Brazil, Russia, India and China Governments' Aerospace Strategies and National Policies: Implications to Canada's Aerospace Industry

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Executive Summary

The Canadian commercial aircraft industry had enjoyed a period of dominance in the North American market since the early 1990s. But Canada's failure to invest in new programs has opened the door for new competitors from Brazil, Russia, India and China (BRIC) to take a leading role in the development of new aerospace products. This study primarily provides an overview of BRIC countries (non-defense, non-military space) aerospace strategies and a discussion of major trends affecting the future of this industry. It is based on interviews conducted by the author with aerospace stakeholders and research on publically available information.

This study offers a critical commentary on significant challenges facing the Canadian aerospace industry from the BRIC aerospace strategies and national policies. The impact of BRICs government policies on the global aerospace industry should receive attention from Canadian policy-makers. While some in the aerospace industry dismiss the impact from the BRIC countries aerospace industries as "government-run hobby shops, not real businesses", they should not under estimate the potential structural changes they can bring to the global aerospace industry due to government policies, funding and national pride. The reasons for intervening in their aerospace industries are to develop economic security, technology development and move to higher-wage engineering and manufacturing jobs and create export revenue.

There are enormous financial costs and technical challenges for starting up a national aerospace industry which is controlled by state-owned enterprises. As a result, only a few countries have economic resources and population growth to sustain such an initiative. The BRIC countries have demonstrated the support to their aerospace industries to help them grow and prosper in the global markets.

This study will further examine the BRIC countries new aerospace initiatives and directions that will have an effect on Canada's global aerospace market share and explore the possibility of new joint ventures between BRIC countries aerospace industries. Our evidence suggests that the Bombardier's C Series aircraft integrator business model along with the lack of replacement aircraft models for the declining CRJ series regional jet and Q Series turboprops programs will not bode well for the Canadian aerospace sector. In light of Bombardier's urgent need for new aircraft programs to compete with manufacturers in Brazil, China and Russia, our principal conclusion is that the financial imperatives driving this business model may soon compromise Canada's aviation industry's ability to maintain a significant presence in the prime contractors and original equipment manufacturers side of the aerospace industry.

I. Introduction

The commercial aircraft industry has been a symbol of Canadian export leadership in product-markets which require high levels of design and engineering innovation. This industry has been at the top of the Canadian export sector for more than 20 years. Many of the advanced production and engineering procedures developed by this sector have been successfully transferred to other Canadian industries.

Bombardier as Canada's national champion is facing competition from government-owned and subsidized enterprises in Russia, China and India to their current product line. This along with fierce competition from the duopoly of Boeing and Airbus on their new C Series single-aisle aircraft leaves them few options to expand their indigenous technologies and lower their costs. In the past few years Bombardier has been expanding their cooperation with China for their family of aircraft. Currently, the C Series fuselage and center wing box will be built by China's AVIC Shenyang Aircraft Corporation. Bombardier's cooperation with China goes beyond aircraft production with its pledging to assist in western certification of China's new C919 single-aisle aircraft. The sharing of aircraft engineering and manufacturing by Bombardier to China has not yielded any orders from China for the new C Series aircraft.

The research for this study was done by reviewing BRIC countries national polices and funding to support the development of their aerospace industries. We will explore the effects on western aerospace companies by state-owned companies with their informal joint venture requirements and defense offset regulations for transferring technology. In the countries of China and India we will review the strategies in place to trade market access for co-design and production of western certified aircraft. Embraer in Brazil is developing its global network of industry and academician research and development resources to advance technologies that benefit their civil and defenses product lines.

This raises an important question that ought to be of interest to the Canadian trade policy analysts whom are concerned with national industrial competitiveness. Specifically, how does technology transfer and cooperative programs between Chinese, Indian, Russian state-owned enterprises have negative long-term economic or industrial effects for the Canadian aerospace industry? In the future, the Canadian policy-makers need to monitor the changes in BRIC governments strategies and policies in foreign direct investment laws, public-private partnerships structure, governments' cooperation across BRIC aerospace industries, issues on import duties and funding of commercial aircraft launches to see if they comply with World Trade Organization rules on aircraft subsidies. The study concludes with a brief discussion of the strategic issues that arise from these developments.

II. Brazil

The successful development of today Brazil's aviation industry is based on Embraer's global strategy. Embraer was created in 1969 as a government-owned corporation to develop aircraft and was later privatized in 1994. In 2000, Embraer made public offerings on the New York Stock Exchange and Brazilian BM&F stock exchange and has a market capitalization of $4.17 billion as of July 11, 2012.

Embraer is the fourth-largest aircraft manufacturer after Canada's Bombardier and is Brazil's top exporter of industrial products. Embraer designs, develops, manufactures sells and service a wide range of aerospace products that includes commercial aircraft, executive jets, military aircraft along with defense and security products. Embraer has a global workforce of 17, 265 employees and has a firm order backlog of $15.4 billion as of December 31, 2011.

