Remaking Cinderella: The Nature and Development of China's Aviation Industry

Tai Ming Cheung

Associate Research Scientist

Institute on Global Conflict and Cooperation, University of California, San Diego

May 20, 2010

Testimony Before the U.S.-China Economic and Security Review Commission

Hearing on China's Emergent Military Aerospace and Commercial Aviation Capabilities

Panel IV: China's Aviation Industrial Complex

China's aviation industry wants to turn from Cinderella into the belle of the global aviation ball. With strong political backing, ample funds, and privileged access to fast-growing domestic civilian and military markets, the country's aviation industrial barons are pursuing an ambitious strategy to build an internationally competitive, innovative and comprehensive aviation design and manufacturing base within the next 1-2 decades. This paper examines the prospects for success by looking at the current state and critical aspects of the Chinese aviation industry's development strategy.

The Current State of China's Aviation Industry: Strengths and Weaknesses

After sixty years of struggle and stagnation, the Chinese aircraft industry has been experiencing a renaissance since the beginning of the 21st Century. The industry is reaping record profits, receiving plentiful flows of orders, developing and producing new generations of advanced aircraft, and forging business and technology ties with some of the world's leading aircraft and aircraft component firms.

This is a far cry from the end of the 1990s when the industry was a loss-making relic of the bygone central planning era. The aviation industry, along with the rest of the defense economy, was severely impacted by the introduction of economic reforms in the late 1970s. Heavy cuts in defense spending and a sharp decline in support for the state sector led to a prolonged downturn during the 1980s and 1990s. The aviation industry's problems were exacerbated by the unwillingness of conservative defense industrial leaders to implement meaningful reforms to reduce enormous waste, inefficiency, and widespread obsolescence.[1]

The inability of the aviation and defense industries to meet the modernization needs of the People's Liberation Army (PLA) became a critical national security concern from the mid-1990s as tensions intensified in the Taiwan Strait. In the late 1990s, the central authorities intervened and carried out sweeping reforms of the defense and aviation sectors:

- **Shifting from Administrative to Corporate Mechanisms:** The outdated administrative management structure was replaced by new corporate arrangements intended to foster market competition. Two new aviation conglomerates, Aviation Industries Corp. of China (AVIC) 1 and AVIC 2, were established and given considerable autonomy.

- **Overhauling the Research and Development (R&D) Base:** Reforms were launched to break down entrenched compartmentalization by integrating R&D and production activities. Funding for R&D activities was also revamped with more money going into viable high priority projects and the culling of lower priority and failing projects.

- **Paying Attention to End-User Requirements:** The aviation industry's blinkered technology-push approach to product development was wrestled open and the PLA, especially the air force, was given the lead role in setting and overseeing equipment research, development and evaluation.

- **Changing the Leadership:** Reform-minded technocrats took charge of the defense and aviation sectors and vigorously implemented far-reaching reforms, including slashing costs and laying off tens of thousands of workers.

The implementation of these and other reforms created the conditions for a remarkable turnaround in the aviation industry's fortunes since the beginning of the 21st Century:

- **Financial Performance:** After more than a decade of losses, the aviation industry became profitable again in 2003 and has posted record earnings and revenue growth annually since then. In 2009, AVIC had profits of US$1.4 billion and revenue of $28 billion, and was also included for the first time on the Fortune 500 list of top global companies.[2]

---

[1] For an analysis of this period, see Tai Ming Cheung, ***Fortifying China: The Struggle to Build a Modern Defense Economy*** (Ithaca: Cornell University Press, 2009).

[2] "Profits of China's Top Aircraft Maker up 14 Percent Last Year", ***Xinhua News Agency***, 20 January 2010.

