

GLOBAL BUSINESS REPORTS

INDUSTRY EXPLORATIONS



QUÉBEC AEROSPACE 2017



*Regional Hubs - OEMs - Supply Chain Providers
Education - Advanced Manufacturing - R&D - Space*



Dear Reader,

In a constantly-evolving industry landscape, Québec's aerospace sector prides itself on remaining at the cutting-edge of research and innovation, a key factor in the province's international success. As a driving force of Québec's economy, support of the sector remains paramount as a strategic area for development.

The global landscape is constantly changing and aerospace hubs around the world must continue to adapt to compete. For this reason, Aero Montréal and the Québec government are investing heavily into Industry 4.0 technologies and supporting their implementation, particularly in SMEs. By fostering a more competitive supply chain, our industry will continue to thrive and maintain its global leadership position.

Alongside our focus on the development of Québec's existing aerospace ecosystem, we remain open for business and ready to support companies looking to relocate or establish subsidiaries in the region. Long favored by foreign companies as an entry point into the North American market, Québec's operating environment is highly attractive and can cater to the needs of any aerospace company.

We are indeed proud to present in the pages that follow some highlights of this industry, an economic linchpin and source of pride for Québec.



Suzanne M. Benoît
President,
Aéro Montréal



Dominique Anglade
Minister of Economy,
Science and Innovation,
Government of Québec

Exclusive Interviews

Leading industry and government figures from Québec's aerospace industry discuss market trends with GBR

12, 13, 14, 15 and many more

Editorial Analysis

GBR's reporters provide unique insights into all aspects of Québec's aerospace value chain after months of research on the ground

8, 38, 86, 116 and many more

Opinion Survey

The results of GBR's survey records market sentiment of Québec's leading aerospace executives

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Québec Aerospace 2017
Industry Explorations
Global Business Reports

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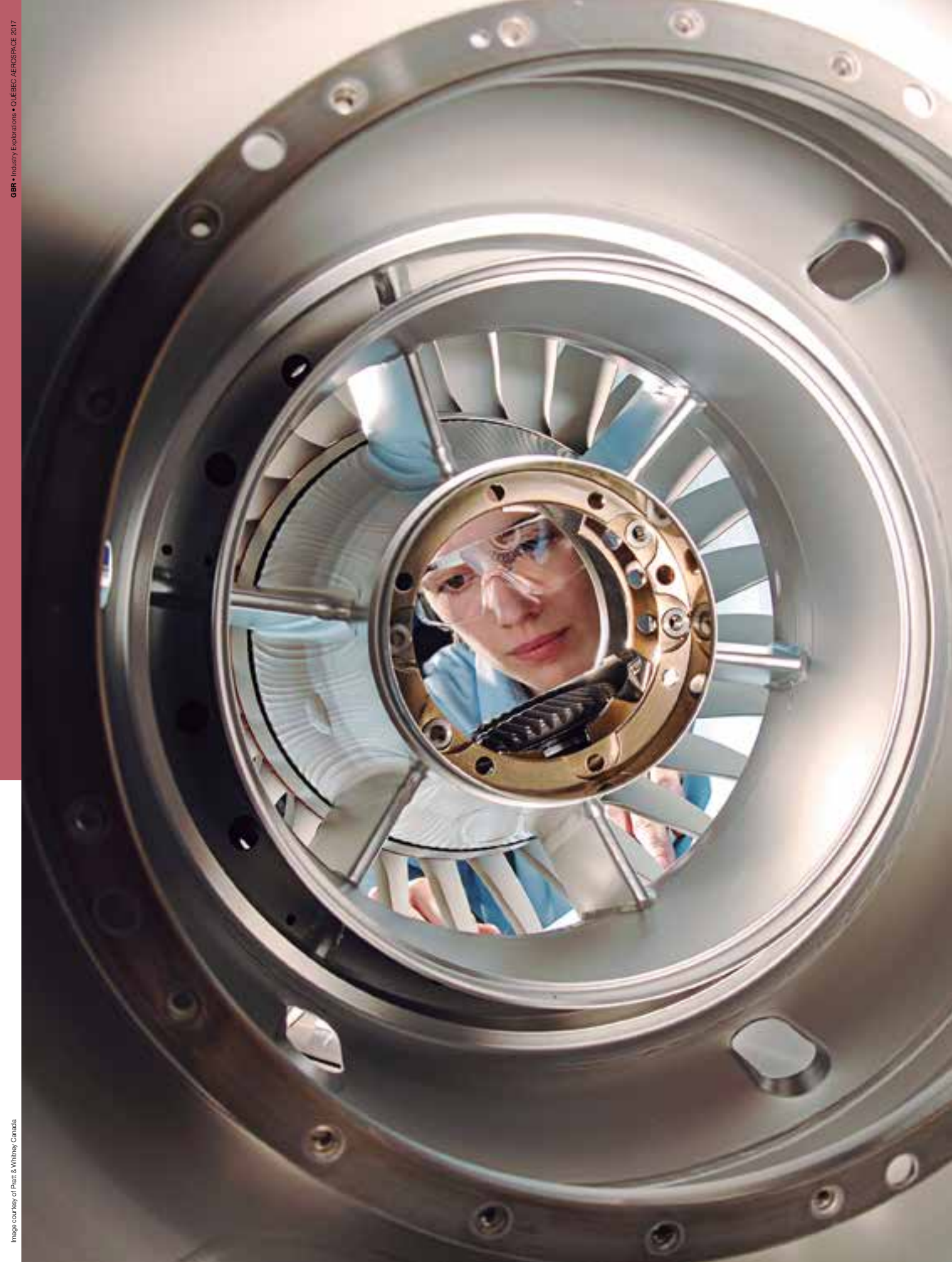
Québec

- Canada
- United States
- ★ National Capital
- Province Capital

Atlantic
Ocean

Saguenay
Trois-Rivières
Saint-Jérôme
Sherbrooke
Ottawa
Montréal
Québec

0 75 150 Kilometers
0 75 150 Miles





INTRODUCTION TO QUÉBEC'S AEROSPACE



“Aerospace is a key area of focus for economic development because it aligns with three main pillars that must be met for economic growth: entrepreneurship, advanced manufacturing and exports... For these reasons, the government has launched industrial strategies over the years to support the industry and has recently made unprecedented investments into developing the sector, particularly focusing on innovation.”

- Dominique Anglade,
Minister of Economy, Science and Innovation,
Government of Québec

Introducing Québec's aerospace ecosystem

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Québec holds a prominent position on the international stage as one of the world's top three aerospace hubs alongside Seattle and Toulouse. From as early as 1928, when Pratt & Whitney Canada (P&WC) was founded to repair and overhaul Pratt & Whitney's Wasp radial piston engines, Québec has been forging its path to the world-leading position it holds today. Driven through the 1980s and beyond by Bombardier through its purchase of Canadair and de Havilland Canada, the province's aerospace industry today is diverse, spanning the entire aerospace supply chain, with four prime contractors, approximately 15 Tier-1 suppliers and roughly 200 small to medium-sized enterprises (SMEs).

Québec's aerospace ecosystem is well supported at both a provincial and national level due to its important economic impact. With 2016 sales of US\$14.4 billion, growing at an average annual rate of 5.2% over the last 25 years, the province ac-

counts for 52% of the Canadian aerospace industry's total sales and is home to 70% of the country's research and development (R&D).

Situated in eastern Canada, the predominantly French-speaking province is ideally located only a short distance from the border of its largest export market, the United States. Alongside its favorable geographic location, Québec's retention of the French language and European flavor make it an ideal choice for European companies to access the North American market. The region's international links are apparent both in the high number of exports—Québec exports over 80% of aerospace production directly or indirectly—and the high number of subsidiaries that have been established in the province over the years. These include Bell Helicopter Textron, Pratt & Whitney Canada (P&WC) and GE Aviation, subsidiaries of U.S.-based Textron, Pratt & Whitney (a division of United Technologies) and General Electric respectively, as well

AEROSPACE INDUSTRY AT A GLANCE

CANADA: ECONOMIC IMPACT

Source: AIAC

contributed close to
US\$28 billion to GDP

and

208,000 jobs

in the Canadian economy

the industry directly generated

US\$27.2B in revenues

over

87,000 in employment

and nearly

US\$13 billion in GDP

QUÉBEC: SALES

Source: Gouvernement du Québec

average annual growth
in sales of

5.2%
(1991-2016)

total annual sales of

US\$14.4 billion
(2016)

52%
of Canadian aerospace sector sales (2015)

80%
of Québec aerospace industry output is
exported outside Canada

“

What makes the Canadian and Quebec aerospace sector unique is our philosophy and vision around promoting industry and research. With the support of government, we are able to export 90% of our products. We have great schools and institutions to work with and a favorable operating environment. The government's innovation strategy has clearly been a part of our investments in advanced manufacturing. The Canadian ecosystem is a basis for our growth and our future.

- Maria Della Posta,
Senior Vice President,
Pratt & Whitney Canada (P&WC)



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as European companies such as Mecaer, Sonaca and notably France-based Safran and Stelia, which formed in 2015 through the merger of Airbus subsidiaries Aerolia and Sogerma.

The presence within the province of major international OEMs such as Bombardier, Bell Helicopter Textron, CAE and P&WC has laid the foundation for a prosperous aeronautics sector. “We are the only province in Canada with OEMs,” stated Suzanne Benoît, president at Aéro Montréal, Québec's main organization for representation of the industry. “They play a vital role in investing in innovation and stimulating research projects and inspiring talent in our universities.”

The Big Four OEMs are supported by approximately 15 Tier-1 integrators, including Héroux-Devtek, Mecaer, L-3 MAS, Sonaca, Safran, Stelia, GE Aviation and Rolls Royce Canada. Nevertheless, the attractiveness of the province lies to a great extent in the approximately 200 special-



AEROSPACE TEAM

AN ESSENTIAL FUND FOR THE AEROSPACE SECTOR

With over \$370 million invested to date, the Fonds de solidarité FTQ plays an important role in Québec's aerospace sector. The Fonds is a partner of key industry players, including Avior, AV&R, Bombardier, Héroux-Devtek and Groupe Meloche.

With its sector expertise, strategic vision and extensive business network, the Fonds helps companies flourish by offering patient capital.

If you're looking for a Québec business partner to help you set up in the province through a merger, acquisition or creation of a subsidiary, we are ready and willing to prosper with you.

fondsftq.com

FONDS
de solidarité FTQ

ized SMEs occupying distinct niches in manufacturing and sub-assembly. The large number of SMEs reflects the entrepreneurial nature of the cluster, which has developed around a private market unlike many rival clusters around the world. In response to cost pressures and increasing demand for more integrated services, Québec's aerospace supply chain is marked by consolidation as SMEs strive to compete with players both nationally and internationally.

Canada has also been very active in the space sector since the early 1950s. Québec plays a key role in the industry, particularly as home to MDA Corporation, which was founded in 1969 and today operates from 11 locations in the United States, Canada and other countries further afield. "Overall, Québec represents around a third of Canada's space industry," commented Sylvain Laporte, CEO at the Canadian Space Agency. "As of 2015, total revenues for the space industry in Canada were about C\$5.3 billion, of which Québec constituted C\$1.67 billion. In addition, there are about 163 organizations that deal with space in Canada, 41 of which are based in Québec...The 163 organizations across Canada spent C\$256 million on R&D in 2015, with Québec's players contributing C\$77 million. In terms of employment, there are around 10,000 direct employees working in the space sector in Canada, of which roughly a third are employed in Québec." Québec's long history in aerospace has secured the sector's place as an important strategic industry for the province's economic development. In 2016, Premier Philippe Couillard announced an investment of C\$510 million over five years—C\$250 million in direct aid and C\$260 million in loans and other financing—towards the expansion and diversification of the aerospace sector, with the expectation to generate up to US\$2.8 billion in investment. "Québec's aerospace industry is critical to the economy," commented Dominique Anglade, the Government of Québec's Minister of Economy, Science and Innovation. "Aerospace is a key area

of focus for economic development because it aligns with three main pillars that must be met for economic growth: entrepreneurship, advanced manufacturing and exports...The sector also employs 40,000 people and Bombardier alone is the largest aeronautics company in Canada. For these reasons, the government has launched industrial strategies over the years to support the industry and has recently made unprecedented investments into developing the sector, particularly focusing on innovation."

Clearly demonstrating its commitment to the sector, the government recently invested heavily in Bombardier's C-series program, of which it owns 49.5%. Although the move has been met with some criticism, Anglade clarified: "Given that we are a shareholder, this should be viewed as an investment, not a subsidy."

The national government also recently announced a 73% increase in defense spending over the next 10 years, which will certainly impact demand in the region's aerospace sector. According to the Stockholm International Peace Research Institute, an independent international institute dedicated to research into conflict, armaments, arms control and disarmament, Canada is already the sixth-highest spender in the North Atlantic Treaty Organization (NATO) and 16th in the world. Increased government spending will likely offset challenges experienced by some companies in securing continued work with the U.S. government. Whilst Canada has long been considered a domestic source for U.S. Defense and the two countries are very integrated from a defense standpoint, potential shifts in trade dynamics could jeopardize the favorable relationship.

Drawing on expertise from different industries, the backbone of Québec's thriving aerospace ecosystem is innovation. With numerous programs coordinated at a regional and national level, collaboration across company types and organizations of all shapes and sizes has been key in driving the industry forward. Larger companies are increasingly outsourcing innova-

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For the U.S. market, we are seeing a higher number of barriers related to military programs. The regulations and complexity are rising. There are currently many variables within the United States that we must monitor as we scope and plan to expand to the United States for more military programs. The speed of introducing a program into production or moving a program forward is very slow because there are many risks involved and the impact of stopping production is big.

- Serge Audet,
General Manager,
ATLAS Aeronautik



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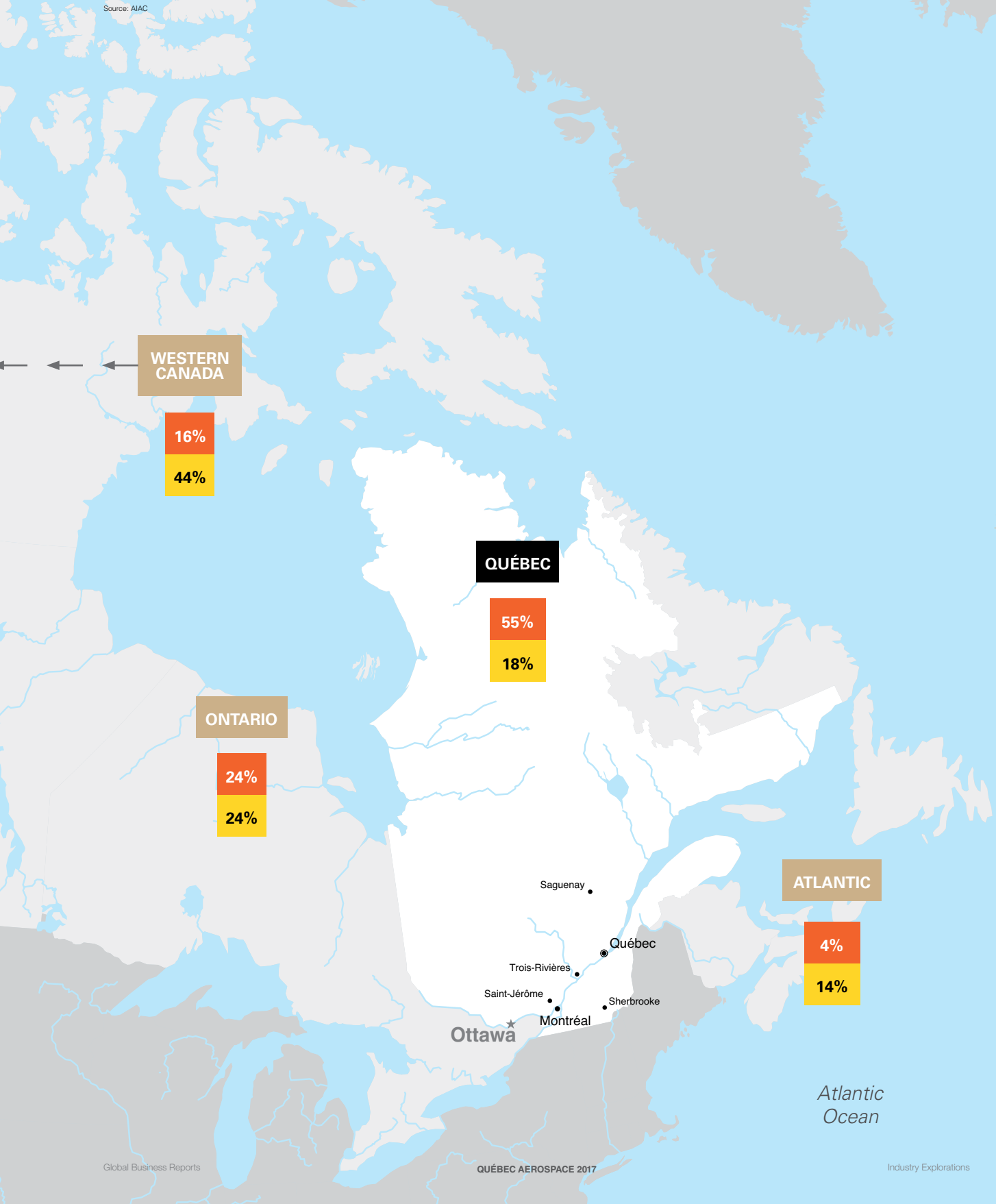
tion and early-stage R&D and, due to its high number of universities carrying out cutting-edge research and the volume of innovative startups and specialized SMEs, Québec is ideally placed to respond to these trends. As well as programs geared towards greener aircraft such as GARDN, the current main area of focus going forward will be towards the adoption of "Industry 4.0" technologies to increase the competitiveness of the cluster. Taken in response to the rapid growth of industries in lower-cost operating environments and the increased efficiency these technologies offer, Québec's aerospace sector has no intention of relinquishing its leading position into the future. —

REGIONAL MAP

Source: AIAC

● AEROSPACE MANUFACTURING
EMPLOYMENT SHARE BY REGION (2014)

● AEROSPACE MRO
EMPLOYMENT SHARE BY REGION (2014)





Dominique Anglade

Minister of Economy,
Science and Innovation
GOVERNMENT OF QUÉBEC

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The mission of the Ministry of Economy, Science and Innovation of the Government of Québec is to support business growth, entrepreneurship, science, innovation, export trade and investment in the province.

With 50% of Canadian aerospace production based in Québec and C\$14.4 billion in sales in 2016, what is the significance of the aerospace sector to Québec's economy?

Generally speaking, Québec's economy is performing well, with low unemployment rates and a balanced budget for three years running, creating a strong framework. Aerospace is a key area of focus for economic development because it aligns with three main pillars that must be met for economic growth: entrepreneurship, advanced manufacturing and exports. For example, aerospace comprises the highest concentration of R&D out of any other industry and is the number one export driver, which is key considering exports (40% to the rest of Canada and 60% internationally) account for 50% of Québec's GDP. The sector also employs 40,000 people and Bombardier alone is the largest aeronautics company in Canada. For these reasons, the government has launched industrial strategies over the years to support the industry and has recently made unprecedented investments into developing the sector, particularly focusing on innovation.

Could you elaborate on the government's support for the industry?

We have introduced many initiatives related primarily to R&D and exports and have chosen to invest heavily in Bombardier's C-series of which we own 49.5%. Given that we are a shareholder, this should be viewed as an investment, not a subsidy. Another example of our commitment was our ability to move Bell Helicopter's production of the 505 model from the United States to Québec. Equally important is our work to support the space sector, apparent in our recent significant investment in a C\$200 million project led by MDA. In total, we have invested C\$400 million in advanced manufacturing this year, associated with 242 projects.

How important are the big four OEMs in driving Québec's aerospace cluster?

The OEMs are the anchors of the industry and set the standards for the SMEs that

support them. The days in which the OEMs had many suppliers are long gone and it is now paramount that SMEs meet the standards of global multinationals in order to approach contracts. This is pushing SMEs to consolidate. The globalization of SMEs is critical and much of the Ministry's strategy is focused on bringing this about.

What is the government doing to support SMEs in reaching international markets?

In order to export, SMEs need to become top performers; to do this they need to invest in Industry 4.0 processes and in automation in particular. For this reason, the Ministry launched the MACH-FAB 4.0 initiative with Aéro Montréal which focuses on helping SMEs transition to Industry 4.0. The Ministry also launched an export strategy in October 2016 and has a dedicated organization to support exports. Every time we travel internationally to events, we bring an aerospace team to promote exports from SMEs and to find forums for them to meet customers.

Do you expect any challenges with the change in U.S. Administration, and in which international markets do you expect to see most growth?

There is no question that relations are getting tougher with the United States. However, counterparts in states such as New York, Texas, Hawaii, Pennsylvania and Maine have made it clear that they want to keep current commercial agreements in place because they see the benefits. The Canadian and the U.S. economies are highly integrated—a finished product may have crossed the border five times during development. In addition, whilst the U.S. trade deficit is huge, the percentage associated with Canada is very low at less than 2%. NAFTA has been in place for some time, and a degree of adapting could in fact be beneficial to all parties.

Where does the greatest opportunity lie in the market for foreign direct investment (FDI)?

Tier 1s are the missing element in Québec's ecosystem. There are specific companies the Ministry is targeting that could add significantly to the sector in Québec. The government will remain focused on attracting, advising and investing in such companies. —

Suzanne M. Benoit

President
AÉRO MONTRÉAL



Created in 2006, Aéro Montréal is a strategic think tank that groups all the major decision makers in Québec's aerospace sector. Its mission is to mobilize Québec's aerospace cluster to support the growth of the industry and its excellence on the global stage.

Could you provide a brief introduction to Aéro Montréal's role in Québec's aerospace industry?

We were created in 2006 by the industry for the industry in order to mobilize companies, universities, research centers and unions around strategic issues to make Québec's aerospace ecosystem more competitive.

How is Aéro Montréal helping companies transition to Industry 4.0?

Compared to industry sectors such as automotive, the aerospace sector is just starting on this trajectory. Our industry is generally more cautious, as lower production volumes make it harder to build the business case for return on investment. Companies such as Pratt & Whitney Canada are embracing the digital shift with intelligent cells and innovative business processes. Aéro Montréal launched the MACH FAB 4.0 Initiative to support SMEs by assisting some of the more advanced companies involved in the MACH program with their transition to Industry 4.0. Through adopting Industry 4.0 processes, SMEs become more digitally connected with their clients, which is a strong incentive for adopting these technologies. Our role is to ensure SMEs' awareness of the importance to make the shift to 4.0 and to identify solution providers to support them in that shift.

SMEs are under pressure to integrate their services, which is a driving force for consolidation. Do you see this as a positive trend?

Consolidation will continue and Aéro Montréal encourages this trend. SMEs are currently too dependent on a limited number of customers; moreover, OEMs are no longer buying directly from SMEs but instead from integrators mostly located outside of Canada. Because SMEs must sell to international integrators, Aéro Montréal assists them in their internationalization and we facilitate meetings between international OEMs and Tier 1s and Québec's SMEs. These include, for example, regular meetings with Boeing and Lockheed Martin.

Québec does not have enough Tier 1s and we need to encourage Tier 3 and 4 companies to work together to fill that gap. This could be achieved through consortiums or joint ventures, not necessarily mergers. Consortiums are not commonly seen in Québec as companies are wary about partnering with competitors. However, there have been

some positive developments, including through the MACH FAB 4.0 Initiative in which SMEs work together to develop automation technology.

How important are the OEMs in driving positive change in the industry?

We are the only province in Canada with OEMs. Four of them are located in the Greater Montréal area: Bombardier, CAE, Pratt & Whitney Canada and Bell Helicopter Textron Canada. They play a vital role in investing in innovation and stimulating research projects and inspiring talent in our universities. Québec is an ideal location for OEMs. For example, Bell Helicopter recently re-patriated the production of its 505 helicopter model due to several factors, including the province's strong talent pool, the industry's flexibility and the support of the government.

Could you give examples of collaboration in the industry leading to advancement in innovation?

In 2011, Aéro Montréal launched the Coalition for Greener Aircraft program, SA2GE (Smart Affordable Green Aircraft), which aims to develop parts and systems in a more environmentally-friendly way as part of the fight against climate change and in compliance with new environmental regulations. We had great success with this initiative, with 27 SMEs, five universities and four R&D centers collaborating. The Québec government and private companies contributed C\$150 million in five R&D projects. Héroux-Devtek, for example, worked on a project to launch more environmentally-friendly surface treatment technologies. Advancements of this sort will place them in a strong position on new generations of aircraft with the OEMs. In 2016, we launched phase two of the SA2GE program, with five projects being selected. Between now and March 2020, Bombardier, CAE, Esterline CMC Electronics, Thales Canada and TeraXion will undertake strategic initiatives for Québec's aerospace industry as part of the SA2GE project. Their work will focus on manufacturing, avionics, optics and analyzing big data, among other areas.

What are Aéro Montréal's main priorities over the next few years?

We need to bring more integrators to Québec, such as subsidiaries of large foreign companies. This will bring opportunities for our SMEs and foster supply links with our OEMs. We have also recently launched a strategic defense committee to create a portal to advertise business opportunities in the defense sector. This will become more important given the federal government's announcement in June 2017 to increase defense spending by 73%. —

Jean Wilhelmy & André Viau

JW: Senior Vice-President Aerospace, Construction, Services and Transportation
 AV: Portfolio Manager, Aerospace Industry
FONDS DE SOLIDARITÉ FTQ



JW



AV

Fonds de solidarité FTQ is a development capital fund with a mission to contribute to Québec's economic growth by creating, maintaining or protecting jobs through investment in SMEs in all spheres of activity.

Could you provide a brief introduction to Fonds de solidarité FTQ (Fonds)?

JW: The Fonds was created in 1983, a time of crisis in which companies lacked equity, to finance companies, particularly SMEs, to help them survive. Since its founding by Québec's largest central labor body, FTQ, the Fonds' primary focus has been to invest in SMEs so that they can grow and ultimately provide more employment to Québécois. Over time, as companies stabilized, our method evolved to support companies which were performing well in their respective industries. Citizens receive a tax credit to incentivize them to invest in the Fonds given that it makes unsecured investments. It now has around 645,000 shareholders and C\$13.1 billion in net assets.

Our main focus is the support of local companies but we also want to attract foreign companies to bring more economic activity into Québec. For example, we have invested in French company Mecachrome, which has facilities in Québec.

How important is aerospace to the Fonds' activities?

AV: The Fonds has a portfolio of around half a billion dollars in the aerospace industry, spread over three funds and about 15 companies. Aerospace is hugely important given the number of people it employs in Québec, the quality of the jobs and the

contribution it makes to the province's exports.

Could you elaborate on the range of funding offered across SMEs and the OEMs?

JW: We have influence at both ends of the supply chain and our support for the OEMs has positive repercussions for SMEs: better performance in the OEMs translates to better demand for the SMEs' services. Whilst we do not sit on the board of companies like Bombardier, CAE and Héroux Devtek, we are strong partners and able to communicate our involvement with their suppliers. When investing in SMEs, we are usually minority shareholders, owning 20% to 40% of the company. Unlike other funds, the Fonds favors a long-term partnership.

Is consolidation in the supply chain the best way to increase the sector's competitiveness?

AV: The OEMs want fewer but stronger suppliers. Companies of C\$20 million are fragile. However, a company of about C\$100 million will have a stronger balance sheet and access to funding that will enable them to better support the OEMs. Our strategy is to support the re-grouping of companies so that they can reach this size range. We have also seen consortiums form, especially in the construction industry, where some companies form a joint-venture when unwilling to invest the necessary capital. Consortiums could work but many captains on a boat can be problematic. We are currently more focused on encouraging acquisitions.

How is the industry structure likely to shift in the longer term?

JW: There will be bigger companies in more traditional fields and smaller companies in niche areas. The bigger machining companies will probably come to resemble integrators by adding services such as surface treatment, engineering and sub-assembly. At the same time, there will be smaller companies that are highly specialized and innovative, such as AV&R in robotics.

AV: There are powerful disruptive technologies coming into play such as 3D printing, robotics and more broadly Industry 4.0, which are evolving fast. Companies will have to adapt or be swept aside. In our role on the board of companies, we want to ensure that they have a strategy in place to adapt to these changes.

Do companies have access to the necessary talent pool?

JW: Companies are struggling to find the right talent and sometimes have to search internationally for it. There are not enough younger people pursuing the technical skills needed by the industry. The transition required by the influx of new technologies can also be a challenge.

What are the main objectives for the Fonds over the next few years with regard to aerospace?

JW: We will continue to support both smaller and larger companies and focus on growing the companies we have in our portfolio. We also plan to take advantage of investment opportunities presented by recent new market entrants. —



Pierre Gabriel Côté

President and CEO
INVESTISSEMENT QUÉBEC

Investissement Québec offers guidance and financial solutions to corporations that are looking to set up in Québec.

In 2016 to 2017 alone, Investissement Québec was involved in C\$1.5 billion of investment into the region. Could you briefly introduce the organization and its significance to Québec?

We manage our business through a dual-funding model. On the one hand, we act as a government arm for economic development. There are mandates through the government economic fund for attracting strategic businesses and maintaining strategic businesses in which the government might decide to intervene and support companies. These decisions lie with the Government of Québec and we are the mechanical parts that execute these mandates. The other type of fund through which we provide industry support is through partnership with other financial entities to do deals on commercial terms. However, Investissement Québec is not a bank or a financial institution like Fonds FTQ. We are there to support business sustainably on a long-term basis. This long-term view separates us from other organizations in our ecosystem. Over the years, we have provided a huge amount of support to the aeronautics industry. We have 12 offices around the world through which we connect our aerospace companies to other international markets. One of our core activities is the attraction of investment and the other is to further the development of the industry in Québec.

Where does the balance lie between attracting healthy competition and filling market gaps versus potentially dislodging companies in the region?

We judge these variables based on analysis of Québec's imports. Meanwhile, it is also important to diversify the supply base for price, quality and innovation purposes. The balance must benefit Québec's ecosystem as well as presenting the best scenario for the OEMs. There are many variables and we are in the middle to find that balance.

When it comes to supporting Québec's ecosystem, are there any gaps in the market or particular ways to increase competitiveness?

When looking at the supply chain at some of the lower tiers, there are many large ma-

chining companies manufacturing parts for Pratt & Whitney, including highly-specialized titanium parts for engines, for example. However, there are also many small entrepreneurs that want to offer these services. Meanwhile, international companies often want to find a company to buy in Québec. When we travel to international events, we often bring entrepreneurs with us and try to match opportunities.

The Tier 2 and 3 subcontractors in Québec are very good and have production models that make them competitive on the international stage, using Industry 4.0 technologies and other innovative processes. Investissement Québec launched a big Industry 4.0 initiative, for which we are now in the second year. The initiative includes financing to grow our entrepreneurs and increase competitiveness, but also non-financial solutions such as the labor support. Only one element of our plan to increase implementation of these technologies is financial; the rest focuses on facilitation through other means to incorporate the culture of innovation into our manufacturing.

What is the vision for Investissement Québec going forward?

Today's economy is favorable, with an average unemployment rate of 6%, one of the lowest in the last 40 years. We have very strong economic stability and a favorable fiscal system. Because our grid runs on renewable energy thanks to Hydro-Québec, many multinational corporations are interested in establishing a base here to promote green power. Private investments are still somewhat of an issue, but with the tools that we have Investissement Québec is able to get a lot of leverage on the dollars spent. For our manufacturing initiative, every dollar generated two-and-a-half dollars of private investment. There is an appetite for innovation.

The other side of Investissement Québec is the attraction of investment, which has become more competitive. Compared to 10 to 15 years ago when there were perhaps 400 to 500 organizations dedicated to the attraction of investment around the world, today there are 4,000. It is a very tough market, but Québec sells itself very well internationally. —

Québec's Aerospace Cluster: A Bird's Eye View

“

Québec also provides aerospace businesses with a competitive operating cost environment, as Montréal ranks second for most competitive operating costs among major metropolitan areas in North America specializing in aerospace.

- Denis Giangi,
President,
Rolls-Royce Canada



”

Today, as throughout the province's history, most of Québec's aerospace activity emanates from Greater Montréal, focused in four main centers: the Agglomeration of Longueuil, the City of Mirabel, the City of Laval and the Saint-Laurent-Dorval-Point-Claire area. Alongside these major hubs lie smaller, specialized centers of aerospace activity spread across Québec.

Across the St. Lawrence River from Montréal, Longueuil stands out for the size of its aerospace industry. It is the base of engine maker P&WC and landing gear systems and components integrator Héroux-Devtek, in total accounting for 8,200 aerospace jobs, representing about 20% of all aerospace jobs in the province and 45% of Québec's aerospace SMEs. Longueuil is a natural home for aerospace companies due to four main factors: the availability of skilled labor, excellent transport infrastructure, a high quality of life and availability of land. “The availability of skilled labor in manufacturing is a major advantage in the area and the first factor companies look for when selecting a location,” commented Julie Ethier, executive director, Economic Development of the Agglomération de Longueuil (DEL).

A high-quality labor force is underpinned by a strong education and research infrastructure with École nationale d'aérotechnique (ÉNA), the biggest aerospace institute in North America, attracting students from around the world. Furthermore, the Canadian Space Agency (CSA), the Canadian National Research Council (NRC) and the Aerospace Technology Center (CTA) are located in the area, all significant contributors to cutting-edge aerospace research.

In terms of transport infrastructure, companies in Longueuil benefit from excellent highway access to the rest of Canada and the United States and from proximity to the Port of Montréal, Trudeau Airport and Saint-Hubert Longueuil Airport. Furthermore, the agglomera-

tion still has 20 million square feet of available land located close to Saint-Hubert Longueuil. Mirabel is a rising star when it comes to attractive aerospace hubs. “Mirabel's population is growing by 40% to 50% every 10 years, with many more workers attracted by factors such as cheaper housing and the excellent school network,” remarked Gilbert LeBlanc C.Ec.D., director at Mirabel économique, the economic development agency for the city.

Recognizing Mirabel's advantages, P&WC opened state-of-the-art assembly and test facilities for its next generation of jet engines in 2011 at a site named the Mirabel Aerospace Center. Equally notably, Bombardier chose Mirabel as the location for the final assembly of its C Series aircraft.

In particular, Mirabel has become a hub for subsidiaries of international companies wanting to establish a base in Québec. Aerostructure manufacturers Sonaca Montréal and STELIA Aerospace, assemblers such as Mecachrome, landing gear specialist Safran Landing Systems and in-service-support (ISS) provider L-3 MAS are all subsidiaries of foreign companies located in Mirabel. Mirabel économique offers generous tax credits to attract companies to the region from all over the world and the city has the lowest taxes of any region in Greater Montréal. “We offer these incentives because we face competition from other aerospace clusters around the world,” commented LeBlanc. “We want to attract more international subsidiaries to the region, particularly those of aerospace companies.”

With 42 million square feet of land available for development, much of it available in the airport's thriving industrial site, Mirabel's aerospace cluster has room for further growth. Occupying a strategic position between Mirabel and the Island of Montréal lies Laval, where companies benefit from the ideal location and proximity to all other major companies found in the Greater Montréal region. Accounting for

around 2,000 jobs and housing 30 companies, the region's aerospace ecosystem is significant and has proven an attractive destination for new entrants. Austria-based F. List, a specialist in aircraft cabins, recently chose Laval as its strategic location in North America, for example. Factors considered, according to Marc Tremblay, assistant general manager at Laval Développement Économique, included: “The excellent infrastructure, enterprise-friendly administration and the availability of highly qualified and experienced aviation professionals.” Other notable companies include Mecaer America, a subsidiary of Italian integrated landing gear specialist Mecaer and Arconic, the producer of titanium airframe components and the only company in the province to have achieved MACH level 5 in Aéro Montréal's MACH supply chain development initiative. Lastly, the Saint-Laurent-Point-Claire-Dorval area on the Island of Montréal is home to over 60 aerospace companies, which draw advantages from its proximity to all of the other major hubs, downtown Montréal and Trudeau Airport. The area boasts representation from companies of all levels of the supply chain and of all sizes: from two of Québec's Big Four OEMs in Bombardier and CAE, Tier 1 integrators like Esterline CMC Electronics and Thales Canada, finishing and surface treatment shops such as TNM Anodizing & Paint and Ultraspec and service providers like MANNARINO Systems & Software.

