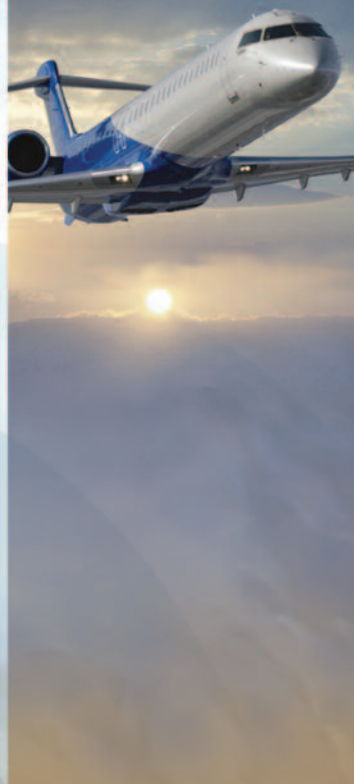
Aerospace Review

Mandated by the Government of Canada

Volume 1

Beyond the Horizon: **Canada's Interests** and **Future** in AEROSPACE

November 2012



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Cat. No. Iu44-89/2012
ISBN 978-1-100-54435-9

Printed on recycled paper:
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Beyond the Horizon: **Canada's Interests** and **Future** in AEROSPACE

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The Honourable Christian Paradis
Minister of Industry

Dear Minister,

I am pleased to submit *Beyond the Horizon: Canada's Interests and Future in Aerospace*, volume 1 of my report pursuant to the mandate given to me as Head of the Review of Aerospace and Space Programs and Policies. Volume 2, entitled *Reaching Higher: Canada's Interests and Future in Space*, focuses on the space sector.

The over-arching objective of this volume is to outline how public policies and programs can help Canada maintain and build upon its status as a global aerospace power. Relative to gross domestic product, our aerospace industry is the second largest in the world. But conditions are changing, new aerospace players are on the rise, and we will have to up our game if we want to keep our competitive edge in the global aerospace business.

I have aimed to produce a report that is evidence-based, grounded in a long-term perspective on global and industry trends, innovative, and practical. The report summarizes the Review's findings and sets out suggested policy directions. Many of the details underlying its analysis and recommendations can be found in working group reports, research reports, and submissions posted on the Review's website: **aerospacereview.ca**.

It has been an honour to serve as Review Head. I hope the advice contained in these volumes will prove helpful to the government, and thank you for the opportunity to lead the Review.

Yours sincerely,

David Emerson

Aerospace Review Head

David Emerson

Advisory Council Members

Jacques Roy

Sandra Pupatello

Jim Quick

Acknowledgements

A policy development process like the Aerospace Review requires the involvement of a large number of experts and stakeholders. The approach of the Review has been to operate to a high level of transparency, independence, and engagement with interested parties while respecting the clear mandate and timelines provided at the outset of the Review. As a result, many were called upon to provide input and support on short notice.

I am very grateful to everyone who answered that call in so exemplary a manner.

Let me begin by expressing my appreciation to the members of my Advisory Council: Sandra Pupatello, Jim Quick, and Jacques Roy. Their professionalism, positive attitude, and wise counsel made our meetings, consultations, and deliberations both productive and enjoyable. Much of what is said in this report reflects their insights and advice.

I would also like to thank the many representatives of the aerospace and space industries, research and academic communities, unions, and provincial governments who chaired or participated in working groups, attended roundtables, hosted my colleagues and me on site visits, met with us bilaterally, and sent in written submissions. I know that for all of you, these activities came on top of your day jobs, and I am grateful for your willingness to contribute your time and expertise.

Special mention must be made of the Aerospace Industries Association of Canada. The Association's board and staff were instrumental in informing aerospace and space companies about the Review and helping to organize the industry-led, multi-stakeholder working groups whose discussions and recommendations have been so important to the Review.

I am appreciative of the willingness of business people, researchers, and government officials in other countries to meet with my colleagues and me during fact-finding trips abroad, and to speak frankly about their own plans and challenges.

The Review also benefited tremendously from information and ideas offered by Canadian public servants from a wide range of departments and agencies in the context of briefing sessions, working groups, and site visits.

Finally, my thanks to the Aerospace Review Secretariat under the leadership of Scott Streiner. The Secretariat provided outstanding support and advice over the intense 11-month period from the initial preparations for the Review to the release of this report. Producing a public policy product covering such a wide range of issues and points of view, and doing so on time and on budget, has been a remarkable achievement.

Having identified many of those whose contributions made the Review possible, let me conclude by emphasizing that I take full responsibility for the findings and recommendations in both volumes of the report.

David Emerson

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Note on data sources

Data in this volume come from multiple sources, including Statistics Canada, Industry Canada, the Aerospace Industries Association of Canada, the Organisation for Economic Co-operation and Development, and reports by various aerospace companies and by consulting firms such as Deloitte.

Unless otherwise indicated, figures in this volume apply exclusively to the aerospace sector as defined on page 5, while figures in the companion volume apply exclusively to the space sector.

Some statistics only became available during the period the Review was under way, and may vary from numbers cited in the past that were produced using different methodologies. For example, new estimates of research and development spending and employment levels in the aerospace industry were generated in summer 2012 by Industry Canada on the basis of Statistics Canada data.

Executive summary

Canada is among the leading aerospace nations in the world. Its aerospace industry is the fifth largest, and the second largest relative to the size of the economy.

The industry generates $22 billion in annual revenues, employs a workforce of 66,000, exports 80 per cent of its output, and is the second most research-intensive industry in Canada. It includes the world's third largest commercial aircraft manufacturer, Bombardier, and a wide range of global leaders in everything from helicopters to landing gear, simulators to engines, and aerostructures to maintenance and repair services. It is a strategic sector in every sense of the term.

Yesterday's achievements, however, are no guarantee of tomorrow's success. The conditions that prevailed over the last several decades are being replaced by new and fundamentally different global trends that are dramatically changing the competitive landscape.

The aerospace business is being reshaped by ascendant powers ready to use the resources and influence of the state to build national aerospace industries. These countries' actions create a whole new set of challenges for Canada's aerospace firms.

At the same time, the aerospace supply chain has globalized, as manufacturers such as Boeing, Airbus, and Lockheed Martin shop the world for systems and components, reduce the number of suppliers with which they are prepared to deal, and require these suppliers to invest in the research and design of systems that meet their performance specifications. A new aircraft takes years to develop and bring to market and it can remain in service for decades. A company that is frozen out of a supply chain today can lose sales and opportunities for decades.

Defence expenditures among Canada's closest allies are shrinking, and with them markets for Canadian military aerospace products. Civil and military maintenance, repair, and overhaul (MRO) activities – which have fuelled a robust aerospace MRO sub-sector in Canada – are increasingly being retained by manufacturers in pursuit of superior profit margins in "after sales service." Meanwhile, the highly skilled workforce that has been the backbone of Canadian aerospace is aging, raising the spectre of critical skills shortages.

Of course, fundamental shifts also create new opportunities. The market for fuel-efficient aircraft that address environmental and commercial concerns is strong. As the North opens to more transportation and resource extraction, there is a need for aircraft that can fly long distances in harsh and frigid conditions to help locate and develop natural resources, support environmental stewardship, supply communities and facilities far removed from southern population centres, and respond to emergencies. And as security concerns shift to non-conventional threats, there is demand for airborne technology that can provide ever more sophisticated surveillance and the capability to strike with surgical precision.

The Canadian aerospace sector is therefore at a critical juncture, the urgency of which occasioned this Review of aerospace-related policies and programs. If the sector is to continue to thrive and to benefit the country as a whole, all players – companies, academic and research institutions, unions, and governments – must understand and adapt to changing realities. Success depends on developing the technologies of tomorrow and securing sales in a highly competitive global arena.

Private aerospace companies will ultimately drive competitive leadership in the new global economy. But thoughtful, focused, and well-implemented public policies and programs can play a critical role in facilitating this success, by encouraging aerospace innovations involving enormous financial risk and long timelines; improving industry's access to global markets and supply chains; leveraging government procurements to support industrial development; and helping to build a skilled, adaptable workforce.

This volume recommends that:

1. The list of strategic sectors under the government's Science and Technology Strategy be expanded to include aerospace and space.
2. The government establish a list of priority technologies to guide aerospace-related policies and programs.
3. The government create a program to support large-scale aerospace technology demonstration.
4. The government maintain Strategic Aerospace and Defence Initiative (SADI) funding at current levels – less reallocations recommended in this volume and the companion volume on the space sector – and modify SADI's terms and conditions to make it a more effective program for stimulating the development of the aerospace and space technologies of the future.
5. The government co-fund a Canada-wide initiative to facilitate communication and collaboration among aerospace companies, researchers, and academics.
6. Application and reporting procedures for programs used by the aerospace industry be simplified and streamlined, especially for smaller companies seeking modest levels of support, and a "one-stop" internet portal be used to provide information on, and links to, those programs.
7. The government endeavour to bring emerging aerospace players into multilateral agreements that create fair, competitive conditions for Canadian aerospace firms, and to clarify rules related to government support for domestic aerospace industries.
8. The government negotiate bilateral agreements with countries where potential market and partnership opportunities are likely to benefit Canada, and the Canadian aerospace and space sectors.
9. Senior-level economic diplomacy be used in a considered and explicit way to encourage foreign governments and companies to give favourable consideration to Canadian aerospace products.
10. The government review export and domestic control regimes to ensure that they are not unnecessarily restrictive and that export permits be issued expeditiously.
11. The government implement a full cost-recovery model for aircraft safety certification.
12. The government co-fund initiatives aimed at strengthening the Canadian aerospace supply chain.
13. When the government seeks to purchase aircraft and aerospace-related equipment, each bidder be required to provide a detailed industrial and technological benefits plan as an integral part of its proposal, and these plans be given weight in the selection of the successful bid.
14. When the government seeks to buy aircraft and aerospace-related equipment, each bidder be required to partner with a Canadian firm for in-service support and to provide that firm with work and data that allow it to strengthen internal capacity and access global markets.

15. Federal programs be used – in collaboration with industry, academia, unions, and provinces – to promote science, technology, engineering, and mathematics studies generally, and aerospace and space careers specifically, among youth; to help college and university students acquire relevant expertise; to bridge new graduates into the aerospace and space workforces; and to bring skilled aerospace and space workers from abroad when efforts to develop labour supply in Canada do not keep up with demand.

16. Mechanisms be developed to support the efforts of aerospace companies to keep their workforces technologically adept and adaptable through continual up-skilling.

17. The government co-fund – with industry, provinces, and academic and research institutions – the purchase and maintenance of up-to-date infrastructure required for aerospace training and research purposes.

These recommendations are practical, fiscally neutral, and fall squarely within the responsibilities of government in a free market economy. They do not substitute the government's judgment for that of the private marketplace, nor the public's money for that of private investors. But they do improve clarity of purpose, remove impediments to performance, and encourage collaboration and partnership. If implemented, they will create conditions for the aerospace sector's success, reducing areas of vulnerability and allowing Canadian companies to take better advantage of opportunities in the global marketplace.

In an international economic environment where change has been breathtakingly rapid, the greatest risks are posed by complacency, and failure to adapt. Inertia would place in jeopardy one of the country's most important industrial sectors and along with it, the critical economic, technological, and security benefits that flow from a healthy and competitive aerospace sector.

Review mandate and process

Canada is among the global leaders in the aerospace business. Its aerospace industry is the fifth largest in the world in absolute terms – behind the United States, France, Germany, and Britain, and ahead of Japan, Russia, Brazil, and China – and the second largest when measured against the size of its national economy, behind only the United States.

The structure of the aerospace industry

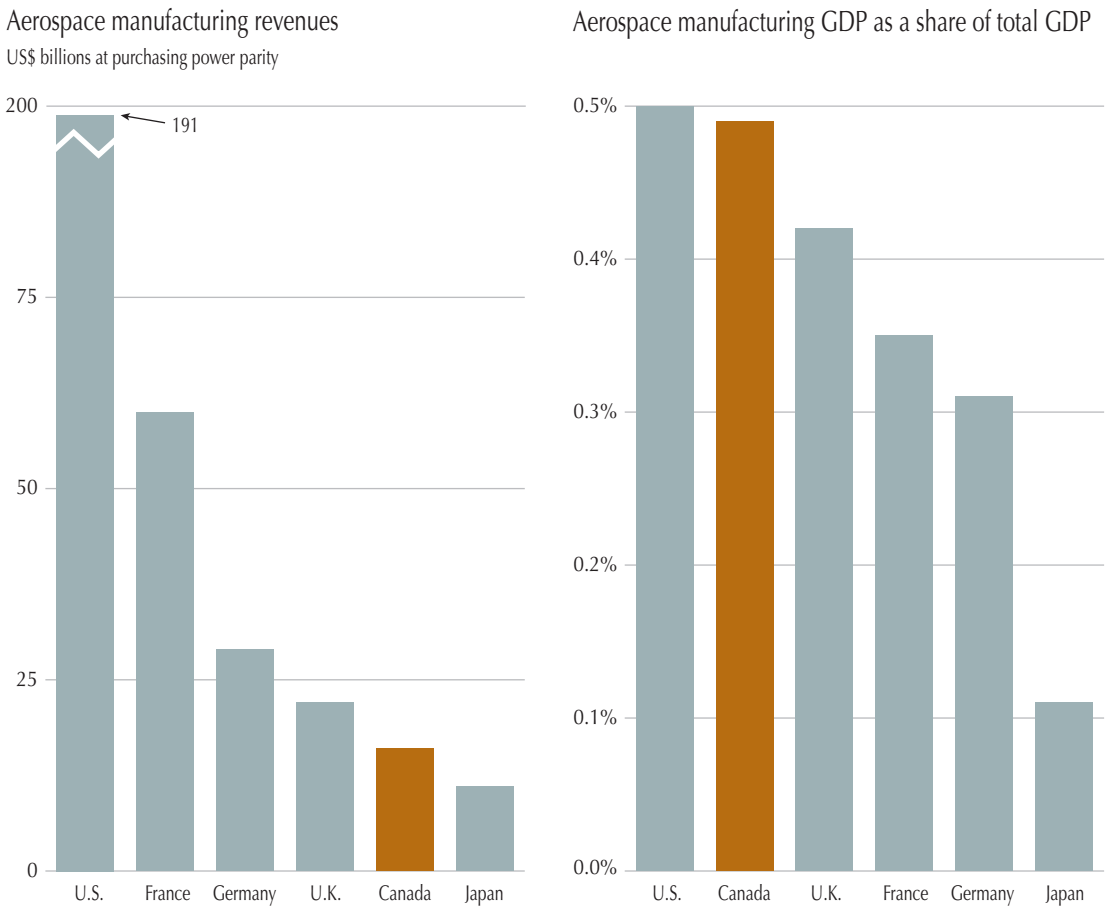
For the purpose of the Review, the aerospace industry is composed of three segments:

- *Civil aerospace includes the design, manufacturing, and sale of commercial and recreational aircraft, related systems and parts, and civil flight simulators.*
- *Military aerospace includes the design, manufacturing, and sale of aircraft used by the armed forces, related systems and parts, and military flight simulators.*
- *Maintenance, repair, and overhaul (MRO) includes services such as upkeep, repairs, refurbishment, equipment upgrades, and modifications, for both civil and military aircraft.*

Airline operations (except for their MRO divisions) and airports were not included in the Review's mandate.

This success has been of tremendous benefit to the country's wealth, security, and international standing. And it is becoming even more important in an era when technological innovation and diversification are critical to Canada's long-term prospects.

Figure 1: The world's top aerospace powers, by revenues and by production-to-GDP ratios – 2010



Source: OECD.
OECD = Organisation for Economic Co-operation and Development

Source: OECD.
GDP = gross domestic product

Changing global conditions, however, mean threatening competitive challenges even as they present new opportunities. In this more demanding and rapidly changing environment, Canada's aerospace sector requires well-designed public policies and programs to meet the challenges and leverage the opportunities.

Canadian governments have long devoted attention to the aerospace sector, motivated by its role in creating high-quality jobs and technological innovations, and the substantial direct and indirect benefits generated as a result. Government involvement has also reflected an understanding that the development of aerospace products is a complex, large-scale endeavour that demands exceptionally large investments of resources and time – investments that have frequently involved the public and private sectors sharing risks and rewards and capturing substantial potential benefits for the country. And Canadian governments' willingness to engage has been a practical response to a world in which other governments routinely invest significant sums in their own aerospace industries through a myriad of measures, some visible, others less so.

But recognizing that a sector has strategic importance does not mean the policies and programs designed to support it should be shielded from scrutiny. In fact, it is more critical than ever that those policies and programs perform at the highest level in response to evolving circumstances – fostering innovation and helping to position the industry to compete in global markets.

Against this backdrop, the government announced that it would initiate "a comprehensive review of all policies and programs related to the aerospace/space industry to develop a federal policy framework to maximize the competitiveness of this export-oriented sector and the resulting benefits to Canadians."[1]

The Aerospace Review was formally announced on February 27, 2012. David Emerson was appointed Review Head, and was joined by a three-person Advisory Council comprising Sandra Pupatello, Jim Quick, and Jacques Roy.

From the outset, a commitment was made to a review that would be independent, evidence-based, grounded in a long-term perspective on global and industry trends, open to innovative but practical approaches and solutions, and aimed at producing concrete, fiscally neutral recommendations. This volume provides the Review's findings and advice with respect to the aerospace sector; a companion volume covers the space sector.

In conducting its research and analysis, the Review relied on four streams of information and advice.

First, working in close consultation with the Aerospace Industries Association of Canada, it established industry-led working groups in the following areas:

- technology development, demonstration, and commercialization;
- market access and market development;
- aerospace-related public procurement;
- small business and supply chain development;[2]
- people and skills; and
- space.

The working groups brought together representatives of industry, academic and research institutions, and unions, as well as federal government officials participating as observers. The working groups were given specific mandates, including questions for consideration, and each held a series of discussions that led to the preparation of reports with findings and advice to the Review Head. While working group chairs and vice-chairs were not obligated to achieve consensus, they were encouraged to strive for the widest possible agreement among participants and to ground their counsel in sound evidence and analysis.

Second, the Review Head and Advisory Council members conducted a series of roundtables, meetings, and site visits in Canada and major aerospace nations. Domestic meetings were aimed primarily at understanding the state of the Canadian industry and its views on which policies and programs have been working well or falling short. International meetings were aimed at learning about best practices in other countries with vibrant aerospace and space sectors, and assessing both emerging competitive challenges and opportunities for increased collaboration and market success.

Travelling mainly as a group, the Review Head and Advisory Council members visited Montreal, Toronto, Winnipeg, Vancouver, and Halifax. Travelling for the most part individually, they visited the United States, the United Kingdom, France, Germany, China, Japan, Russia, and Brazil.

1 Government of Canada, *Budget 2011: The Next Phase of Canada's Economic Action Plan*, (Ottawa: Public Works and Government Services Canada), 2011. **budget.gc.ca/2011/home-accueil-eng.html**

2 This working group ultimately submitted two separate reports: one on small businesses and one on supply chain development.

Third, the Review commissioned 16 studies from independent experts (see Appendix A) on a range of topics, including the impact of global trends on Canada's aerospace sector; various countries' strategies for facilitating the success of their aerospace industries; export control regimes in Canada and abroad; the financing needs of small and medium-sized aerospace companies; and options for dealing with the impacts of cyclicality on the aerospace industry's highly skilled workforce.

Finally, the Review invited written submissions (see Appendix B) from interested parties through its website, ultimately receiving some 25 documents from a variety of organizations, companies, academics, and private citizens.

Most of the material and analysis generated through these four streams of information and advice are available through the Review's website (**aerospacereview.ca**) and, it is hoped, will continue to serve for some time as an important source of information and ideas for those interested in the shape and future of the aerospace and space sectors.

Drawing on all four streams, the Review examined current conditions and long-term trends, and considered the roles and perspectives of all players.

The Review's analysis was guided in part by the principle that in a market economy, industry has the primary responsibility for its own fate and the role of government must be carefully delimited. Public policies and programs can foster conditions that help companies thrive – which is good for owners, employees, shareholders, and the national economy – but they are not a substitute for business acumen and entrepreneurship.