- **R&D and Innovation:** Heavy investment in R&D has led to a strong surge in innovation activities, especially with the establishment of dozens of research laboratories and expansion of aviation universities and institutes. By 2009, AVIC had received more than 5,300 patents, the vast majority of which were obtained in the last few years.[3]

- **Product Development:** An extensive range of military aircraft from fighters to electronic warfare aircraft has emerged from the Chinese aviation industry over the past 10 years. Chinese air force officials proudly stated that more than 90 percent of the 15 types of military aircraft that took part in the 60th national day anniversary fly past in October 2009 were indigenously developed products.[4]

While these performance indicators show impressive gains, the aviation industry still suffers from serious structural weaknesses that threaten its long-term ability to narrow the technological gap and catch up with the top tier of global aviation powers. One of the biggest Achilles heels is the aero-engine sector, which has struggled mightily to develop and produce state-of-the-art high performance power plants to equip the new generations of military aircraft coming off the production lines. This has forced the aviation industry and PLA Air Force to be dependent on engine imports from Russia for its Chengdu J-10 and Shenyang J-11 fighter aircraft.

Another major structural weakness and a legacy of the Maoist past is the widespread duplication and balkanization of industrial and research facilities. The aviation industry has more than 130 large and medium-sized factories and research institutes employing 250,000 workers scattered across the country, especially in the deep interior, and often possessing the same manufacturing and research attributes. But intense rivalry, local protectionism, and huge geographical distances mean that there is little cooperation or coordination among these facilities, preventing the ability to reap economies of scale, engage in innovation clustering, and also hampering efforts at consolidation.

The extended cut-off in ties between the Chinese and Western military aircraft industries since the Tiananmen Square crackdown in 1989 has also contributed to its technological weakness. But Beijing has fortunately been able to mitigate the severity of these restrictions by forging a close relationship with Russia that has allowed the Chinese aviation industry to gain access to state-of-the-art weapons, and technology and knowledge transfers through off-the shelf purchases, offsets and license production arrangements.

---

[3] Xu Zelong, Jiang Chunyan, & Liu Wenbo “AVIC in 2009 Bucks Trend and Attains Impressive Achievements”, ***Zhongguo Hangkong Bao*** (China Aviation News), 21 January 2010, p1.

[4] Sun Maoqing, Wang Dongming and Dong Ruifeng, "New Observation of New Military Aircraft", ***Liaowang***, 5 October 2009, pp 34-37.

A Proliferation of Aviation Industrial Development Plans

The Chinese government, defense industrial authorities, and AVIC are building on the success of the past decade's reforms by drawing up ambitious development plans to propel China into the top ranks of the global aviation hierarchy within the next 10-15 years. This represents an important new approach in the industrialization of the sector that had previously pursued a muddling through policy and paid little attention to long-term strategic planning.

These blueprints include:

- A medium and long-term civilian aviation development plan currently being finalized by the Ministry of Industry and Information Technology (MIIT)[5];
- A long-term corporate plan devised by AVIC in 2009 that sets out key priorities to 2017[6];
- The 12th Five Year defense industrial program currently being drafted by the State Administration for Science, Technology and Industry for National Defense (SASTIND) that will begin in 2011;
- Civilian and defense versions of the 2006-2020 Medium and Long-Term Science and Technology Development Plan promulgated by the State Council and SASTIND's predecessor.[7] These state-level plans help to locate the aviation industry's place within overall national development priorities and also serve to promote the coordination and integration of civilian and military activities.

While some of these plans are classified, especially those related with military activities, the key elements and contours of them can be discerned. First, the long-term building of a world-class civilian airliner industry is a strategic priority for the Chinese authorities. The nature of this approach is a cautious step-by-step process of building progressively more advanced and larger airliners with increasing levels of local technological content. The first two stages of this plan have already been laid out with the development of the 70-110 seat ARJ21 trunk liner, which is now undergoing flight testing, and the COMAC C919 150 seat airliner, which is scheduled to fly for the first time at the end of 2014. Only 10 percent of the ARJ21 will be local in content while

---

[5] "China will Start to Formulate a Long-Term Aviation Industry Development Plan", ***Xinhua News Agency***, 1 June 2009.

[6] "AVIC in 2009 Bucks Trend and Attains Impressive Achievements", ***Zhongguo Hangkong Bao***, op cit.

