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Report

Canada's Aerospace Industry
The Impact of Key Global Trends

Presented to:

Aerospace Review

by

The Conference Board of Canada
July 2012

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EXECUTIVE SUMMARY

Aerospace is a key sector of Canada's economy. The sector's share of global aerospace activity is greater than the country's share of global gross domestic product. In fact, Canada ranks fifth overall in industry size as measured by revenue, while the country has the fourteenth largest economy as measured by GDP. This means that relative to the size of its economy, Canada's aerospace sector ranks second in the world. By almost any measure, Canada punches above its weight in aerospace relative to most other advanced economies.

Although Canada's aerospace sector has had a long-run of success, its continued growth is not assured. There are a number of profound shifts taking place in the industry and across the globe that will challenge Canada's status as a global leader in aerospace. Seizing the opportunities and meeting the challenges that will come from these changes requires a sound understanding of long-term trends. Accordingly, the goal of this report is to identify the key long-term trends that will affect the aerospace sector going forward. The six trends that this report identifies are:

1) The emergence of new economic powers, notably China, but also India, Brazil, and others;
2) A shift in the way that aircraft are conceived, produced, and supported;
3) New security and national sovereignty concerns, including the protection of maritime borders and territorial waters;
4) Growing concerns about carbon emissions and other environmental impacts;
5) Expanding natural resource extraction activity and pressure to intensify agricultural yields;
6) The rapid expansion of global telecommunications and connectivity.

The shift in economic power from advanced economies to emerging ones is ongoing and independent from the aerospace sector. However, the emergence of new global powers presents both challenges and opportunities for Canadian producers. The challenges will come in the form of new competitors. In particular, China is targeting the regional jet and single-aisle aircraft markets through state-owned COMAC. The regional jet market remains a key market for Bombardier Inc., Canada's biggest aerospace company. Bombardier also has its eyes on the single-aisle market with its CSeries aircraft, which is currently under development.

These emerging economies also represent a huge opportunity for Canada's aerospace sector as these markets are expected to post the strongest growth in air travel going forward. This is expected to significantly boost the demand for aerospace products and services. Given this long-term trend, it will be imperative for Canadian aerospace companies to pursue growth outside of North America. But the fact that China is fostering its own indigenous aircraft manufacturer also raises the question of how open the Chinese market will be to foreign competition. Gaining access to these growth markets may require joint ventures with domestic producers.

The second trend, which parallels the rise of the emerging economies, is the accelerating pace of globalization. More and more companies are seeking out the best places in the world to do business as national borders become increasingly irrelevant for economic activity. The Conference Board has

referred to the phenomenon of firms taking apart their supply chains and repositioning them around the world to maximize returns as "integrative trade."

The aerospace sector is increasingly being reshaped by the process of integrative trade. Aerospace original equipment manufacturers (OEMs) continue to reposition their supply chains across the globe, buying parts and systems from suppliers throughout the world, with the primary objective of minimizing costs and gaining market access. A consequence for parts suppliers is that proximity to OEM's assembly plants is becoming less of an advantage.

This trend has important implications for the Canadian aerospace industry. In particular, the integrative trade phenomenon has led to closer integration of OEMs and Tier 1 suppliers. OEMs are choosing Tier 1 suppliers that are able to bear a significant share of the development costs and program risk. This puts Canada at a competitive disadvantage because Canada has very few Tier 1 suppliers that are capable of funding large projects. OEMs are also looking to share responsibility for research and development and design for new aircraft platforms. This also puts the Canadian industry at a disadvantage because it has historically lagged its counterparts in other countries in terms of R&D intensity.

New security and national sovereignty concerns encompass another trend that will impact Canada's aerospace industry over the long term. The process of globalization, with all its attendant benefits, also has important security implications, especially in the form of transnational threats. In light of these new security challenges, many governments have placed greater emphasis on defence and adjusted the mix of military equipment they employ.

Governments will increasingly turn to modern aerospace equipment to monitor and mitigate these emerging threats. For example, satellites are increasingly depended on for the surveillance of national borders and the support of military operations, and unmanned aerial vehicles (UAVs) are being used more and more to penetrate enemy territory while minimizing casualties. As a result, the military aerospace industry will need to adapt its product lines to meet these evolving needs. The growing use of satellites could be a boon for Canada's space sector, since it has carved a niche in this area.

An emerging security and sovereignty concern for Canada is the opening of the Arctic. One of the consequences of global warming is the potential of an ice-free Northwest Passage, which will increase the number of ships that operate in the Arctic and could also lead to an increase in illegal activity. The mandate to defend Canadian sovereignty in the Arctic has been identified as one of the primary missions of the Canadian Forces in the 21st Century. Defending Canada's sovereignty in the Arctic will require the capability to operate search and rescue missions and conduct airborne surveillance of the waterways and surrounding regions. Surveillance in the Arctic region will also require, among other things, the increasing use of UAVs and satellites.

More broadly, the issue of climate change—specifically the effects of global warming due to increasing atmospheric concentrations of human-made emissions of greenhouse gases (GHG)—is potentially one of the most profound challenges of our time. Given that the broad transportation sector is a major source of greenhouse gas emissions, efforts to reduce emissions will have significant implications for aerospace.

The aerospace industry will be under intensifying pressure to improve efficiency and limit or reduce its carbon footprint. The aerospace industry will respond to the threat of climate change in several ways, including increasing use of composite materials to reduce aircraft weight, implementing more efficient engines, using biofuels to reduce oil consumption, and moving to turboprops on short-haul flights and larger planes on longer routes.

The fifth long-term trend identified in this report is the expansion of natural resource extraction and the pressure to intensify agricultural yields. The demand for food is expected to grow briskly in the coming years, driven by rising population and income growth. The World Bank has estimated that global cereal production will have to increase by nearly 50 per cent and meat production by 85 per cent from 2000 to 2030 to meet this growing demand. At the same time, the International Energy Agency (IEA) has predicted that global energy use will rise 40 per cent between 2009 and 2035. Both trends bode well for Canada, given that it is rich in natural resources and arable land.

The aerospace and defence industry can play a key role in meeting the growing demand for resources and food. Satellites, UAVs, and other aircraft will be increasingly used to search for natural resource deposits across the entire globe. Satellites will also have a role to play in improving crop yields, particularly through the growing adoption of precision farming. Again this trend is positive for the Canadian space sector, given its expertise in satellite production and services.

The final long-term trend identified in this report is the rapid expansion of global telecommunications and the widespread adoption of the internet. Thanks to the rapid growth of wireless mobile broadband, the era of a ubiquitous internet is fast approaching. In fact, the smartphone could be the fastest spreading technology in human history. Their widespread adoption, along with other mobile devices, will drive vigorous demand for mobile data services, which, in turn, will drive demand for satellite products and services. This is more good news for Canada's space sector.

Profound shifts are taking place in the aerospace industry and across the globe. The six long-term trends outlined in this report will significantly affect the aerospace industry for years to come. Canada's aerospace sector has had a long-run of success. A sound understanding of these long-term trends and their consequences will allow this success to continue, by allowing the sector to meet the challenges and seize the opportunities that are sure to come.

1 INTRODUCTION

Aerospace is a key sector of Canada's economy. The sector's share of global aerospace activity is greater than the country's share of global gross domestic product. In fact, Canada ranks fifth overall in terms of aerospace revenues, while the country has the fourteenth largest economy as measured by GDP.[1] This means that relative to the size of its economy, Canada's aerospace sector ranks second in the world, behind only France. By almost any measure, Canada punches above its weight in aerospace relative to other advanced economies.

Although aerospace companies are scattered across Canada, by far the largest concentration of aerospace activity in the country occurs in Montreal. In fact, Montreal is considered to be one of the three world class aerospace centres in the world, along with Toulouse (France) and Seattle (United States). Montreal is also one of the few places in the world where an entire aircraft can be assembled using parts sourced from within a 30 mile radius.[2]

The Canadian aerospace industry is dominated by a small group of large companies, and the largest—Bombardier Inc.—is one of nine companies that control over 95 per cent of global civilian aerospace revenue.[3] (See Table 1 for more information on the structure of the Canadian aerospace industry). Unlike its global counterparts, Canada's aerospace industry largely operates within the civilian sector; military related activity accounted for less than 17 per cent of total revenues in 2009.[4] It is also largely export-based. Close to 80 per cent of total aerospace revenues are generated from sales to foreign markets.[5] Canada's largest foreign market for aerospace products is by far the United States—over half of our exports go there.

But Canada's continued success in the aerospace industry is not assured. It will be an enormous challenge for Canada and its aerospace industry to maintain its status as one of the most important in the world because of profound shifts taking place in the industry and across the globe. These changes present both opportunities and challenges for Canadian aerospace companies. Seizing these opportunities and meeting these challenges requires a sound understanding of long-term trends. Accordingly, the goal of this report is to examine the implications of key long-term trends on the aerospace sector. The six key trends that this report discusses are:

1) The emergence of new economic powers, notably China, but also India, Brazil, and others;
2) A shift in the way that aircraft are conceived, produced, and supported;
3) New security and national sovereignty concerns, including the protection of maritime borders and territorial waters;
4) Growing concerns about carbon emissions and other environmental impacts;
5) Expanding natural resource extraction activity and pressure to intensify agricultural yields;

[1] AeroStrategy, *Aerospace Globalization 2.0*, 2.
[2] Deloitte, *Global Aerospace Market*, 63.
[3] Ibid, 14.
[4] Deloitte, *Profile of the Canadian Aerospace Industry*, 5.
[5] Ibid, 18.

6) The rapid expansion of global telecommunications and connectivity.

This report will describe these trends and outline their implications for the global aerospace industry in general and for the Canadian aerospace industry in particular. This report is organized as follows: each of these six trends will be a focus of a chapter, while the eighth chapter will provide some concluding remarks.

Table 1

Structure of the Canadian Aerospace Industry

Tier Position	*Definition*	*Key Areas*	*Main Players*
OEM	Original equipment manufacturers (OEM) are companies that have complete control of design, selection of suppliers, detailed development and manufacturing of critical equipment, assembly and servicing and solutions.	Regional aircraft, helicopters and simulators.	Bombardier, Bell Helicopter, Diamond, Viking, CAE.
Tier 1	These companies have full responsibility for the equipment to be provided to the OEM, with full engineering and design authority and assumption of some financial risk.	Propulsion, landing gear, environmental control systems, avionics.	Pratt & Whitney Canada, Thales, Honeywell, Goodrich, Héroux- Devtek, CMC Esterline, Messier-Dowty.
Tier 2	These companies assemble aircraft structures but have no design authority.	Aero structures, landing gear components, transmissions.	
Tier 3	These companies are parts suppliers to equipment manufacturer or OEM.	Specialty product, components.	

Source: Aerospace Review.

2 THE EMERGENCE OF NEW GLOBAL POWERS

The shift in economic power away from developed economies towards emerging markets is one of the biggest trends of the 21st century. The economic transformation taking place in China has been particularly remarkable. But other emerging economies, such as India and Brazil, are also enjoying impressive and sustained economic growth.

The emergence of these new global powers presents both challenges and opportunities for Canada's aerospace sector. They represent a challenge in the sense that most of these emerging economies are serious about developing indigenous aerospace sectors. Civilian aerospace is still currently concentrated in the developed world—Europe and North America—but that is likely to change. Most governments view the aerospace sector as one that is worth developing, especially given its strategic importance. Therefore, many governments in emerging economies are actively fostering growth in this sector. Indeed, Brazil is already a major global player, thanks to the success of Embraer. Both China and Russia hope to follow in Brazil's footsteps by turning the Commercial Aircraft Corporation of China (COMAC) and Sukhoi, respectively, into global players. Embraer is a direct competitor to Canada's Bombardier, while both COMAC and Sukhoi, based on their current aircraft development plans, seek to become direct competitors. COMAC also has aspirations to challenge the Boeing-Airbus duopoly in the large civil aircraft segment.

But these emerging economies also represent a huge opportunity for Canada's aerospace sector, as these markets are expected to post the strongest growth in air travel going forward. This is expected to significantly boost the demand for aerospace products, particularly large commercial aircraft, business jets, and helicopters. In other words, growth in these emerging economies presents an opportunity for Canadian aerospace companies to sell more planes, helicopters and satellites.