The role of government in supporting Canadian industry is concentrated in a number of key areas:

- Supporting research and development (R&D) that might take years to produce marketable results but has the potential to generate substantial benefit to the public good, in part through risk-sharing.
- Improving the functioning of markets and business performance by facilitating communication between firms whose needs and capacities may be complementary – both in Canada and abroad – and between industry and academic and research institutions.
- Making procurement decisions that strengthen domestic industries, and therefore the national economy, while respecting international trade rules and acquiring the best product for a reasonable cost.
- Protecting the public – and the industry – by ensuring that Canadian products are safe and that sensitive technologies do not fall into the hands of hostile states or interests.
- Improving labour market efficiency by supporting vibrant academic institutions that understand the needs of industry and by facilitating recruitment of talent from abroad where serious domestic skills shortages exist.
- Levelling the global playing field for Canadian companies by negotiating equitable rules of the game, ensuring that these rules are respected in practice, and providing companies with information about foreign markets.
- Providing financing to support the purchase of Canadian products, as long as the terms of such financing produce a benefit to taxpayers and the economy, and fall within the bounds of international agreements.

Delineating clear boundaries for the role of government is sound economic policy. It is important, however, that Canada not be shy or half-hearted about making full use of the tools available within these boundaries. Around the world, the aerospace business is conducted within an elaborate framework of support, regulation, and incentive, which can sometimes be as pivotal to corporate success as engineering ingenuity and marketing savvy. Canadian aerospace companies face competitors whose governments are determined to build national industries by investing heavily and employing a range of measures in support of their domestic firms. Canada need not and should not adopt all the same approaches, but to compete globally in aerospace, we will have to respond to what other nations are actually doing.

If the government is fully engaged and acts with foresight and focus, Canada's aerospace industry can improve its position, with significant benefits for national security and overall economic and environmental performance. Failure to respond and adapt to changing global circumstances will not mean maintenance of the status quo but rather, steady decline, significant lost opportunities, diminished industrial and innovative capacity, fewer rewarding jobs in advanced manufacturing, and the gradual eclipse of an industry that has been a major contributor to the country's well-being.

Context

Chapter 2.1
Canada's aerospace industry: past and present

Few human achievements are as technologically sophisticated and exhilarating as flight, and few have so profoundly affected how people live, do business, and protect national territory.

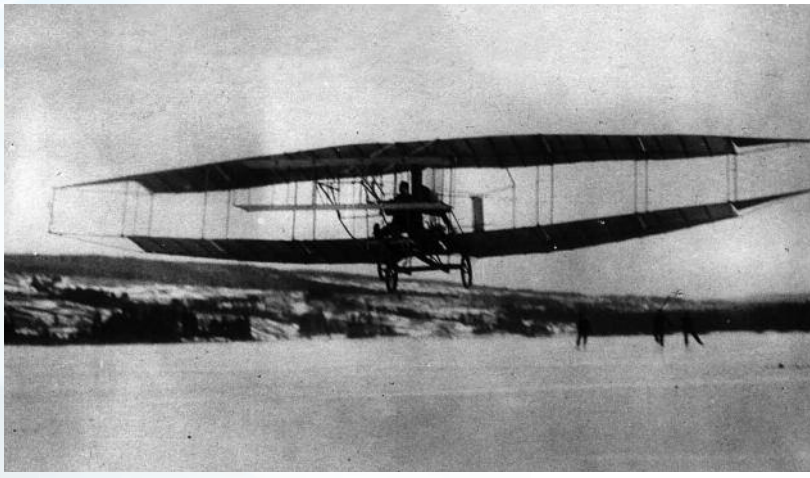
In Canada, throughout the 1890s – the decade before the Wright brothers' success at Kitty Hawk on December 17, 1903 – Alexander Graham Bell had turned his genius to experimenting with kite designs as the most stable structure for an aircraft one could both power and steer, employing the young women and men of Baddeck, Cape Breton, as seamstresses, machinists, pulley operators, and photographers in his nascent aviation industry.

By 1907, Bell had formed the Aerial Experiment Association, a Canadian-American research collaboration. The team designed and built the Silver Dart, which first flew in early 1909 in Hammondsport, N.Y., and then on February 23, 1909, from the frozen surface of Baddeck Bay, making it the first piloted, powered flight of an aircraft in Canada and the British Empire. From its earliest days, the aerospace industry in Canada was a competitive but collaborative enterprise, pioneering the most advanced new technologies in international partnership, and creating employment for skilled workers – indeed, creating new skills – in anticipation of commercial application and reward.

Subsequently, industrial manufacturing in Canada was allied to interests of the industrial powers, first Great Britain and later the United States, and often undertaken in branch plants of British and American companies.

In 1938, the Canadian aerospace industry employed about 4,000 workers and produced 40 planes a year. The Second World War massively expanded Canadian aircraft manufacturing. At the peak of wartime production, the industry employed some 120,000 men and women and produced 4,000 aircraft a year.

Silver Dart



J. A. D. McCurdy pilots the Silver Dart over Baddeck Bay in the first airplane flight in Canada, February 23, 1909.
Source: National Film Board of Canada.

The government formed two Crown corporations to coordinate the war effort, taking over National Steel Car as Victory Aircraft and Canadian Vickers as Canadair. Following the war, both these corporations were privatized, and the Canadian industry began to demonstrate its own design and development expertise.

Avro Aircraft Ltd. designed and produced the first North American passenger jet, the Jetliner, which flew in 1949 only 13 days after the maiden flight of the British de Havilland Comet, the world's first commercial passenger jet – though Avro's Jetliner never went into production as the company was directed by the Canadian government to concentrate its resources on producing the domestically designed CF-100 Canuck all-weather military interceptor. De Havilland Canada, meanwhile, specialized in small aircraft particularly suited to transport in the Canadian bush, producing the Beaver in 1947 and the Otter in 1951.

1950s de Havilland Twin Otter and the modern Viking Twin Otter

Legacy Twin Otter during the early days of de Havilland development.
Source: Viking Air.

Series 400 Technical Demonstrator, Viking Air.
Source: Viking Air.

Most famously, in the mid-1950s Avro committed itself to the design and production of the CF-105 Arrow. In 1959, as a result of the government policy decision to purchase defence matériel "off the shelf" from foreign, mainly U.S., manufacturers, the Arrow project was cancelled. To compensate, the Canadian government negotiated improved access to U.S. defence markets for Canadian aerospace companies, and introduced the Defence Industry Productivity Program, which provided funds to assist Canadian firms in exploiting this new access.

With the shift away from original designs for defence contracts, the Canadian aerospace sector repositioned itself toward production for civil aviation. Pratt & Whitney Canada designed and manufactured the PT6 turboprop engine, which powered de Havilland's new Twin Otter. Canadair mainly produced jets for the Canadian military under licence from the United States, but also designed the CL-215 water bomber for use in fighting forest fires.

Other elements of the Canadian aerospace sector of the 1960s were also integrated with the U.S. aerospace industry. For example, Boeing established a parts production plant in Winnipeg. But a global recession in the early 1970s threatened the two largest Canadian aerospace manufacturers, de Havilland and Canadair, with closure.

With no other buyers interested, the federal government purchased them both – de Havilland in 1974 and Canadair in 1976 – rather than forfeit the companies' expertise, potential, and manufacturing capacities, and began operating them as Crown corporations. To become profitable, each company identified a niche market in civil aviation, Canadair embarking on the design of the Challenger executive jet and de Havilland developing the Dash 7 and Dash 8 turboprop commuter planes.

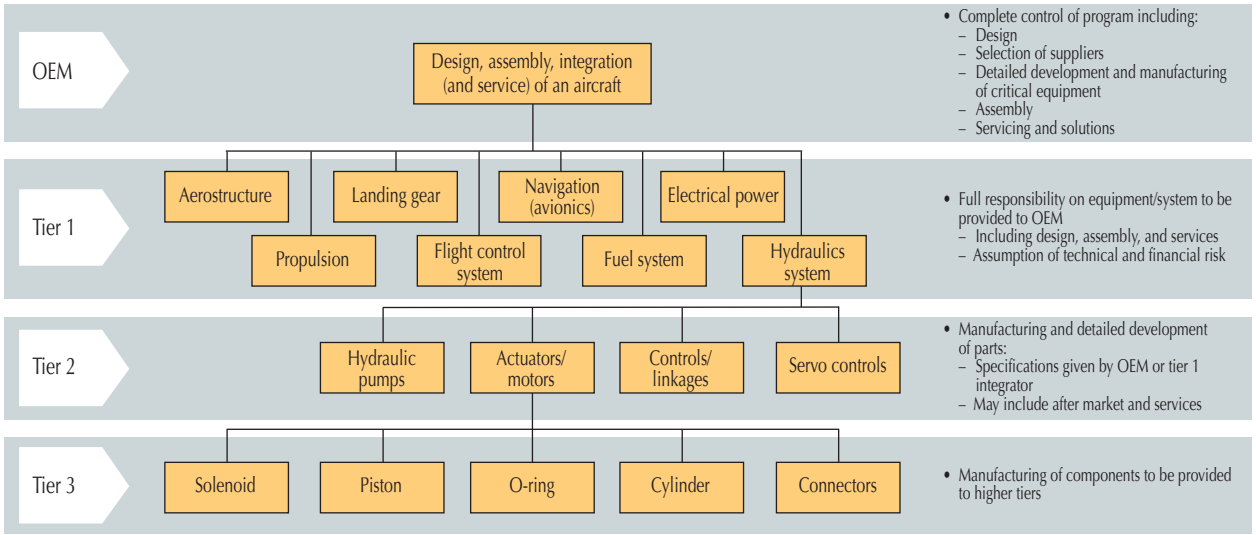
The government purchase of a fleet of CF-18 Hornet fighters in 1980 buoyed the Canadian aerospace sector. Maintenance of the fleet was awarded to a consortium of firms headed by Canadair. General Electric, which built the plane's engine, established a parts manufacturing plant in Quebec, and scores of other Canadian companies benefited from the purchase in ways far removed from the procurement itself.

In 1986 both de Havilland and Canadair were privatized. Boeing bought de Havilland. Bombardier – at the time a Canadian firm specializing in ground transport vehicles such as trains and snowmobiles, and with no previous experience in aerospace – purchased Canadair.

In 1990 Bombardier announced it would design and build a regional transport jet, which resulted in its hugely successful CRJ line of aircraft. In 1992, it acquired de Havilland from Boeing, adding the company's turboprop planes to Bombardier's lines. In July 2008, it announced the launch of the CSeries, a long-range, 100-149 passenger aircraft that would compete with the smaller passenger jets manufactured by Boeing and Airbus.

Today, Canada's 700 aerospace companies generate $22 billion in annual revenues, export 80 per cent of their output, commit $1.6 billion a year to research and development, and directly employ 66,000 people, most of whom are highly skilled and educated. According to some analyses, approximately 92,000 additional jobs are generated in Canada by the aerospace sector's demand for everything from advanced metal alloys to electrical systems to training. Production is primarily oriented to the commercial market: 77 per cent of Canadian industry revenue comes from sales for civil use, compared with 46 per cent for the global industry. The aerospace manufacturing industry has a small set of very large players, with the top 19 firms representing 87 per cent of sales; in fact, Bombardier alone represents about 37 per cent of sales. The industry is home to a limited number of tier 1 system integrators, and some 670 small and medium-sized enterprises (SMEs), which are integrated into local and global supply chains.

Figure 2: Tier structure of the Canadian aerospace industry for the production of an aircraft

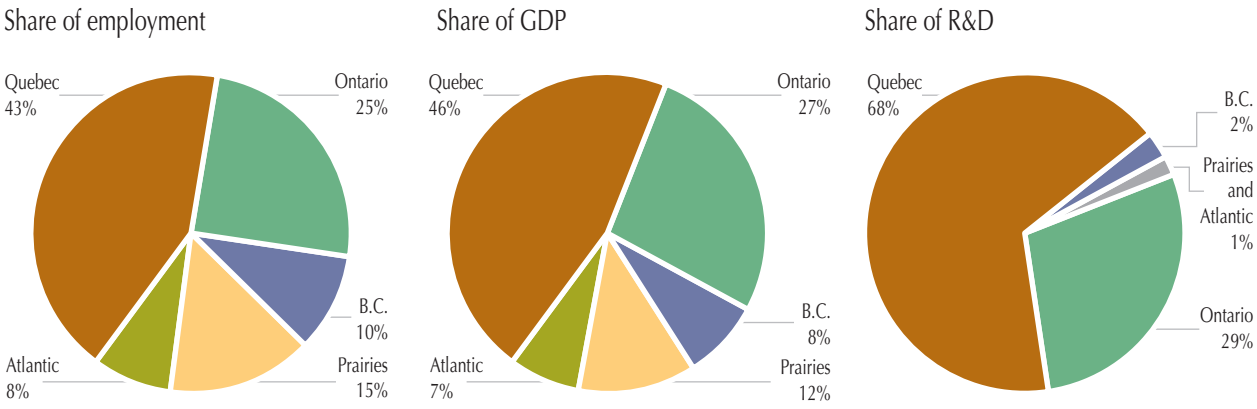


Source: Adapted from PricewaterhouseCoopers, *Globalisation in Aerospace and Defence,* January 30, 2008.

For more information regarding the aerospace industry's tier structure and examples of Canadian companies within each tier, please refer to the *Final Report of the Supply Chain Working Group,* "Structure of Aerospace Industry in Canada."
OEM = original equipment manufacturer

Geographically, the industry is concentrated in a number of regions. Montreal's aerospace cluster – which brings together a wide range of firms and academic and research institutions – is the third largest in the world and accounts for about half of all Canadian aerospace manufacturing employees. Indeed, Montreal, Toulouse, and Seattle stand apart from all other aerospace centres in terms of their sheer scale. The Canadian industry also has a strong presence in the Toronto region, and a smaller but still significant footprint in Winnipeg, Vancouver, and Atlantic Canada.

Figure 3: Regional distribution of Canadian aerospace activity – 2010



Source: Based on data from Statistics Canada.

Note: Values may not sum to 100% because of rounding.
GDP = gross domestic product R&D = research and development

Several Canadian-headquartered aerospace companies are global leaders in their markets. Bombardier is the third largest commercial aircraft manufacturer in the world, behind Boeing and the European Aeronautic Defence and Space Company (EADS), parent company of Airbus. CAE is dominant in the production of flight simulators and the provision of flight training services. Héroux-Devtek competes globally in the production of landing gear systems. Viking Air produces and maintains contemporary versions of historic de Havilland aircraft. And Magellan, Avcorp, and Noranco are providers of complex aerostructures to major aircraft manufacturers.

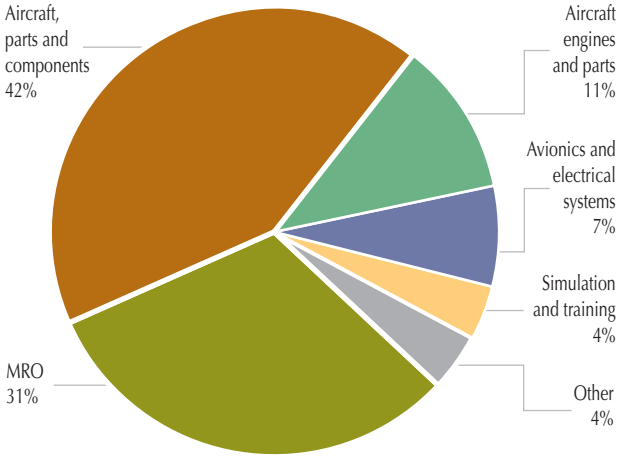
Every second, a Pratt & Whitney Canada-powered aircraft takes off or lands somewhere in the world. There are currently more than 49,000 Pratt & Whitney Canada engines in service on more than 28,000 aircraft operated by some 10,000 operators in 200 countries.

Canada's recognized aerospace prowess, unique position between the United States and Europe, stable business climate, and respect for diversity have enabled it to attract significant direct investment by major foreign-owned companies. Pratt & Whitney Canada, a leader in the design and production of aircraft engines, is a subsidiary of U.S.-based United Technologies Corporation (UTC). GE Aviation and Rolls-Royce have Canadian operations that support their global aircraft engine businesses. U.S.-based Textron established Bell Helicopter Textron Canada, a company that produces virtually all of Bell's commercial helicopters. General Dynamics Canada provides electronics and system integration to aircraft manufacturers, and Honeywell Canada supplies environmental control systems. Goodrich (now owned by UTC) has a Canadian facility that designs and produces landing gear. Messier-Bugatti-Dowty, which designs and manufactures landing gear systems, is owned by France's Safran. Esterline CMC Electronics and Thales Canada are leaders in the avionics sector, and are owned, respectively, by American and French parent companies. ASCO, headquartered in Belgium, designs and manufactures a variety of aircraft components at its Delta, B.C. facility. Eurocopter, owned by EADS, has a helicopter manufacturing facility in Fort Erie. Mitsubishi Heavy Industries has recently made a significant investment in Mississauga, and EADS/Aerolia has announced plans for a new facility in Montreal.

Bell 429 helicopter

Bell 429 helicopter manufactured in Mirabel, Quebec.
Source: Bell Helicopter Textron Canada.

Figure 4: Canadian aerospace revenues by sub-sector – 2011



Sources: Based on data from the Aerospace Industries Association of Canada and Statistics Canada.

Note: Values may not sum to 100% because of rounding.
MRO = maintenance, repair, and overhaul

The Canadian aerospace industry has benefited tremendously from the establishment of local subsidiaries by firms from abroad, and its vibrancy can be enhanced by additional foreign direct investments, particularly in areas where the sectoral structure needs to be strengthened, such as tier 1 capacity.

In addition to a strong manufacturing industry, the Canadian aerospace sector has a record of achievement in the civil and military maintenance, repair, and overhaul (MRO) business. The MRO segment includes a mix of independent service providers, such as StandardAero, Cascade, Vector, L-3 MAS, Provincial Aerospace, IMP Aerospace and Defence, Field Aviation, and Kelowna Flightcraft; aircraft systems manufacturers with MRO operations, such as Héroux-Devtek and Pratt & Whitney Canada; and aircraft operators with MRO divisions, such as Air Georgian, Harbour Air, and Discovery Air.

The industry, in all its sub-sectors, draws engineers and skilled workers from universities and colleges across Canada – some 30 of which have departments and programs dedicated specifically to aerospace – and has one of the most highly skilled and productive workforces in the world. Wages in the industry are relatively high: the average salary for all employees in aerospace manufacturing is about $63,000, while the average across all manufacturing sectors is $51,000.

The Canadian aerospace sector, then, has a long and impressive history, and is today not only one of Canada's proudest accomplishments – an emblem of what this country and its people are capable of – but also an engine of technological innovation and economic growth. However, the industry was built in a time when there was a limited number of competitor nations, when Canadian companies enjoyed significant technological leads over foreign firms, and when our geographic proximity and relationship with the United States were a distinct advantage that could be readily leveraged.

All that has changed, and changed rapidly. New market and production realities lend urgency to efforts to advance the competitiveness of the Canadian aerospace sector. For Canada to remain an aerospace power, the government must move with focus and determination to modernize policies and programs. That done, industry, researchers, and others must step up.

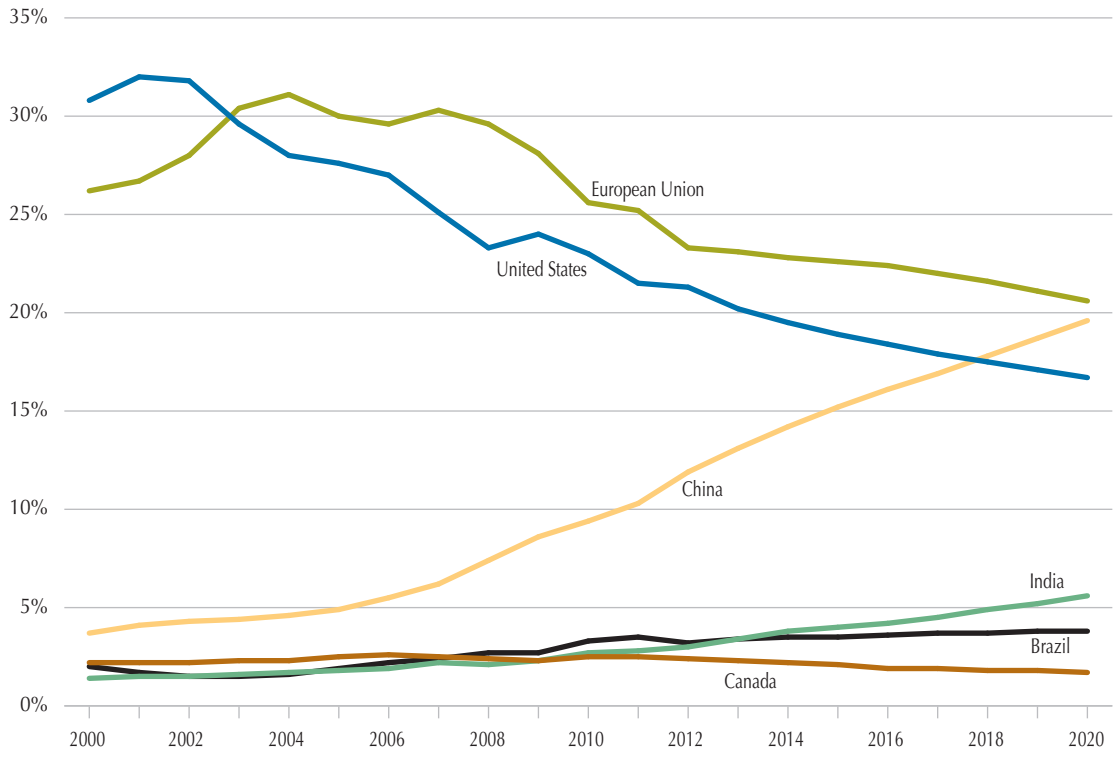
Chapter 2.2
Global trends

The Canadian aerospace industry is subject to rapidly evolving global conditions that will affect market and production realities for the next 20 to 30 years. To ignore these factors, or to respond to them inadequately or belatedly, is to place our industry and its contributions to Canada's wealth and security at risk.

