China's commercial jet aircraft business – competition concerns

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Abstract: The aircraft industry has, in recent decades, frequently been used as a target and tool in many emerging economies as means for economic and industrial development. For a number of years, China has tried to foster a modern commercial aircraft industry and has benefited from the increasing participation in joint-projects with the world's leading aerospace firms. China's own domestic aircraft projects are facing major challenges in the coming years due to the pace of technology change and limited capability in crucial areas such as management and compliance to international rules and regulations of airworthiness. The fierce competition poses great dilemmas for those who have ambitions to enter the global market in an industry with such high and complicated entry barriers.

Keywords: China's aircraft industry; entry barriers aerospace; commercial aircraft business; competition aircraft industry; high-tech industry barriers; China.

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1 Introduction

The numbers of countries that have tried to foster an aircraft industry in 'the shadow' of the leading aerospace nations have steadily increased (Todd and Simpson, 1986; Eriksson, 1995; Vértesy, 2011). The aerospace/aircraft industries have in recent decades frequently been used as a target and tool in many developing and emerging economies as means for economic and industrial development. The development of an aircraft industry is based on several factors, some rational, such as technology spill-over (Eriksson, 2000), other less so. To the latter we can count the factor of prestige (Eriksson, 2003).

Aircraft, whether military or commercial, are assembled in many countries, but few of them have the capability to design, develop and produce an entire aeroplane.

Technology used in modern aircraft is extremely demanding due to the high levels of functional performance, reliability, safety and efficiency required at the system level.

Thus, emerging aerospace firms and nations have a great dependency on established companies in the leading aerospace nations because of the needs for transfer of technology, but the success of technology transfer is determined both by the installation of a technology at the destination site and by the utilisation of the technology after it has been transferred (Steenhuis and de Bruijn, 2001).

Long-term competitiveness in advanced technology industries, such as aerospace, is also based on innovative capability. Thus, catching up and overtaking established technological leaders poses formidable problems for imitators and aspirants for leadership, since they must aim at a moving target. It is no use simply importing today's technology from the leading countries, for by the time it has been introduced and assimilated, the leaders have moved on (Freeman, 1988).

China (PRC) has the largest aircraft industry in terms of employment of any emerging/newly industrialising country, with a huge dominance of military aircraft production. Most of the production has been designated for the domestic market.

The industrial patterns of many economies in East and Southeast Asia have shifted from labour-intensive manufacturing to more capital and knowledge intensive sectors. In some of these economies, including China, statements were made in the 1980s and 1990s that aircraft production would be an important industry in the new stages of growth also aiming at building an indigenous aerospace capability (Eriksson, 1995). In the early 21st Century China's government decided to make large investments in the development of commercial jet aircraft.

This paper will initially focus on the general development of China's aircraft industry and then narrow it down to analyse the large scale efforts in recent years to move into the development and manufacturing of commercial jet airliners.

2 Development of the aircraft industry

After 1949, the communist government decided to develop an aircraft industry, mainly for defence. As the West had imposed an economic embargo in the wake of the revolution, China imported foreign technology from the Soviet Union. At the time of the Soviet's abrupt withdrawal from China in 1960, China had just begun to manufacture on licence the next generation of Soviet military aircraft. The imports of components and raw material ceased, and a period of reorientation towards technical and industrial independence began. At the beginning of the 1960s China set out to design its own aircraft, necessarily based on available Soviet designs. This task, along with the development of transport aircraft, became difficult with the onset of the anti-technological Cultural Revolution in 1966. The main strategy was to reverse-engineer Soviet developed aircraft and give them Chinese designations (Eriksson, 1995).

A special case was when, in 1970, the local government of Shanghai and the Ministry of the Aerospace Industry decided to launch the Y-10 commercial aircraft program. This closely resembled the old US Boeing 707 and similarly was equipped with four Pratt and Whitney JT3D turbofans. Only a few prototypes were built and it is by most experts considered to be a reverse-engineered project.

