



**ROYAL  
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# **THE CHINESE AEROSPACE INDUSTRY: A Background Paper**



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Front cover: Two Chengdu J-10s.

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A Shenyang J-15 during flight trials from China's new aircraft carrier, Liaoning in November 2012.

## INTRODUCTION

Chinese aerospace policy represents one of the most comprehensive attempts to enter the top levels of aerospace development and production. If successful, this would be a serious long term challenge to established western companies. The drive is powered by a heady mix of security, foreign policy and economic interests.

In the first instance, China's aerospace ambitions follow directly from the nation's determination to become a great regional power, and perhaps ultimately a global power to match the US. Since its inception in 1949, the Peoples' Republic of China (PRC) has sought in the first instance to defend its integrity against what it perceives as a hostile alliance of capitalist powers, to regain 'lost' provinces such as Tibet and Taiwan, as well as laying claim to various islands on the Chinese littoral. This also entailed fighting a major war in Korea against the US and its allies. Up to the 1960s, China was closely linked to the Soviet Union, until ideological and national interests diverged to the point of military conflict and periodically China has fought over disputed border territories with India. More ambitiously, and presenting a direct threat to the US homeland, China acquired a trans-continental nuclear capability. But internal problems, especially those related to the turmoil of the Cultural Revolution, handicapped the growth of Chinese economic and regional power during the 1970s.

Since the 1990s, however, China has adopted a hybrid system of state-capitalism, which triggered a period of massive economic growth. This has provided the wherewithal to develop nascent power projection capabilities and the means of funding a wide range of higher technology industries, including aerospace. This has allowed China

further scope to lay claims to influence over its immediate region, events which have given rise to anxiety and tension among its regional neighbours and to alarm the US. Initial steps to develop a carrier centric naval force combined with area denial long range anti-aircraft and anti-ship missile systems may yet confirm these fears.

There is no doubting the resources currently devoted to defence: in 2011, Chinese military spending rose by 11.2% to between \$120 and \$ 180 billion, with about 30% of the budget spent on equipment. This was followed in 2013 with a 10.7% increase. However, this increase represented a slow down on past trends, reflecting China's overall economic position. And allowing for inflation neared 4% in real terms.<sup>2</sup> This is hardly the performance of a defence dominant state, but it still confirms China's continuing force modernisation as a significant part of this goes on new military aerospace programmes. While this is less than a quarter of US spending, it is four times that of Japan and more than the combined defence budgets of the Asia-Pacific region. It is also likely to be the case that the Chinese can buy more capability for their 'dollar' than the US or many of its regional neighbours. What ever the exact spend, the military interest in aerospace (and conversely the source of some of the constraints on domestic civil aviation) is therefore pervasive.

But equally important, aerospace has been targeted as a primary means of raising China's overall economic performance through climbing "the ladder of high-tech industrial economic value".<sup>3</sup> This has two components: contributing to

<sup>2</sup>Financial Times, 5 March 2013.

<sup>3</sup>Fallows, op cit, p 146.

the development of a modern transport infrastructure and increasing the quality of Chinese manufacturing, in part to capture the lion's share of the expanding domestic market for civil aircraft. Again driven by state planning, direction and control the overall objective is a 12.2% annual expansion of civil aviation over the next decade. By 2020, 89% of the Chinese population should have access to air travel.

This paper will examine developments in Chinese military aerospace, civil aerospace and the space sector, focusing on developments in policy and doctrine. This will be followed by a description of the current state of Chinese industrial and technological progress. It will conclude with a brief appraisal of the implications of Chinese aerospace developments and their potential to affect US and European industries.

## CHINESE MILITARY AEROSPACE

### *Airpower Doctrine and Concepts*

The Peoples' Liberation Army Air Force (PLAAF) is in the midst of a fundamental modernisation of doctrine, tactics and hardware. This includes a comprehensive expression of 'Air-Space Power', network-centric concepts and all manner of new kit. But there is still a way to go before the PLAAF has sufficient force in being to threaten a major shift in the regional balance of power. Barriers to change include ideological and political conservatism, bureaucratic rivalries and the limitations of Chinese industry to deliver new aircraft and systems. Although the study is as much about potential and aspiration as contemporary reality, progress has already been sufficient to cause ripples throughout the Asia-Pacific area including the US 'Pivot to Asia' — a redirection of US national security policy towards the region.

### *History and Revolutionary Experience Conditions Current Events*

The PLAAF is an integral part of the People's Liberation Army (PLA) that fought a guerrilla civil war from the 1930s until the formation of the Peoples' Republic of China in 1949. Largely because air power as such had no impact on that struggle, nor figured in Communist party-directed doctrine, the early PLAAF struggled to establish an independent existence. Indeed for much of the early years of Communist China, and despite the Korean War and exposure to western air superiority, ground forces were regarded as the key to military victory. Initially, this insouciant disregard for the impact of technology applied equally to nuclear weapons — Mao's famous reference to a nuclear-armed America as a 'Paper Tiger'. At a tactical level, following Soviet doctrine, air power was an adjunct to the army and offensive air power concepts were generally neglected. For much of the period up to the 1990s, the primary use of conventional airpower would be a deterrent to direct imperialist aggression, particularly in respect to Taiwan.

This largely passive view of air power was slow to change. In military terms, the 1991 Gulf War was a key turning point in changing Party attitudes towards airpower. The decisive impact of western and especially US air assets galvanised change and stimulated thinking about an integrated approach to military aviation and space. While political control would still determine the ends of military policy, there was evident encouragement to innovate in shaping means. This intellectual shift of emphasis also marked a determination to modernise Chinese indigenous aerospace capabilities and to move away from dependence on imported weapons.