The most important trends include:

- *Global rebalancing.* We are witnessing a rapid rise in the economic and geopolitical power of regions and countries other than those that dominated during the second half of the 20th century. North America, Europe, and Japan are being joined by China, Russia, Brazil, India, and other rising powers across Asia, the Middle East, Latin America, and Africa. Many of these countries are populous, geographically large, geopolitically ambitious, and willing to use state power and resources to build sectors considered to have strategic importance.

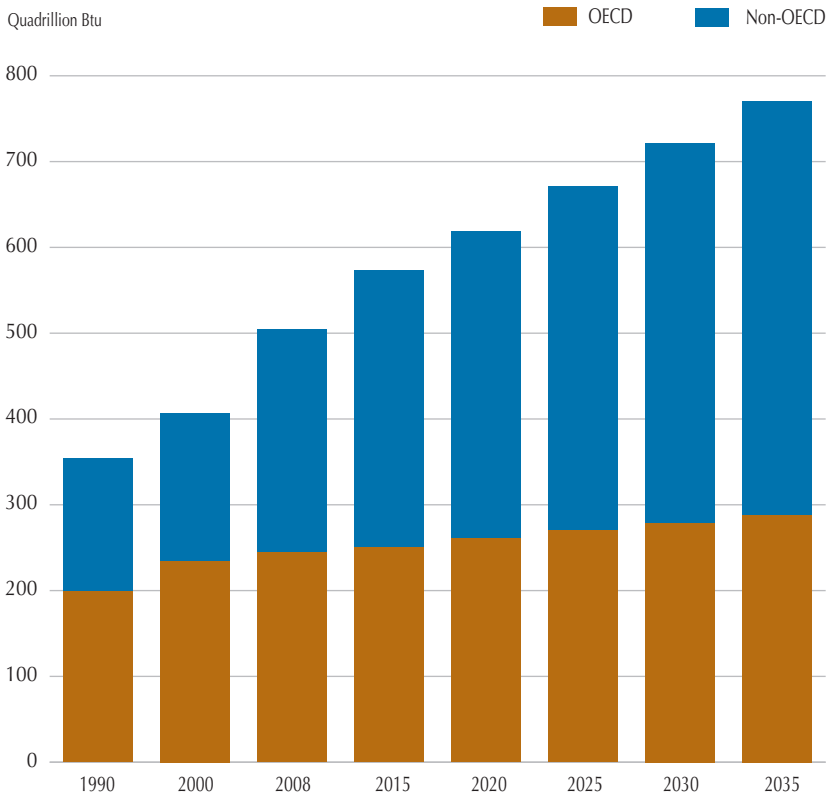
Figure 5: Share of world GDP – 2000 to 2020



Source: IHS Global Insight.
GDP = gross domestic product

- *The hunger for natural resources and agricultural production.* As hundreds of millions of people move from a rural, subsistence existence to more urban, middle-class lifestyles, there are significant increases in the demand for fuel, the raw materials from which consumer goods are manufactured, water, and food.
- *Climate change and environmental concerns.* Rising concern about the effects of climate change and other environmental issues – including air quality and noise pollution – are driving changes in consumer behaviour, regulatory agendas, and corporate conduct around the world.

Figure 6: World energy consumption – 1990 to 2035

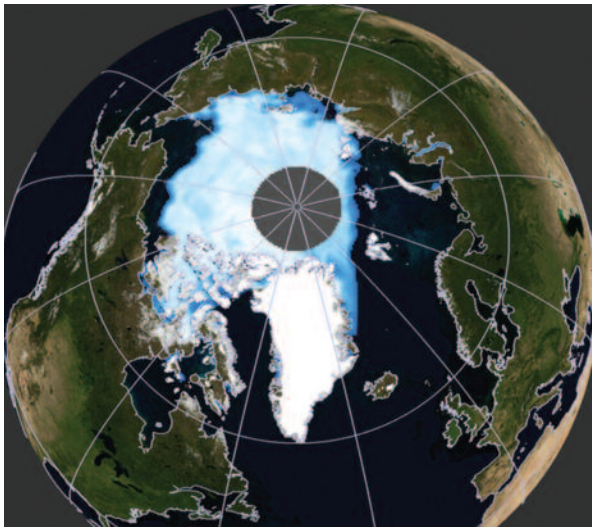


Source: U.S. Energy Information Administration.
OECD = Organisation for Economic Co-operation and Development

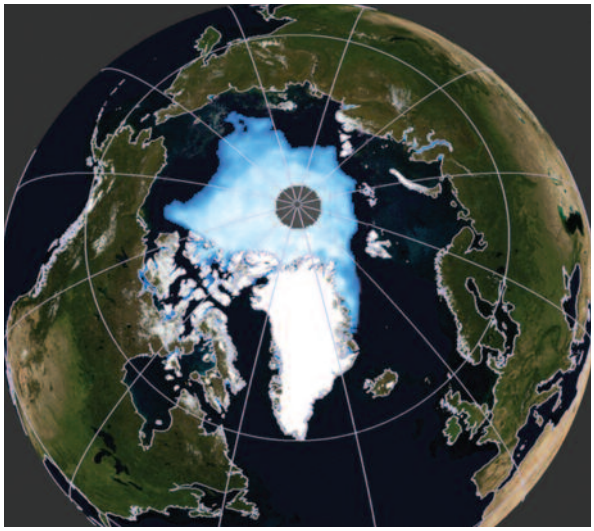
Decrease in Arctic sea ice, 1979 and 2011

Sea ice extent

September 1979 (7.2 million km^2)



September 2011 (4.6 million km^2)



Source: Adapted from an image by Matt Savoie, National Snow and Ice Data Center, University of Colorado, Boulder, using SSM/I data overlaid onto the NASA Blue Marble.

- *The decline in defence expenditures and advent of non-conventional security threats.* In a climate of fiscal restraint, Western countries are reducing defence budgets while national security planners focus increasingly on managing non-conventional threats as well as the risks of traditional war.
- *The digital revolution.* We are in the middle of an epochal communications transformation driven by exponential increases in computing power, the advent of wireless technology, and an explosion of social media. The economic, social, and political impacts are already profound – and they are just beginning.
- *An aging population.* Shifting demographics are creating new challenges – and necessitating new strategies – for companies that rely on a highly educated, highly skilled workforce.

These trends have significant implications for the global and Canadian aerospace industry.

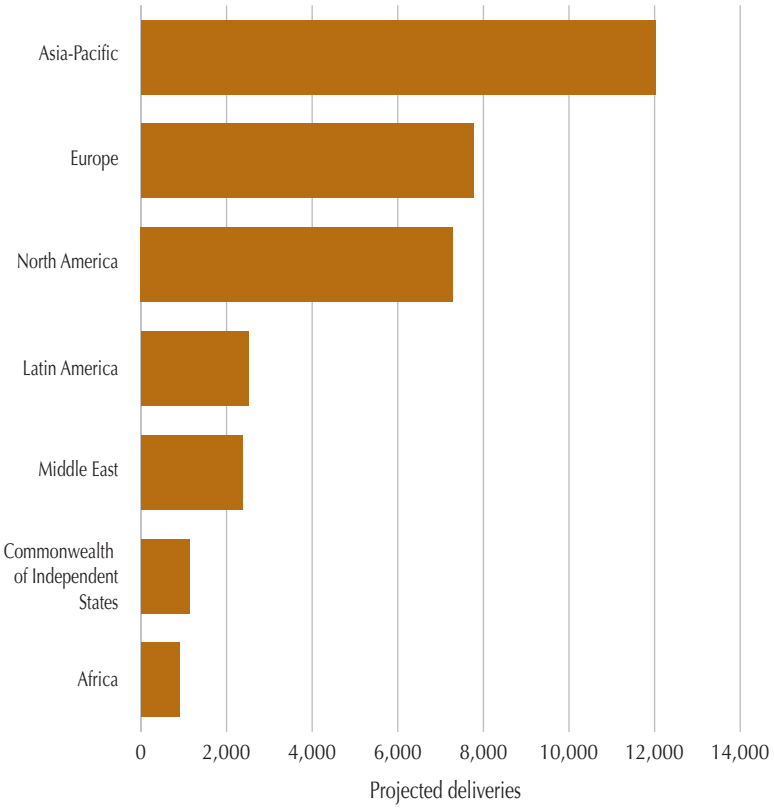
Global rebalancing has accelerated the globalization of the industry itself. Although neither an entirely new phenomenon nor one restricted to aerospace, transnational production chains – where systems and components are built on many continents and brought together for assembly at one of several sites – have gone from novelty to norm as new entrants have established increasingly advanced manufacturing bases. In part, the globalization of aircraft production reflects a simple competitive imperative, with aircraft manufacturers shopping the world for suppliers offering the most technologically advanced products at the best prices. But it also reflects market access considerations, as local production can sometimes be an advantage – if not a prerequisite – for a firm hoping to make sales in growing markets.

And markets are growing, notwithstanding global economic uncertainty. According to Boeing's forecasts, approximately 34,000 new commercial planes worth $4.5 trillion will be required by airlines over the next two decades. Half of these sales will take place in the emerging markets of Asia – particularly China and, to a lesser extent, India – the Middle East, and Latin America. In all these regions, increasing wealth will fuel strong growth in business, leisure, and cargo air traffic.

Ascendant nations are not content just to be parts suppliers for, and customers of, the global aerospace business; they are determined to become aerospace powers themselves, and have invested massively in their industries to make this happen. This means additional competition for established aerospace nations. These new players benefit from comparatively low domestic production costs and are rapidly catching up to Western companies in terms of technological sophistication. Russia, for example, is making the Superjet 100, an aircraft in the regional jet market segment that Bombardier and Embraer currently dominate, while China's similarly sized ARJ21 is expected to enter into service in late 2013. Both projects have faced technical issues and delays, but Russia and China have redoubled their efforts, and each will roll out additional models over the next two decades. Other nations, from Ukraine to Mexico, are also making concerted bids to build their own planes or secure a position at the high-value end of global aerospace supply chains.

In short, for established aerospace powers like Canada, global rebalancing means new customers, new partners, and new competitors. This has created a more complex, dynamic market and production environment with a new and different set of risks and potential rewards.

Figure 7: Projected global deliveries of commercial airplanes, by region – 2012 to 2031



Source: Boeing, *Current Market Outlook 2012-2031.*

Note: Commercial airplanes include large, twin-aisle and single-aisle airplanes, regional jets and freighters, but exclude business jets and turbo props.

If global rebalancing affects how and where planes are built and sold, climate change and environmental concerns are reshaping the planes themselves. Airlines must deal with ever-tighter emissions standards, high fuel prices, and public reactions to contrails in the sky and noise in cities. In a business where margins are thin and regulations strict, the demand is for lighter, more aerodynamic aircraft designs and quieter, more fuel-efficient engines.

Emerging global conditions, climate change, and evolving government priorities are also leading to the opening of polar regions, particularly Canada's North, spurring resource extraction and other development in places that are not easily accessible by land or sea. A range of aircraft – from short-takeoff-and-landing turboprops to modern airships – may prove to be the best, or only, option for transporting personnel and equipment to these areas, particularly as the permafrost melts and surface transportation becomes increasingly difficult and costly. In addition, companies seeking to locate natural resources will require both piloted aircraft and drones to survey vast uninhabited areas. As the economy grows and communities expand in the North, there will also be an increasing need for activities related to the protection of people, property, and the environment – for which aerospace technologies, products, and services are particularly well-suited, given the geography and topography of this region.

In contrast to the positive growth projections for civil aerospace markets, the military aerospace segment faces reductions in defence expenditures. The United States and the European Union, which together account for almost two-thirds of global military spending, are paring military budgets as a result of fiscal pressures. Shrinking demand for military aerospace products could spill over to the civil sector, as companies are often active in both segments and use technologies developed for military purposes to improve their commercial offerings.

The emerging security environment also means that governments are looking for new equipment to address non-conventional security threats. These threats include the activities of small, secretive, militant groups, and require more effective surveillance of borders and oceans, and an ability to strike quickly, with precision, in far-flung locations. Aerospace technologies are vital to meeting these needs: witness, for example, the rapid expansion in the use of increasingly capable, and comparatively inexpensive, drones.

The increasing use of drones

More and more nations, including Canada, are operating unmanned aerial vehicles (UAVs), or drones, for commercial and military purposes. The U.S. Department of Defense's inventory of drones increased from 167 in 2002 to nearly 7,500 in 2010.

Canada's Department of National Defence currently operates a number of drones such as the Heron and the ScanEagle, which are being used for a wide array of applications including coastal patrol, mapping, and intelligence gathering. In addition, high-tech drones are being tested at Defence Research and Development Canada's Suffield, Alberta, facility for future use by Canada's military.

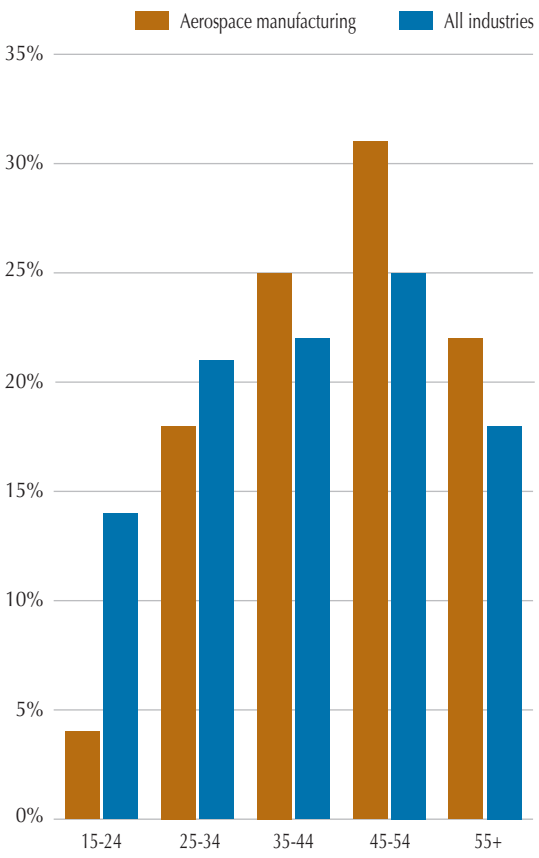
Drones are also being used in the Prairies to monitor crop health, such as nutrient and moisture levels, and by the Royal Canadian Mounted Police for crash site investigations. Future applications include enhanced monitoring of oil and gas pipelines and Canada's borders.

Sources: Ed Wolski, Unmanned Aircraft Systems, "OUSD (AT&L) Unmanned Warfare," briefing, January 9, 2009; and Dyke Weatherington, "Current and Future Potential for Unmanned Aircraft Systems, OUSD (AT&L) Unmanned Warfare," briefing, December 15, 2010.

The Boeing ScanEagle.
Source: Boeing.

Aeryon Scout™ micro-UAV.
Source: Aeryon Labs Inc.

Figure 8: Age profiles of workers of the Canadian aerospace manufacturing industry and all Canadian industries – 2011



Source: Statistics Canada.

Whatever the segment in which an aerospace firm is active, it relies heavily on a well-educated and productive workforce. The demographic profile of workforces in most established aerospace nations suggests a wave of retirements in the coming decades, which could make it challenging for companies to maintain production capacity at a time when emerging aerospace countries, most with relatively young workforces, are steadily closing the skills gap. Even with a sufficient number of graduates, firms will need to adapt to the reality of experienced employees being replaced by fresh talent with limited experience.

These broad global developments are transformative. They mean more opportunities, but also more risks – and they establish a new global context in which the aerospace industry must meet tougher standards of performance to achieve competitive success. If Canadian companies, academic and research institutions, unions, and governments are clear-eyed and resolute in navigating these emerging conditions, the sector can emerge stronger. A weak or ambivalent response, however, could mean irreversible losses to the industry and the country.

Chapter 2.3
Opportunities and challenges

As it faces changing market and production conditions, the Canadian aerospace industry has a number of key strengths. These include its long track record, demonstrated ability to innovate and adapt, world-class technological capabilities, highly skilled workforce, vibrant and diverse centres of activity, exceptionally close relationship with the American industry, and reputation for reliability.

These qualities – supported by a web of academic and research institutions, trade agreements, public policies of general application designed to foster productivity and competitiveness, and sector-specific programs – are core to the success of the Canadian aerospace sector and help position it to seize emerging opportunities.

The fortunes of Canadian firms depend on capturing a meaningful portion of the demand for military and civil aircraft, both in emerging markets with rapidly expanding fleets and in established markets where commercial carriers plan to replace aging planes with more fuel-efficient models.

Bombardier CSeries

For Canadian original equipment manufacturers (OEMs), this means identifying which markets are likely to be most receptive to Canadian offerings and vying with huge players like Boeing and Airbus. Bombardier has launched the CSeries because it believes that there will be demand for more fuel-efficient aircraft in the lower end of the single-aisle segment of the market. Its partnership with China's national aerospace firm, Comac, should facilitate access to the enormous Chinese market and help both companies compete globally. Other OEMs are also endeavouring to access emerging markets: Viking Air, for example, has found buyers for Twin Otters in China, Russia, Vietnam, Argentina, Peru, and Turkey, and Bell Helicopter Textron Canada is expanding sales of commercial helicopters in countries such as Brazil, India, and China.

Bombardier CSeries 300.
Source: Bombardier.

For Canadian tier 1 integrators and smaller suppliers, the opportunity presented by rising commercial demand is different: they must strive to secure a place on the platforms that all OEMs, wherever based, are developing to meet this demand. Because the design, development, and manufacture of a new aircraft is such a long-term undertaking, to be frozen out of its supply chain means lost sales, not simply for the immediate future, but for years and perhaps decades. Although a proven record of reliability and a history of partnership with an OEM are to the advantage of integrators and suppliers, in a globalized industry, price and quality considerations frequently trump sentiments of loyalty between OEMs and suppliers. Each new product results in a new wave of negotiations and contracts. To succeed, Canadian firms must be included in design conversations and sales consideration from the outset, and demonstrate that they can offer excellent products at competitive prices. Long-term supplier relationships will be a product of consistently high performance to a global standard.

A substantial slice of the global demand for aerospace products can be met only through innovations that meet customer expectations in areas such as fuel efficiency, noise abatement, and the ability to service isolated locations over long distances, and monitor coastlines. Canadian technological capabilities, as well as patterns of collaborative research within the aerospace sector's centres of activity, should help. So should the country's geography, which creates a natural domestic market and proving ground for innovations in some of these fields.

But even as existing aerospace markets expand, new markets emerge, and demand grows for cleaner, quieter technologies, the Canadian aerospace sector faces challenges.

First, countries such as China, Russia, and India do not simply offer expanding markets for Canadian products. Their own aerospace ambitions make for increasingly fierce competition. These new players – and some established aerospace nations as well – are more inclined than Canada to stray from open and competitive market principles in order to develop products, out-manoeuvre competitors, and capture sales. They have not been hesitant to use the power and resources of the state to incubate, support, and grow their own aerospace industries – whether that means having the state take partial or outright ownership of aerospace companies, providing generous public support for aerospace research and commercialization, or aggressively using state-directed procurement.[3] Furthermore, they are not always parties to international agreements that apply to the aerospace sector, and even where they have signed on, the transition to full implementation of the agreements' provisions can take years, and there will likely remain a readiness to test those agreements' limits.