In 2011, Embraer delivered 105 commercial and 99 business jets with revenue of $5.8 billion with earnings before interest and taxes depreciation and amortization (EBITDA) of $318 million which is 5.5%. Embraer's commercial aviation had $3.7 billion in revenue which is 64% of total sales and has a backlog 249 E-Series commercial aircraft as of December 31, 2011. The E Series family has seating range of 70 to 120 passengers and has had good success in the global market place. This family of aircraft has a total of 1091 firm orders and delivered 802 aircraft as of December 31, 2011. Embraer is at a 6 year low in its backlog of firm orders totaling $12.9 billion as of June 30, 2012. This is relatively a short time frame compared to Boeing's and Airbus's single-aisle (e.g. Boeing 737 and Airbus A320) aircraft backlogs of more than 7 years.

In 2011, Embraer's executive aviation delivered 99 aircraft with $1.1 billion revenue which accounts for 19.2% of their sales. The defense and security business revenues were $851 million and accounts for 14.7% of sales.

Brazil's state-owned Brazil Development Bank, BNDES, implements the government's industrial policy and is a source of long-term financing. In 2011, BNDES has total assets worth $334 billion and recognized a net income of $5 billion. The Brazilian government supplies Embraer financing assistance in several ways:

- Research and Development grants through Financiadora de Estudos Projetos (FINEP)
- Project development financing through (FINEP)
- BNDES, the government's technology development institutions
- Short and long-term financing through the government-sponsored Banco do Brasil.
- The BNDES-exim sponsored program is a Brazilian government program that provides Embraer's customers with direct financing for their aircraft.

The FINEP loans were extended primarily to fund R&D expenses related to the Embraer's Phenom executive jet program. Brazil's corporate income tax structure gives Embraer benefits that allow them a "super deduction" for R&D expenditures that equals to 160% of total R&D expenditures.

Embraer has been expanding its global network for research and development by working with universities and collaborating with western aerospace companies. In the past few years, Embraer has benefited from several projects financed by Brazil's FAPEESP the Sao Paulo Research Foundation under its Partnership for Technological Innovation Research (PITE) program. FAPEESP is an independent public foundation with the mission to foster research and the scientific and technological development of the State of Sao Paulo, Brazil. Embraer has benefited from government funded research in technology enhancement of their aircraft. The following three university projects can have direct technology transfer to Embraer's commercial aircraft and business jets programs.

- Aircraft Interior Innovations-The Polytechic School of Universidade de Sao Paulo and Universidate Federal de Santa Catarina research focuses on studies on incorporating innovative comfort trends into the cabins of the aircraft. The parameters will investigate the thermal comfort, pressure, noise, vibration, illumination of an aircraft and will be tested under a cabin simulation.

- Aircraft Noise Reduction-The researchers from Embraer, Polytechic School of Universidade de Sao Paulo, and Universidate Federal de Santa Catarina, Universidade de Brasilia and Universidade Federal are currently working on a project for silent aircraft in which its main objective is to develop and test noise-suppressing methods and equipment. The research will identify the noise generation from the aircraft aerodynamic surfaces and landing gears. This project has received $5 million in funding and has requested noise reduction patents.

- Aircraft Composite Development- Instituto Tecnológico de Aeronáutica (ITA) advanced research with emphasis in aerospace science and technology which is supported by the Brazilian Government with the support of the Brazilian Air Force along with Polytechic School of Universidade de Sao Paulo and Technological Research Institute are conducting research in composite structures in aircraft structures. The research on the development of design procedures for reinforced composite panel for aircraft structures with the goal of 10% to 15% reduction in weight and cost compared to conventional materials. The project for the new technologies will include processes and methods for manufacturing. The manufacturing processes will include resin infusion, automatic lamination, thermoplastics and ultrasound inspection

Boeing and Embraer have signed a cooperation agreement that will focus on commercial aircraft improvements to safety and efficiency, research and technology and sustainable aviation biofuels. This agreement came at the same time the Governments of Brazil and United States signed a memorandum of understanding (MOU) on the Aviation Partnership. This MOU agreement is intended to promote private sector initiatives that will include air transport safety/security, aircraft bio fuel development and aeronautical industry. Boeing has signed a letter of intent with Brazil's FAPEESP the Sao Paulo

Research Foundation for matching financial support on Aviation Biofuels Gap Analysis Study.

Embraer's three-pronged industrial strategy (non Maintenance Aircraft Services) to expand its global footprint with licensing assembly of their aircraft through joint ventures, foreign direct investments and strategic alliances with aerospace companies.

In June 2012, Brazil and China signed trade agreements that will allow Embraer to receive the approval from the Chinese government to enter into an agreement to assemble its Legacy 600/650 business jets which is based on the Embraer ERJ-145 regional jet in its joint venture facility. The Harbin Embraer Aircraft Industry Co. Ltd. is a joint venture company which is 51% owned by Embraer and 49% by Harbin Aircraft Industry Co Ltd a subsidiary of Aviation Industry Corporation of China (AVIC) a state-owned enterprise. The joint venture was started in 2003 to assemble the Embraer's 50-seat ERJ 145 regional jet which is no longer in production. After ceasing production of the ERJ 145, Embraer wanted to start assembling their Embraer E Series 190 commercial aircraft (seats 90-110) but the Chinese government did not allow the production of this aircraft because it would be in direct competition of their indigenous ARJ 21 regional aircraft.