### *New Times, New Demands*

At much the same time China embraced a hybrid form of capitalism and began rapidly to achieve rates of economic growth that have now put it within a decade of overtaking the US measured in GDP. This has enabled an annual increase in defence spending of around 12%. These new circumstances also saw a radical shift in the Chinese view of air power. The increasing importance of air power was detailed in the 2008 Defence White Paper, which laid the foundation for a more high-tech force structure.

In some respects, Chinese doctrinal thinking tries to anticipate possible US technological innovation. This has an element of 'worst case' scenario building, and assumes a rate of progress and commitment to exotic technologies that may yet be beyond the US. But it does reflect the Chinese view that they should be in a position to exploit potentially disruptive and 'game changing' technology such as hypersonic vehicles. More immediately, developments are directed at achieving a position where China could deny American ability to intervene in regional conflicts around the Chinese periphery.

The PLA generally has long viewed the threat of conventional ballistic missiles as a primary instrument of aerospace power projection and strategic attack. Development of short and intermediate range missiles was to some extent compensation for more conventional air power capabilities. This has evolved into a higher level of potential strategic value, implying a capability to hit US naval task forces with highly accurate conventionally armed ballistic and cruise missiles. Such a capability has major implications for American global military influence in the form of its aircraft carrier battle groups. These have been at the core of US power projection for decades. Anti-access technology, or even a credible threat of such capability would imply a major shift in military-political influence.

The Chinese are also investigating 'counter-stealth' technology with the clear intention of eroding American air power advantages. Possibly more worrying is the increasing doctrinal emphasis of taking the strategic offensive, and perhaps a willingness to strike first to achieve local superiority. This entails acquiring stand-off and escort jammers as well as other electronic warfare assets.

These developments are also paralleled by Chinese interest in 'cyber warfare' as part of both defensive and offensive operations, with computer network attack capabilities as a way of countering US network centric assets, including anti-satellite weapons to threaten US space-based communications and surveillance systems. This is in keeping with a wider view of the value of asymmetric warfare against a better armed potential adversary — the US. But China seems to have generally embraced information-based operations that emphasise full scope ISTAR and integrated 'kill chain' concepts.<sup>4</sup>

There is also perhaps the longer-term goal of achieving a degree of power projection designed to protect wider Chinese economic and strategic interests. As China becomes more dependent on access to overseas raw materials, Chinese security might come to echo those of the US in the Gulf and elsewhere. This is more speculative, but its achievement will depend heavily on acquiring a fully comprehensive suite of air-space power capabilities.

<sup>4</sup>It does follow that increasing Chinese dependence on space implies its own vulnerability.

Whether or not China is close to achieving such highly ambitious technical as well as organisational objectives is still difficult to assess. The National Defence University study asserts that the chances for fielding missiles capable of hitting fixed and mobile targets out to 2,200 kilometres 'are high'. There is certainly evidence that China is working intensively to enhance the precision of its long range cruise missiles. But even just a reasonable credible threat of a regional access denial capability would seriously complicate US strategy, and as will be considered below, has already triggered a US doctrinal response.

### *Inter-Service Rivalries*

Military modernisation has affected almost all arms of the PLA. At its most mundane, this has been observed in the better kit equipping the humble infantry soldier. More eye-catchingly, the revelation of apparently 5th-Generation fighter concepts and jet carrier landings has shown a determination to develop a full range of indigenous weapons. All of this has been fuelled by a direct link to double digit economic growth and matching increases in defence budgets.

What is less evident is that these resources have to be split between several competing military bureaucracies. Responsibility for space, for example, is contested between the PLAAF's emerging interests in air-space warfare and the role of the General Staff and General Armaments Departments (GAD). The latter two currently own much of Chinese military space activities, including launch and satellite operations, satellite imagery processing and communications. The PLAAF makes a clear distinction between development and deployment of space systems and operational use of space-based assets, which it feels should be left to the air force.

Since the early years of this century, although still responsible for oversight of a wide range of technology acquisition activities, the GAD has had to concede more authority over weapons technology development to the individual services. However, this has had the effect of decentralising the competition for resources. For example, the Second Artillery and the PLAAF share long-range offensive and defensive air power — with a demarcation set at a range of 100 kilometres. The former is also fighting for resources to develop the high accuracy, real time anti-shipping ballistic missile capability. The navy, of course, has been looking to develop maritime airpower centring on a long-term build up of carrier-based capability.

In short, the PLAAF, while acquiring a greater sense of independence in terms of both doctrine and weapons procurement, has both to fight its corner within the wider PLA hierarchy, still heavily influenced by the 'great land army' and regional command structures. And of course, Party control in turn shapes the strategic direction and speed of modernisation. But modern airpower has achieved much greater prominence than at any time in recent Chinese military history.

## THE CHINESE SPACE PROGRAMME

### *A Brief History*

The Chinese have had a long standing commitment to building an extensive space industry. This was directly related to its security interests and the development of an independent ballistic missile capability, and dates from the late 1950s. As in aerospace generally, China's first steps were aided by Soviet co-operation. Following the Sino-Soviet split in



*China launches Shenzhou-10 on 11 June with three Taikonauts on board. Xinhua photo.*

the 1960s, China started to develop a series of indigenous rockets. This led to development of the Long March launch vehicle family and a first successful satellite launch in 1972. In 1990, China entered the commercial launch market, offering considerably cheaper prices, albeit with a lower reliability. In 2003, a Long March booster put the first Chinese astronaut into space, becoming only the third state to launch humans into space.