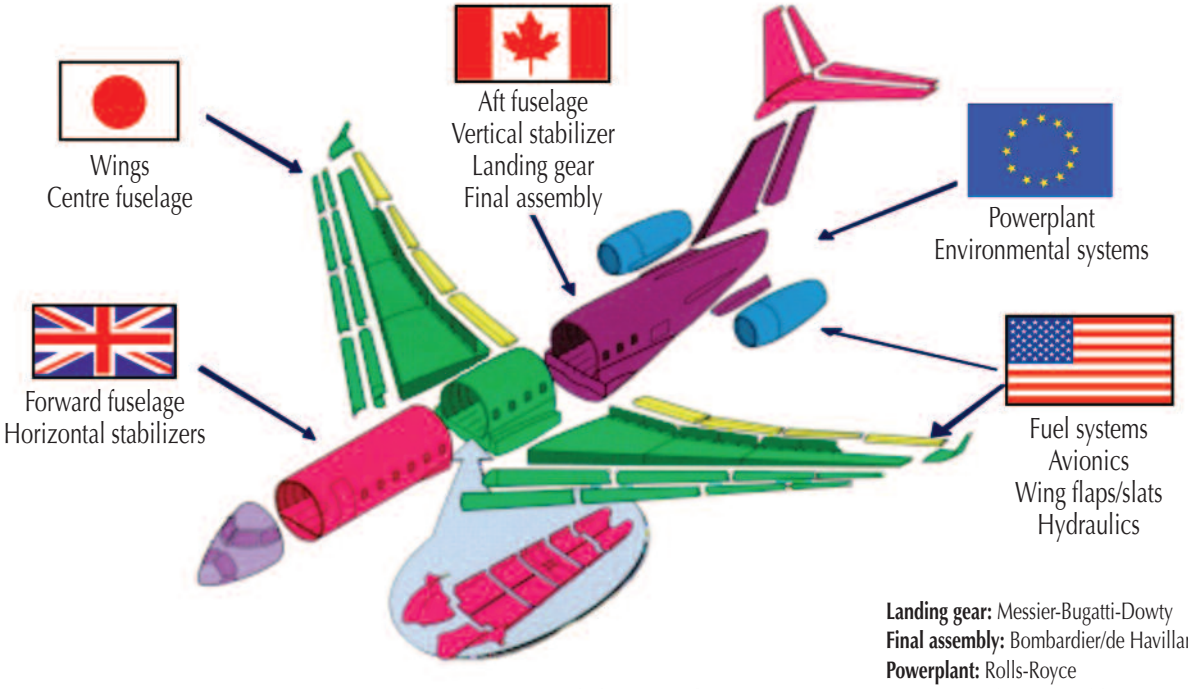
> *"[D]eveloping economies around the world are working hard to build their own aerospace industries. To ensure that we continue to participate in the success of this global industry we need new initiatives, re-invigorated policies, and vision from our elected leaders. Our continued success depends upon it."*
>
> Canadian Auto Workers, *Pulling out of a stall: Plotting a renewed course for Canada's aerospace industry,* submission to the Aerospace Review.

Second, access to emerging markets can be unpredictable and, in some cases, depends on establishing a production footprint that satisfies foreign governments. Given the intense competition for market position in these countries, Canadian firms, despite their efforts, could be shut out. The not-so-subtle link between operations and sales in countries with growing aircraft markets could also make it more difficult for Canada to attract foreign aerospace firms to establish subsidiaries and place facilities in this country, where the market is small and access to it is not contingent on local operations.

Third, the globalization of supply chains has reduced the advantage Canadian companies once enjoyed as a result of geographic proximity to Bombardier and Boeing. This has been accompanied by competitive pressure on suppliers to consolidate – as OEMs and tier 1 integrators increasingly prefer to deal with a manageable number of proven suppliers – and to conduct the research necessary to develop new or updated systems or components, forcing them to shoulder new costs, accept more risk, and build design capacity not required in the past.

3 Pravco Aviation Review L.L.C., *Brazil, Russia, India and China Governments' Aerospace Strategies and National Policies: Implications to Canada's Aerospace Industry*, July 2012. Research report commissioned by the Aerospace Review.

Figure 9: Global supply chain for the Bombardier Global Express



Wings: Mitsubishi Heavy Industries
Centre fuselage: Mitsubishi Heavy Industries
Forward fuselage: Bombardier/Short Brothers
Horizontal stabilizers: Bombardier/Short Brothers
Aft fuselage: Bombardier/de Havilland
Vertical stabilizer: Bombardier/de Havilland

Landing gear: Messier-Bugatti-Dowty
Final assembly: Bombardier/de Havilland
Powerplant: Rolls-Royce
Environmental system: Liebherr LLS
Fuel system: Parker Aerospace
Avionics: Honeywell
Wing flaps/slats: Mitsubishi Heavy Industries/ Bombardier Aerospace Belfast
Hydraulics: Parker Aerospace

Source: Bombardier.

Figure 10: Global supply chain for the Boeing 787

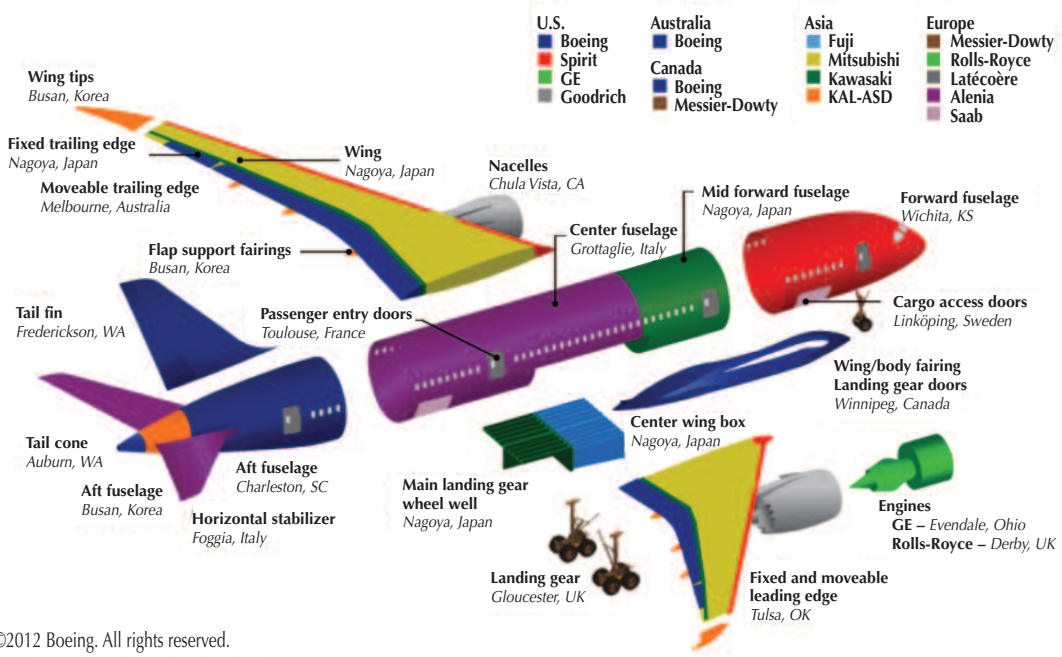
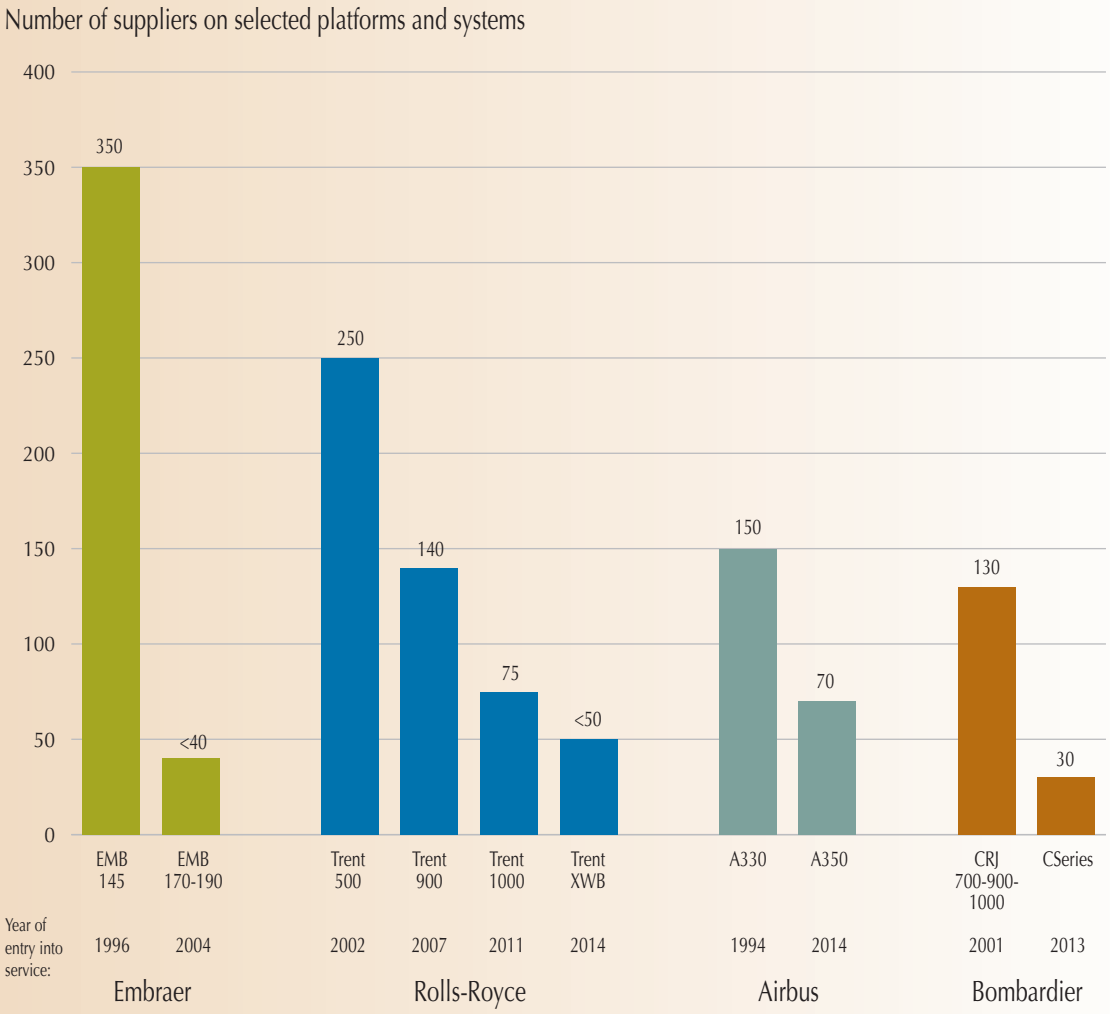


Figure 11: Consolidation of supply chains

To reduce the risk and cost of managing their supply bases, airframe manufacturers are moving from a business model with many direct supplier relationships to one where they partner with fewer tier 1 integrators. In turn, the tier 1 integrators are adopting the same model and reducing their supply bases by choosing fewer tier 2 suppliers. This is leading to the concentration of aerospace work with fewer tier 1 and 2 firms.

The chart below shows examples of older versus newer programs for Embraer, Rolls-Royce, Airbus, and Bombardier. For each company, the number of suppliers in newer programs has decreased significantly.



Sources: Company reports, airframer.com, PricewaterhouseCoopers.

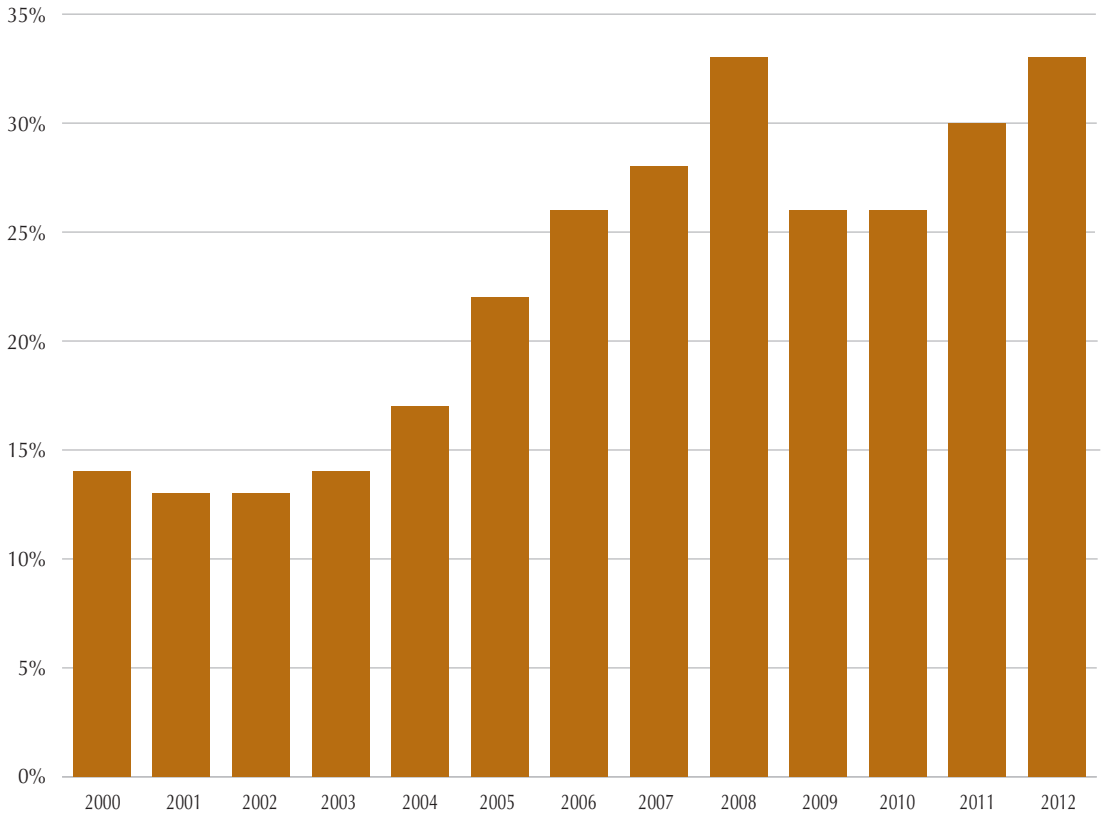
Fourth, rising oil prices over the last decade have led to a surge in the price of fuel, which currently accounts for about one-third of airlines' operating expenditures. As fuel costs rise and profits shrink, airlines are bargaining harder with aircraft manufacturers, squeezing margins throughout the aerospace supply chain.

"The nature of complex aerospace programs and the growing number of original equipment manufacturers competing on a global scale creates not only complex technologies, but very complex supply networks. It also creates the urgent need for increased competitiveness from our domestic supply base. To realize our full potential we need to actively develop globally competitive supply chain expertise in aerospace in Canada and rapidly advance small and medium sized enterprises from Tier 3 and 4 level suppliers to Tier 1 system integrators and Tier 2 equipment providers."

Final Report of the Supply Chain Working Group, September 2012.

Fifth, declining defence budgets among Canada's allies are shrinking demand and prompting the producers of military aircraft to be ever more assertive in holding on to maintenance and repair work and the technical data required to perform that work. Similarily, in the civil aerospace segment, Canadian companies specializing in aircraft maintenance and repair are being squeezed between OEMs who wish to retain a greater share of this high-margin activity and low-cost operators, many of whom are closer to the growing markets in Asia, Latin America, and the Middle East.

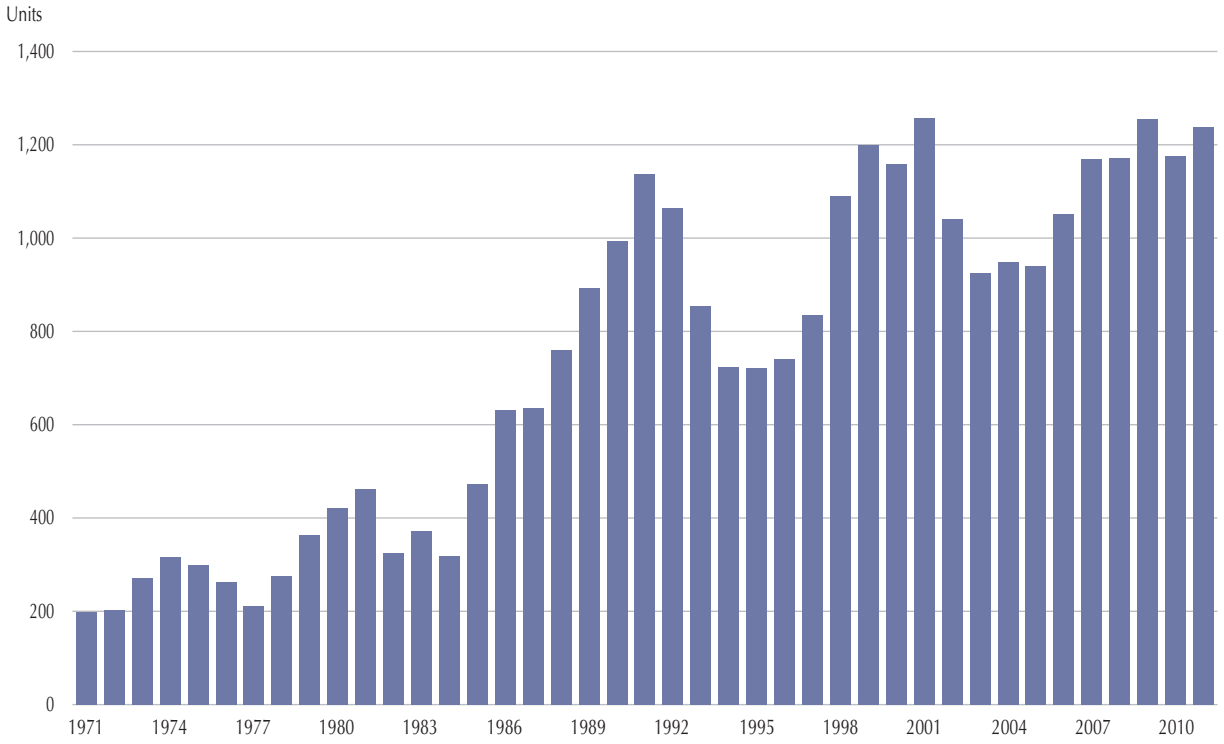
Figure 12: Airlines' fuel expenses as a share of operating expenses – 2000 to 2012



Source: International Air Transport Association, *Financial Forecast,* September 2012.

Finally, the aerospace industry is inherently cyclical, with ups and downs driven by the long lead times needed to design and commercialize new products and platforms, the instability inherent in aerospace manufacturing schedules, and the fluctuations in capital spending by customers in the civil and military markets. When sales dip, Canadian firms are vulnerable to the loss of highly specialized employees, who may be lured out of the country by offers of employment from foreign competitors. This risk is heightened during a period when firms and governments from other countries – particularly those committed to quickly building their own industries – are searching the world for the best talent.

Figure 13: Cyclical nature of the aerospace industry as illustrated by global commercial aircraft deliveries – 1971 to 2011



Sources: Bombardier Analysis, OAG Aviation Solutions.

The Canadian aerospace sector is at a critical juncture. Emerging conditions carry tremendous potential for growth in sales, increased profits, more high-quality employment, more technological progress, and increased prosperity for Canada. But there are also real risks of contracting market share, diminished industrial capacity, and the loss of innovation and skilled jobs. Industry, government, academic and research institutions, and unions – individually and collectively – will have to undertake a series of practical, results-focused actions to respond to these conditions. If we get it right, Canada will still be a global aerospace power to reckon with 30 years from now.

Analysis and recommendations

While this volume focuses on the aerospace sector and the companion volume, *Reaching Higher: Canada's Interests and Future in Space*, focuses on the space sector, many of the recommendations in this volume will be helpful to companies that design and produce space products and services, as well as academics and researchers who study and teach on space.

The companion volume lists the recommendations from this volume that have at least some relevance for the space sector. Where that relevance is particularly great, space is specifically mentioned alongside aerospace in the following chapters.

Chapter 3.1
Developing the technologies of the future

The core truth of the aerospace industry is this: it turns on innovation at all levels. Technological superiority, from product design to manufacturing processes, is essential to the fortunes of individual firms and the sector as a whole.