[7] "China Unveils Plan for Developing Defense Technologies", ***Xinhua News Agency***, 25 May 2006; and State Council, ***The Guidelines for the Implementation of the National Medium- and Long-Term Program for Science and Technology Development (2006–2020),*** February 2006.

the target for the C919 is 30 percent. The third stage is the development of a two aisle wide-body airliner after 2020.[8]

A second major goal contained in these plans is the construction of a new geographical structure for the civilian aviation industry with specialized clusters concentrated in the Pearl and Yangtze River Deltas in South and East China and the Bohai Rim centered on Tianjin. A commercial engines base will be established in Shanghai, generation aviation operations in Zhuhai, Guangdong Province, and helicopters in Tianjin. These new clusters are intended to complement the existing military-intensive aviation industrial complex that was built in the Maoist era and is concentrated in the country's interior, such as Chengdu, Xian, Shenyang, Guizhou, and Harbin.

A third notable feature is the opening up and diversification of the aviation and defense sectors to new market-based sources of funding and ownership structures. The goal is to reduce the overwhelming dependence on the state for funding for research, development and production, and allow aviation and defense firms to raise their own sources of finance. This overhaul of the financial and ownership structure began in 2007 and the regulatory authorities have allowed a growing number of aviation and defense companies to raise investment through initial public offerings, private share placements, bond issues, and bank loans.

AVIC is one of the leading defense conglomerates to take advantage of this opening up to the capital markets. It currently has 22 companies listed on stock markets in Shanghai, Shenzhen and Hong Kong with a market value of close to Rmb 150 billion at the end of 2009. The conglomerate has set an ambitious goal of listing 80 percent of its total assets by 2012. This reform of the financial system allows the aviation industry to overcome one of its biggest obstacles to technological innovation.[9]

This financial acumen is a critical plank in the highly ambitious development goals of AVIC. The company unveiled an aggressive expansion strategy in 2009 that has a target of increasing revenues five-fold by 2017 to Rmb 1 trillion.[10] Besides investing heavily in civilian airliner development, AVIC plans to also expand its involvement into non-aviation business sectors such as clean energy and environmental technology, information technology, and technology consulting services.

AVIC is also looking beyond the Chinese market and has set its sights on becoming global aviation player within the next 5-10 years. One reason behind the re-merger of AVIC 1 and

---

[8] Gao Lu, "Chinese Jetliner Development is on Track", ***Guoji Xianqu Daobao***, 9 June 2009.

[9] Lu Zhou, "In Welcome Trend, AVIC Will List Three Large Asset Classes Within the Next Five Years", ***Zhongguo Zhengquan Bao*** (China Securities News), 21 September 2009.

[10] "AVIC in 2009 Bucks Trend and Attains Impressive Achievements", ***Zhongguo Hangkong Bao***, op cit.

AVIC 2 in 2008 was that these two companies were too small to be able to compete against the likes of Boeing, EADS, Lockheed Martin and other Western aerospace firms that are significantly larger in size. While the new AVIC is still overshadowed financially by these U.S. and European behemoths, it does now have growing economies of scale and is beginning to make its presence felt at international air shows and a pick-up in export orders. In 2009, for example, AVIC announced its best-ever year for foreign military sales, which was primarily due to the sale of 42 JF-17s to Pakistan for $1 billion.

AVIC has also expressed a strong desire to follow in the footsteps of its Western counterparts and expand its international presence through the acquisition of foreign companies. As a major beneficiary of the Chinese government's economic stimulus program in 2008-2009, AVIC has built up an enormous war chest of bank loans totaling $49 billion.[11] But the company will have to be cautious in its foreign acquisition strategy, especially because of widespread national security concerns in the West towards China. One of AVIC's first forays occurred in 2009 when it acquired FACC, an Austrian general aviation firm.

One of the aviation industry's foremost medium and long-term development priorities is the acceleration and deepening of its military research, development and production activities. The military aviation sector is engaged in a diverse array of R&D projects, of which the central focus is on the building of a next generation fighter aircraft during the 12th Five Year Plan.[12] Although Chinese aircraft designers claim that they are capable of producing a platform that is as technologically sophisticated as the U.S. 5th generation F-22 and F-35 fighters that have stealth, super-cruise, active electronically scanned array (AESA) radar, and other advanced features, it is far more likely that the next generation Chinese fighter aircraft would be in the class of a 4.5 generation aircraft such as the French Rafale, Swedish Grippen, and European Typhoon aircraft that have limited stealth and super-cruise capabilities.