Smaller, specialized hubs

Just beyond the perimeter of the Greater Montréal area, specialized areas of activity can be found in clusters such as Québec City, Granby and Sherbrooke.

Québec City, for example, is built on a culture of innovation spanning many industries. With over 400 laboratories, institutes and research centers in a city with a population of under one million people, this concentration is one of the highest in Canada. Photonics is one of the city's key areas of excellence, with others including composites and plastics. Indeed, Québec City is home to the National Optics Institute as well as ABB's Space & Defense Systems division, which specializes in optical-based analyzing and sensing instruments for the space sector. Québec City is also home to the largest R&D center in defense and security, the Valcartier Research Centre (DRDC), and the largest centers in nutrition and infectious disease. "An important element is the capability to transfer that R&D from the research centers to the private sector," emphasized Carl Viel, president and CEO at Québec International, the regional economic development agency. "INO has been able to create over 30 companies over the years. In general, we place an emphasis on facilitating the commercialization of technologies. Over the last 10 years, over 40% of jobs created in Québec City have been innovation-based. This is double the Canadian average, which sits at 20%, and 10% more than the province. We want to continue to bridge the gaps and build relationships with universities and research centers to ensure that companies continue to foster innovation and grow."

Granby, meanwhile, has 15 aerospace companies, accounting for close to 1,000 jobs, and has become a center of expertise for metal fabrication and high precision machining. Significant companies include machining and assembly integrators NSE Automatech, Avior and ATLAS Aeronautik. The region is supported by Granby Industriel, which promotes companies within Granby's two poles of excellence, aeronautics and transport, and manages six million square feet of land. "Granby Industriel offers land at competitive prices and offers a 100% property tax credit for the first five years," highlighted Eric Tessier, industrial commissioner at Granby Industriel. "Granby is also well located, near Montréal and only 30 km from the U.S. border. In addition, the production and labor costs are 20% cheaper here than in Montréal and the living costs are lower while the quality of life is arguably higher."

Highlighting the organization's strong networks with government institutions and foreign investors, Granby Industriel's general manager, Patrick St. Laurent, added: "Each time a foreign delegation makes a trip to Canada we receive a phone call, often due to companies wanting to establish a subsidiary or develop an aerospace partnership with one of our companies."

Located approximately 90km east of Granby, the town of Sherbrooke is the base of a number of highly specialized SMEs and Sherbrooke University. The university stands out for its strong industry ties and the key role it plays in many programs throughout the development cycle, contributing and adding value from the very early stages of innovation at technology readiness level (TRL) 1 to product launch at TRL 10.

Innovative SMEs include Exonetik, which develops magnetorheological fluid actuators and NGC Aerospace, which develops guidance, navigation and control (GNC) systems for autonomous vehicles used in the space and aeronautical industries.

Montréal's Airports: a natural home for aerospace companies

Montréal's airports are also focal points for the aerospace industry, of which Mirabel Airport stands out. Until the early 2000s, Mirabel's airport shared passenger traffic with Trudeau Airport but it has since flourished as an all-cargo and industrial airport. In fact, all of Mirabel's international companies are located on the airport's industrial site. Aéroports de Montréal, which operates Mirabel and Trudeau airports, has made 50 million square feet of land available at Mirabel Airport, half of which is serviced and ready for use. The airport works closely with Aéro Montréal, Investissement Québec, Montréal International and the City of Mirabel to attract more aerospace companies to the site. "As ADM is a not-for-profit company, we are able to offer very competitive rates. As an example of the support offered to companies locating in Mirabel, two years ago, ADM financed and built a facility for STELIA Aerospace, an Airbus division, at the airport. As a result, we won Airbus' supplier of the year award," commented Charles Gratton, vice president, real estate and commercial services at Aéroports de Montréal (ADM). ADM also recently invested C\$60 million into one of its two 12,000-foot runways, which are now able to service any type of aircraft in the world 24/7.

“

We offer a very rich ecosystem and a favorable geographic location to export to locations such as the United States and Mexico. We therefore offer access to Québec's OEMs, such as Bombardier, and companies are also able to position themselves close to other OEMs in North America, such as Boeing in the United States. The proximity of these markets is a very strong attraction.

- Pierre Gabriel Côté,
President and CEO,
Investissement
Québec



”

Despite its focus on passenger traffic, a large number of Québec's aerospace companies congregate in close proximity to Trudeau Airport, benefitting from the doubling of direct international flights from 2005 to 2015 to over 75 destinations. In addition, Saint-Hubert's airport is making its own claim as an aerospace center. While much smaller than Trudeau or Mirabel airports, it is Canada's fifth-busiest airport due to the presence of major pilot training schools and its position as a hub for general aviation. As of 2015, the airport is receiving investment of C\$17 million from the federal government to improve its runways, including raising the load of one runway to accommodate heavier aircraft such as Bombardier's C Series and the Boeing 737. As a result, MRO specialist Pro Maintenance Aviation is looking to set up a service center for the C Series at the airport, which could attract more aerospace companies to the site.

Whilst Québec has several nodes of excellence and clusters of activity, the province's aerospace industry is characterized by collaboration and ease of access. Supported by excellent infrastructure, companies work closely with each other across the region and beyond; proximity is less important today than it once was and companies increasingly look to the talent pool and quality of life as one of the most important factors when selecting a location. —

CITY OF LAVAL

Source: Gouvernement du Québec

Mayor: Marc Demers

Area: 477 sq. km

GDP: 14.3 billion

GDP Per Capita: US\$33,644

Population: 430,000

Jobs: 200,000

AEROSPACE

COMPANIES

30

JOBS

2,000

MAJOR COMPANIES

**Arconic,
Héroux Devtek,
M1 Composites,
Mecaer America**

LAVAL

Montréal

Boucherville

Longueuil

Brossard

Pointe-Claire

Beaconsfield

Fleuve Saint-Laurent

LAVAL

**AT THE HEART OF
THE METROPOLITAN
AEROSPACE INDUSTRY**

Strategically located, Laval offers a prime business location, a highly dynamic environment and easy access to qualified labour.

Contact us to learn more about our services, incentive programs and tax credits available to businesses.

450-978-5959

lavaleconomique.com
lavaleconomique@laval.ca



Economic development



Marc Tremblay

Deputy General Director,
Economic Development
CITY OF LAVAL

Laval's convenient location has helped the area to become an important hub for the aerospace industry supported by the Economic Development Division.

Could you introduce the region and the aerospace ecosystem you have in Laval?

Laval offers a dynamic economic environment and access to a skilled workforce. Currently the 3rd largest city in the province of Québec, with 430,000 residents, it ranks 1st among Québec regions for anticipated population growth over the next 20 years. As part of a greater metropolitan area of 4 million people, it benefits from an abundant qualified and skilled workforce.

Boasting 11,400 companies in key sectors, including many head offices and subsidiaries of foreign companies, Laval constitutes a diversified environment that is conducive to economic success. Laval's 4 municipal industrial parks, 15 private parks and 5 industrial zones offering 40 million sq. ft. of industrial space available for development mean that real estate availability in Laval is very attractive. Furthermore, the close proximity of highway and integrated public transit networks provides Laval companies with easy access to the entire educational and research infrastructure in the Greater Montreal Area.

The aerospace industry in Laval is comprised of over 30 companies that employ nearly 2,000 people. It is a very significant industry in this city, not only because of the quality of the jobs that it offers, but also in terms of the impact on large and diverse industrial subcontractors and providers. We are proud to count on an industry that makes the Greater Montreal Area shine internationally that is well represented in Laval. Among the 30 aerospace sector companies in Laval, key players are: Arconic, Avior, Héroux-Devtek, M1 Composites Technology Mecaer America, Liebherr Canada, FACC Solutions, F. List, Latecoere Services, Electro-Kut, NTS Consulting and others demonstrate that Laval is the premier area to do business.

What are some of the advantages to operating in this region?

Located in the heart of the Greater Montreal aerospace hub, Laval is approximately 20 to 30 minutes from downtown Montreal, Montréal-Trudeau International Airport, the Port of Montreal or Montréal-Mirabel International Airport, in addition to being less than 100 km from the US border. A highway network connecting Laval to Montreal by different routes provides fast access from any direction in the

Greater Montreal Area. We are strategically located near Mirabel, Dorval, and Longueuil, where the 4 OEMs are located.

What is the role of the development council in supporting existing companies?

The City of Laval Economic Development Division promotes and ensures Laval's economic development by seeking out new investments, by welcoming and supporting businesses and entrepreneurs in order to stimulate job growth and business expansion to ensure sustainable benefits for Laval citizens.

We offer financial incentives and guidance for businesses and entrepreneurs. We are recognized as having the best customer service for company implementation and issuing permits among the 10 largest cities of the province. Our real estate investment team assesses the needs of businesses and institutions, searches for and proposes implementation sites, and supports new implementations or the expansion of existing businesses. Finally, our mobility and international business team supports businesses in their exporting efforts, organizes trade missions, and recruits, hires and supports the integration of specialized foreign workers.

What is the value proposition for Laval over other attractive regions?

The most important factor is our strategic location; we are close to everything. Furthermore, we have put together a very interesting incentive program through which the owner of an eligible building will be granted a property tax credit for a period of 60 months. Two other advantages are cost of living and quality of life. The cost of doing business and of living are more affordable here than in other cities. Laval offers a fabulous quality of life because it is an urban city with plenty of green space. Being at the edge of downtown Montreal, our location is especially good for young families seeking a high quality of life and easy access to services that meet all their needs.

What are the objectives for the Laval Economic Development Division to further develop the region?

The first is to continuously improve our business environment; make it easy for companies to implement or expand their facilities here. Secondly, providing fast and efficient service is key. We must develop strategies that support speed in transporting people and parts. The third objective is to continuously develop competitive incentives, starting with ease of access to labour. —

Source: Gouvernement du Québec

President: Monique Bastien
Area: 282.4 sq. km
Population: 419,677
Cities: Boucherville, Brossard, Longueuil, Saint-Bruno-de-Montarville and Saint-Lambert

AGGLOMERATION OF LONGUEUIL

THIRD-LARGEST
AGGLOMERATION
IN QUEBEC

AEROSPACE

COMPANIES

85

JOBS

8,200

MAJOR COMPANIES

Héroux-Devtek,
Pratt & Whitney Canada

LONGUEUIL

Saint-Bruno-de-Montarville

Saint-Lambert

Montréal

Brossard

Chambly

INDUSTRIAL PARKS


15 zones
and industrial parks

MANUFACTURING COMPANIES

40% manufacturing companies
of which
45% are exporters

MNCs

235 subsidiaries of multinationals
generating 15,200 jobs



45 %
OF QUEBEC'S SMEs
ARE HERE

THE AGGLOMÉRATION DE
LONGUEUIL

THE UNIQUE
LANDING SITE
FOR YOUR
BUSINESS

1 866 599-2335
info@delagallo.ca

DEL
DRIVING
DEVELOPMENT
IN AGGLOMÉRATION
DE LONGUEUIL



Julie Ethier

Executive Director

ECONOMIC DEVELOPMENT OF THE AGGLOMÉRATION DE LONGUEUIL (DEL)

DEL supports economic development within the agglomeration of Longueuil by attracting new businesses and offering a wide range of services to simplify, facilitate and accelerate the implementation of local companies' business plans.

Could you provide a brief introduction to the region and DEL's activities?

The agglomeration of Longueuil is composed of five different cities—Boucherville, Brossard, Longueuil, Saint-Bruno-de-Montarville and Saint-Lambert. There are around 2,000 companies located in the region's different industrial zones, with most involved in manufacturing. Our agglomeration is home to 85 companies involved in aerospace, 45% of the total number in Québec, accounting for around 8,000 jobs. DEL's ultimate goal is to help facilitate collective wealth in the area through job creation and increased investment. Our mission has two main elements: to accelerate the realization of business plans of companies located here with our personalized services and to attract new businesses to the territory in partnership with the five cities and organizations like Investissement Québec and Montréal International.

What are some of the ways in which DEL supports aerospace companies in the local area?

With its wide array of services, DEL is considered a one-stop shop for SMEs. We visit about

250 different companies every year and conduct an annual census of their requirements, so we really understand their needs and are able to adapt our service offering accordingly. One of the most important services we offer is financial assistance—we provide grants and help companies to identify different incentives offered by the government and other public and private agencies. We recently helped an aerospace SME by finding financial partners, providing preparation support in the pitch to these partners and organizing a roundtable for rapid feedback. This resulted in significant capital raised to finance the company's research and development.

DEL also supports innovation by connecting companies with research organizations and assisting them with their intellectual property and commercialization strategy. The types of businesses in our agglomeration are those that typically invest the most in R&D. Compared with the Québec average, there are twice as many businesses that reinvest over 5% of their revenues into R&D. Building on this strong foundation, DEL helps and encourages these companies in their future development and growth. We have also more than 600 exporters in the region and we help them identify foreign partners, prepare for trade shows and meet customs and logistics requirements. We are always looking to add to our services. For example, next September we are launching an incubator for startups. This September, we are also announcing a very big project involving the purchase of new technologies in line with Industry 4.0 that we will loan to local companies and training programs in partnership with Emploi-Québec.

What are the main advantages for companies looking to locate in the agglomeration of Longueuil?

The availability of skilled labor in manufacturing is a major advantage in the area and the first factor companies look for when selecting a location. This partly reflects the training offered by many schools located here for the aerospace industry. Secondly, the agglomeration has excellent transport infrastructure with highway access to the rest of Canada and the United States, close proximity to the Port of Montréal and Montréal-Pierre Elliott Trudeau International Airport and the location of Montréal Saint-Hubert Longueuil Airport on our territory. Thirdly, aerospace companies value the very high quality of life in our agglomeration. Finally, we still have more than 20 million square feet of well-positioned land available close to our airport. DEL works with the city

authorities in the zoning of this land to make it easily available for new companies to use.

How strong is the research and education infrastructure in the agglomeration of Longueuil?

The agglomeration is home to many research agencies, including the Canadian Space Agency (CSA), the Canadian National Research Council (NRC) and the Aerospace Technology Center (CTA). The CSA is where Canadarm was designed and the CTA houses cutting-edge test equipment not found elsewhere in North America and works with aerospace companies from across Québec. There are also private research centers at Pratt & Whitney Canada (P&WC) and Héroux-Devtek.

The École nationale d'aérotechnique (ÉNA), located here, is the biggest aerospace institute in North America and attracts students from around the world. It is also the only institution in North America which specializes on teaching skills in aircraft construction and maintenance.

What types of companies are you particularly focused on attracting to the region at present?

We want to attract new aircraft carriers and a maintenance center for Bombardier's C Series, which we hope will be achieved through the construction of a new passenger terminal at Montréal Saint-Hubert Longueuil Airport. Together with the provincial government, we are financially invested in the airport's expansion; if it goes ahead, we expect it to attract new businesses and generate many jobs for the region. In addition, we want the machining and manufacturing suppliers of P&WC and Héroux-Devtek to set up facilities on the large amount of available land located near these two companies' facilities.

What are DEL's keys goals for the aerospace sector in the region over the next five years?

We want aerospace to remain the leading sector in the agglomeration and want to be considered the number one region in Québec. DEL will continue to collaborate with its many partners to attract companies to the region. Overall, we want to make our companies even more competitive, position the region as an innovation hub and develop new specialized services for the aerospace industry. For example, next fall we will be holding conferences for the aerospace industry focused on innovation and exporting and bringing together smaller companies with bigger players and research organizations. —



“Of the 23 international companies based in Mirabel, most are linked to the aerospace industry, making the sector very important to the region... Montréal-Mirabel International Airport also brings many advantages to the region and companies operating near the site. It holds two runways of 12,000 feet which can handle any type of aircraft in the world, 24/7.”

- Gilbert LeBlanc
C.Ec.D., Director,
Mirabel économique

MIRABEL

CITY OF MIRABEL

Source: Gouvernement du Québec

President: Mayor: Jean Bouchard

Area: 477 sq. km

Population: 50,513

Median income: C\$43,080 (2015)

AEROSPACE

COMPANIES

14

JOB

4,000

MAJOR COMPANIES

Pratt & Whitney Canada,
Bell Helicopter,
Bombardier,
Sonaca Montréal,
Mecachrome,
Safran,
L-3 MAS

INVESTMENTS 2016

C\$419,099,825
creating **953 jobs**

INDUSTRIAL PARKS

5

MANUFACTURING JOBS

7,600

MNCs

23

LAND AVAILABLE

42 million sq. ft
of greenfield land

QUEBEC CITY

Source: Gouvernement du Québec

Mayor: Régis Labeaume

Area: 3 349 sq. km

Population: 807,211

GDP: C\$34.6 billion

GDP per capita: \$44,404

Universities: 5

AEROSPACE

KEY COMPANIES

**APN,
Amec Usinage,
INO,
ABB,
Creaform,
TeraXion**

OVER
400
LABS, INSTITUTES AND
RESEARCH CENTERS

**US\$189.4
million**

IN ECONOMIC BENEFITS

“Whilst Montréal has a wide range of OEMs and Tier 1s, Québec City has a concentration of Tier 2s that can be built into their manufacturing chains.”

- Carl Viel,
President and CEO,
Québec International



Ottawa

Montréal

QUÉBEC



“Sherbrooke is an innovative human-sized city; not too small and not too big, with two French and English universities.

As a small community, we are able to communicate well and decide collectively on our priorities. If a company has a mid- or long-term R&D project, we sit down with our researcher and his team to make sure the company finds the right research team and infrastructure for the project to have and achieve its milestones.”

- Josée Fortin,
General Director,
Sherbrooke Innopole

SHERBROOKE

Source: Gouvernement du Québec

Mayor: Bernard Sévigny

Population: 163,623

Area: 366 sq. km

Urban boroughs: Brompton, Jacques Cartier, Rock-Forest, Saint-Élie-de-Deauville, Mont-Bellevue, Lennoxville

Universities: 2

AEROSPACE

COMPANIES

**NGC Aerospace,
Mesotec,
Tekna Plasma Systems,
Composites BHS**

RESIDENTS

+3,010

**THE STRONGEST GROWTH OF
POPULATION IN QUÉBEC**

GDP

+4.9%

**A THRIVING
MANUFACTURING SECTOR**

UNEMPLOYMENT RATE

6.2%

**BELOW THE PROVINCIAL
AVERAGE FOR FIVE YEARS**

Ottawa

Montréal

Québec

SHERBROOKE

GRANBY

Source: Gouvernement du Québec

Mayor: Pascal Bonin

Area: 48.24 sq. km



“As well as metal fabrication and high precision machining, Granby also has capabilities in composite manufacturing and tooling machines for OEMs.”

- Patrick St. Laurent,
General Manager,
Granby Industriel



“Each time a foreign delegation makes a trip to Canada we receive a phone call, often due to companies wanting to establish a subsidiary or develop an aerospace partnership with one of our companies.”

- Eric Tessier,
Industrial Commissioner,
Granby Industriel

AEROSPACE

COMPANIES

15

—

JOBS

894

—

INVESTMENTS 2016

C\$13,048,385

—

KEY COMPANIES

NSE Automatec,
Avior,
ATLAS Aeronautik

Ottawa

Montréal

GRANBY

Québec

The Big Four: Québec's OEMs

One of Québec's defining characteristics is the presence of not just one but four OEMs: Bombardier, CAE, Pratt & Whitney Canada (P&WC) and Bell Helicopter Textron Canada. Each focused on different areas, these prime contractors drive Québec's aerospace ecosystem and provide strong bridges to the international markets for many of their suppliers. "We are the only province in Canada with OEMs," highlighted Suzanne M. Benoît, president at Aéro Montréal. "They play a vital role in investing in innovation and stimulating research projects and inspiring talent in our universities."

Bombardier takes top spot as Canada's biggest aeronautics company and the global leader in airplanes and trains, posting revenues of C\$16.3 billion in 2016. The company's commercial aircraft segment has been marked by the production ramp-up and revenue-generation phase of the C Series aircraft, the first all-new clean-sheet designed family of single-aisle aircraft in the 100- to 150-seat segment in nearly 30 years. Following the CS100's entry-into-service with SWISS and the CS300 with airBaltic, in conjunction with significant orders from Air Canada and Delta, the aircraft backlog was increased to over 350. In 2017, the CS100 aircraft completed a non-stop transatlantic flight from London City Airport to New York's John F. Kennedy Airport and was awarded steep approach certifications, enabling SWISS to start operating the aircraft at London City Airport on August 8, 2017. "The performance and reliability of the aircraft have been outstanding so far, with more than 1.5 million passengers flown on more than 100 routes and airBaltic operating the aircraft up to 17 hours per day," highlighted Olivier Marcil, Bombardier's vice

president of external relations. "Following this successful entry-into-service in Europe, the C Series will make its Asian debut later in 2017 with Korean Air."

On the business jet side, the Global 7000 and Global 8000 aircraft have set the standard for a new category of large business jets. The Global 7000 aircraft is the first and only clean-sheet business jet with four living spaces.

It should come as no surprise that the impact of the OEM on the region is significant. "While Canada represents less than 10% of Bombardier's revenues, we have a strong footprint here with over 21,000 employees, including more than 15,000 in Québec, and several production and engineering sites," noted Marcil. "This reflects our 75-year history and our strong commitment to this country. It also enables us to leverage Canada's competitive strengths, such as strong R&D capabilities, world-class engineering talent and high-value manufacturing."

For the C Series, the final assembly, systems integration and pre-flight operations all take place at Bombardier's Mirabel site, while the carbon-fiber fuselage and cockpit are built at the site in St. Laurent. "Québec suppliers are also part of the effort," highlighted Marcil, referencing Pratt & Whitney Canada and CAE as suppliers of the engines and pilot-training simulator respectively. "So, while the C Series aircraft relies on a truly global supply chain, Québec ingenuity played a central role in its success."

Just around the corner from Bombardier's main Mirabel site is Bell Helicopter Textron Canada, a subsidiary of U.S.-based Textron. Bell Helicopter's Mirabel facility focuses on commercial helicopters, currently the Bell 505, Bell 439, Bell 412 and Bell 407 programs. In March 2017, Bell Helicopter also unveiled its FCX-001 concept aircraft, which includes a plethora of innovative features, including a rotorless tailboom and an electric motor as part of a hybridized propulsion system. Stepping further into the future, the rotorcraft company announced a partnership with Uber for the development of air taxis.

Reaching its 90th year of operation in 2018, Pratt & Whitney Canada (P&WC) is Québec's aircraft engine manufacturer and a global leader. Having produced its 100,000th engine in April 2017, the company today has upwards of 65,000 engines in service on 13 different families of aircraft. Exporting 90% of its products, P&WC is nevertheless a

strong driving force behind a lot of innovation that takes place in Québec. "We are very involved in all aspects of our community and the Canadian ecosystem," commented Maria Della Posta, P&WC's Senior Vice President. "We have more than 23 ongoing university agreements in Canada and major ongoing projects with CARIC, CRIAQ and GARDN which connect us with all kinds of SMEs, universities and colleges to develop our technologies with. We run 10 of the 13 Natural Sciences and Engineering Research Council of Canada (NSERC) chairs... With the support of the Canadian government, we are also working with the aerospace cluster to create a consortium with themes related to advanced manufacturing and digitization. Additionally, we work with more than 1,300 suppliers in Canada. In collaboration with the federal government, we have put in place a program to help suppliers gain aerospace accreditation. We derive a lot of value from these collaborations, and we try to give as much back to the community as possible."

P&WC's focus on innovation is apparent in that almost 8,000 of the engines in service have full engine health management and communication capabilities. "We also have a new Oil Analysis Technology, which gives high visibility into the health and efficient operations of the engine without intrusive inspection," expanded Della Posta. "These technologies allow us to be more proactive with our customers, while helping them move toward more fully planned maintenance environments and providing insights to pass on to our engineering organization to develop better next-generation products. We are immersed in how to transform our business model and bring more customized solutions to serve the diverse missions and needs of our customers. Other areas of great investment are product lifecycle management (PLM) and other systems and technologies that position us well for the future."

With its mission, "Performance. Personal. Guaranteed.", in mind, P&WC is now working on the next large PT6 for general aviation and is currently modernizing and digitizing all its early engines.

Founded in 1947, CAE Inc. is a Canadian manufacturer of simulation technologies, modelling technologies and training services and a leader in training pilots, offering cadet to captain training solutions. With the increase in expected passenger trips and number of flights, CAE stands in good stead to capitalize on the expected demand

growth for its services. “Over the next 10 years, IATA forecasts that passenger trips will grow by more than 4% yearly, meaning the commercial aviation industry will double over the next 20 years,” outlined Marc Parent, CAE’s president and CEO. “Airlines will need more pilots. In fact, at the Paris Air Show, we introduced our first-ever CAE Airline Pilot Demand Outlook to the market. It indicates that more than 255,000 pilots will be needed in the next 10 years and that over 50% of them have not yet started to train.” As with its other OEM peers, CAE places a heavy focus on R&D, investing more than C\$1.3 billion over the past 10 years.

Selecting suppliers

The industry is currently transitioning from a bullish market, where huge orders were secured for new aircraft in development, to a bearish one in which OEMs are focused on ramping up production at an unprecedented scale to meet order books, rather than on new aircraft sales. As a result, OEMs are experiencing pressures on their margins, translating into cost pressures across the entire supply chain. “OEMs have spent heavily on developing their current programs and there are no new ones in development, so they have reached a period of the business cycle where they are not selling many new planes,” commented Sylvain Boisvert, general manager at Safran Engineering Services. “For this reason, they are focusing on productivity, which translates to cost reductions. Safran Engineering Services has therefore received a lot of demand from Tier 1s for assistance with improving profitability through weight reduction and identifying other cost saving measures.”

Concurrently, in recent years, OEMs have shown a clear preference for long-term contracts rolled out to fewer, often larger suppliers that can offer integrated services due to the efficiency gains that can be secured. “Our priority is finding suppliers that are very cost-competitive and agile in meeting market demands,” emphasized Cynthia Garneau, president at Bell Helicopter. “Proximity is also important for us.”

In today’s globalized environment, there is often a better business case for establishing supply chains closer to the export market or in lower-cost jurisdictions. “We transferred the build of all of our cabins and wire harnesses to our facility in Chihuahua, Mexico,

a few years ago, transferring our supply chain along with it,” added Garneau. “We now have much more of a Mexico-focused supply chain in these areas. Similarly in Québec, as we look towards the next generation of helicopter and next commercial program, we will be building a strong Canadian supply chain, looking for companies that can match us in innovation and follow us where we are heading in terms of technology.”

The presence of major OEMs elevates Québec’s aerospace industry on a global scale; many local suppliers have used these relationships as stepping stones to the international markets. “We invest in our suppliers by developing them and providing them with green belt training sessions,” explained Parent. “We use the Aéro Montréal MACH program for supplier development in order to increase competencies and the ability to drive joint cost-reduction initiatives.”

Citing quality as the most important factor in selecting a supplier followed by cost, Parent continued: “Thirdly, we look for suppliers that can deliver subassemblies involving mechanical parts, electrical wiring and electronic equipment. Fourth, as a signatory to the UN Global Compact, we are taking steps to ensure responsible procurement... Social and environmental factors are considered alongside financial factors when making procurement decisions and are detailed among the criteria used for supplier selection. Finally, supplier innovation is captured through appropriate partnerships with relevant subcontractors.”

In order to compete in today’s environment, suppliers must meet global standards and measure up against international players on aspects such as quality, cost and delivery time. The government and key organizations such as Aéro Montréal are therefore focused on increasing the competitiveness of regional players through initiatives such as Aéro Montréal’s MACH program. The MACH initiative aims to strengthen the supply chain structure by creating special collaboration links among customers and suppliers. Initially deployed in 2011 over five years under Bombardier’s mentorship, in December 2016, Aéro Montréal received C\$2 million in financial support for the initiative.

Government support

The government plays a key role in supporting the industry, recently investing

US\$1 billion into Bombardier’s C Series, for example. Whilst some have criticized the move, the government’s 49.5% stake in the company indicates the commitment to the program’s development as an investment that will benefit the entire region. The government also recently invested C\$200 million in support of the space sector, in a project led by MDA.

In great part due to significant government investment, Québec’s aerospace sector has become a key economic driver for the region. “The aerospace industry is recognized for creating high quality jobs, generating steady R&D investments and stimulating exports,” underscored Marcil. “This results in significant economic benefits for both governments and society. In fact, since Bombardier entered the aerospace sector in 1986, the company and its employees have been the source of almost C\$18 billion in government revenue through direct program repayments and taxes paid. This is why a growing number of countries compete to grow their local aerospace industry and attract foreign aerospace investments.”

Government support is essential for a thriving industry and has played a part in attracting new business to the region as well as supporting its existing ecosystem. For example, Bell Helicopter Textron recently decided to locate its Bell 505 operations in Québec over Louisiana, United States. “The first consideration is the expertise developed within the region through the years, and the access to talent we have in Canada... Second is the support offered by the government here in Québec and Canada at large,” noted Cynthia Garneau, president at Bell Helicopter Textron Canada. “We get more attention here than companies in the United States because the sector’s economic impact is proportionally much greater.”

Supported by the broader ecosystem with an increasing emphasis on collaboration, Québec’s OEMs continue to drive the region’s aerospace industry through economic impact and access to global markets. Government provisions will continue to play an important role in the success of Québec’s aerospace industry and, reflecting the growing importance of SMEs as a source of innovation, there will be a more equal focus on smaller companies going forward. In an increasingly global industry, continuing to foster a competitive supply chain in Québec will be key in ensuring heightened economic return from the region’s OEMs. —



Olivier Marcil

Vice President, External Relations
BOMBARDIER

HQ location: Montréal, QC

Other office locations: Dorval, Mirabel and Saint-Laurent, QC; Toronto, ON; Belfast, United Kingdom; Wichita, United States; Querétaro, Mexico; Casablanca, Morocco (aerospace only)

Company type:

original equipment manufacturer

Key products and services: business aircraft, commercial aircraft, aerostructures and engineering, services, rail transportation solutions

Key industries served: Aerospace: 53%; Rail

Key aerospace customers:

Business aviation: 65%;

Commercial aviation: 30%;

Aerostructures and Engineering Services: 5%

Exports: 84%

Bombardier is a Canadian multinational and one of the world's leading aircraft manufacturers.

Could you update us on the C Series highlights and the significance of the program to the region?

The performance and reliability of the aircraft have been outstanding so far, with more than 1.5 million passengers flown on more than 100 routes and airBaltic operating the aircraft up to 17 hours per day. Following this successful entry-into-service in Europe, the C Series will make its Asian debut later in 2017 with Korean Air. In parallel, our facilities in Québec are bus-

ting with activity. More than 2,000 Bombardier employees are currently focusing on ramping up C Series production.

Where else is Bombardier currently focusing its resources?

We refocused our resources on the development of the Global 7000: Bombardier's new ultra-long range business jet. This aircraft has four distinct living spaces and a wing designed to optimize performance while ensuring a perfectly smooth ride, even at a speed of Mach 0.925. As of September 2017, we had three flight testing vehicles in flight testing. The aircraft had already reached its maximum altitude and a speed of Mach 0.995.

The Global 7000 is on track to enter into service in the second half of 2018 as planned. Meanwhile, we are also expanding our Global Completion Centre in Montréal, where the design, manufacturing and installation of passenger interiors of the new aircraft will take place, creating nearly 1,000 jobs.

The Québec government has shown a great deal of financial support for Bombardier's C Series. Could you elaborate on the importance of the government in driving the industry?

The aerospace industry is recognized for creating high quality jobs, generating steady R&D investments and stimulating exports. This results in significant economic benefits for both governments and society. Since Bombardier entered the aerospace sector in 1986, the company and its employees have been the source of almost C\$18 billion in government revenue through direct program repayments and taxes paid.

There is often a stronger business case for OEMs in receipt of government investment to offshore. How should the balance be managed so that the region's ecosystem sees maximum return?

While Canada represents less than 10% of Bombardier's revenues, we have a strong footprint here with over 21,000 employees, including more than 15,000 in Québec. This reflects our 75-year history and our strong commitment to this country. It also enables us to leverage Canada's competitive strengths, such as strong R&D capabilities, world-class engineering talent and high-value manufacturing.

Complementing our footprint in Canada with facilities abroad enables us to harness the comparative advantages they can offer, enhancing our competitiveness. It can also help us gain greater market access, creating new opportunities for growth at home and across our global network of sites. It is not a zero sum game – quite to the contrary – developing global value chains is critical to make our Canadian operations more efficient and to keep Bombardier among the world's top three aerospace players.

In today's research and development environment, a great deal of innovation is arising from universities and SMEs. How open is Bombardier to collaboration?

Bombardier is, by far, the top R&D investor in Canada and invested more than C\$6 billion in R&D in the past 10 years. In our Québec aerospace operations, we are actively participating in close to 20 collaborative projects involving universities, SMEs and other industry players.

Could you outline Bombardier's main objectives over the next few years?

In 2015, Bombardier launched a five-year turnaround plan that aims to transform this company into a US\$25 billion business with a 7% to 8% EBIT margin by 2020. To reach these objectives, we first de-risked the company by securing the right level of liquidity to execute our plan. We then turned our focus to building our earnings power and cash flow. To get there, we are driving an operational transformation across Bombardier, tackling all aspects of cost. This will enable us to translate the significant investments we made in our new commercial and business aircraft into higher margins and to deleverage the company's balance sheet.

On the revenue front, two of the largest growth drivers will be the C Series and the Global 7000 aircraft. Our Commercial Aircraft team is currently ramping up production to meet our target of 90 to 120 C Series aircraft deliveries per year by 2020 and at Business Aircraft, all hands are on deck to bring the Global 7000 aircraft into service in the second half of 2018, as planned. Additional growth will come from Bombardier Transportation, our US\$8-billion rail transportation business, which has a healthy order backlog of more than US\$32 billion. —



Cynthia Garneau

President

**BELL HELICOPTER
TEXTRON CANADA**

HQ location: Fort Worth, Texas, USA

Other office locations:

Training Academy in Fort Worth, Texas, USA
Advanced Composites/Rotor Systems/Drive Systems/Flight Research Centers in Texas, USA
Assembly Centers in Amarillo, Texas, USA; in Lafayette, Louisiana, USA and in Chihuahua, Mexico.

Supply Center in Calgary, Canada

Many sales, support and service Centers and Customer service facilities around the world

Key products and services:

Focus on commercial helicopters: assembly and composite parts manufacturing, product development, flight testing, customization and customer support.

Key industries served: Aerospace

Key aerospace customers: For Bell Helicopter as a whole: 64% military, 36% commercial (Utility, Corporate, Private, HEMS, Parapublic, Oil and gas, etc.)

Exports: 90%

(for Bell Helicopter Textron Canada)

Bell Helicopter is a manufacturer of commercial and military helicopters headquartered in the United States with operations in Mirabel and is counted amongst Québec's "Big 4" OEMs.

Could you introduce and contextualize Bell Helicopter's Mirabel operations?

Our business in Mirabel is focused on commercial helicopters, currently the 505, 429, 412 and 407 programs. The aircraft we build here are specific to our facilities and not manufactured by any other division worldwide. Encompassing the full spectrum of a helicopter's lifecycle, our capabilities span design, product development, building of prototypes, flight-test activities and certification, working very closely with Transport Canada for certificates and validation-type certificates with the FAA, YASA, and other international airworthiness authorities.

How strong is current demand, and where do you see the greatest growth opportunity?

Demand has been very stable for the last three years, although not as high as it has been in the past. Right now, we mainly work on the day shift, which is the appropriate schedule given the market demand. However, we have the capacity to increase to a second or third-shift opportunity, if required. We are very agile when it comes to meeting market demand and always able to adjust with little impact to the workforce.

The biggest opportunity for us is with the 505. We are starting delivery of the first aircraft, transforming the backlog of 400 letters of intent into firm orders. Market demand remains strong for the 407, 429 and 412 and we see increasing demand for the 429 in particular.

What are Bell Helicopter's priorities when it comes to selecting suppliers and how should companies differentiate themselves?

Our priority is finding suppliers that are very cost-competitive and agile in meeting market demands. Proximity is also important for us. We recently transferred the build of all of our cabins and wire harnesses to our facility in Chihuahua, Mexico, transferring our supply chain along with it. We now have much more of a Mexico-focused supply chain in these areas. Similarly in Québec, as we look towards the next generation of helicopter and next commercial program, we will be building a strong Canadian supply chain, looking for companies that can match us in innovation

and follow us where we are heading in terms of technology.

One area of opportunity lies in automation as our implementation is limited. We intend to work closely with our suppliers to improve our manufacturing processes and capabilities through automation.