Space is an integral part of China's industrial modernisation, either directly through the technological advances implied by an indigenous space programme and indirectly through the infrastructural benefits of space-based communications and Earth observation. There is also a prestige element in demonstrating to the world China's competence and as a means of projecting 'soft power' through international co-operation in space, especially with regional allies and the developing world generally. However, at heart the Chinese space programme remains an important factor in national security and national security doctrinal evolution.

### *Air-Space Power*

One of the most striking aspects of Chinese thinking about space and air power applications is a vision of integrated air and space operations, with the air and space battlespace a 'seamless whole', linked by a network-centric force capable of acting over large distances with high levels of precision strike. Initial thoughts on the concept can be traced to the early 1990s, but a 2009 interview with the PLAAF Commander, General Xu Qilang, put the seamless web at the core of air force thinking. While the Chinese government moved rapidly to disavow any hint of an overt militarisation of space, ASAT capabilities and, of course, the more passive aspects of military space were not excluded.

Naturally enough, the PLAAF laid claim to a leading role in developing and deploying air-space power. Such radical thinking was consistent with the 'New Historic Missions' promulgated by the Communist Party between 2004 and 2007. Space was designated as one of the new areas of Chinese strategic interest (these also included distant waters). Space undoubtedly had economic value to the new China, but military-strategic interests were equally important. Space-based force was a critical force-multiplier utilising network-centricity to integrate all armed forces and their operations across vast distances.

Chinese progress in space supports the general belief in the importance of space-based assets in supporting China's rise

as a first rank military power. But the more radical thinking on exo-atmospheric and hypersonic vehicles is more problematic. Chinese technical literature abounds with references to hypersonic air-space systems, and there are reports of work on research vehicles and propulsion concepts. This activity has received high priority and senior political and military endorsement. Work on advanced platforms has been complemented by comparable activity on guidance systems and high altitude sensors, including synthetic aperture radars. Nevertheless, this aspect of air-space power has some way to go before it constitutes a realistic aspiration, let alone a reality.

### *Building an Air-Space Capability*

China has been best able to close the gap with the West in space and missile technology. Although given an initial boost from ex-Soviet technology, the Chinese have acquired an impressive set of indigenously developed space and missile capabilities.

China now has a wide range of space-based military assets, including the Beidou satellite navigation and positioning network, communications and Earth imaging. Of the 70 satellites in orbit, 40 are controlled by the military. While China's spy satellites might not yet have the resolution of US systems, capability is growing and there are plans to develop a network of high resolution imaging satellites. The latest generation of communications satellites will have ion-drive propulsion which will enhance on station lifetime and increase payload capacity. The Chinese have also demonstrated a crude anti-satellite system.<sup>5</sup>

China has already deployed a range of cruise and ballistic missiles to support its nuclear force. China has developed less vulnerable solid-fuelled rockets and multiple warheads and penetration aids. The Chinese inventory also includes a conventionally armed ballistic missile capability and specialised anti-ship missiles such as the Dongfeng-21D.

### *Latest Developments*

In December 2011, the Chinese announced an ambitious five-year plan for space that would significantly close the gap with the US and move beyond European capabilities.<sup>6</sup> The plan is consistent with China's wider national economic, security and political strategies. It is the latest stage in a steady investment in space over the past 50 years. Space is at the heart of Chinese military modernisation that will improve national power projection capabilities. Space is seen as major vehicle to build China's prestige and reputation as an advanced state. Continued space spectaculars such as in-orbit docking missions will underline China's overall competence in space, adding to a growing credibility as a commercial actor in satellite launches and infrastructure provision.

The plan outlines a series of short and medium-term objectives:

- Further expansion of the Beidou navigation and positional system: the ten-satellite system currently provides full national coverage. This will progressively increase to cover the Asia-Pacific region and full global reach by 2020 with a 35 satellite constellation. The system is already available on a trial basis to Asia-Pacific users. This will soon

match current US GPS coverage, as well as the Russian Glonass and the emerging European Galileo systems. Critically, while Beidou would not be as accurate as the highest level of GPS or Galileo signals, it would give the Chinese military an independent positioning and navigational system.

- Further development of China's in orbit data-relay system. China is already only the third country to possess this capability, which is essential to support manned space operations including space-docking missions vital to the assembly of a orbital space station.
- Steps will be taken to improve Chinese commercial space applications, with a new range of Earth-imaging and communications satellites. The former will include a family of synthetic radar imaging satellites that will enable an all-weather, 24-hour multi spectral observation. This will also enhance China's military space capabilities.
- Massive improvements in space infrastructure, including the building of a fourth launch centre at Hainan closer to the Equator, so increasing the lift power of its rockets. The Hainan centre will specialise in supporting manned and deep space probes. Generally, China's network of ground stations will be expanded and modernised. The Chinese also intend further to expand space technological education and training as well as advanced research facilities.
- Proposed upgrading and new versions of the Long March rocket will more than double the weight of satellite that China could put into low Earth orbit. The new launchers will allow the Chinese greater facility to put satellites into polar orbits that will provide better surveillance and imaging capability. One of the planned developments will also give China a rapid response launch capability which would improve its ability to respond to emergencies and to support military operations.
- For the longer term, steady expansion of manned space activity centring on a near-Earth orbital space station to be established in 2016 as a spring board to a lunar expedition in the 2020s. This will also entail a programme of unmanned lunar exploration missions, and the development of a heavier man-rated launch vehicle. Manned space is a fundamental element in capturing the world's attention and underlining the clear political and prestige goals of Chinese space policy.