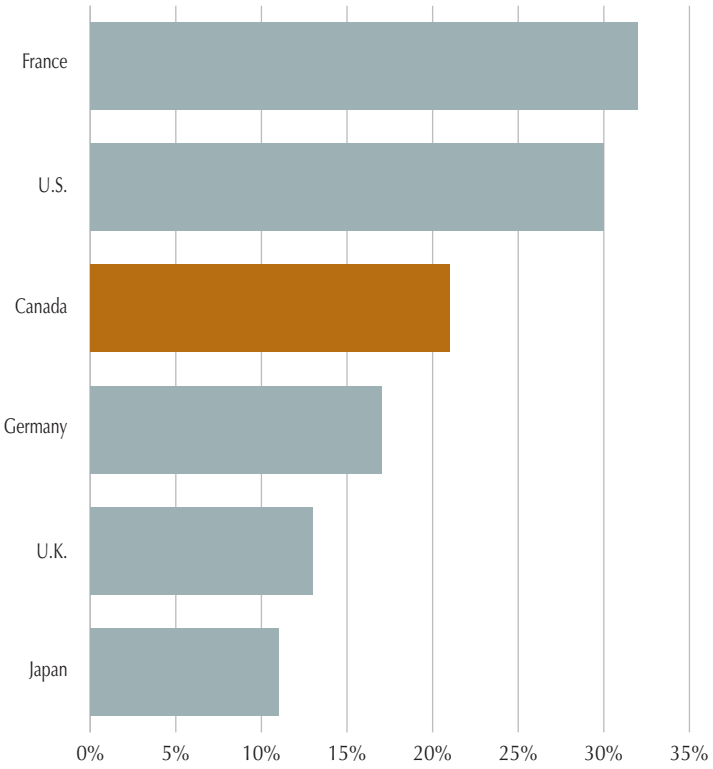
To secure and enhance its competitive standing in the years to come, the Canadian aerospace industry must be a leader in inventing, developing, manufacturing, and marketing the technologies of the future. This, in turn, means it must cultivate the robust, original research on which innovation is based.

Creating conditions in which innovation is encouraged and accelerated requires coordinated efforts on the part of industry, research institutions, and governments. Each holds a piece of the puzzle. If companies and researchers do not do their part, policy and program support will be for naught.

The research intensity of the Canadian aerospace manufacturing industry currently lies in the middle of the pack among major aerospace powers. The Technology Development, Demonstration and Commercialization Working Group underscored the urgency of not only doing more, but also ensuring that research is focused in areas where the benefits to the industry and the country are likely to be greatest.

The largest aerospace-specific program to support innovation in the sector is the Strategic Aerospace and Defence Initiative (SADI), which provides repayable contributions to aerospace, space, defence, and security companies. Since its creation in 2007, SADI has authorized $825 million in assistance to 25 projects and disbursed $405 million.[4] SADI applications must describe the objectives of the proposed research project and provide a detailed plan of how the project will be implemented. Applications are assessed against criteria such as the technological feasibility of the project, the applicant's managerial capabilities and financial capacity, and broader benefits to the Canadian economy. SADI contributions typically amount to 30 per cent of a project's total eligible costs and repayment is generally over a 15-year period. Standard repayment provisions can be conditional on the applicant's gross business revenues or unconditional.

Figure 14: Aerospace manufacturing R&D intensity by country – 2010



Source: Organisation for Economic Co-operation and Development.

Note: R&D intensity is calculated as R&D performed by the aerospace manufacturing industry within each country divided by aerospace manufacturing gross domestic product.
R&D = research and development

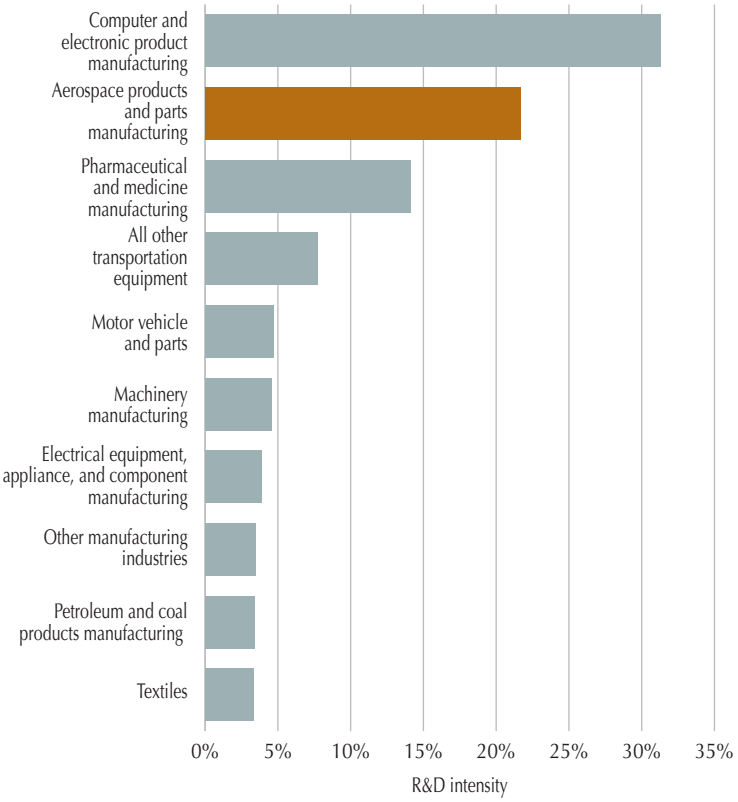
In addition to SADI, a number of smaller programs and initiatives help aerospace companies undertake pre-competitive R&D activities:

- National Research Council (NRC) Aerospace has five laboratories through which it works with industry and universities to develop products and services. It has an annual budget of $58 million, with $34 million coming from the federal government and $24 million from industry partners. In addition, the NRC-Industrial Research Assistance Program (NRC-IRAP) helps SMEs build innovation capacity and develop technologies that can be commercialized in Canada and abroad. IRAP offers technical and managerial advice, funding, and networking opportunities, and provides about $24 million each year to support aerospace-related projects.
- The Green Aviation Research and Development Network (GARDN) funds collaborative research projects aimed at reducing aviation's environmental footprint. The program was established in the context of support for business-led Networks of Centres of Excellence and was given annual funding of about $3.25 million from 2009 to 2013 from the federal government and a similar amount from industry partners.
- The Industrial Research Chairs initiative and Collaborative Research and Development grants of the Natural Sciences and Engineering Research Council (NSERC) are widely used by aerospace companies as they undertake research projects in cooperation with universities. These projects help ensure that students are trained as potential future employees and that companies have access to the expertise and equipment available in academic institutions. In 2011-12, NSERC provided about $20 million in support of aerospace research and the amount continues to rise each year with increased demand from industry.

4 Data from Industrial Technologies Office of Industry Canada, as of September 30, 2012.

- Sustainable Development Technology Canada (SDTC) supports the development of clean technologies. The program, which is primarily targeted to SMEs, provides about $9.5 million in annual support to the aerospace sector.
- The Canadian Innovation Commercialization Program (CICP) helps Canadian businesses move new products and services from the lab to the marketplace by awarding government contracts to firms with pre-commercial innovations, testing those innovations within federal operations, and providing feedback that companies can use for the purposes of commercialization. CICP, which is managed by Public Works and Government Services Canada, was launched in 2010 as a pilot project with funding of $40 million over two years. Budget 2012 announced that the program would be made permanent, with funding of $95 million over three years, starting in 2013-14, and $40 million per year thereafter.

Figure 15: Top 10 research-intensive industries in Canada – 2011



Source: Based on Statistics Canada data.

Note: R&D intensity is calculated as R&D performed by each industry in Canada divided by each industry's gross domestic product.
R&D = research and development

Finally, aerospace firms, like all companies in Canada, can offset R&D costs through the Scientific Research and Experimental Development (SR&ED) tax incentive program. Based on recommendations from the Review of Federal Support to Research and Development,[5] the rules governing SR&ED were tightened in Budget 2012 to free up funds for more direct forms of R&D support, including a doubling of IRAP's budget and an investment of $100 million to support the Business Development Bank of Canada's venture capital activities. While none of these programs are sector-specific, aerospace companies can and do take advantage of them.

Federal efforts to promote research, development, and innovation in the aerospace sector are not large by international standards, but they have made important contributions to the sector's competitiveness. Examples of technological and commercial successes that were facilitated by such programs – sometimes in combination with investments by provincial governments – include:

- the development of technologies that have been incorporated into Pratt & Whitney Canada's advanced engines, used in applications spanning a variety of aircraft, including Virgin Galactic's White Knight Two, a craft designed to carry a commercial space vessel to high altitude before being launched into space;
- Héroux-Devtek's development of the landing gear for the Bombardier Learjet 85 business jets and Embraer Legacy 450/500 business jets, which target the medium-sized segment of the business jet market; and
- CAE's Project Phoenix, one of the largest R&D efforts in its history, which paved the way for new lines of cutting-edge flight simulators that cemented the company's status as the dominant global player in the synthetic training market.

5 Review of Federal Support to Research and Development, *Innovation Canada: A Call to Action* (Ottawa: Public Works and Government Services Canada), 2011. **http://rd-review.ca/eic/site/033.nsf/eng/h_00287.html**

These sorts of achievements would have been much more difficult, and may not have happened in Canada at all, without support and risk-sharing by government. But as conditions evolve, policies and programs must evolve with them.

Recommendation 1: Aerospace and space as a science and technology priority

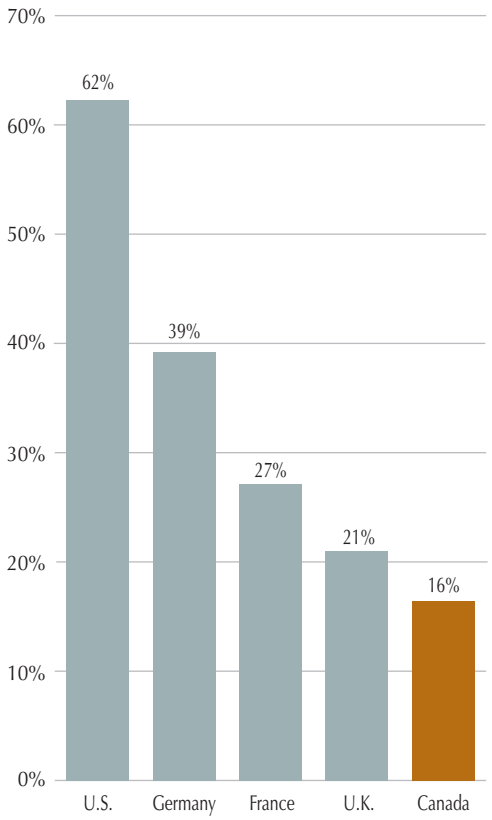
The Government of Canada's Science and Technology (S&T) Strategy, released in 2007, identified four strategic areas of national interest from a social and economic perspective: environmental science and technologies, natural resources and energy, health and related life sciences and technologies, and information and communications technologies. These areas benefit from additional policy consideration and resources, notably through NSERC's Strategic Project Grants and Strategic Network Grants, which support research and training.

In spite of being among the global leaders in aerospace and despite the central economic, social, and security roles of aircraft in a vast country with a geographically dispersed population, Canada does less than other aerospace powers to recognize the sector as having national strategic importance.

It is recommended that the list of strategic sectors under the government's Science and Technology Strategy be expanded to include aerospace and space.

By adding aerospace and space as a fifth strategic sector, the government will send an important signal regarding the sector's importance to Canada and the government's commitment to its long-term competitiveness. This has value both at the symbolic level and as a form of guidance to those who administer funding programs of general application, such as NSERC granting programs and the NRC's IRAP.

Figure 16: Share of R&D performed in the aerospace manufacturing sector that is funded by government expenditures – 2009



Sources: U.S.: National Science Foundation; Germany: Stifterverband statistics on R&D; France: Ministère de l'Enseignement supérieur et de la Recherche; U.K.: Office for National Statistics; Canada: Statistics Canada, Industrial Technologies Office of Industry Canada, and firm-level data.

Note: Includes funding from all levels of government.
Data for Germany, France, and the U.K. include funding from the European Commission programs.
Does not include tax credits.
R&D = research and development

Recommendation 2: A list of aerospace technology priorities

Given the increasingly competitive global marketplace and the significant amount of time and money required to develop aerospace innovations, it is important that, in addition to making aerospace an S&T priority, public policies and programs concentrate on the aerospace technologies with the greatest long-term potential.

Aerospace companies and researchers are already developing responses to some of the challenges Canada faces in its pursuit of wealth creation, national security, delivery of critical public services, emissions reductions, and environmental stewardship. A "sweet spot" exists where there is a confluence of the tools vital to Canada's future, rising demand in the global marketplace, and the technologies and products conceived and tested by Canadian researchers and businesses.

Emphasis should be placed on these areas. Otherwise, support will end up being spread too thinly across a wide range of initiatives that, in many cases, have little chance of global success. It makes far more sense to focus on technologies where Canadian industry can build on its comparative advantages and secure a global leadership position.

That said, this focus cannot be absolute. An unduly prescriptive and detailed approach to priority technologies risks starving promising possibilities of support just because they fall into areas that eluded attention at the time priorities were being determined.

The goal should be to find a midpoint between a poorly targeted approach that disperses efforts and dissipates their impacts, and an excessively prescriptive approach that sees governments attempting to pick winners among specific products and firms.

It is recommended that the government establish a list of priority technologies to guide aerospace-related policies and programs.

To strike an appropriate balance, the list of priority technologies should be relatively high level and limited in number. If there are more than 10 priorities, it can fairly be said there really are no priorities at all.

The list should be established on the basis of advice from a network of industry, academic, and government experts from across the country. Given its objectives, and the long-term nature of aerospace technology development, the list should be relatively stable over time, but reviewed and adjusted annually for relevance and efficacy.

To ensure that the selected priorities help maximize the competitiveness of the aerospace sector, they should reflect the intersection of areas in which:

- the Canadian aerospace industry and research community have a competitive edge thanks to existing technological strengths or natural advantages afforded by factors such as Canada's geography;
- Canadian governments are expected to have public policy and procurement requirements, thereby creating a natural market; and
- domestic and global demand more generally is likely to remain strong or grow.

In light of current and anticipated demand in the global aerospace market, it can be expected that the list of priority technologies will be influenced in no small part by the need to increase aircraft efficiency and reduce fuel use and environmental impacts.

Once established, the list – along with priorities for the Canadian Space Program established pursuant to the recommendation 1 in the companion volume – should be used to guide decisions around R&D funding and industrial benefit policies. Proposals in areas not covered by the list should not be automatically excluded, but they should have to pass a much more demanding test in terms of their transformational and commercial potential.

Recommendation 3: A technology demonstration program

Technological development requires systemic progress from principles and concepts through testing and refinement to the point where a new technology is ready for commercialization. This process is often described by industry, researchers, and government as comprising nine technology readiness levels (TRLs), which are clustered into three general phases: basic and applied research; technology demonstration, which is used to prove the viability of a technology through trials and adaptation; and the development and commercialization of products. Public policies and programs need to provide reasonable coverage of all these phases if they are to help industry conduct the research necessary to remain at the cutting edge of innovation.

The role of technology demonstrations in aircraft development

In the first phase of technological development, basic concepts and principles are studied, often in collaboration with universities or research institutions. Practical applications of the technology start to be defined and laboratory-based studies are conducted to validate new concepts.

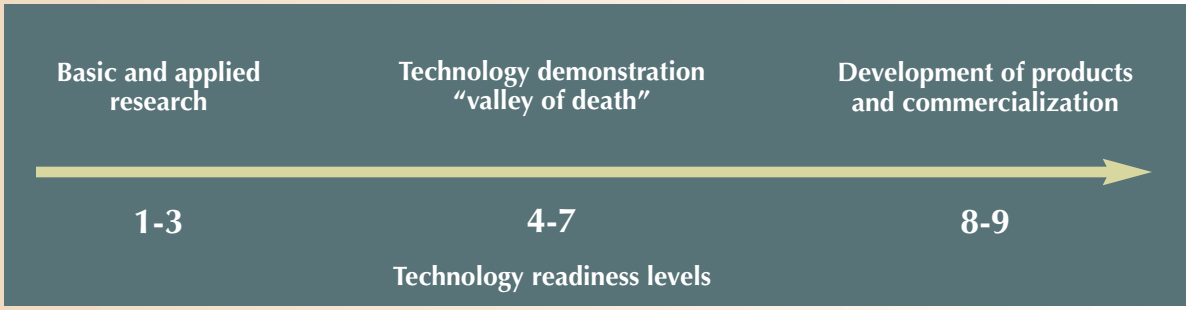
The second phase, called technology demonstration, involves gradually moving the new technology out of the laboratory to test and validate it in increasingly realistic settings, involving temperature extremes, severe vibrations or sudden impact, for example. This process is essential to ensuring that the new technology can fulfil its intended use and not conflict with other components or systems of the aircraft.

Technology demonstrations involve a progression in the test environment, as the new technology is first validated in a simulated setting, such as a hangar or a wind tunnel, before ultimately being assessed during test flights on board an aircraft. Demonstrations also entail increasing system complexity. The technology is initially tested in isolation, which is a small-scale process that can often be managed by the innovating firm. But the technology is eventually tested in an entire system (e.g., an engine, landing gear, or wing) – alongside new technologies produced by other firms that also require testing – before finally being integrated onto the test aircraft. These large-scale demonstrations are complex, time-consuming and require specialized equipment, facilities, and researchers. As a result, they are almost always conducted through collaborative efforts involving various firms, universities, and research institutions.

Given the strict regulations surrounding safety of aircraft, the demonstration phase is conducted under close scrutiny, with precise measuring instruments and extensive documentation of results. The entire demonstration phase can last several years.

It is only after the demonstration phase is successfully completed that the technology can be moved to the third phase, which involves certifying the final product for operational use and commercialization.

Three phases of technological development



Current federal programming accessed by the aerospace sector provides adequate levels of support at early and later TRLs, and for small-scale technology demonstration through initiatives like SDTC and GARDN, both of which are funded on a temporary basis. For larger projects, however, existing programs fall short with respect to technology demonstration. This gap is problematic, given that technology demonstration is expensive, the technologies are complex, and – because they are as yet unproven – they may entail considerable risk for the companies developing them. Even if a technology is clearly shown to have commercial potential, it may not generate cash revenue for years.[6] In addition, technology demonstration frequently requires cross-industry collaboration: one cannot fully assess new landing gear, for example, without testing it on an aircraft.

6 Jeff Xi, *A Research Assessment Report on Integrated Technology Demonstration and the Role of Public Policy*, Ryerson Institute for Aerospace Design and Innovation, July 2012. Research report commissioned by the Aerospace Review.

Among the aerospace powers, Canada is notable for its lack of support for this crucial phase in the development of new technologies. Within the industry, technology demonstration is known as the valley of death: the stage at which innovations are often abandoned due to lack of capital to test them. This is a structural deficiency affecting the performance of the Canadian aerospace industry, and an area where government can appropriately play a role in unlocking innovations to the benefit of the sector and the economy as a whole.

It is recommended that the government create a program to support large-scale aerospace technology demonstration.

The focus of this new program should be on large-scale technology demonstration that involves at least one OEM and/or tier 1 integrator, at least one university or research organization, and at least one smaller supplier. Annual funding for the program should be set at $45 million per year, to be paid through reallocation of $20 million from SADI and $25 million of the savings from the tightening of SR&ED eligibility criteria. Support should cover up to half a project's costs, and take the form of non-repayable contributions. The terms and conditions of the program should be carefully reviewed to ensure compliance with international trade rules.

The European Union's Clean Sky Joint Technology Initiative

The European Union funds aeronautical technology demonstrations through its Clean Sky Joint Technology Initiative. Clean Sky supports the development of breakthrough technologies to achieve specific targets with respect to reducing aircraft noise and emissions. Clean Sky is organized around six integrated technology demonstrators focusing on different research themes:

- *smart fixed-wing aircraft;*
- *green regional aircraft;*
- *green rotorcraft;*
- *systems for green operation;*
- *sustainable and green engines; and*
- *eco-design.*

Clean Sky is one of the largest European research programs ever, with a total budget of €1.6 billion (about $2 billion) over seven years, shared equally between the European Commission and the industry. Public funding therefore covers up to 50 per cent of the costs of technology demonstrations, and is entirely non-repayable.

The technology demonstration program will have a number of important benefits. First, it will accelerate technology development and save costs because several participating firms will have the opportunity to prove their technologies simultaneously. Second, it will result in greater knowledge diffusion, since all partners in the collaborative project will share their expertise and gain access to the resulting intellectual property. Third, it will support supplier development because small firms involved in the project are likely to be retained for the production phase. Finally, it may encourage the emergence of tier 1 system integrators – an area of relative weakness for the Canadian aerospace sector – since large-scale demonstrations require the integration of many technologies and the coordination of activities and resources from many participants.

In addition to creating a program for large-scale technology demonstration, consideration should be given to maintaining existing levels of funding for initiatives such as SDTC and GARDN that support smaller-scale technology demonstration.

Recommendation 4: SADI improvements

SADI is a key program with clear and important policy goals. Experience shows, however, that its terms and conditions have a number of design limitations that have reduced its value as a facilitator of the sort of innovation required to position the Canadian aerospace and space industries for long-term competitive success. These limitations should be corrected, given the scale and determination of other countries' investments in aerospace and space R&D.