The US Federal Aviation Administration (FAA) awarded Embraer with a production certificate to assemble their Phenom 100 executive jet at its wholly owned Melbourne Florida facility. In 2008, Embraer's strategy was to open their first US industrial site to better service their North American executive business jet customers. Embraer invested $50 million in the construction of their new 150,000 square foot facility for the assembly of the Phenom 100 and Phenom 300 executive jets (seats-4-8). Embraer's Melbourne facility has an assembly operation, paint shop and flight test delivery center. Embraer's $50 million investment will be partially funded by the $12.5 million assistance package, including $8.5 million from Florida's state programs. The planned production rate of 8 Phenom aircraft a month will include the mating of wings to the fuselage, installation of the engines, avionics and interior. The aircraft's metal fuselages and wings are produced in Embraer's facility in Botucatu, São Paulo, Brazil and then are shipped by sea to the Melbourne, Florida facility.

Embraer announced that they will establish an engineering and technology center in Melbourne Florida for product and technology development for all their business lines. Embraer plans to partnerships with US universities to develop aeronautical projects that are mutually beneficial.

Boeing and Embraer agreed to cooperate on developing the Embraer's military transport KC 390 which is a direct competior to Lockheed Martins' Hercules C130 (not Boeing's C-17 large military transport). Initially the two companeis will jointly explore the global market for a midsize military transport aircraft. One could envision Boeing's military global service and support business unit could provide after sales support for the customers of Embraer's KC 390s.

Embraer have been making foreign direct investments (FDI) in Portugal and United States. Embraer's FDI strategy is based on expanding its components and assembling manufacturing as part of a global strategy to compete in many international markets.

In Portugal, Embraer has three industrial operations that produce metal and composite aero structures for their commercial aircraft, executive jets and military aircraft. In 2005, Embraer acquired a 65% controlling stake in Portuguese aircraft maintenance company OGMA located in Alverca and remaining 35% is owned by, Portugal's state defense company Empresa Portuguesa de Defesa Empordef. Embraer's FDI strategy in OGMA was to strengthen the strategic partnership between Brazil and the European Union.

In 2008, Embraer invested $215 million to build two plants in Évora, Portugal for manufacturing components for the Legacy business jet. These two plants will become operational in 2012 and will eventually employee 600 workers, one for metal wing structure and another for tail assembly made from composite materials. In 2011, Embraer signed a partnership contract with EEA Empresa de Engenharia Aeronatuica to develop the engineering of KC 390 military transport for Aero Structures which then will be produced by Embraer's subsidiary OGMA.

Embraer received defense sales from India for three Embraer 145 Airborne Early Warning and Control Platforms worth $250 million. Embraer will act as the overall system integrator, supplying the jets, mounting the radar and electronics into the AWACS fuselage and flight recertification. Based on India's defense offset regulations, Embraer would need to meet offset obligation of 30% of the contract value or $75 million. In May 2012, Embraer stated in media that they are in talks with "some partners" to supply its commercial aircraft. Embraer statement was not clear about if it was discussing sales or co production of their aircraft, but it seems a logical extension to satisfy Embraer's defense offset obligations to start a civil aviation program in India.

In the future, Embraer's continued participation in India's defense and space industries could allow them access to technology to further develop their own satellite programs. In November 2011, Embraer and Telecomunicacoes Brasileiras S.A. (Telebras) a state-owned enterprise signed a memorandum of understanding to form a new company (Embraer 51% and Telebras 49%). This venture will work on Brazil's government plans for satellite development which includes strategic defense and governmental communications.

III. Russia

The Russian Ministry of Industry and Trade develops both on the strategic and operational plans for the civil aviation industry. In its strategic planning the Russian Ministry of Industry and Trade develops a SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) for the aviation industry. It assesses the internal and external situations for aircraft equipment and technology; competitiveness assessment of the Russian aviation programs and analysis of the industry potential in design and production.

The Russian government created and funded the program "Development of Civil Aviation Technology of Russia in 2002-2010 and up to the year 2015" which focuses on the civil aircraft industry. The total amount of investments for this program is 137 billion rubles ($4.17 billion), which includes research and development for 97 billion rubles, ($2.95 billion) and technical re-equipping of 40 billion rubles ($1.22 billion). The goal of this program is to satisfy the demand for domestic and international civil and cargo air aircraft. The four main objectives of the program are:

- To create a system of sales and technical services for domestic and international aircraft markets.
- To develop the Russian aircraft industry into a strong player able to compete in the international markets for its aircraft products.
- To overcome the gap in technology between Russian aircraft industry and the leaders of the market and to work with international collaboration.
- To create a modern R&D infrastructure for the aircraft industry organization.

In 2007, the Russian government consolidated the civil aircraft industry under one state-owned enterprise under United Aircraft Corporation (UAC). The strategy for this move is to address priority problems that confront the Russian civil aviation. The Russian government expects changes in the commercial aircraft design and production to address the need to increase domestic sales of civil aircraft within the business units of UAC. UAC is a Russian open joint stock company with a majority stake belonging to the Russian Government (80%) with annual revenues of $4 billion and rates 6th among the major aircraft manufacturers.