With the end of the Cultural Revolution China changed direction and adopted an open-door policy in 1979. It also brought changes in the aviation industry, such as an increased emphasis on civil air transport, supporting the expected growth of China's economy.

In April 1985, an agreement was signed between the Shanghai Aviation Industrial Group of China and McDonnell Douglas (USA) to start assembly of the MD-82 airliner. After the first batch of 25 aircraft, an extension was granted for ten more MD-82s with a final delivery in 1994. It was to be followed by the production of the new MD-90, but the program failed after only three aircraft were produced. The MD-82 assembly project was the first modern airliner ever built in China and thus it became an important learning experience for the emerging Chinese aerospace industry (Eriksson, 1995, 2010).

With the open-door policy in 1979, it became very obvious that the outdated Chinese aircraft industry was in great need to get access to modern technology and production methods. Another important problem was the lack of management skills and methods.

A suitable way to start the modernising process was to initiate a development to become a supplier, i.e. subcontractor, to foreign aircraft manufacturers. Already in 1979 China signed its first agreement with a foreign aircraft manufacturer for the manufacture of landing gear doors for the MDC MD-80 series of aircraft (production started in 1980). This agreement, as many others that followed during the 1980s and 1990s were based on the strategic tool of offset for aircraft sales of aircraft to Chinese airlines (Eriksson, 1995, 2010).

In other words, China demanded technology transfer in exchange for market access. Later, this was complemented by the need to lower production costs by outsourcing the production of components and parts to China. In the early stages, the main jobs were 'simple' parts such as fairings and small doors, while later Chinese subcontractors increasingly became more involved in advanced components, systems, materials and technologies (Eriksson, 1995, 2010). This process has continued in the early 21st century (Eriksson, 2011, 2013, 2015) implying a movement up the technology ladder, increased aerospace design skills, and a general increased competence of China's aerospace industry. Thus, China has benefited from the increasing participation of its aircraft industry in the international supply-chains and joint-projects with the world's leading aerospace firms.

This development has taken place alongside the increased ambitions to develop the nation's own commercial aircraft industry, but that step is much more complicated, demanding not only modern manufacturing skills, but also other kinds of knowledge, such as management, marketing skills, appropriate logistics knowledge, compliance to international rules and regulations of airworthiness and safety, and trust from the customers (airlines and passengers). Not least one very demanding task remained – to develop and integrate all the complicated technology systems, and to work in an integrated way, i.e., system integration.

In the 1990s, after the MD-82 program experiences and a general modernisation and competence increase in China's aircraft industry, ambitions to move into the development and manufacturing of commercial jet aircraft have increased, albeit with foreign firms heavily involved in design and technology transfer. As China and other Asian countries became increasingly important as markets, but also potential financiers of joint projects, Western companies saw a possibility for cooperation with Asian partners. The first attempt for such a joint-venture was made by Boeing in the early 1990s, with the NSA regional jet. This aircraft, resembling the B737, was planned to be a joint venture

between the USA, China, South Korea and a few other Asian countries, but it never came off the drawing board.

Instead, in 1994, China and South Korea initiated a proposal to develop the Asian Air Express 100 (AE-100) twin-engine 100-seat regional jet, represented on the project by Aviation Industries of China (AVIC) and the Korea Commercial Aircraft Development Consortium. Disagreements between the two partners, led to the Korean consortium's withdrawal from the project. As there was a need for a leading Western company, China wanted Airbus to join the consortium (Lewis, 1996). Airbus joined, but after a period of intense discussions the AE-100 developed into the AE31X aircraft project and the final blow came in 1998, when Airbus withdrew from the project. Yet, another attempt of China to move into the commercial aircraft industry had failed.

3 Commercial aircraft projects in the 21st century

In 2000, the Commission of Science, Technology and Industry for National Defense acknowledged that China's aircraft industry lacked the capability to develop and manufacture modern medium-sized and large aircraft. Owing to the large demand for new aircraft in the Chinese market, now and in the foreseeable future, decision makers considered that the nation's aviation sector would be incomplete without developing its own civil aircraft. Plans were made for capturing parts of the large and growing aviation market with domestically developed and manufactured aircraft.