It will also give Canadian companies an opportunity to expand their supply chains to the developing world and also to become part of growing global supply chains, both of which will improve their competitiveness. (See Chapter 3). Increasingly OEMs and Tier 1 suppliers will be able to source systems and components from around the world. For maintenance, repair and overhaul (MRO) firms, it represents the chance to service more planes. For other aerospace services companies, it represents the chance to sell in-services support to clients from around the world.

2.1 Global Economic Outlook

Air travel growth, which is typically measured in revenue passenger-kilometres (RPK), is highly correlated with gross domestic product (GDP) growth. In fact, RPK growth has historically outpaced GDP growth, by approximately 1.5 to 2 per cent per year.[6] This means that other factors, such as the relative cost of competing transportation modes, also determine air travel growth. As well, as people become wealthier they are better able to afford discretionary expenditures, such as air travel.

[6] Boeing, *Current Market Outlook*, 8.

Accordingly, a good way to project air travel growth is to examine the economic outlook of key countries to see where GDP growth will be the strongest. The areas with the strongest GDP growth will likely have the strongest RPK growth and, in turn, will see the highest growth in demand for aerospace products and parts. Analyzing the GDP growth outlook of key countries will also highlight the global shift in economic power that is taking place.

Table 2 displays a long-term forecast of GDP for the G20 economies plus Nigeria and Vietnam. This forecast was conducted by PricewaterhouseCoopers (PwC) in January 2011. This group of 22 countries includes ten advanced economies: the G7 economies (United States, Japan, Germany, United Kingdom, France, Italy and Canada) plus Spain, Australia and South Korea. It also includes 12 emerging economies: the seven largest emerging economies (China, India, Brazil, Russia, Indonesia, Mexico, and Turkey) plus South Africa, Argentina, Saudi Arabia, Nigeria, and Vietnam. The seven largest emerging economies are sometimes referred to as the E7.

The GDP data are measured in purchasing power parity (PPP) terms instead of market exchange rates. Using PPP to deflate GDP results in a better indicator of average living standards because using the PPP measure means the data are adjusted for price level differences across countries. In general, price levels are significantly lower in emerging countries, so using GDP at PPPs narrows the income gap with the advanced economies compared to using market exchange rates.

PwC predicts that the E7 economies will be larger than the G7 economies by 2020, and China's economy will surpass the U.S. economy by this date too. The forecast also predicts that India's economy, on a PPP basis, will overtake the American economy by 2050. In fact, by 2050, the E7 economies are expected to be nearly twice as large as the G7 economies. This would be quite an achievement given that, as of 2010, they were nearly 25 per cent smaller.

The speed at which the emerging economies are expected to overtake the advanced economies in GDP-level terms speaks to how much faster economic growth is expected to be in the emerging economies. The last column in Table 2 shows the average annual compound growth rate of GDP from 2011 to 2050. Average annual GDP growth is projected to be 2.1 per cent in the G7, much lower than the 4.6 per cent anticipated in the E7. India is expected to boast the fastest economic growth among the E7 at 6 per cent per year. Growth is expected to be even stronger in other emerging economies not counted among the E7. For instance, annual GDP growth in Vietnam and Nigeria is forecast to average 6.9 per cent and 6.5 per cent, respectively, from 2011 to 2050. In contrast, Australia is expected to post the strongest growth among the developed economies at just 2.6 per cent per year.

Table 2

Economic Outlook
(Gross Domestic Product at Purchasing Power Parity, 2009 $ billions)

	2010	*2015*	*2020*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*	*2010-2050 AAGR*
United States	14,655	16,785	18,750	21,011	23,767	26,931	30,475	34,151	38,061	2.4
China	9,786	14,700	20,010	25,501	30,538	36,032	42,613	50,132	57,785	4.5
India	4,067	5,937	8,006	10,721	14,400	19,321	25,496	32,791	41,374	6.0
Japan	4,263	4,646	5,095	5,535	5,956	6,296	6,664	7,110	7,641	1.5
Russia	2,822	3,484	4,051	4,636	5,249	5,865	6,448	6,949	7,422	2.4
Brazil	2,168	2,693	3,269	3,950	4,792	5,814	6,979	8,282	9,772	3.8
United Kingdom	2,293	2,583	2,887	3,208	3,556	3,975	4,475	5,031	5,617	2.3
Germany	3,059	3,322	3,604	3,834	4,052	4,373	4,776	5,200	5,629	1.5
France	2,205	2,422	2,725	3,046	3,393	3,778	4,229	4,749	5,339	2.2
Italy	1,943	2,090	2,332	2,558	2,738	2,924	3,155	3,451	3,806	1.7
Spain	1,485	1,611	1,824	2,036	2,244	2,445	2,639	2,876	3,199	1.9
Canada	1,324	1,517	1,706	1,893	2,107	2,364	2,655	2,984	3,348	2.3
Australia	886	1,043	1,188	1,339	1,509	1,704	1,936	2,195	2,480	2.6
Korea	1,403	1,718	1,982	2,210	2,423	2,621	2,833	3,041	3,262	2.1
Mexico	1,606	1,951	2,391	2,919	3,522	4,184	4,918	5,744	6,638	3.6
Indonesia	1,025	1,334	1,691	2,112	2,624	3,261	3,970	4,802	5,788	4.4
Turkey	1,103	1,384	1,715	2,109	2,589	3,146	3,776	4,487	5,303	4.0
Saudi Arabia	616	766	960	1,206	1,501	1,838	2,216	2,639	3,085	4.1
Argentina	625	740	898	1,090	1,322	1,589	1,875	2,195	2,547	3.6
South Africa	524	607	712	860	1,060	1,306	1,595	1,929	2,308	3.8
Vietnam	276	386	565	841	1,244	1,755	2,364	3,085	3,910	6.9
Nigeria	355	478	636	894	1,297	1,837	2,528	3,399	4,478	6.5
G7	29,741	33,365	37,100	41,085	45,568	50,641	56,429	62,675	69,441	2.1
E7	22,576	31,483	41,133	51,949	63,715	77,623	94,199	113,187	134,081	4.6

Sources: World Bank, PwC.

2.2 Aerospace Outlook

The strong economic growth in many emerging economies will lead to vigorous growth in RPK and thus, will spark significant increases in aircraft orders. Other factors will also boost air travel demand in the emerging economies, including rising living standards, rapid urbanization, and deregulation in the airline industry.

Most major aircraft manufacturers, including Boeing, Airbus and Bombardier, project long-term aircraft deliveries. For instance, Boeing's most recent long-range forecast, which they view as conservative, anticipates that growth in global passenger traffic will average 5.1 per cent per year from 2011 to 2030, while growth in cargo traffic will average 5.6 per cent per year over the same time frame. [7] This will result in the delivery of 33,500 new airplanes over the next 20 years, nearly doubling the worldwide fleet from some 19,400 airplanes today to more than 39,500 airplanes in 2030. More than half of these deliveries are expected to occur in emerging markets.

However, demand in emerging economies could be held back by supply-side constraints. Growth in airline infrastructure has lagged demand for air transport services.[8] Demand in China, for instance, will be curtailed by a shortage of general aviation airports and qualified pilots.[9] Indeed, China had only 71 airports for general aviation and 160 airports for scheduled flight at the end of 2008, compared with more than 18,000 general aviation airports in the United States.[10]

Air travel demand will also be affected by investment in high-speed rail. In fact, high-speed rail plans in China are quite extensive. [11] According to the Chinese government's Medium- to Long-Term Railroad Network Development Plan (2008), China will construct approximately 16,000 km^2 of high-speed passenger designated lines (PDL) by 2020.[12] Given that China's population is highly concentrated, it seems likely that some of these high-speed rail lines will be competitive with domestic air travel, at least on short-haul routes.

2.2.1 Commercial Airplane Outlook

Demand for commercial airplanes is driven by passenger and freight traffic. Given the anticipated strong economic growth in emerging economies, nearly 80 percent of deliveries for new airplanes will be outside of North America over the next twenty years, with about 34 percent of deliveries going to the Asia-Pacific region.[13] In fact, fleet growth in the Asia-Pacific region is expected to average 5.7 per cent per year from 2010 to 2030, according to Boeing. (See Table 3). Right behind will be Latin America, where annual average fleet growth is projected to reach 5.6 per cent. The Middle East is also expected to experience vigorous fleet growth of 4.9 per cent per year. Still, in level terms, the U.S. will remain the largest market for new aircraft sales.

[7] Boeing, 6.
[8] Boeing, 16.
[9] RAND Corporation, *Ready for Takeoff*, 10.
[10] Ibid.
[11] Ibid, 17.
[12] Ibid.
[13] Boeing.

Table 3

Commercial Airplane Fleet by Region

Region	*2010*	*2030*	*2010-2030 AAGR*
Asia Pacific	4,410	13,480	5.7
China	1,750	5,930	6.3
Northeast Asia	690	1,520	4.0
South Asia	470	1,880	7.2
Southeast Asia	1,050	3,150	5.6
Oceania	450	1,000	4.1
North America	6,610	9,330	1.7
Europe	4,380	8,010	3.1
Latin America	1,150	3,390	5.6
Middle East	1,040	2,710	4.9
Commonwealth of Independent States	1,140	1,400	1.0
Africa	680	1,210	2.9
World	19,410	39,530	3.6

Source: Boeing.

The next twenty years will also see different growth rates among different airplane types—regional, single aisle, twin aisle, and large. According to Boeing's most recent outlook, single-aisle airplanes will account for the majority of deliveries over the next twenty years—70 per cent to be exact.[14] Indeed, growth in the fleet for this segment is expected to average 4.2 per cent annually between 2010 and 2030. (See Table 4). Rapidly expanding air service in China and other emerging economies, along with the spread of low-cost carriers throughout the world will drive growth in the single-aisle fleet.[15]

The twin-aisle market is expected to post the fastest increase, with fleet growth forecast to average 4.4 per cent per year over the next twenty years. High fuel costs will compel airlines to accelerate the replacement of older, less fuel efficient airplanes with newer ones like the Boeing 787 Dreamliner and Airbus A350. [16] They will also be encouraged to buy these new planes because their longer ranges will allow them "to take advantage of the ongoing liberalization of air transport markets to open new non-

Table 4

Commercial Airplane Fleet by Type

Type	*2010*	*2030*	*2010-2030 AAGR*
Regional	2,900	2,070	-1.7
Single Aisle	12,100	27,750	4.2
Twin Aisle	3,640	8,570	4.4
Large	770	1,140	2.0
World	19,410	39,530	3.6

Source: Boeing.

[14] Ibid, 4.
[15] Ibid.

stop routes."[17]

The large aircraft fleet, which includes the Boeing 747 and Airbus A380, is expected to experience modest growth over the long term, averaging 2 per cent per year from 2010 to 2030. According to Boeing, nearly all the gain in the large aircraft fleet will come from the freighter market, as the number of large passenger airplanes is expected to remain fairly constant over the long term.[18] At the opposite end of the spectrum, Boeing expects the number of regional jets to shrink over the next twenty years. They argue that fuel and operating cost pressures will persuade airlines to go to larger seat counts in all airplane size categories.[19]

Bombardier is more sanguine about the long-term outlook of the regional jet market, although they agree with Boeing that the 20 to 59 seat segment fleet will decline over the next twenty years. (See Table 5). [20] However, Bombardier expects that the airplane fleet in the 60 to 99 seat segment will grow by 5.8 per cent per year between 2010 and 2030.

Table 5

Commercial Airplane Fleet by Seat Size

Seat Size	*2010*	*2030*	*2010-2030 AAGR*
20 to 59 seat	3,600	1,400	-4.6
60 to 99 seat	2,200	6,800	5.8
100 to 149 seat	5,200	9,200	2.9
Total	11,000	17,400	2.3

Source: Bombardier.

Bombardier is also optimistic about the 100 to 149 seat segment, which is part of the single-aisle market. Bombardier predicts that growth in this segment will average 2.9 per cent annually over the next twenty years. They agree with Boeing that airlines will show a preference for larger capacity aircraft to reduce costs. Environmental regulations will also encourage airlines to seek, on a per-seat basis, lower fuel burn and emissions aircraft. Bombardier also agrees that emerging markets will be an important source of growth, with about half of deliveries for aircraft with between 20 and 149 seats over the next 20 years going to these countries.