Bell Helicopter recently decided to locate its 505 operations in Québec over Louisiana, United States. What motivated this decision, and what are the advantages of operating in Québec?

The first consideration is the expertise developed within the region through the years and the access to talent we have in Canada. We have universities with very strong aerospace portfolios. Whilst we are only a 900-person company, we have close to 40 interns this year and we are focused on developing and retaining talent. A large ramp up can be problematic without securing the right talent for the future. Second is the support offered by the government here in Québec and Canada. We get more attention here than companies in the United States because the sector's economic impact is proportionally much greater. When we announced the 505 relocation from Louisiana to Mirabel the timeline was astounding. Our CEO raised the idea on a Friday, requested a meeting with the Québec government on the Tuesday and a month later we had a done deal, bringing an additional 100 jobs to the region.

Bell Helicopter recently unveiled its FCX-001 aircraft. What are some other areas of R&D focus?

The concept aircraft unveiled at HAI Heli-Expo in March 2017 has many innovative aspects, including a rotorless tailboom and an electric motor as part of a hybridized propulsion system. Aside from the FCX-001, there is increasing interest around UAVs and optionally-piloted aircrafts. At Uber's 2017 Elevate Summit in Dallas, we announced our partnership with Uber on developing the air taxi of the future. The 525 is also currently in development and to be built in Emerald, Texas due its large size. Following the unfortunate event of last year, we put our flight test on hold but we hope to resume our flight operations as soon as NTSB releases its report. The V-280, the next generation of tilt rotor, is going well and is focused right now on the U.S. Future Vertical Lift (FVL) military program. We spend approximately C\$25 million every year on R&D, and our Mirabel operations are very much integrated into the strategy. —



Maria Della Posta

Senior Vice President
PRATT & WHITNEY CANADA (P&WC)

HQ location: Longueuil, QC

Other office locations:

Lethbridge, Halifax, Mississauga, Ottawa, Mirabel, St-Hubert, Kalisz, Rzeszow, Shanghai, Singapore + many other locations worldwide

Company type: Gas turbine engine design, manufacturing, services

Key products and services: Gas turbine engines, sales, repair and overhaul services

Key industries served: 100% aerospace

Key aerospace customers: Business aviation, general aviation, regional turboprops, civil helicopter, auxiliary power units, military, after-market services

Exports: 88%

Pratt and Whitney Canada is a leading engine manufacturer and is counted amongst Québec's "Big 4" OEMs.

Celebrating its 90th year of operation in 2018, Pratt & Whitney Canada is well established both within Québec's ecosystem and worldwide. Could we begin with a brief introduction to P&WC today and any major updates since we met in 2015?

In April 2017, we produced our 100,000th engine. Today, we have upwards of 60,000 engines in service in over 200 countries and territories, on 14 different families of engines for everything from helicopters to APUs. Our PurePower® PW800 engine, now certified, is meeting and exceeding all of its performance expectations. Inaugurated in 2010, the Mirabel Aerospace Centre is now moving at a very good pace and our Advanced Manufacturing Center, which manufactures parts for the PW800 and NGPF engines, is ramping up production. In 2015, we welcomed the Auxiliary Power Units (APUs) business, adding almost 10,000 engines to our fleet. Our APUs can be found in nearly every large airline in the world.

Additionally, we have launched a whole new suite of digital engine services. One is a brand new customer portal, MyP&WC Power; another is additional functionality in our engines' capabilities—almost 8,000 of the engines in service today have full engine health management and communication capabilities. We also have a new Oil Analysis Technology, which gives high visibility into the health and efficient operations of the engine without intrusive inspection. These technologies allow us to be more proactive with our customers, while helping them move toward more fully planned maintenance environments and providing insights to pass on to our engineering organization to develop better next-generation products. Other areas of great investment are product lifecycle management (PLM) and other systems and technologies that position us well for the future.

What are P&WC's greatest focus areas for process innovation?

For the past few years, we have been developing advanced manufacturing and automation, moving from automating machines to building fully automated production cells which machine complex components end-to-end. We have three new cells in Québec and others in our facilities around the world. These cells incorporate closed door machin-

ing, automated in-process inspection, self-compensation, robotics and advanced line health monitoring. We are pushing towards predictive maintenance across our operations.

These technologies also require a completely different skillset for our employees. We have moved from traditional machinists, inspectors and maintenance technicians to highly trained cell leaders with multi-disciplinary skills for problem-solving. We also need engineers who are skilled in mechatronics, automation and metrology. We are working with local schools to adapt their programs to our needs.

When it comes to P&WC's supply chain, is the Québec ecosystem still considered very competitive?

What makes the Canadian and Québec aerospace sector unique is our philosophy and vision around promoting industry and research. With the support of government, we are able to export 90% of our products. We have great schools and institutions to work with and a favorable operating environment. The government's innovation strategy has clearly been a part of our investments in advanced manufacturing. The Canadian ecosystem is a basis for our growth and our future.

Going forward, what are the key objectives and the next areas of focus for P&WC?

Our mission is to continuously inject technology into all of our product lines. We are working on the next large PT6 for general aviation and civil helicopters and have a big effort afoot to inject new technology in all of our platforms. A consistent focus for us is developing next generation engines, which we are currently working on. We will continue to bring a high level of capability in technology to all of our facilities in Canada and worldwide.

When it comes to serving our customers, our simple mission is "Performance. Personal. Guaranteed." More customization will also be the way of the future. Our focus is on bringing in different levels of customization and transforming our business model in line with global trends. We also play a leadership role in establishing the direction of some of the Canadian aerospace cluster initiatives. We need to join forces to ensure we have what it takes to bring our vision to reality and promote Canadian aerospace on the world stage. —



Marc Parent

President & CEO
CAE

HQ location:

8585 Cote-de-Liesse
Saint-Laurent, Quebec

Other office locations:

160 sites in over 35 countries

Company type: Training products and services

Key products and services: Training and simulation, in-service support and crew sourcing

Key industries served:

Aerospace, defence and healthcare

Key aerospace customers:

Civil aviation: 58% of revenues

Defence and security: 38% of revenues

Healthcare: 4% of revenues (2017 figures)

Exports: 90%

CAE is a global leader in modelling, simulation and training for civil aviation and defense, offering cadet to captain training solutions.

CAE is celebrating its 70th anniversary this year. What are some of the defining characteristics of the company today?

Training is all we do and innovation still defines who we are. We operate more than 65 training centers and flight schools around the world and train more than 120,000 pilots annually. We continue to be the leader in the sale of flight simulators. Today, we are truly a training services company with 60% of our business coming from our services vs products.

This year, CAE announced a number of large aviation training contracts. Could you expand on some of these?

We recently announced our fiscal 2017 results; it has been one of the best years in our seven-decade history. We expanded our relationships with customers around the globe. In Civil Aviation Training Solutions we continued to lead the market with a near-record year of 50 full-flight simulators sold and in training services we signed long-term contracts with Jet Airways in India, Vietnam Airlines and Korea Airports Corporation, among others.

Our Defense & Security business secured major long-term training contracts in which CAE provides the full solution—we call these Training Systems Integrator (TSI) contracts. In fact, we ramped up orders by 40% for a record US\$1.4 billion contracts this year. Our innovative approach enabled us to win the contract to create the U.S. Army's new fixed-wing training center and program, which we inaugurated ahead of schedule. Other defense contracts include a 20-year naval training program for the United Arab Emirates and a contract for the French Air Force Initial Flight Training. We also won key national programs with the Fixed Wing Search and Rescue Airbus C295 training program for the Royal Canadian Air Force where CAE will provide the training center, flight training devices, courseware and instructors. In addition, we extended our NATO Flying Training Centre program, which we deliver here in Canada, to 2023.

How is demand for skilled personnel developing?

Over the next 10 years, IATA forecasts that passenger trips will grow by more than 4% yearly, meaning the commercial aviation industry will double over the next 20 years. Airlines will need more pilots. In fact, at the Paris Air Show, we introduced our first-ever CAE Airline Pilot Demand Outlook to the market. It indicates that more than 255,000 pilots will be needed in the next 10 years and that over 50% of them have not yet started to train.

New and innovative pilot career pathways and training systems will be required, which is great news for CAE.

What are CAE's current areas of focus in terms of R&D?

One of the key elements will be how we leverage existing technologies and big data to create training programs that are tailored to the specific needs of each pilot. We call that adaptive training. If the data shows that the pilot has problems in landing with crosswinds, for example, the training program will focus on this aspect until it is mastered.

The aerospace industry is embracing Industry 4.0. How is CAE keeping up with these trends?

CAE's global leadership in training comes in large part from our commitment to invest in both technological and operational innovation. CAE is a 4.0 company, well positioned to leverage the current technological revolution. We are embracing new digital technologies such as big data, artificial intelligence and machine learning at a fast speed. Our annual Innovation Challenge initiative, launched in 2012, leverages employees' creativity to spark winning ideas that often evolve into concrete improvements and new products. This helps us to harness the value of the digital world. This year, we received more ideas than ever before, with submissions focused on cloud computing, cybersecurity, new training media and the environment.

Could you outline CAE's main objectives over the next three to five years and the overall vision for the company?

Over the last couple of decades, CAE has established itself as a thought leader in aviation training and we are now bringing to market some of the most innovative and comprehensive solutions that we believe will enable us to unlock a greater portion of the civil aviation training market. —

Image courtesy of CAE



Crossing borders: Québec's outward facing aerospace supply chain

Despite standing out as a self-sufficient hub of activity, Québec's aerospace ecosystem is far from contained. Not only is the province well connected nationally, the region also exports 80% of its production either directly or indirectly. Aerospace is, in fact, the number-one export driver in Québec, which is significant considering exports account for 50% of Québec's GDP. Of these exports, 40% are to the rest of Canada and, of the remaining 60%, the biggest export market is the United States.

Strong export strategies are particularly important for SMEs for two main reasons. Firstly, in today's globalized environment, companies along the supply chain are able to source suppliers with fewer geographic restrictions and are therefore able to pursue competitive offers more freely. Secondly, in response to OEM demands for fewer suppliers, SMEs must grow and extend their capabilities. SMEs therefore need to be bigger and more robust; growth is only possible by winning more contracts, so it follows that SMEs must look further afield than their domestic market. Equally, by competing more actively internationally, companies can further raise their visibility on their home turf. "Suppliers in Québec need to break out of the Québec bubble," commented Stephen Kearns, president and CEO at Avior (Produits Intégrés). "It is a major challenge as this takes considerable time and investment. It makes sense for suppliers to diversify their customer and program base and move up the food chain towards

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The government is aware of the challenge; the clock is ticking on a lot of the smaller suppliers. Their reliance on a very local OEM customer base is a big vulnerability, so they need to penetrate international markets outside the Québec cluster. For the cluster to evolve, the smaller companies need to be supported in addressing these challenges. The Québec Government as well as Canada are very aggressive in helping to promote companies and assist them in penetrating new markets. Government officials are not sticking their heads in the sand and ignoring the problem.

- Stephen Kearns,
President and CEO,
Avior (Produits Intégrés)



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more integrated structures, which will come from exports. Companies remaining at the Tier 4 level will need to develop new customers which includes emerging Tier 2 suppliers such as Avior.”

Avior is a full-service manufacturer of lightweight structures and complex mechanical assemblies aiming to become a Tier 2 supplier by building a track record of performance and innovation, investing in 3D printing technology and robotics, for example.

In light of Québec’s export orientation, companies and government organizations will be keeping a close eye on international trade dynamics. For the province as a whole, 20% of GDP is tied to exports to the United States. As a close neighbor, the country is often first in mind for companies wishing to expand their footprint. “As half of our [aerospace] production is exported to the United States, we are very tied into the U.S. economy, which is quite cyclical,” explained Alexandre Faria, vice president, business development at Export Development Canada (EDC), Canada’s self-financed export credit agency. “Any changes to NAFTA would have a huge impact on Québec companies. Since we do not know where the negotiations will lead, diversification is the way to avoid challenges later on. It is essential that the SMEs increase their participation in both local and global supply chains.”

With representation across the globe, EDC’s role is to facilitate trade between key buyers with Québec companies, regularly creating a financing pool for the buyers and leveraging these relationships to identify procurement opportunities from Canada. In addition, EDC also supports foreign direct investment (FDI) for companies with a subsequent export angle. Commenting on further regions of focus outside of North America, Faria continued: “With the CETA agreement imminent, Europe will be a key market for us to focus on. Mexico is another area of focus. Market growth in Asia is immense, so more companies are looking to supply or invest into the region. The key to success is in choosing the right partner, the right place to be established and protecting patents. EDC is getting more experience in

dealing with countries such as China and is therefore better positioned to support companies entering these regions.”

The true impacts of a reformed NAFTA are still under a great deal of speculation and, considering Canada has had a longstanding free-trade environment with the United States even prior to NAFTA, the relationship is unlikely to be uprooted. In addition, whilst the U.S. trade deficit is large, in the region of US\$46 billion, less than 2% is associated with Canada.

“Changing trade dynamics is the biggest challenge facing the global industry,” noted Alain Ricard, head of the transport team at Norton Rose Fulbright. “However, the trading relationship between Canada and the United States is very intertwined. Whilst there is currently a lot of rhetoric about renegotiations of trade deals, in the end it would achieve little because the trading relationship between the United States and Canada is already well balanced in terms of advantages and disadvantages for both countries. The industry will remain highly globalized, despite any policy hurdles that may arise.”

As with customer portfolios, diversification across different markets is key in order to mitigate arising risks across different borders. “Diversification of markets is always good for the industry,” added Ricard. “This trend, along with the move towards consolidation in order to gain a bigger share of the global market, should prevail no matter what political disruption occurs or not.”

Other organizations such as the Centre de recherche industrielle du Québec (CRIQ) help manufacturers achieve compliance with regulations across export markets, with a dedicated facility in Montréal that can conduct more than 1,000 tests to ensure conformity with all required export markets. Government agencies such as Export Québec provide further export services.

Companies across the supply chain will continue to focus on export markets with encouragement from Québec’s government. Not only does this foster greater competitiveness among suppliers in the region, but of course drives the industry’s reputation on the international stage, attaining greater market share. —

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There is no question that relations are getting tougher with the United States. However, counterparts in states such as New York, Texas, Hawaii, Pennsylvania and Maine have made it clear that they want to keep current commercial agreements in place because they see the benefits. The Canadian and the U.S. economies are highly integrated—a finished product may have crossed the border five times during development. In addition, whilst the U.S. trade deficit is huge, the percentage associated with Canada is very low at less than 2%. NAFTA has been in place for some time, and a degree of adapting could in fact be beneficial to all parties.

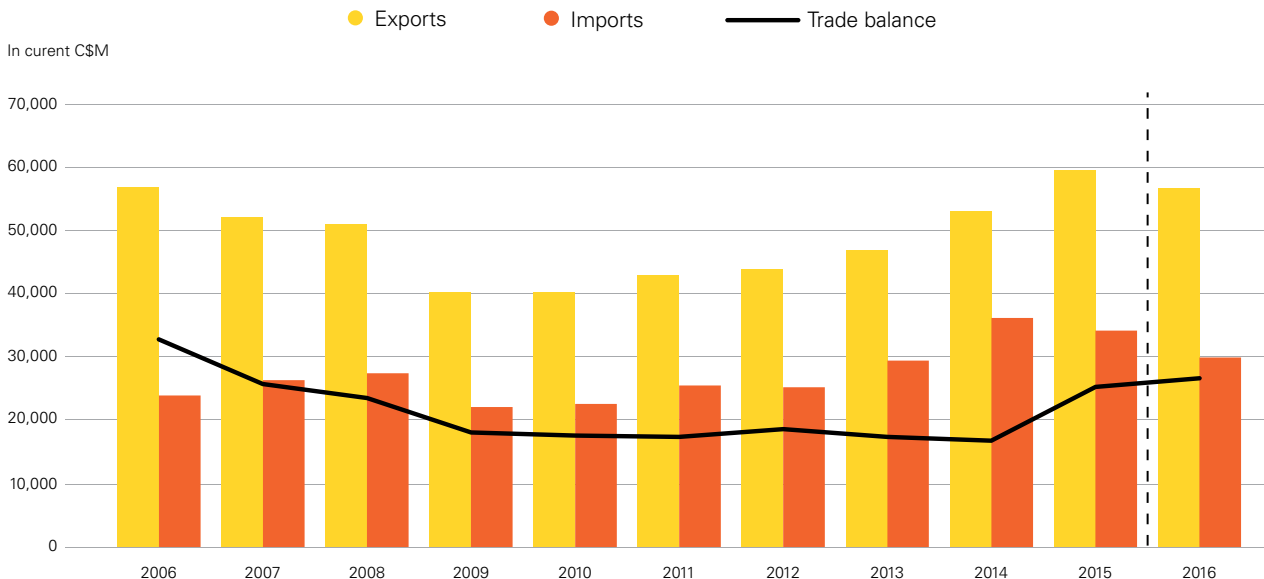
- Dominique Anglade,
Minister of Economy
Science and Innovation,
Québec government

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QUEBEC EXPORTS TO THE UNITED STATES

Source: Desjardins



Alexandre Faria

VP Business Development
**EXPORT DEVELOPMENT
 CANADA (EDC)**



Established over 70 years ago, Export Development Canada (EDC) is Canada's self-financed export credit agency.

Have export strategies changed recently in line with greater demands from potential customers?

Québec has a highly-diversified economy and 20% of our GDP is related to export. Within that, manufacturing represents 90% of the region's exports. Since more OEMs are asking for fewer suppliers, SMEs need to be solid and be able to provide what the OEMs are asking for. To achieve success, SMEs must be bigger, stronger and more competitive. Québec's companies are very competitive and our currency helps. Nevertheless, Québec companies prefer to deal with companies close by rather than step-

ping out of their comfort zone. EDC's role is to help these SMEs grow to a certain level for them to be able to serve the larger companies in the way that they expect.

How do you ensure that exporting companies still have the appropriate economic impact in the Québec region?

Companies we support must have a footprint in Québec. They must already be established here and contribute to Québec employment. If they are opening business elsewhere, it must be another arm of their company here. We have not experienced difficulty in establishing a balance because exporting makes Canadian companies stronger, more innovative and increases their sales. In the end, the integrated processes should make the company more competitive worldwide.

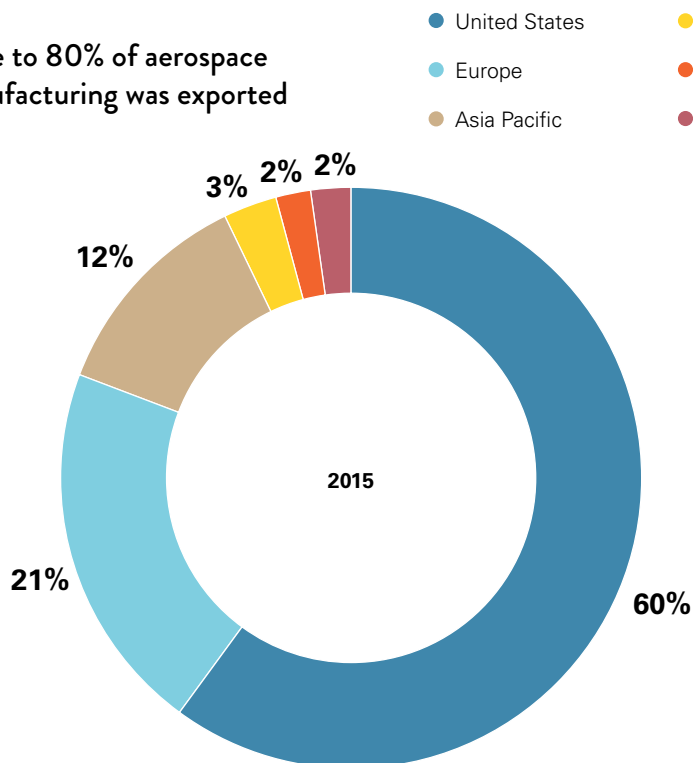
What are the objectives for EDC over the next three to five years?

Our aggressive goal is to grow our clientele from 7,000 to 30,000 customers. We want to help as many companies as possible with knowledge and services to truly support their needs. We are looking into different approaches, such as financing tooling. Companies are facing pressure to support development costs, which is a challenge for SME's. We are recognizing a need to assess our current offerings and look for innovative solutions that are aligned with the way in which the sector is changing. Our goal is to continue identifying gaps that we can fill; cash flow is the key component for company growth, so we step up when we can. —

AEROSPACE EXPORTS BY REGION

Source: AIAC / Statistics Canada CANSIM and Trade Data Online (2015)

Close to 80% of aerospace manufacturing was exported



Aerospace was twice as trade diverse* as the manufacturing sector.

Aerospace export intensity was 55% higher than that of the manufacturing sector average.**

Aerospace exports grew 54% between 2010 and 2015. Exports to the Asia Pacific market registered the highest growth (+105%) during that period.

* Trade diversity refers to the share of total exports to non

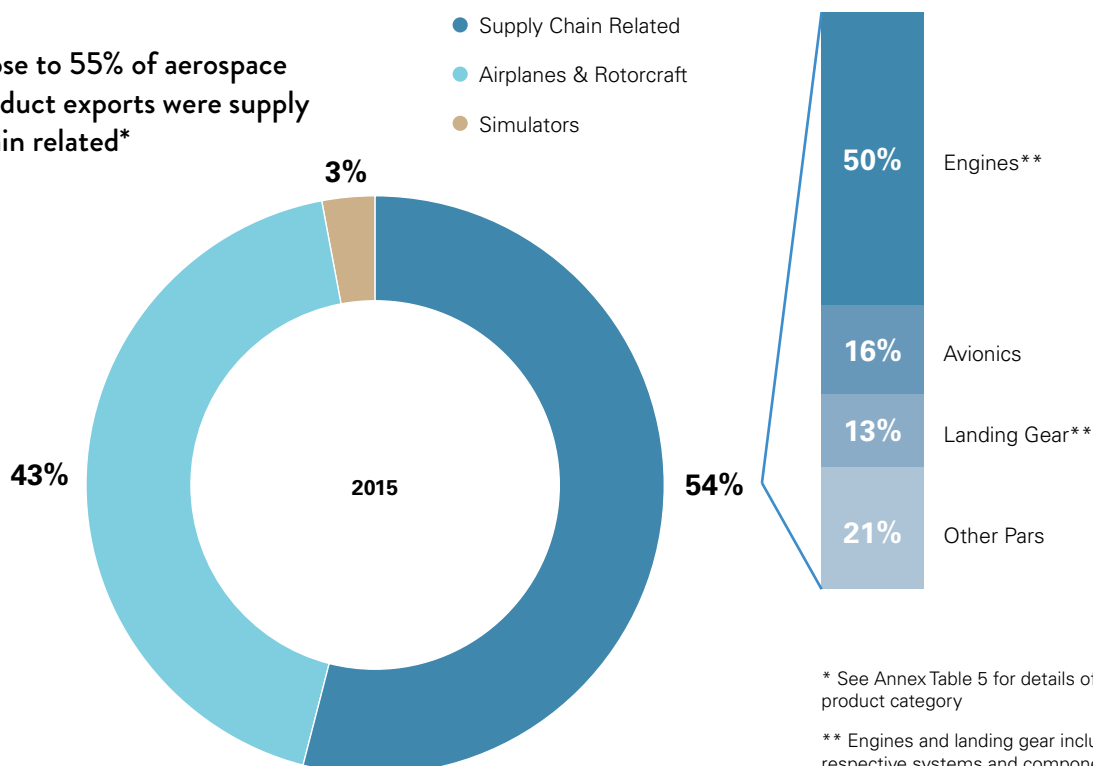
** Export intensity: Exports/Shipments

35

AEROSPACE EXPORTS BY PRODUCT CATEGORY

Source: AIAC / Global Trade Atlas

Close to 55% of aerospace product exports were supply chain related*



* See Annex Table 5 for details of exports by product category

** Engines and landing gear include their respective systems and components





FROM THE GROUND UP: **AIRCRAFT BUILDING BLOCKS**



“Consolidation will continue and Aéro Montréal encourages this trend. SMEs are currently too dependent on a limited number of customers; moreover, OEMs are no longer buying directly from SMEs but instead from integrators mostly located outside of Canada. Because SMEs must sell to international integrators, Aéro Montréal assists them in their internationalization strategies by encouraging them to integrate and adopt Industry 4.0 technologies.”

- Suzanne M. Benoît,
President,
Aéro Montréal

A New Order: Québec's supply chain reaches turning point

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Alongside the Big Four OEMs and Tier 1 integrators, Québec's aerospace cluster is home to over 200 SMEs occupying distinct niches in manufacturing and sub-assembly and making a significant contribution to the sector's economic impact. The large number of SMEs reflects the entrepreneurial nature of the cluster, which has developed around a private market unlike many rival clusters around the world.

The industry is currently transitioning from a bullish market, where huge orders were secured for new aircraft in development, to a bearish one in which OEMs are focused on ramping up production at an unprecedented scale to meet order books, rather than on new aircraft sales. As a result, OEMs are experiencing pressures on their margins, translating into cost pressures across the entire supply chain. Currently, in recent years, OEMs have shown a clear preference for long-term contracts rolled out to fewer, often larger suppliers that can offer integrated services due to the efficiency gains that can be secured.

Largely because of these trends, Québec's aerospace supply chain is undergoing an evolution marked by consolidation with-

in the Tier 1 and Tier 4 levels and more broadly amongst the region's SMEs. Many smaller companies lack the capacity and resources to truly meet demands for more integrated services and evermore cost-effective solutions but also lack the investment capital to address these areas. Unable to grow rapidly and significantly increase their international presence, these companies are likely to either be bought up or drop out of the market. Companies along the supply chain with sufficient capital are likely to make acquisitions to increase capacity to take on more customers or larger contracts or add capabilities to offer a more complete solution.

Consolidation within the industry is not a new theme but the trend is certainly increasing and having more pronounced effects. "The industry has talked about consolidation for 25 years but it has not happened before," commented Chris O'Neill, president and COO of Mecaer America, a division of the Italian supplier of integrated landing gear systems. "The demands of OEMs are becoming more sophisticated every year. This makes it harder for smaller suppliers to compete, which will cause further consolidation."

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Consolidation is likely to continue into the future and has been a continuous trend at the Tier 1 and Tier 4 levels. This creates pressure on the industry from both ends: the customers will continue to demand price reductions and the raw material suppliers increasing costs because they are bigger and more powerful. In turn, this creates difficulty for Tier 2 and will make it increasingly difficult for SMEs to remain competitive and stay in the market at all.

- Claude Baril,
Managing Director,
STELIA Aerospace
North America



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Commenting on the resulting reduction in available work, O'Neill continued: "Every momentous change in business allows for both opportunity and concern. We will find a way to exploit this opportunity but the impact on smaller companies producing manufactured parts will be more pronounced. They will either need to integrate or will be forced to drop out of the market."

Mecaer America is focusing on diversifying its client base utilizing Aéro Montréal's MACH initiative to reach this goal. The initiative aims to encourage companies, particularly SMEs, to develop more integrated services and better identify and serve the needs of OEMs and Tier 1 integrators.

SMEs' awareness of the need to better align themselves with the demands of their customers has driven numerous acquisitions since 2015. For example, PCM INNOVATION acquired TechFab in April 2016 to form a small integrator focused on tooling and Sinters America purchased DCM Group in December 2015 to form an integrated design and components manufacturing company. "The objective of the acquisition is an integral one and one that is difficult to accomplish: we needed a stronger base in order to win confidence from the OEMs and Tier 1 suppliers. We therefore decided we needed to exert more control over our supply chain than we had been so we chose to grow vertically and horizontally," stated Éric Ledoux, DCM Group's president and CEO.

With market conditions becoming more and more challenging, companies must tick all the boxes to get a seat at the table.

Identifying opportunity

In this environment, it is difficult for new players without a longstanding reputation to enter the market without a breakthrough technology. However, as OEMs increasingly look to start-ups and universities for new technologies, there are opportunities available for those offering something unique that offers measurable value or benefit. Collaboration is at the heart of many new development programs, furthering innovation through combined effort among companies that once saw collaboration as a competitive disadvantage. These models also provide a platform for smaller compa-

nies to work on contracts for which they might not otherwise have the resources.

Alongside industry-led projects run through the Consortium for Research and Innovation in Aerospace in Québec (CRIAQ), there are initiatives such as SAGE and now SA2GE, launched by Aéro Montréal to develop parts and systems in a more environmentally-friendly way. The initial program, launched in 2011, involved 27 SMEs, five universities and four R&D centers with contributions of C\$150 million from the Québec government and private companies across five R&D projects. Phase two of the program, launched in 2016, is in fact led by the SME TeraX-ion.

After safety, the two themes at the center of innovation in commercial aviation are efficiency and cost reduction (without a tradeoff on quality). Indeed, whilst much of the industry is experiencing slower demand, it is the engineering services seg-

“Over the last five years, OEMs and Tier 1s transferred parts of their supply chain responsibility to Tier 1s and some Tier 2s. However, some Tier 1s and Tier 2s do not have the supply chain maturity to receive these transfers from their customers. Some SMEs do have this maturity, which is why they are growing faster than the others. On the opposite side, OEMs and Tier 1s need to help their subcontractors in order to support their cost reduction initiatives. The supply chain is not changing; it has changed. We must see the supply chain as a global entity and not just buying parts, creating real partnerships with suppliers.

- Real Julien,
President, J2 Procurement



ment that has seen the most recent growth. Companies offering solutions to accelerate timelines, increase efficiency and reduce costs are generally in strong demand. Montréal-based AV&R which specializes in automation and robotics has an order backlog of over five years, for example.

Whilst the benefits of these technologies are clear, the upfront investment can be problematic for SMEs and does not present a strong business case if volumes are low. However, through initiatives like MACH FAB 4.0, Aéro Montréal and the Québec government are promoting SMEs' uptake of Industry 4.0 processes, such as automation, robotics, additive manufacturing and internet of things (IOT), to increase their competitiveness, particularly against international rivals. Equally, supporting companies in their export strategies means increased volumes, making automation and implementation of robotics more feasible. By increasing operational and cost efficiency, SMEs will improve their competitiveness by better serving OEM's needs and narrowing the cost gap with lower-cost jurisdictions. Uptake of these processes is therefore essential for SMEs to retain their position in the market. The support offered by Aéro Montréal and the Québec government further cements continued investment into this area and widespread implementation of these technologies. With this focus, Québec is set to sustain a more efficient and competitive SME network, although continued consolidation is still to be expected to address demand for integrated services.

Gaps in the market

Presently, the vast majority of Québec's approximately 15 integrators are foreign companies. These include Airbus subsidiary Stelia Aerospace, which supplies part of the fuselages for the Bombardier Global 7000 and 8000 business jets, and Belgium's Sonaca, which manufactures wing panels and stringers. However, there is a gap in the market for Tier 1 integrators that can provide services such as flight control systems, power and distribution electric systems, hydraulic systems, fuels systems and air management systems.

Given the market is heavily skewed towards SMEs, it would be a challenge for Québec's companies to fill this gap.

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We need to bring more integrators to Québec, such as subsidiaries of large foreign companies. This will bring opportunities for our SMEs and foster supply links with our OEMs. Québec also needs to invest more in showcasing its capabilities to the global market and allocate more resources to help SMEs accelerate the digital shift.

- Suzanne M. Benoît,
President,
Aéro Montréal

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“SMEs in Québec typically have revenues of between C\$5 to 10 million, whilst OEMs are demanding to work with C\$100 to C\$200 million businesses,” commented Guillermo Alonso, president of Montréal-based SME Alta Precision, an international leader in supplying build-to-print landing gear assemblies and sub-assemblies for the military and commercial aerospace markets.

A potential solution is the consortium model which has seen a great deal of uptake in European countries such as Italy and France. By collaborating and combining capabilities, companies are able to increase their resources to take on larger contracts and provide a more integrated service offering. However, this has so far proved unpopular in Québec. “Over the years, consortiums have been attempted but it causes concern among OEMs about who is ultimately accountable for the contract and is liable for any problems,” explained Alonso. “Instead, OEMs want one owner of the different integrated services. Therefore, mergers and acquisitions should be a bigger priority.”

Alta Precision doubled its facility’s size following winning a long-term contract on Embraer’s E2 program in 2014 and plans to double its sales in the next three to four years based on recently-signed contracts. Vertical integration is also a priority for Alta Precision, which aims to become an integrator and gain extra volume from OEMs.

There is a big opportunity for foreign investors to fill the gap in Québec’s aerospace market for Tier 1 integrators. Indeed, this is already happening; for

example Stelia North America, which focuses on the design, development and fabrication of advanced composites structures, was formed through the merger of France-based Airbus subsidiaries Sogerma, which owned Canada-based Composites Atlantic, and Aerolia.

The future of the supply chain

As supply chains become increasingly globalized and the world becomes smaller, Québec’s aerospace sector will be marked by consolidation as companies strive not only to compete internationally but to stay in business. However, a key question going forward will be whether consolidation will achieve this goal. “Consolidation has gripped the industry and it will continue in the next few years. However, in ten or twenty years from now the industry will realize that some of these moves towards consolidation are not very efficient and therefore some mergers will be dismantled,” commented Ledoux.

Effective management of Québec’s supply chain will be important in maintaining the region’s prominent position on the global stage. SMEs will only be able to survive if they have a unique product or are able to offer a complete solution. Without this differentiation, they will have to compete on price and will need to continue innovating in their processes. Today’s climate requires business to be well-rounded in all areas and, as such, continued government support will be needed to help companies raise the bar and avoid off-shoring by the region’s OEMs. —

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The evolution in small businesses will likely not be the same in the near future. We will see a lot of companies consolidating into mid-sized businesses in order to compete. Change is the only constant, so it is unclear how long the trend will last. As the young people entering the workforce today mature and choose their direction, their ideas will begin to stimulate more small business again.

-Glen Lynch,
President & CEO,
GAL Aerospace



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“Consolidation will continue and Aéro Montréal encourages this trend. SMEs are currently too dependent on a limited number of customers; moreover, OEMs are no longer buying directly from SMEs but instead from integrators mostly located outside of Canada. Because SMEs must sell to international integrators, Aéro Montréal assists them in their internationalization strategies by encouraging them to integrate and adopt Industry 4.0 technologies. We also facilitate meetings between international OEMs and Tier 1s and Québec’s SMEs. These include, for example, regular meetings with Boeing and Lockheed Martin.”

- Suzanne M. Benoît,
President, Aéro Montréal



“Looking objectively at the industry, there is definitely a need for greater consolidation among SMEs. There are many people with a lot of expertise, experience and ideas in the lower levels of Québec’s aerospace supply chain and this brings opportunities for acquisitions. Alongside this, there is a clear need for SMEs to integrate additional services into their business. Whether this will happen, however, depends on the mindset of the individual entrepreneur running these smaller companies.”

- Alain Ricard,
Head of Transport Team, Norton Rose Fulbright



“For many years, the OEMs have wanted to work with fewer suppliers, which has led to increased pressure on SMEs to consolidate. Initially, SMEs believed this pressure would result in loss of control. However, many now recognize that consolidation can be beneficial because they can maintain their entity while gaining new contracts and projects.”

- Jacques Comtois,
Vice President and General Manager, L-3 Communications MAS



“The Canadian government is definitely trying hard to change the dynamic in Canada’s aerospace industry by encouraging companies to collaborate more. Due to the entrepreneurial nature of Canada’s SMEs, some smaller companies would prefer to have 100% of a niche market than tackle a market that is 100 times larger and share the proceeds with their competitors through a consortium. In addition, whilst research consortia are easily formed and therefore the most common form of consortium, commercial projects are much more complicated.”

- Phil Cole,
VP Business Development, Marinvent



“The ecosystem will continue to experience a lot of consolidation because OEMs increasingly want to work with larger SMEs. OEMs nowadays will not consider a company with less than 150 employees unless it has a unique product or operates in a specialized niche.”