In May 2000, the Brazilian aircraft manufacturing company Embraer opened an office in Beijing, making it a base for increased cooperation and sales in China. At the 2002 Asian Aerospace in Singapore, Embraer made it clear that it aimed at establishing a final assembly line for its regional jets (Goldstein, 2006).

The Brazilian president involved himself in the deal, which included discussions with the Chinese president Jiang Zemin, without being able to solve some remaining issues (Aviation Daily, 2001). In April 2002, the Chinese government increased import tax on foreign-produced aircraft from 5% to 23%, thus giving favourable conditions for domestically produced aircraft. This tax increase could be seen as pressure from the Chinese government to produce these Brazilian aircraft in China. The Embraer Harbin Aircraft Industry, producing the ERJ-145 regional jet, is a joint-venture between Embraer (Brazil) and the Aviation Industry Corporation of China (AVIC), the main state-owned aerospace company, whereof Embraer holds 51% and the Chinese partner 49% share. In June 2004, the first China-made Embraer delivery was made to China Southern Airlines.

The ERJ-145 assembly project ended in 2011, when 41 aircraft had been built. As Embraer had no follow-on orders from Chinese customers for ERJ-145s, it wanted to keep its Harbin Embraer manufacturing joint venture going by making the larger E-190s instead, but it required approval from China's central government. The E-190 competes in the Chinese market against the domestic Comac (Commercial Aircraft Corporation of China Ltd) ARJ-21 regional jet (see below) developed by AVIC. Comac is another state-owned aerospace company, established in 2008, with the purpose to implement large passenger aircraft programs in China, such as the C919 airliner (further below), and also handles the marketing of the ARJ-21. There has been some political lobbying going on behind the scenes in which some parties have been lobbying the government to stop Embraer from manufacturing in China, in order to protect the ARJ-21 (Francis, 2011).

No agreement was reached concerning the assembly of the E-190. Instead an agreement was reached after almost two years of negotiations, to assemble the Legacy 650 business jet, which is a variant of the ERJ-145 model, for the Chinese market. The company converted its assembly line in Harbin, where it assembled the ERJ145 regional jet, into a Legacy 650 facility during 2013 (Hashim, 2012). The first Legacy 650 assembled in China made its first flight in 2013, and only two Legacy aircraft were delivered during 2014 and Embraer is considering closing the factory due to slow sales (Sciaudone and Park, 2015). Yet another decisive factor implying a closure is China's taxes imposed on imported components making the production costs higher than the Brazilian main production line (Toh, 2015).

The first modern domestically developed jet aircraft, the ARJ21 regional jet, was unveiled at the 2001 Beijing Air Show, representing China's most comprehensive effort to build a modern indigenous aircraft, although with a number of foreign partners and suppliers and technical assistance from large US and European companies. Although the Chinese advertising of the aircraft refers to the ARJ21 as an independent design with independent intellectual property rights, all its main technologies are Western-based such as avionics, engines and the fly-by-wire system. Indeed, more than 20 American and European contractors supply a large number of critical materials and technical systems and parts. Included among the foreign supplying companies are CFM International (France/USA), Eaton (USA), General Electric (USA), Honeywell (USA), Goodrich (USA), Hamilton Sundstrand (USA), Moog (USA), Parker Aerospace (USA), Rockwell Collins (USA), Liebherr Aerospace (Germany/France) and SAFRAN (France) (information received at a seminar at Asian Aerospace 2007 Congress, Hong Kong, 5 September 2007).

In fact, the ARJ21 has the same cabin cross-section, nose profile and tail as the US MD-80/90 series of aircraft (earlier licensed and manufactured in Shanghai) that ceased production in 1999 (Eriksson, 2013). It implies that the ARJ21 nose section uses the same tooling as for the manufacturing of the MD-80/90 nose section. Another technology input is that Ukraine's Antonov supplied the ARJ21 with a new super-critical wing as well as integral analysis of the construction strength. It also performed additional wind tunnel testing (Antonov News, 2007).