There are three fundamental shortcomings with SADI's existing terms and conditions:

- They set repayment terms that are based on a company's general financial situation rather than the success of the funded project. As noted in the report of the Technology Development, Demonstration and Commercialization Working Group, there is a perception within the industry that SADI's funding terms essentially track prevailing rates of interest, making SADI similar to a public version of conventional loans. While this characterization can be debated, it raises questions about the financing terms that will be most conducive to supporting higher-risk innovation.
- They do too little to encourage collaboration among different companies and researchers. Consequently, most SADI funding goes to individual firms rather than broader consortia.
- They restrict the use outside Canada of intellectual property generated through SADI-sponsored R&D. These constraints are intended – reasonably enough at first blush – to ensure that the investment of public funds will produce jobs for Canadians. But they have downsides for an industry that is enmeshed in global supply chains and whose member firms prominently include subsidiaries of foreign-headquartered companies. If they are too rigid, these constraints can actually undermine Canadian companies' competitive position and reduce the wealth-generating value of technological advances for the Canadian economy.

It is recommended that the government maintain Strategic Aerospace and Defence Initiative (SADI) funding at current levels – less reallocations recommended in this volume and the companion volume on the space sector – and modify SADI's terms and conditions to make it a more effective program for stimulating the development of the aerospace and space technologies of the future.

First, SADI funding should be provided more on a risk-sharing basis: when a specific innovation is supported, the timing and rate of repayment to the public purse should be linked to the revenue generated by that innovation, not to a firm's overall financial performance. This approach focuses more directly on a specific technology and its development rather than a more broadly secured corporate loan with technology "hooks" to qualify. Corporate debt markets are well-developed and it is doubtful that SADI in its current form adds much to what is already available in the marketplace.

Second, the criteria for receiving SADI support should provide more incentives for collaborative efforts among companies and between industry and academia, with each participant in a funded project being entitled to use resulting intellectual property to advance commercial and research efforts. As noted in the government's Science and Technology Strategy, collaboration is worthy of support because it tends to produce more dramatic innovations in a shorter time, as a result of synergies between different players' expertise and infrastructure. Sharing intellectual property also multiplies the economic benefits produced by joint research, as innovations are adapted and applied in a wide array of areas.

"The Government of Canada will support [science and technology] collaborations involving the business, academic, and public sectors, at home and abroad. Partnerships are essential to lever Canadian efforts into world class successes and to accelerate the pace of discovery and commercialization in Canada. Through partnerships, the unique capabilities, interests, and resources of various and varied stakeholders can be brought together to deliver better outcomes."

Mobilizing Science and Technology to Canada's Advantage, 2007, p. 11.

Finally, there should be a relaxation of limitations on the use outside Canada of intellectual property generated through SADI-supported research. While some measures are appropriate to promote direct benefits to Canadians from SADI-sponsored activity, they need to be better attuned to global production and market realities. SADI administrators already have the ability to loosen intellectual property restrictions on a case-by-case basis, but this is inadequate, as it may lead to inconsistent treatment and the general provisions of the program may discourage applications from companies unaware that tailored approaches are possible or unwilling to deal with procedural hassles. More flexible language needs to be written directly into SADI's terms and conditions.

Recommendation 5: A national initiative to enhance collaboration

As noted under the previous recommendation, collaborative approaches to R&D, as a rule, yield better results for both participants and the economy. This is particularly true for an industry like aerospace, in which R&D is a costly, long-term undertaking. But collaboration often requires a special effort: organizational structures and cultures tend to foster internal cooperation more than collaboration across corporate and institutional boundaries.

Initiatives whose primary mission is to serve as catalysts for collaboration can help overcome these silo effects and promote faster, more relevant R&D. The Consortium de recherche et d'innovation en aérospatiale au Québec (CRIAQ) is a prime example. CRIAQ brings together firms, academics, and research institutions to discuss emerging technological needs and to develop collaborative, open innovation research projects and training to meet those needs.

Over 10 years, CRIAQ has proven its worth as a mechanism for improving communication and closing information gaps between companies and researchers. The result has been an acceleration of innovation, and better matching of research and training activities to the practical needs of industry. CRIAQ currently involves 50 companies, of which more than 35 are SMEs, and over 21 academic and research institutions from Quebec and other provinces. Each CRIAQ-supported project involves at least two companies that contribute financially and two research partners. More than 100 projects are currently in preparation, in progress, or completed, including 18 international collaborations.

CRIAQ receives funding from the Government of Quebec for its ongoing operations as well as for research projects. At the moment, federal support comes from NSERC and is directed to specific projects. In its current configuration, CRIAQ is largely, though not exclusively, focused on the Quebec aerospace sector. Extending a CRIAQ-based model to the Canadian aerospace sector would offer a competitive advantage to participating organizations and stimulate activity beneficial to the economy as a whole.

The Consortium de recherche et d'innovation en aérospatiale au Québec (CRIAQ)

CRIAQ has facilitated many early-stage, collaborative research projects whose results were ultimately transferable to industry. Canadian university students also benefit from the opportunity to work on such innovative research projects.

In one such project, three companies (Bombardier, Bell Helicopter, and Delastek) along with three universities (McGill, Concordia, and the University of British Columbia), the National Research Council, and the Centre de développement des composites du Québec undertook research into the performance and production costs related to the manufacturing of composite airframe structures. The results were used in the design and development of Bombardier's Learjet 85 aircraft and are also being evaluated by Bell Helicopter for inclusion on some existing airframe components and future platforms. Additionally, a prototype tool manufactured by Bell Helicopter is currently in use at Delastek for demonstration trials.

Source: CRIAQ.

It is recommended that the government co-fund a Canada-wide initiative to facilitate communication and collaboration among aerospace companies, researchers, and academics.

This recommendation could be achieved in one of several ways: CRIAQ could be provided with the resources for operational expenses to extend its activities across the country; the mandate of existing initiatives like GARDN could be expanded; or a separate program could be created to complement CRIAQ in other parts of the country. The choice between these options should take into account advice from the Government of Quebec and other provincial governments, industry, and academic and research institutions. Whichever option is chosen, federal support should be conditional on contributions from other orders of government and participating organizations – as is currently the case for CRIAQ – and should be reallocated from the SADI funding envelope. Required federal funding to support operational expenses is likely to be in the order of $2 million per year.

Recommendation 6: Simplification of application and reporting procedures

When firms seek to access funding from government programs, they have to complete application documents, and when they receive support, they must report on how it was spent. Such administrative procedures are, of course, appropriate and necessary to ensure that the public's money is allocated and used in a manner consistent with policy goals. But when the demand for safeguards and accountability creates procedural burdens so high that smaller businesses do not even bother to seek support – as seems to be happening with SADI in particular – the unintended consequences of well-intentioned processes become problematic.

Public policies and programs should not favour companies of any particular size. But neither should they stack the deck against small firms by imposing administrative requirements designed for larger companies seeking higher levels of support.

It is recommended that application and reporting procedures for programs used by the aerospace industry be simplified and streamlined, especially for smaller companies seeking modest levels of support, and that a "one-stop" internet portal be used to provide information on, and links to, those programs.

Such streamlining and simplification should result in increased program uptake by smaller companies, which will help them bring new ideas to market and adapt to competitive pressures. In addition, it should reduce, if not eliminate, the need for smaller companies with limited internal capacity to obtain the assistance of intermediaries. Such middlemen charge a fee to prepare application documents, and their involvement can erode both the impact and credibility of funding programs.

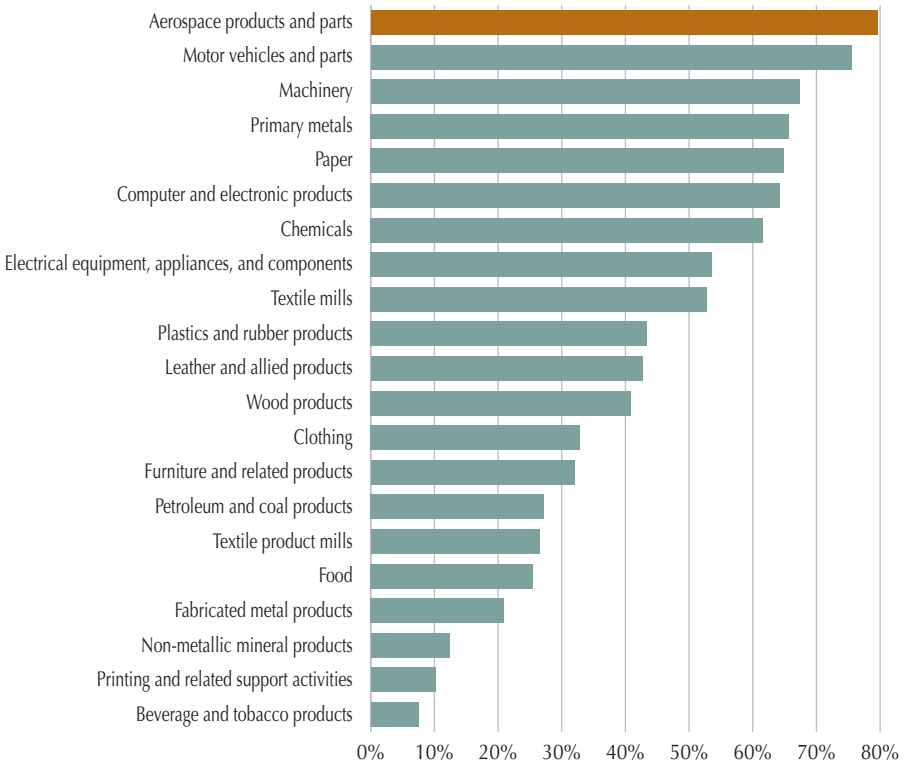
Chapter 3.2
Accessing global supply chains and markets

Fostering innovation is critical to securing the future of Canada's aerospace industry, but turning a healthy profit depends on finding enough customers for the new, superior products that innovation allows. Because the aerospace business is global – and because the Canadian domestic market is small – access to global supply chains and markets is essential.

The Canadian industry has done well in this regard. It earns 80 per cent of its revenue from sales abroad and is respected around the world for the quality of its products and the reliability of its services. But these past successes are not a guarantee of future performance. The rise of determined new players, pressure on suppliers to consolidate and do more technology development, and a high exchange rate all mean that Canadian aerospace companies will need to redouble their efforts to maintain and expand their place in supply chains and markets abroad. Public policies and programs need to keep pace.

Those policies and programs cannot, of course, guarantee sales. But they can help ensure that when Canadian aerospace companies venture into the global marketplace, they compete on fair terms, get a fair hearing, and have the information necessary to strike deals. This is the logic underlying Canada's Global Commerce Strategy, which was first issued in 2009 and is currently being updated.

Figure 17: Export intensity of manufacturing industries – 2010



Source: Based on Statistics Canada data.

Note: Export intensity is calculated as export sales divided by total sales.

Canadian firms seeking business abroad already receive support to attend international air shows and exhibitions, along with market intelligence and introductions to foreign companies from trade commissioners housed in Canada's embassies and consulates. In parallel, Export Development Canada (EDC) is available to provide financing in support of sales of Canadian aircraft, systems, and components. And the Canadian Commercial Corporation can facilitate sales to foreign governments by acting as a contractor and guarantor. These organizations' services are viewed positively by the Canadian industry.

In addition, under the auspices of the Organisation for Economic Co-operation and Development (OECD), Canada and other established aerospace nations have negotiated the Aircraft Sector Understanding, which sets out parameters for financing provided by EDC and other countries' export credit agencies. Similarly, the trade rules established through the World Trade Organization (WTO) can be invoked by any member country that believes another member has unfairly subsidized its domestic aerospace industry. Support provided to four of the world's largest OEMs – Boeing, Airbus, Bombardier, and Embraer – has been challenged at one time or another through WTO processes.

Canada has also introduced an array of export and domestic controls designed to ensure that sensitive technologies do not fall into the hands of organizations or countries for which there are security concerns. These controls help meet Canada's international security obligations and reassure the United States – still the Canadian aerospace industry's largest market and partner – that aerospace technologies can be shared and jointly developed with Canadian firms at no risk to national security.

Finally, Transport Canada certifies new aircraft designs to internationally recognized safety standards, then facilitates certification in other countries, thus enabling the sale of Canadian designed aircraft abroad. Transport Canada's expertise is well-regarded internationally, and its ability to conduct its work in a timely manner while ensuring the highest safety standards is key to the export success of Canadian aerospace companies.

These services and regimes go a significant distance toward giving Canadian aerospace companies a fair shot at securing business abroad. But in light of changing conditions, more is needed.

Export Development Canada and aerospace financing

Export Development Canada (EDC), Canada's export credit agency, operates on commercial principles, providing financial services such as trade and investment insurance, working capital guarantees, and direct financing to Canadian companies and to foreign buyers of Canadian goods. EDC's mandate is consistent with the role that governments around the world play in financing the export sales of the aerospace industry, a role that reflects the scale of the financial transactions and associated risks.

EDC provides all its aerospace sales financing on terms outlined in the Aircraft Sector Understanding (ASU) negotiated under the auspices of the Organisation for Economic Co-operation and Development. The ASU aims to level the playing field on sales financing among aircraft manufacturers by ensuring that competition is based on the quality and commercial competitiveness of the aircraft, rather than on the most favourable financing terms. It sets out the lowest financing terms and conditions that governments are allowed to support through their export credit agencies. In addition to Canada, other participants in the ASU are Australia, Brazil, the European Union, Japan, South Korea, New Zealand, Norway, Switzerland, and the United States.

As part of Canada's Economic Action Plan in 2009, EDC was temporarily granted the power to lend domestically without the normal requirement for ministerial authorization. These powers enable it to support loans on ASU terms to domestic airlines for new Canadian-made aircraft.

Recommendation 7: More inclusive multilateral agreements

Multilateral arrangements like the OECD's Aircraft Sector Understanding and WTO agreements help ensure that sellers from different countries compete for business on terms that are fair and consistent, and prevent governments from dipping deeply into their coffers to give their own companies an unfair advantage. It can take years of hard bargaining to hammer out these arrangements, but as long as all parties respect them, they minimize the chances that states will constantly ratchet up their spending in response to one another's actions. For a country like Canada – with a relatively small population, a large, export-oriented aerospace industry, and a commitment to fiscal probity – this is critical.

Current international agreements that shape trade in aerospace products have demonstrated their value, but are being stressed by two factors. The first is the rise of new aerospace powers such as China and Russia that are ready to invest substantial state resources and influence in building their aerospace sectors, and are not currently parties to the Aircraft Sector Understanding. As a result, firms from Canada and other established aerospace powers may be placed at a disadvantage for reasons unrelated to the quality of their products and services, the productivity of their workforces, or their cost competitiveness.

The second stressor is the lack of clarity in WTO rules with respect to the type and scale of permissible public support for aerospace companies. This ambiguity has resulted in time-consuming, sometimes costly disputes about the correct interpretation and application of these rules.

It is recommended that the government endeavour to bring emerging aerospace players into multilateral agreements that create fair, competitive conditions for Canadian aerospace firms, and to clarify rules related to government support for domestic aerospace industries.

Amending and expanding international accords are obviously not within the exclusive purview of the Government of Canada, but only governments have the ability to push forward the negotiation of international rules that prohibit trade-distorting subsidies, minimize friction, and provide all competitors with a level playing field. Canada has a lot at stake and can be an effective advocate internationally. The long-term global competitiveness of Canada's aerospace industry will be enhanced if the government can successfully work with like-minded countries to clarify the ground rules around domestic support, and persuade China, Russia, and other rising aerospace countries to adhere to rules-based regimes governing the production and export of aerospace products.

Recommendation 8: More bilateral agreements

Multilateral arrangements can be complemented by more in-depth bilateral agreements that facilitate trade in aerospace and space products, as well as collaboration between aerospace and space companies and researchers from Canada and partner countries. Whether they take the form of broad economic framework agreements or more sector-specific accords, such agreements can play an important role in expanding market opportunities for Canadian aerospace and space firms.

In cases where a fairly comprehensive trade agreement is already in place, bilateral agreements can add value by drilling down to very specific areas such as clarifying security-related export restrictions, bilaterally opening up commercial and military aerospace and space procurement opportunities, and enabling greater mobility of people with critical skills. In other cases, when there are limited framework agreements to build on, a bilateral sectoral accord can enhance the broader trade relationship while encouraging collaboration and more open markets for aerospace and space goods and services.

Bilateral agreements should not be pro forma in nature. If they are to make a real difference for companies and researchers – and avoid the fate of the many bilateral agreements and memoranda of understanding that end up being little more than high-level statements of good intentions – they must provide for practical actions that are specific in nature, properly resourced, and embedded in detailed implementation and management plans.

It is recommended that the government negotiate bilateral agreements with countries where potential market and partnership opportunities are likely to benefit Canada and the Canadian aerospace and space sectors.

To ensure that they advance Canada's interests, such agreements should:

- be negotiated with input from industry, researchers, and provincial governments;
- entail genuine reciprocity with respect to the likely benefits for each country, including improved access for Canadian companies to expanding markets and supply chains; and
- provide adequate protection for intellectual property and for Canadian investments in partner countries. Some exchange of technologies is inevitable in the context of globalized production and transnational partnerships, but such an exchange should be voluntarily negotiated by companies on the basis of commercial considerations.

Canada has relatively strong sectoral relations with the United States, Europe, and Japan, but there may be scope for using bilateral agreements to energize those relations and strengthen aerospace- and space-related collaboration, trade, and investment.

Emerging countries with which Canada should consider new or stronger aerospace and space sector agreements include China, Russia, India, and Brazil. Each offers a growing market for manufacturers of aircraft and aerospace and space systems and components, along with increasing opportunity for profitable partnerships – and in each, a combination of public policies and informal practices can pose hurdles for Canadian firms seeking to make sales and build business relationships. Government-to-government agreements can help remove those hurdles.

Recommendation 9: Senior-level economic diplomacy

There is a handful of sectors in which the high price and prestige of products and the benefits of sales to national economies result in vigorous and visible efforts by national leaders and senior officials to gain advantage for their countries' companies. That relatively short list includes nuclear power plants, major military hardware, large infrastructure projects – and aerospace.

"Commercial" or "economic" diplomacy refers to activities conducted by senior leaders and officials to support international business activities by their country's firms. As noted by the Working Group on Market Access and Market Development:

"With many countries viewing aerospace as a key national and strategic industry, engaging in 'economic diplomacy' and supporting campaigns of Canadian industries is crucial to complement efforts of Canadian firms abroad and often sets the stage for business relations."

Final Report of the Working Group on Market Access and Market Development, September 2012.

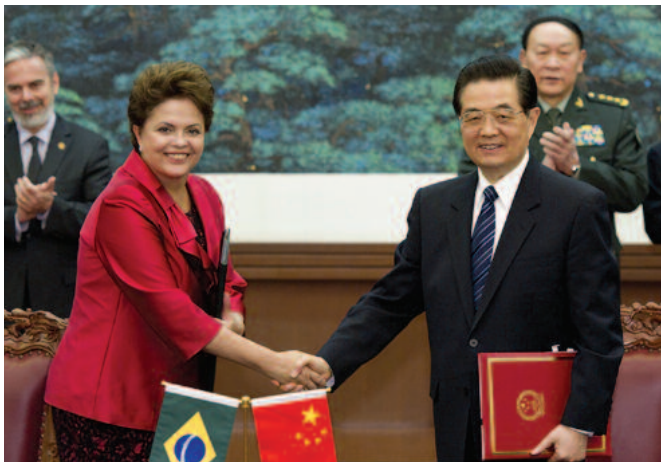
China and Germany

June 2011: China Aviation Supplies Holding Company and ICBC Leasing signed agreements for a total of 88 Airbus A320-family aircraft, worth about US$7.8 billion.

Shown in picture, from left to right: (standing) Chinese Premier Wen Jiabao; German Chancellor Angela Merkel; (seated) Li Xiaopeng, Senior Executive Vice President of ICBC and Chairman of ICBC Leasing; Tom Enders, CEO of Airbus; and Li Hai, President of China Aviation Supplies Holding Company.

Source: Airbus.
Photo credit: Guido Bergmann.

Brazil and China



April 2011: Embraer sold 35 E190 commercial jets to China, a transaction valued at US$1.4 billion.

Shown in picture: Brazilian President Dilma Rousseff (left) shakes hands with Chinese President Hu Jintao.

Source: Xinhua Photo.

Indonesia and the United States

November 2011: Lion Air of Indonesia purchases 230 Boeing 737 jets, worth about US$22 billion, the largest commercial order in Boeing's history.