- Mario Lepine,
General Director, F. List



Company	Number of employees in Québec	Number of employees in total	Revenue 2016 (USD)	Components and standard parts	Industrial engineering	Systems and software	Subassemblies and structures	
ABB			33 billion (wider group)		x	x		
Adacel		110	20 million			x		
Aeroneuf Instruments								
AKKA Technologies		14,500	18.7 million (N. America)		x	x		
Alphacasting	160	160		x			x	
Alta Precision	110	110	20 to 30 million	x			x	
AMEC Usinage	54	54		x				
Anys NTI		3000	988.6 million			x		
APN	100	150		x				
Arconic	500	41,500	12,4	x	x		x	
Astonics LSI		150				x		
ATLAS Aeronautik	150	150		x			x	
AV&R	100	-		-	-	-	-	
Avior	230	230					x	
Avitec Tools	45	45		x				
Bell Helicopter	900	7500	3.2 billion	x	x		x	
Bombardier	15,700	66,000	16.3 billion	x	x		x	
BUILDIT Software & Solutions	19	23	-	-	-	x	-	
CAE	3100	8500	1.9 billion					
Creaform	230	550			x			
DCM Group	200	200	30 million	x			x	
Elisen		15					x	
EMG Technologies				x				
ÉQUIPEMENT D'ESSAI AÉROSPATIAL C.E.L.	76	84			x	x		
Exonetik	17	17						
F. List	100 (projected)	800	94.8 million		x	x	x	
Fonds FTQ	600	600	861 million					
GAL Aerospace				x				
GE Aviation	800	44,000	26 billion	x		x	x	
GGI Solutions	190	190			x		x	
Héroux-Devtek							x	
ICAM Technologies						x		
Ingenio Aerospace						x		
Innotech-Exeaire Aviation Group								
INO	200		28 million	x				
J2 Procurement Management	25	25						
L-3 Communications MAS				x	x	x		
LATECOERE Services					x			
Luxia Innovation	20	20	3.5 million	x	x			
M1 Composites Technology	36	36	-	x				
Mannarino Systems & Software	55		4 to 8 million			x		
Marinvent	12	14	1 million			x		
MAYA Simulation	140	150			x	x		
McMillan LLP								
MDA	800	4800	1.65 million	x				
Mecachrome	175	3500	54 million (Canada)				x	
Mecaer America	122	550	29 Million		x		x	
MPB Communications	135	150	30 million	x			x	
Nüvü Caméras				X		X		
P3 Group Canada		60,000	400 million (Group)		x	x		
PCM Innovation	180	210	-		x			
Pratt & Whitney Canada (P&WC)	4800	9400		x				
Presagis	80	120				x		
PUDDLEJUMPER FLOATS				x				
Radix		90	31.7 million			x		
Robotmaster, Hypertherm Robotic Software	25	1300+	-					
Rockwell Collins	50	30000	5.26 billion	x		x	x	
Rolls Royce	800	49,900	18.2 billion					
Safran Engineering Services		3700			x			
Sonaca Montréal							x	
STELIA Aerospace	122	6600	76 million	x	x	x	x	
TAS (Techno Aero Services)								
Techniprodec							x	
Tekalia Aeronautik	130	130	12.5 million	x			x	
Thales		1800	444 million			x		
Thermetco		70		x				
Titanium Industries				x			x	
TNM Anodisation et Peinture								
Varitron	300	375	70 million					
Vestshell				x				

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From foundry to final assembly

Québec's extensive proficiencies stem from its large number of specialized suppliers across all the required disciplines within the aerostructures field. From fuselage, landing gears and actuation systems to flight control systems and engines, Québec's comprehensive supplier base are advanced in capabilities and processes, supporting the region's OEMs across the vast requirements of aircraft assembly.

Directly below the OEMs in the supply chain are the Tier 1 integrators, of which Québec has upwards of 10. Whilst capabilities at this level are extensive, covering fuselage, engines, landing gear, there is an effort within the region to attract more Tier 1 companies. "Tier 1s are the missing element in Québec's ecosystem," commented Dominique Anglade, Minister of Economy, Science and Innovation, Government of Québec. "There are specific companies the Ministry is targeting that could add significantly to the sector in Québec. The government will remain focused on attracting, advising and investing in such companies."

Québec is already familiar ground for several foreign companies at this level, including Safran, Sonaca, Mecaer and Stelia.

With consolidation at the Tier 4 level and resulting price power in conjunction with OEM demands for price reductions at each end of the supply chain, the middle tier levels are being squeezed on cost. Cost reduction is therefore at the forefront of manufacturing considerations after quality and performance. "Our current supply chain is performing well and we look to Québec companies to bring innovation to the table for cost reduction and performance," highlighted Francesco Calcara, aerostructures sales director – Americas at Mecachrome. "We remain able to find competitive pricing within our Québec cluster. Whilst it is important for our suppliers to innovate, execution is the most important aspect."

Mecachrome is pursuing innovative manufacturing processes such as 3D printing and currently has 3D-printed parts in service on

Boeing's 787 Dreamliner. Because the buy-to-fly ration of material is substantially reduced, there is excellent opportunity for cost reduction. Mecachrome also has several 4.0 factories, with a fully automated line at its Sablé-sur-Sarthe facility, which produces blades for the Leap 1A, 1B and 1C engines. Alongside additive manufacturing, Québec's supply chain is also embracing automation and other Industry 4.0 technologies to ensure competitiveness in a globalized environment. Stelia Aerospace, for example, uses automated fiber placement technology in its manufacture of aerostructures. "A lot of traditional composite structures are done by hand whereas AFP uses a robot," explained Claude Baril, Stelia North America's managing director. "The robot uses a series of filaments that is deposited in a specific sequence and orientations onto or into a mold/mandrel. The process is often more accurate, highly repetitive and lends itself for fabrication of larger structures."

Referencing the large expense involved with the technology and challenges in terms of inspection, Baril continued: "The amount of material that can be deposited in a given number of hours is limited (although improving) which makes it difficult to form a business case for small parts. The process is better suited to large organizations that can support such an investment and for very complex parts and in the defense sector where cost is not necessarily a leading factor. Nevertheless, because a lot of these structures are being produced internally by the OEMs or Tier 1, we need to focus on smaller assemblies where there is a larger (and growing) pool of qualified suppliers. To be successful, we need strong performance with on-time and on quality deliveries (OQD & OTD) while remaining competitive."

Stelia will continue to invest in composite fabrication and assembly capabilities to increase its dominance as a Tier 1 supplier in North America to match its current standing in Europe.

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Because the Tier 4s are large billion-dollar companies, they have a lot of leverage in price negotiations and can afford to be inflexible. They are the Arconics of this world and are also moving quickly into the Tier 3 market. With OEMs enforcing cost pressure and Tier 4s not budging on price at the other end of the supply chain, the middle tiers are squeezed, forcing them to become more and more efficient.



- Sylvain Bedard,
CEO,
Sonaca Montréal

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Also focusing on automating processes to increase competitiveness is the Montréal subsidiary of Belgium-based Sonaca, a world leader in the manufacture of large aluminum wing aerostructures for commercial and business aviation. "We welcome these technologies because they are essential," said Sylvain Bedard, CEO at Sonaca Montréal. "The aerospace supply chain is now international and ours is mostly North American. Therefore, in order to compete, we need to implement automation as much as we can. Our latest investment was into Industry 4.0 machines with automation capability; they do not interact with each other yet but they have the software to do so. We are one of the first companies that entered into the Industry 4.0 program and we have a project with the government to implement it."

Sonaca will continue to channel its innovation investment into manufacturing processes as it does not have design authority on its products.

As Tier 1 companies continue to move towards cost reduction and process efficiency to surpass their competitors, pressure on their suppliers is mounting. In order to win contracts, SMEs will need to either excel in a specialized area or offer a suite of services that is integrated enough to provide value as an integrated supplier, whilst ticking all the boxes in terms of quality, on-time delivery and cost competitiveness. —

Sylvain Bedard

CEO

SONACA MONTRÉAL



Sonaca Montréal, a subsidiary of the Belgian group Sonaca, is a world leader in the manufacture of large aluminum wing aerostructures for commercial and business aviation.

Sonaca Montreal is part of Sonaca Group, following its acquisition in 2003. Where is the division positioned in the market today ?

Sonaca Montreal specializes in long bed machining of aluminum parts up to 60 feet long. Since the acquisition, Sonaca invested over US\$ 30 million in new equipment to increase its capacity with new gantries, an extrusion mill, a fully automated surface treatment line and a final assembly foot print. Within the group, Sonaca Montreal has a unique capability for large structural components. Being fully integrated is a major advantage we have over our competitors; having all of our processes under one roof also means shorter cycle times and limited transportation.

In 2015, Sonaca Montreal wanted to expand into larger aircraft. How has this plan been implemented?

We have been successful in expanding our customer base into larger aircraft by signing, recently, two contracts for the Boeing 767 and 787. Following the acquisition of new equipment, we have been successful in the stringer business through the Airbus 330 program and new programs such as the Embraer E2-175 and the Global 7000.

As a major player in Quebec's aerospace industry, what are the dynamics of the region's ecosystem?

The ecosystem is strong but we are all competing for manpower. Whilst the academic programs are fantastic, the challenge lies in attracting people into these programs, especially women. There are not enough students graduating to meet current market demand. Those that apply to school often obtain job offers before they finish their programs.

When seeking suppliers or partners, does Sonaca still view the Quebec ecosystem as competitive over other regions globally?

Sonaca Montreal's supply chain is very unique. The number of suppliers is very limited because we are very vertically integrated, taking raw materials and transforming them into finished products. There are no local players for raw materials with the required certification so we have no choice but to source elsewhere. OEMs enforcing cost pressure and Tier 4s not budging on price at the other end of the supply chain, the middle tiers are squeezed, forcing them to become more and more efficient. —

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Francesco Calcara

Aerostructures Sales

Director-Americas

MECACHROME



Mecachrome Canada designs and produces complex assemblies made of critical structural parts.

What is the extent of Mecachrome's presence and capabilities in Canada today?

Mecachrome Canada was established in 2004 and currently has 170 employees. Through strong partnerships with local suppliers, we have become a Tier 1 supplier to the majority of OEMs on this side of the world. However, we would like to expand our reach to all OEMs. In our Mirabel Quebec Facility, we deal primarily with aerostructures.

The group has over 400 machines and 500 spindles, of which Mecachrome Canada accounts for about 10%. We recently added a second 5-spindle gantry, which is almost one-of-a-kind in the industry. Our key business is the assembly of complex structures and complex machining for hard and soft metals. We also offer design and build solutions and a lot of engineering services to our customers.

In 2015, automation had yet to play a dominant role in the machining of large parts at Mecachrome. How has the company moved in this direction?

We now have several 4.0 factories within the Mecachrome group. In addition, a lot of our experience from the automotive industry has transversed to the aerospace sector, which has also helped us a lot. Mecachrome Canada has recently added a full-time digital innovation manager to reach our goal of being completely paperless by 2018.

What are some other areas of R&D focus?

We will be the world's first serial production cryogenic machining site in our Portugal facility. We will be delivering our first serial production parts for aero engines to Safran later this year. We have several patents for cryogenic machining, which substantially reduces the cost of titanium machining. Material nesting is another big focus area. —



Jacques Comtois

Vice President and General Manager
L-3 COMMUNICATIONS MAS

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L-3 Communications MAS (L-3) is a leading in-service support (ISS) integrator.

L-3 MAS was created through L-3 Communications' acquisition of Bombardier Defense Services in 2003 and has diversified over the years. Where is L-3 MAS positioned in the market today?

We maintain a leading edge over our competitors by having one of the largest engineering departments in Canada outside of the OEMs, with approximately 150 engineers and technicians. We offer a full range of services from basic MR&O to fleet management, prototyping missionization and integrated environment. Over the years we have also achieved a number of certifications and obtained airworthiness delegations that allows us to provide further guidance beyond the OEM-recommended maintenance activities. About 30% of our current revenues come from exports and we are actively looking to increase this percentage, focusing mainly on the United States and European markets.

Could you elaborate on L3 MAS' capabilities and service offering in Québec?

We are mostly focused on providing ISS services which now include the provision of integrated environments, a requirement we have identified as a result of working closely with our customers. An integrated environment allows for huge efficiencies in fleet maintenance activities. For example, we are currently developing databases and software tools that allows for the most efficient use of aircraft maintenance data.

A big focus for Québec's aerospace industry is the transition to Industry 4.0, which includes health monitoring and predictive maintenance for aircraft. Are these focus areas for L-3 MAS?

We are focusing our research and development investments in tools or systems that can significantly achieve efficiencies and reduce in-service support costs to our customers. Health monitoring, robotics and augmented reality are three examples of where we distinguish ourselves.

Over the years, we have facilitated our technician's work by digitalizing the work

instructions. Publications are no longer required as a technician can now have all the required information on a tablet. Last year, we pushed that notion further by deploying the "technician companion". Through the use of augmented reality, technicians have now their hands free at all times and can carry their tasks while seeing the works instructions in front of their eyes with virtual reality goggles. By integrating other technologies, they can also see the systems they are working on in operation thereby facilitating troubleshooting. They can also order parts by simply pointing, call for engineering support and complete many other tasks hands-free, without having to leave their work location on the aircraft.

How do you expect new technologies to affect the shape of the workforce in Québec?

We are currently in a phase where a large number of organizations in our industry are hiring and it is therefore harder to find the right talent. If one looks on the different job websites, they will see that there are currently approximately 1000 positions advertised. Recent graduates are now also very accustomed to using intelligent devices to complete tasks and to communicate. They therefore expect to use the same type of devices in their job and it is necessary for our industry to accommodate these expectations in order to attract and retain them.

Going forward, what are the key objectives for this division of L-3?

We are very active in identifying new ISS opportunities in Canada and elsewhere in the World. Canada will soon renew its fighter fleet and has identified in the latest Defense Policy Review many other potential acquisitions such as a manned intelligence, surveillance and reconnaissance (ISR) platforms. Another objective is to see how we can apply our current ISS expertise outside our traditional aerospace market. There are no reasons why naval and land operators of 'fleets' could not achieve the same benefits that our air operators customers are realizing today by making use of our services. —

Claude Baril

Managing Director
**STELIA AEROSPACE
NORTH AMERICA**



Created in 2015 through the merger of two Airbus subsidiaries, STelia Aerospace offers global solutions for aeronautical manufacturers and airline companies and is a leader in the areas of aerostructures, pilot seats and Business and First Class passenger seats.

STELIA Aerospace was created in 2015 through the merger of Aerolia and Sogerma. What direction has the company taken since the merger and where do the Mirabel operations fit in the context of the wider group?

Before the merger, the Aerolia and Sogerma facilities catered to two different applications and, since the merger in 2015, they continue to have two distinct operations under STelia Aerospace North America in Mirabel. The airport facility is focused on the design, development and fabrication of Global 7000 and 8000 fuselages for Bombardier, whereas the composites manufacturing facility focuses on composite structure fabrication. With revenue of €2.4 billion and more than 6,600 employees worldwide, STelia Aerospace supports major aeronautical companies such as Airbus, ATR, Boeing, Bombardier, Dassault, Etihad Airways, Singapore Airlines and Thai Airways.

Are there any areas of R&D focus for aeronautics, particularly on the composite side?

The main aim is to reduce the cost and improve the flexibility of fabrication. We purposely built the composites manufacturing facility in Mirabel in 2008 to develop large composite structures with Bombardier, Bell Helicopter and the National Research Council (NRC) using Automated Fiber Placement technology (AFP). The NRC provided a fiber replacement machine and we worked with Bombardier and Bell Helicopter to develop complex composite structures.

STelia Aerospace has also developed in France a unique technology called 3D milling, which is a replacement to the old chemical milling fabrication process.

Could you elaborate on some of the specifics of fiber replacement and its advantages?

A lot of traditional composite structures are done by hand whereas AFP uses a robot. The robot uses a series of filaments that are deposited in a specific sequence and orientations onto or into a mold/mandrel. The process is often more accurate, highly repetitive and lends itself for fabrication of larger structures.

What are the key objectives for STelia Aerospace in the North America region?

We are looking at increasing composite fabrication and assembly capabilities. Our vision is to diversify our customer base and we will use our well-established position as a platform to expand our activities within North America. Within a few years, our objective is for STelia Aerospace to be recognized as a dominant Tier 1 supplier in North America, as we are today in Europe. —

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Stephen Kearns

President & CEO
**AVIOR
(PRODUITS INTÉGRÉS)**



Avior is a full-service manufacturer of lightweight structures and complex mechanical assemblies.

Can you give us an update on where the company currently positions itself in the market?

The company's base elements were established in 2012 through 2015. In the last several years, the company has become more focused towards penetrating new markets, and our primary focus has been south of the border to the United States.

One of the biggest obstacles in penetrating a market is having the necessary special process approvals to manufacture certain types of components or structures. We recently won a couple of new con-

tracts with Boeing that required new composites-related approvals for products on the 787 and 737 Max. Attaining these approvals is a big step for Avior as they allow us to penetrate a substantial barrier. Our participation in a high-visibility program in Seattle is strategically significant as a Tier III Québec company. These contracts elevate us in the market for the types of structures we are positioning ourselves to specialize in: lightweight integrated structures that incorporate metal fabrication, plus an advanced composite capability at our Granby business unit.

Is Avior pursuing any areas of R&D investment?

We have started to invest along two fronts. The first is using 3D-printing technology for tools in composites and sheet metal fabrication. The second area is robotics; we are now starting the process of introducing robotics into our processes, especially the more labor-intensive ones, and we are conducting a pilot project this year.

What are the main objectives and growth plans for Avior in the near future?

One is to improve our competitiveness by streamlining our processes and eliminate as much waste as we can, for which we have developed an ambitious plan to reduce production cycle time on our shop by a significant percentage year on year. Secondly, we are trying to become more paperless and challenge the cycle time in our administration as much as we challenge the shop. —

Aircraft building blocks: components and sub-assembly

At the foundation of the value chain, SMEs that have managed to survive and see success are those which are specialized in a niche area or that have developed proprietary technologies. Even so, the great degree of consolidation and increasing vertical integration in this segment of the supply chain makes the space extremely competitive.

As OEMs continue to strive to reduce weight as a means of cost reduction, material selection is key. “Generally, OEMs are looking for materials that have high strength, low weight, resistance to extreme temperature conditions and corrosion resistance, typically selecting the lowest-cost material that meets the criteria,” commented Peter Piotrowski, business development manager at Titanium Industries, a Québec-based SME manufacturing and distributing titanium and nickel mill products for various industries, including aerospace. “Because they often want a very specific mix of these qualities, they look for specialty materials such as ours... In terms of material usage, the advent of composites has been very beneficial to titanium demand as composites do not generally have high structural intensity and therefore need reinforcement with materials like titanium. There is also a drive to reduce the cost of engine materials, which has meant titanium-aluminides are to some extent replacing titanium and nickel alloys.”

Titanium is favorable for its strength-to-weight ratio, while stainless steel and steel alloys are also in high demand due to their strength. Titanium Industries stocks these materials as well, also selling a lot of nickel for engine production, which is used because of its extreme strength in very high temperatures and resistance to corrosion.

The company recently purchased a water-jet cutting company in New Jersey, supplementing its capabilities in Montréal and the United States with a value-added solution. “Our in-house expertise means we can offer titanium with varied tolerances and cut a profile which is in many cases ready for use,” said Richard

Brosseau, Titanium Industries’ general manager.

“Our goal is to provide as near a net-shape as possible to the customer so that no material is wasted,” added Piotrowski. “Waterjet cutting makes this possible as it allows for the nesting of complicated parts into a plate.”

Additive manufacturing

Additive manufacturing resonates with manufacturing priorities to produce components faster and most cost effectively. While not a new technology per se, its uptake is certainly increasing and development of the technology is a great area of focus for many companies. “Additive manufacturing has been used by the investment casting industry, including Vestshell, in rapid prototyping for 20 years,” highlighted Joseph Laflamme, president at Vestshell, which specializes in investment casting of ferrous alloys and stainless steels for the aerospace, medical and military industries. “This saves us the four to six weeks it would take to make a mold. Now, the debate is centered on 3D-printed metal parts. We are looking into how we can use this technology to complement our offering. Vestshell is a participant in a metallurgical research consortium with companies such as Héroux-Devtek to examine the potential for 3D-printed alloys. However, at present, the speed at which 3D machines can produce components is slower than what we can achieve with traditional manufacturing methods. The surface finishes are also not as smooth as casted components. Nevertheless, the potential of the technology is impressive and we want to be part of this innovation.”

By continuing to implement new technology and processes, Vestshell plans to capture more growth in the United States and Europe and add more value to its services by adding capabilities such as machining and light assembly. CRIQ is also focused on the development of additive manufacturing and has a large 3D-

printing lab, which it uses to help companies adopt this technology and optimize their manufacturing processes. The organization plans to add a machine dedicated to titanium printing and is pursuing activities with the Québec 3D-printing network and has made an alliance with Canada Makes to synergize the teams. In May 2016, CRIQ launched Fab3D, its new additive manufacturing training program for the industry.

Other companies have found success through proprietary processes. Alphacasting, a SME catering to the high-end part area of the foundry business, has developed a proprietary Cool Cast process, for example. “The process is rapid solidification; the same process used to make jewelry,” outlined Steve Kennerknecht, Alphacasting’s vice president of engineering and the developer of the process. “Normally, stainless steel, titanium or aluminum is poured into a pre-heated mold so the metal flows into the cavities. The problem is the metal cools very slowly because everything is hot, which results in large grain size with low mechanical properties. We needed a process to cool the metal quickly. Our proprietary technology cools the mold very quickly, which cools the casting and gives us great mechanical properties.”

Yielding 35% higher strength while using the same parts, the process foregoes the need to redesign the mold whilst offering greater strength, resulting in greater security and better margins. Kennerknecht added: “We seek to offer complex high-value-added parts that cannot be machined out of solid or composite material. Customers want high-strength aluminum which we can provide through our Cool Cast process. Composites and titanium are now more prevalent and customers are increasingly seeking stainless steel with high heat resistance for fire suppression around the engine, for example.”

Rather than specializing in one specific metal, Alphacasting casts all alloys under the same roof. Beyond focusing on the Americas and Europe, the company also plans to enter countries with booming aerospace industries that lack foundries with iron-casting capabilities, such as Romania and Russia.

Building reputation

In order to be considered competitive, many SMEs consider the pursuit of innovative manufacturing processes essential to measure up to global competitors. In reference to the competitiveness of lower-cost countries, Ken-

nerknecht projected: “They will probably be where we are today in about 15 years. That is why we need to continue to push on. Because companies like Bombardier and Safran have such high volumes, they need multiple suppliers and will therefore encourage Asia to build up that capability. Taiwan and China are likely to be capable suppliers in the future.”

In response, companies are seeking to automate processes and increase cost efficiency. For example, AMEC Usinage, an SME adjacent to Québec City specializing in high-precision machining for small and mid-sized aircraft parts, is adopting more Industry 4.0 processes and has taken steps to automate its machining processes. “The OEMs have been moving production to countries such as Mexico, Morocco and India and are subsequently using more local suppliers at these locations,” commented Geneviève Paré, business development director at AMEC Usinage. “We therefore experience competition from these countries but we maintain the advantage of being closer to our clients in North America.”

AMEC has recently bought a new 5-axis machine with 320 tools that can perform 32 jobs simultaneously in addition to its 20 CNC machines, CMM machines and optical comparators and is simultaneously producing 15 parts for the cockpits of the C-Series with a consistent lead time. The company will also update its ERP system to automatically communicate the latest information in the execution of orders to its clients. Through managing sub-contractors, AMEC now provides turnkey solutions to clients, including painting, anodization, zinking and electro polishing and was recognized by Aéro Montréal as ‘Company of the Year’ for the MACH initiative and has reached MACH 3. Whilst the 54-employee company is yet to export its services, an acquisition in the United States may be on the horizon.

Another company turning to innovative processes to drive success is APN, a SME specializing in processes for complex high-precision machining for materials of very high hardness, which is recognized as a forerunner in Industry 4.0 technologies, having begun to develop systems before the trend started to grow in Canada. “Data is the key and essence of everything in manufacturing,” emphasized Yves Proteau, co-president at APN. “Our realization of this and the subsequent steps we have taken has made APN number one in implementing Industry 4.0 technologies in Québec. In reflection of our belief in these processes, we have invested C\$2.5 million into our systems in the past five years. APN has five full-time computer programmers,

mathematicians and two team members with Master's degrees in automation.”

As upfront investment into these technologies can often be a challenge for small companies, SMEs such as APN are able to take advantage of funding offered by government organizations and other bodies that support the industry. Indeed, APN received financial aid through Investissement Québec and the Ministry of Economy, Science and Innovation in 2017, fueling the company's growth. The company is in discussions to make an acquisition in the foreseeable future and prides itself on zero non-conformities or late deliveries to its primary customer, Pratt & Whitney Canada, in the last three years.

Scaling up

As well as increasing process efficiency to be more competitive, SMEs are also under pressure to diversify their service offering and become more of a “one-stop-shop”, causing companies to vertically integrate their services wherever possible. Many companies are therefore adding finishing capabilities into their portfolios.

Companies such as Tekalia Aeronautik and TNM Anodizing and Paint have been expanding their capabilities in surface treatments along these lines, with automation also being an area of focus. Because these processes can be very human-resource intensive when done by hand, the uptake of robotics is increasing, particularly in painting. “Another reason for turning to robotics is the demand for better transfer efficiency as manual spraying leads to wasted paint due to overspray,” noted Frederic Charnoz, global strategic account manager, automotive and aerospace at Sames Kremlin, which designs and manufactures process equipment for sealing and bonding, protection, anti-corrosion and embellishment with multiple colors for various industries, including aerospace. “A related trend is an increasing demand for a better-quality finish on aircraft.” Sames Kremlin aims to provide robotized solutions for painting and possibly sealing of aircraft and views Québec as an important part of its strategy to grow its aerospace market share. Québec's vast network of SMEs makes for a competitive ecosystem, encompassing a broad range of capabilities, many of which are highly specialized and therefore in high demand by their customers. Nevertheless, it will likely be innovation on the process side that will determine success in the longer term. —



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Jeremy Halford

President

ARCONIC TITANIUM AND ENGINEERED PRODUCTS

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Arconic is a global technology, engineering and advanced manufacturing leader.

Arconic has a presence in 25 countries. Where does aerospace fit into Arconic's Québec operations?

Aerospace is Arconic's largest end-market, representing 43% of its total revenues in 2016. Our Québec operations include two facilities in Laval: a casting plant which focuses on aluminum investment casting for aero structures and aero engines, and a machining facility (the former RTI Claro), which focuses on the machining of structural components for large commercial aircraft. These two facilities are part of Arconic's Engineered Products and Solutions (EP&S) segment, which develops and manufactures high performance, engineered products and solutions for aerospace and other markets. We work with all the major manufacturers of airframes globally, such as Bombardier, Boeing and Airbus, and all the large engine manufacturers.

Since 2015, the EP&S segment has signed more than US\$11 billion in new contracts with aerospace companies. What makes Arconic the favored choice?

Arconic is a leader in customer focused innovation and our vertical integration presents a major advantage to customers. When we innovate, we do so because our customers are asking for it and we help them solve a challenge. We are a leader in advanced manufacturing processes, such as additive manufacturing, for which we already have three agreements with Airbus, and new material development. For example, we have developed a new titanium alloy called THOR which performs well in high temperatures and can be used in certain instances as a lighter weight alternative to nickel-based alloys. We have also developed numerous advanced forging technologies, such as our proprietary Ampliforge™ process, a hybrid additive and traditional manufacturing process, allowing us to forge products closer to their net shape, thereby using less metal and reducing costs for our customers. Arconic is innovating to develop unique capabilities that make us a valuable partner and ensure we continue to lead the market.

In terms of our integrated services, our customers choose us because we offer a range of solutions, including casting, machining and other services for the same part, often offering an end-to-end solution. In addition, we partner with our customers to propose advanced materials and manufacturing processes. Furthermore, drawing on our deep engineering expertise, we can offer minor design variations which can have a very meaningful impact on cost. Overall, we offer a complete solution.

How will demand for composites and titanium in aircraft develop going forward?

Titanium is the fastest growing metal used in aerospace. Demand for titanium is related, in part, to demand for carbon fiber due to the materials' compatible properties. We are seeing a long-term trend towards the increasing adoption of carbon fiber reinforced polymer (CFRP), which means demand will continue to grow for these two

materials. In addition, titanium will continue to be popular due to its high strength-to-weight ratio. It is also more resistant to high temperature conditions, such as in engines, than other light-weight metals. Arconic is well-positioned to capture growth in titanium through our acquisition of the former RTI International Metals.

Could you elaborate on Arconic's additive manufacturing capabilities?

Arconic has global additive manufacturing capabilities in direct, prototyping and hybrid technologies. We also recently made an investment in technologies to develop metal powders optimized for 3D printing of aerospace parts. Additive manufacturing technologies give us another tool in our portfolio to manufacture parts that perform better, with less material input and shorter lead times. There is growing demand for these products, and Arconic is leading the way. We have signed agreements to supply 3D printed metal parts for Airbus commercial aircraft and to Lockheed Martin for service on the Orion spacecraft.

What effect is the increasing use of automation among OEMs having on how Arconic conducts business with its customers?

Automated systems work best with the least amount of variability in input parts. That means manufacturers need to secure the best produced parts. As our customers automate more, this will result in higher demand for our products due to our unique manufacturing capabilities which enable us to meet these requirements.

What are your key goals for the next three to five years?

We are absolutely focused on growing our market share, which we will do by leading the market in innovation. Our customers are competing fiercely with each other to build the next generation of more efficient aircraft and aero engines, and our goal is to be their partner of choice in reaching this target. Arconic is uniquely placed to help them due to our complete service offerings and our investments in advanced manufacturing technologies. —



Michel Martel

General Manager

TNM ANODIZING & PAINT

TNM Anodizing & Paint is a one-stop shop for surface finishing from nondestructive testing (NTD) to paint for small, medium and large parts.

2016 marked TNM's 20th anniversary. Where does TNM position itself in the aerospace market today following implementation of its five year plan?

The overarching goal of TNM's last five-year plan, implemented from 2013, was to place the company within the elite of the finishing industry by reaching high standards in on-time delivery (OTD), quality and service to customers. Having reached this goal, TNM is now embarking on a major expansion previously put on hold due to uncertainty in the industry.

TNM works with Tier 1 and Tier 2 integrators that receive huge orders from OEMs. We have a 98% OTD rate and our parts per million (PPM) has gone down as volumes have gone up; in other words, quality has improved even as orders have increased.

TNM currently achieves fewer than 5,000 PPMs, which is half of what the industry recommends for excellence. Due to our success in achieving our standards, we even receive orders from companies that offer finishing services themselves, either OP's or manufacturer's wishing to offload work to our company when their capacity or production lines have issues.

How has the company balanced quality and OTD as volumes have increased?

Our quality department has expanded and we have implemented new processes to drive PPMs down.

How is TNM able to successfully manage price pressures from OEMs that are passed down the supply chain?

OEMs have asked the industry for additional discounts on those already given ten years ago; the pressure is therefore immense. TNM's five-year plan included a risk assessment to make sure we are set up to respond to changing OEM demands such as these. We have adjusted by further integrating our supply chain and TNM are now increasingly working with groups of integrators that receive large orders. These integrators and their supply chain offload work to other companies and TNM helps them manage that process. By working together and being leaner we are able to show beneficial savings for all involved.

Could you elaborate on TNM's collaboration and relationship with different players along the supply chain?

TNM has high-level conversations with OEMs and major integrators/ customers supplying the OEMs. TNM also collaborates with paint suppliers to ensure we know about new developments, such as thinner paints to meet the demand for reduced weight from OEMs. The key development driver is finding solutions to improve efficiency. Companies now accept they have to collaborate both up and down the supply chain.

How is TNM adapting to Industry 4.0?

Our customers and partners now demand more sophisticated communications

through information technology (IT). TNM is part of an Industry 4.0 program run by CEFRIO. TNM wants to be on par with the leaders in the industry for new IT processes.

All process shops in the future will be more automated and we have plans in the pipeline to automate some of our processes here at TNM. Areas such as NDT will not be heavily automated because the impact of mechanical failure would represent too big a risk. Unlike in the automotive industry, for example, finishing shops in aerospace have many different part numbers and comparatively low volume. It therefore makes less sense to automate all processes in this industry than in others. Eventually, TNM will employ a hybrid model between automation and manual processes at TNM 1. In the near future at our TNM 2 facility, a more advanced IT and automation systems will be employed, which will deal in higher volumes.

How do you see the industry developing in the next few years?

Looking at the build rates of OEMs and existing capacity, the period between 2018 to 2020 will be critical in terms of increased demand and further supply chain integration. However, the orders will be funneled to the stronger companies. If a company has not changed its processes to become more efficient, it may already be too late. Many major players have been in acquisition mode for some time in both manufacturing and finishing facilities, and this will continue. OEMs have succeeded in downsizing their supply chain and this is now having a huge impact on the make-up of the industry.

Where do you see TNM in the next three to five years?

I see TNM in the near future being acquired for strategic reasons by an important player in the industry and this should prove to be very beneficial to both parties. —

Dany Dumont & Erick van de Water

DD: General Manager

EVDW: Business Development Manager

TEKALIA AERONAUTIK



EVDW

Fonds de solidarité FTQ is a development capital fund with a mission to contribute to Québec's economic growth by creating, maintaining or protecting jobs through investment in SMEs in all spheres of activity.

It has been almost two years since GBR last spoke with Tekalia Aeronautik. What new developments have there been at Tekalia since then?

EvdW: Tekalia has been implementing its vision to expand, both organically through new surface treatment offerings and through the industry by gaining new approvals from different OEMs. Our main goal is to build on our one-stop-shop capabilities and offer greater added value to our clients by furthering our vertical integration.

Tekalia is currently working on the addition of processing titanium parts and zinc-nickel coating to its service portfolio. What is the significance of this trend in the industry?

DD: This is definitely an emerging trend and part of our core strategy. Part of our capital expenditure budget this year is devoted to putting zinc-nickel plating capabilities in place and we have had many conversations on this topic with our main customers such as Safran. This stems from Tekalia's quest to strengthen its position as a one-stop-shop.

Tekalia prides itself in being a quick response manufacturer, which requires a great deal of flexibility. How does Tekalia ensure on-time delivery?

DD: We want to become one of the first surface treatment companies in North America to be fully automated. We already automate

some of our processes – it is unlikely another plating company on the Continent employs automation to such an extent as Tekalia. It is in our DNA. Soon customers will have visibility into our workshop through live KPIs fed into a client portal. We also want to use Industry 4.0 processes to help our employees achieve better results with greater efficiency.

EvdW: Alongside this, the agility of our employees is very important. Tekalia has a very detailed training program for our employees that enables us to better adapt to the fluctuation of incoming orders and better adjust to the workloads throughout our many processes.

In 2015 and 2016, Tekalia experienced strong growth in orders from OEMs. Is Tekalia still seeing healthy demand trends?

EvdW: Overall growth is strong. Demand for certain wide body platforms is slowing a little, although the long-range forecasts highlight sustainable growth, albeit subdued past 2020, given the expected increase in air travel.

DD: Tekalia expects 30% growth in demand over the next three years. Our capabilities in complex parts and special processing are very strong and there are more customers in the area that would benefit from our services. As well as Boeing and Airbus, Tekalia is already working with Embraer and we also hope to work with Bombardier, Airbus and Pratt & Whitney soon.

Québec has a thriving network of around 200 SMEs. What factors do you attribute to their strong performance?

DD: Québec's five major OEMs have created a baseline for everyone. The region also has a very good educational infrastructure to sup-

port the industry. The aerospace ecosystem is very tight-knit; everyone knows each other and tries to help each other.

Québec's government has invested large sums into the aerospace industry. What more could the federal or regional government do to help companies like Tekalia?

DD: The focus should be to help companies like ours put in place Industry 4.0 measures, which is really the future for the aerospace industry. The need is not so much financial, but a need for the knowledge infrastructure to be created so that companies can understand how best to implement automation and other new techniques into their processes.

What are the main challenges and barriers to success for SMEs like Tekalia in Québec?

DD: There are too many tiers in the supply chain. We want Tekalia to be a higher level integrator to support the tier 1 integrators like Heroux-Devtek or Alta Precision by removing sub-levels in the supply chain. SMEs will need to consolidate so they can win the bigger contracts. We also see a lot of partnerships between SMEs forming in order to increase integration in the supply chain.

What are Tekalia's strategic goals for the next few years?

DD: Our focus will be to win new specifications, expand our product offering and continue to add value to our client's products. Over the next three years we aim to be recognized as one of the most efficient plating companies in North America. We also want to focus more on marketing and business development in order to expand our business with new clients and contracts. —

Actuation and Landing Gear

An integral component of any aircraft, responsible for its suspension and control, is its landing gear and associated actuation system. Québec is home to a number of companies driving innovation in this field, including internationally-recognized Héroux-Devtek and Mecaer America, the Canadian subsidiary of Italian Mecaer Aviation Group.