Initially, planned for delivery in 2007, it has been prone to a number of delays, due to a variety of flaws and problems, such as wings wiring, computer systems, re-design of the landing gear, etc. During a stress test in mid-2010, the wings of the ARJ21 broke, or 'cracked' (Reuters, 2012). Comac's Chairman Jin Zhuanglong blamed delays in the ARJ21 program on China's inexperience in designing, building and certifying commercial jetliners (Bodeen, 2013). In late November 2015, the first ARJ 21 was delivered to Chengdu Airlines and is planned for service entry during 2016 (Reuters, 2015). It implies a service entry nine years later than scheduled and 14 years after the development began. A serious matter is the fact that China's first domestically designed passenger jet will be delivered without international certification, a potential dent to both the aircraft's international credibility and to joint safety efforts by Chinese and US regulators (Govindasamy and Miller, 2015).

In 2006, the European aircraft consortium Airbus decided to build an aircraft assembly plant in Tianjin. The production site is a joint venture between Airbus and a Chinese consortium of the Tianjin Free Trade Zone and AVIC. It is the first Airbus final assembly plant outside Europe, and it was a strategic decision to strengthen Airbus's position in China relative to its main competitor Boeing (Eriksson, 2010). This project

has so far been the most successful commercial aircraft industrial project in China. The facility was inaugurated in 2008 and the first aircraft was delivered to Sichuan Airlines in June 2009.

An Airbus press release (Airbus, 2014), dated 3 December 2014 stated that the 200th A320 Family aircraft had been assembled by the Airbus Tianjin Final Assembly Line (FALC). In March 2014, Airbus, TJFTZ and AVIC agreed to extend the successful Joint Venture for another ten years, from 2016 to 2025. The extension, called 'phase 2', will include the final assembly of the A320neo Family from 2017 onwards for delivery to the Asian region (ibid.).

The supply of aircraft parts and components used in Tianjin's production comes from Airbus Europe, but since 2010, the wings are supplied locally by the Xi'an Aircraft Company, which has built a facility very close to Airbus assembly line. The structures are assembled in Xi'an and then equipped in Tianjin. Airbus has also established a logistics centre in Tianjin to support all the parts coming in and out of China (information received during a visit to FALC in October 2012).

The most recent domestic project aiming at becoming a global player in the commercial aircraft industry and China's long-term goal to break Airbus and Boeing's duopoly in the medium-sized jet aircraft market is the Comac C919 narrow-body jet-airliner. It is a planned family of aircraft, resembling the Airbus A320-series, accommodating 158–174 passengers. When the program was launched in 2008, the first flight was scheduled for 2014 and delivery to customer in 2016. The rollout took place on 2 November 2015 (Perrett, 2015), and with several years of flight testing ahead the first service entry will probably not take place before 2020. Also this aircraft is hugely dependent on foreign subcontractors and suppliers of critical systems.

According to Comac, customers have ordered more than 400 C919s, but the contracts have little binding effect, according to people who have seen some of them (Perrett, 2014). All orders, except one, are Chinese, giving the impression that the orders are from national policy (ibid.). One problem with the aircraft is the lack of clear path to endorsement of its airworthiness by Federal Aviation Administration (FAA) or the European Aviation safety Agency (EASA) as originally intended, but the C919 is being developed to international standard, according to Comac (ibid.). If the aircraft does not receive the necessary international certification it will limit the aircraft to the Chinese market. The C919 project relies on a number of foreign suppliers, although the Chinese has the main responsibility of the system integration.

4 Conclusions and final comments

China's commercial aircraft development is facing major challenges in the coming years. As regards commercial jet aircraft produced so far, they have been foreign, or foreign-based, constructions assembled in China, although some with local parts production. As seen in Table 1 the only aircraft produced in any significant numbers is the Airbus 320-series manufactured in Tianjin. In late 2014 it passed the 200 mark and an agreement has extended the joint venture until 2025.