Shown in picture, from left to right: (standing) Edward Sirait, General Affairs Director for Lion Air; Robert Morin, Transportation Vice President for Export-Import Bank; Dinesh Keskar, Senior Vice President of Asia-Pacific and India sales for Boeing; U.S. President Barack Obama; (seated) Rusdi Kirana, President of Lion Air; and Ray Conner, Senior Vice President of Boeing.

Sources: Courtesy of the White House.

Presidents, prime ministers, ministers, and senior officials around the world help open doors for their nations' aerospace firms by highlighting those firms' strengths and successes. Canada, almost culturally, has been reticent to engage in aggressive "diplomacy" of this kind. While making sales is the job of businesses themselves, it is important to draw the attention of foreign governments and companies to the world-class aircraft and aerospace systems the Canadian industry has to offer. Companies indicate that other governments have taken notice of Canada's relatively passive approach and have sometimes interpreted it as a lack of enthusiasm for and commitment to Canadian products. In many countries, state-to-state engagement is a very important part of successful aerospace business transactions.

It is recommended that senior-level economic diplomacy be used in a considered and explicit way to encourage foreign governments and companies to give favourable consideration to Canadian aerospace products.

Such diplomacy can be carried out by representatives from the highest political echelons – through more junior ministers – to senior officialdom from the public service and Canadian Forces. Each effort will be reflective of the opportunity and audience, but Canada needs to adopt a more assertive approach.

Recommendation 10: A balanced approach to export and domestic controls

The access of Canadian companies to global markets and supply chains is shaped not just by international agreements, bilateral accords, and economic diplomacy, but also by the export and domestic control regimes. Such controls are designed to guard against the leakage of sensitive goods and technologies, and are necessary both to protect national security and to preserve Canada's unique trade relationship with the United States.

Export and domestic controls

Export controls

Export controls are intended to ensure that sensitive goods and technologies are not available to countries or organizations that might use them in ways detrimental to the security of Canada or to global peace and stability. These goods and technologies are identified in an Export Control List agreed to by the members of various international export control regimes and are based largely on multilateral and bilateral non-proliferation agreements. Items on the Export Control List range from enriched uranium to optical sensors to missile systems.

Complementing the Export Control List is an Area Control List, which focuses on specific countries to which all exports are controlled. Currently, North Korea and Belarus are the only countries on the Area Control List.

Each country administers its export control regime in its own way. In Canada, exports of controlled items require pre-approval in the form of export permits issued by the Department of Foreign Affairs and International Trade pursuant to the Export and Import Permits Act.

Domestic controls

In order to ensure that sensitive goods and technologies are not accessed by people within Canada who may use them to threaten the security of Canada and its allies, the Controlled Goods Regulations *were established under the* Defence Production Act. *Administered by Public Works and Government Services Canada, these regulations serve to prevent the unlawful possession or transfer of controlled goods in Canada. Controlled goods are a subset of the goods included in the Export Control List and include items such as weapons, military equipment, and satellite Global Positioning Systems.*

The evidence suggests, however, that Canada's interpretation and application of these controls may be unduly sweeping and rigid, even going further, in some instances, than is typical in Washington. This stringency complicates the ability of the aerospace and space industries to sell their products abroad. Meanwhile, companies from countries with more balanced export control regimes, including North Atlantic Treaty Organization allies, are able to make sales in China, Russia, and elsewhere – sales that might otherwise have been made by Canadian companies. The result is lost business for Canada with no material enhancement of security.

> *"Like most countries with military and defence exports, Canada's export controls are not intended to hamper legitimate trade. Instead, Canada's export controls try to seek a balance between the legitimate commercial interests of Canadian exporters and the national [security] interests of Canada. While attempting to strike the right balance, Canada also attempts to ensure its controls are stringent enough to enable its exporters to benefit from more relaxed U.S. export controls…. Nonetheless, the impact on Canadian industry and the Canadian economy are still very significant. Compared to many other countries, Canadian exporters of controlled goods and technology incur higher compliance costs and opportunity costs (e.g., lost sales) … Unlike most countries, Canada also has put in place domestic controls which are some of the most stringent, if not the most stringent, in the world."*
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> Advantage Trade Controls Ltd., *Aerospace Export and Domestic Controls Review*, July 2012. Research report commissioned by the Aerospace Review.

The timeline for obtaining an export permit can be long and unpredictable. While partly a function of the complexity and far-reaching nature of controls, this issue also relates to the types of permits that are used and the efficiency of processes for considering and approving permit applications. Whatever its cause, the effects on Canadian aerospace and space firms seeking international sales can be significant.

It is recommended that the government review export and domestic control regimes to ensure that they are not unnecessarily restrictive and that export permits be issued expeditiously.

A robust set of export and domestic controls must be maintained. But the current regimes need to be examined to ensure that trade in non-sensitive technologies is not unnecessarily restricted because of overly inclusive definitions or interpretations. Such a review is particularly urgent with respect to controls on dual-use technologies – those with both civilian and military applications – that are easily obtained in global markets.

Wherever feasible, use should be made of general export permits and permits that allow for sales to multiple rather than individual countries. And to improve predictability for business and avoid a loss of sales due to procedural delays, reasonable timelines should be adhered to for processing export permit applications.

In parallel with these efforts, the government should encourage the United States to continue reviewing its *International Traffic in Arms Regulations* and export control regimes, given that the North American aerospace and space industries are highly integrated and that American companies and experts themselves have argued that U.S. controls may overreach.

The Committee on Science, Security, and Prosperity, co-chaired by Brent Scowcroft (former National Security Advisor under presidents George H. W. Bush and Gerald Ford) and John Hennessey (President of Stanford University), has expressed concern about the stringency of American export controls. In a 2009 report, the Committee stated:

"Our export controls retard both the United States and its allies from sharing access to military technology and handicap American business from competing globally.

"…As a nation, we cannot and should not abandon well-conceived efforts to keep dangerous technology and scientific know-how out of the hands of those who would use this knowledge to create weapons of mass destruction and other, equally dangerous military systems. However, such knowledge and technology represent a very narrow and limited set of goods, technology, and know-how… A strategy of international engagement is a path to prosperity that can be coupled with a smart approach to security using an adaptive system of government regulation and incentives."

National Research Council (U.S.), Committee on Science, Security, and Prosperity, *Beyond "Fortress America": National Security Controls on Science and Technology in a Globalized World,* 2009, pp. 2 and 81.

Recommendation 11: Cost recovery for certifications

Conducted by Transport Canada, the National Aircraft Certification program reviews and approves more than 1,500 new and modified aerospace products manufactured or used in Canada each year. This safety certification service is well-respected both domestically and internationally. When certifications are both rigorous and timely, they improve the competitiveness of the industry while protecting the public. Should they slow down because of a mismatch between demand and capacity, however, they will create a bottleneck that weakens the industry's ability to make sales. Such a situation has not yet emerged, but there are reasons for concern as new aircraft models come into service, production levels increase, demand rises for staff qualified to carry out certifications, and fiscal restraint in the public sector continues.

It is recommended that the government implement a full cost-recovery model for aircraft safety certification.

Transport Canada already has the ability to collect fees for aircraft safety certification, but at the moment, only a small part of actual costs is recovered. Existing cost-recovery authorities should be built upon to increase revenue, which should be applied directly to the maintenance and expansion of certification capacity. Cost recovery should be structured in a manner that protects the real and perceived independence and integrity of the certification regime by avoiding any perception that individual companies' payments result in special attention.

As it is renewed through a new funding model, Canada's expertise in safety certification could be a bargaining chip in the context of bilateral negotiations on sectoral agreements. Technical assistance in this area would be valuable to countries seeking to rapidly build their aerospace industries, and could facilitate quicker validation of Canadian certifications by countries where Canadian companies wish to sell. However, Canada's certification proficiency is also a competitive advantage, and assistance that would help other countries catch up should only be offered on the basis of reciprocity; that is, the Canadian aerospace sector – and by extension, the Canadian economy – must gain tangible benefits from any sharing of this capacity.

Recommendation 12: Supplier development initiatives

Although most of the media attention related to Canada's aerospace industry focuses on higher-profile OEMs and tier 1 companies, Canada's aerospace industry has a large number of smaller suppliers. These companies are facing challenges as a result of the globalization of supply chains – which is eroding any advantage they once enjoyed because of proximity to Bombardier and Boeing – and pressures to assume more of the cost and risk associated

with technology development. The Small Business and Supply Chain Development Working Group went so far as to call this situation a "fundamental crisis for aerospace SMEs." The viability of these suppliers depends on rapid improvements to business practices and processes.

Dealing with these challenges is, first and foremost, the responsibility of the companies themselves. But given that suppliers play an important part in the overall aerospace "ecosystem" – spawning new ideas and supplying products and personnel to larger companies in higher tiers – it is appropriate for governments to partner with industry to support the upgrading of managerial skills among small suppliers, facilitate exchanges of information between them and larger firms with respect to technological and product development priorities, and improve their ability to operate globally. A strong and balanced Canadian supply base is important to the long-term growth and vitality of the aerospace sector.

It is recommended that the government co-fund initiatives aimed at strengthening the Canadian aerospace supply chain.

The idea of systematic aerospace supplier development programs has gained momentum in recent years. Such programs have been set up by some OEMs and tier 1 firms, as well as through the cooperative efforts of industry and governments in aerospace clusters in countries such as the United Kingdom, France, and Brazil.

In Canada, aerospace supplier development initiatives exist or are being established in Quebec, Manitoba, and Ontario. The most advanced is the MACH initiative, a public-private partnership developed by Aéro Montréal that will spend $15 million over five years to help 70 suppliers better appreciate the needs and expectations of OEMs and tier 1 integrators, and build the internal capacity to operate at that level.[7]

MACH initiative

Launched by Aéro Montréal, the MACH initiative is a change program for accelerating the aerospace supply chain's competitiveness and performance through three main strategic goals:

1. *to create an improved business culture for more openness, collaboration and innovation;*
2. *to improve supply chain competitiveness, one company at a time; and*
3. *to develop new local integration capabilities.*

The initiative also aims to develop strategies and projects that will help fill the gaps in integration capabilities in Quebec and to foster the development of a world-class supply chain.

With a budget of $15 million over five years, the MACH initiative targets 70 suppliers that will join the program in five annual cohorts. It enables participants to enhance their capabilities across key business processes and areas through a variety of tools and training.

Small and medium-sized enterprises (SMEs) participating in the program are supported in their activities by an original equipment manufacturer or equipment manufacturer that acts as sponsor or mentor for the SME. MACH helps suppliers assess their performance, identify gaps, and determine the actions necessary to improve.

The MACH initiative started operations in July 2011 with a group of 20 suppliers supported by nine sponsors. The second cohort entered in September 2012 with 10 additional suppliers and eight new sponsors.

Source: Aéro Montréal.

7 For more details on these initiatives, see the following sections in the *Final Report of the Supply Chain Working Group*: "MACH Initiative," "Competitive Edge," and "Esprit – Ontario Aerospace Council Global Clusters Accelerator," September 2012.

To foster supplier development across the Canadian aerospace industry, the government should co-fund either an extension of the MACH initiative across the country – as proposed in the *Final Report of the Supply Chain Working Group* – or more regionally based programs. The choice between these options should be based on consultations with provincial governments and industry, both of which should make their own contributions to program costs. Any supplier development initiative receiving public funding should:

- help suppliers understand and respond to the needs of OEMs and tier 1 firms;
- provide suppliers with information on global supply chains and with international business readiness training;
- be structured in a way that does not discourage consolidation among smaller suppliers where that is the natural tendency in the marketplace; and
- include rigorous measures to assess participating suppliers' performance and progress.

Chapter 3.3
Leveraging government procurement

Government spending on aircraft the world over is significant, even if defence budgets are falling in many Western countries as a result of fiscal restraint. The vast majority of these expenditures are on military aircraft and equipment, though there is also some purchasing in support of police forces, emergency response organizations, and the like. Given that international trade rules contain exceptions for security-related procurement, governments in countries with companies that manufacture military aircraft and systems typically make their purchases at home, which sends industrial benefits rippling through the industrial structure of their economies. The U.S. military, for example, always "buys American" when it comes to combat aircraft, and the same is normally true for the armed forces in other nations with firms that make fighter jets, including Russia, China, France, and Sweden.

A country such as Canada, however, must typically buy its military aircraft from foreign sources. Given this reality – and the fact that the Canadian aerospace sector can only thrive if it is technologically advanced and well-integrated into global supply chains – it is essential that Canada leverage government procurement to build the domestic aerospace sector, just as every other country does.

Public aerospace purchases should be planned and executed with three goals in mind: providing men and women in uniform with products that meet their operational requirements, getting good value for the Canadian taxpayers' money, and strengthening the Canadian industrial and technological base.

Balanced achievement of these objectives has proven elusive in Canada.

Efforts to advance the first two goals require that there be clear responsibilities, checks, and balances among federal departments and agencies. User organizations – the Canadian Forces for military aircraft, the Canadian Coast Guard for some search-and-rescue aircraft, and the Royal Canadian Mounted Police for policing aircraft – should articulate high-level operational requirements, while Public Works and Government Services Canada should lead transparent bidding and selection processes with clear, firm timelines to ensure that the women and men in uniform have the equipment they need, when they need it. To the greatest degree possible, companies should be able to bring forward a range of options to meet users' operational needs. If the description of those needs veers too far into detailed specifications, it gives rise to the impression that there is a particular product being sought from a particular supplier. There is a perception among some in the industry that procurement decisions have been influenced by familiarity with specific assets or the fact that certain aircraft are already operated by Canada's closest allies. Whether or not it is well-grounded, such a perception can have an impact on competition, costs, and credibility – and can be avoided, or at least minimized, through well-designed and well-executed procurement processes.

> *"Canada has a robust aerospace sector that currently ranks 5th in the world. Much of Canada's aerospace activities are in commercial and dual-use aerospace products. However, in terms of military aviation products, which are the bulk of aerospace-related public procurement, Canada's domestic base is very limited. This causes our government to look off-shore for most major procurements. It is therefore imperative that these off-shore investments be leveraged to the maximum extent possible to benefit Canadian industry and the economy."*
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> *Final Report of the Aerospace-Related Public Procurement Working Group*, September 2012.

The third goal – strengthening Canadian industry – can be advanced by requiring investments in the aerospace sector by companies that secure procurement contracts. It is standard practice internationally to require foreign vendors to "offset" military acquisition costs by spending money in the purchasing country. In fact, Canada was one of the first to introduce such a requirement. Since the mid-1980s, offsets have been secured in Canada through the Industrial and Regional Benefits (IRB) Policy, which requires firms that win government defence contracts to spend sums equal to the value of the contract on Canadian goods and services.

The merits of IRBs, however, have been much debated, and the Review of Federal Support to Research and Development issued a special report on procurement that called for government purchasing to be used more effectively to nurture Canadian businesses and stimulate innovation. Further work has now been commissioned on how, in practice, this could be done.

Procurement can also strengthen the Canadian industry when indigenous firms take on a significant share of the ongoing maintenance and repair of purchased aircraft. In the past, Canadian companies benefited from providing in-service support (ISS) for planes bought for the use of the Royal Canadian Air Force, using engineering and technical data provided by the aircraft manufacturers. This arrangement provided those companies with a steady earnings stream and allowed them to develop advanced engineering and design capacity that could be marketed to other clients in Canada and abroad. It also provided Canada with greater sovereign capacity to keep its air force flying, reducing any risk that in a time of crisis its combat aircraft might be grounded because ISS facilities abroad were too busy servicing their own countries' assets to carry out essential maintenance and repairs of Canadian planes. Finally, it permitted adaptation of equipment to Canadian operating conditions and requirements.

More recently, however, a "single point of accountability" model has been adopted, under which the aircraft manufacturer also provides maintenance and repair services. This change has been spurred by the intersection of several factors, including:

- manufacturers' desire to expand their business lines, realizing that there are good margins to be earned through the provision of ISS services, and reluctance to transfer data on sophisticated technologies that were developed through years of investment and complex engineering; and
- the Department of National Defence's desire to incent dependable asset performance rather than pay by the repair – and its assessment that as aircraft have become increasingly complicated, the companies that make them are best positioned to service them reliably and at reasonable cost.

Canadian ISS firms have voiced concerns about the recent change in approach, with some suggesting that its effects on the domestic industry could be devastating.

In both these areas – industrial benefits requirements and ISS – it is possible to adjust policies and programs in ways that will produce better outcomes for both the Canadian industry and for the government as the purchaser and user of aircraft.

Recommendation 13: Earlier, clearer, firmer commitments on industrial and technological benefits

There is broad agreement on the goal of ensuring that when the government purchases aircraft and aerospace equipment from manufacturers, those manufacturers spend money in ways that benefit Canada's economy. But there are questions about the best means of achieving this end.

During its first two decades, the implementation of the IRB policy was too ad hoc. Aircraft manufacturers with whom the obligations rested were given credit for a wide range of purchases made in Canada that did not do enough to enhance the technological foundations of the Canadian aerospace industry or position it to compete globally.

Changes to the policy in recent years have sought to improve the situation. These changes include better recognition of work that is given to Canadian companies on major aircraft platforms sold by the manufacturer around the world, work that helps to position Canadian companies in global value chains; an updated list of key technologies; and the establishment of incentives, through "multipliers," for the creation of research consortia involving industry and academic institutions.

Despite these improvements, Canada's approach to procurement-based industrial benefits still falls short. The main issue is that obligations to spend in Canada are generated at the time of purchase, but vendors, government, and the Canadian aerospace industry have insufficient clarity on how those obligations will be satisfied. As the years pass, manufacturers accumulate offset commitments in other countries to which they also have made sales – commitments that effectively compete with obligations to spend money in Canada. Over time, the sellers' obligations to the development of the Canadian industry and growth of the Canadian economy become ever more difficult to enforce, even as the government offers increasingly generous terms in an attempt to attract high-quality spending.

There are other approaches to leveraging procurements. The National Shipbuilding Procurement Strategy, for example, required that bidders describe the comprehensive value propositions of their proposals for Canadian industry before any contract was signed.

Negotiating clearer, more specific industrial and technological benefits plans earlier in the procurement process – when the government's leverage is greatest – will almost certainly produce quicker and more tangible results.

It is recommended that when the government seeks to purchase aircraft and aerospace-related equipment, each bidder be required to provide a detailed industrial and technological benefits plan as an integral part of its proposal, and these plans be given weight in the selection of the successful bid.

Each industrial and technological benefits plan should clearly specify the post-sale activities the vendor will undertake in Canada. Industry Canada should take the lead in assessing these plans as part of the bid selection process, with the assessment counting for a weight of at least 10 per cent in the scoring system used to rank bids.

The criteria for assessing industrial and technological benefits plans should include the extent to which, over a defined and reasonably tight time frame, they strengthen the Canadian aerospace sector's:

- capacity with respect to priority aerospace technologies;
- ability to innovate through collaboration involving industry and researchers; and
- position in global supply chains.

The more a plan advances these goals – through the sourcing of sophisticated systems and services from Canadian companies, technology transfer in the context of business relationships, investments in research and technology demonstration, and the like – the higher its score should be. Assessments may also consider the business opportunities for SMEs that a plan creates – which would be consistent with the existing IRB policy – to the extent that such opportunities add to the overall health and vitality of the Canadian aerospace supply chain.

An approach to industrial and technological benefits that requires clear, detailed commitments during bidding is overdue, but it does carry several risks. One is that bidders will be forthcoming with impressive commitments to win a sale, but will not deliver on those commitments once tendering has been completed. This risk can be mitigated through strong contractual language that empowers the government to impose penalties or seek damages if the stipulations of an industrial and technological benefits plan are not met.

A second risk is that the pressure to submit detailed plans will result in too many low-value transactions. The use of the criteria listed above to guide assessments will reduce this risk, as will more transparent processes that give bidders enough time to develop firm, credible plans, along with increased flexibility for companies to "bank" high-value investments in Canada, as long as they can demonstrate that those investments were motivated in part by the expected procurement.

"… the [Industrial and Regional Benefits (IRB)] program is not achieving the desired results. The program as currently structured is not really stimulating the kind of [intellectual property]/technology transfer to create innovation and export prowess.

"Part of the reason for this is that the IRB program under the current pass/fail system is not having any meaningful effect on the government's buying decisions, and companies know that. The belief in industry is that no company will risk losing a bid on something [the Department of National Defence] wants because of a weak IRB plan.

"IRBs can be made more relevant if the IRB plan is rated in the procurement process. Then companies start to pay more attention and view IRBs as a truly important part of the bid... Making the Canadian industrial development proposal a real determining factor in a bid will create the right behaviours."

Canadian Association of Defence and Security Industries (CADSI), Submission of CADSI to the Aerospace Review, Annex C.