2.2.2 Business Jet Outlook

Business jet deliveries are also expected to increase over the long term, according to Bombardier's latest market outlook. Over the period 2011-2030, 24,000 business jets are expected to be delivered.[21] The global business jet fleet is expected to more than double from 14,700 in 2010 to 30,900 by 2030, net of

[16] Ibid, 10.
[17] Ibid, 4.
[18] Ibid, 9.
[19] Ibid.
[20] Bombardier, *Bombardier Commercial Aircraft*, 24.
[21] Bombardier, *Bombardier Business Aircraft*.

retirements. Activity in this market will be driven by growth in emerging markets and replacement demand in developed economies.

Demand for business jets is expected to be particularly strong in China. In fact, the country's fleet numbered only 150 in 2010, but it is expected to climb to 2,470 aircraft by 2030.[22] Buoyant economic growth will help fuel the 15 per cent annual average growth in this market. But other factors will also play a role. Growing cultural acceptance of business aviation, the rapid rise of high net-worth individuals, plans for new airports, and improvements in flight plan regulation and airspace liberalization will allow private aviation to bloom over the long term.[23] Since China does not appear to have an indigenous business-aircraft development program, all of these aircraft will presumably have to be imported. [24]

2.2.3 Military Aerospace Sector Outlook

Emerging economies are also expected to actively expand their militaries, including their air forces, in the coming years.[25] Indeed, China has one of the fastest growing military aerospace sectors in the world. [26] RAND predicts that Chinese military spending would reach $403 billion in 2025, which would put their military spending at 1.3 times that of the United States.[27] Part of these expenditures will go to the development of the Chengdu J-20, a fifth-generation fighter. At the same time, India is becoming one of the largest sources of military spending in the world, with the third largest defence procurement budget in Asia.[28]

On the one hand, demand from emerging economies should help offset uncertain outlooks in the developed world where many countries are struggling with large budget deficits. Indeed, defence companies are expected to aggressively pursue opportunities in growth markets like the Middle East, Brazil, South East Asia, and India. However, barriers to entry in the defence sector can be challenging.[29]

The Canadian defence market is relatively small compared to many of their counterparts around the world. This means that trade with other countries is and will remain an important source of growth for the Canadian military aerospace industry. It follows, therefore, that this trade-dependent industry is more sensitive to export controls, whose principal objective is to ensure that exports of certain goods and technology are consistent with Canada's foreign and defence policies. The Canadian military aerospace sector can also be stymied by governments that use national security grounds to seek exemptions on their requirement to treat all bidders in a "non-discriminatory" fashion.[30] Unfortunately, neither export controls nor national security exemptions are likely to disappear in the foreseeable future.

[22] Ibid.
[23] Ibid.
[24] RAND Corporation, 11.
[25] PwC, 16.
[26] Deloitte, *Global Aerospace Market*, 56.
[27] Ibid.
[28] Ibid.
[29] PwC, 13.
[30] Ibid.

2.2.4 Helicopter Outlook

The rise of the emerging markets also bodes well for the outlook for helicopters. In particular, the helicopter market should grow rapidly in China in the coming years. As of September 2009, China had a total of just 208 civil helicopters, including those used in police and emergency services.[31] Moreover, the country had only 12 civilian maritime search and rescue helicopters as of July 2008. Chinese aviation officials project that the country's civil market will have a total requirement of 1,440 helicopters by 2018, requiring approximately 1,250 new deliveries.[32] Like the business jet segment, China currently imports most of its helicopters.

2.2.5 Unmanned Aerial Vehicles Outlook

The market for unmanned aerial vehicles (UAVs) is also expected to grow rapidly, in part due to robust demand from the Asia-Pacific region. The Teal Group, a team of aerospace and defence analysts, estimates that the global UAV market will nearly double over the next decade and the Asia-Pacific region will represent the second largest market, behind only Europe.[33] The Teal Group indicated that it could even be underestimating demand from Asia because Japan and China have not been particularly forthcoming about their plans for UAVs.[34]

2.3 Competitive Threats

We have discussed how demand for aerospace products and services from emerging economies is expected to grow strongly over the long term. But the supply of aerospace products and services from these countries is also expected to climb rapidly in the coming years. Governments hope to parlay their growing market clout into an increased industrial footprint. [35]

This will lead to new competitive threats for Canada's aerospace and defence industry. Indeed, we are already seeing and will likely continue to see a shift in manufacturing activity towards countries with relatively low labour costs and high government support. In short, the competitive pressures on the Canadian aerospace sector will only intensify.

Currently, Bombardier and Embraer dominate the regional jet market, while Boeing and Airbus control the larger commercial aircraft market. But the duopolies that characterize both the regional and larger airplane markets are poised to change with companies from Russia, China, and Japan all targeting the regional jet market and China also seeking to enter the larger aircraft market.

The fact that China, Russia and Japan are targeting the regional and single-aisle jet market could spell trouble for Bombardier. Bombardier dominated the regional jet segment before Embraer's rise, but is expected to capture an estimated 22 per cent of this segment from 2008 to 2018.[36] Bombardier is also making its own play for the single-aisle market with the CSeries plane that it is currently developing. The

[31] RAND Corporation, 5.
[32] Ibid, 11.
[33] Ibid.
[34] Ibid.
[35] AeroStrategy, 15.
[36] Ibid, 16.

single-aisle market is the single largest portion of the commercial aviation segment, but it looks like it will become increasingly competitive in the coming years.

There are three specific competitive threats of varying degrees to the Bombardier-Embraer duopoly in the regional jet market: Sukhoi of Russia, COMAC of China, and Mistubishi of Japan. Sukhoi began development of the Superjet 100, a single- aisle plane with 75 to 95 seats, in 2000. Its first commercial flight was in April 2011. Mistubishi is developing two planes—the MRJ 70, which will seat 70 to 80 passengers, and the MRJ90, which will seat 86 to 96 people. The MRJ70/MRJ90 is scheduled to take its maiden flight in 2013. It is the first airliner designed in Japan since the 1960s.

China currently produces two domestically designed commercial passenger aircraft: the MA60-series turboprop and the ARJ21 regional jet, which has not yet entered into service. The MA60 is a 60-seat turboprop airliner manufactured by the Xi'an Aircraft Corporation (XAC), a subsidiary of the state-owned Aviation Industry Corporation of China (AVIC). The MA60 is effectively a copy of the Soviet Antonov An-24 airliner, which entered into service in 1963. China purchased 40 of these aircraft and reverse engineered them.[37]

The ARJ21 was developed by COMAC. The ARJ21 is a 90-seat regional jet that has been in testing since November 2008. To build this plane, COMAC partnered with Bombardier and based the design on the McDonnell Douglas MD-90. All the major subsystems are sourced from North American companies, including GE, Rockwell Collins, and Honeywell. The wings were designed by the Antonov Aeronautical Scientific/Technical Complex of Ukraine. As of October 2010, the ARJ21 reportedly had 257 orders; virtually all from small domestic Chinese airlines.[38]

COMAC is also developing the C919, a single-aisle 130- to 170-seat narrow-body aircraft intended to compete with the Boeing 737, Airbus A320, and Bombardier's CSeries. The project was launched in 2009 with the goal of initial production in 2014 and sales by 2020. Ultimately, COMAC hopes to produce 150 C919 aircraft per year, to meet one-third of China's domestic demand and 10 per cent of the international market.[39] The Chinese government is fully behind the design and development of this plane; the program is heavily state-supported, and Chinese engineers are reportedly getting paid twice the going rate to work on it.[40]

The C919 single-aisle airliner is a very ambitious project for COMAC. But it is just the start. As part of its long-term plans, the company also has its sights set on the twin-aisle market with the C929 and the C939. In fact, COMAC's long-term goal is to capture one-third of the domestic market in the next two decades.[41]

[37] RAND Corporation, 26.
[38] RAND Corporation.
[39] Ibid, 27.
[40] Ibid, 27.
[41] Rabinovitch, *China's COMAC Confronts Aircraft Duopoly*.

China also has plans to get a foothold in the helicopter market. AVIC's helicopter subsidiary—Avicopter—will establish a helicopter industrial base in Tianjin. The company's long-term ambition is to build a "unified, internationally competitive brand" for the Chinese helicopter industry.[42]

2.3.1 How Serious is the Threat?

Given the looming competition for Bombardier and its Canadian suppliers, an important question to ask is 'how serious is the competitive threat?' It is difficult to come up with an answer because these companies have little or no track record. The looming competition also raises the question about how accessible these markets will be to Canadian suppliers. Governments in both Russia and China hope to fulfill domestic demand in their markets with their own indigenously produced aircraft. The answer to this question is particularly important in the case of China because growth in air travel is expected to be very strong there. In fact, according to Boeing projections, roughly half of the world's air traffic growth over the next twenty years will be driven by travel to, from, or within the Asia-Pacific region.[43]

How competitive these companies will be depends on how close their airplanes come to matching the quality of those produced by Bombardier, Embraer, Boeing and Airbus. There are doubters. For instance, aviation analyst Richard Aboulafia of Teal Group contends that "state-owned companies make terrible airplanes."[44] Indeed, Embraer, which is no longer controlled by the Brazilian government, is the only one so far to show that it can produce world-class aircraft.[45]

Even China's "Big Three" airlines—Air China, China Eastern Airlines, and China Southern Airlines—have been reluctant to purchase planes from COMAC. At the 2010 Airshow China, these three companies committed only to purchasing five C919s.[46] China's airlines have apparently argued that they should not take on more exposure to a program they regard as risky.

At the same time, important capability gaps remain in a number of important areas for China's aerospace sector. Therefore, many of the subsystems on Chinese-built aircraft, particularly the engines, must still be imported.[47]

Only a small fraction of the ARJ21 is composed of composite materials, meaning it will be heavier than current Bombardier and Embraer aircraft.[48] Similarly, the weight of the C919 relative to its length and capacity "suggests its design is no more advanced than that of the 1980s era Airbus A320."[49] Given that fuel efficiency is of prime importance to airlines, "it is not clear why airlines would choose to forgo brands with proven safety and reliability records to purchase an unproven and less-efficient aircraft."[50]

[42] RAND Corporation, 29.
[43] Boeing, 15.
[44] Fast Company, *That's So Fly*, 50.
[45] Ibid.
[46] RAND Corporation, 27.
[47] Ibid, 116.
[48] Ibid.
[49] Ibid, 118.
[50] Ibid, 117.

On the other hand, high-tariffs may dissuade China's domestic airlines from purchasing foreign-designed jets, while direct pressure from the Chinese government may persuade them to purchase planes made in China.[51] At the same time, some state-owned airlines in Third World countries may also purchase Chinese planes in return for diplomatic or other considerations.[52]

There is also no question that China's expertise in aerospace will continue to advance. Indeed, both the ARJ21 and the C919 programs may ultimately be valued not for the profits they produce but for the learning experiences they provide, "enabling China to acquire the skills needed to develop a commercially competitive aircraft in the future."[53]

In fact, progress in China's aerospace and defence sector to-date has been rapid. According to RAND Corporation, "China is now able to produce modern military aircraft, highly reliable space launch vehicles, a wide range of military and civilian satellites, and an increasingly wide and sophisticated range of components for Western airframe and engine manufactures such as Boeing, Airbus, Eurocopter, Pratt & Whitney, GE, and Rolls-Royce."[54]

2.3.2 If You Can't Beat Them Join Them

The fledgling aircraft manufacturers in emerging markets also represent a new market opportunity for Canadian aerospace suppliers. But access to these growing markets, especially China's, often comes with an implicit quid pro quo: willingness to transfer technology to local companies. Indeed, "the Chinese government is leveraging the appeal of its growing domestic travel market to force foreign aerospace firms into favourable partnership terms—thereby gaining access to the technology of the global market leaders."[55] Joint ventures with partners abroad are becoming an increasingly important way for aerospace firms to gain access to growth markets.

All the major players in the aerospace industry have forged relationships with China in one way or another. For example, China performs final assembly on Airbus' A320 airliner and on Embraer's ERJ-145 regional jet under license.[56] Assembling planes offers Chinese companies the opportunity to acquire the knowledge that comes from repeatedly manufacturing the same product. Although Boeing does not make planes in China, it has been the biggest purchaser of made-in-China aviation parts.[57]

Bombardier has also been active in China. In 2007, the company signed an agreement with AVIC to provide technical assistance in the development of the ARJ21 program.[58] Bombardier has also signed sub-contracting agreements with Chinese manufacturers for its Dash-8 Q400 aircraft.[59]

[51] Ibid, 118.
[52] Ibid.
[53] Ibid.
[54] Ibid, 116.
[55] Deloitte, *Global Aerospace Market*, 65.
[56] RAND Corporation, 25.
[57] Rabinovitch.
[58] RAND Corporation, 60.
[59] Ibid, 82.