This is because the Chinese aviation industry has so far lacked the expertise and experience to develop composite materials required in stealth technology and has yet to begin serial production of its own high-performance turbofan engines, such as the WS-10 engine. Without extensive foreign assistance, the track record of the Chinese aviation industry indicates that it has a low probability of making the necessary technological breakthroughs to produce a 5th generation fighter aircraft within the next decade, and possibly longer.

---

[11] Liu Weixun, "Aviation and Military Manufacturer Reloads for Oveseas", ***Jingji Guancha*** (Economic Observer), 14 August 2009.

[12] "Exclusive News By Our Newspaper: Fourth Generation Combat Aircraft to be Included in '12th Five Year Program' and it will Vigorously Challenge U.S. F-22", ***Wen Wei Po***, 14 March 2010.

A more credible and fruitful strategy is to pursue incremental upgrades of the J-10 aircraft, which appears to be already taking place. The aviation industry is also actively conducting R&D in the construction of a new generation large transport aircraft, with possible assistance from the Ukraine with its An-70 transport aircraft project, attack and large transport helicopters, upgrades of other combat aircraft such as the JH-7 and J-11, and production of airborne early warning platforms.[13]

Another important thread running through all these development plans and strategies is the promotion of civil-military integration (CMI), which is the notion of harnessing the technological and industrial capabilities of the civilian economy to advance defense capabilities. Instead of relying on its own resources, the aviation and defense industries seek to make use of commercially available technologies and manufacturing processes as a suitable substitute. CMI advocates argue that most of the technological needs of the military can be met through commercially available channels.

A growing array of military combat systems that incorporate commercially available sub-systems and components include avionics equipment, micro-electronics, new materials, information technologies, and computer-aided manufacturing (CAM) processes. The development of the FC-1/JF-17 fighter by Chengdu Aircraft Corporation (CAC) is an example of design and project management innovation that has resulted from the growing impact of commercial practices on the defense industry. CAC was able to shorten the time-period for the design and research of the fighter by as much as 50 percent in some areas through the use of CAM design and manufacturing processes that were developed in the 863 dual-use science and technology development program.[14]

Taken together, these development plans provide a comprehensive map of the aviation industry's long-term development approach. But there is also significant risk that this proliferation of programmatic guidelines may sow more confusion than clarity if they are not carefully coordinated with each other, especially as they originate from different bureaucracies with often competing interests.

The Aviation Industry's Diverse Pathways to Innovation

The Chinese aviation industry is pursuing a number of different approaches to technological innovation in its efforts to catch up. The first pathway is imitation, which has been the dominant

[13] "China-Ukraine Negotiations on An-70 Transport Aircraft", ***Kanwa Intelligence Review***, 10 May 2009.

[14] Yang Xinggen, "Transformation from 'Mechanical Military Factory' into a Digital Military Factory", ***Hangkong Kexue Jishu*** (Aviation Science and Technology), Jan. 2004, pp39–40.

strategy employed by the Chinese aviation sector since the Maoist era.[15] This has gone through several stages of evolution from simple duplication of Soviet designs in the early years to more sophisticated design copying and creative adaptation in the 1970s and 1980s in which there was extensive local upgrading and modifications of existing models. The Chengdu J-7 and Shenyang J-8II fighters are prime examples of this creative adaptation strategy.

Reverse engineering is another form of imitation that the Chinese aviation industry has used extensively and effectively, including most recently with the copying of the Russian Su-27 Flanker fighter-aircraft. China had acquired license production rights to the Flanker in 1995 and manufactured nearly 100 aircraft between 1998 and 2005. After absorbing and mastering the technology and knowledge transfers that the Russians provided for the aircraft, the Chinese undertook the illicit reverse engineering of the Su-27, which they referred to as the J-11B. As the Chinese were engaged in this imitation, they terminated negotiations with Russia to build more Su-27s. Moscow was incensed after it discovered what was going on and this led to a sharp, but temporary, chill in Chinese-Russian defense technological cooperation. Russia subsequently demanded assurances by China that it would not engage in such illegal behavior in the future.