The plan should help to address recent uncertainty over organisational and decision-making structures. In 2008 the Chinese National Space Agency, ostensibly the civilian face of China's space operations was demoted. But reflecting the importance attached to space in contemporary military operations, the Chinese military continued to play a key role in delivering space policy. The new plan should bring Chinese space operations greater stability and external coherence, improving co-operation with other states in the space arena.

Despite these indigenous advances, China continues to buy western satellites, and has done since the 1990s and the start of economic liberalisation. These were initially supplied by American companies, but since the imposition of strict technology transfer controls (including restrictions on the use of Chinese launchers), most have come from Europe. In 2011, the Chinese acquired three high performance surveillance satellites from SSTL, a British subsidiary of Astrium. The implication is that while China has made tremendous progress in space technology, there are still gaps in capability.<sup>7</sup> This again suggests that China still has deficiencies in

<sup>5</sup>Although a test of capability and subsequent debris field led to wide-spread international protest and may have given China occasion to review the utility of such systems.

<sup>6</sup>See Norris, op cit.

<sup>7</sup>Norris, op cit.



Comac ARJ21. Peng Chen photo.



Airbus' new single-aisle assembly line in Tianjin, China. Airbus photo.

certain crucial areas of electronics that will hamper developments generally in the aerospace sector.

### CHINA'S CIVIL CHALLENGE

Although civil aerospace has perhaps even higher (and more subtle) barriers to entry than developing military aircraft or even space vehicles, China has begun to set ambitious targets. The level of systems integration and parallel improvement in several technological areas represents a major challenge, especially when required to meet stringent safety and quality standards demanded by international regulators and international airline customers. Canada's Bombardier and Embraer of Brazil have both produced small jetliners, in their latest products edging into the bottom end of the Boeing-Airbus market. Other companies that have tried to play in the 'big boys club' of commercial aircraft production — Mitsubishi, Sukhoi, Indonesia's IPTN — have all failed, or are struggling to make a permanent impact on the civil sector.

China does have some important advantages compared to previous new entrants: China is the world's second largest national air travel market — and expanding rapidly. China buys around 200 new passenger jets every year, about one-eighth the world's total demand. Consequently, there is a huge domestic market to tap into and build upon.

A second major consideration is prestige. The decision to enter the large commercial aircraft market was made at the very top, by the State Council of China and by the Central Committee of the Chinese Communist Party. The Commercial Aircraft Corporation of China Ltd (COMAC) — the state-owned company created in 2008 to take charge of passenger jet development — is wrapped in what Bitzinger calls "self-described aeronautical patriotism". From this perspective, the Chinese government views its mission as equivalent to the nation's development of nuclear weapons and the launch of the country's first satellite.

China has benefitted from long term collaboration with western manufacturers. Beginning with the McDonnell Douglas MD-82 'Trunkliner' programme in the 1990s, China has worked with a number of US and European companies.<sup>8</sup> More recently, Airbus has agreed to build the A320 in Tianjin. This may lead to work on the A320neo. Airbus

<sup>8</sup>Rolls-Royce, for example, has an even longer history of working in China. The Trunkliner is perhaps a good example of the problems associated with Chinese collaboration. MDD hoped that this would lead to a major sales breakthrough and a long-term relationship; neither transpired.

currently still has four years to run on its contract with Avic. As the first Airbus assembly line outside Europe, the aim was to use the Tianjin plant as a base to tap the huge Chinese domestic market. China, with a view to China working on future programmes.

### The 2011 State Council Policy Paper

In 2011, the Chinese state council issued a policy guideline on civil aviation. Dissatisfied with progress in implementing the current national plan, the council memorandum was designed to galvanise the provincial governments into faster action citing a lack of coordination and balance in developments so far. The key weaknesses identified by the state council included:

- Restrictions due to unreasonable allocation of airspace
- Slow infrastructure development
- Skills shortages
- Lack of competitiveness
- And an over bureaucratic management structure

With the backing from the top level of Chinese political authority, there will be increasing pressure on vested interest obstructing liberalisation in all aspects of Chinese civil aerospace and aviation. However, there are emerging contradictions in Chinese policy as liberalisation embraces private ownership and commercial interests.

There is still bureaucratic resistance to the cultural changes implied by a more liberalised air transport system. This is especially so with the military, perceiving liberalisation as a threat to national security. This is especially acute in the case of new coastal routes. Currently, key routes are saturated and forced further in land than is economically efficient. The military have conceded demands to open up lower altitude airspace to accommodate growth in general aviation and business traffic. However, problems over the allocation of airspace would appear to stem more from a lack of central direction to force other key actors to move on the issue. In particular, the Chinese military will need to liaise more directly with civil authorities to open new routes, to straighten existing air corridors and to modernise air traffic control.

Further contradictions are apparent in attitudes towards foreign investment and competition in the airline industry. There is a clear need for increased capital to fund growth, and several of the major airlines have foreign partners. However, in practice, the state continues to intervene to regulate the market, including route allocations and to set

strategic objectives, especially in relation to the promotion of hub airports at Beijing, Shanghai and Guangzhou.