The UAC is developing a strategy to overcome the problems in their civilian and cargo transport product lines. In 2010, only 7 civil aircraft were delivered (4 AN 148 and 3 TU 204 series), the UAC has two new civil programs the Sukhoi Superjet 100 (70-95 seats) which is now in serial production and Irkut MS 21 (150-230 seats) which is now under development with first flight scheduled for 2016. Both programs used western supplier and partners to supply the latest flight hardware technologies. The MS 21 was launched in 2008 and will feature an all composite wing with Pratt and Whitney engines. The main problem plaguing all Russian civil aircraft has been out of country service support for foreign airline customers. The Sukhoi Superjet 100 program is trying to address this concern by partnering internationally with the Italian-Russian SuperJet International joint venture. SuperJet International (SJI) is a joint venture between Alenia Aermacchi (51%) and Sukhoi Holding (49%), headquartered in Venice, Italy and will be responsible to sell and provide after sales support for the Sukhoi Superjet 100 operators

In 2010, there were negotiations with the Chinese aviation industry for co-production of twin-aisle long haul aircraft. UAC and the China's Commercial Aircraft Corp (COMAC) formed task groups to conduct joint research on the Russian and Chinese markets to examine the demand for this aircraft. In June 2012, the two countries agreed on setting up a joint venture to build new twin aisle long haul aircraft based on the design of the Russia's Ilyushin IL 96 (294 seats) commercial aircraft. The Russia's Deputy of Minister

and Industry Trade said "the sum is likely to be between $ 7-12 billion and given a 7-year production cycle." Russia will provide the know-how and technology while China will be responsible for the cash. In other terms, Russia will be responsible for the design while China's part will be for the production of the aircraft.

Boeing and Airbus has been developing international collaboration with Russia for the past decade. Boeing has both a technical research center and design center that works on research projects and structural design with over 1500 engineers. Since 2001, Boeing played an advising role to the Sukhoi Superjet 100 program in the areas of program management, marketing, certification and after-sales support. Airbus has engineering joint venture with Kaskol which has over 200 technical specialists that works on aircraft structure design.

The UAC plans on reengineering their corporate industrial model so it can transition from full-integrated plants with entire aircraft produced in single factory to a model that will have facilities that will develop technologies and competences. This will create and define final assembly sites, competence and specialization centers that would collaborate with international suppliers to develop a technologically advance civil aircrafts. The goal for UAC is to build a new family of civil aviation aircraft to service the domestic and international markets in range of regional jets, short-medium range single aisle aircraft and transport aircraft. (see the India section for the joint venture for the Multi Role Transport).

Space

The Russian Federal Space Agency is responsible for the planning, development and execution of the space science program with am annual budget in 2011 of $3.8 billion. The main focus for the commercial space programs is for earth science, communication, and scientific research.

The Russian space industry consists of about 100 companies and employs 250,000. The current Russian space industry companies are from the Soviet design bureaus and state production companies. Several of the Russian space companies moved into joint-ventures with foreign companies which provided western marketing expertise along with capital. The largest company in the Russian space industry is RKK Energia which is a manned space flight contractor. The other launch vehicle producers in Russia are Khrunichev and TsSKB Progress while largest satellite developer is Reshetnev Information Satellite Systems.

IV. India

The Government of India's Ministry of Aviation developed a strategy and vision for civil aviation. In the Ministry of Aviation's 12th Five-Year Plan (2012-2017) addresses new initiatives for the development of the aerospace industry. This is based on India's forecasted air traffic growth for the next twenty years and the country's large requirement

of new aircraft. In 2011, Boeing forecasted that India will take delivery of 1,320 aircraft for this period with a list value of over $130 billion. The biggest segment will be for single-aisle aircraft (e.g. Boeing 737 and Airbus A320).

The Indian government is planning to develop a indigenization program for aeronautical products. The industry should have the capability to produce small/mid-sized aircraft using in country resources. Currently there is no government master plan for developing the Indian aeronautical industry. In the 12th Five-Year Plan, the Ministry of Aviation identifies that in the past there were problems and private industry did not want to engage because of "long gestation period and perception of significant risk". They understand that most of the aircraft requirements will be single-aisle aircraft to service India's Tier II and Tier III airports. The Ministry believes the development of civil aeronautics industrial base can benefit from the outsourcing requirements from defense offset programs. In 2011, India Defense Procurement Procedure (DPP) changed the offset policy by including civil, internal security and training in the list of eligible products and service. The Government of India are using the defense offset requirements as a national priority to build their indigenous capabilities by encouraging cooperation with countries/companies willing to transfer technology and are interested in co-designing, co-development and co-production. Some forecasts project $50 billion in defense purchases from foreign suppliers in the next 10 years which relate to $15 billion in offset obligations.

India's Ministry of Aviation 12th Five-Year Plan addresses the need to develop their aeronautical infrastructure in the following areas:

- Developing and production of 20 seat turboprop.
- Developing aircraft quality material processing and quality standards
- Encouraging international joint ventures by providing allotment of land for factories
- Establish tax benefits to attract foreign manufacturers.
- Establish a National Aviation University to address the growing education and training requirements for aerospace engineers

The Government of India has many challenges for their aerospace industry to establish an indigenous family of civil aircraft. The national and regional governments need to develop strategy and policies in the following areas:

- Encourage the Public Private Partnership (PPP) through outsourcing from state-owned corporations (Public Sector Undertaking) to private companies.
- The national and regional governments will need to expand the use Special Economic Zones for aerospace activities to consolidate the dispersed under developed indigenous supply chain base.
- Implement changes to their offset policies, intellectual property laws, import tariffs and corporate tax structure to attract FDI and joint ventures from foreign aerospace companies and encourage private domestic companies to invest in India's aerospace industry which is capital intensive.

