High Temperature Gas Dynamics in Beijing. Also in late 2007 a Chinese internet image showed a wind tunnel model of a possible hypersonic test vehicle. Future hypersonic combat platforms could perform attack or reconnaissance missions from the edge of Low Earth Orbit.

There is also a suggestion that the PLA may be considering the arming of a large four-engine transport with a laser for the purpose of attacking satellites. An image released on Chinese web pages at the time of the November 2009 PLAAF Anniversary, itself likely from a display to commemorate the anniversary, showed a new four-engine transport armed with a laser attacking a satellite. The PLA is known to have made great investments in military laser programs and it is not inconceivable that they would develop a large laser, perhaps a chemical laser, for use on a future four-engined transport known to be a program of the Xian Aircraft Corporation. While the U.S. has recently curtailed the Boeing YAL-1 laser-armed B-747 in part due to concerns the laser's short range makes it vulnerable for its anti tactical missile mission, such a large laser armed aircraft could conceivably perform an ASAT mission from protected airspace.

Large Civil and Military Transport Aircraft

Military transports China's ambition to build new large military and civil transport aircraft has been affirmed many times since the 2006 National People Congress meeting. On November 5, 2009 Chinese reports stated that during a press conference AVIC officials revealed that a mockup of a new 200-ton "military transport" aircraft would appear by the end of 2009. While this did not occur, it can be expected that during this year or next that AVIC will reveal more details on this large transport. In 2006 Ukrainian officials noted they had been hired as consultants by X'ian Aircraft Design and Research Institute (603 Institute) to consult on large aircraft programs, to include the possible adaptation of Antonov's turbofan-powered An-70 for turbofan propulsion. Then in 2007 a Ukrainian official confirmed that images of a model of a Chinese four-turbofan military transport was another AVIC-1 design. It is not clear if the "200-ton" aircraft is the same as the AVIC-1 transport concept, but Chinese internet reporting has indicated this aircraft is designed to carry a 60-ton payload, which would place it in the same class as the Russian Ilyushin Il-76 and the U.S. Boeing C-17.

In addition, it appears that the X'ian Aircraft Company has made progress on smaller twin-turbofan powered high-wing transport, first revealed in model form at the 2004 Zhuhai Airshow as the "WJ" for Whoshan Jiaolian. It was described as a 50-passenger 20-ton aircraft for training. But in mid-December 2009 an image of a new model of this aircraft appeared, indicating the first example to have been built. This aircraft may eventually serve as a training aircraft, or this design may also serve as the basis for a reported larger 25-ton payload twin-turbofan medium transport slated to replace the turboprop powered Y-9 program. Such an aircraft would be competitive with the proposed Brazilian Embraer C-390 high-wing twin-turbofan transport, which is being developed for a 20-ton payload. Such an aircraft might allow X'ian to gain a leading position in an emerging medium-transport market for a more modern and faster replacement for the market-dominant turboprop-powered Lockheed-Martin C-130 Hercules (@2,300 built).

Civil transports Convinced that producing competitive large airliners is critical for goals of national power, China is now entering the highly risky and expensive civil airliner market. China can be expected to produce a family of airliners over the next two decades that will compete with most of the market segments now covered by Boeing and Airbus. China's COMAC can be expected to capitalize on the assurance of generous state funding, an ability to claim a sizable portion of an expected Chinese demand for about 3,000 new airliners, the ability to rapidly exploit new foreign technologies, and very likely, an attractive price. At the January 2010 Singapore Airshow officials from two Chinese airlines stated they would purchase the future COMAC C919 airliner. But as COMAC becomes a major competitor it appears that Airbus may have the better "hedge" to protect its share of the Chinese airliner market: the building of a final assembly facility for its A320 airliner in Tianjin.