Héroux-Devtek, which has a 75-year history in the region, has been a prominent player in Québec's ecosystem for some time, already reaching a significant milestone with the manufacture of the Apollo Lunar Module landing gear in 1969. More recently, the landing gear expert secured a contract for the Boeing 777 for which, since 2013, it has invested over \$110 million in equipment and capacity. Having se-

cured its first shipment in July 2016, five weeks ahead of schedule, the company is now in ramp-up mode. Going against the grain of the diversification trends that currently characterize the industry, Héroux-Devtek actually sold its industrial and aerostructure divisions in 2012 to focus on landing gears and with highly positive results: the business has grown from C\$250 million to C\$400 million and is targeting half a billion by 2021. The company nevertheless plans to further its capabilities in fields such as actuation systems and flight control through acquisitions.

The other notable international player is Mecaer America, which supplies the likes of Airbus, AgustaWestland, Bell Helicopter and United Technologies Corporation, which in fact accounts for 70% of the companies build-to-print business. Whilst not a national company, Mecaer America is a significant contributor to the region, announcing a C\$40.4 million investment into its Laval facility in July 2016.

As in other segments of the industry, the major players are supported by a network of part suppliers, several of which are highly competitive not just in Québec but

worldwide. A prime example would be Alta Precision, a world leader in build-to-print landing gear assemblies and sub-assemblies, which also exports over 90% of its production. The company doubled the size of its Montréal premises after securing a long-term contract in 2014 to produce major landing gear components for Embraer's E2 program. The capacity increase included the purchase of high-technology equipment, making the company more efficient in its processes. "At one point, Alta Precision considered expanding its operations to Mexico and the United States rather than increasing its Québec presence," commented Guillermo Alonso, president at Alta Precision. "However, as we increasingly rely on automation, the low-cost labor environment of Mexico is less attractive. With regard to the United States, we were not big enough to make a greenfield investment and did not find any suitable acquisition targets."

Alta Precision continues to pursue its vision of becoming an integrator through vertical integration and expects to double its sales in the next three to four years based on recently-signed contracts.



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Aside from process innovation and increased efficiency, one of the most notable trends on the product side is the shift from pneumatic and hydraulic systems towards electro-mechanical actuation, favored mostly due to its weight advantage. Exonetik, an SME based in Québec City, is driving innovation in this area, developing actuators with high bandwidth without compromising on cost and weight. “Actuators that interface with humans work best when they can deliver above 20Hz of bandwidth and provide strong force with high precision, which ours can do while many others cannot,” explained CEO Pascal Larose. “Direct-drive motors, a common form of actuator, are easy to control but heavy and large, making them impractical for aircraft use. Therefore, aerospace companies usually compromise on force quality to achieve a reduction in weight, which is where our technology shines because it is both low in weight and produces a high-quality force.”

Highlighting a preference for Exonetik’s technology due to there being no mechanical contact between inputs and outputs but instead a fluidic contact creating force by triggering a magnetic field in the fluid that varies its viscosity, Larose continued: “This makes it is easy to build redundancy, making it possible to rely on one system if another is failing in the same unit, with the knowledge that the first will not cause any blockage to the unit as a whole.”

Exonetik is currently working with partners in the United States, Canada and Europe, including Bell Helicopter Textron through

CARIC. Because its aerospace technology is currently at technology readiness level (TRL) 5, the company is currently mostly focused on delivering prototypes. Exonetik has also developed a haptic side stick with a handling quality rating (HQR) of one and is currently developing a haptic seat with the intent to cancel vibration, making it more comfortable for pilots.

Additive manufacturing is also an area of interest for companies but not yet developed enough for widespread use. However, its potential advantages are widely acknowledged. “Additive manufacturing in particular is a very interesting technology for our product,” commented Gilles Labbé, president and CEO at Héroux-Devtek. “In the forging of products, a very long lead time is required for building and obtaining parts from the supplier, plus the subsequent machining can result in wasting 80% of the material. Additive manufacturing reduces the long lead time and can reduce the material cost and waste by large amounts. It is now proven, with GE as a good example, that the additive manufacturing process can design lighter and more reliable components at a lesser cost. Additive manufacturing will become more and more present in our industry and will be a game changer.” Particularly due to the presence of two of the five landing gear integrators worldwide, Québec continues to play a prominent role in this field, catalyzed by proficiencies within the ecosystem in technologies such as additive manufacturing and automation. With increasing focus on these technologies, Québec’s landing gear suppliers

will likely stay ahead of the curve when it comes to innovation in this space. —

“

The increasing use of hydraulic servo control of flight surfaces in helicopters is reducing the pilot's ability to understand what is happening on the helicopter. When problems occur, pilots only receive feedback in the form of beeps and visual warnings, which can be difficult to understand in a quick time-frame and can potentially lead to helicopter failure. We are working on adding haptic feedback to helicopter controls to give pilots an understanding of the helicopter's condition through transmission of real-time tactile signals to their hands and fingers. The technology also provides the pilot with better knowledge of recommended rotorcraft limits, something which is not available on regular rotorcraft. As a result, there will be less need for maintenance on helicopters as fewer pilots will unknowingly exceed rotorcraft limits.

- Pascale Larose,
CEO,
Exonetik

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Guillermo Alonso

President
ALTA PRECISION



Alta Precision is a world leader in supplying build-to-print landing gear assemblies and sub-assemblies for the military and commercial aerospace markets.

Could you provide an update on the expansion of Alta Precision's Montréal facility and any other major developments since we met in 2015?

In 2014, Alta Precision was awarded a long term contract to produce the major components for the landing gear of Embraer's E2 program, the second-generation of this jet series. This project necessitated the doubling in size of our Montréal premises and the purchasing of high-technology equipment allowing more modern fabrication methods. Alta Precision has now delivered the first parts to Embraer and, following a successful first flight, the certification campaign is also going very well. We are now working on the ramp up of production.

At one point, Alta Precision considered expanding its operations to Mexico and the United States rather than increasing its Québec presence. However, as we increasingly rely on automation, the low-cost labor environment of Mexico is less attractive. With regard to the United States, we were not big enough to make a greenfield investment and did not find any suitable acquisition targets.

How important are new processes such as automation and Industry 4.0 to ensure SMEs remain competitive?

If SMEs do not implement these technologies, they will not survive—labor in Québec is too expensive. Automation reflects a broader shift in the workforce due to technological advancements which are unstoppable. Previously, around 80% of

employees worked on the production line and 20% worked in office based jobs; now this ratio is being reversed. Machinists on the shop floor will transition to become support for the software engineers working on computer numerical control (CNC) programming. Alta Precision has a C\$3.5 million transformation program to transition to more automated processes in order to remain competitive. We now receive detailed feedback on our machines' performance and they are equipped with laser probes, physical probes and tool life management features. For some SMEs, this level of investment is unfortunately prohibitive, meaning they will find it hard to remain competitive.

Alta Precision has a stake in Tekalia Aeronautik. How important are partnerships such as this one to ensure suppliers remain competitive?

Vertical integration is critical as OEMs are demanding to work with bigger, more integrated suppliers. SMEs in Québec typically have annual revenue figures between C\$5 million and C\$10 million, whilst OEMs are demanding to work with C\$100-million to C\$200-million businesses. Over the years, consortiums have been attempted but this model actually causes concern among OEMs over ultimate accountability for the project and liability for any problems. Instead, OEMs want one owner of the different integrated services. Mergers and acquisitions should therefore be a bigger priority within the industry.

How supportive is the government of the industry?

The investments required for new equipment are very high and OEMs are asking

suppliers to absorb more of the non-recurring costs of production such as software, workforce required and certification. Commercial banks do not typically finance these soft costs, so government support is critical, especially from organizations such as the Business Development Bank of Canada (BDC) which creates tailored programs to finance costs such as these. Initiatives such as MACH FAB 4.0 are also crucial to help companies transition to new processes.

Alta Precision exports more than 90% of its production. What do you attribute to the company's success in exporting?

Alta Precision's decision to focus on landing gears forced the company to win clients internationally as there are only five landing gear Tier 1s worldwide and of those, only one, Héroux-Devtek, is located in Québec. We invested a lot into international business development activities, building on the networks we made at the Farnborough, Paris and Singapore airshows.

What are Alta Precision's key goals for the next three to five years?

Alta Precision will double its sales in the next three to four years based on contracts it has recently signed. We will also continue with our vision of vertical integration, potentially through a merger, so that we can become an integrator. Through business development, resourcing programs or possibly an acquisition, we will gain extra volume from OEMs. The outlook for the industry is strong—passenger and cargo volume is on the rise. We are in a winning industry; we just need to capitalize on its strength. —



Chris O'Neill

President & COO
MECAER AMERICA INC.

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Mecaer America Inc. specializes in the design, manufacturing and qualification of integrated landing gear systems.

What is the relationship between Mecaer America and its parent company Mecaer Aviation Group?

Mecaer America is a Canadian company and a wholly owned subsidiary of Mecaer Aviation Group. In Canada, our operations are self-sufficient in terms of the development, design, manufacturing and testing of landing gear systems. Mecaer America is the world's smallest landing gear design integrator which allows us immense flexibility compared to our much larger competitors.

Could you expand on the company's service offering?

Mecaer America offers plug-and-play design and manufacturing. We are a build-to-print integrator as well as a design integrator for sub-assemblies and entire systems, working mostly with large clients such as Airbus, AgustaWestland, Bell Helicopter and United Technologies Corporation (UTC). Our business is split 70% for build-to-print for UTC and 20% to 40% for design programs split equally between Europe and North America.

In July 2016, Mecaer America announced a C\$40.4 million investment into its Laval facility. What are the plans for the facility's development?

The investment will help Mecaer America to support new product development programs where the upfront costs for design and certification are onerous; landing gear programs cost upward of C\$10 to 20 million to certify. We will also be investing C\$12 million to C\$15 million over the next 10 years in new machinery and a large drop tower to be able to test our products.

How supportive are the regional and national governments of the aerospace industry?

The Québec and federal government are very supportive and are in fact contributing to the investment in our Laval facility. In order to compete with emerging economies, it is essential that governments offer support to aerospace companies to level the playing field. However, the industry also needs to stand on its own two feet.

Are there any notable areas of development and innovation on which Mecaer is currently focusing?

A big focus is electro-mechanical actuation and steering control, which contributes to weight reduction. It is a first-generation technology which is still finding its feet but is here to stay. Additive manufacturing is beginning to make an impact on aerospace production but is in its infancy and is not yet a great area of focus for us.

What effect will the consolidation supply chains have on Québec's aerospace industry?

The demands of OEMs are becoming more sophisticated every year. This makes it harder for smaller suppliers to compete, which will cause further consolidation. In addition, there is less work as consolidation takes root. Given our position as an order placer and Tier 1 supplier, this affects Mecaer America less than smaller companies. Every momentous change in business allows for both opportunity and concern. We will find a way to exploit this opportunity but the impact on smaller companies producing manufactured parts will be more pronounced. They will either need to integrate or will be forced to drop out of the market.

What are your views on smaller companies forming consortiums?

In theory, it is a great idea. However, the aerospace industry in Québec has developed solely in a private market, meaning that there is a strong sense of entrepreneurialism which can impede consortiums forming. Companies in the US are beginning to band together and this should happen more in Québec.

Where should the industry focus its progress to remain competitive?

The industry should focus on investment in the bricks and mortar and heavy equipment. We need to turn the page on supporting the big OEMs. While assembly, fixtures and computers for engineers are easy to move abroad, it is not as simple to move heavy equipment. The government should also heavily invest in Industry 4.0 but in a practical way that enables the entrepreneur to take advantage of their support.

What is Mecaer America's vision for the next three to five years?

Mecaer America is focusing on diversifying its client base. We have created a strategy document using the MACH initiative to help us with this. We will also focus on investments into our product offering and new equipment. —



Gilles Labbé

President & CEO
HÉROUX-DEVTEK

What have been the key developments since we spoke in 2015?

The highlight has been the progress in our contract for the Boeing 777 aircraft landing gear, for which we had to invest over US\$110 million on equipment and capacity. Since the contract was signed in December 2013, we have built and expanded factories, installed the required equipment and have developed the manufacturing process. In July 2016, our first shipment was five weeks ahead of schedule and we are now in ramp-up mode.

Following an acquisition in the United Kingdom, we have been able to expand our customer base in Europe. We won a contract in South Korea to design and build the landing gear for the next Korean Fighter, the KFX, working in partnership with Hanwha Corporation.

In addition to capacity investment, were there any innovative aspects that needed developing for the 777 contract?

The contract is build-to-print, but one thing we had to develop was the necessary surface treatment. These components are very large, and the landing gears are in fact the tallest in the world. The surface treatment is state-of-the-art and we installed some special equipment to machine titanium much more rapidly. We have also installed flexible manufacturing systems (FMS) to automate the process, through which one employee can run four or five pieces of equipment simultaneously, making us very competitive. We will also be the first in the aerospace industry to employ robotics to paint these landing gear parts. This process is still under development, but we should achieve our goal by the end of 2017. The technology is being jointly developed with another Québec company.

The United States is a huge export market for Canadian aerospace companies. With many changes underway internally and potential changes to trade agreements, do you foresee any challenges?

Our industry is very linked to the U.S. market and we have long enjoyed a free trade environment, even prior to concluding the North American Free Trade Agreement (NAFTA). Canada is considered an industrial domestic source for the United States Defense. There was a treaty signed between the United States and Canada called the Defense Product Sharing Program. If we win a con-

tract with the U.S. Air Force, for example, the Canadian military will perform the quality assessment and vice versa. Therefore from a defense standpoint, we are very integrated. Similarly, we also export without any duties on the civil side. We hope that free trade will remain in place.

In light of an increased industry focus on the environment, what initiatives is Héroux-Devtek involved in?

In the landing gear business, the typical coating used for protection against corrosion and general wear is cadmium or chrome. We have developed some new coatings, such as zinc-nickel to replace the cadmium as it is potentially harmful and can cause cancer. We are therefore looking to replace this material where possible. In relation to weight, we are developing a composite component for aircraft landing gear. Because of its nature the product has to be very resistant.

The aerospace sector is also very focused on the implementation of Industry 4.0 and breakthrough technologies. What steps is Héroux-Devtek taking in this direction?

We are currently undertaking an initiative in digitization of our manufacturing process, using less and less paper, with visual instructions on the computer. Additive manufacturing in particular is a very interesting technology for our product. In the forging of products, a very long lead time is required for building and obtaining parts from the supplier, plus the subsequent machining can result in wasting 80% of the material. Additive manufacturing reduces the long lead time and can reduce the material cost and waste by large amounts. Additive manufacturing will become more and more present in our industry and will be a game changer.

What is Héroux-Devtek's strategy for growth over the next few years?

Now that our U.K. subsidiary is well integrated, we have a solid business and are in ramp-up mode for the 777. The company is financially in very good stead. Having sold the industrial and aerostructure divisions of our business in 2012 to focus on landing gears, the growth pattern has been exponential: up from a US\$250 million business to US\$400 million, and we are targeting half a billion by 2021. We plan to make further acquisitions in complementary fields such as actuation systems and flight control where there is a lot of IP. —

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*Engine manufacturers prove
major proponents of R&D*

In the midst of its assorted structural components lies the heart of the aircraft, its engine. Hugely transformed over the years through advances in technology and a constant drive for greater efficiency, aircraft engines are a significant R&D driver in Québec as well as other regions worldwide. All three major commercial engine manufacturers, namely Pratt & Whitney, General Electric and Rolls-Royce, have a base in Québec and have all made major contributions to the region's ecosystem over the years.

For example, GE Aviation's Bromont facility recently agreed to a five-year grant proposal with Investissement Québec. This particular facility is considered highly advanced due to its widespread use of automation and robotics. On the engines themselves, GE Aviation is driving implementation of new technologies such as additive manufacturing, currently focused on its LEAP and GE9X engines. "We are investing a huge amount into additive manufacturing and CMCs on the GE9X, slightly modifying the architecture to improve performance," highlighted Alain Ouellette, operations director at GE Aviation. "At the same time, we have the Advanced Turboprop (ATP) in Europe where additive manufacturing will be a big game-changer. With ATP, we will replace over 800 parts with only 15 as additive manufacturing allows us to combine multiple parts into one."

Due to its first-in-class additive part for fuel nozzles, the LEAP engine is 15% more fuel-efficient than CFM, clearly indicating the advantages this technology can offer. The LEAP ramp up is set for completion in three to five years.

As one of Québec's four OEMs, Pratt & Whitney Canada plays a significant role in driving the region's aerospace ecosystem, producing its 100,000th engine in April 2017. With over 60,000 engines in service in over 200 countries and territories, it comes as no surprise that the company's prominent global position can largely be attributed to a continuous emphasis on innovation. Indeed, P&WC has over 23 ongoing university agreements in Canada and is partaking in projects with CARIC, CRIAQ and GARDN. The prominent OEM also runs 10 of the 13 Natural Sciences and Engineering Research Council of Canada (NSERC) chairs. Its PurePower® PW800 engine is now certified and exceeding performance expectations and its recent addition of Auxiliary Power Units (APUs) in 2015 has added a further 10,000 to the company's fleet. "Our mission is to continuously inject technology into all of our product lines," said Maria Della Posta,

senior vice president at P&WC. “We are working on the next large PT6 for general aviation and civil helicopters and have a big effort afoot to inject new technology in all of our platforms. A consistent focus for us is developing next generation engines, which we are currently working on. We will continue to bring a high level of capability in technology to all of our facilities in Canada and worldwide.”

Applying advanced processes, the next developments on the horizon in tandem with product innovation center around health monitoring and predictive maintenance. Major engine manufacturers are seeking to reduce maintenance costs by ascertaining engine performance and accurately determining when parts might need to be replaced or serviced. P&WC, for example, has a new Oil Analysis Technology, which gives high visibility into the health and efficient operations of the engine without intrusive inspection. Montréal-based SME AV&R is currently making waves in this area, as well as other applications for Industry 4.0 processes such as surface finishing and surface inspection. AV&R is in fact currently developing a solution with Rolls-Royce at its AMRC facility in Sheffield, United Kingdom.

Speaking broadly of the advantages of AV&R’s technologies, Jean-François Dupont, CEO, commented: “We will be able to follow the complete life of a part—we digitalize the surface of the part so we know exactly where the potential defects are...This will allow us to monitor any deterioration and predict defects over the life of a part. In our extensive database, we will then be able to find where all these parts are involved and will be able to ground only the one plane with a potential defect. Normally, an engine is verified with all tests done on a computer with parts modelled after their initial design. All simulation parts are perfect. We will be able to simulate the real engine, recreating its real performance.”

AV&R is currently operating off a backlog of airline orders for solutions to automate the production of plane engines, but will also focus on the medical device market in the future.

With such strong representation within Québec’s ecosystem, the region is set to remain a hub for engine innovation and a driver of technologies such as automation and additive manufacturing due to the already-advanced capabilities of the cluster. —

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When it comes to serving our customers, our simple mission is “Performance. Personal. Guaranteed.” More customization will also be the way of the future. Our focus is on bringing in different levels of customization and transforming our business model in line with global trends. We also play a leadership role in establishing the direction of some of the Canadian aerospace cluster initiatives. We need to join forces to ensure we have what it takes to bring our vision to reality and promote Canadian aerospace on the world stage.

- Maria Della Posta,
Senior Vice President,
Pratt & Whitney Canada



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Alain Ouellette

Operations Director
GE AVIATION



GE Aviation is a provider of commercial, military, business and general aviation jet and turboprop engines and components as well as avionics, electrical power and mechanical systems for aircraft.

Since we met in 2015, what have been some of the major developments at the company's Bromont facility?

GE Aviation's Bromont facility has recently agreed to a five-year grant proposal with Investissement Québec. The first component of the new grant is next-generation turbomachinery that we have been working on with Airbus, Boeing and Comac. This facility is involved in the LEAP 1A, 1B, and 1C engine and the investments over the next five years will be to support its entry into service. The second component is product manufacturing. The third component involves financially supporting our engineering business entities at the site to develop their capabilities, especially in vibration analysis. Québec will be supporting our global competitiveness with a grant of approximately US\$12 million over the next five years. We will use some of that funding for product manufacturing and to become more R&D-focused for the next generation of GE's automation deployment.

We are migrating from CFM production, a technology of the 1980s, into our 2017 technology, LEAP. There is a huge difference between their manufacturing processes. LEAP has more technology on the engine, resulting in higher performance than CFM, and includes the first additive part for fuel nozzles, making it 15% more fuel-efficient. LEAP also has ceramic matrix composites (CMCs) and an enhanced

compressor; all the compressor hardware for LEAP comes from this facility.

The Bromont facility is highly automated. In what ways is GE Aviation driving progress in this area and what are the main advantages?

We consider automation to be one of the major components for improving health and safety, quality and cost, which all impact deliveries. Although companies began to implement automation in the 1980s and 1990s, we now have a better understanding of automation and how it can best support aviation needs. The cost of automation today is also much lower than previously and processes are more flexible, manageable and widely available. The mission of our team is to help our industry understand where automation makes sense.

With significant operations in the United States, how is business segmented between the different markets?

We cannot focus on the Canadian market because we do not provide a finished product. However, we are trying to highlight Québec and Canada as a place to do business and our vision is to have a bigger manufacturing presence in Québec. We need to be competitive with technology and innovation to stay ahead and we take advantage of Québec's strong ecosystem of SMEs, universities, academia and government support.

Meanwhile, our sales force is focused in the U.S. and, whilst there is a degree of uncertainty surrounding the United States right now, our CEO has positioned us as a global company. We sell worldwide, so

we cannot restrict our activities. We need to follow our customers and businesses and adapt to the environment.

What are the next areas of innovation on the horizon for GE?

LEAP is a big focus and GE9X is another. We are investing a huge amount into additive manufacturing and CMCs on the GE9X, slightly modifying the architecture to improve performance. At the same time, we have the Advanced Turboprop (ATP) in Europe where additive manufacturing will be a big game-changer. With ATP, we will replace over 800 parts with only 15 as additive manufacturing allows us to combine multiple parts into one. Additionally, the military side of the business will likely take off between 2020 and 2022.

We are working hand in hand with GE's Global Research Center in Niskayuna and are very excited about the prospects for Artificial Intelligence (AI). We have a lot of data available but lack the power to analyze everything to make decisions. In the future, we will be a more connected facility and AI will bring the computing power to allow us to make decisions on analyzed data on a continual basis. It will lead us to do things differently and better.

What are the objectives for GE Aviation over the next few years?

In three to five years, our LEAP ramp-up should be completed and we will be looking at a cleaner, quieter engine for the next generation. Airlines are always asking for an engine with lower fuel consumption. With LEAP, GE9X, and ATP coming, the next five years will be very dynamic. —



Denis Gangi

President

ROLLS-ROYCE CANADA

Rolls-Royce Canada Limited specializes in providing civil and military aircraft engine repair and overhaul services.

Could you give a brief introduction to Rolls-Royce Canada and the development of its aerospace presence since its establishment in 1947?

Rolls-Royce Canada was the first aerospace plant built by our company outside the United Kingdom. In the 1950s, we supported primarily Canadian customers, such as the Royal Canadian Air Force, by performing maintenance on their NENE, J-34 and Tyne engines. Today, our Montreal plant has grown into a successful and diversified aerospace repair and overhaul business, supporting over 600 civil aircraft operators in 30 countries. These include airlines, corporate operators, private jet owners and even some famous Hollywood stars!

It is worth noting that Rolls-Royce currently employs over 1,000 people across Canada. Outside of Québec, we also operate facilities and offices for the marine business in Peterborough, Ontario; St. John's, Newfoundland and Dartmouth, Nova Scotia, as well as a state-of-the-art ice testing facility, GLACIER in Thompson, Manitoba, as a joint venture.

What are Rolls-Royce's core capabilities in Québec?

Our Montreal site is an authorized maintenance center for the BR710 engine, which powers the Gulfstream V, G500/G550, the Bombardier Global Express and Global 5000 corporate aircraft; the BR715 engine, which powers the Boeing 717 aircraft; the AE3007 engine, which powers the Embraer ERJ 135/140/145 regional jets, Embraer Legacy and the Cessna Citation X business jet; the Tay engine that powers the Gulfstream IV, 350, 400 and 450s. As a Center of Excellence for the repair of fan blades and combustion chambers, our Montreal plant also offers component repair services for a wide range of Rolls-Royce products, including the Trent, RB211 and BR700 engine family.

Are there any particular advantages to Québec's operating environment over other parts of the world?

The Montréal aerospace cluster is one of the world's three major aerospace centers, along with Seattle and Toulouse. This gives us access to an excellent pool of skilled labor

generated by the extensive infrastructure of Québec universities, collaborative research centers, aerospace educational institutions, government support programs, as well as a wide range of local suppliers and service providers that target the real needs of the aerospace industry. Québec also provides aerospace businesses with a competitive operating cost environment, as Montréal ranks second for most competitive operating costs among major metropolitan areas in North America specializing in aerospace.

Where is Rolls-Royce currently investing most R&D in relation to aerospace?

In 2016, Rolls-Royce invested £1.3 billion in research and development. These activities take place in various countries around the world, including Canada. Over the last couple of years, our Montreal plant has played an increasing role in supporting the development of the company's new generation of civil aerospace engines by further developing its engine testing capabilities. Recent investments allowed us to add new capabilities to our service offering, such as water ingestion and cold start testing. These tests allow our R&D team to understand how the engine would perform when exposed to severe weather conditions and form an important part of the certification process for new business aviation engines.

As the industry moves towards Industry 4.0 with encouragement from the Québec government, how do you see these technologies impacting the market and supply chain?

Industry 4.0 will bring about a much greater utilization of big data, which is a significant driver of providing effective and efficient 'fleet management' in an MRO environment to ensure overall customer satisfaction. This will support us in our on-going efforts to design innovative solutions to our customers' needs, while continuously improving our manufacturing processes and business performance.

What are the primary objectives for Rolls-Royce Canada going forward?

Rolls-Royce Canada's primary objectives are to continue to be our customers' first choice for civil engine maintenance repair and overhaul services, while developing new capabilities and technologies to support the development and test of the next generation of Rolls-Royce civil aircraft engines. —

Avionics

Facilitating Safe Flight

Covering a wide range of applications, avionics play a critical role in aircraft. From performance optimization to flight safety, essential functions catered to by this segment include flight control, navigation and collision avoidance. Québec is home to three particularly prominent players in this field: Rockwell Collins, Thales Avionics and CMC Electronics.

A division of Thales, headquartered in France, Thales Canada focuses on the design and integration of flight controls, fly-by-wire

and avionics systems and is enrolled on programs with companies such as Bombardier, Cessna, Gulfstream and Embraer. Placing a strong focus on R&D, Thales Canada is a key contributor to programs such as SAGE and SA2GE and also collaborates with CRIAQ. Notably, Thales has recently acquired a Big Data company in Silicon Valley, further securing its position as an important player in Montréal's bid to be a thriving artificial intelligence (AI) and Big Data cluster.

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Image courtesy of Rolls Royce Canada

Rockwell Collins, although a U.S. company, has a strong Canadian base focused on its government systems and commercial systems business units. Also with a strong innovative edge, the company is focused on improving its Pro Line Fusion product line, which includes its flight management systems (FMS).

As well as a number of developments in fly-by-wire systems, one of the key trends in cabin systems is the shift from hard to touch interfaces, including in the cockpit. Another is aircraft connectivity, an area of focus for both Thales and Rockwell Collins. “Almost every air framer is interested in obtaining diagnostic data from aircraft,” noted Louis Brunet, director of business development, business aviation at Rockwell Collins Canada. “We support these efforts and have product solutions that enable in-flight data acquisition and communication. Rockwell Collins also has the capability to provide many of the services related to connected aircraft, such as moving data on and off an aircraft. We are also looking into investigating the internet of things (IoT) for Interior Systems.”

Along similar lines, Thales has developed the Iridium Next SATCOM transceiver and Topmax, a head-worn display to replace more expensive head-up displays (HUDs).

As aircraft move towards connectivity and manufacturers place greater importance on data collection, Québec’s avionics leaders are well positioned to drive this innovation and form an integral part of the supply chain. —



Michel Grenier

Vice President & General Manager
THALES CANADA



Thales Canada focuses on the design and integration of flight controls, fly-by-wire and Avionics systems.

Thales has a strong presence across Canada. Could you give a brief introduction to the company's Québec operations?

Our Québec operations center around the aerospace sector, specifically the business and regional aircraft market. We are involved in programs with Bombardier, Cessna, Gulfstream and Embraer and primarily offer flight control and Fly-By-Wire (FBW) and Avionics systems. The products are complex and require the highest level of safety. We have about 160 employees in Montréal and are very involved in the Montréal cluster. With the support of the Québec and Canadian governments, we are investing heavily into the development of new products that go beyond the pure flight control systems we currently offer.

Recently, we have been quite successful at Textron Aviation with Cessna, where our rudder-by-wire system has been selected for the Cessna Longitude Program. We were also selected by Cessna on their latest business jet, the Hemisphere, where we provide the full flight-by-wire system for the aircraft. This is similar to the full flight-by-wire systems we have been producing for Gulfstream and we certainly hope to sell this great product to other OEMs in the future.

Are there any changes in requirements for the flight control systems and the fly-by-wire systems?

Yes, to some extent. For example, at Gulfstream, we have been adding functionality to the G500/G600 Flight Control Computer (FCC) compared to the first system we delivered the G650, such as the autopilot inner-loop and the Active Side Stick back drive controls. We are trying to embed other critical functions into that system wherever possible.

There is a lot of cost pressure from the OEMs on the supply chain. How is Thales adapting?

All our customers are asking us to be more competitive, so we are trying to come up with solutions that allow them to achieve their targets. One of our products currently in development is the Multi-Application Critical Computer (MACC), which is designed to combine several aircraft computers into one. We have designed sophisticated control mechanisms to allow critical functions to be

hosted together into one box. This allows OEMs to have fewer computers on board and reduces cost as they need only to acquire the software functions rather than the full hardware. We are also trying to reuse more products that are available within the group and adapt them to our market.

It is important to note that safety is always first and will never be compromised for cost reduction activities. Whatever we do has to be safe because we manage the highest level of criticality in an aircraft. Cost reduction comes into play early in the design phase and in the equipment manufacturing.

A lot of innovation is stemming from startups and universities. How is the innovation environment evolving in Québec?

Canada in general has a very strong innovation environment and we are well-supported by the governments. For example, we have programs with the Quebec government on SAGE I and SAGE II to continue development of the MACC initiative. Another program is with the Canadian government and Bombardier for technology demonstration, where we are developing flight control applications for future aircraft. We also have projects with CRIAQ to develop technology with low readiness level (TRL).

Thales has been involved with the artificial intelligence (AI)/Big Data cluster in Montréal and has made a recent acquisition in Silicon Valley of a company working on big data. We recognize that we need to be involved in this sector to develop the right solutions in the future particularly for data collection and predictive maintenance. Connectivity is another important topic for Thales and we are now proposing to our customers the Iridium Next SATCOM transceiver developed by our colleagues in Florida. Finally, we are working at bringing to the market an innovative Headworn Display called Topmax that would replace the more expensive Head Up Display (HUD) on some market. Of course, we keep an eye on the defense industry because it is a strong area for innovation.

Going forward, what are the key objectives for Thales in Québec?

We are looking to grow globally and to further develop products similar to flight controls and are heavily involved in selling other products from our global business unit. Our business in Québec has grown over the last few years and we are certainly looking forward to this continuing. —



Louis Brunet

Director of Business Development,
Business Aviation

**ROCKWELL COLLINS
CANADA**

Rockwell Collins Canada is focused on the production and support of advanced avionics and communications systems and systems engineering services.

Could you provide an introduction to Rockwell Collins' operations in Canada?

Our business in Canada reflects two Rockwell Collins business units: Government Systems, catering to defense clients, and Commercial Systems, catering to business and commercial aircraft. Our commercial systems operations are lead from Montréal and provides services for business, regional and main-line aircraft. We focus on sales and customer support for the Canadian market, with Bombardier being a key client. Our engineering team integrates our systems into Bombardier's aircraft providing integrated avionics suites, cabin management systems, communications systems and flight controls systems.

Under our chairman, president and CEO, Kelly Ortberg, Rockwell Collins is growing quickly. In 2013, we purchased ARINC, now Rockwell Collins Information Management Systems, making us a leader in flight services. Most recently, in April 2017, Rockwell Collins also acquired B/E Aerospace, now Rockwell Collins Interior Systems, adding passenger cabin interior products for the commercial and business jet aircraft markets to our portfolio.

What accounts for Rockwell Collins' success as a key provider of integrated services in the supply chain?

Rockwell Collins is committed first to our customers' success. This means we focus first on issues, working to ensure that development and manufacturing operations are productive. We build long term relationships based on trust.

How have demands from the OEMs changed in recent years?

Demands from the big OEMs are becoming increasingly contractual. This has come with an influx of staff from the automotive sector to the aerospace industry, which has empowered supply chain departments. Contractual requirements for suppliers have multiplied under their influence.

How has product demand changed in line with changing consumer expectations?

The biggest change has been a rapid migration from hard to touch interfaces. This is

more pronounced in business aviation but is also creeping into air transport. Our latest programs have focused on touch-control primary flight displays in the cockpit, such as those in Beechcraft's King Air. We've also applied these in the aftermarket to in-service King Air's Citation CJ3's and we are now developing a solution for Bombardier's Challenger 604. Anything that pilots would have once completed using a dial knob or a keypad can now be done via touch.

What areas of product innovation is Rockwell Collins currently working on?

Rockwell Collins has a history of innovation which it continues to build on. We are continuously working on improvements to our Pro Line Fusion product line, including our flight management systems (FMS). We have secured over 20 aircraft programs with Pro Line Fusion, each of which requires a unique instance of the core product. For example, the C-Series has specific engine systems, flight data recorder and other avionics systems that we need to be integrated with the core Pro Line Fusion product. Mission requirements also require FMS product developments such as future air navigation systems and the required navigation performance authorization procedures.

How is Rockwell Collins taking advantage of Industry 4.0 processes to influence design of its products?

The connected aircraft is an area we are moving into. Almost every air framer is interested in obtaining diagnostic data from aircraft. We support these efforts and have product solutions that enable in-flight data acquisition and communication. Rockwell Collins also has the capability to provide many of the services related to connected aircraft, such as moving data on and off an aircraft. We are also looking into investigating the internet of things (IoT) for Interior Systems. The industry is reaching a phase where technology uptake is accelerating. However, it will always be constrained by the industry's low volumes.

What are Rockwell Collins Canada's primary objectives with regard to Québec?

We want to maintain and build on our relationship with Bombardier and apply our expertise to a wider range of clients. As the region rolls off a development cycle, the company is maintaining the center of excellence it has built in Montréal. —



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Enhanced experiences: Cabin Interiors

In commercial aircraft, many aspects of the cabin interior and its associated systems are changing as airlines and aircraft manufacturers seek to enhance the passenger experience. From companies providing integrated solutions to those with niche expertise to apply, Québec's aerospace ecosystem has a broad range of companies catering to this field.

On the more integrated side lies GAL Aerospace, a poster child for companies following an aggressive consolidation strategy. "We recognized that the aerospace industry was consolidating and looked at the potential opportunities that arise with change," commented Glen Lynch, GAL's president and CEO.

Growing from 11 employees in 2011 to 200 today, the interiors company started as a build-to-print cabinet shop and now has extensive capabilities in engineering, advance composites and even aerospace staffing. 40% of the company's business lies in commercial aviation with the remaining 60% in business aviation. "Since most of the new aircraft programs are already launched and underway, most of our current growth is in the in-service commercial market," noted Lynch. "However, in terms of customers, our biggest area of growth right now is with airlines. We can offer our services from the conceptual phase right through to certification."

A prime example of a highly specialized company is GGI Solutions, which has developed its niche in Human Machine In-

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For years, the industry was focused on the evolution of technology associated specifically with flight. However, due to a number of changes such as regulatory and environmental concerns, aircraft interiors became a major focus. Making the aircraft lighter has always been at the center of investment but we now also have an enormous increase in passenger awareness. There is a requirement for more efficient use of space and creating the illusion of more space than there might be.