- The Government of India will have to promote higher education in aerospace fields to eliminate shortage of high skilled aerospace workers.

Hindustan Aeronautics Limited (HAL) is a state-owned company that is under the management of the Indian Ministry of Defense. HAL is the largest aerospace company in India with annual 2011 revenue of $2.6 billion and employs over 33,000. The company's product lines in aerospace mostly includes manufacturing and assembling of defense related aircraft. In the commercial export market they produce low technology airframe assemblies with Airbus's A320 forward passenger doors, Boeing's 737-300 Cargo Conversion Door and Embraer's Legacy 450/500 business jets passenger doors. HAL has not progressed up the manufacturing value chain in the last 20 years and western aerospace companies have moved to outsourcing engineering activities to Indian companies. Boeing and EADS have opted to work with the private sector companies like TATA Group and Dynamatics Technologies to meet their offset production requirements.

HAL has recently updated an agreement for the design and production of Multi Role Transport Aircraft with a 50:50 joint venture with Russia's state-owned enterprise United Aircraft Corporation (UAC). HAL will develop and manufacture components and sub assemblies of the composite structure at its Transport Aircraft Division located in Kanpur India. India's objective is to achieve self-reliance in design, development and production of aircraft (size of a 100 seat aircraft) and manage a global supply chain that supports the program. In Indian Air Force's Request for Information to potential suppliers they are requiring them to find private Indian partners. This program will have an initial government's investment of $300 million and plan test flights by 2020.

National Aerospace Laboratories (NAL) a constituent institution of the Council of Scientific and Industrial Research (CSIR) and is directed by the Ministry of Science and Technology. NAL's mission is to develop national competencies in aerospace science and technologies along with design and develop small and medium size civil aircraft. NAL has 1350 employees including 330 scientists.

The Council of Scientific & Industrial Research through the National Aerospace Laboratories will create India's National Civil Aircraft Development (NCAD) design bureau. Dr Upadhya the former director of India's National Aerospace Laboratories stated "India is only BRIC country not to have a civil aviation program and its appropriate time to launch a major initiative in capability building civil aircraft design and development". The plan is to have the prototype aircraft flying within 5 years and certified for series production in 8 years. The size and type of aircraft for use in the Indian market is currently being debated within India's aviation community. One of the concepts being considered to meet India's market demands would be 70-90 seat advance regional jet (turbofan). Early indications for the program looks like the project will move from the traditional state-owned enterprise to some form of public/private partnership. It's too early to know if the NCAD program will be based on a vertically integrated supply chain within India (e.g. China) or have decisions based on an economic rationale which will lead to developing a global risk-sharing supply chain (e.g. Embraer in Brazil).

In May 2012, an Embraer official stated in the India media that Embraer is in "talks with some partners to supply its commercial aircraft as it looks to tap the market potential". It's too early to tell if Embraer is considering component manufacturing and/or assembly of regional and/or business aircraft. Embraer partnership with India's civil aerospace stakeholders can provide a win-win situation. Embraer can get access to India's civil aircraft market while India can assist Brazil in the development of their space industry.

Space Program

The Government of India's space program is managed by the Indian Space Research Organization (ISRO). Indian Space Program is an indigenous effort to develop space-technology, system management and new applications that are relevant for India. Indian National Satellite System has been established for communication, broadcasting and meteorology. The infrastructure and expertise is developed within the indigenous high technology industries and research organizations to provide support to space missions (satellite and launch vehicles). The structural hardware of communication satellite is produced by state owned Hindustan Aeronautics.

The Government of India's space budget for 2011 was $1.26 billion making it the 6th largest program in the world with half of the budget focusing on development and operation of launch vehicles. The remaining budget is earmarked to space technology and applications, satellite operations and satellite communications.

V. China

China has already moved onto a scientific and rational track of development. China has designated construction of the jet (150 seats) as one of the 7 rising industries in the China's 12th Five Year Plan (2011-15). In 2007, the State Council approved research and development of large aircraft being officially made a major scientific and technological project. Wen Jiabao, Premier of China's State Council, once noted that manufacturing commercial jets is the state's will, a strategic move and a symbol of the country's prosperity and development. It also has direct significance related to science, technology and economic benefits**.**

China has industrial policy for developing their civil aircraft and aerospace industries. In 2003, China's State Council conducted a feasibility study for developing a mid-size indigenous passenger aircraft. In 2006, China started their 15 year "Medium to Long Term Plan for the Development of Science and Technology" (MLP) which commits to developing capabilities for "indigenous innovation" and take a leading role by the 2020. In China's MLP it listed 8 fields of technology and 16 mega-projects that China deemed necessary to become an advance technological country. The MLP listed Aerospace Technology as one of the 8 fields of technology with two engineering megaprojects with large aircraft and manned aerospace and moon exploration with the following goals:

Large aircraft

- China will institute feasibility studies for developing the key technologies required for the domestic production of large aircraft.
- Key focuses will include the design, R&D and manufacture of power systems and testing systems for large aircraft.