China's ambitions to build a competitive civil airliner became serious in 2002 when AVIC announced its ARJ-21 65-90 seat regional airliner, which made its first flight in November 2008. To help ease market acceptance China has enlisted reputable global component suppliers: Antonov and Boeing for design consultation; General Electric for their CF-34-10A turbofans; Hamilton Sunstrand for the auxiliary power unit; Rockwell Collins avionics; Parker Hannifin hydraulics; Liegherr for landing gear and Sagem for cabin systems. COMAC claims sales of 200, including the first foreign sale to Laos, and 60 for a leasing company owned by General Electric. One Chinese report notes the ARJ-21 could be sold for about $28 million, which may represent a discount from a 2007 reference to a price of $30 million. This is competitive with the $35 million 70-seat Bombardier CRJ-700. Chinese leaders have pressed for rapid U.S. certification of the ARJ-21 as a means to build market confidence.

Before the ARJ-21 has proven itself in the market, COMAC has placed a much larger bet on its 80-ton 150+ seat single isle C919 airliner, which will directly compete with the Boeing B-737 (6,000+ built) and the Airbus A320 (4,000+ built). It will also be competing with the Russian Irkut MC-21 and Canadian Bombardier C-Series, which like the C919 intend to quickly exploit new engines and technologies to gain market share from the B-737 and A320. The C919 is expected to fly by 2014 and enter service by 2016, powered initially by the new CFM Leap-X turbofan, which give a 16 percent fuel efficiency over the CFM-56 turbofan, and then by a version of the domestic 30,000lb thrust SF-A turbofan after 2016. Reportedly about 20 percent of its airframe will be made from weight and fuel-saving composite materials. While not a high as the 50-percent goal of the latest Boeing B-787 airliner, it is much higher than the older B-737 and A-320. Airbus officials have recently stated that a re-engined A320 can beat the C919 and other newcomers, but other analysts contend that without the new wing and lighter airframe of the C919 and its stable mates, Airbus and Boeing may have to invest in a next generation 150-seat class airliner sooner than a projected timetable of just after 2020.

Chinese companies and aviation officials have disclosed very little about a possible larger wide-body four-engine passenger transport program. The designation for this aircraft is unknown, but since 2007 occasional computer graphics and photos of models of this aircraft have appeared on the Chinese Internet. The most famous was taken at the end of 2007 at X'ian's Aircraft Design and Research Institute (603 Institute) during a visit by Premier Wen Jiabao, seen standing next to a partial view of the model. Subsequent photos of this model also indicate it a X'ian concept. This aircraft appears to be about the size of a Boeing B-767, or a 140+ ton max-weight airliner.

An aircraft this size would likely obtain adequate power from four 13-ton thrust SF-A engines. The FWS10-118 turbofan is also linked to a 150-ton aircraft program, which would increase the possibility that X'ian's four-engine transport is a real program.

Powered by Chinese-made engines, both the C919 and the undesignated four-engine transport could also serve a range of missions for the PLA. The C919 could be adopted as a regional maritime patrol aircraft, similar in concept to the Boeing P-8 based on the B-737, or it could be outfitted with a linear phased array radar to fly at a higher altitude than the similarly equipped turboprop-powered Shaanxi Y-8W AWACS aircraft. The larger four-engine transport could be outfitted for long-range AWACS, electronic intelligence/attack and tanking missions, or as the laser-armed ASAT aircraft noted earlier in this article. A tanker version of this aircraft would provide a much more useful replacement for the smaller HU-6 tankers currently in use, and allow PLAAF transports, bombers and strike fighters to achieve global projection capabilities.

Helicopters

China's tragic May 2008 Sichuan earthquake quickly resulted in a critical spotlight on China's helicopter industry; China did not have enough helicopters to quickly meet urgent requirements and China's helicopter sector did not produce a heavy-lift (20-ton payload) helicopter like Russia's Mil Mi-26, one of which was hired to contribute to earthquake relief. There has since been a commitment to build such a heavy lift helicopter and Russia's Mil is likely to be the lead co-development partner, as it may be helping China with a less well reported 13-ton helicopter program.

While China has greatly increased investment and funding for its helicopter companies in the last 20 years, they have yet to break out a dependence on foreign design assistance and design inspiration. The heavy-lift helicopter program apparently will follow a long list of copied helicopters. During the 1980s the PLA established a strategic relationship with what became Eurocopter and now co-produces five Eurocopter designs: SA321 as the Z-8; AS565 Dauphin as the Z-9; AS350 as the Z-11; EC-120; and the EC-175 as the Z-15. The latest EC-175 is a state-of-the-art 7-ton class helicopter that uses advanced rotor and avionics technology. Previously Eurocopter officials would tell the author that China would not produce a military version of the EC-175 but in late 2009 Eurocopter officials stated that there was no impediment to China making military versions of the Z-15.