There is a growing private sector. The Shanghai-based Spring Airlines is the largest Chinese low cost carrier, with 60 domestic routes and seven overseas. Spring has had to overcome fierce resistance from the large state-owned airlines. Regulators have held up applications for years on end, and have forced *en route* diversions to secondary airports. When slots have been allocated, they have tended to be the least convenient. Low fares have attracted fines. Spring is currently recording modest profits and is looking for an initial public offering later this year.

The rigidity in practice of Chinese policies is also evident in airliner procurement policy. The Five-Year planning process is inconsistent with the needs of ordering aircraft from Boeing or Airbus. Given the current high level of demand for the latest generation of narrow-bodied aircraft, Chinese airlines cannot get approval for orders fast enough to win early delivery slots. Given that the Chinese are likely to want a large number of aircraft (some of which will be delivered from Airbus' Chinese factory), this may not ultimately cause too many problems, as the manufacturers will try to anticipate Chinese requirements. A current case in point is Xiamen airlines' order for 40 Next-Generation 737-800s worth \$3.5bn. This is awaiting government approval.

The planned arrival of the Chinese-built Comac C-919 would complicate matters. The expectation is that Chinese airlines should satisfy a large part of its narrow-body requirement from domestic production. However, the airlines are sceptical about the C-919 meeting its schedule and are keen to protect their position on western production lines.

A further sign of liberalisation was the move by Superior Aviation of Beijing to buy Hawker Beechcraft. If successful, this will pose a major challenge to Avic, which currently has a monopoly on executive jet activity in China. Superior has made a \$1.79bn bid for the bankrupt American company (minus its defence division). Superior is 40% owned by the Beijing government, and although production will remain for now based in the US, it is likely to presage development of an aerospace capability in the Beijing region. Cessna and Embraer are already co-operating with Avic plants in Harbin and Chengdu. Beijing's ambitions may be constrained by lack of aerospace skills in the region, and Superior may be forced to work alongside Avic. There may also be other problems in accommodating test and delivery flights in the congested airspace around Beijing, but other issues such as planning and construction permissions are unlikely to be an issue. The development of a private aviation sector is also severely hampered by strict military controls on airspace and aircraft movements. There have been recent moves to liberalise access to lower airspace altitudes, but progress is slow.

**ACQUIRING THE CAPABILITY, CHINA'S AEROSPACE AND DEFENCE AEROSPACE BASE**

*Industrial and Technological Issues*

These doctrinal and operational advances have to some extent been matched by an increasingly sophisticated domestic defence industrial and technological base (DITB). Reliance on domestically sourced equipment has been a matter of choice (dependency reduction) and circumstances (reluctance on the part of traditional allies — Russia and the Ukraine — to transfer technology. China has put a considerable effort into overcoming serious technological deficiencies through systematic investment in R&D. There is



A model of the C-919 at Asian Aerospace 2009. Bill Read photo.

also the little matter of seeking illicit access to western technology through exploitation of dual technology, cyber attack or conventional espionage.

The results have been impressive, but patchy. Space and missile technology have progressed more rapidly than aviation, especially propulsion and avionics. This has reflected high-level national priorities determined by the political leadership but it also follows shortcomings in Chinese aviation industry capabilities and organisation. A degree of self fulfilling prophecy may well have set in, but there are clear signs that the Chinese are looking to remedy these deficiencies, primarily through industrial re-organisation and switching space and missile industry executives to run the aerospace sector.

As Chinese indigenous capabilities grow, there is more scope for extending Chinese influence through arms sales. China has been here before: purveyor of cheap Soviet copies to impecunious Third World states. The newer generation of equipment is better and comes with a growing awareness of after-sales support. All of which builds security relationships rather than collecting disappointed customers.

Historically, China bought much of its defence equipment from Russia, or reverse engineered foreign technology to produce copies. Reverse engineering is still an important tactic, but China has now begun to develop advanced indigenous aircraft and space systems. While some of this capability is still based on acquired technology — sometimes through illicit means — after a decade of work, China is now thought to have reached in some areas a comparable level of technical capability with Russia and western suppliers.

Growing domestic capability has enabled China to reduce its dependence on arms imports, mainly from Russia. These fell by 58% since 2007. Since 2001, China's arms export have increased by 95%, making it the world's sixth most important arms exporter, primarily to less developed states. China appears also to have learnt some important lessons about after-sales support, which will make it an increasingly formidable competitor at the lower end of the market. This will bring economic benefits, but increasing arms sales will also further support China's 'soft power' potential.

*Creating a Modern Aerospace Industrial Base*

The modern Chinese aerospace industry started operations in 1951 to support China's Soviet-built aircraft. This soon evolved into production based on transferred Soviet technology. China's first indigenously produced military aircraft was the CJ-5 trainer of 1954 vintage. A series of Soviet licence produced aircraft followed culminating in 1965 with the first



flight of the Q-5, a development of the MiG-19 — the first military jet developed and manufactured in China.<sup>9</sup>

The contemporary industrial base has followed three waves of re-organisation starting in 1993. After a number of false starts, the current structure was defined by the Party leadership in 2007 with the creation of a single defence aerospace unit — AVIC — and a centre for civil development — COMAC. At every stage, while economic and commercial interests have shaped Chinese civil aerospace, the main driver for industrial reform has been to provide concrete support for military modernisation. Even COMAC is seen as a match to perceived western practice of linking civil aerospace technology to military progress.