As this chapter has shown, air travel growth will be strongest in emerging economies located in the Asia-Pacific, Middle East and Latin America. Thus, demand for aerospace products and services will be strongest in these regions. Given this long-term trend, it will be imperative for Canadian aerospace companies to pursue growth outside of North America. Partnering with firms in emerging markets and/or using suppliers based there is a key means of gaining market access.

3 SHIFTS IN AIRCRAFT CONCEPTION, PRODUCTION AND SUPPORT

Globalization, along with the accompanying rise in global trade and foreign direct investment, has been defined by George Ritzer as "an accelerating set of processes involving flows that encompass ever-greater numbers of the world's spaces and that lead to increasing integration and interconnectivity among those spaces."[60] More and more companies are seeking out the best places in the world to do business as national borders become increasingly irrelevant for economic activity. The globalization phenomenon parallels the rise of China and other emerging countries. Despite a setback caused by current global economic weakness, the globalization trend appears irreversible.

The Conference Board has referred to the phenomenon of firms taking apart their supply chains and repositioning them around the world to maximize returns as "integrative trade." Integrative trade incorporates the following elements: exports, imports of goods and services used to create exports, inward and outward foreign direct investment (FDI) used to develop value chains, sales from foreign affiliates, and offshore outsourcing.[61]

3.1 Globalization and Aerospace

The aerospace sector, along with many other industries, is increasingly being reshaped by the process of integrative trade. Emerging markets, in particular China, Russia and possibly India, are becoming increasingly well positioned to supply Western aerospace OEMs.[62] As a result, proximity to OEM's assembly plants is becoming less of an advantage for parts suppliers. This phenomenon shows no signs of abating and should continue for many years to come.

There are several advantages to pursuing this more complex form of industrial organization, including higher productivity, access to a significantly wider talent pool, improved market access, and shorter product cycle times.[63] According to PricewaterhouseCoopers' 2011 review of the global aerospace and defence industry, companies are reporting increased foreign direct investment, with the rate approximately doubling from a decade ago.[64]

The supply chains of both the civilian and military aerospace sectors have become more complex. However, the increased pace of globalization is more difficult to achieve on the defence side, given "local content requirements and national security restrictions."[65]

[60] Ritzer, *The Blackwell Companion to Globalization*, 1.
[61] Hodgson, *Making Integrative Trade,* 2.
[62] Bédier, Vancauwenberghe, and van Sintern, "The Growing Role of Emerging Markets in Aerospace, 1.
[63] AeroStrategy, 5.
[64] PwC, 4.
[65] AeroStrategy, 9.

Aerospace OEMs and their suppliers are increasingly integrating functions like engineering, manufacturing, and support in multiple locations across the globe.[66] We analyze the consequences for each of these three functions below.

3.1.1 Manufacturing

Manufacturing is usually the most obvious choice for outsourcing and offshoring. But the motivation for globalization in manufacturing goes beyond cost savings. As mentioned in Chapter 2, one main motivation is enhanced market access, while others include meeting offset obligations and hedging currency risk.[67] An offset is defined as an agreement wherein a country requires a prime contractor (usually foreign) selected to supply its defence needs to "compensate" for the expenditure through the undertaking of activities that benefit the country's economy. The aim of an offset agreement is to improve a country's balance of trade.

3.1.2 Engineering and R&D

The rapid proliferation of broadband networks and the advent of digital design software are allowing engineering to become globalized and have expanded the global talent pool of engineers.[68] But cost is not the only consideration when hiring engineers—the need to create high quality designs in shorter time cycles is also important.[69] Positioning engineers and designers across the globe makes it possible for products to be developed 24 hours a day. And high quality design does matter, as evidenced by the fact that, despite relatively high wages, the United States remains the second most popular destination for engineering and R&D expansion.[70]

Even research and development is becoming globalized. Indeed, OEMs are increasingly shifting responsibility for R&D and financial risk to suppliers.[71] OEMs are choosing Tier 1 suppliers that are able to bear a significant share of the development cost and program risk, while also managing their own supply chain.[72] In other words, Tier 1 suppliers are becoming responsible for choosing Tier 2 and Tier 3 suppliers. This means that Tier 2 and Tier 3 suppliers, to become involved in an OEM platform, will increasingly have to work through Tier 1 suppliers.

3.1.3 Maintenance, Repair and Overhaul

The maintenance, repair and overhaul (MRO) industry, of which Canada boasts several industry-leading companies, is also being reshaped by globalization. Not surprisingly, MRO activity is expected to increasingly shift to regions where air traffic growth is expected to be the strongest—Asia-Pacific, Middle East, and Latin America. This is especially true because maintenance and customer support infrastructure is currently thin in these regions.[73] In particular, airframe heavy maintenance, a labour-intensive activity,

[66] AeroStrategy, *Aerospace Globalization 2.0*, 1.
[67] AeroStrategy, 9.
[68] AeroStrategy, 7.
[69] Ibid.
[70] Ibid.
[71] AIAC, *Future Major Platforms Report*, 7.
[72] Ibid.
[73] AeroStrategy, 11.

is increasingly moving to regions where labour costs are low. On the other hand, engine and component MRO activity is capital intensive and remains focused in advanced economies.

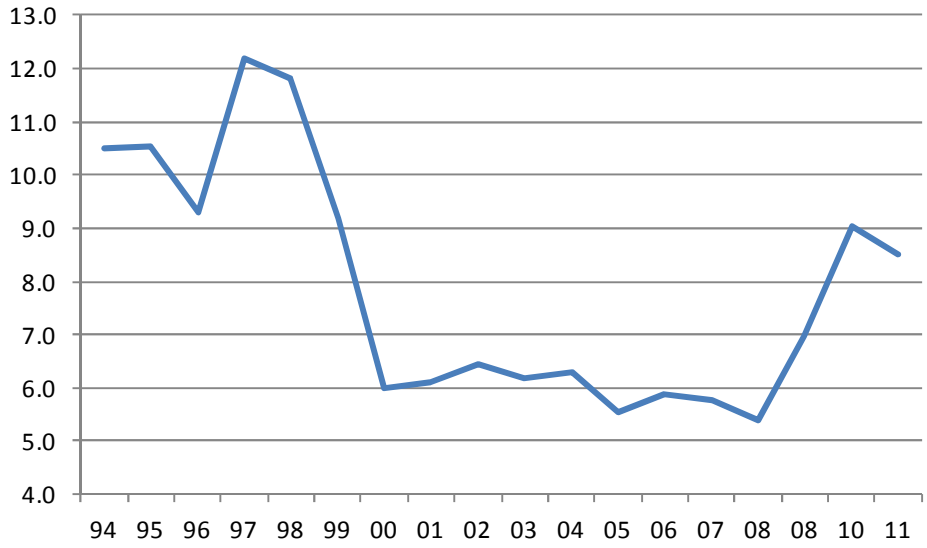
3.2 The Implications for the Canadian Aerospace Industry

The integrative trade phenomenon has important implications for the Canadian aerospace industry. In particular, the closer integration of OEMs and Tier 1 suppliers puts Canada at a competitive disadvantage because "Canada has very few Tier 1 system integrators that are able to fund large work packages."[74] This may explain why few Canadian suppliers were selected for the Boeing 787 and Airbus A350 platforms.[75] To remedy this situation, the Aerospace Industries Association of Canada (AIAC) urged the industry to foster the development of Tier 1 suppliers.[76] If Tier 1 suppliers remain limited in number, then Canada's participation on future aircraft platforms will be limited. This would be unfortunate because companies that are selected to work on these platforms are often guaranteed work for 20 to 30 years.[77]

OEMs are also looking to share responsibility for R&D and design for new aircraft platforms. But the Canadian aerospace industry's recent track record on R&D does not bode well. Indeed, the Canadian aerospace industry lags its counterparts in other countries in terms of R&D intensity (R&D as a percentage of sales). Chart 1 shows that R&D intensity in the Canadian aerospace products and parts industry averaged about 6 per cent for most of the 2000s. On a positive note, the ratio increased in both

Chart 1

R&D as a Percentage of sales in Canada's Aerospace Manufacturing Industry
(per cent)



Sources: Statistics Canada; The Conference Board of Canada.

[74] AIAC, 6.
[75] Ibid.
[76] Ibid, 9.
[77] Ibid, 8.

2009 and 2010. On the one hand, the ratio increased because R&D expenditures rose, thanks in part to Bombardier's R&D spending on its CSeries aircraft. On the other hand, the ratio increased because of a weakness in sales during the recession. Nonetheless, Canada's competitors in the aerospace industry invest 10-15 per cent of sales on research and development.[78] That kind of R&D intensity gap is a competitive disadvantage in a world where OEMs are looking for suppliers to share in the costs of R&D.

Accordingly, the AIAC argues that the Canadian aerospace industry's current level of investment in research and development "is inadequate to support future growth."[79] Moreover, the majority of Canadian industry participation in the existing programs at Boeing, Airbus, and Bombardier rely on current generation technologies.[80] These technologies will be substantially diminished in the next generation of aircraft. For instance, the increasing adoption of composite materials, in response to environmental concerns and high fuel prices, means that R&D spending is only going to grow in importance. (See Chapter 5).

[78] AIAC, 12.
[79] Ibid.
[80] Ibid, 10.

4 SECURITY AND SOVEREIGNTY CONCERNS

New security and national sovereignty concerns encompass another trend that will impact Canada's aerospace industry over the long term. The process of globalization, with all its attendant benefits, also has important security implications. Indeed, "a variety of threats have become global in scope and more serious in their effects as a result of the spread of knowledge, the dispersion of advanced technologies and the movements of people."[81] The greatest manifestation of this threat came with the September 11, 2001 terrorist attacks.

Along with terrorist attacks, a 2003 paper by the RAND Corporation lists several transnational threats brought on by increasing globalization: weapons proliferation, cyber attacks, ethnic violence, global crime, drug trafficking, environmental degradation, and the spread of infectious diseases.[82] These threats could affect Canada directly or indirectly through its allies.

As a result of these new security challenges, governments worldwide will need to place greater emphasis on defence, in turn, requiring them to adjust the mix of military equipment they employ. Governments will increasingly turn to modern aerospace equipment to monitor and mitigate these emerging threats. For example, satellites are increasingly depended on for the surveillance of national borders and the support of military operations, and unmanned aerial vehicles (UAVs) are being used more and more to penetrate enemy territory while minimizing casualties. As a result, the military aerospace industry will need to adapt its product lines to meet these evolving needs.

4.1 The Canadian Military Aerospace Sector

Globally, the military aerospace sector is larger than the civilian aerospace sector. In 2009, the military aerospace sector accounted for about 54 per cent of total revenues, compared to 46 per cent for the civilian aerospace sector.[83] In contrast, the military aerospace sector comprises a much smaller share of overall activity in the Canadian aerospace sector. In 2009, less than 17 per cent of total revenues were generated within the military aerospace sector.[84] This is not surprising because the Canadian government's defence spending relative to other governments is low.

The military aerospace sector produces goods and services for the Canadian government in pursuit of their defence and national security requirements. In particular, the industry provides equipment and related support services to the Department of National Defence, Canadian Forces and other agencies entrusted with public security.[85]

When the government makes purchases of foreign-made platforms, the Canadian aerospace sector's involvement can include supplying parts to the platform and providing life cycle support for those

[81] Davis, *Globalization's Security Implications*, 1.
[82] Ibid, 2.
[83] Deloitte, *Profile*, 5.
[84] Ibid, 17.
[85] Deloitte, *Impact*, 42.

platforms. The Canadian military aerospace sector also exports a portion of its goods and services, primarily to the United States and Europe.[86]

4.2 Canada First Defence Strategy

The federal government's Canada First Defence Strategy provides a detailed road map for the modernization of the Canadian Forces. Through this strategy, the federal government has pledged to invest in the Canadian Forces so that they will be ready if any transnational threats materialize.[87] The investments are expected to help the Canadian Forces fulfill its three main goals: defend Canada, defend North America, and contribute to peace and international security.[88]

According to the strategy, defending Canada requires the constant monitoring of Canada's territory and air and maritime approaches, including the Arctic. One of the goals of the modernization plan is to ensure that the Canadian Forces are capable of detecting threats and addressing them as quickly and efficiently as possible.