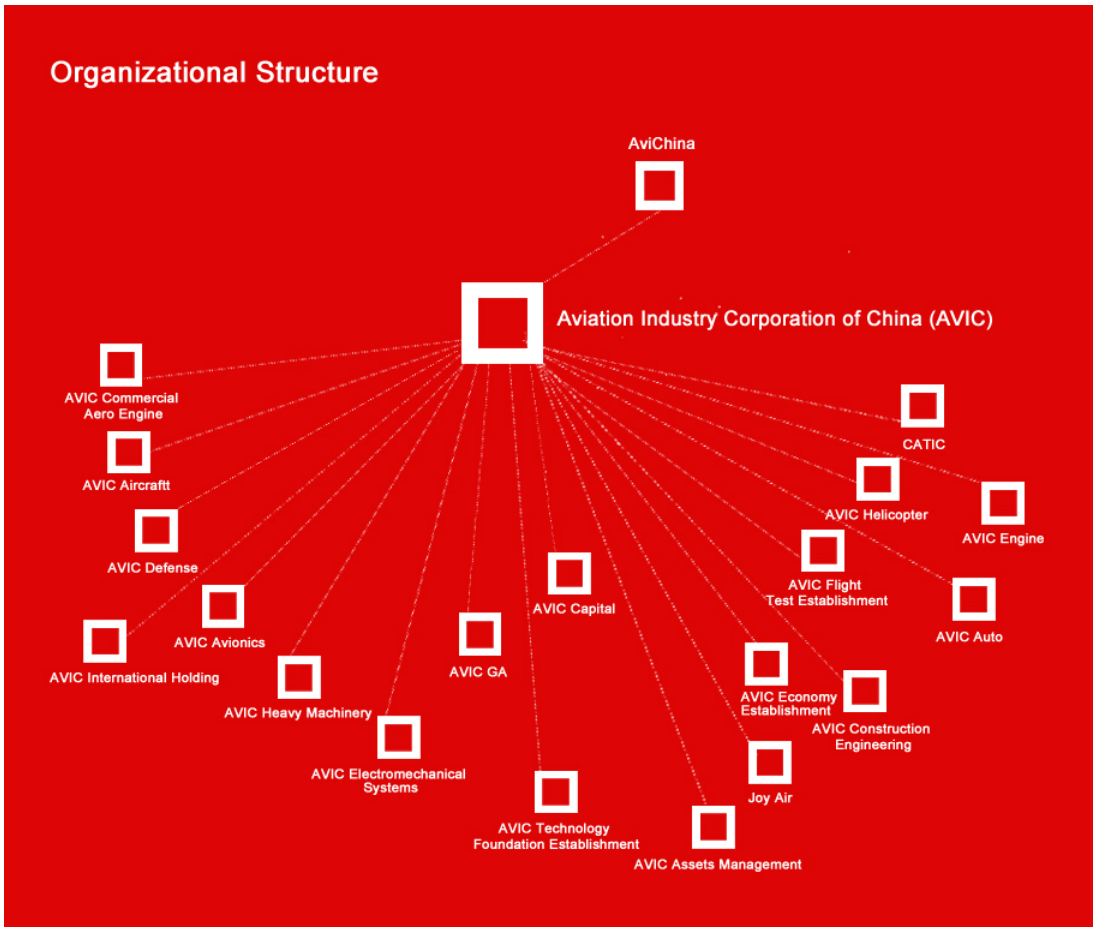
Manned spaceflight and lunar probe programs

- China seeks to make advancements in key technologies required for extravehicular activities for astronauts, and for the Rendezvous and Docking (RVD) for spacecraft.
- A central focus of this project will be to establish a man-operated, orbiting space laboratory.

In 2008, China reorganized their aerospace and defense companies by combining Aviation Industry Corporations (AVIC 1 and II) into one company AVIC with an estimated 400,000 employees and it's the parent company to Commercial Aircraft Corporation of China (COMAC). In May 2008, a new state-owned company Commercial Aircraft Corporation of China (COMAC) was created for developing, manufacturing, and commercializing China's indigenous passenger aircraft with a registered capital of 19 billion RMB (approx $3 billion). COMAC is currently overseeing the development and production of a large civil aircraft now called the C919 (seats 168-190) and was given responsibility for most of China's commercial aircraft programs, including the ARJ21 regional jet (seats 75-90). The ARJ 21 program began in 2002 and was part of China's 10th Five-Year Plan. This is the first indigenous civil aircraft program that China is designing and developing in accordance with international airworthiness regulations and is seeking airworthiness certification from both CAAC and FAA. The aircraft had several major program problems causing a 5 year delay. In July 2012, COMAC officials stated that the first deliveries to Chinese airlines will occur by the end of 2013. The C919 Aircraft currently has 235 firm orders from Chinese government-controlled airlines and 10 firm orders from western leasing company GECAS (General Electric Capital Aviation Services). (See appendix 1 and 2 for international suppliers). The C919 has a planned first flight in 2014 with deliveries starting in 2016. There are indications from industry analysts that a schedule slip of one or two years is possible.

AVIC Organizational Structure

AVIC is a state-owned aviation company that controls the China's aviation vertically integrated supply chain with owning over 200 subsidiaries and has total assets of 500 billion RMB (approx. $78 billion). In 2009, AVIC annual revenues were 191 billion RMB (approx. $30 billion) with annual growth rate of 14%. In 2009, AVIC signed agreements with 15 domestic state-owned banks for credit availability of 482 billion RMB (approx. $74 billion).