China has also re-organised its defence industrial assets the better to design, develop and manufacturer advanced weaponry. This will include a limited privatisation of all but the most sensitive of the state-owned defence companies to encourage private investment. The aim is to rationalise disparate assets and to improve efficiency and effectiveness. Currently, China's defence companies have assets worth an estimated \$315bn have some 70 subsidiaries with over 40 defence listed businesses.

### Big League Contenders

COMAC has two serious civil aerospace projects: the ARJ21 90-105 seat regional jet, which was launched in 2002 with its first flight in late 2008. The ARJ-21 is intended primarily to meet China's burgeoning demand for internal air transport. However, specific domestic requirements, such as the need to fly into Lhasa airport at an altitude of 11,500ft, could hamper its appeal to wider markets. However it has already secured over 300 firm orders, but mainly from Chinese domestic airlines. More ambitiously, the C-919 150-200 seat narrow-body jet launched in 2008 is in the same category as the Boeing 737 and the Airbus A320. Nearly 400 of these airliners have been ordered, again mainly to Chinese carriers. The first flight is scheduled for 2014 and deliveries will begin in 2016. The C-919 is seen as the first of a family of airliners, including the 400-seat C-939.

The ARJ21 and the C-919 have world class specifications, but both face hurdles to make a breakthrough in world markets — the largest non-Chinese customer for these planes is the American leasing company GECAS. Even Chinese airlines are reluctant fully to accept the C-919 without some assurances of quality and commercial effectiveness. The Chinese government has had to lean on airlines to accept a limited number of initial deliveries. Both airliners are already behind schedule, due to technical setbacks. The ARJ21 was two and a half years late in achieving first flight. In late 2010, the plane's wing failed its predicted load rating during static tests; wing cracks and other problems have been rumoured. Altogether, the aircraft is already several years behind schedule, and initial deliveries are not expected before the end of 2013.

However, the Chinese remain heavily reliant on foreign firms to provide critical components and technologies for these aircraft. More than 20 overseas firms are partnering on the ARJ21, including General Electric (engines), Rockwell Collins (avionics), Liebherr (landing gear), and Parker Aerospace (flight controls). In addition, the ARJ21's nose cone is a direct copy of the MD-82. For its part, CFM International will supply its LEAP turbofan engine for the C-919, and it



The Chengdu J-20 is one of two stealth projects revealed by China. Chinese Internet photo.

will subsequently build an assembly line in China for series production.

Building large passenger planes is one of the most daunting undertakings in manufacturing. Safety and reliability, as well as comfort and economy, are at least as important as price. China has a poor reputation for delivering high technology projects; the safety questions over its high speed railway system are particularly salient in this respect. Even if China can assure quality control of its commercial airliners, however, it will be difficult to overcome airlines' ingrained preferences for proven products like the A320 or the 737. Interestingly, one of the Chinese domestic carriers has been remitted to "stress test" COMAC's ability to provide after sales support for its products. Nevertheless, for the next decade at least, Chinese-built passenger planes are likely to remain overwhelmingly a Chinese-bought item.<sup>10</sup>

### Combat Aircraft Show-Stoppers

The speed of China's developments was most dramatically demonstrated by the revelation of two fifth-generation fighter aircraft, the Chengdu J-20 and a smaller Shenyang J-31. With a first flight in 2011, the J-20 programme alone is enough to signal both the capability and the determination to become a first rank military aerospace power. Ostensibly, the J-20 would match the US F-22 and F-35 — leaping ahead of the UK and France. But while the J-20 has recorded over 53 test flights, it may not even go into service, and may be merely a technology demonstrator like the European EAP aircraft, which flew eight years before the Typhoon. However, both types have weapons bays and may yet anticipate operational concepts, but full, operational deployment is several years off — 2018 is the soonest date predicted.

The main problem facing the Chinese is developing an adequate jet engine: the indigenous WS-10 is unreliable and largely incapable of delivering adequate performance, especially super cruise, the ability to fly sustained supersonic speeds. Engine technology is one of the most difficult of the aerospace disciplines, and China's weakness in this

<sup>9</sup>Richard Hallion et al (eds), op cit and P Saunders and J Wiseman, op cit.

<sup>10</sup>Bitzinger, op cit.

area has also spilled over into its civil ambitions. Similarly, while both the J-20 and J-31 have stealthy structures, there are doubts that China has developed the radar absorbing materials required for full stealth capability or fast data links, integrated electronic warfare suites or sensor fusion avionics to produce a genuine fifth-generation fighter.<sup>11</sup>

Reverse engineering, the usual way to fill in technology gaps, has its limits where engine development is concerned. China's historical links to the Russian aerospace industry would not have helped much either — engines are also a Russian relative weakness. Collaboration with Israel has also helped Chinese fighter development.<sup>12</sup> Other limitations are in Chinese military transport capability, where the armed forces are still dependent on Russian or Ukrainian equipment. A domestic product, the four-engined Y-20, equivalent to the US C-17, flew last year but series production is some way off. The Y-9, equivalent to the US C-130, was a co-development with the Ukrainian company Antonov, with indigenous turboprop engines. Antonov is also involved in Y-20 development. Domestic helicopter designs are also based on Russian or western types. China still relies on Russian built air defence missiles.

### **Unmanned Systems**

Reflecting current trends in military airpower, China is investing heavily in unmanned aerospace systems (UAS), with over a dozen reported programmes underway. In September, AVIC sponsored a competition for new concepts. Participants included some of China's leading engineering schools. The SH-1 tactical UAS, first shown in 2010, is now in service. AVIC has also developed the Pterodactyl 1, comparable to the US Raptor, as well as several other advanced UAS concepts, including a vertical take-off platform. Other Chinese companies are working on civil UAS platforms.