A final risk is that circumstances will evolve in ways that make commitments that looked promising during bid selection less relevant and valuable over time. Excessively specific and rigid plans may impede adaptation to changes in markets, production patterns, or the Canadian industry itself. To guard against this risk, it is important that contractual provisions related to industrial and technological benefits plans focus on initiatives that are medium term in nature. Contract amendments should be permitted in the face of fundamental changes in conditions and the advent of new technologies, as long as these amendments are consistent with the objectives of industrial and technological benefits plans and agreed to by both the obligor and the government.

Recommendation 14: A partnership approach to in-service support

The choice of strategies for the provision of ISS for aircraft bought by the government needs to advance the twin goals of ensuring a single point of accountability for durable aircraft performance and strengthening the Canadian aerospace industry.

There is no inherent incompatibility between these goals. The government does not have to select either the aircraft manufacturer or a Canadian ISS firm to provide maintenance and repair services. Instead, it can use its purchasing leverage to create the conditions for mutually beneficial business relationships between manufacturers and Canadian companies.

It is recommended that when the government seeks to buy aircraft and aerospace-related equipment, each bidder be required to partner with a Canadian firm for in-service support and to provide that firm with work and data that allow it to strengthen internal capacity and access global markets.

The specific details of partnership arrangements would, of course, be up to the parties themselves, but as a matter of public policy, it is important that those arrangements provide for more work by the Canadian partner than simple "metal-bending" tasks. In addition, they should ensure significant and ongoing transfer of technical data and intellectual property, which will permit the Canadian company to develop engineering and design expertise that protects Canadian security interests and facilitates the company's participation in the global market.

The government should also explore, when existing procurement contracts come up for scheduled reviews, whether ISS arrangements can be revised to deliver more data and advanced engineering and design work to Canadian ISS firms.

"…[In-service support (ISS)] contracts will normally be awarded to the platform suppliers (i.e., original equipment manufacturers), which may often be foreign-based companies. By virtue of the contract's Industrial Regional Benefits (IRB) requirements, much of the ISS work will be subcontracted to Canadian firms. IRB requirements, however, do not typically identify specific tasks that must be performed in Canada. As a result, there is a risk that Canadian firms will be relegated to work of low intellectual value – work that will neither preserve critical defence capabilities nor support the sustainment and growth of Canadian industry."

Cogint, *Approaches to In-service Support (ISS), Optimized Weapon System Support (OWSS) and Single Point of Accountability (SPA)*, July 2012. Research report commissioned by the Aerospace Review.

Chapter 3.4
Building the aerospace workforce

A competitive Canadian aerospace sector is founded in part on a well-educated workforce that includes highly skilled engineers, technicians, technologists, and production personnel. The need for such a workforce is not limited to the aerospace sector – it extends to the whole economy, which increasingly depends on a pool of young people committed to careers in science, technology, engineering, and mathematics (STEM). Because the aerospace sector is seen as exciting, and pays relatively well, its vitality and a growing STEM pool are, in a sense, mutually reinforcing.

> *"Skilled workers must become agile and take on business functions that they have never done, such as: lean manufacturing, design for Six Sigma, concurrent engineering practices, strategic planning, marketing and business development, program management, supply chain management, financial management, and human resources management. These capabilities, as well as 'soft skills', have become critical for managing large complex projects, forging international alliances, and conquering markets. Companies, particularly [small and medium-sized enterprises], are now faced with the challenge of learning how to manage new business activities, hiring and training people to carry them out, and performing with excellence on cost, quality and delivery while evolving to become the 'go-to' supplier for higher value-added products and services."*
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> *Final Report of the People and Skills Working Group,* September 2012.

Currently, the Canadian aerospace industry enjoys a competitive edge thanks to a workforce known for its expertise and productivity, but this advantage is at risk. Given the demographics of the workforce, concerted efforts on the part of industry, academic institutions, unions, and governments are required to shore up the aerospace sector's skills base. Labour market forecasts indicate that specialized and experienced aerospace workers will be in short supply over the coming decades, particularly in engineering, technology, and supervisory occupations. Indeed, some aerospace firms report that they are already struggling with labour shortages.

[Translation] "Strategic talent is becoming increasingly mobile and contributing more and more to the economic prosperity of cities. The availability of these specialized workers is usually a key factor in aerospace firm investment decisions. In short, having available talent in large metropolitan centres is a first-rate asset in an economy that is based on knowledge and innovation.

"Competition for a skilled workforce has now become global, and includes countries which, like Canada, are facing demographic issues, as well as other countries like Brazil, Russia, India and China (BRIC), which are experiencing unbroken cycles of economic growth."

Montréal International, *Keeping the Greater Montreal Aerospace Industry Attractive*, submission to the Aerospace Review.

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"The greatest recruitment and retention challenges identified by aerospace and space companies are in occupations and trades characterized as highly skilled, technically oriented and specialized."

Prism Economics and Analysis, *Current and Future Human Capital Needs in the Aerospace Industry and Strategies for Harnessing the Potential Workforce*, July 2012. Research report commissioned by the Aerospace Review.

Efforts to strengthen the aerospace skills base must focus not only on attracting young talent to the right fields of study, but also on continual up-skilling. Global realities that challenge the industry to constantly adjust to technological evolution, shifting market and regulatory demands, and new design and manufacturing methodologies mean that employees on the shop floor and in laboratories must always be learning and adapting. As noted in the *Final Report of the People and Skills Working Group*, "market success will be achieved by those firms who not only have access to a highly skilled and adaptable workforce, but who can also keep those skills relevant over the long term." Canada's international aerospace competitors are deploying public resources to ensure that their workforces have relevant skills and can respond quickly to change by, for example, funding customized training programs, providing training-related tax incentives, and offering grants for workforce up-skilling.

Finally, fostering and maintaining a skilled, adaptable aerospace workforce requires that up-to-date infrastructure be available at academic and research institutions.

Aerospace training and innovation hub in Germany

The new Bavarian International Campus Aerospace and Security (BICAS) was launched in 2012 at the European Aeronautic Defence and Space Company (EADS) site in Ottobrunn, Germany. At this unique facility – developed by EADS and six other founding partners with backing from the German state of Bavaria – universities and research institutions have merged to create an educational campus at an industrial site.

Ottobrunn is one of the main locations for EADS Innovation Works, the corporate research arm that reports to the EADS Corporate Technical Office. BICAS will be based on three "pillars": research projects; scientific equipment; and teaching and study programs. Initial project funding of €20 million (about $26 million) has been pledged by Bavaria, matched by private investors and industry, which will ensure sustained activity at the campus for the next five years.

Four main areas of focus have been established for the BICAS: green aerospace; public security; autonomous systems; and integrated systems. These will be pursued with the goals of educating and motivating students in both innovation and entrepreneurship. BICAS will also offer a set of new master's-level study programs, shaped around identified engineering skills and requirements needed for future programs and applications in the field of aerospace and security.

Many of these issues are relevant not just to the aerospace industry, but also to space companies and other sectors that rely on innovation and engage in advanced manufacturing. The primary responsibility for responding to them rests with industry – given its fundamental business imperatives – and provincial governments – given their jurisdiction over education. But the federal government also has a role to play. Vibrant, innovative companies with well-educated, highly skilled workforces provide economic benefits to the country as a whole and are part of building a strong economic union. Through Human Resources and Skills Development Canada, NSERC, Citizenship and Immigration Canada, the Canada Foundation for Innovation, and the tax system, the federal government delivers programs and funding to support skills development, nurture Canadian talent, and address persistent skills shortages. While these programs do not typically target specific sectors, with more focus, they can be better leveraged to maintain and enhance the competitiveness of Canada's aerospace workforce.

> *"A talented and adaptable workforce is at the heart of innovative economies. Every part of the economy therefore has a stake in educating, training and effectively integrating highly qualified and skilled Canadians into the workforce, and in attracting and retaining talented individuals to Canada. While the development of talent is the responsibility of the provinces, the Government of Canada plays an important role through the granting councils and can have a particular focus on the deployment of talent in support of business innovation."*
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> Review of Federal Support to Research and Development Expert Panel, *Innovation Canada: A Call to Action*, October 17, 2011, p. 5-14.

Recommendation 15: Promotion of aerospace- and space-related studies and workplace experience

The aerospace and space sectors offer a world of possibilities to young Canadians. With creative and engaging outreach programs, students at the elementary and secondary levels can be awakened to career opportunities in aerospace and space, and given an appreciation of the training – including courses in science and math – that they must follow in order to realize their dreams. And when these students reach the post-secondary level and enrol in aerospace-related studies, their success can be facilitated through workplace experience and bridging programs.

The federal government cannot make these things happen on its own. But it can and should work with industry, academic institutions, and provincial governments to understand the human capital needs of the aerospace sector and to deal with potential labour force shortages that, if left unaddressed, will affect the sector's long-term competitiveness.

It is recommended that federal programs be used – in collaboration with industry, academia, unions, and provinces – to promote science, technology, engineering, and mathematics studies generally, and aerospace and space careers specifically, among youth; to help college and university students acquire relevant expertise; to bridge new graduates into the aerospace and space workforces; and to bring skilled aerospace and space workers from abroad when efforts to develop labour supply in Canada do not keep up with demand.

Taking the long-term view, collaborative initiatives should seek, in the first instance, to boost STEM program enrolment and completion rates and to inform youth about aerospace and space career options. Particular efforts should be made to encourage the participation in STEM and aerospace- and space-related studies of young women – who are under-represented in these areas – and Aboriginal youth – who are a growing proportion of the population and who sometimes face challenges with labour market integration.

Governments, industry, unions, and academia should also cooperate in efforts to help students in engineering and trade school programs acquire hands-on experience in the aerospace and space sectors through internships, applied research projects, co-ops, and flexible apprenticeships. Federal contributions to these efforts should include:

- more focused support for undergraduate-level internships in aerospace and space companies, which will accelerate the progress of engineering students and make them more work-ready upon graduation; and
- targeting programs toward strengthening the skilled trade base for aerospace and space by supporting relevant co-ops, flexible apprenticeships, and bridging from post-secondary studies into workplaces.

In the event the sorts of concerted, coordinated efforts described above do not result in a skilled labour force large enough to meet the aerospace and space industries' needs, the federal government should be responsive to companies' requests to use the immigration system – including recently announced changes to facilitate the immigration of skilled tradespersons and professionals – to deal with demonstrated shortages.

Recommendation 16: Support for up-skilling

Aerospace companies and their workforces must continually adapt to changing technologies, products, and regulatory requirements to remain competitive. Firms at the OEM and tier 1 levels already invest substantial sums in ongoing skills upgrading, sometimes assigning dedicated teams to develop in-house training programs. Tier 2 and 3 companies, particularly smaller ones, have less capacity to invest in learning and adapt to pressures, which is one impetus behind the supplier development programs discussed in recommendation 12.

Given that continual up-skilling is critical to the long-term vibrancy of the aerospace sector and, in turn, for the economy – and the reality that a capable, adaptable workforce is a key reason why aerospace firms choose to locate and remain in Canada – it is appropriate for public policies and programs to recognize and incent it, something they do not generally do at present. For a modern, innovation-based, globalized industry, a more inclusive approach is needed.

It is recommended that mechanisms be developed to support the efforts of aerospace companies to keep their workforces technologically adept and adaptable through continual up-skilling.

Such support could take a number of forms, including:

- Funding or tax credits for supplier development activities that transfer skills to workers across the supply chain, as risk is pushed down the tiers.
- Training grants to employers that partner with educational institutions to develop customized training programs that help employees work with new technologies and products.
- Targeted tax support in recognition of employers' investments in enrolling workers in accredited courses in fields such as manufacturing or transportation technology. This would go beyond the general deduction for business expenses and be aimed at strengthening the skilled trades base in Canada.

Measures such as these could be paid for from budgets for existing skills development programs and/or reallocation of savings resulting from the tightening of SR&ED eligibility criteria.

Recommendation 17: Co-funded infrastructure

Both initial skills training through post-secondary studies and ongoing up-skilling for the aerospace workforce require access to up-to-date training infrastructure, such as simulators and engines. This infrastructure costs a great deal to buy and maintain. But when aerospace research and training infrastructure is allowed to get outdated, the impacts on skills development and innovation can be serious.

It is recommended that the government co-fund – with industry, provinces, and academic and research institutions – the purchase and maintenance of up-to-date infrastructure required for aerospace training and research purposes.

Wherever possible, such infrastructure should be located in "hubs" that are accessible to a wide range of companies, researchers, and students. Given the level of aerospace activity in Montreal and Toronto, they would be among the most obvious places to create or nurture such hubs.

Some of the federal government's regional development agencies may be in a position to provide support for infrastructure-related partnerships between industry and academic and research institutions, where those partnerships stimulate economic growth and prosperity. Another source of funding may be the Canada Foundation for Innovation, which has a mandate to fund state-of-the-art equipment, laboratories, and other infrastructure in cooperation with universities, colleges, and research institutions. Finally, the NRC could be a participant in hub development, given its significant role in aerospace research.

Aerospace training and research hubs

An aerospace training and research "hub" brings together colleges, universities, firms, and government-supported research and technology transfer centres that are situated in proximity to one another, to work collaboratively to develop relevant skills and nurture innovation. For example, in Quebec, the École nationale d'aérotechnique and the Centre Technologique en Aérospatiale *– which features state-of-the-art laboratories and equipment – are among those that collaborate closely with industry and universities within the Montreal aerospace cluster.*

In keeping with the aerospace training and research hub model seen elsewhere in Canada and globally, a new aerospace campus is being proposed in Ontario. The campus would involve, among others, Centennial College, the University of Toronto's Institute for Aerospace Studies, and Bombardier. As noted in one submission to the Aerospace Review, the proposed campus would serve a number of purposes:

"One of the significant constraints to industry growth identified is an aging workforce and skilled labour shortage. One proposal to address this challenge, for which there [is] significant support, [is] to establish an aerospace campus at the Downsview Park site. This would leverage Ontario's very best educational institutions in a unique partnership designed to develop innovative new technologies, aid in workforce training and skills development, and participate in supply chain development activities. This campus would provide an anchor point to a proposed aerospace technology corridor between Toronto and Montréal and enhance the capabilities of both centres."

Canada 2020, *Taking Flight: Making an Ontario Aerospace Cluster a Reality – Detailed Report*, submission to the Aerospace Review.

Chapter 3.5
Small businesses in Canada's aerospace sector

Small suppliers are part of a healthy aerospace "ecosystem." Besides providing components to companies in higher tiers, small firms help drive industry growth, as they are less likely than larger players to offshore their operations, more likely to buy their own supplies from Canadian companies, and motivated to expand.

Trends in the global aerospace industry, however, mean that smaller firms are facing unprecedented challenges. To reduce the risks associated with supply chain complexity, OEMs and tier 1 integrators increasingly prefer to deal with a smaller, more manageable number of proven suppliers. In addition, since OEMs are no longer willing to bear the main burden of developing new products, small suppliers are required to undertake more and more research and design activity.

In the face of these challenges, many small suppliers feel that they have only two options:

- Get bigger and win more business in higher tiers.
- Develop a niche offering that offers a unique competitive advantage.

As stated in the *Final Report of the Small Business Working Group*, "[Small businesses] want to excel as suppliers and contribute value-added products and services to the primes, systems integrators, and government departments while providing high-quality jobs for Canadians across the country. They seek opportunities to prove their innovative products and services to end customers, and to design to build, rather than to build to print, to be competitive and attractive to their customers."

It is expected that seven recommendations will directly facilitate the pursuit of these strategies:

- Recommendation 3 on the creation of a new large-scale technology demonstration program.
- Recommendation 5 on a national initiative to enhance collaborative research.
- Recommendation 6 on the simplification of application and reporting procedures for government programs, and the use of a "one-stop" internet portal to provide information on, and links to, those programs.
- Recommendation 12 on supplier development initiatives.
- Recommendation 13 on industrial and technological benefits plans in the context of aerospace procurement.
- Recommendation 15 on the promotion of aerospace and space-related studies and workplace experience.
- Recommendation 16 on support for up-skilling.

Access to financing is another issue often raised by smaller firms, both in and outside the aerospace sector. Where they have difficulty obtaining commercial loans, smaller businesses may turn to a number of federal organizations and programs – such as the Business Development Bank of Canada, Export Development Canada, and the Canada Small Business Financing Program – and to provincial government support programs.

Conclusion

Global trends in the first 12 years of the 21st century have had a major impact on Canada. Thanks in part to the country's rich endowment of natural resources, that impact has been largely favourable. But Canadian prosperity and stability are also the result of the creative energies of a skilled and educated population working in a range of advanced industries that are powered by innovation, audacity, and hard work. Prominent among these is the aerospace sector. Maintaining a healthy balance between resource extraction and advanced industries will be critical to economic growth and prosperity in the decades ahead.

This review has been occasioned by the recognition that conditions affecting the vitality and competitiveness of the Canadian aerospace sector have changed in fundamental ways, some threatening, some promising. The international environment is increasingly competitive, with new companies hosted by ambitious governments positioning to challenge incumbents, even as demand rises and a growing premium is placed on fuel efficiency and environmental stewardship.

At the same time, technological and economic transformations, the opening of the North, and the need to protect sovereignty and security in the face of new challenges provide opportunities for the aerospace sector to expand its business while contributing to the realization of Canada's national potential.

The Review has produced recommendations for responding to these realities in practical, meaningful ways, from better-targeted support for R&D, to stronger international agreements and economic diplomacy, to more astute procurement processes, to support for developing and maintaining a highly skilled workforce.

These recommendations are eminently realizable, if government acts on them – and if companies, research and academic institutions, and unions make the necessary investments, demonstrate entrepreneurial spirit, and collaborate effectively – the Canadian aerospace sector will flourish and perform to its full potential through the middle of the century.

We live in an age of short attention spans and immediate gratification. But a sector that requires a decade or more to design and build a new product is, of necessity, oriented towards the future. Success requires all partners not only to think about current conditions, but also to have the foresight to anticipate and react to what lies beyond the horizon.

Appendix A
List of research reports

The research reports listed below were commissioned by the Aerospace Review to provide information and advice on key issues. The complete text of these reports may be found on the Review's website, **aerospacereview.ca**, under "Research and Consultations."

These reports are available only in the language submitted, and are not subject to official languages, privacy, or accessibility requirements.

The Aerospace Review is not responsible for the accuracy, reliability, or currency of the information supplied by external sources. Users wishing to rely upon this information should consult directly with the authors.

Aerospace Export and Domestic Controls Review, by Advantage Trade Controls Ltd.

Aerospace Small and Medium Sized Enterprises Financing, by Patrick Hum, MBA Candidate, Queen's University

Approaches to In-service Support (ISS), Optimized Weapon System Support (OWSS) and Single Point of Accountability (SPA), by Cogint

Brazil, Russia, India and China Governments' Aerospace Strategies and National Policies: Implications to Canada's Aerospace Industry, by Pravco Aviation Review L.L.C.

Canada's Aerospace Industry: The Impact of Key Global Trends, by the Conference Board of Canada

Canada's Space Sector: The Essential Enabler of Canada's Northern Strategy, by Norstrat Consulting

Current and Future Human Capital Needs in the Aerospace Industry and Strategies for Harnessing the Potential Workforce, by Prism Economics and Analysis

Defence Industrial Policy Approaches and Instruments, by Ugurhan Berkok, Christopher Penney and Karl Skogstad, Queen's University

International Overview of Space Governance and Policies for the Canadian Aerospace Review, by Euroconsult

Policies and Programs of Canadian Provinces and Territories: Mechanisms to Support SMEs and Established Aerospace Firms, by Acacia Policy Consulting Inc.

R&D Support for the Aerospace Industry: A Study of Eight Countries and One Region, by Dr. Jorge Niosi, Université du Québec à Montréal

A Report on the Development of a National Space Infrastructure to Support the Global Competitiveness of the Canadian Space Industry, by Lansdowne Technologies Inc.

A Research Assessment Report on Integrated Technology Demonstration and the Role of Public Policy, by Dr. Jeff Xi, Ryerson Institute for Aerospace Design and Innovation

Sectoral Structure Analysis, by PricewaterhouseCoopers

The State of the Canadian Space Sector, by Hickling Arthurs Low

Strategies for Attracting and Retaining a Skilled Workforce in a Cyclical Industry, by John O'Grady Consulting Ltd.

Appendix B
List of submissions

Written submissions were received by the Aerospace Review from the organizations and individuals listed below. The complete text of these submissions may be found on the Review's website, **aerospacereview.ca**, under "Research and Consultations."

These submissions are available only in the language submitted, and are not subject to official languages, privacy, or accessibility requirements.

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ISR Technologies

JMJ Aerospace

Lark, Eva-Lane

Montréal International

Prentice, Barry E.

SAR Corporation

Space 1 Systems

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