The China's State owned Assets Supervision and Administration Commission (SASAC) of the State Council is a commission of the People Republic of China directly under the State Council. SASAC responsibly is to manage China's state-owned enterprise which includes approving mergers and sale of assets. In China's listing of 120 central state-owned enterprises, 3 of the first 5 listed companies are involved in the aerospace/aviation industry, while another 4 aviation companies are included in the complete list. Some analysts believe that centrally controlled state-owned civil aviation enterprises are becoming stronger as they are following China's *guojin mintui* policy "the state advances as the private sector retreats" to foster national champions in this strategic industry. There is a clear strategy by the Chinese government for the development of their civil aircraft industry. Based on a China Daily article:

> "Much of COMAC's ambitions also stem from the government's plan to transform China as an aviation major capable of making jumbo jets, regional planes, business jets, propeller planes and helicopters all at home. That in turn is expected to have a positive impact on a host of allied industries related to the aviation industry."

The China syndrome

The term 'China syndrome' was originally coined to metaphorically dramatize the consequences of a reactor meltdown from a US nuclear power plant, where radioactive material would drill through the center of the earth and end up in China (albeit defeating the laws of physics on the way 'down' or 'up'). We use the term as a simile for techno-market meltdown, in that the North American and Europe aerospace suppliers have cooperative agreements on COMAC's ARJ 21 regional jet C 919 aircraft programs. (see appendix 1 and 2)

One of the roles for China's civil aviation state-owned enterprises is to trade market access for technology. The decades of industrial offset agreements between Western aerospace companies and Chinese subcontractors have endowed China with the technological fundamentals required to build commercial passenger aircraft. These offset agreements were designed to secure sales of Western built aircraft to China, and often involved critical streams of knowledge-transfer from prime contractors to Chinese suppliers via technology transfer and joint development.

China has a long-term commitment to the development of a family of aircraft that will meet Western certification standards, allowing the Chinese to spread and consolidate their global footprint in this sector. With the vision of becoming more competitive as a low cost producer with high quality and better productivity, the Chinese commercial aircraft industry has decided to take advantage of its "centers of competence" from decades of industrial cooperation with the main global airframers. These strategic alliances and joint ventures will allow the Chinese to develop leaner cost structures than their Western competitors. The Chinese are interested in learning to better manage, coordinate, and synchronize within and across such areas as customer relations (e.g. marketing, sales, service), product development (e.g. innovation, engineering, testing, development, deployment), and supply chain management (e.g. planning, sourcing, manufacturing, distribution). Developing these assets is the key to China's future competitiveness and long-term economic viability in the aerospace sector.

It is often argued in the business press that China is decades away from developing large commercial aircraft, and that China lacks the technological capability to enter this market in the near future. You should examine this perspective in light of the sheer volume of investment capital that China's government can allocate to its infant aircraft industry. Some Western aviation executives are estimating a $30 billion investment by China into their new C919 commercial aircraft program.

China will be one of the largest markets for commercial passenger aircraft in the next 20 years. Boeing and Airbus are both forecasting that China will take delivery of 3,800 aircraft for this period with a list value of over $400 billion. China is now building 42 new airports to accommodate this growth in air traffic. China currently accounts for 22% of Airbus' and 15% of Boeing's backlog of firm orders. Western aircraft analysts have predicted the market share split of 50/50 between Boeing and Airbus for single-aisle and twin-aisle aircraft would continue indefinitely. They gave no real consideration or merit

to the Chinese on developing their own family of aircraft which would lower their outward investment in Western aircraft.

Many Western airframers and system integrators have an industrial cooperation or joint ventures so they can gain or maintain their Chinese market share. Below is a list of major airframe programs:

Airbus	Final Assembly of A320 in Tianjin, China
Embraer	Final Assembly of the Legacy Business in Harbin, China
Bombardier	Subcontract to Shenyang Aircraft for C Series fuselage
Bombardier	Q-400 turboprops fuselage sections

The Chinese aviation industry has been very transparent about their desire of receiving western certification for the ARJ21 regional jet and the C919 single-aisle aircraft so they can export to emerging and western markets. China has actively sought joint ventures with Western aerospace companies for the co-development of the critical technologies and systems. The COMAC C919 program has Chinese state-owned enterprises partnering with Western an aerospace company that includes Parker Aerospace, General Electric, Honeywell and Goodrich that involve technology transfer and/or joint development. One of the main concerns for Chinese national policy in civil aviation is to keep western build content low so they can keep the price of their aircraft below its mature western competitors and keep focused on the long-term plan of the Chinese government's indigenous innovation policy.

Manned Space Exploration and Commercial Satellite Launches

China's National Space Administration developed a white paper in 2003 that it's short and long term goals. While some of longer-term endeavors for building a manned space station and sending manned missions to the Moon are not being seriously consider by some western analysts, the Chinese just completed a 13 day mission that achieved docking a manned spacecraft to another craft in orbit. This does demonstrate China's space capability by making China the only third country after the United States and Russia to accomplish manned dockings. The short-term goals should be more concern to the West with China's plans to build an independent satellite telecommunication network and possibly offering commercial satellite launch services that would compete with Western aerospace companies.