Defending North America also means the Canadian Forces will continue to collaborate with their U.S. counterparts in the North American Aerospace Defence Command (NORAD). Contributing to peace and security often means working under the auspices of the United Nations (UN) and the North Atlantic Treaty Organization (NATO).

To meet these ends, National Defence is expected to replace the Canadian Forces' core equipment platforms. These procurements will include 17 fixed-wing search and rescue aircraft, 10 to 12 maritime patrol aircraft, and 65 next-generation fighter aircraft.[89] As well, Canada is improving its lift capabilities through the acquisition of 17 C-130J Hercules tactical lift aircraft, 16 CH-47F Chinook helicopters, and four Boeing C-17 strategic airlift aircraft. The search and rescue aircraft and next-generation fighters are discussed in more detail below.

4.2.1 F-35

In July 2010, the Canadian Government announced that it would be purchasing the Lockheed Martin F-35 fighter jet—a fifth generation fighter jet—to replace the fourth generation CF-18. The F-35 fighter jet is part of the multinational Joint Strike Fighter Program, an example of the growing appetite for capability and cost-sharing between nations. Countries involved in the program include Canada, the United States, the United Kingdom, the Netherlands, Italy, Turkey, Denmark, Norway, and Australia.

Participation in the program has been a boon to the Canadian aerospace industry. Since 2002, the Joint Strike Fighter Program has led to more than $350 million in contracts for more than 85 Canadian companies, research laboratories, and universities.[90] Moreover, in exchange for agreeing to purchase the

[86] Deloitte, *Global*, 47.
[87] National Defence, Canada First Defence Strategy, 6.
[88] Ibid, 7.
[89] Ibid, 4.
[90] Deloitte, *Impact of the Canadian Aerospace Industry*, 61.

F-35, Canadian industrial opportunities have been estimated to potentially exceed $12 billion over the 40-year program.[91]

However, there has been recent controversy regarding Canada's F-35 purchase. The Auditor-General of Canada accused National Defence of understating the operational costs of the planes and Public Works of not following proper procedure when it signed off on the purchase. The Government responded by launching a review of the acquisition process of the F-35 as well as the costing estimates.

4.2.2 Search and Rescue Aircraft

The Canadian government is expected to issue a draft request for proposal in the winter of 2012 for a $3.8 billion purchase of new fixed-wing search and rescue aircraft.[92] These new aircraft will replace the Royal Canadian Air Force's fleet of Buffalo and C-130-H transports. The winning bidder is expected to be announced in 2014.

4.2.3 Could Budget Cuts Derail the Canada First Defence Strategy?

Briefing notes prepared for Associate Defence Minister Julian Fantino after the 2011 federal election and obtained through Access to Information showed he was warned that government spending reductions meant that the Canada First Defence Strategy would be impossible to fulfil.[93] Therefore, it is possible that not all of the expected purchases will be made, but any cuts may come from land or sea programs rather than aerospace.

4.3 Arctic Sovereignty

As mentioned above, the Canada First Defence Strategy explicitly states that the Canadian Forces must be capable of defending the Arctic. One of the consequences of global warming is the potential of an ice-free Northwest Passage, the set of navigation routes linking the Atlantic and Pacific Oceans via the Canadian archipelago. Such a scenario would shorten the maritime routes between major commercial centres, and thus increase the number of ships that operate in the Northwest Passage. These changes in the Arctic could also lead to an increase in illegal activity.

Canada's sovereignty over the waters that make up the Northwest Passage in the Canadian Arctic Archipelago is undisputed.[94] What is under dispute, however, is to what degree Canada's sovereignty is limited by international law and the rights of others.[95]

No matter what the outcome is over Canada's dispute over the Northwest Passage, the expected warming of the Arctic Archipelago has made the region a strategic priority of the Canadian government. Indeed, the mandate to defend Canadian sovereignty in the Arctic has been identified as one of the primary missions of the Canadian Forces in the 21st Century.[96] It has also been argued that Canada's claim

[91] Deloitte, *Impact of the Canadian Aerospace Industry*, 62.
[92] Den Tandt, "Government Moving on $3.8 Billion Purchase".
[93] Pugliese, "Canada First Defence Strategy Unaffordable".
[94] Rutten, *Security in Canada's North*, 4.
[95] Ibid.
[96] Bond, *JUSTAS and Project Epsilon*, 24.

to sovereignty over its Arctic Regions will be strengthened by having the capability to operate search and rescue missions and conduct airborne surveillance of the waterways and surrounding regions.[97]

Surveillance in the Arctic region will require, among other things, the increasing use of UAVs and satellites. To help meet this end, the Canadian Force's Polar Epsilon project was announced in 2005. This project provides all-weather day and night surveillance capabilities utilizing imagery from the RADARSAT-2 earth observation satellite.

The Polar Epsilon project will be enhanced by the RADARSAT Constellation mission, which comprises a group of three satellites that are expected to be launched between 2016 and 2017. [98] The objective of the RADARSAT Constellation mission is to ensure data continuity and provide improved system reliability.[99] The three-satellite configuration will provide complete coverage of Canada's land and oceans.[100]

Canada's Arctic surveillance capabilities are expected to be further enhanced through other programs. For instance, a UAV and satellite surveillance program—Joint Uninhabited Surveillance and Target Acquisition System (JUSTAS)—tasked to keep Canada's maritime approaches, including the Arctic, safe and secure is currently in the Options Analysis Phase at National Defence. [101]

Similarly, the Polar Communication and Weather (PCW) Mission, which is described in more detail in Chapter 7, also aims to support Canadian sovereignty and security in the Arctic by providing continuous and reliable high data rate (HDR) communications services in order "to enable Canadian Forces, Canadian Coast Guard, Fisheries and Oceans Canada, Nav Canada, Transport Canada, Indian and Northern Affairs Canada and Environment Canada activities in high Arctic."[102]

4.4 Military Aerospace Equipment Exports

Governments worldwide will also invest in their militaries to manage and mitigate transnational threats. As mentioned above, the Canadian military aerospace sector largely trades with North America and Europe. However, like the civilian sector, military spending is expected to be strongest in emerging economies, particularly in China and India. In fact, military spending has already been growing rapidly in these two countries for a number of years. Specifically, China and India increased their military expenditures by 219 per cent and 68 per cent, respectively, from 2000 to 2009.[103]

But unlike the civilian aerospace sector, the ability of Canadian aerospace companies to take advantage of the strong growth in military spending in China and Asia will be limited by export controls. National

[97] The Canadian Society for Senior Engineers, *A Recommended Canadian Aerospace Policy*, 23.
[98] Ibid.
[99] Canadian Space Agency, *RADARSAT Constellation*.
[100] Ibid.
[101] Antle, "MacKay Hints".
[102] Canadian Space Agency, Polar *Communication and Weather Mission*.
[103] Deloitte, Global, 48.

security concerns create significant barriers to entry within the military aerospace sector, therefore limiting the opportunities offered by the sector to Canadian companies.[104]

This stands in stark contrast to Canada's relationship with the United States. For instance, Canada has certain exemptions to the U.S. International Traffic in Arms Regulations (ITAR).[105] Also, the Defence Development Sharing Program allows Canadian companies to perform R&D for the U.S. armed forces.[106]

But Canada's ability to take advantage of these exemptions and programs will be limited by fiscal realities. The U.S. federal government and many governments in Europe have turned their focus to deficit reduction. As a result, defence budgets in these countries will continue to experience downward pressure as spending shifts to other priorities. Governments must always choose between "guns or butter", i.e., spending on military goods or spending on civilian goods. An aging population will put significant strain on social safety nets, making it likely that governments will have to increasingly choose "butter".

On the other hand, the average age of military aircraft is increasing, particularly in the United States, increasing the likelihood of new procurement programs. In 2008, the average age of the U.S. Air Force fleet was 24 years old. Moreover, many transport aircraft and aerial refuelling tankers are more than 40 years old.[107] Old equipment is expensive to maintain and is compelling governments to commit more resources on MRO. This may force the hand of the U.S. government to invest in new equipment, and provide opportunities for the Canadian military aerospace sector going forward.

[104] Deloitte, Global, 8.
[105] Ibid, 48.
[106] Ibid.
[107] Ibid, 57.

5 ENVIRONMENTAL CONCERNS

The issue of climate change—specifically the effects of global warming due to increasing atmospheric concentrations of human-made emissions of greenhouse gases (GHG)—is one of the most profound challenges of our time. The fact that developing economies are becoming more industrialized, and thus are generating more GHG emissions, means the challenge will only become more difficult going forward. Despite international agreements on climate change, such as the Kyoto Protocol, leaders in government, the business community, the research community, and other organizations are struggling to come up with effective, equitable, and feasible ways of responding to this threat.[108]

Carbon dioxide (CO2) accounts for a major percentage of human-generated GHG emissions.[109] Most CO2 emissions are produced by fossil-fuel combustion. Thus, it should come as no surprise that the transportation sector is one of the biggest greenhouse gas contributors. The transportation sector in general, and the air transportation sector in particular, will be under intensifying pressure to improve efficiency and limit or reduce its carbon footprint.

5.1 Air Transportation's Contribution to GHG Emissions

Environment Canada tracks greenhouse gas (GHG) emissions in Canada. Statistics Canada uses this data to build estimates of GHG emissions by industry, including the air transportation sector. GHG emissions in Canada's air transportation sector continue to increase despite efficiency gains. From 1991 to 2008, GHG emissions in this sector increased by an average of 1.2 per cent per year. In relative terms, however, the air transportation sector's share of total emissions in Canada has been fairly stable at around 2.2 per cent.

The Conference Board conducts long-term forecasts of GHG emissions. Our forecast does not incorporate any regulatory changes but rather depicts the progression of GHG emissions over the long term in the absence of any new initiatives.[110] In other words, our forecast can be thought of as a status quo forecast. Admittedly, new and more stringent regulations, coupled with unforeseen technological advances, will likely result in lower total emission than projected in our baseline scenario.[111]

In our model, air transportation is included in the other transportation sector, which also includes rail, water, scenic and sightseeing transportation, and support activities for transportation. The other transportation sector also experienced rising emissions over history, increasing by 0.9 per cent per year from 1991 to 2008. Its share of total emissions was also fairly stable at 4 per cent. Therefore, air transportation represents about half of the other transportation sector. In our most recent forecast, we predicted that GHG emissions in the other transportation sector would increase by 2 per cent annually from 2012 to 2035. As a result, the sector's share of total GHG emissions is expected to edge up from 4.1

[108] Blank, *Freight Trucks and Climate Change Policy,* 2.
[109] Ibid, 3.
[110] Macdonald and Ades, *Despite Intensity Improvements, Greenhouse Gas Emissions Keep Growing*, 74.
[111] Ibid, 79.

per cent in 2012 to 4.5 per cent by the end of the forecast. A similar outlook is projected worldwide. Indeed, the International Panel on Climate Change ("IPCC") forecasts rising aircraft CO2 emissions well into the future.[112]

This increase is expected to occur despite the fact that emission intensity (GHG emissions as a share of GDP) in the other transportation sector is expected to trend downward throughout the forecast period. Intensity will fall because GDP growth will be faster than CO2 emissions growth. In other words, there will be efficiency gains, but they will not be transformative enough to offset the expected growth in air travel.

5.2 High Oil Prices

The air transportation industry also has a more self-interested reason to boost fuel efficiency—high oil prices. The run-up in oil prices has hurt airline profitability. In fact, jet fuel now accounts for about one-third of airline operating costs, up from just 13 per cent ten years ago.[113]

The Conference Board believes that oil prices will climb over the long-term. In our most recent long-term forecast, we predicted that the West Texas Intermediate (WTI) oil price, in nominal terms, would increase from $95 a barrel in 2011 to $195 a barrel in 2035. Stronger demand will put sustained upward pressure on oil prices throughout the forecast.[114] All of the expected increase in global oil demand will come from developing regions of the world.[115] Although there will be sufficient supply, oil reserves will increasingly be found in difficult to reach frontier lands, involve new and more costly extraction technology, or belong to current OPEC members.[116] The supply limitations will also fuel oil price growth.