- Glen Lynch,
President & CEO,
GAL Aerospace



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Image courtesy of Ingenio Aerospace

terface (HMI) solutions and technologies. “As HMI specialists, our designers understand the ways in which humans interact with a system and our engineers are experienced in designing and producing solutions that are of high quality and reliability while ever striving to reduce cost,” explained Eric Saint-Jacques, CEO at GGI. Referencing customers such as Boeing, Airbus, Rockwell and Stelia Aerospace, Saint-Jacques continued: “This is why these customers turn to GGI with continued demand for our solutions. GGI is also working higher up in the supply chain with the design companies that work with the airlines to create the optimal user interfaces right at the outset of the cabin interior design process.”

GGI aims to be a global conglomerate by following an acquisition strategy and continuing to invest in innovation.

As more emphasis is placed on the customer experience, companies could well look to the business aviation space for inspiration. Companies such as Innotech Aviation lead the way in beautiful design, recently joined in the market by Austrian interiors company F. List.

Whilst aesthetics are hugely important in this market segment, functionality is also key. INGENIO Aerospace is one of Québec’s rising stars when it comes to SMEs excelling in a selected niche. Established only in 2012, the company has already designed 34 products and has 14 more in the pipeline. “Many OEMs and Tier 1s were moving towards software-centric cabin entertainment systems, but the desire of the customer was to bring the consumer market into the cabin,” outlined INGENIO’s CEO, James Bell. “We designed new hardware infrastructure for cabins moving

away from traditional hardwired, clunky video monitors to a Personal Electronic device-driven system. We focused on very highly stylized, functional electromechanical products; everything from Tablet arms, to Smartphone holders as PC-based cabin controllers. We also introduced Bluetooth receivers to relay audio directly to the aircraft’s CMS through a phone, Bluetooth wireless headset transmitters, projectors for presentations inside cabins and personalized LED Reading lights.”

INGENIO is now pursuing CAR 562 manufacturing approval from Transport Canada and aims to become a Design Ap-

proval Organization next. “Most companies would not pursue these goals as they can create significant complexity, but they would allow us to design, manufacture and certify our own products,” commented Bell. “Transport Canada has taken us under its wing as a young, innovative Canadian company producing a large number of products for aviation. They have been nothing but excellent to deal with for INGENIO.”

INGENIO will continue to focus on innovation and has begun to build a pathway into commercial aviation to take advantage of the segment’s higher sales volumes. —

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We envision a world in the near future where airplanes are a platform on which different applications and experiences can be accessed onboard. This is becoming increasingly important for passengers and will completely revolutionize the way we travel. The increased use of cell phone applications for completing daily tasks will naturally translate into aircraft. In the future, passengers will simply ‘google’ their destination then customize their trip according to their unique entertainment, dietary and seat pitch preferences. It will no longer matter what airline seat one chooses, rather what one can do with the seat. Different seating configurations are also being discussed by airlines, including benches and standing room to fit more people per flight. As companies start designing open-platform aircraft where customizations can be made easily and affordably, innovation will continue to snowball.

- Mark Makoukji,
Managing Partner,
P3 Group



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Rob Brooks

Vice President and General Manager
INNTECH-EXECAIRE
AVIATION GROUP

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Innotech Aviation offers services in the business aviation segment, including maintenance repair and overhaul (MRO), refurbishments, avionics upgrades and full green aircraft completions and paint.

Could you briefly outline any key milestones for the company and where Innotech Aviation positions itself in the market today?

We built the Montreal facility in 2015 to accommodate the growing fleet and scale of aircraft, primarily driven by the development and capabilities required for the large Bombardier aircraft.

Our approach is to offer our clients a full range of services and we have always been regarded as a very high-quality one stop shop. Beyond top-quality service across the board, customers are able to benefit from our knowledge, expertise and background in refurbishment, including areas such as upholstery, woodwork and specialty fibers. Most of our work is done in-house, with the exception of plating and some certification testing. Innotech offers and delivers highly-customized aircraft with technological applications such as communication technology, entertainment systems and LED lighting. In the past, we have met highly-specific customer demands, such as LED crystal lighting with luxurious LED-integrated Swarovski crystal chandeliers and wall appliques for one particular aircraft.

How diversified is Innotech's customer base and do requirements differ between regions?

The main growth we see is in opportunities arising from the support of aircraft through deliveries for Bombardier and the accompanying refurbishment and maintenance work. Over the last two years, Asia has seen somewhat of a quiet period but activity is picking up again and demand is growing. We have had ties with companies in Asia and the Middle East for over 30 years.

Many companies within the aerospace sector are responding to increasing cost pressures. How do these pressures translate to the business aircraft market?

There is a huge amount of cost pressure on the industry as a whole. These are trying times in terms of cost management and cost control for the entire industry and owners of the aircrafts. No one region is showing more strength over any another. There is a

huge retraction in the luxury goods marketplace. Generally, there seems to have been a bit of a lull by which we have been somewhat affected. Our work is therefore always cost sensitive. However, because the requirements are more specific, customers will continue to pay more for the expertise if they are confident in the capabilities of their supplier. Therefore, although the market has definitely slowed, demand for our services as a premium supplier of unique and customized products remains high.

What measures has Innotech taken to ensure environmental friendliness in line with recent trends in paints and coatings?

Our facility here is a purpose-built paint facility for aircraft based on very stringent environmental standards that are set and monitored by the local municipality and province. The environmental side is always a challenge because the aircraft surface is subjected to extreme variations in temperature and other conditions. Adhesion is very critical, so we have a very expensive filtration system in place. Our facility is one of the few in Montreal that meets and exceeds the high environmental standards of the region.

How do you expect the market to evolve going forward?

Airlines are working on making flying easier, quicker and more comfortable. The autonomous vehicle is coming soon but it might take some time to develop. Drones are also coming more into play and we are starting to see air taxis in Dubai. However, our industry has a long way to go to be able to accommodate this model.

What are the objectives for Innotech over the next few years?

We will continue to offer specialized services and provide custom work and maintain our position as a global market leader in quality and standards, delivering the latest in communication and finishing technologies. We are not trying to be everything to everybody. We want to work with customers looking for bespoke interiors and continue to implement technology that no one else has successfully incorporated into aircraft. Another area of focus is the delivery of aircraft communication access in blackout areas in the next two to three years. —

Glen Lynch

President & CEO
GAL AEROSPACE



The GAL Aerospace Group of Companies is a North American based 'super sub-tier' supplier to the aerospace interiors market.

GAL Aerospace was established in 2011 as a reaction to industry trends such as consolidation in the supply chain. Could you expand on the motivations and circumstances surrounding the company's establishment?

We recognized that the aerospace industry was consolidating and looked at the potential opportunities that arise with change. For years, the industry was focused on the evolution of technology associated specifically with flight. However, due to a number of changes such as regulatory and environmental concerns, aircraft interiors became a major focus. Making the aircraft lighter has always been at the center of investment but we now also have an enormous increase in passenger awareness. There is a requirement for more efficient use of space and creating the illusion of more space than there might be. The passenger cabin area has seen a great deal of evolution and, because it had not previously been an area of focus for the major players in the industry until a number of years ago, it presented a tremendous opportunity, furthered by a lack of manufacturing capacity within this space.

How has GAL developed over the years with its numerous acquisitions?

The company has grown from 11 employees in 2011 to 200 today. We started out as a build-to-print cabinet shop. Now, we have design engineering capabilities. We partner with local engineering firms and also have our own engineering department based out of Bogota, Columbia. In Atlanta, Georgia, we have an advanced composites facility that builds countertops, fairings, VVIP show-ers and other composite components. In Montréal, we have a large aircraft cabinetry for monuments and machine parts and a machine shop that runs 24 hours a day. The goal was for GAL to become a super sub-tier supplier.

Our customer base is currently split about 60:40 between business and commercial aviation. Since most of the new aircraft programs are already launched and underway, most of our current growth is in the in-service commercial market. However, in terms of customers, our biggest area of growth right now is with airlines. We can offer our services from the conceptual phase right through

to certification. Finally, there is the aerospace staffing part of the business, with three areas of focus: field and technical support, basic staffing services, and aircraft modification and installation.

In such a cost-sensitive market, where are OEMs currently willing to increase spending?

Cost used to be the number one consideration with weight a close second. They are now neck-and-neck but often flip back and forth. There is always pressure on cost and some of that challenge is driven by globalization. The need to compete with companies in other parts of the world creates pressure on those in typically higher-cost jurisdictions.

Due to environmental changes, aesthetics have become key. In the last 18 months, we have developed a capability for hydrographics in our Atlanta and Montréal facilities. Through this technology, we have the ability to produce almost a limitless number of finishing potentials in both the business jet and commercial environments.

Does GAL actively pursue partnerships with other entities in the Québec region, particularly SMEs and universities?

By nature, SMEs do not tend to trust each other because they are all competitors, but we do collaborate in the United States. Our facility in Atlanta works very closely with the Georgia Institute of Technology, for example. They are very involved in assisting us with product evolution, R&D development, staff development strategies and training. In Québec, we do work with the aerospace educational institutions but more on the staffing side.

What will be the main areas of focus for GAL going forward?

The main change for us for at least the next five years is to focus more on direct OEM relationships and end-user requirements. North America is our biggest market but we are now doing business in Europe and China and the Middle East. We will continue to follow the opportunities as a team of outstanding professionals who are all motivated to provide solutions in the areas of business and commercial aircraft cabins. We want to be involved in the evolution of new technologies and new manufacturing methods. We are also interested in becoming a partner and willing to engage in risk sharing as well as the development of products and solutions. —

Mario Lepine

General Manager

F. LIST CANADA CORP.



AV

F/LIST is an Austrian company specializing in interiors for business jets, currently establishing a presence in Québec.

Could you briefly introduce the company and the reasons for establishing a base in Laval, Québec?

F/LIST is strongly rooted in innovation, with a portfolio including products such as F/LIST® STONE FLOORING, which could be optionally heated. We have found a niche within interiors and have developed ways to bring more beautiful top-of-the-line furniture into airplanes. In Austria, our research and development department is constantly introducing new materials and new ways of making furniture. We decided to develop a presence in Québec as a supplier to Bombardier and because 70% of the business jet market is based in North America. In addition, we wanted to be closer to the refurbishing market, which we are currently entering.

F/LIST intends to increase its employees in Québec from 15 to 100 by 2020. Are there plans to source from Québec's talent pool?

The focus is to hire from Québec but there are no borders when it comes to talent. There will be representatives sent from Austria to transfer knowledge and some of our Québec staff sent to Austria to learn as well. It takes time to transfer knowledge acquired over many years, so there will be a higher degree of movement in the initial stages. Also, as veneer specialists are quite rare in Québec, we will have to search for workers with that talent. Québec has an extraordinary talent pool compared to many regions but demand

is also high. We therefore need to be very creative to attract talent and retain it.

How will F/LIST's capabilities in Laval differ from those in Austria?

We want the capabilities to be exactly the same; a manufacturing facility with an R&D area. This will enhance our strategies with the possibility to determine which facility is most suitable for specific R&D projects to distribute the work more efficiently. We will also have a section to prepare veneers, initially supplying our North American customers, which makes sense because the raw materials come from this region. After that, we will be introducing some furniture that we recently negotiated with Bombardier on its Global 7000.

Could you expand on some of F/LIST's R&D work?

A lot of work is being done in F/LIST flooring solutions, especially on hardwood and leather floors. We are also producing very high quality lightweight stone for cabin interiors (e.g. granite for countertops in the galley or lavatory section) with better aesthetics because our material is really natural, but also thin and flexible to be wrapped around edges. Usually, the cabinet is made and the veneer slipped on top. At F/LIST, however, every part is installed with veneer first and the assembly takes place after. We also have a close collaboration with HILITECH, the joint venture between F/LIST and Hintsteiner Group, to develop new furniture made from carbon fiber, which have 15% to 25% less weight in comparison to conventional cabinets. We are able to make

monolithic pieces of furniture with many shapes and curves and a narrow radius. Furthermore, we have a strong cooperation with INAIRVATION, the joint venture between Lufthansa Technik and F/LIST. INAIRVATION offers amongst others, a chair which is a fully certified seat-concept for different configurations (club, office and lounge model) and design possibilities without any expensive additional testing as well as pre-developed retrofit packages for the Bombardier Global 5000 / 6000 plus Challenger family and for the Gulfstream G450 / G550.

Could you expand on the potential for collaboration with universities in Québec?

We will start collaborating with universities at the end of 2018 or 2019. This will be the next step after completing the new facility, ramping up production, and introducing assembly. Québec is a great place for R&D; the presence of so many excellent universities is one of the region's unique characteristics.

What are the objectives for F. List's Québec operations going forward?

We want the facility to be up-and-running by October 1st, 2017. We will start with the veneer section, then set up the assembly and start the refurbishing section. We will have to set up a team to attend to MROs and provide repairs. There are no competitors in this industry; all SMEs need to focus on their core business, work hand-in-hand and collaborate with each other. This is how we will make the industry better and stronger than ever. —

James Bell & Antony Rawlinson

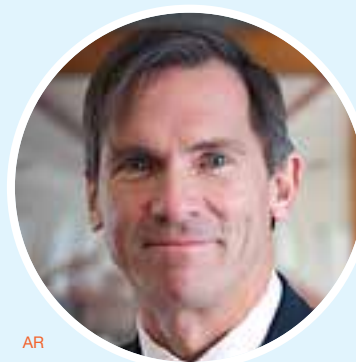
JB: President and CEO

AR: VP Sales & Market Development

INGENIO AEROSPACE



JB



AR

INGENIO Aerospace is focused on the design, certification and manufacture of electrical and mechanical components for the aerospace industry.

Since its establishment in November 2012, where has INGENIO found its niche in the market?

INGENIO spent the first 22 months of its existence focused on product development after researching niche markets in aviation that offered the most opportunity for sales of innovative electromechanical products. Whilst aerospace has higher barriers to entry than many other industries, the procurement cycle in corporate aviation is relatively shorter than that of commercial aviation. Subsequently, it is more straightforward to penetrate OEMs and Tier 1s with innovative products. We therefore focused on this market with niche, targeted electrical and mechanical products for passenger use in the cabin and with pilots for cockpit products. INGENIO has designed 34 products within three years and currently has 14 additional in the pipeline.

We began with the design of new products to help facilitate the Wi-Fi wireless environments in corporate aircraft. We penetrated a number of OEMs such as Bombardier, Dassault, Sikorsky, Boeing and L-3 Communications; Mitsubishi on the commercial side; and Rockwell Collins a major Tier 1. Approximately 98% of our sales are exports and extend across the United States, Europe and Asia.

What are some of INGENIO's flagship products?

Many OEMs and Tier 1s were moving towards software centric cabin entertainment systems, but the desire of the customer was to bring the consumer market into the cabin. We designed new hardware infrastructure for

cabins moving away from traditional hard-wired, clunky video monitors to a Personal Electronic device-driven system. We focused on very highly stylized, functional electromechanical products; everything from Tablet arms, to Smartphone holders as PC-based cabin controllers. We also introduced Bluetooth receivers to relay audio directly to the aircraft's CMS through a phone, Bluetooth wireless headset transmitters, projectors for presentations inside cabins and personalized LED Reading lights.

How do you cater to different demands from customers and implement their needs from the design phase?

The design and concept for our products always begins with the customer. Our designs flow from what customers are looking for: something highly stylized yet very organic and unobtrusive.

How integral is innovation to INGENIO's rapid growth and success?

In an industry with high barriers to entry and many larger companies, our intellectual property (IP) is an extremely important asset. Some of the big players have phenomenal resources and can easily be inspired if they catch wind of a good idea. Our strategy has been to approach aircraft manufacturers and operators directly with our products and solutions rather than having a wide after-market entry strategy. Now that INGENIO products are recognized by many of the critical players in the market, we are beginning to roll them out more widely. With our solid foundation for innovation, product development and speed to market it is now very difficult for companies to copy our products. Our business is growing at a rate of about 50% to 60% per year, despite difficult market conditions. Product innovation is driving our growth.

Has INGENIO encountered any challenges in certification processes?

It is difficult to start a company from scratch in aerospace, in part because regulation and certification standards are very high and complex. Just simple products cost hundreds of thousands to certify; the investment is significant and the risk is high. Mistakes are not permitted.

Attaining AS9100 certification, the aerospace ISO standard for example, is an incredibly laborious exercise. Just jumping this hurdle is significant for a young company. Having achieved AS9100, the next steps for us are to continue to do the basics exceptionally well.

In what ways can you ensure that INGENIO continues along its growth trajectory?

We now have our sights set on achieving CAR 561 manufacturing approval from Transport Canada, which would allow us to manufacture and certify our own parts. Next, we want to become a Design Approval Organization to complete design certification on our own as a Transport Canada design delegate. Transport Canada has taken us under its wing as a young, innovative Canadian company producing a large number of products for aviation. They have been nothing but excellent to deal with for INGENIO.

What are the objectives for INGENIO over the next few years?

The concept is to be product innovators in the aerospace market. We will likely be tripling or even quadrupling our business over the next few years. As well as developing new product lines, we have been doing significant research into different niches and to start building pathways into commercial aviation, which is where the higher volume sales are. —

Eric Saint-Jacques & Steve Birrell

ESJ: CEO

SB: VP Sales and Marketing

GGI SOLUTIONS



ESJ



SB

GGI Solutions is a global leader in the design, engineering and manufacturing of Human Machine Interface (HMI) solutions and technologies.

What are some of the most notable developments that have taken place at GGI Solutions since we met in 2015?

GGI is privileged to have been acquired by a private equity team that includes Caisse de Dépôt et Placement du Québec (CDPQ), Fond Manufacturier Québécois and Namakor Holdings. CDPQ has over C\$260 billion of assets under management and provides GGI with the financial resources to fuel its international growth-through-acquisition strategy. GGI's financial partners share a common vision of long-term value creation and can now support the company as it grows internationally. GGI now has access to the financial resources, management experience and market partners to position the company to its maximum potential in international markets. Aerospace and Defense is a core area of focus and we intend to make acquisitions internationally both to grow our geographic reach and to add additional technologies and products to GGI's portfolio. GGI now also has a very focused and innovative R&D team creating high value IP in the field of printed electronics, including curved capacitive surfaces, printed flexible frequency shields and printed heating surfaces.

Could you elaborate on GGI's human machine interface (HMI) product portfolio for the aerospace market?

GGI's main product areas are membrane switches, electromechanical integrated solutions, printed electronics, application-based virtualization of HMI and voice recognition. Our presence spans various sectors, including medical, industrial, transportation and aerospace and defense. On a commercial aircraft, GGI provides solutions at every interaction point where passengers or crew interface and control equipment and systems: seat controls, in-flight entertainment systems, lighting systems, ovens, other galley systems, and so on. GGI designs these interfaces to enhance the passenger experience and facilitate crew operations by delivering durable and efficient solutions. Our solution portfolio is broad and extends past electromechanical systems. For example, GGI's touch surface technology enables us to embed system control directly into struc-

tural surfaces, like a seat armrest. Our printed electronics solutions enable us to provide frequency-protection flexible shields that allow the augmentation of Wi-Fi access points to provide better coverage for passengers and better protection for the cock-pit by preventing outside access over Wi-Fi or other frequencies.

Cost saving across the supply chain is a prominent theme in the industry at present. How does GGI ensure cost savings while still maintaining quality?

The acquisition by GGI's new partners enables us to bring in top talent from global leaders such as Esterline CMC, Thales, AlliedSignal and Inmarsat to re-structure and optimize our entire supply chain and go-to-market teams. We are firmly embarked on cost reduction initiatives that will also drive higher quality through greater efficiency and reallocation of resources. The entire aerospace ecosystem is under price pressures. It is our responsibility to respond to this pressure and ensure lower costs for our clients. Quality, on-time delivery and innovation are the ante to enter the market but now more than ever, cost reductions are an essential element of our value proposition to customers; AS-9100 certification is not enough in of itself. This is why GGI has launched an ambitious and innovative program to restructure and consolidate its global supply chain across all four of its key verticals, which will directly benefit aerospace customers.

Can you tell us more about your defense offering?

GGI provides defense-orientated interfaces for highly complex and mission critical defense systems. Our products and solutions focus on protecting human lives. For example, GGI provides the control panels and masks for explosive ordinance disposal suits and control systems for personnel protection communication systems.

Where do you see GGI in three to five years' time?

GGI will be a global conglomerate with a geographic presence in every market through strategic acquisitions. We will be investing ever more in innovation and R&D across our five key product/technology pillars; electromechanical solutions, membrane switches, printed electronics, handheld app and voiced based control interfaces. —

Eric Gagnon

Vice-President and
General Manager

ASTRONICS - LSI CANADA



Astronics – LSI Canada focuses on the design, manufacture and service of lighting and electronic systems for the aeronautics and related industries.

Astronics' Québec division is a center of excellence in human-machine interface (HMI). Where does the division fit into the wider company?

Astronics Corporation (NASDAQ: ATRO) is the trusted provider of innovative solutions in lighting, power, connectivity, entertainment, and test systems for the world's aerospace, military, and other high reliability industries. Annual revenue for 2016 was about \$630 million. Astronics consists of an aerospace and a test segment. The aerospace segment accounts for the majority of sales and is divided into five product areas, including "Lighting and Safety". LSI falls under the Lighting and Safety product area and manufactures at locations in New Hampshire, New York and Montreal (LSI Canada). Across these divisions, we work on external lighting, cabin lighting and cockpit lighting. Within cockpit lighting, we have human-

machine interface expertise, which is where LSI Canada fits into Astronics. We offer anything from lighted panels and avionics key-boards to full control panels and sometimes integrated displays.

What are some of the greatest areas of focus when it comes to innovation?

The rapid shift towards touch services is a trend to which we pay a lot of attention in determining our next projects.

Is LSI Canada making use of Industry 4.0 technologies, such as increased automation and digitization?

The automated processes we have in place for testing lighting is key, as is the automation of all of our electrical tests. We are currently spending a lot of time trying to automate these processes as much as possible. It saves time, increases test coverage, reduces potential human error and provides valuable data to increase future performance.

What are the key goals for LSI Canada over the next five years?

Our pillars of success are performance, service and innovation. Tier 1 avionics companies are currently looking into outsourcing higher value content and we believe we are well positioned to provide that service. —

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Francis Labonté & Eric Roberge

FL: CEO and Owner

ER: CFO and Owner

LUXIA INNOVATION

Could you provide a brief overview of Luxia's history and main activities?

ER: Luxia, a company of 20 employees, has been in operation for 27 years and grew from a small business run by an artist producing carpets for commercial and residential buildings. In the 1990s, he was approached by Bombardier to work on the CRJ platform and over the years the company's business with Bombardier grew. Francis and I purchased the company three years ago and made the decision to focus solely on aerospace.

How has the government helped Luxia grow?

FL: In 2016, the federal government provided Luxia with C\$100,000 to invest mainly in 3D scanning technology. Because private aircraft owners usually do not have their own drawings of their aircraft, it can take about eight hours to create a template of business jets like the Bombardier Challenger 350. However, the 3D technology we have developed can create a digital template in about an hour. With the help of the government funding, we also updated our ERP system to replace the paper-based system the company had before.

What recent trends have you noticed in the market?

FL: Hard flooring is becoming more popular in aircraft cabins because it is easier to clean. Recycling has also become a theme in the market.

What are Luxia's key objectives in the next few years?

ER: The next step is to penetrate the U.S. market. Luxia works with all the major companies in Canada that would buy floor covering, such as Air Canada and Bombardier. However, there are many more private aircraft owners in the United States compared to Canada which presents a big opportunity. Luxia plans to capitalize on this opportunity either through opening a plant or through an acquisition. We are confident we are the best in the business, which means Luxia will continue to grow. —

Driving efficiency to increase competitiveness: Québec's service and equipment providers

Due to aerospace suppliers' increasing focus on efficiency and cost reduction as they endeavor to meet ramp-ups on existing platforms, companies offering solutions to accelerate timelines and meet these targets are in strong demand. Therefore, whilst many players in the industry are experiencing slower demand due to fewer new aircraft sales, the engineering services segment has seen a great deal of growth. "OEMs need to increase their speed of production as the book of orders keeps growing," commented Fernando Ledesma,

corporate director at AKKA Technologies, an engineering and technology consulting company.

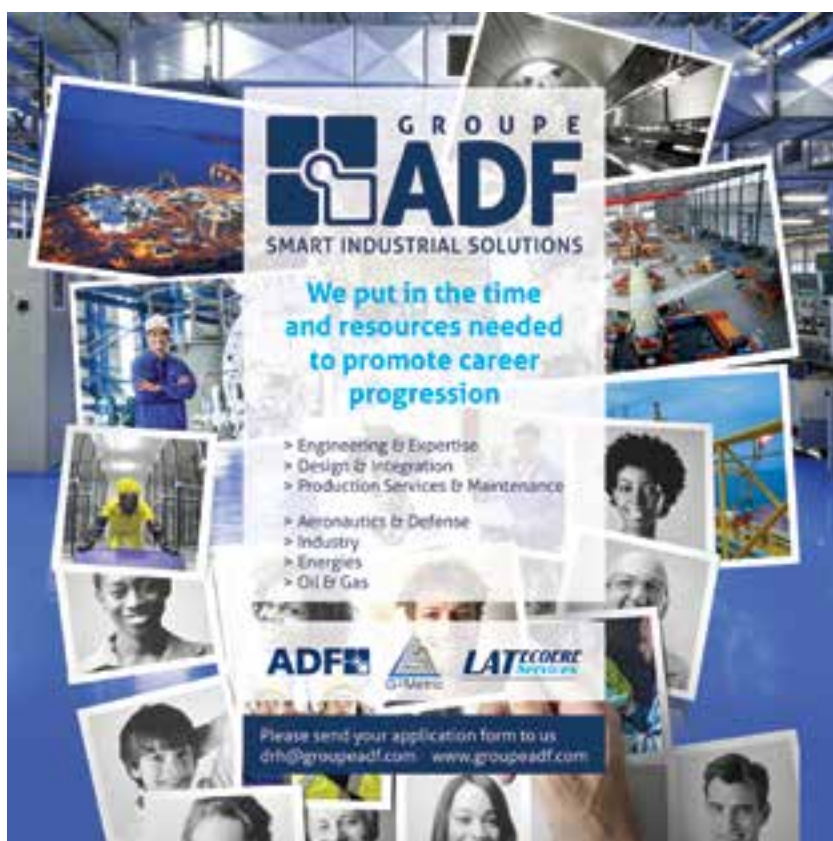
As well as increasing efficiency on existing projects, companies must also adopt more innovative processes in order to be competitive globally and win new contracts. Small companies offering specialized solutions are in high demand, sought out due to proof of fast and tangible results. "There are now more service providers and competitors as it is easier for startups and overseas companies to penetrate the

North American market," said John Mannarino, president at Mannarino Systems & Software Inc. "We have seen more cost pressure from South American and Asian companies, which did not exist before. However, while globalization and lower-cost offshore rates are in demand, the complexity and cost of running OEMs are quite high. We are trying to take advantage of this and offer our expertise in combination with the advantages of higher efficiency and leaner services offered by an SME to win bigger contracts."

Mannarino aims to offer complete turn-key packages, developing complete embedded software packages including certification. The company is the only service-based organization in Canada that is authorized as a Design Approval Organization (DAO) for airborne software and airborne electronic hardware. In recognition of the SME's promise, Lockheed Martin recently invested in Mannarino to facilitate the development of its own proprietary airborne software products. The investment also marks the largest ever made by Lockheed Martin into a Canadian SME.

Whilst many companies want to increase efficiency, implementation of the relevant technologies can sometimes be a challenge. "Advanced manufacturing techniques are gaining ground in the aerospace industry to help meet this challenge," continued Ledesma. "AKKA is working with some aerospace companies to bring the lean manufacturing techniques and the automated processes of the automotive industry into the building of planes."

Echoing the need to address implementation challenges, John Nassr, president at ICAM Technologies noted: "The number one challenge companies have in manufac-



turing is finding affordable engineers with programming skills. Our service targets this need and helps companies cut down on programming and machining time, so that they get parts cheaper, better and faster. There are not many companies like ICAM that are able to bridge the gap between the world of automation, aerospace programming and CNC machines. Our employees have a high level of knowledge of CNC programming, CATIA and SIEMENS systems, CNC machine milling and software. We also provide consultations at customers' facilities and offer them solutions based on the technology available. Customized solutions are the key to offering automation to aerospace."

Alongside customization, scalability is also a key consideration as smaller companies are often unable to make the necessary investments to overhaul their processes. ICAM is now expanding internationally through an established network of resellers.

Equally, companies look to equipment that offers a quick return on investment through increased efficiency and reduction of costs. As equipment generally represents a non-recurring cost, companies are keen to invest in machinery with a quick return on investment (ROI). "With regard to our tooling services, we see a strong demand for high-precision, tight-tolerance parts and components," noted Luis M. Aguilar, business development manager at Avitec Tools Inc. "There is also a big push for more automation projects that re-

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OEMs have spent heavily on developing their current programs and there are few in development, so they have reached a period of the business cycle where they are not selling many new planes. For this reason, they are focusing on productivity, which translates to cost reductions. Safran Engineering Services has therefore received a lot of demand for assistance with improving profitability through weight reduction and identifying other cost saving measures.



- Sylvain Boisvert,
General Manager,
Safran Engineering Services

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quire complex tooling solutions involving robots or other forms of automation. Because tooling equipment is a non-recurring cost, price pressures are not as pronounced as for production parts for example, where cost reduction initiatives must be incorporated into any program, although there is always competition."

Avitec's main business consists of special cutting tools and ground support equipment services as well as high-precision, tight-tolerance, machined parts and components. "With regard to special cutting tools, the most significant changes in demand have been for high quality carbide and Polycrystalline Diamond (PCD) tools, which

improve the durability of tools," added Aguilar. "Responding to these changing needs, Avitec leverages its decades of experience to work on designing new tools using PCD's. One of our main areas of R&D focus at present is on new technologies for supporting PCDs."

Avitec is now focused on developing new markets and expanding its base into the rest of Canada, the United States and Mexico. With high proficiency in innovative technologies and processes, Québec's service companies and equipment providers are well-placed to deliver cost-effective solutions to drive the aerospace sector's competitiveness. —

TRUSTED LEADER IN AEROSPACE R&D AND CERTIFICATION SERVICES SINCE 1983

Marinvent at its core is about research and development. Our flight path is high and strong—in industry leadership, in experience, in innovation, in tools and processes. But we don't fly alone—we're strong in partnerships, in joint ventures, in relationships with aerospace leaders and regulatory agencies too. We develop and license our own Intellectual Property to the benefit of the worldwide aerospace industry, and we help our customers get from design concept to certified market-ready product. We are AS9100 certified and registered under the Controlled Goods Program.

Marinvent supports its new venture, Cert Center Canada in navigating customers smoothly through the complex and costly certification process. And, we share a vision of training excellence in creating Canada's certification professionals of the future.

marinvent
CORPORATION

WWW.MARINVENT.COM

Marc Eliayan

CEO
GROUPE ADF
(LATECOERE SERVICES)



LATECOERE Services Canada, the Canadian subsidiary of French group LATECOERE Services, offers structural and electrical design engineering services. Groupe ADF acquired LATECOERE Services in December 2016.

Groupe ADF recently purchased LATECOERE Services. What services will the newly-formed company provide to aerospace clients?

Groupe ADF wants to offer its clients a total cost of ownership solution, meaning partnering with aircraft manufacturers on projects from design to ramp-up, including maintenance activities and transferring more risk from them to our company. For example, this would involve us partnering with them on the design, materials management and providing engineering services so that they achieve the best quality and on-time-delivery (OTD). In today's market, there is a tendency for aircraft manufacturers to outsource many aspects of development and manufacturing and to purchase engineering services during ramp-up periods. However, this is sometimes not the most effective solution and, with the advent of companies like SpaceX, new modes of production are taking shape. Therefore, we want to position ourselves as a total solution partner to the more established players in the market that can ensure they remain competitive through the introduction of new ideas. Groupe ADF has particular strengths in ground system equipment used to carry out testing of aircraft and engineering services focused on increasing productivity. LATECOERE Services was acquired to broaden the company's service offering, especially its Engineering and Expertise services, and thereby offer a more total solution.

Who are you typical clients in the aerospace sector?

Generally, we work with OEMs such as Safran, General Electric and Airbus. In Québec specifically, we work with Bombardier, CAE, STELIA Aerospace and Arconic. We are looking to establish a subsidiary in the United States by the end of 2017 to increase our presence there. We have begun providing total cost of ownership solutions to our European clients and we now want to extend this offering to our clients in Québec.

Aircraft manufacturers are currently focusing on improving productivity and reducing costs as new orders for aircraft have slowed. How does Groupe ADF help them reach these goals?

Groupe ADF works across many different industries so we can see what has worked well in one industry and apply it to another one, such as aerospace. For example, we leverage our experience in helping improve OTD and time-to-market in the oil and gas, automotive and micro-electronics sectors to inform the services we provide to aircraft manufacturers during ramp-up periods where OTD is crucial. Alongside this, we have employed a successful lean manufacturing policy for the last 12 years. Groupe ADF also has a strong innovation policy. For example, we have several partnerships with robotics companies to develop robot end effectors that can carry out welding, splitting and other functions, helping companies to improve their productivity. G2Metric, a subsidiary of Groupe ADF, is developing automatic vision technology which will replace manual quality inspection.

Could you provide more detail on your services to the space industry?

LATECOERE Services has a long history of assisting in the development of satellites. We have a white room in which we can assemble satellites and we have been very involved over the years with companies like Thales, CNES and Airbus in developing the pilots in new series of satellites. These projects involved a lot of manpower and little automation. However, we are now a partner on the OneWeb satellite constellation where for the first time we are building satellites in an automated assembly line that will produce one satellite every day. The project will ultimately consist of 900 satellites, with 600 in the air and 300 substitutes. On the Ariane 6 European Program, LATECOERE Services is widely involved in the assembly lines in France, Germany, French Guyana (Kourou) and on the cryogenic umbilical arms on the launch infrastructure zone.

How do you expect the space industry to evolve going forward?

The space industry is fundamentally changing as there are many more private programs, whereas before public programs dominated the industry.

What are your key goals for Québec in the next three to five years?

We want to triple the size of our company in Canada and diversify our service offering beyond engineering services. This will include the development of work packages to install assembly lines, special equipment to support the production of testing in the space and aeronautics sectors, as well as all of the further services Groupe ADF provides in other locations. —

Jean-François Hamel

President

PCM INNOVATION GROUP



PCM INNOVATION. (PCM) is a specialist and leader in engineering and tooling for the aerospace industry. PCM INNOVATION acquired TechFab in April 2016.

What were the motivations for PCM INNOVATION's acquisition of TechFab?

The acquisition allowed the company to obtain new technology for aeroengines, such as turning technology and gun drilling. It also increased PCM's capacity to handle large assembly lines and brought the company geographically closer to its customers. We have done this by focusing TECHFAB's facility on tooling for aeroengines and large assembly tooling for aerostructure manufacturers and OEMs.

What other major developments have occurred since 2015?

In September 2015, PCM became the owner of Halberg USA, specialized in aeroengine tooling. This gave PCM its first footprint in the United States and increased its engineering workforce to 55 employees that are mainly dedicated to our core business in tooling, tooling design and fabrication for aerospace. In November 2015, PCM also began managing tooling operations for Bombardier in Querétaro, Mexico, as part of a long term contract. Last month, we opened our own facility in Querétaro to provide services to more customers.

Demand for tooling in Mexico is advancing as the autonomy of the OEMs' divisions there is becoming greater. However, most tooling purchases are still made in developed markets, so the market in Québec is still robust. PCM therefore plans to use its Mexico operations both to target the Mexican aerospace market and to leverage the cost advantage to supply the North American market.

OEMs are demanding more integrated services. How important a factor was this in the acquisition of TechFab?

The acquisition of TechFab is indeed an example of integration, as it added supplementary manufacturing of tooling to our portfolio, whereas we had previously relied on the supply chain. Integration was also the precise reason behind the acquisition of Halberg Design, reflecting our strategic goal of positioning the company as a tooling integrator. There is no other tooling integrator in Canada besides PCM that holds engineering and fabrication capacity for many different types of tooling.

How has demand shifted since 2015 and how has PCM responded to increasing cost pressure?

Cost pressures are somewhat different in tooling, which represents a non-recurring cost. The market is driven more by knowledge and the ability to deliver. We are therefore focused on ensuring we excel in these areas. This includes having the ability to manufacture tooling ourselves, whilst sub-contracting some products in lower-cost countries. There is a very strong trend towards larger packages of tooling, total risk transfer to the supplier and full integration. As a result, companies like PCM are providing less individual tools and more total solutions for entire assembly lines, including design services.