### **Genesis of a Maritime Capability**

China has also bought a refurbished Russian aircraft carrier to test and to develop maritime airpower skills. China is also developing a naval version of the Russian Su-33 design, designated J-15. In the future, the new J-31 design might also be the basis for an advanced naval airpower capability — pictures again suggest design features implying carrier-basing potential. For the moment, although aircraft have been pictured near or on the flight deck, it is unlikely that the new carrier will be deployed as a fully capable military asset. Carrier aviation and associated naval support is one of the most complicated and expensive of military skills. Even the Russian navy only has a limited naval airpower capability. In the first instance, the Chinese carrier could be deployed as an amphibious helicopter assault platform. A dedicated helicopter platform is also under consideration.

### **So Where Does This Technology Come From?**

For much of the period since the 1950s, China has depended on a mixture of, "buying, building or stealing" to acquire a military aerospace capability. The balance between the three approaches has depended on the degree of co-operation with other states, predominantly the Soviet Union and its successor states — but also Israel, generalised access to western technology, and growing indigenous competence,

which itself follows China's economic development and overall technological standing. The latter is also a vital aspect of the country's ability to absorb technology either legitimately or illicitly obtained.

Legitimate access to western technology has been affected by wider political factors. With the advent of Deng Xiaoping's Open Door policy of the late 1970s and early 1980s, China's defence aerospace industry benefited from direct technology transfer, such as GEC-Marconi avionics used in several Chinese military aircraft. Western technology also helped China to develop a fly-by-wire competence.

The negative fallout from the 1989 Tiananmen Square crackdown led to severe restrictions on co-operation and sale to China, which included pressure from the US on the EU to restrict a range of dual technologies in addition to a formal arms embargo. Conditions have eased over the past decade, but there are still constraints on technology transfer involving dual technology. These have included the sale of Super Computers that have been employed in military-related research.

The rise of Chinese economic power and the attractions of its market have begun to change the balance of bargaining power with prospective partners in the west and seem to be overriding Russian reluctance to sell its most advanced products. Western companies have begun to locate R&D facilities in China as part of wider commercial initiatives; this increases China's overall research competence through training and exposure to new knowledge. In the latter case, Russian desperation to maintain its own indigenous industry may be a critical factor in effecting the shift in bargaining power.

Nevertheless, China's ambitions are still helped by industrial espionage and reverse engineering.

Russia delayed delivery of its latest version of the Sukhoi Su-35 fighter because of concerns about the possibility of Chinese copying its technology. With an order for only 24 aircraft but with additional orders of spare engines, the implication is that these aircraft are destined for the copy-shop. While in practice the Chinese might have trouble absorbing the technology embedded in this advanced weapon system, reverse engineering will remain a useful short cut.

Deals are closely watched by Western governments, with UTC already facing penalties for supplying China with electronic control software that was sold for incorporation into a civil helicopter but which has been converted into military applications. China is known to have launched a major industrial espionage campaign against Western aerospace and defence companies. There are rumours that Chinese cyber attacks against BAE Systems and other contractors, including Lockheed have led to leaks of F-35 technology.

### **But Also National Talent**

Reverse engineering at this level itself implies a high degree of technical competence; China has invested heavily in the research and technological infrastructure that is the pre-condition of acquiring a world class aerospace industry. For example, the China Academy of Aerospace Aerodynamics in Beijing is the country's primary centre for aerodynamic research and testing. It already has 25 wind tunnels, including transonic and supersonic facilities and its activities also include missile and space research.

<sup>11</sup>The J-20 has forward stealth but not rearward stealth, as its all-moving tail fins, canards and nozzles are radar reflecting surfaces.

<sup>12</sup>Significantly, the US vetoed Israeli participation in a Chinese equivalent to AWACS.



A Chinese Su-27 Flanker. USAF photo.

The 2006 central plan was an important step forward in the development of indigenous R&D. It specifies that China should have an independent base for its entire military R&D capability by 2020. This entails further investment in material and human resources. It will certainly require a comprehensive commitment to a range of R&D. Some of this expertise may come via collaboration but China will be to some extent constrained by continuing restrictions on collaboration with western suppliers. It will also have to overcome the highest barriers to entry associated with systems integration and the simultaneous development of combinations of advanced technology, which becomes more difficult “the closer a country moves closer to the technological frontier”.<sup>13</sup> This has defeated many more advanced economies; but this is not an absolute restriction, simply one of time, resources and the political will to force the pace of progress, and, when necessary, ruthlessly to endorse the use of covert means to acquire critical technologies.

## CHINESE AEROSPACE — AN APPRAISAL

### Military Ripples in a Big Pond

The speed of Chinese military development continues to surprise observers. Although the limitations described above will constrain some aspects of Chinese air power capabilities, there is enough evidence to suggest that China will continue to move forward at a rapid rate. Take the carrier: when first revealed, it was believed that this was likely to be simply an expensive training vessel; with a verified jet landing and take off coming much earlier than expected, there may have to be a re-consideration of China’s maritime power projection. There is still very much more to operating a carrier-centric task force, but this is a key step for the Chinese navy.