5.3 How the Aerospace Sector Will Respond

The aerospace industry will respond to the dual threat of environmental regulations and cost pressures largely by designing and developing technologies that optimize fuel efficiency. Airplanes will become more fuel efficient by reducing weight and by implementing more efficient engines. At the same time, airlines will reduce fuel costs by increasingly using biofuels to help curtail their oil consumption. It will also push airlines to move to larger planes, so they can carry more people on fewer flights, thereby reducing fuel consumption per RPK.

5.3.1 Composite Materials

Aircraft manufacturers are increasingly adopting composite materials in the design of their planes. Composites have several advantages over traditional metals. First, composite materials are lighter than metals, enabling better fuel economy and therefore lowering operating costs.[117] Second, composite materials can be formed into more complex shapes than their metallic counterparts.[118] This reduces the

[112] Deloitte, *Global Aerospace Market*, 36.
[113] Hernandez, *IATA Conference*
[114] Crawford, "Energy Weathers the Global Economic Turmoil", 36.
[115] Ibid.
[116] Crawford, "Canada's Oil Extraction Industry", 5.
[117] Quilter, *Composites in Aerospace Applications*, 3.
[118] Ibid, 2.

need for fasteners and joints, lowering the number of weak points and allowing for a shorter assembly time.[119] On the other hand, composite materials are likely to take longer to fabricate than metals.[120]

The first significant use of composite material in a commercial aircraft was by Airbus in 1983 in the rudder of the A300 and A310, and then in 1985 in the vertical tail fin.[121] Composites make up 28 per cent of the weight of the A320 airframe, while both the A380 and Boeing 777 are about 20 per cent composite by weight.

The Boeing 787 is the first mostly composite airplane and the first to adopt composite-material wings. In fact, composite materials constitute about 50 per cent of the model by weight. Composites are also used in major structural elements of many modern helicopters. For instance, the Bell Boeing V-22 Osprey tilt-rotor aircraft is about 50 percent composites by weight.[122] Bombardier's CSeries airplane will also be comprised of a significant share of composite materials—the fuselage will be an aluminum-lithium composite, while the wings will be an advanced composite material.

The increasing use of composite materials may one day encourage the transition to more advanced production techniques such as 3D printing, replacing traditional manufacturing techniques like metalworking. In a recent article, the Economist profiled research being conducted by EADS Innovation Works, the research arm of EADS, the aerospace group best known for building Airbuses.[123] They were attempting to build a landing-gear bracket by using 3D printing technology. The researchers' ultimate goal is to print the entire wing of an airliner.

Engineers and designers have been using 3D printers mainly to make prototypes. But as 3D printers become more capable and able to work with a broader range of materials, the printers will be increasingly used to make final products. As a low volume high value industry, aerospace components are ideal candidates for manufacture using 3D printing techniques.

5.3.2 More Fuel Efficient Engines

Although the growing use of composites will boost fuel efficiency, the component most critical to improving efficiency—the engine—will also be a focus of research and development projects going forward. Indeed, manufacturers have been busy designing new engines that offer significant improvements in fuel efficiency. Here is a summary of some of the key next generation technology being explored by engine OEMs:

- Pratt & Whitney has developed a geared turbofan engine, which improves fuel efficiency by up to 15 per cent, while also yielding substantial noise reductions. This engine will be used in the Bombardier CSeries, as well as the A320neo and the Mitsubishi Regional Jet.

[119] Ibid.
[120] Ibid.
[121] Ibid. 3.
[122] Ibid, 4.
[123] The Economist, "The Printed World."

- General Electric has developed a dual rotor high-bypass turbofan, which also can improve fuel efficiency by 15 per cent over comparable existing models. This is being used on the Boeing 787.
- CFM International, a partnership of Snecma (SAFRAN Group) of France and GE of the United States, is developing a high-bypass turbofan named LEAP-X. This engine reportedly increases fuel efficiency by 16 per cent, reduces carbon dioxide emissions and nitrogen oxide emissions by 16 per cent and 50-60 per cent, respectively.
- Rolls-Royce's Trent 1000 engine is also being used on the Boeing 787. According to the company, the Trent 1000 is 25 per cent more fuel efficient than the first RB211 jet engine. Rolls Royce is also developing the Trent XWB for the Airbus A350. The company claims it will have the lowest carbon emissions of any wide-body engine.[124]

5.3.3 Larger Aircraft and More Turboprops

As mentioned in Chapter 2, it is expected that demand for larger airplanes will be stronger than demand for regional jets. This is because larger planes are more fuel efficient than smaller ones on a litres per RPK basis. In addition, congestion at major airports will also drive demand away from the smallest planes.[125]

Although demand is expected to be relatively weaker for the regional jet market, within this market turboprop usage may increase on short-haul flights (flights that are less than 800 km) because they are more fuel efficient than regional jets at short distances.[126] In fact, Deloitte has shown that turboprop orders are positively correlated to fuel prices.[127] Given that we expect fuel prices to rise over the long term, this suggests that the outlook for turboprops is positive.

5.3.4 Developing Biofuels

The air transportation sector is also likely to move toward the consumption of biofuels as a way to reduce its carbon footprint. In fact, aircraft manufacturers and airlines have been working together to develop aviation biofuels. The aerospace industry hopes that the introduction of alternative fuels will significantly curtail the industry's carbon emissions.

Research and development of aviation biofuels has been particularly active in South America, thanks to the International Civil Aviation Organization's "Flightpath to Sustainability" biofuel initiative for the Rio +20 UN Conference on Sustainable Development, which was held in June 2012. As part of this initiative, Air Canada and Airbus successfully conducted North America's first biofueled international flight between Toronto and Mexico City in June. The newly designed Airbus A319 jetliner was powered by a 50 per cent biofuel blend made from used cooking oil.[128] The jet was fitted with high-tech equipment that optimized its routing and flight altitude and used several operational procedures, such as single engine-taxiing to minimize fuel use and carbon emissions.[129]

[124] Deloitte, *Global Aerospace Market*, 37.
[125] Deloitte, Profile, 7.
[126] Deloitte, *Global Aerospace Market*, 38.
[127] Ibid.
[128] Kabange, "The Perfect Flight."
[129] Ibid.

Other initiatives are also underway. In 2008, Boeing funded research by Yale University's School of Environmental Studies that focused on establishing sustainable jet fuel production from the Jatropha plant, an oil-producing non-edible plant indigenous to Brazil and Mexico.[130] According to Airbus, Jatropha has proven to be the most cost-effective and sustainable feedstock for renewable jet fuel.[131] Likewise, the Mexican government's Airports and Auxiliary Services, the country's sole provider of jet fuel, has established a plan to develop biofuel production capacity at up to four refineries by 2020.[132]

5.4 Climate Change and Space

The study of climate change will also lead to opportunities for Canada's space sector. For instance, one of the main objectives of the Polar Communication and Weather (PCW) Mission is to monitor Arctic weather and climate change. Specifically, the PCW mission is expected to "improve the understanding of global climate change and the ability to model and predict phenomena associated with it."[133]

[130] Pereira, "Green and Growing", 59.
[131] Ibid.
[132] Ibid.
[133] Canadian Space Agency, Polar *Communication and Weather Mission*.

6 EXPANDING NATURAL RESOURCE EXTRACTION AND INTENSIFYING CROP YIELDS

Another long-term trend that will affect the aerospace industry is expanding natural resource extraction and the pressure to intensify agricultural yields. Demand for metals, non-metallic minerals, and oil and gas is expected to be strong going forward. This will keep commodity prices high compared with their historic norms, creating the incentive to seek more deposits of natural resources. Food demand is also expected to be robust, as the world's population continues to rise and incomes continue to grow. However, not all of the increased demand can be satisfied from the expansion of arable land. Thus, there will be tremendous pressure to increase yields.

The aerospace industry can play a key role by aiding in the hunt for natural resource deposits and helping to improve agricultural crop yields and environmental stewardship. Canada is a major player in mining and agriculture. Going forward, it may be possible for Canada to leverage its comparative advantage in these areas by utilizing aviation and space technologies that boost the country's and the world's production of natural resources and agricultural products.

6.1 Food Outlook

The demand for food is expected to grow briskly in the coming years. Rising population and income growth will be the main drivers of demand. The U.S. Census Bureau is forecasting that the world population will expand from 6.9 billion in 2011 to 8.6 billion by 2035. To meet the projected demand, the World Bank estimated that global cereal production would have to increase by nearly 50 per cent and meat production by 85 per cent from 2000 to 2030.[134]

Over the coming years, Canadian agricultural exports are expected to shift to non-traditional markets with high growth in population and wealth, such as India and China. For example, China is becoming increasingly dependent on agricultural imports. This reflects the improvements in Chinese living standards and the resulting shift to a diet higher in protein.

The strong demand bodes well for Canada, which is a major exporter of agricultural products. In fact, Canada is the world's largest producer of products like canola, peas, lentils, and some specialty products like mustard seed and linseed.[135] It is also a major global producer of products like wheat (fifth globally), pork (sixth globally), and soybeans (seventh globally). In the Conference Board of Canada's most recent long-term forecast, we predicted that output in the animal and crop production sector would increase by an average of 2.4 per cent per year from 2012 to 2035, up from an average annual gain of 2.1 per cent recorded in the previous 24-year period.

[134] World Bank, *World Development Report 2008*, 8.
[135] Grant et al, *Valuing Food*, 24.

6.2 Energy Outlook

According to the International Energy Agency (IEA), global energy use is projected to rise 40 per cent between 2009 and 2035.[136] Consumption of all energy sources will increase, with almost 90 per cent of the projected gains coming from countries outside the Organisation for Economic Co-operation and Development (OECD). While demand for renewable energy will increase at a faster pace than for all other fuel types, by 2035 the share of renewables in the global energy mix will still be far below the share of any single fossil fuel. Oil will remain the dominant fuel in the world, although its relative share of total energy consumption is projected to fall from 33 per cent to 27 per cent over the outlook.

6.2.1 Oil Demand

From 89.2 million barrels per day (mmbd) in 2011, the IEA estimates that global oil demand will rise to 99 mmbd by 2035. Oil demand in the on-road transportation sector is projected to increase 32 per cent over the outlook as the global vehicle fleet doubles in size by 2035. In 2009, the number of passenger light-duty vehicles (PLDVs) averaged 40 per 1,000 people in non-OECD countries, while in OECD countries that ratio was 500 per 1,000. Thus, as vehicle ownership rates in the developing world rise (they are projected to reach 125 per 1,000 people by 2035), the non-OECD vehicle fleet will expand rapidly and will surpass the developed world's fleet within the next 25 years. However, improved efficiency of use and higher penetration of hybrid and electric vehicles will help slow the gains in oil demand to some extent.

Canada is well positioned to meet this rising demand. According to British Petroleum's *Statistical Review of World Energy 2012*, Canada's proven oil reserves now total in excess of 175 billion barrels.[137] That puts Canada behind only Saudi Arabia and Venezuela in terms of proven reserves, and represents 10.6 per cent of global reserves.[138] Most of these reserves are in the oil sands. Thus, this incredibly large resource will dominate the Canadian production mix for years to come. Importantly, Canada is easily the world's largest holder of oil reserves not controlled by a state-owned oil company.

Canada's oil sands are located in four major deposits that lie mostly or entirely in Alberta—Athabasca, Peace River, Wabasca, and Cold Lake. Of the remaining proven reserves, only 26 billion barrels are currently under active development.[139] With dozens of oil sands projects on the horizon, non-conventional production in Canada will surge throughout the forecast. In fact, the Conference Board of Canada's 2012 long-term forecast predicted that production would climb from 1.6 mmbd in 2011 to 4.2 mmbd in 2035.[140]

Although waning in importance, the conventional oil sector still has much to contribute to the Canadian economy going forward. Remaining conventional reserves are estimated to be roughly 34 billion barrels. However, geographic placement of these reserves makes future development a challenge. Seventy-two per cent are in what are considered "frontier" regions, which include East Coast offshore fields, Northern

[136] This section relies on information described in the "New Policies Scenario" from the most recent World Energy Outlook, produced by the International Energy Agency. See *World Energy Outlook 2011*.
[137] British Petroleum, *BP Statistical Review of World Energy 2012*, 6.
[138] Ibid.
[139] Energy Resources Conservation Board, *Alberta's Energy Reserves 2011*, 72.
[140] Crawford, "Energy Weathers the Global Economic Turmoil", 41.