Is PCM using any new processes to improve efficiency?

PCM has strengthened its capabilities in laser technology, 5-axis machining of tooling and composite tooling. This has allowed the company to provide solutions for satellites and aeroengine composites. We would also like to offer Industry 4.0 solutions to our customers, such as automation and intelligent manufacturing and are strengthening our services in these areas.

What does consolidation in the supply chain mean for PCM's business?

In terms of our customers, it will be positive for us because it will mean they are bigger and stronger and will demand more sophisticated tooling solutions. Consolidation among tooling and engineering companies is also a good thing because we are prepared and are therefore well positioned to take advantage of the trend. In line with this, PCM decided a few years ago to acquire other companies and position itself as a small international integrator. Our business plan will put us in a position to compete with the bigger tooling companies in the United States in the next few years.

What will be the main areas of focus in R&D for PCM going forward?

Aside from automation and intelligent manufacturing, PCM is investing in composite capabilities as the composite content of aircraft is still growing both in terms of complexity and quantity. PCM also invests to stay ahead of advancements in machining technologies and is monitoring additive manufacturing techniques, although the business case is not strong enough to invest in this yet. —



Mark Makoukji

Managing Partner
P3 GROUP

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P3 Group (P3) is a service and consulting company that specializes in engineering and project management for the aerospace, automotive, telecommunication and energy industries.

Could you outline the importance of aerospace to P3's business and your main activities in the sector?

Aerospace accounts for nearly half of our global revenues across the 14 countries in which we are located. We work with the Big Four commercial aircraft manufacturers—Airbus, Boeing, Bombardier and Embraer—as well as with Tier 1 and Tier 2 companies and occasionally with other levels on behalf of the OEMs.

Traditionally, P3 has been a consulting company. Our experience managing Airbus' supply chain gave birth to our engineering business, which has grown to represent half of our headcount. We work a lot on cabin engineering, electrical wiring, structural design, stress analysis and advanced aerodynamics. The European Aviation Space Agency (EASA) has also granted us Design Organization Approval

(DOA) status meaning we can make modifications and approvals of aircraft on their behalf.

As airlines increasingly focus on the customer experience, what trends have become apparent in cabin engineering?

We envision a world in the near future where airplanes are a platform on which different applications and experiences can be accessed onboard. This is becoming increasingly important for passengers and will completely revolutionize the way we travel. The increased use of cell phone applications for completing daily tasks will naturally translate into aircraft. In the future, passengers will simply 'google' their destination then customize their trip according to their unique entertainment, dietary and seat pitch preferences. It will no longer matter what airline seat one chooses, rather what one can do with the seat. Different seating configurations are also being discussed by airlines, including benches and standing room to fit more people per flight. As companies start designing open-platform aircraft where customizations can be made easily and affordably, innovation will continue to snowball. P3 is actively investing into the cabin space. Through our new subsidiary, P3 aero systems GmbH, we are at the forefront of providing consulting and engineering support for companies that want to move towards greater customization. We are also working on developing airport applications and benchmarking them according to their improvement of the customer experience prior to boarding. This will be the differentiating factor for airport service providers in the future and those ahead of the curve will have a lot more success than those that adhere to the traditional approach.

To what extent does P3 take on a collaborative approach to innovation?

P3 is a spin-off from the Fraunhofer Institute for Production Technology (IPT), so our roots stretch back to academic research. We collaborate with many European universities and provide annual innovation scholarships. Annually, P3 and the German government jointly sponsor an innovation challenge, whereby the country's best and brightest minds are offered the chance to change the way we fly, and are given a national stage on which

to showcase their ideas. Traditionally, we hire many of our employees directly from universities to engage students at an early point in their careers, get the best talent and immerse them in our culture, of which innovation is a key part. In the US market, P3 opened an innovation center in Portland, United States, in March 2017, which features a help center for startups to exchange ideas and launch their products. P3 places a lot of importance in being at the forefront of developments and maintaining its open-mindedness.

How do you expect Industry 4.0 to transform the aerospace supply chain?

Automation is completely changing the industry. We are investing further into these technologies, which continue to shape the way we work in the manufacturing and engineering sides of our business. We help support companies by developing augmented reality applications to help train their teams, and we're helping to improve manufacturing processes by automating work orders, and other innovative solutions. P3 Digital Systems, a Romanian company recently acquired by P3, produces many of these applications for our customers, including the augmented reality aspects.

What are the key objectives going forward?

Our customers have asked us to focus on the cabin space and are accordingly investing in the development of new products in this area. We are in the process of acquiring a business in Switzerland to strengthen our commercial and VIP cabin design capabilities. This will complement our aero systems division which is focused on connectivity and mobility. Additionally, although we are a service company, we keep an open mind regarding the development of new products, especially for under-served niches.

Our next big focus is the implementation of Industry 4.0 into the engineering world, helping our customers understand what that means to their product lifecycle and making sure they plan accordingly. Aerospace plays a big part in our growth plan and our two biggest growth markets are North America and India. We are focusing a lot of energy on our North American customers, particularly Bombardier and Boeing. —

Phil Cole & John Maris

PC: President

JM: VP Business Development

**MARINVENT AND
CERT CENTER CANADA**



PC



JM

Marinvent provides consulting, services, training, tools and IP to reduce customers' program/product risk, cost and schedule and to help them innovate quickly.

Could you provide a summary of Marinvent's history and main activities?

PC: Marinvent was borne out of an idea to improve the efficiency of flying, stemming from John Maris' previous experience as Program Manager for the Canadarm 2 work station, a test pilot and Commander of search and rescue aircraft. In essence, our work comprises the creation of IP that addresses industry challenges. The primary goal of the company has always been to assist the development of the aerospace industry rather than to be purely commercial. 30% of our activities are volunteer work and we invest 80% of our revenue into R&D, driving our creativity and innovation.

JM: We are an extremely international company and very agile. The bedrock of our business is the talent and breadth of experience of our 12 employees; one of our employees wrote the telemetry system for the Mir space station, for example, and another certified the most complex ever cross-platform system for electronic charting which has become the world standard. We sold the license to this standard to Jeppesen, leading to its acquisition by Boeing for C\$1.5 billion. Although we are a small company, we work with some of the world's largest contractors. Thanks to our Transport Canada Design Approval Organization (DAO) accreditation, we are also able to audit and certify their products.

What are a few of Marinvent's flagship products and notable projects?

PC: We have developed IP that is two to three generations more advanced than the original

IP we licensed to Jeppesen. Our exclusivity agreement has recently expired, presenting a big opportunity in this area. Secondly, we have developed a set of software tools called Synthesis®. This product was initially intended to support clients in the planning, optimization and management of flight test certification programs. Since its launch, we have broadened the product's offering to include all aspects of certification in both commercial and defense applications for aerospace and are broadening it further for shipping, automotive, rail, medical and other sectors. Synthesis removes the reoccurrence of testing that currently occurs at every single step in the supply chain by storing information on any previous testing completed on a product. As well as increasing efficiency of testing in complex supply chains, Synthesis is also perfect for bringing together players in different locations, as may be the case when companies collaborate or form consortiums.

JM: Another product in our portfolio, an extension of my Master's thesis, is APM, an electronic alternative to the wind tuft that analyzes the air flow around an aircraft's air foil. APM calculates the needed thrust and angle of attack to maintain an aircraft's lift under different weather conditions in order to prevent stalling. APM is hugely beneficial to the safety of air travel; presently, pilots have no accurate tools to measure air around an air foil—a problem recognized as a top-five safety risk by the U.S. National Transportation Safety Board. It is particularly advantageous in icy conditions where ice can disrupt airflow on the air foil. APM is also being deployed in UAVs and will soon be implemented on wind farms. Unfortunately, uptake among aircraft manufacturers has been slow thus far due to the sensitivities involved in acknowledging the shortcomings of current technology.

Marinvent is a strong proponent of government-supported consortiums in the aerospace industry. Could you explain your stance?

JM: Much of my work as Chair of AIAC last year and as chair of the small business working group involves promoting the consortium model in Canada's aerospace supply chain. As part of this, AIAC has produced a best practice guide for SMEs based on international case studies. Whilst government support of the Big Four OEMs is essential as they are too big to fail, the focus needs to extend to the SMEs to a greater extent to maintain Canada's competitiveness. The Big Four OEMs are public companies whose focus must be on reducing cost and time to market as a priority. Government funding, an integral component of a thriving industry, can therefore end up being rationally invested in lower-cost jurisdictions to create the best return on investment for shareholders. Ironically as a result, government investment in OEMs often does not lead to investment in Canada's SMEs but rather to increased offshoring for the industry as a whole. The solution is for the government to break the loop by creating an aerospace policy that encourages a more strategic investment distribution across the whole sector to encourage SMEs to grow and prosper.

What are the key objectives for Marinvent and Cert Center Canada going forward?

JM: Marinvent's objective is to grow through investment, as well as provide services for 3C. With regard to 3C, the foundations are in place, and it now needs to be supported by outside players to become a national resource. As we are a small company, we cannot afford all of the early set-up costs of the Center on our own to ensure it grows, making support from the government and potentially the OEMs essential. —

Safety first: Optimizing inspection, testing and maintenance measures

An integral step for any aircraft prior to entering service is the evaluation of its performance and safety. Whilst companies may pursue cost reduction, quality and safety are aspects that will never be compromised. Companies operating in the testing and maintenance and repair overhaul (MRO) spaces or offering technologies to enhance inspection and testing processes will therefore continue to be integral to aircraft manufacture and operation.

Inspections, testing and maintenance are becoming ever more sophisticated, particularly thanks to developments in simulation and predictive maintenance. Accuracy of inspections is now being increased through the introduction of robotics to reduce human error, whilst also increasing efficiency of the task at hand. Radix Inc., headquartered in Ontario and part of the Active Industrial Solutions (AIS) group, provides customized software which enables companies to visualize and collect data and provide traceability on employees' work activities to improve their task efficiency. "Radix's tools save clients time and improve process efficiency," highlighted Michael Muldoon, Director of Aerospace Operations.

Two of Radix's main products are Tool Tracker and Inspect Tracker; the latter is an integrated, vision-based system for manual inspections. "For example, Inspect Tracker can reduce inspection time by 50% and results in more accurate data and ultimately improves the quality of the products our clients produce," commented Muldoon. "It

also improves their own client communication through the data collected by our tools and shared with other systems. Whilst we develop our software to address as many challenges as possible, we also partner with our clients to provide custom solutions." Radix is starting to utilize artificial intelligence (AI) and augmented reality technologies in its solutions and aims to grow its aerospace division from 10% to 25% of the company's business.

Meanwhile, simulated environments are at the fore of non-destructive testing (NDT). "Independent research shows that using an integrated simulation platform results in a faster development time (nine times faster) and reduced overall product costs (four times less expensive)," highlighted Paolo Colombo, global aerospace & defense industry director at ANSYS NTI, the global leader in engineering simulation software. "Overall, companies using an integrated simulation platform are 26% more likely to meet product cost targets. 20 years ago, simulation was only utilized by experts, but an increase in automation and a reduction in required training have made it more accessible."

Canada is home to ANSYS' development offices and center of expertise for aerodynamics, including de-icing and icing prevention simulation. Tools such as ANSYS Integrated Multiphysics (AIM) aim to empower companies to deploy simulation at the pre-design phase, which would lead to a significant decrease in development costs.

Optimizing in-service support

The uptake in health-monitoring technologies has been particularly impactful on increasing efficiency and reducing support costs by decreasing aircraft downtime and

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Industry 4.0 can make the biggest impact on MRO turnaround by streamlining and automating communication between OEMs and Tier 1s and the rest of the supply chain.

- Lorenzo Marandola,
Manager,
Business & Technology Development,
M1 Composites Technology Inc.



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Countries such as China, Russia, India and Japan are hot on the heels of Canada in terms of aerospace. Since only certifying bodies in Canada, Europe, the United States and Brazil are currently recognized worldwide, Canada has an advantage of a few years. However, since this barrier will only last so long, there is little stopping emerging countries reaching Canada's level of expertise.

- John Maris,
President,
Marinvent and Cert Center Canada



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part replacement through an understanding of a part's defects and resulting lifetime. “We will be able to follow the complete life of a part—we digitalize the surface of the part so we know exactly where the potential defects are,” outlined Jean-François Dupont, CEO at AV&R, a firm specializing in automation, vision and robotics. “Following a cycle, we will re-inspect the parts during the maintenance overhaul and compare the surfaces with the originals. This will allow us to monitor any deterioration and predict defects over the life of a part. In our extensive database, we will then be able to find where all these parts are involved and will be able to ground only the one plane with a potential defect. Normally, an engine is verified with all tests done on a computer with parts modelled after their initial design. All simulation parts are perfect. We will be able to simulate the real engine, recreating its real performance.” Greater utilization of Big Data will also drive more effective fleet management. For example, CEL Aerospace, a leader in aviation engine test cells and accessories test

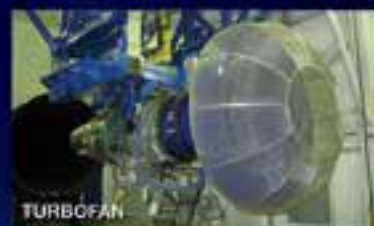
benches, has introduced new-generation component stands for fuel control units and other engine accessories with a fully integrated Data Acquisition and Control System. “Now in service at P&W Poland and P&W Aeropower in West Palm Beach, our fuel control stands offer a testing environment with a higher level of accuracy and test parameter stability for a single shot data capture, so the quality of data is much higher and is well documented,” explained Claude Lauzon, corporate vice president at CEL Aerospace. “The system converges to the DAS' data point and we can also offer an automated test routine from beginning to end. Again, it is all about our customer effectiveness and efficiency. This is being introduced in fuel nozzle test stands too.” In response to China's emergence as a force in engine R&D and maintenance, CEL is pushing its growth into the Asian market, starting with a Service and support offering out of Singapore in late 2017.

Safety, certified

Attaining the required certification credentials can be extremely challenging and cost-heavy, particularly for SMEs. Furthermore, certifiers themselves are difficult to retain due to the cyclical nature of aircraft development. “Certification accounts for approximately 80% of the development costs of an aircraft and so represents the biggest risk to OEMs' bottom line,” asserted Phil Cole, vice president, business development at Marinvent and Cert Center Canada. “A major challenge is that OEMs' delegates are only licensed by Transport Canada for their own OEM's products and are therefore unable to speedily transfer to another company.”

The recently-established Cert Center Canada (3C) seeks to reduce the loss of knowledge by registering and housing certification staff under its own name.

Whilst a great deal of R&D expenditure is funneled into innovation on aircraft themselves, OEMs and aircraft operators rely heavily on the services of supporting industry segments to ensure optimal performance and maintenance in the longer-term. Technology developments leading to health monitoring and predictive maintenance will also secure cost savings further down the line through a reduction of unnecessary maintenance work. —



TURBOFAN



TURBOPROP



APU



CEL DAS™

Building Test Solutions

We design, develop and commission fully integrated aviation gas turbine test cells for OEMs and Independent Maintenance Organizations; we specialize in APUs, Turboprops, Turbochaffes, small and mid-size Turbofans. Our expertise also covers related systems and components, for aerospace and industrial applications. CEL is headquartered in Canada with capabilities in Poland and the USA; we are 80 people strong and have delivered over 700 projects over a quarter century.

CEL is a project-oriented company. It is structured to perform consistently at all levels of its diverse service and product offering, from the design of state-of-the-art test cells and data acquisition systems to the delivery of operational turnkey test facilities, anywhere in the world.

OEM relationships and Test cell developed with:
GE – HONEYWELL – LHTEC – P&W AEROPOWER –
PRATT & WHITNEY CANADA – ROLLS ROYCE – SAFRAN
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Paolo Colombo

Global Aerospace &
Defense Industry Director
ANSYS NTI

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ANSYS produces engineering solution software.

Could you briefly introduce ANSYS and its global operations?

ANSYS is the global leader in engineering simulation software. Established 47 years ago in Pittsburgh, ANSYS is now present in more than 80 countries worldwide through direct offices and technology partners. Canada is home to ANSYS' development offices and center of expertise for aerospace aerodynamics, including de-icing and icing prevention simulation. Our speed, accuracy and the ease of use of our software improve engineering productivity while lowering the cost and risk of innovation. Our platform is constantly updated. Of approximately 3,000 employees globally, one third work in research and development, where we invest around 18% of our annual turnover.

Along with automotive, energy, high-tech and healthcare, aerospace and defense is a key industry for ANSYS. We address many engineering aspects of aircraft design using a single, open and seamless simulation platform. Not only do we perform coupled physics-based simulations such as structural, aerodynamic, thermal and electromagnetic analysis, but we also simulate aircraft control and display software and automatically generate it to FAA standards, thus checking the entire system performance of the aircraft through a digital prototype.

What is new in ANSYS 18?

The pace of innovation in the engineering software space is extremely rapid. Every year we deliver a major software release, with step changes in new capabilities and workflows. Within every new release, we integrate newly acquired codes so customers can test a complete digital prototype and save time and money. The integrated workflow results in a much lower total cost of ownership of customers' overall simulation environment.

Some of the key ANSYS 18 developments for aerospace companies include a better solution for automatic topology optimization that supports additive manufacturing, improved Reduced Order Models and technology that supports customers in their journey to the digital twin. We have improved tools like ANSYS Integrated Multiphysics (AIM) to empower companies to deploy simulation at the pre-design phase, and we now automatically create embedded control software for critical applications already certified ac-

cording to DO-178 standard (up to level A) and test it into our simulation platform. This process reduces the cost and time for embedded software certification by as much as 50% compared with more manual methods, saving months or even years of work. ANSYS looks forward to sharing more news when we announce ANSYS 19.

What other advantages can the software offer?

Increasing product complexity is a top challenge for most aerospace companies that are looking for competitive differentiation with limited resources. The three most important advantages include a reduction in overall cost, a reduction in development time and decreased risk of innovation.

Independent research shows that using an integrated simulation platform results in a faster development time (nine times faster) and reduced overall product costs (four times less expensive). Overall, companies using an integrated simulation platform are 26% more likely to meet product cost targets. Twenty years ago, simulation was only utilized by experts, but an increase in automation and a reduction in required training have made it more accessible. With AIM, which is fully automated and workflow-based, we hope engineers will use simulation at the beginning of the design process, leading to a major decrease in development costs.

What are the next stages of development and key objectives for ANSYS?

ANSYS vision and strategy has remained constant for over a decade. We enable our customers to create a complete virtual prototype of their product in its operating environment that uses an integrated simulation platform based on the best solvers on the market and is extensively supported by experienced people. As part of this strategy, we constantly engage our customers, industry consortia and leading universities to work on what is next, like digital twins, autonomous systems, electrification and artificial intelligence. This ensures that we meet the needs of the industry—not just today, but for the future. Beyond the additional capabilities, we continuously improve our entire platform adding speed, reliability and ease of use to all our tools. The connections between the software disciplines are also very important: we need to simulate even more complex systems and make it even easier to retain, manage and reuse the knowledge from all this simulation effort. ■

Claude Lauzon

Corporate VP
CEL AEROSPACE



CEL is a leader in design, build and deliver turnkey, OEM compliant, aviation engine test cells and accessories test benches for turbopropeller, turboshaft, small & medium turbofan and APU applications.

CEL is coming up to its 30th anniversary next year. Could you briefly introduce the company and how it has developed?

CEL was founded by Charles Emile Lussier, an ex-director for Pratt & Whitney Canada (P&WC) with expertise in design, development, build, project management and installation of test cells. Our genesis was with P&WC; we built test cells and rigs directly for R&D, engine production and post-maintenance testing. For some time, 75% of our business was in P&WC's ecosystem, and 80% of the time we were adding new engines. More recently, for sustainability, we entered into other OEM eco-systems, with an intent to add one OEM per year to our portfolio. Today, our business is diversified between General Electric, Honeywell and P&WC/P&W Aeropower, on top of having designed and delivered Test Cells for RR, Safran and LHTEC engines.

Has the competitive landscape developed much in recent years?

On small engines, there are a few companies working in niche segments but, in terms of integrated solution providers with mechanical, instrumentation and software capabilities across small engine types, there is a handful of players including ourselves. There have been, however, changes in the market share and we are now number one in APU and one or two in every other market segment that we serve.

What are some of the different considerations between different engine types?

A helicopter engine testbed requires a high-technology solution due to its high output speed, power range, engine control and data acquisition. Our ability to make an advanced test cell for helicopter engines is clearly demonstrated our third T700 helicopter engine test cell, recently awarded by TAI in Turkey, on top of our P&WC/RR/Safran Engine applications. All engine OEMs are significantly developing their existing engines or launching new ones every year. Therefore, in order to be able to serve in the R&D segment, we need increasing capabilities with the latest R&D measurement techniques.

Could you elaborate on the CEL CELDAS™ Data Acquisition

and Control System and some of its advantages?

Customers value the engine OEM compliance, on top of quality of data and reliability of the system, and this is what we have historically delivered in both software and instrumentation with CELDAS™. With OEMs in the R&D environment, and some other applications, more flexibility is required; in response, we are adding an increasing amount of COTS building blocks, and a toolkit that allows real time reconfiguration of the displays, algorithms and plotting routines. We also provide Internet-based communications, meaning that any test or performance engineer can look at the data in real-time remotely, with the same flexibility. Being able to change the parameters in real-time improves the efficiency and effectiveness of the testing.

What new technologies are coming into play?

We introduced new generation component stands for fuel control units and other engine accessories with a fully integrated Data Acquisition and Control System. Now in service at P&W Poland and P&W Aeropower in West Palm Beach, our fuel control stands offer a testing environment with a higher level of accuracy and test parameter stability for a single shot data capture, so the quality of data is much higher and is well documented.

Where would you like to see the company in a few years?

CEL is an unsung hero in its own technology niche, with over 80 employees currently, and we are globalizing. After CEL Aero USA (2015) and CEL Poland (2011), CEL's growth in Asia is now a key focus. We have several active test cells to support, maintain and upgrade in Singapore, China and Indonesia with more coming in the near future. China is an emerging force in engine R&D and Maintenance; to that effect, CEL Asia is in the startup phase, and will initially be offering Service and Support in the region, out of Singapore, later in 2017.

Longer term, we are still in a position to grow organically, doing more of what we do and doing it better for more OEMs, MROs and fleet operators across Civil and Military markets. Beyond this, we are exploring adjacent markets and assessing organic Vs non-organic growth. Operationally, to continue to evolve our own product offering we have an initiative to standardize our products with repeat-sales potential to reduce non-recurring cost and acquisition costs for our customers. —





SPACE



“Over the years, Canada has developed a very positive reputation due to its delivery on missions at a much higher quality than required and within the timeframe subscribed, making it highly competitive. Canada is a strong partner in international space programs and its international reputation for space development opens a lot of doors for our industry to participate on international missions and to export their goods to international markets.”

- Sylvain Laporte,
Chief Executive Officer,
Canadian Space Agency

Punching above its weight: Québec's space industry

Canada has an impressive track record in space, entering into the Space Race in 1962 with the launch of the Alouette-1 scientific satellite, becoming the first country after the Soviet Union and the United States to construct a satellite. With a particularly strong legacy in space robotics and satellite communications, the country is perhaps best known for spearheading the Canadarm project. Canadarm 1 was used in NASA's Space Shuttle program in the 1960s to deploy, maneuver and capture payloads. Canadarm 2, launched in 2001 and still active, was used to assemble the International Space Station (ISS) while in space and is now used to move supplies and equipment.

To this day, Canadian technology is used in 80% of all commercial satellites launched internationally. RADARSAT-1, launched in 1995 and led by the Canadian government, provided the world with large amounts of earth observation data. RADARSAT-2, still active, built on its predecessor's success with enhanced marine surveillance, ice monitoring, disaster management, environmental monitoring, resource management and mapping in Canada and around the world. The project took place as a unique collaboration between the Canadian Space Agency (CSA) and Canadian industry. MacDonald, Dettwiler and Associates Ltd. (MDA) owns and operates the satellite and ground segment, whilst the CSA contributed to the funding of the construction and launch.

Québec makes an outsized contribution to Canada's space industry relative to

its size. Overall, the province represents around a third of Canada's space industry, accounting for C\$1.67 billion of a total of C\$5.3 billion in revenues in 2015. "Over the years, Canada has developed a very positive reputation due to its delivery on missions at a much higher quality than required and within the timeframe subscribed, making it highly competitive," stated Sylvain Laporte, the CSA's president.

In addition, Québec's space ecosystem spends C\$77 million each year on research and development.

CSA and MDA: stalwarts of Canada's space industry

With its headquarters in Saint-Hubert, Québec, the CSA is a symbol of the province's capabilities in space. From here, the CSA's flight controllers operate the majority of Canadarm2's maneuvers and crew members of the International Space Station (ISS) train how to operate the MSS once in space. L-3 MAPPS, a Montréal based company and a supplier of control and simulation solutions for space, built the simulator the CSA uses to carry out this training.

Drawing on an annual budget of C\$360 million provided by the federal government, the CSA has had three main mandates since its founding: promoting the peaceful use and development of space activity; advancing the knowledge of space through science; and ensuring space

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The CSA, provincial and federal governments are generally supportive. The challenge for us in Canada is that our country has relatively modest means when compared with the countries where our main competition comes from—the United States and Europe—largely because Canada does not have a large domestic commercial or military market. We therefore need to develop robust export markets. With Canada having been an early pioneer in satellite communications, the sector has not recently been a priority for the Canadian government. As a result, we are at a disadvantage compared to our competitors in terms of industrial returns to Canadian industry for its government spending. This seems to be changing, but we have lost precious time.

- Joanna Boshouwers,
Vice President and
General Manager,
MDA



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As of 2015,
total revenues for the space
industry in Canada were about

C\$5.3 billion

Revenues in Québec

**C\$1.67B
in 2015**

(almost on third of Canada's total)



Revenues in Québec (2014-2015)
decreased by

7% or C\$130M



Exports increased by

11%

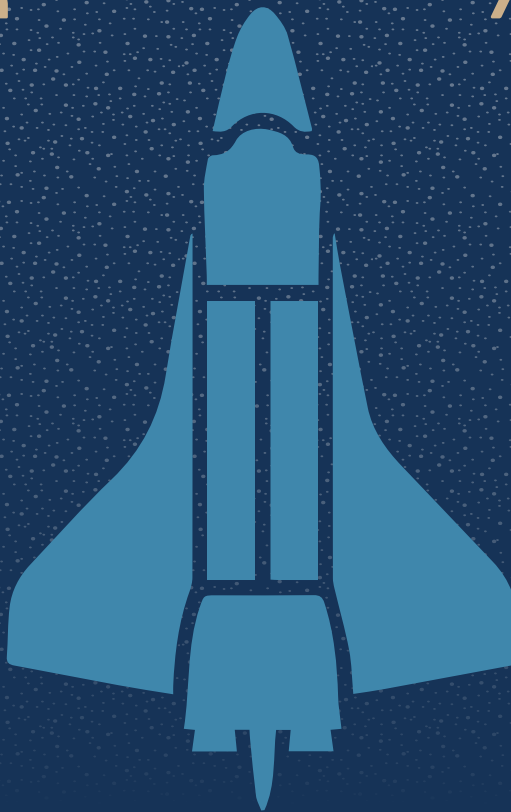
over the last five years,
from

C\$202M

in 2010 to

C\$225M

in 2015



The Canadian
space workforce totaled

9,927

space-related full-time
equivalents (FTEs) in 2015

Québec represented

33%
(3,298 FTEs)

There are about

163 organizations

that deal with space in Canada

41

of which are based in Québec



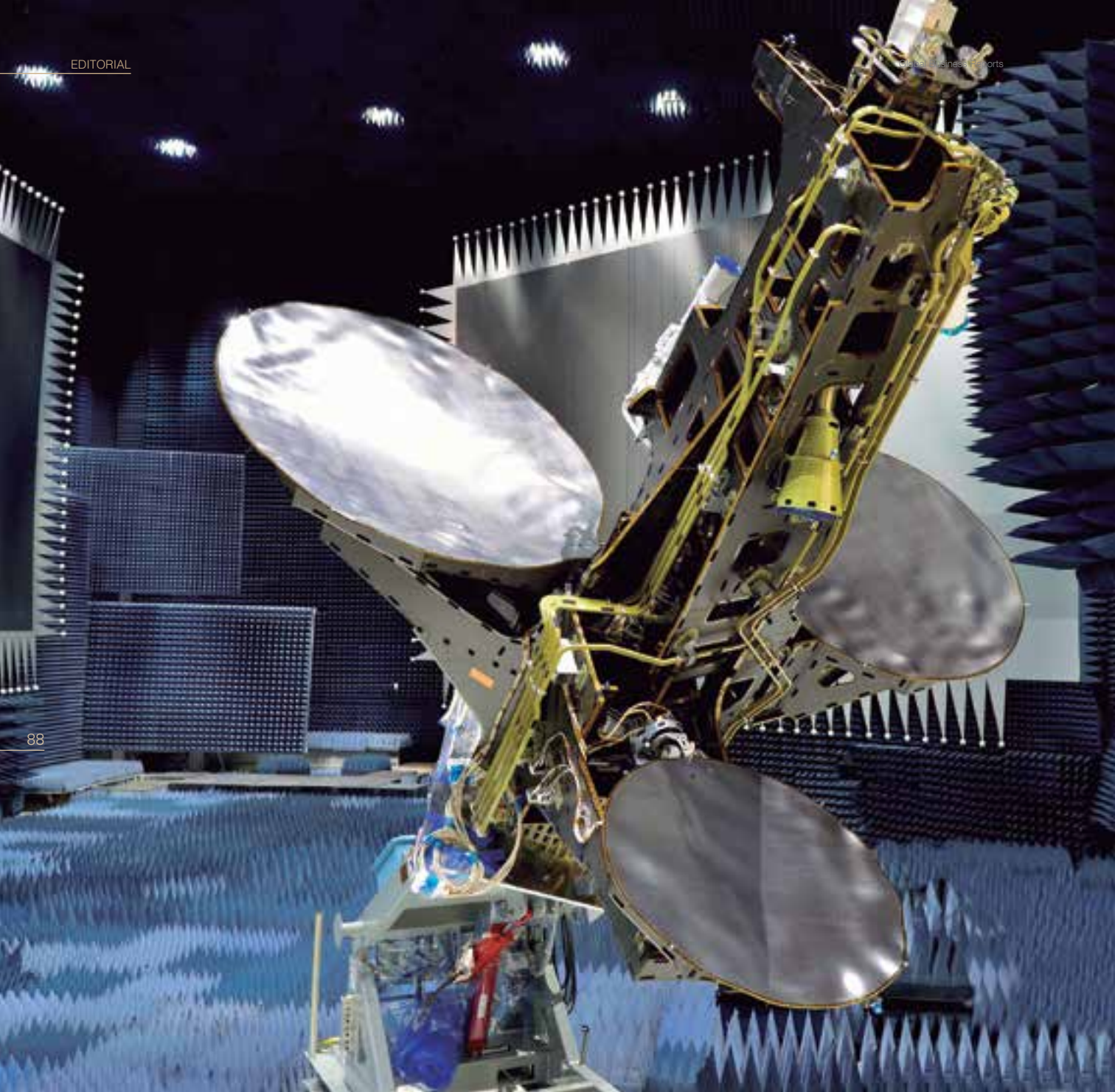
The 163 organizations spent

C\$256 million

on R&D in 2015,

C\$77 million

from Québec's players



88

◀ 84

science and technology brings social and economic benefits to Canadians. Its role in the space industry has changed over time as the space sector has matured. About 10 years ago, for example, it stopped building satellites, devolving this responsibility to the private sector. The CSA now focuses more on providing R&D funding and supporting numerous private companies involved in producing payloads for satellites.

Headquartered on the other side of the country in Richmond, British Columbia,

MDA has a history in space stretching back 50 years with involvement in more than 200 space programs. These include many of the world's premieres in satellite services such as Anik A (first domestic communications), Anik C (first direct forecast), MSat (first mobile communications), and RADARSAT-1 (first commercial radar). MDA also developed the Mobile Servicing System (MSS), the suite of robots on the ISS that includes the Canadarm.

MDA's satellites subsystems business, based in Montréal, is a key driver of Qué-

bec's success. The company employs over 800 highly-skilled employees in Montréal and has a 365,000 square foot facility with state-of-the-art integration, assembly and test capabilities. Through its own investment and external investment of C\$48 million mostly in the form of loans from the Québec government, MDA is also developing the Satellite Center of Excellence. This center will provide support to the next generation of technologies believed by MDA to be essential in addressing the changing needs of the satellite communi-

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Canada and Québec have some of the most pre-eminent space companies in the world. MDA has carried out outstanding work and rightly has a strong international reputation. They, along with the CSA, drive the industry and are supported by a strong network of SMEs. We hope that there will be a Canadian-led constellation project driven by these players.

- Jane Bachynski,
President,
MPB Communications



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cations sector. “This investment will also ensure that industry can develop a steady stream of young Québec engineers able to provide continuity to the workforce,” commented Joanna Boshouwers, MDA’s vice president and general manager.

Québec’s SMEs: an outsized contribution

Although MDA and the CSA remain key players, Québec’s success is increasingly

underpinned by a network of SMEs. Almost one third of the 163 Canadian companies dealing with space are located in Québec and, of these, 95% are SMEs. NGC Aerospace is a stellar example of an SME making waves in the space industry. While the company has less than fifteen employees, it has designed and deployed artificial vision and Guidance, Navigation and Control (GNC) systems for satellites, landers and rovers in numerous missions, most recently on the European Space Agency’s Sentinel 3A satellite.

Québec also has strong expertise in the field of optics and photonics. Companies and organizations such as ABB, which focuses on optical-based analyzing and sensing instruments, and the National Optics Institute (INO), which specializes in optic and photonic solutions for SMEs and large corporations, are some of the larger players in this field. However, many SMEs also operate in this area, and the INO itself has spawned numerous start-ups.

The international space industry is currently undergoing a rapid evolution as the size and development cost of satellites has decreased. “The development of constellations represents a paradigm shift in the building of satellites. Previously, organizations built one large satellite per mission but now they build hundreds and sometimes thousands of smaller satellites, which has fundamentally changed the dynamics of satellite manufacturing,” commented Laporte.

Influenced by this revolution, Québec’s space sector is undergoing a period of change. Total revenues in Quebec declined by 3% from 2010 to 2015 but exports increased by 11%, from C\$202 million to C\$225 million, in the same period, painting a mixed picture. Québec’s ecosystem has twice as many upstream companies—companies devoted to sending objects into space—than downstream companies—companies which use the research and technology from upstream activities for various applications—but downstream activities made up 87% of the sector’s revenues in 2015. This reflects the increasing commercial applications of space data and technology, a shift which will shape Québec’s space industry for years to come. —

Sylvain Laporte

Chief Executive Officer
CANADIAN SPACE AGENCY



Established 1989, the Canadian Space Agency (CSA) is committed to leading the development and application of space knowledge for the benefit of Canadians and humanity.

Could you provide a brief introduction to the CSA and how it interacts with companies involved in Canada's space industry?

Although the CSA is relatively new by historical standards, Canada has been very active in space from the early 1950s onwards. Since its founding, the CSA has had three mandates: promoting the peaceful use and development of space activity; advancing the knowledge of space through science; ensuring space science and technology brings social and economic benefits to Canadians. We execute these mandates by concentrating our work in three main areas: space exploration, utilization of satellites and building capacity. Space exploration includes our astronaut, planetary and astronomy programs, ranging from human space exploration to the placement of robots and sensors on other planets, paving the way for eventual human exploration. Canada has been part of the Mars Exploration Rover (MER) mission for decades and also participates in key astronomical programs for space observation. The utilization of satellites refers to earth applications such as GPS, monitoring climate change and weather forecasting. In terms of building capacity, the CSA invests to nurture knowledge and skills in space activities and to attract the best researchers, scientists and engineers to work in space development.

How competitive is Canada's space industry in a global context and how strong is the ecosystem in Québec?

Over the years, Canada has developed a very positive reputation due to its delivery on missions at a much higher quality than required and within the timeframe subscribed, making it highly competitive. Canada is a strong partner in international space programs and its international reputation for space development opens a lot of doors for our industry to participate on international missions and to export their goods to international markets.