Incremental innovation is another approach to technological advancement that is extensively practiced by the Chinese aviation industry and which complements its imitation model. This involves the limited updating of existing systems and processes. This innovation is often the result of organizational and management inputs aimed at making products more suitable to different markets and users rather than through original research and development. For example, more than 30 versions of the J-7 were developed or proposed between the 1960s and the 1990s, many of which were intended for export. Incremental innovation is likely to be the primary pathway of innovation for the Chinese aviation industry for the near-to-medium term because it is the most suited to its technological capabilities.

Architectural innovation is a third development pathway that the Chinese aviation industry is embracing, especially in the civilian sector. This consists of changes “to the architecture of a product without changing its components”.[16] This type of innovation requires “strong systems integration and strategic marketing capabilities” coupled with “a deep understanding of market

---

[15] See Wei Xie and Steven White, “From Imitation to Creation: The Critical Yet Uncertain Transition for Chinese Firms”, ***Journal of Technology Management in China***, Vol.1, No.3, 2006, pp229-242.

[16] Rebecca Henderson & Kim Clark, “Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms”, ***Adminstrative Science Quarterly***, Vol. 35, No.1, March 1990, p12.

and user requirements".[17] This typifies the approach that the commercial aviation sector is taking with the development of the ARJ21 and C919. Most of the components of these aircraft are sourced from foreign suppliers and incorporated into a Chinese designed platform that is intended for sale in the Chinese market.

Modular innovation is the next step up the innovation ladder and involves the development of new component technology that can be installed into existing system architecture. While imitation and incremental and architecture innovation depend more on 'soft' organizational and marketing innovation skills, modular innovation emphasizes 'hard' technological innovation capabilities such as advanced research and development facilities, a cadre of experienced scientists and engineers, and large-scale investment outlays.

Modular innovation is an area of major weakness for the Chinese aviation industry. Chinese avionics, radars, fire-control systems, and engines lag at least 1-2 generations behind leading international competitors and the near-term prospects of narrowing this gap are poor because of the under-development of the country's R&D capabilities. A telling example of the weak state of Chinese aviation component innovation is the reported efforts of Pakistan, one of China's staunchest allies, to re-equip its Chinese designed JF-17 combat aircraft with Western systems such as advanced radars and avionics.[18] The JF-17 is also powered by the Russian Klimov RD-83 engine.

At the top of the innovation chain is radical innovation, which is presently beyond the reach of the Chinese aviation sector. Radical innovation requires major breakthroughs in both new component technology and architecture and only countries with broad-based, world-class R&D capabilities and personnel along with deep financial resources and a willingness to take risk can engage in this activity. This is the type of innovation that is required for the development of 5th generation stealth aircraft and, to a lesser extent, wide-bodied jetliners. Other sectors of the Chinese economy appear to be nearing the threshold of engaging in radical innovation, such as the development of a new generation pebble bed nuclear reactor and 4th generation mobile telecommunications systems.

Concluding Thoughts

The Chinese aviation industry is making robust progress in its quest to catch up and become a leading global player within the next 1-2 decades. The industry has managed to escape the

[17] Dieter Ernst, ***A New Geography of Knowledge in the Electronics Industry? Asia' Role in Global Innovation Networks***, East-West Center, Policy Studies #54, 2009, p10.

[18] "France in Good Position for Mega-Contract in Pakistan", ***Les Echos***, 29 January 2010.

quagmire of stagnation and isolation that had threatened its very survival in the 1990s, and today is profitable, displays growing innovative traits, and enjoys high-level political backing.

Over the next few years, the aviation industry will transition from being a technological imitator to becoming an emerging innovative power, although this will likely be at the lower rungs of the innovation ladder focusing on incremental and architectural types of innovation. The ability to successfully conduct modular and radical innovative activities is still beyond China's reach for now. While the Chinese aviation industry will continue to chip away at the technological gap with the world's leading aviation powers, its aspirations to join their ranks still remain a long-term prospect.