Canada, and other basins that are still relatively unexplored.[141] The more developed light and heavy deposits are in the mature Western Canadian Sedimentary Basin (WCSB).

6.2.2 Natural Gas

The global natural gas industry is in a state of evolution as the wide availability of new unconventional resources and resulting weaker pricing makes natural gas a preferred source of energy. Natural gas is the cleanest of the main fossil fuels. And because stricter regulation of emissions is expected over the outlook, its importance in the global energy mix is expected to increase from 21 per cent in 2009 to 23 per cent in 2035, as consumption rises at an average annual pace of 1.7 per cent. Indeed, the absolute increase in natural gas demand over the outlook is nearly equal to the expected increase in oil and coal combined.

Regional trends in natural gas demand are largely expected to mirror those in greater energy demand. That is, growth in demand in non-OECD countries is expected to increase 2.4 per cent a year over the forecast, compared with just 0.7 per cent in the OECD members. The largest incremental increases in demand will come from China and the Middle East, with smaller increases from India. Higher rates of energy consumption are consistent with the faster growth in population, economic activity, and urbanization in these regions. Non-OECD countries are expected to account for 61 per cent of global natural gas consumption in 2035, compared with 51 per cent in 2009.

The natural gas industry in Canada faces a variety of risks. Production has fallen considerably over the past decade, as the maturity of the WCSB has led to higher production costs and falling well productivity. More recently, prices have been weak in the face of surging U.S. production of shale gas, further limiting exploration and drilling activity. The next decade will be marked by uncertainty, as pricing is projected to remain extremely weak and estimates of the remaining resource base in Canada vary considerably, depending on the estimator's opinion of unconventional and frontier reserves.

Volumes will fall precipitously in Alberta—still the largest source of natural gas production in Canada. Operating costs are relatively high in the province due to competition for labour and material inputs from the neighbouring oil industry, and that is pushing up the break-even cost for new drilling. Conventional production in particular will fall throughout the forecast, as the maturity of the WCSB continues to weigh negatively on the outlook.

Activity in the industry has focused on deep conventional, tight, and shale gas resources over the last few years, as technological advances have lowered production costs. This has contributed to a recent uptick in initial well productivity, as the most prolific pools are being exploited early on in the unconventional revolution. All in all, Canadian oil and gas extraction output is forecast to climb by 1.6 per cent per year from 2012 to 2035, according to the Conference Board of Canada's 2012 long-term forecast, but all of this growth will be driven by rising oil sands production. Thus, natural gas related opportunities for aerospace are more likely to be found elsewhere.

[141] National Energy Board, *Canada's Energy Future: Energy Supply and Demand Projections to 2035*.

6.3 Other Mining

Similarly, strong economic growth in emerging economies is expected to drive demand for other minerals produced in Canada. For instance, food demand growth will contribute to big increases in potash-based fertilizer use, especially given the fact that soil nutrients are expected to gradually erode. Saskatchewan sits astride 46 per cent of the world's supply of potash.[142] Potash accounts for the largest share of non-metallic mineral production in Canada at nearly half, but other non-metallic minerals, such as diamonds, are also important.[143] Output in non-metallic minerals will grow at an annual compound rate of 6.5 per cent from 2011 to 2020, and another 1.6 per cent from 2021 to 2035. Much of this will be driven by planned expansions of existing potash mines in Saskatchewan.

Prospects for the metal mining industry are also bright. Indeed, when it comes to the global metal mining industry, Canada has many advantages. Political stability, a highly skilled workforce, and access to North American markets complement Canada's large untapped reserves. As a result, Canada routinely is the single largest destination for expenditures on mineral exploration globally, accounting for 19 per cent in 2010.[144] Increased global demand for metals will result in real metal mining growing at an average annual compounded rate of 10.5 per cent from 2011 to 2020, and 1.3 per cent from 2021 to 2035. Key areas of growth will include precious metals (particularly gold), and base metals. There are also a variety of projects that could be developed in Canada in the coming years, such as the "Ring of Fire" chromite deposits in Northern Ontario.

6.4 Natural Resource Extraction and Aerospace

Aerial and satellite imagery is an important tool in natural resource extraction. Imaging sensor technology continues to advance, enabling explorers to collect increasing amounts of information before they begin digging or drilling. Aircraft and satellites are fitted with sensors that use the spectral properties of materials (what wavelengths of materials they absorb or reflect) to identify the materials without having to view them in person.[145]

Geologists use data from these electromagnetic sensors to pick out rock units and seek surface clues such as alteration and other signs of mineralization to subsurface deposits of ore mineral, oil and gas, and groundwater.[146] The main advantage of spectral sensors on aircraft is that they have much higher resolution than sensors on satellites. But the benefit of using satellites is that they have the ability to collect more data, from greater areas, without having to fly aircraft over the land in interest.[147]

There is every reason to believe that the capabilities of these sensors will continue to advance going forward. Thus, the aerospace sector will continue to play a key role in the development of Canada's natural resources. Given the current environment of high prices and keen interest in exploration and

[142] USGS.
[143] NRCAN.
[144] Mining Weekly.
[145] Toovey, "Satellite Imagery and Gold Exploration."
[146] Ibid.
[147] Ibid.

development both here in Canada and abroad the development of natural resources represents significant opportunities for aerospace.

6.4.1 The North

One particular area where the aerospace sector can assist in natural resource extraction is in Northern Canada. Much of Canada's untapped resources are in remote areas of the North where little or no infrastructure or manpower is present. These resources are becoming increasingly accessible due to the warming effects of climate change and advances in exploration and exploitation technology. In particular, Northern Canada is a significant source of potential natural gas production. Northern Canada is thought to contain 115 trillion cubic feet of remaining marketable gas—half of it in the Mackenzie–Beaufort region.

The Polar Communication and Weather (PCW) mission, described in more detail in Chapter 7, would assist in the exploration and exploitation of natural resources in the North. The PCW mission, which is being developed by the Canadian Space Agency (CSA), features two satellites in a highly elliptical orbit (HEO) that would provide reliable and continuous communication services and monitor weather and climate changes in the entire Arctic region. [148] The CSA argues that "Canada needs better communications, weather prediction, and climate and environment monitoring capabilities in the North" if the country is "to profit from the natural resources in the North."[149]

6.5 Agriculture and Aerospace

The aerospace sector plays an important role in the agriculture sector through Canada's expertise in the satellite sector. Today, farmers increasingly have access to data from earth-observation satellites to forecast crop yields, boosting their chances of success. More than 60 of these satellites, including the CSA's RADARSAT-2, are in operation and provide a reliable assessment of environmental change.[150] Given that they remain in place for long periods of time, the satellites draw attention to gradual changes, which is very useful when monitoring soil conditions. Soil conditions that fluctuate throughout the growing season impact crop yields.

Data from RADARSAT-2 allows agricultural planners to map crop characteristics over large areas. Specifically, the data allows them to develop soil-drainage and permeability-classification models and maps, while also allowing them to determine soil water-erosion risks to agricultural land at spring melt. Agricultural planners can also use information from RADARAT-2 to learn more about the dynamics of drought and flooding.

RADARSAT-2 also helps farmers develop better land-management practices by providing information on crop residue after harvest. Different crops provide varying amounts and types of residue cover on soil, which can significantly affect soil health and the risk of erosion.

[148] Canadian Space Agency, *Polar Communication and Weather Mission*.
[149] Ibid.
[150] This section relies on information described in Dan Gayton's "Farming From Space" article in Canadian Geographic. See Gayton, "Farming From Space."

At the same time, the CSA has partnered with the European Space Agency on the SMOS (Soil Moisture and Ocean Salinity) Earth-observation satellite. This satellite generates precise data on soil moisture to a depth of up to two metres, known as the root zone. Gaining a better understanding of soil moisture can lead to a better understanding of variability in crop yields. The information from SMOS, RADARSAT-2 and other satellites can also help in the implementation of precision farming—an emerging trend in agriculture that could boost crop yields. This is where we turn to next.

6.5.1 Precision Farming

Precision farming is a farming management concept that uses advanced technologies to observe and respond to intra-field variations. The advanced technologies include Global Positioning Systems (GPS), Global Information Systems (GIS), and satellite imagery, along with a wide range of sensors, monitors, and controllers for agricultural equipment.

As Alberta's Ministry of Agriculture and Rural Development puts it, precision farming "will enable farmers to use electronic guidance aids to direct equipment movements more accurately, provide precise positioning for all equipment actions and chemical applications and, analyze all of that data in association with other sources of data."[151] In other words, farmers can tailor their practices to the varying conditions of the land so that they apply inputs like seed, fertilizer, and pesticides in just the right amounts, resulting in higher crop yield and more effective soil conservation practices.[152]

Moreover, on-board GPS monitors enable auto-steering, which aligns and steers the tractor precisely relative to the last pass down the field. It can compute an "optimum path" that minimizes the number of overlaps the tractor drivers have to make as they traverse the field, preventing the waste of seed and fertilizer.[153]

In short, precision farming will boost agriculture productivity. Small changes in topography, soil type, fertility, and moisture levels within a given field can translate into big changes in crop yield.[154] Precision agriculture will enable farmers to respond to those in-field variations by applying different amounts of crop inputs in different parts of a given field. This predicted gain in agricultural productivity will not be possible without information from satellites and, in turn, without the participation of the aerospace sector.

[151] Alberta Agriculture and Rural Development, *What is Precision Farming*?
[152] Gayton, "Farming From Space."
[153] Ibid.
[154] Ibid.

7 THE RAPID EXPANSION OF GLOBAL TELECOMMUNICATIONS AND THE SPACE SECTOR

The internet has become a pervasive part of many people's lives. Thanks to the rapid growth of wireless mobile broadband, the era of a ubiquitous internet is fast approaching. Smartphones, the vanguard of mobile computing, may be the fastest spreading technology in human history.[155] Along with smartphones, other mobile devices like the Apple iPad tablet and the Amazon Kindle e-reader continue to gain in popularity. Other devices that will enable machine-to-machine (M2M) communications will also use mobile broadband.[156] Examples of M2M devices could include devices that enable smart power grids, vehicle-to-vehicle communications, and remote meter reading.[157] The potential for these devices, which are just in their infancy, are immense.

7.1 Mobile Broadband Demand

Global mobile-broadband subscriptions have grown 45 per cent annually in the past four years.[158] And according to a forecast by Cisco, annual global internet traffic will surpass the zettabyte threshold by the end of 2016; one zettabyte is equal to 1 billion terabytes.[159] To put this into perspective, the gigabyte equivalent of all the movies ever made will cross the internet every three minutes in 2016.[160] Moreover, Cisco expects that traffic from wireless devices is expected to exceed traffic from wired devices by 2016.[161] The move from wired to wireless devices, as the internet becomes increasingly mobile, means maps and global positioning (GPS) services will become increasingly important.

One of the main sources of revenue growth for satellite services has been mobile data services, which include services such as high speed data, mobile TV, and emergency communications services. Revenue growth in this category jumped by 18 per cent in 2009 and now represents two-thirds of mobile satellite service revenue. [162] The other source was high definition television (HDTV), which saw revenue growth of approximately 80 per cent between 2008 and 2009.[163] GPS systems are also forecast to be a continued driver of growth.[164]

7.1.1 GPS Receivers

Most smartphones include a satellite-supported GPS global receiver. The combination of a GPS receiver and mapping service allows the smartphone user to get real-time position tracking, text- and voice-guided directions, and points of interest. It has also led to an explosion of location-based services, which are services available on a mobile phone that makes use of geographical position and is tailored to where a user is and what a user is doing. When used in conjunction with motion or other sensors, the location-

[155] Degusta, "Are Smartphones Spreading Faster than any Technology in Human History?"
[156] Lehr, *Mobile Broadband*, 13.
[157] Ibid.
[158] International Telecommunication Union, *ICT Facts and Figures*, 2.
[159] Cisco, *The Zettabyte Era*, 1.
[160] Ibid.
[161] Ibid.
[162] Deloitte, *Global*, 45.
[163] Ibid.
[164] Ibid.

awareness can help customize services to how fast or how slow the user is moving.[165] Examples of location-based services include Yelp, Foursquare, Gowalla, and Google Places.