Table 1 Commercial jet aircraft produced in China

Aircraft	*Origin of aircraft*	*Production period*	*Engines*	*Production location*	*Max. pass.*	*Number built*
Y-10	China (reversed engineered Boeing 707?)	1970s–1983 (project cancelled)	Four wing-mounted turbofans	Shanghai	178	Three (never went into airline service)
MDC MD-82	USA	1986–1994	Two rear-mounted turbofans	Shanghai	172	35
MDC MD-90	USA	1995?	Two rear-mounted turbofans	Shanghai	172	Three (originally 40 planned)
Embraer ERJ-145	Brazil	2004–2011	Two rear-mounted turbofans	Harbin	50	41
Embraer Legacy 650 Business jet	Brazil	2013 – in production	Two rear-mounted turbofans	Harbin	14	A few
Airbus A320 family	Europe: Airbus	2008: start of production 2009: first delivery	Two wing-mounted turbofans	Tianjin	180 (A320)	200 by early December 2014
Comac ARJ21	China 'influenced' by MDC MD-82/90	2002: project start 2007: roll-out. In production	Two rear-mounted turbofans	Shanghai	105	One delivered-yet not in service. Six to seven in flight-testing. Additional aircrafts have been produced, but not yet delivered
Comac C919	China	2008: project start.	Two win-mounted turbofans	Shanghai	174	One rolled out: first flight in 2016?

Note: Remark: production figures/information as of March 2016.

Source: Compilation by the author

The number of US and Brazilian aircraft assembled in China are rather limited and the Embraer Harbin Aircraft Industry is close to shutdown, currently only producing a few Embraer Legacy 650.

In spite of decades of ambitions in commercial jet airliner business, including the start of the ARJ-21 project in 2002, China has not yet delivered one single jet aircraft into service. This aircraft will be delivered without international certification, a potential dent to both the aircraft's international credibility and safety. There is a substantial risk that the ARJ21 will be obsolete to most airlines, once it is put into service. The C919, the

'second' Chinese jet airliner is an even more demanding project and it is facing a similar problem, i.e. the lack of clear path to endorsement of its airworthiness by FAA or EASA. If they not receive the necessary international certification it will limit the aircraft to the Chinese market.

Originally the Chinese policy makers had hoped for capturing shares of the huge Chinese airliner market with their own designed aircraft, but the large aircraft market is shared by Airbus and Boeing, while Embraer is an important actor in the regional jet market and the Canadian Bombardier (CRJ-series of aircraft) less so. From industrial policy views it reminds of similar situations in a few other countries with ongoing or previous ambitions to become players in the commercial aircraft industry. It represents some kind of unawareness and ignorance among governments, policymakers and companies about the difficulties involved in developing a viable aircraft industry (Eriksson, 2015). In some of these cases it is possible to sense a degree of prestige in the perennial efforts to move into aircraft manufacturing. Realistic market analysis and pure business dimensions often seem to be lacking and subordinated to other factors (ibid).

Another issue in China's aerospace industry has been low productivity and an overstaffed production system (Brömmelhörster and Frankenstein, 1997). Many Western industry specialists have reported an excessive number of people working in Chinese managed aircraft factories, and with that little incentive to increase efficiency. One problem in the factories is that managers are still struggling with the Soviet model, in which the more employees you have, the more important you are (Perrett, 2013).

This very complex industry is not only a matter of the transfer of technology – there are a large number of other dimensions, practices and skills involved to be able to succeed. There is a need to develop and master management and marketing skills, working methods, compliance to international rules and regulations of airworthiness, safety and after-sales services. The pace of technology change and fierce competition poses great dilemmas for those who have ambitions to enter global market.

For some decades China has had the fastest growing passenger air market of any country in the world and over the next two decades, predicted growth in China's domestic market will make it the largest domestic aviation market in the world. As the market continues to grow, airlines in China will need 4,630 new single-aisle airplanes, in the size of the ARJ-21 and C919, valued at $490 billion between 2015–2034 (Boeing, 2015).

Will China's domestic aircraft manufacturer be able to capture a share of this? current domestic projects have still to prove its legitimacy and the development so far also raises a number of questions about the future competitiveness.

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