VI. Summary and Conclusions

The Canadian aerospace industry has been a leader in its contribution to its country's innovation and technology prowess. In recent years Bombardier has moved into a system integrator with C Series aircraft while using China state-owned enterprises as foreign risk-sharing partners for a conduit to court their government's funding. One has to question the long term implications to Bombardier on the exchanging of their western commercial aircraft engineering know-how, manufacturing processes and western certification knowledge to the China's aviation industry for funding aid by the Chinese government. It's been reported that $400 million in Chinese government money is believed to be invested in the Chinese state-owned companies for the C Series program.

But the financial advantages need to be balanced against the broader economic and strategic concerns, including the possible erosion of the Canadian supplier base and the fact that rising levels of foreign content ultimately contravene the interests of Canadian workers in skilled occupations.

The countries of Russia, India and China are backed by major public subsidies and layers of state-sponsored technological support which the Canadian aerospace companies do not have available. The policy-makers need to focus on the threats that BRIC country's aerospace indigenous innovation policies have pose to Canada's knowledge-based economy. The results of these policies are the accumulation of technological and financial wherewithal so they can be successful in the global aerospace industry. These countries have extensive and flexible industry-university-government combinations that can foster cross border collaborations. These collaborations include the recent announcements of Russia and China designing and producing a large long haul commercial aircraft, Russia's and India's joint venturing a Multi Role Transport that can be configured to 88 passenger aircraft and Brazil's and China's agreement on the assembly of business jets should have Canadian aerospace stakeholders concerned on how they will be able to compete in the future.

The BRIC countries have the long-term economic growth that will allow them to emerge as a financial and indigenous innovative powerhouse. The concern for the Canadian aerospace industry is how to collaborate with the BRIC aviation industries in the short-term while not find themselves pushed to the side in the long-term. The Canadian policy-makers are at crossroads to engage in developing aerospace strategies for the Canadian aerospace industry so they can keep their competitive advantage or continue the current path of having domestic aerospace companies compete on individual basis against the BRIC government supported aerospace industries.

Appendix 1

China's COMAC ARJ21 International Suppler List

U.S. Suppliers

Alcoa, Inc.	Advanced alloys for airframes and fasteners
B/E Aerospace, Inc.	Oxygen equipment
Eaton Corporation	Flight-deck instrument panel and control panel
General Electric	Propulsion (engines, nacelles, and accessories)
Goodrich Hella Aerospace	Lighting equipment
Hamilton Sundstrand	Auxiliary power unit (APU)
Honeywell International	Flight control system integration
Kidde Aerospace	Fire protection
Parker Aerospace	Fuel, hydraulic, and electrical flight controls
Rockwell Collins	Integrated avionics system, weather mapping radar
Rosemount, Inc.	Windshield wiper and heater
Zodiac Air Cruisers Company	Emergency evacuation system

Non-U.S. Suppliers

Antonov ASTC (Ukraine)	Wing design, structural strength analysis
CAE Inc. (Canada)	Full flight simulator
Fisher Advanced Composite Components (Austria)	Cockpit, cabin interior, kitchens, restrooms
Liebherr Aerospace (France)	Air management system
Lindenberg (Germany)	Landing-gear braking system
Meggitt Vibro-Meter SA (Switzerland)	Engine interface control unit
Safran Sagem (France)	Flight-deck control suite
Saint-Gobain Sully (France)	Windshields and opening windows
Zodiac Evac	Vacuum Systems
Zodiac Sicma Aero (France)	Crew seating

Appendix 2

China's COMAC C919 International Supplier List

U.S. Suppliers

Crane Aerospace	Brake Control, Tire Pressure Indication and Brake Temperature Monitoring System
Cytec Industries Inc.	High-performance composite and adhesive materials
Eaton Corporation	Pipelines for fuel and hydraulic systems, Instrumentation lightning
General Electric	LEAP -1c Turbofan engines (CFM International), Engine nacelle, thrust reversers (Nexcelle); avionics system core processing and display; onboard maintenance and flight data recording
Goodrich Corporation	Exterior lighting; landing gear and engine nacelle components
Hamilton Sundstrand	Electric power generation and distribution; cockpit pilot controls.
Honeywell International	Flight control system; APU ; wheels and tires, braking system; inertial reference and air data systems
Kidde Aerospace	Fire and overheat protection systems
Michelin Aircraft Tire Corp	Air X radial tire
Monogram Systems	Water and waste systems
Moog Inc.	High lift system will include all flap and slat actuation
Parker Aerospace	Fuel tanks and systems, Fuel inerting systems Primary flight-control actuation, Fuel and hydraulic systems
Rockwell Collins	Communication and navigation systems; integrated surveillance system; cabin core system

Non-U.S. Suppliers

Avio SPA (Italy)	Engine parts for LEAP engine
Cobham plc (UK)	Cabin address system
Evonik Roehm (Germany)	Rigid foam core material - composite rear pressure bulkhead
Firan Technology Group (Canada)	Cockpit control panel assemblies
Fisher Advanced Composite Components (Austria)	Cockpit, cabin interior, kitchens, restrooms
Liebherr Aerospace (France)	Air management system and ice protection equipment
Liebherr Aerospace (Germany)	Landing gear system
Safran	Joint venture for wiring systems
VSMPO-AVISMA Corp. (Russia)	Titanium forgings for the wing