It is likely that demand for location-based services will continue to rise rapidly in the future. The rapid adoption of smartphones will require new and more technologically advanced GPS satellites to meet the growing demand for GPS services worldwide. Indeed, the next generation GPS satellites—GPS III—are under development, with the first launch scheduled for May 2014.

7.1.2 Aerial Mapping

Maps are also another key feature of smartphones. The companies behind the two biggest smartphone platforms—Google and Apple—offer their own mapping and navigation systems. In 2012, both companies announced 3D mapping technology. To offer this upgrade to their mapping services, Apple and Google have deployed fleets of airplanes, equipped with cameras, to capture images of buildings in major cities. By the end of 2012, Google expects to have 3D mapping coverage for metropolitan areas with a combined population of 300 million people.[166] This could be another source of demand for aerospace equipment going forward.

7.2 The Space Sector

The global space sector is a relatively small component of the aerospace industry, accounting for about 5 per cent of total aerospace revenues in 2009.[167] Over the long term, growth in the space sector is expected to come largely from civilian customers, with growing demand for bandwidth fuelling the need for more and better satellites.

7.2.1 Satellites

The satellite communications sector has experienced significant growth in recent years, thanks to the rapid rise in demand for communications services throughout the world. Demand has been particularly strong in emerging markets, where wired infrastructure has never been fully developed. The satellite sector is expected to continue to enjoy strong growth for years to come. Accommodating this rapid growth in mobile device traffic will generate substantial opportunities for the producers of satellites and satellite services.

Specifically, the industry is trending toward launching more profitable micro- and nano-satellites.[168] In particular, geosynchronous-earth orbit ("GEO") and low-earth orbit ("LEO") satellite activity will be driven by significant growth in HD and 3D video, internet video, global file sharing, mobile broadband usage, and global positioning.[169]

The Teal Group has been using its mission model since 1992 to provide a snapshot of known possible satellite launches over the next 20 years. In its most recent release, it estimated 2,315 payloads between

[165] Lehr, 11.
[166] National Post Wire Services, "Google Sends Fleet of Planes to Create 3D Map of Earth".
[167] Deloitte, *Profile*, 33.
[168] Ibid.
[169] Ibid.

2011 and 2030.[170] Many of these payloads will be commercial satellites destined for low earth orbits. Of the 2,315 payloads, 38 per cent are commercial, 35 per cent are civilian, 20 per cent are military, and 7 per cent are university and other types. However, the Teal Group expects that at least half of these proposed missions will not go ahead for several reasons, including insufficient funding, technical challenges, or the perceived lack of a user market.

Not only will increased demand drive growth in the satellite sector, but so too will replacement demand for existing satellites. The Teal Group highlighted two future sources of growth: the replacement of Globalstar and Orbcomm LEO mobile communications constellations before 2015, and Iridium LEO satellites before 2020.[171] At the same time the GEO satellites used for communications, broadcasting, and positioning will be retiring at a steady pace through 2024.[172] The majority of these satellites will need to be replaced because of the critical role they play in terrestrial communication systems. Finally, elliptical and MEO satellites will be retiring between 2013 and 2015, although they will be replaced by lower cost LEO and GEO satellites.[173]

Some of the satellites that are expected to be launched over the next twenty years are being developed by the Canadian Space Agency (CSA). Canada has a strong legacy in the satellite sector. With the launch of the Alouette 1 in 1962, it became the third nation after Russia and the United States to design and build its own satellite. It was also the first country to have a commercial geostationary communications satellite network in 1972 and the first direct broadcast satellite in 1976.

As the CSA has argued, "satellites are the most economical way to connect users to advanced communication services, since they eliminate the need for extensive, cumbersome ground-based infrastructure."[174] This is particularly true for Canada, given its large territory and sparse population.

The satellite sector remains important to the Canadian space industry today. For example, revenue growth in 2010 was almost entirely driven by satellite communications and accounted for nearly 80 per cent of total revenues.[175] The CSA plans to build on this legacy with a variety of satellites currently under development. The next generation of Canadian satellites is approaching the end of the preliminary planning and design stage. Indeed, one of the core thrusts of the CSA is "to look upon space as a means of communicating with each other by relaying information via satellites."[176] Satellites under development include the Polar Communication and Weather (PCW) System, Constellation RADARSTAT, and NEOSSat.

The Polar Communications and Weather (PCW) mission features two satellites in a highly elliptical orbit (HEO) that would provide reliable and continuous communication services and monitor weather and climate changes in the entire Arctic region.[177] In fact, it would have the ability to image the entire Arctic

[170] The Teal Group, *Mission Model*.
[171] Deloitte, *Profile*, 33.
[172] Deloitte, *Global*, 45.
[173] Ibid.
[174] Canadian Space Agency, *The Canadian Space Strategy*, 16.
[175] Canadian Space Agency, *State of the Canadian Space Sector 2010*, 12.
[176] Canadian Space Agency, *The Canadian Space Strategy*, 13.
[177] Canadian Space Agency, *Polar Communication and Weather Mission*.

region every 15 minutes. GEO satellites can provide near continuous imagery everywhere except over Polar Regions. The HEO system has been endorsed by the World Meteorological Organization (WMO) to improve earth observations over polar latitudes. Approval and funding are still required, but launch of satellite 1 is scheduled for August 2016 and the launch of satellite 2 is scheduled for November 2016. Operations should begin in January 2017.

The RADARSAT Constellation is a three-satellite configuration that will provide complete coverage of Canada's land and oceans as well as daily access to 95 per cent of the world to Canadian and international users.[178] The satellites are scheduled to be launched in 2016 and 2017.

The Near-Earth-Object Surveillance Satellite (NEOSSat), which is slated for launch in 2012, will be the world's first space telescope dedicated to detecting and tracking asteroids and satellites.[179] The satellite will pinpoint asteroids that may someday pass near Earth. It is slated to launch in 2012.

Along with domestic satellite work, Canada also relies on export demand for its satellite goods and services. In 2010, 50 per cent of the Canadian space sector's revenue was generated from exports.[180] Export demand should be strong going forward, given the telecommunications revolution that is currently underway and the robust growth in satellite goods and services that it should engender. However, like the military aerospace sector, foreign sales opportunities for satellite producers could be limited by export controls, if the goods and technologies designed for use in space are considered dual-use—i.e., they can be used for both civilian and military purposes.

7.2.2 Space Sector (Excluding Satellites)

The non-satellite portion of the space industry, which is mostly driven by government activity, has a more cautious outlook. Although the exploration of space, particularly through the International Space Station (ISS), remains a priority for many governments, their participation will be limited by budget constraints in many developed countries.

This will be somewhat offset, however, by growing space activity in emerging markets, especially in China. China's strongest space capability is its launch capacity[181], an area in which Canada has chosen not to develop an expertise. China's satellite capabilities, meanwhile, have gone from rudimentary to near-state-of-the-art. [182] But the only buyers of China's communications satellites to-date, according to RAND Corporation, have been Nigeria and Venezuela.

Budget woes in the developed world will leave an opening for commercial space exploration. Indeed, commercial interests are finally becoming viable. A prime example of this was the SpaceX Dragon, which became the first commercial spacecraft to visit the ISS this past May. In fact, the service market for the

[178] Canadian Space Agency, *RADARSAT Constellation*.
[179] Canadian Space Agency, *NEOSSat*.
[180] Canadian Space Agency, *State of the Canadian Space Sector 2010*, 6.
[181] RAND Corporation, 112.
[182] Ibid, 107.

ISS is expected to account for one quarter of new launches through 2020 because of the cancellation of NASA's space shuttle program.[183]

[183] Deloitte, *Profile*, 33.

8 CONCLUSION

This report has identified six long-term trends that will affect the global and Canadian aerospace industries going forward. The first trend is the shift in economic power that is taking place from advanced economies to emerging ones. The emergence of new global powers presents both challenges and opportunities for Canada's aerospace sector. In particular, China is targeting the regional jet and single-aisle aircraft markets through state-owned COMAC. The regional jet market remains a key market for Bombardier Inc., Canada's biggest aerospace company. Bombardier also has its eyes on the single-aisle market with its CSeries plane, which is currently under development.

But these emerging economies also represent a huge opportunity for Canada's aerospace sector as these markets are expected to post the strongest growth in air travel going forward. This is expected to significantly boost the demand for aerospace products and services. Given this long-term trend, it will be imperative for Canadian aerospace companies to pursue growth outside of North America. But the fact that China is fostering its own indigenous aircraft manufacturer also raises the question of how open the Chinese market will be to foreign competition. Gaining access to these growth markets may require joint ventures with domestic producers.

The second trend, which parallels the rise of the emerging economies, is the accelerating pace of globalization. More and more companies are seeking out the best places in the world to do business as national borders become increasingly irrelevant for economic activity. The Conference Board has referred to the phenomenon of firms taking apart their supply chains and repositioning them around the world to maximize returns as "integrative trade."

The aerospace sector is increasingly being reshaped by the process of integrative trade. Aerospace OEMs continue to reposition their supply chains across the globe, buying parts and systems from suppliers throughout the world, with the primary objective of minimizing costs and gaining market access. A consequence for parts suppliers is that proximity to OEM's assembly plants is becoming less of an advantage.

This trend has important implications for the Canadian aerospace industry. In particular, the integrative trade phenomenon has led to closer integration of OEMs and Tier 1 suppliers. OEMs are choosing Tier 1 suppliers that are able to bear a significant share of the development costs and program risk. This puts Canada at a competitive disadvantage because Canada has very few Tier 1 suppliers that are capable of funding large projects. OEMs are also looking to share responsibility for R&D and design for new aircraft platforms. This also puts the Canadian industry at a disadvantage because it lags its counterparts in other countries in terms of R&D intensity.

New security and national sovereignty concerns encompass another trend that will impact Canada's aerospace industry over the long term. The process of globalization, with all its attendant benefits, also has important security implications, especially in the form of transnational threats. In light of these new

security challenges, many governments have placed greater emphasis on defence and adjusted the mix of military equipment they employ.

Governments will increasingly turn to modern aerospace equipment to monitor and mitigate these emerging threats. For example, satellites are increasingly depended upon for the surveillance of national borders and the support of military operations, and unmanned aerial vehicles (UAVs) are being used more and more to penetrate enemy territory while minimizing casualties. As a result, the military aerospace industry will need to adapt its product lines to meet these evolving needs. The growing use of satellites could be a boon for Canada's space sector, since it has carved a niche in this area.

The issue of climate change—specifically the effects of global warming due to increasing atmospheric concentrations of human-made emissions of greenhouse gases (GHG)—is one of the most profound challenges of our time. This represents the fourth long-term trend that will affect the aerospace sector, given that the transportation sector is one of the biggest greenhouse gas contributors. Indeed, the aerospace industry will be under intensifying pressure to improve efficiency and limit or reduce its carbon footprint. The aerospace industry will respond to the threat of climate change in several ways, including turning to composite materials to reduce aircraft weight, implementing more efficient engines, using biofuels to reduce oil consumption, and moving to turboprops on short-haul flights and larger planes on longer routes.

The fifth long-term trend identified in this report is the expansion of natural resource extraction and the pressure to intensify agricultural yields to meet growing demand. The aerospace industry can play a key role in meeting this growing demand for resources and food. Satellites, UAVs, and other aircraft will be increasingly used in the search for natural resource deposits across the entire globe. Satellites will also have a role to play in improving crop yields, particularly through the growing adoption of precision farming. Again this trend is positive for the Canadian space sector, given its expertise in satellite production and services.

The sixth and final long-term trend identified in this report is the rapid expansion of global telecommunications and the widespread adoption of the internet. Thanks to the rapid growth of wireless mobile broadband, the era of a ubiquitous internet is fast approaching. The smartphone could be the fastest spreading technology in human history. Their widespread adoption, along with other mobile devices, will drive vigorous demand for mobile data services, which, in turn, will drive demand for satellite products and services. This is more good news for Canada's space sector.

Profound shifts are taking place in the aerospace industry and across the globe. The six long-term trends outlined in this report will significantly affect the aerospace industry for years to come. Canada's aerospace sector has had a long-run of success. The sector will give itself the best chance for continued success if it has a sound understanding of these long-term trends and their consequences, allowing it to meet the challenges and seize the opportunities that are sure to come.

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