Eurocopter and Italy's Agusta provided design assistance for what has become China's first modern medium attack helicopter, the Z-10. About the same size as the Agusta A-129 and U.S. Bell A-1W attack helicopter, when produced in numbers it will provide effective tactical support for ground forces. There is some question over what engine the Z-10 will use; prototypes have been powered by Pratt-Whitney Canada PT6C-67C turboshaft, while reports note that Russian and Ukranian engines have been tested on the Z-10. Reports also suggest the Z-10 will use a less powerful but indigenous WZ-9 turboshaft. It is armed with the HJ-10 anti-tank missile that is similar to the U.S. *Hellfire*.

Russia has sold about 200 of its Mil Mi-8/17 family of 13-ton helicopters to the PLA Army and 18 of the Kamov Ka-28 naval helicopter to the PLA Navy. There are reports as well of program

to co-produce the Mi-17 in China. Meanwhile China is benefitting from competitive pressures on helicopter makers to succeed in the China market, which has resulted in relaxations on previous Tiananmen restrictions on the sale of U.S. helicopters to China. For the future, Chinese sources suggest an interest in large tandem rotor helicopters while universities have studied tilt-rotor technology. China is also working on a number of unmanned helicopters from small size to sizes approaching the U.S. Northrop Grumman MQ-8 *Fire Scout.*

Conclusions

Despite a dearth of information on China's aerospace programs there is enough data to conclude that China intends to challenge America's current dominance of the aero-space realm. China is able to direct massive state resources toward this goal as it seeks to harness market forces and opportunities to its advantage. China's challenge is not just military but also commercial. While the 1990s showed China a difficult learning curve, by 2010 it can be said that China is nearing that curve in many respects and that this coming decade could prove a time of "harvest." China's 4th generation fighters will advance to 4+ gen levels of capability and initial 4-to-4+ generation level carrier fighters will enter service just before China's 5th generation fighters appear on the scene. China will also sell its modern combat aircraft to its rogue partners and to other states. As it is in other spheres, the United States is in a military airpower race with China. The prospect of the PLA building a force of over 1,000 4th generation fighters plus 300 5th generation fighters by the mid-2020s, with advanced weapons and support aircraft, has the potential to end the assurance of U.S. air superiority in Asia absent a vigorous U.S. response. As such, the 2009 decision to end production of the F-22 can only be viewed as incredible given U.S. reliance on assured air superiority for its military forces. The U.S. needs sufficient numbers of F-22s as it must now move quickly move to lead the development of 6th generation air capabilities, UCAVs, hypersonics and energy weapons, if it is to sustain deterrence in Asia.

By the 2020s new strategic aircraft may also allow the PLA to combine new capabilities in maritime power projection with long-range strategic air force projection. The advent of a large intercontinental strategic bomber would tend to undermine the impression that China projects that it does not seek nuclear parity or superiority over the United States and Russia. A large fleet of C-17-size transports plus the new airmobile medium weight armor forces the PLA is building today will give China options for global rapid military maneuver.

China's commercial challenge is just starting but could accumulate rapidly. This experience too will not be easy for China. There will be the expensive challenge to build global support networks. There may also be market disruptions such as being denied Western markets and technology if China initiates military conflicts. Nevertheless, in the COMAC C919 China is betting for high stakes that it can succeed, with the West's help, to produce the first of many competitive commercial airliners. Major commercial producers like Airbus and Boeing have previously been united in their defense of policies that preserve their ability to sell to China. They also have invested in component production in China that in many ways helps China's ability to become a competitor. China's response to a potential challenge to COMAC by Western next generation narrow body airliners will be telling. Should China decide to use its large domestic market to rapidly expand COMAC's product line and then subsidize foreign sales, then it will be clear that it is aiming for commercial air dominance as well.