As China acquires more air power capability, it will begin to threaten area denial in the western Pacific to US naval forces as well as support any operations over Taiwan. These are explicit objectives of stated Chinese strategy. Concern over China’s potential has already begun to trigger a conventional arms-race in the Asia-Pacific region. Japan,

South Korea, Singapore and Australia are considering or are already planning to buy the F-35 in direct response to the Chinese build-up. Despite these qualifications, the J-31 (and to a lesser extent, even the J-20) represent a rapidly maturing challenge to US military power, and to the US’s regional allies.

Combined with the declaratory policies emerging from the PLAAF, the PLA generally and statements from the Party leadership (albeit with a degree of deliberate ambiguity), there is enough substance to warrant a solid response: the risk is that this becomes a more dangerous anticipation-fuelled military build up in the Asia-Pacific region. Several key regional players, notably Japan have begun to anticipate expanded Chinese capabilities with force modernisation programmes and renewed security links with other Asian and Oceanian nations. Overall, members of ASEAN boosted defence spending by 13.5% in 2011.

More importantly, the US has announced a ‘Pivot to Asia’, based on a re-orientation and recommitment of military resources and diplomatic attention the region. This follows what Douglas Stuart, the Dickenson College-based American analyst, views as a long period of relative neglect. The result is that the US has “a great deal of catching up to do in the Asia-Pacific. Solutions will require a mixture of military ‘hard’ power and economic ‘soft’ power at a time when evidently China has expanded both in the region.

The US still has a marked military superiority in the region, but will increasingly face a direct challenge to its freedom of manoeuvre. The promotion of the new AirSea Battle operational concept is an attempt to anticipate the arrival of Chinese area-denial weaponry. On the positive side, the US will have several years to meet effective Chinese deployment; on the negative, as Stuart points out, “any new military doctrine that requires new high-tech weapons systems will be a hard sell at home.” While there is enough evidence of a growing military competitiveness from China, both in terms of declaratory policy and military preparedness, there is also an element of ‘looking for an enemy’ to justify one’s own defence spending. US anticipation of China could in turn trigger a Chinese over reaction. There is no sign yet of China seeking an expeditionary capability of the scale possessed by the

<sup>13</sup>Saunders and Wisemen, op cit.



CAC/PAC JF-17 Thunder lightweight combat aircraft jointly developed by China and Pakistan. Chris Male photo.

US. But there remains the 'elephant in the room' of Taiwan; in recent years, the two Chinese players have evolved a *modus vivendi*, but there is still the chance of misperceptions leading to renewed tension and an American rush of old Cold War behaviour.

Modern China is very different from the state created some 64 years ago: but the dominant role of the Communist Party and its interests in maintaining position and legitimacy, combined with the longer historical tradition of regional hegemony betrayed by its own backwardness, is to say the least a dynamic mixture. There are powerful economic disincentives to fight either its immediate neighbours or the US.

There are powerful forces at work within China to acquire the wherewithal to match any local military force and to neutralise American capability to assist allies. Air power in all of its forms is a key element in Chinese force modernisation and by implication China's emergence as a regional force to be reckoned with. At the very least, as one of the National Defense University authors concludes: "Barring the fielding of effective countermeasures, Chinese conventional aerospace power, specifically short and medium-range ballistic and extended-range land attack cruise missiles, may over time give the PLA a decisive advantage in future conflicts around China's periphery".

#### *Arms, exports and 'soft power'*

Growing domestic capability has enabled China generally to reduce its dependence on arms imports, mainly from Russia. These fell by 58% since 2007. But more important, since 2001, China's arms export have increased by 95%, making it the world's sixth most important arms exporter, primarily to less developed states. The ability to export arms has enhanced China's influence in Africa and parts of the Far East, and has supported its 'soft power' capabilities, especially when linked to economic interests, particularly in securing access to raw materials. These countries might also provide a useful market for China's civil aircraft, especially if linked to aid packages and offered as cheap, but reasonable effective alternatives to Western products.

Overall, however, China's penetration of aerospace markets is still limited — a combination of quality and external

constraints (such as US ITAR restrictions on the sale of Long March launches) will inevitably constrain expansion. This is, of course, in marked contrast to China's overall export success, albeit in much lower technology sectors. The potential is there, as now increasingly evidenced in some areas of consumer electronics, to move up the ladder of export value. Nevertheless, this may yet require several years seriously to affect western civil aerospace manufacturers.

#### *Taking on the Boeing-Airbus duopoly*

In developing a civil aerospace capability, the Chinese government decided deliberately to take on the Boeing-Airbus duopoly in the medium-to-large jetliner business. However, given China's recent successes in consumer electronics, semiconductors, space, and the automotive industry, the Chinese were confident of breaking into this potentially lucrative market.<sup>14</sup> Equally, although the direct links between defence and military aerospace are not as strong as they once were, there is sufficient connection between the two sectors to generate some useful synergies, particularly in sustaining R&D and a large scale engineering and technological training programme.

However, as this paper has noted, China has several important deficiencies in key aerospace technologies — weaknesses that might be finessed in military programmes but major impediments in mounting a global challenge in the civil sector. These might be mitigated through collaboration with western suppliers, but links between civil and military interests may yet obstruct sufficient levels of technology transfer to satisfy Chinese policy requirements. Western companies may also be reluctant to invest so heavily in China that they do succeed in unleashing a competitor.

The full extent of China's commitment to aerospace is undeniable. It is less evident whether we are seeing the rise of a new aerospace superpower. It may yet take another generation of investment to provide an answer. But one thing the Chinese do well is to take a long term view of things.

<sup>14</sup>Richard A Bitzinger, op cit.