Overall, Québec represents around a third of Canada's space industry. As of 2015, total revenues for the space industry in Canada were about C\$5.3 billion, of which Québec constituted C\$1.67 billion. In addition, there are about 163 organizations that deal with space in Canada, 41 of which are based in Québec. SMEs make up the majority of these organizations. In terms of employment, there are around 10,000 direct employees working in the space sector in Canada, of which roughly a third are employed in Québec.

How does the CSA support the development of commercial satellites?

Canada has a long history of breaking ground in commercial satellites. Previously, the government fulfilled the role of building satellites to demonstrate new technologies, but decided to take a step back about 10 to 15 years ago as the industry had matured to an extent where it was able to perform this function by itself. Instead, the CSA refocused its attention on providing R&D support. We provide funding for sat-

ellite communications companies to pursue R&D programs focused on the development of satellites. This strategy has had a positive effect, apparent in the number of successful Canadian satellite communications companies.

Could you provide an update on the RADARSAT earth observation mission?

Canada has always been the leader in this program, with RADARSAT 1 launched in 1995, RADARSAT 2 still in operation, launched in 2007 and the planned launch of a constellation of three satellites in September 2018. This constellation will greatly improve the refresh rate of earth observations and enable us to perform three separate functions simultaneously, giving us much greater flexibility. Because of the radar technology, the satellite is just as successful on cloudy days and at night as well as in the day and is therefore more effective than an optical satellite. The CSA is the delivery and operations arm of RADARSAT.

What are the CSA's key goals for the next five years?

The CSA wants to ensure that space continues to drive innovation and economic growth for the benefit of Canadians. We will therefore leverage all of the new economic and technological opportunities presented by the possibilities of cheaper, faster and more frequent space activity. We will ensure that the Canadian space sector is connected with our international partners so that it remains at the forefront of innovation. Finally, we want to maintain the skills capacity in terms of scientists and engineers to exploit these opportunities. —



Joanna Boshouwers

Vice President and General Manager
MDA

MDA is a satellite communications and information company

What key developments have there been at MDA since our interview in 2015?

MDA has been very active in its two principal markets: communications and surveillance and intelligence. In the satellite communications market, which is the primary focus of our Montréal business, flexibility is becoming increasingly important as business requirements for satellite data are changing more rapidly and new communications applications are emerging. Where historically a satellite was designed for a 15-year lifespan with a pretty good

idea of who would be buying its capacity over that time, today demand profiles are changing much faster. In order to adapt to this new business reality, MDA is investing in development of products that can help operators adapt their satellite service over its lifetime.

Historically, many communications satellites were placed into geosynchronous orbit; however, today we are continuing to see the emergence of many constellation projects, which consist of large numbers of satellites launched into alternative medium or low earth (MEO or LEO) orbits. Unlike geosynchronous satellites that remain in a fixed spot over the earth, these satellites are moving with respect to the earth and require handoffs between satellites to cover any one spot on the ground. Due to the large quantities of satellites required for these constellations, the cost of each satellite becomes a major driver for the operator's business case. In order to support an operator's ability to adapt to this new technology environment, MDA is investing in development of processes and products that can be less cost-intensive when ordered in higher quantities.

Could you outline some of the programs MDA is working on?

MDA is currently in the final stages of integrating the three earth observation satellites for Canada's RADARSAT Constellation Mission. These three satellites will fly in formation to image the earth via a highly complex radar antenna, providing images of the earth day and night through any weather conditions. We also have over 20 projects ongoing for various communications satellites in LEO, MEO and geostationary (GEO) orbits. We are also working on Ku-Band communication subsystems for the International Space Station. Plus, we recently were selected by the Canadian Space Agency (CSA) to develop a concept for a radar instrument as a potential payload on a future Mars mission.

Could you elaborate on the key goals of the Satellite Centre of Excellence?

The centre will provide support to the next generation of technologies that MDA must develop to address changing needs of the satellite communications sector. Along with MDA's own investments, the Québec

government is investing C\$45 million as a royalty-based contingent venture loan for a next-generation digital payload satellite system development and manufacturing project, plus C\$3 million in the form of a non-refundable financial contribution which will be used to support the center. This investment will also ensure that industry can develop a steady stream of young Québec engineers able to provide continuity to the workforce.

What are some of the innovative areas in which MDA is currently working?

Following on from the need to develop products providing on-board flexibility to our customers, one of the key enablers is increased use of digital technologies where analog prevailed in the past. A key driver of MDA's leadership in innovative constellation satellite missions is smart design, which allows us to build a holistic view of a project through detailed evaluation of customer requirements, current and new manufacturing techniques, automation, smart batching, the use of up-screened commercial off-the-shelf (COTS) components and streamlined test campaigns. We are always exploring new manufacturing techniques as a means of increasing efficiency while reducing recurring costs.

Where do you see the most demand for MDA's products?

The greatest demand driver for MDA Montréal's satellite communications products continues to be satellite sub-systems and equipment. MDA is very well known for its antennas and is strong in communications. This is a very international market—MDA sells to companies all over the world.

What is MDA's vision for the next three to five years?

At a corporate level, MDA is actively pursuing growth in the U.S. government sector as a mission-critical partner with an expanded portfolio of end-to-end solutions. We expect that this growth will benefit our Montréal division directly or indirectly. Here in Montréal, our vision is to be the best satellite equipment and subsystem provider in the world. We have achieved substantial growth in the last 10 years, and intend to continue on this path going forward. —

The Science of Light: Québec's booming optics and photonics industry

In the Atacama Desert in Chile, four bright orange lasers are directed 90km into the night sky, lighting up sodium in the atmosphere and helping scientists on the ground calibrate their telescopes and better observe the galaxy. This laser technology, deployed at European Southern Observatory's Very Large Telescope in Chile was developed by Montréal-based MPB Communications (MPBC). The company is a leading supplier of high performance fiber laser and fiber amplifier subsystems to the space industry and just one among many examples of the province's prowess in optics and photonics. "Québec is very competitive in this area, with many companies working together in a closely knit network," commented Marie-Eve Ducharme, president and CEO of Nüvi Caméras, which has developed ultrasensitive cameras used in space – up to 100 times more sensitive than any other product on the market.

There are more than 40 optics and photonics companies based in Québec and five major optics and photonics research centers, accounting for 300 jobs and C\$400 million in annual sales, with space as a growing area of application for the technology generated in this field. Québec City in particular is recognized as a hub for optics and photonics. Laval University generates much of the province's manpower in the field and is home to the Center for Optics, Photonics and Lasers (COPL), Canada's largest university research center in optics and photonics. Other major research institutions include the National Optics Institute (INO) and the Defense R&D Canada facility, both also located in Québec City.

The roots of the province's strength in optics and photonics can be traced back to the introduction of optical fiber in telecommu-

nications under companies such as Nortel, now part of Cisco. "Since then, the province has had strong optics components suppliers such as CorActive and INO, which in turn has led to a network of companies which produce reliable components such as ITF Technologies and MPBC," commented Jane Bachynski, president and CEO at MPBC.

Increasingly, optics and photonics is used for space instrumentation, planetary and earth observation and space telecommunications, but overall its use in space is relatively nascent. "The technology is very mature in terms of its applications terrestrially but space is the next frontier, with the adoption rate likely to be rapid over the next five years," added Bachynski.

A highly innovative sub-sector

This ecosystem has led to various breakthroughs in space applications. The INO, for example, has spun out a number of companies in optics and photonics. "By generating such a high number of companies, INO has also contributed to the ecosystem given that most of them have chosen to locate here," remarked André Fougères, Vice President Business Development and Operations at INO. "Some of these companies are now bigger than INO."

One example is TeraXion, which is developing a fiber optic telecommunication platform for multi-sensor deployment onboard aircraft. INO has also completed numerous technology transfers in the space industry. For example, it has worked with the CSA and the European Space Agency to develop a fiber laser transmitter for optical-based communication between satellites and has

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Laval University is a very important player as it generates a lot of highly skilled manpower in optics and photonics. Defense Research and Development Canada (DRDC) has an optronics center in the city which also generates many new ideas and technologies. Along with INO, these two organizations have been most active in building the optics and photonics ecosystem in Québec City.

- François Châteauneuf,
Program Manager, Environment,
National Optics Institute



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developed technology for thermal cameras used by NASA to measure the ocean's surface temperature.

ABB's Space and Defense Systems division, based in Québec City, develops optical-based analyzing and sensing instruments typically used to measure the atmosphere with applications such as weather forecasting, measurement of pollution and greenhouse gases and measurement of land for use in agriculture and urban planning. The company has a contract worth over \$100 million with the U.S. government on

the CrIS weather forecasting program, reflecting the strength of demand for its services.

Québec also has a thriving optics and photonics start-up scene, often linked to research institutes. For example, Nüvü Caméras was founded on the back of co-founder Olivier Daigle's PhD thesis on electron multiplying charge coupled device (EMCCD) technology at the University of Montréal and quickly garnered the interest of NASA, which requested a prototype of the camera Daigle was developing. "The number of applications is endless and we are continuously finding new opportunities," commented Marie-Eve Ducharme, president and CEO at Nüvü Caméras.

Some examples of applications include observing exoplanets, adaptive optics in conditions of atmospheric turbulence and for surveillance purposes by the military. Another company that found its roots in research is MPBC, which began as a spin-off of RCA Canada's, the electronics company, Research and Development Laboratories.

Safer, lighter, with extra capacity

Optical components offer many advantages for space activities. Broadly outlining their benefits, Fougères elaborated: "Compared to electrical components, optical components do not create a spark or electromagnetic interference (EMI), making them a safer option overall. Fiber optics are also lighter than electrical components and use a low amount of energy."

In the field of communications specifically, optical technology can transfer a lot more data than radio frequency technology. "We have seen in the space industry that radio frequency (RF) links are now not sufficient to transfer large amounts of data from and between satellites, which has only increased in volume over time. Optical technology, on the other hand, can transfer much higher levels of data," explained Bachynski. MPBC's technology is ideal for satellite communications because it offers high content capabilities through highly precise beams and the ability to select very specific wavelengths.

However, as the amount of space activity and demands for data increase, requirements are becoming more demanding. "A

long-term trend is the increasing demand for enhancements to the accuracy, sensitivity and coverage of measuring sensors," remarked Jacques Giroux, business development manager at ABB's Space & Defense Systems division. Another key trend is the rising demand for smaller constellations of satellites which poses a challenge for optical based components. Giroux further remarked: "In some cases though, spatial resolution and sensitivity may limit the size reduction of satellites so more sizable instruments will certainly remain."

Positioning the cluster for the future

The opportunities for space technology are seemingly infinite and optical components have clear advantages over other forms of instrumentation and communications. The CSA will likely play a prominent role in driving the industry as it has done in the past. From an early stage, the CSA has backed Nüvü Caméras with millions of dollars and it is the main client for the INO's technology transfers related to the space industry. Indeed, changes in the CSA's funding distribution can have important implications for the cluster.

"In the last five years, the proportion of our projects with aerospace-focused companies has been about 8% and these have been mostly focused on payloads," remarked Fougères. "The percentage has previously been higher but the freeze on the CSA has affected demand for our services.

Indicating that extra funding should be made available outside of large projects such as the RADARSAT Constellation Mission for Canada's participation in international projects, Fougères assessed: "It would be better if the CSA had a base budget to engage in technological development and additional funding if Canada would like to engage in international projects. This would help position the Canadian space industry more competitively globally, especially given foreign governments want the assurance that a company's home government has shown confidence in their technology before also investing in it."

However, the CSA is by no means the only driver of the industry, with the neighbouring U.S. market acting as a particularly pronounced source of revenue. "The Ca-

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There is somewhat of a misconception that countries' space industries rely almost exclusively on the budget of their national space agencies. In fact, in the last 10 years or so, many explicitly commercial entities have done very well without the support of government, pursuing activities such as collecting and selling space data or constructing rockets in the case of SpaceX. Indeed, there is a stronger trend in private commercial ventures supporting the work of national space programs through the services they provide.

- Sylvain Laporte,
Chief Executive Officer,
Canadian Space Agency



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nadian business is very important for us, with the CSA being our largest client, but it is not our largest market. On average, we sell more outside the country than inside, especially to the United States," explained Giroux.

By way of another example, U.S. defense sub-contractors use MPBC's technology due to the low probabilities of interceptions. Looking ahead, the cluster is building on its success to position itself for the future. Québec's government will be establishing the Québec Optical-Photonics Center of Excellence later this year to further develop the cluster through support for innovation, marketing and skills training. With the number of satellites in space increasing exponentially and high demand for the data collected, the number of applications for optics and photonics will only multiply. Québec is well-positioned to meet and capitalize on this demand. —

AF



FC



André Fougères & François Châteauneuf

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AF: Vice President Business Development and Operations

FC: Program Manager, Environment
NATIONAL OPTICS INSTITUTE (INO)

The National Optics Institute (INO) is a not-for-profit technological design and development company specializing in optic and photonic solutions.

Could you provide a brief introduction to INO and its main product and service offering?

AF: INO is a research and technology company of around 200 employees, the vast majority of which are dedicated to developing technology based on optics and photonics. About two thirds of our work is with SMEs, whilst approximately 15% is with large corporations and the rest with government and universities. 50% of funding for internal research comes from the Québec and federal governments and the other 50% comes from direct contracts with companies. This balance is important for us to preserve because it helps maintain

our role as a key player in the innovation chain between universities and companies. Even more importantly, it demonstrates the relevance of our internal R&D activities and their contribution to the growth of industries.

Over the years, we have executed 68 technology transfers and 32 spin-off companies. In the last five years, the proportion of our projects with aerospace-focused companies has been about 8% and these have been mostly focused on payloads. The percentage has previously been higher but the freeze on the Canadian Space Agency (CSA) has affected demand for our services. With regard to aeronautics projects, we have participated in eight technology transfers.

Québec City is a center of excellence for optics and photonics. How dynamic is the local ecosystem?

FC: Laval University is a very important player as it generates a lot of highly skilled manpower in optics and photonics. Defense Research and Development Canada (DRDC) has an optronics center in the city which also generates many new ideas and technologies. Along with INO, these two organizations have been most active in building the optics and photonics ecosystem in Québec City.

AF: By generating such a high number of companies, INO has also contributed to the ecosystem. Examples of successful SMEs we have spun off include Optel and TeraXion.

Could you provide more details on INO's involvement in international aeronautics and space projects?

FC: Since the global space industry is very nation-state focused, we mostly work with the CSA. Where we do work with international space agencies, it is because of our specialist knowledge in niche areas. Uncooled infrared microbolometers is one of them since INO is, to our knowledge, the only organization offering custom developments around that technology. We also have conducted several space projects with the CSA and European Space Agency (ESA) such as investigating the radiation hardness of optical fibers and transceivers and developing a fiber laser transmitter

for optical based communication between satellites. In addition, we have developed technology in the area optical processing of synthetic aperture radar (SAR) images and in the area of carbon-reinforced polymer materials, allowing us to create extremely light-weight optical payloads that are also very robust against to temperature change. This technology will become more important as the space industry continues to move towards smaller spacecraft with lower thermal mass, which are therefore more susceptible to large swings in temperature.

What are some of the advantages of using fiber optics in aircraft?

AF: Compared to electrical components, optical components do not create a spark or electro-magnetic interference (EMI), making them a safer option overall. Fiber optics are also lighter than electrical components and use a low amount of energy.

How could the government better support Canada's space industry?

FC: Canada is relatively small compared with countries like the United States or China and the government's support is commensurate with the country's size. Nevertheless, a large part of the CSA's budget is allocated to large projects such as the RADARSAT Constellation Mission, which restricts funding for other important initiatives that we might work on. It would be better if the CSA had a base budget to engage in technological development and additional funding if Canada would like to engage in international projects. This would help position the Canadian space industry more competitively globally.

What are the key objectives for INO in the next few years?

AF: One of the key goals is to provide packaging solutions for integrate photonics devices which includes optical fibers and electrical feedthroughs. Printed photonics is also a new area we are working on that will be a big area of focus. It is expected that printed photonics technology will lower the cost of photonics devices and the new types of sensor will include capabilities for physical, chemical as well as biological detection. —



Jacques Giroux

Business Development Manager,
Space & Defense Systems
ABB

ABB is a global engineering company

Could you briefly introduce ABB's Space & Defense Systems activities in Canada?

ABB is organized into four global divisions and is present in about 100 different countries, with many locations in Canada. The business unit that develops products for space applications is part of ABB's industrial automation division and is based in Québec City. This business unit specializes in optical-based analyzing and sensing instruments. We market these for use in various applications, including several within the space industry.

Could you provide more insight into the product offering and the applications within the space industry?

Our optical instrumentation is mostly used for remote sensing applications, i.e. taking measurements from a distance. One typi-

cal application is the monitoring of species or characteristics of the atmosphere in areas such as weather forecasting, measurement of pollution and greenhouse gases. Other applications include the measuring of land, which involves more imagery with multi- or hyperspectral instruments for use in activities such as agriculture, forestry and urban planning.

Our developments tend to be based on our analysis of future needs. As the government is an important customer, we follow their direction in their programs and position ourselves to respond to their needs. The Canada missions are a good indication of what is done elsewhere, so we are successful in finding business further afield. Through other agencies and companies we also work in the United States, Japan and Europe.

The business unit exports 70% of its space products. What were the reasons for setting up a base in Canada?

The roots of our business in the space industry stem from a small company that was founded in Québec City that developed research instruments. This company was acquired by three successive companies, the last of which was ABB in 2000. The company was very complementary to ABB because it required sensing devices for its automated processes. ABB draws much benefit from this business unit because our instruments help them measure the efficiency of processes, power distribution and generation, energy efficiency and environmental impacts—all key areas in the wider company's work.

Could you comment on the space ecosystem in Canada and its importance in supporting ABB's business?

The industrial ecosystem revolves around MDA in many ways because they are the only major prime contractor. At ABB, we tend to work directly with agencies or prime contractors to offer them our instrument modules for satellites. However, whilst the CSA is a key strategic client, Canada is not our largest market. Our biggest contract, the CrIS weather forecasting program with the U.S. government, is worth in excess of US\$100 million. On the other hand, many of our suppliers are

located in Canada, such as those providing optical parts and machined parts. However, we must buy some of the more sophisticated parts internationally because they are not completely available in Canada.

Are there any key trends in satellite payloads that have influenced ABB's product offering?

A long-term trend is the increasing demand for enhancements to the accuracy, sensitivity and coverage of measuring sensors. We are able to continue improving our sensors by keeping up with technology and always being proactive in anticipating and pursuing new developments in detectors, sensing techniques, etc. In terms of the production process, we are seeking better ways to efficiently develop our instruments and follow trends for different components and materials.

To what extent are private companies becoming more involved in space activity?

More and more private companies are becoming involved in the new space economy, particularly in constellations, where there are many commercial opportunities. An example of this is satellite imagery of the ground—there is an appetite in the market for new developments in agriculture, such as precision farming, from both governmental and commercial organizations. We are trying our best to follow activities in these areas and be prepared to respond to changes. In some specific cases we are directly involved in supporting the establishment of business cases for constellations to ensure that we have a primary role when these new initiatives progress. For example, we have been working with MDA on some studies it has done for the CSA.

What are the objectives for the business unit over the next few years?

Opportunities in earth observation are multiplying, so we want to tap into this area. We need to diversify and closely monitor what instruments will be needed. We will try to be proactive with all agencies, space industries and new players looking for funds and starting commercial initiatives. —

Jane Bachynski

President

MPB

COMMUNICATIONS



MPB Communications (MPBC) is a leading supplier of innovative, high performance fiber laser and fiber amplifier subsystems to the international high tech industries, including the space industry.

Could you briefly introduce MPBC and its work with the aerospace industry?

MPBC was founded in 1976 as a spin-off of RCA Canada's Research and Development Laboratories, so its roots are very much in R&D. With the advent of the optical amplifier in the 1990s, MPBC began to focus its R&D on long-distance communications and repeated links using this technology. We have seen in the space industry that radio frequency (RF) links are now not sufficient to transfer large amounts of data from and between satellites, which has only increased in volume over time. Optical technology, on the other hand, can transfer much higher levels of data. Our technology in particular offers very high content links and very directed beams for transferring data, making it ideal for satellite communication. The fiber material we use is also ideal for airborne structures due to its light weight and because it allows for the selection of very specific wavelengths.

One application of our technology is the self-healing system for spacecraft developed in collaboration with Concordia University for the Canadian Space Agency (CSA) and Institut National de la Recherche Scientifique - Université du Québec (INRS). The technology works by releasing a resin when cracks appear in the material used in spacecraft, rather like our bones self-repair over time.

To what extent is the increasing use of constellations affecting demand for MPBC's services?

In order for companies like Google and Facebook to provide internet service to remote areas, they will increasingly need to use satellite communication. We see this as the new wave of development in telecommunications. Driven by the need to make remote areas more connected, Canada has become a leader in satellite communications. Technology developed in the country by players such as MPBC will play a big part in capturing opportunities presented by this new wave.

With the decrease in costs associated with developing satellites, there will be increasing opportunities for applications that provide a commercial and societal benefit. MPBC partnered with GHGSat in the launching of its first nanosatellite which has a spectrometer measuring CO₂ and methane in the atmosphere. This shows how a small company has the ability to launch small platforms that can have long term implications that benefit all citizens. If we know how to use space to our advantage, it opens up many possibilities to improve life here on Earth.

What are your key goals for the next three to five years with regard to the space sector?

We want to ensure that our optical amplifiers are flying on satellites and sending data at gigabit speed. To that end, we are focusing on the design of our amplifiers so that they have the optimal power efficiency, meaning maximum optical output for the least amount of electricity used.

Marie-Eve Ducharme

President and CEO

NÜVÜ CAMÉRAS



Could you provide a brief introduction to the company?

Our technology works by using EMCCD detectors, which are a thousand times more sensitive than the human eye, to count photons in conditions of very low light. Light consists of waves and particles and we build electrical systems to transform these elements into electrons and amplify them to make them more visible.

What are the main applications of your technology in the space industry?

Nüvü Caméras technology was first used in astronomy, including in NASA's observatories, as it improves the sensitivity of telescopes by

four times. Depending on the detector used, we offer fast-imaging or wide-view imaging. Fast-imaging is used where adaptive optics is needed, such as in conditions of atmospheric turbulence. This means signals can continue to be sent and received, even in challenging conditions.

What benefits do Nüvü Caméras' partnerships with research organizations in the province bring to the company?

In the face of competition from much bigger, publicly-traded companies with large R&D budgets, collaboration with universities, government institutions and complementary companies is essential and allows us to become even more specialized. So far, this strategy has served us well as Nüvü Caméras' technology is 10 times to 100 times more sensitive than any other solution on the market. This competitive edge has meant we have been able to secure millions of dollars of funding from the Canadian Space Agency. Another area in which universities are aiding our work is in the development of wider fields of view for our cameras—currently their main limitation.

What are your key goals for the next three to five years?

Nüvü Caméras is working in collaboration with manufacturers of detectors to drive further innovations in EMCCD technology, such as increasing the speed of detection. Our first off-the-shelf commercial space cameras will be launched in September 2018. We are also working on a lot of applications for our technology in space instrumentation and are developing a version of our camera for the medical industry.

Space: Québec's new economic frontier

The space industry is undergoing a fundamental change. From the beginning of the 'Space Race' in the 1950s to the early 2000s, the vast majority of space activity was conducted by governments. This is now changing as more private sector companies have entered onto the scene in a myriad of areas such as building satellites, earth observation, broadband internet access and space transport. Driving this development is the increasing use of data obtained from space in everyday life on Earth, made possible by falling costs of satellites and technological developments to transfer the functions of larger satellites to smaller ones, often as part of a constellation.

The production of smaller satellites is linked to improvements in consumer electronics; smartphones have shown that much of the technology that would have been hosted on a large satellite can now be stored in a very small object. "The miniaturization of satellites is a very positive trend as it brings the development of full satellites within budgetary reach of many smaller companies, leading to increased competition and a further downward pres-

sure on costs," explained Sylvain Laporte, Chief Executive Office of the CSA.

Furthermore, automation is now playing a role in the production of satellites. Groupe ADF, whose subsidiary Latecoere Services has a base in Montréal, is a partner on the production line for the OneWeb satellite constellation, which intends to bring broadband internet to hundreds of millions in hard-to-reach areas of the globe. This line will produce one satellite per day at a production rate 50 times faster than any previous project. These developments meet the demands for more data services used on Earth. "Due to increasing digitalization, the demand for constellations will only increase," highlighted Marc Eliayan, Latecoere Services' CEO. "The space industry is fundamentally changing as there are many more private programs, whereas before public programs dominated the industry. Formerly, we worked mostly with the different space agencies but now we are working on at least three private programs."

Following Groupe ADF's acquisition of Latecoere Services in December 2016, the plan is now to triple the size of the com-

pany in Canada and diversify its offering. The company's growth will hinge on development of work packages to install assembly lines, special equipment to support the production of testing in the space and aeronautics sectors, as well as development in other industrial sectors.

The democratization of the space economy

Increasing demand for nanosatellites and constellations is profoundly changing the space industry landscape globally, with Québec being no exception. Today, even SMEs, start-ups and universities can launch satellites and the number of commercial and societal applications is multiplying. GHGSat, a Montréal-based company, is a prime example. With no more than 15 engineers, it has launched microsatellites into space to measure greenhouse gas (GHG) emissions and provides services to buyers all over the world. "10 to 15 years ago, this could only have been achieved by governments...As development costs continue to decrease and space becomes more

Image courtesy of MDA

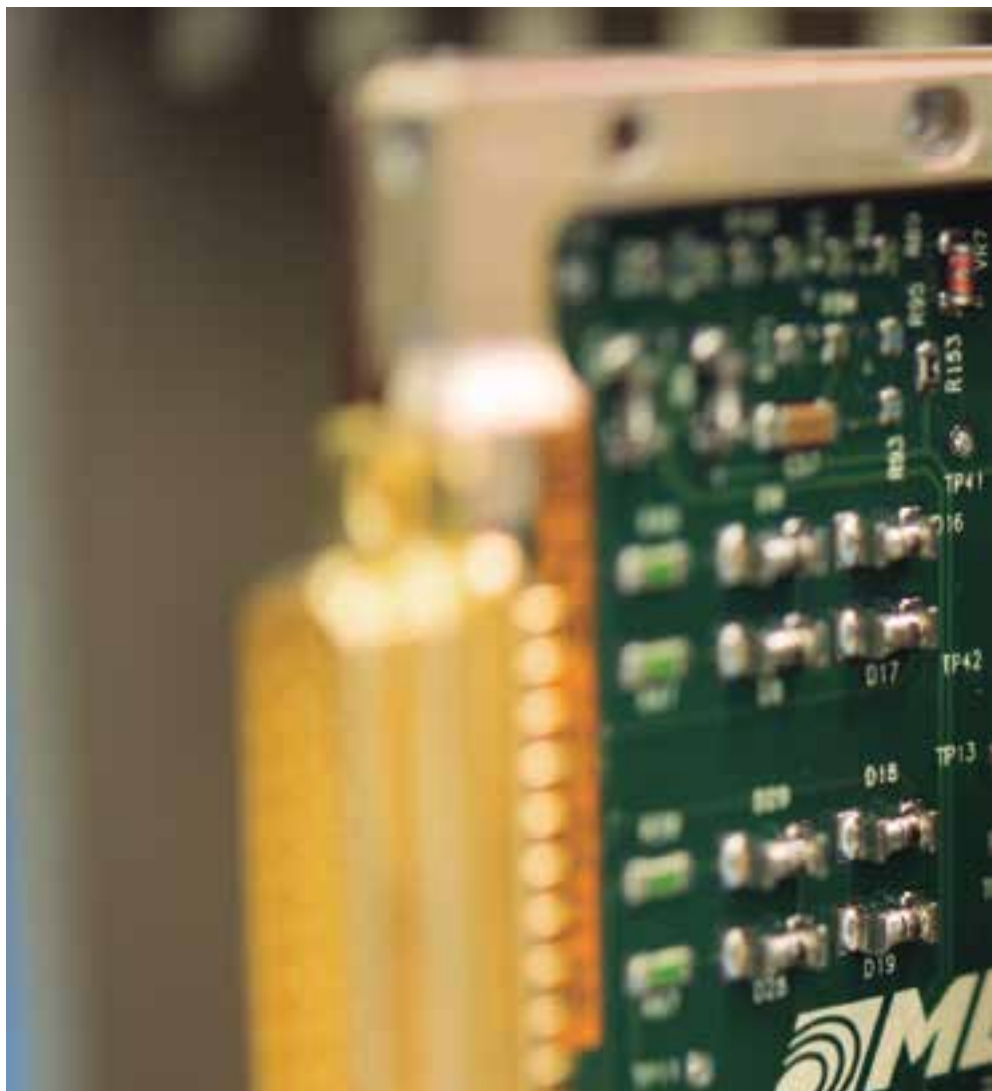
accessible to many more organizations, there will be a growth in open-source data providers and start-ups using this data for a wide range of commercial applications which improve citizens' quality of life and benefit society as a whole," predicted Laporte.

GHGSat also exemplifies the changing dynamic between the Canadian government and Québec's space industry. "The government has also become a customer of companies that launch constellations and smaller satellites and has consequently de-risked itself of some of the costs involved in launching satellites into space," Laporte commented.

Furthermore, with constellations of satellites replacing larger, single satellite missions, a failure of one or two satellites in a mission is a less critical issue. This has led the CSA to change the thinking behind its funding strategy as it is now prepared to take on more risk given the increase in the number of satellites produced and the lower costs associated with each. Remark- ing on this shift in the relationship between the state and the private sector, Eliayan remarked: "The space industry is fundamentally changing as there are many more private programs, whereas before public programs dominated the industry. Formerly, we worked mostly with the different space agencies but now we are working on at least three private programs."

Flexibility is the key

This dramatic shift towards constellations has led to a change in strategy of Québec's prime space industry contractor, MDA. Joanna Boshouwers remarked: "Flexibility is becoming increasingly important as business requirements for satellite data are changing more rapidly and new communications applications are emerging. Where historically a satellite was designed for a 15-year lifespan with a pretty good idea of who would be buying its capacity over that time, today demand profiles are changing much faster."



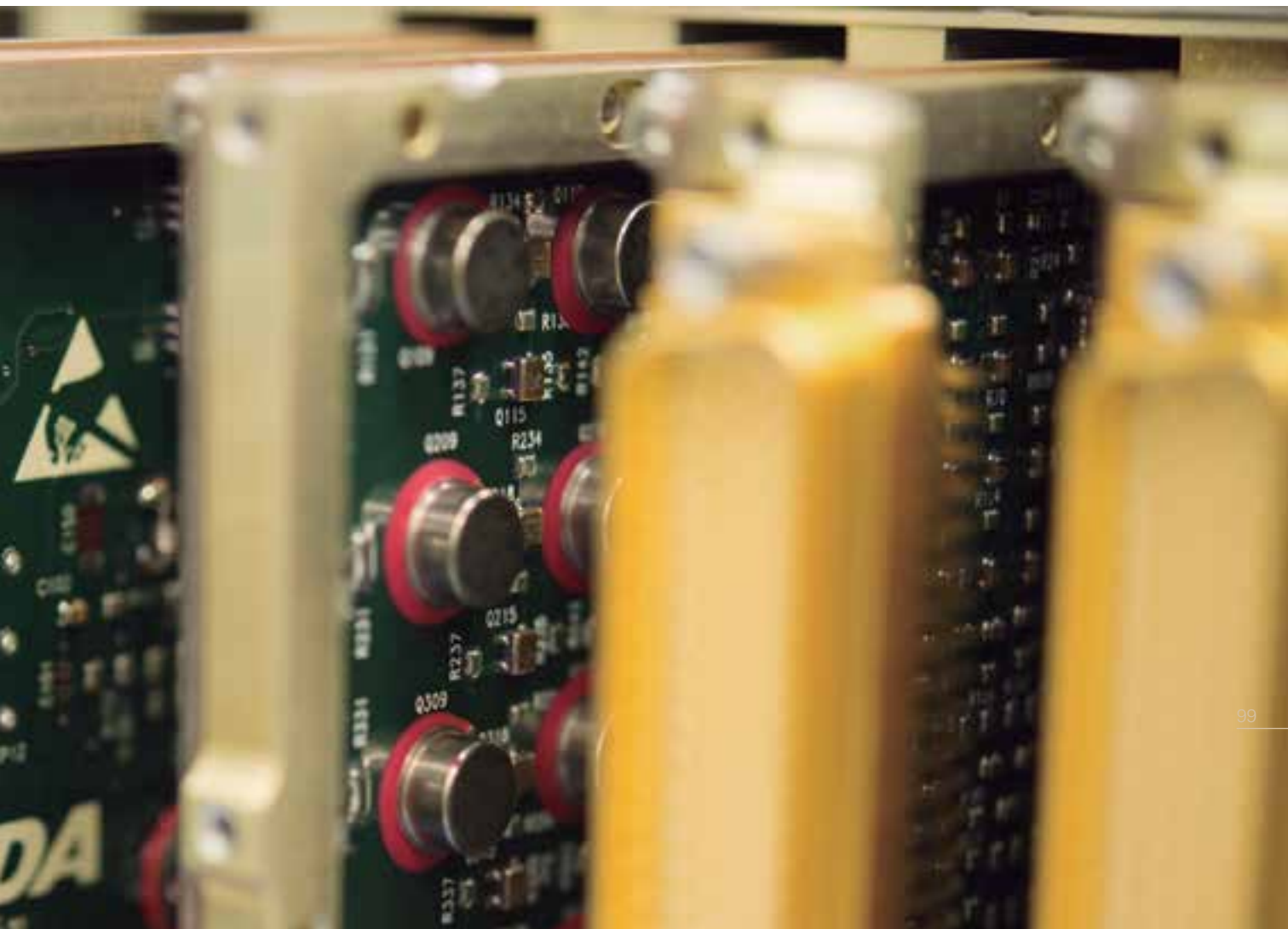
MDA is therefore investing in enhancements to its satellites which will allow operators to adapt their satellite service over the lifespan of its existence.

With the increasing number of satellites being launched into space by operators, coupled with increased competition among satellite assemblers, cost per satellite is an increasing area of focus for MDA's clients. In response to this trend, MDA is investing in the development of processes and products that can be less cost-intensive when ordered in higher quantities. As part of its mission to maintain its leadership in innovative constellations, the company is embracing what it calls 'smart design', which involves a detailed evaluation of a client's needs, using current and new manufacturing techniques, smart batching and the use of up-screened off-the-shelf (COTS) com-

ponents and streamlined test campaigns. Going forward, MDA's philosophy is that new manufacturing techniques will increase efficiency and reduce non-recurring costs.

Where next?

The space industry is changing at such a pace that in fifteen years from now it will likely look completely different and become dominated by private players. "Space is evolving very rapidly with the advent of new technologies leading to a large increase in available data and new countries entering into the industry, making it a very dynamic environment," summarized Laporte.



Amidst this change, established companies like MDA and ABB are adapting, whilst new entrants with new ideas enter into the market. “We are trying our best to follow activities in these areas and be prepared to respond to changes,” commented Jacques Giroux, business development manager at ABB’s Space & Defense Systems division. In some specific cases, we are directly involved in supporting the establishment of business cases for constellations to ensure that we have a primary role when these new initiatives progress. For example, we have been working with MDA on some studies it has done for the CSA.”

An interesting question is what exactly the future role of the government will be in the space industry as, although more private companies are becoming involved in the industry, the CSA is still the main source

of funding at present. While the CSA actively encourages more private companies to become involved in the space sector, the back-seat role it has played in satellite development in the last 10 years may have had drawbacks as well. “With Canada having been an early pioneer in satellite communications, the sector has not recently been a priority for the Canadian government,” explained Boshouwers. “As a result, we are at a disadvantage compared to our competitors in terms of industrial returns to Canadian industry for its government spending. This seems to be changing, but we have lost precious time.”

For its part, the CSA has stated it is committed to funding R&D programs for new satellites.

Nevertheless, Canada faces competition from larger countries with much bigger

military and defense budgets and ecosystems as a result, such as the United States, China and the European Union, which serve as a key source of demand for space companies located in those countries. In the shadow of giants with relatively ample means, Canada’s space industry may have to look elsewhere to secure the resources to invest in the sector’s future. Canadian companies therefore need to develop robust export strategies and links to international markets. Although currently successful, Québec’s space industry will have to continue to innovate to keep up with the dramatic technological changes affecting the sector. Just as importantly, it will need to export to ensure it has the resources to invest in the very innovations it needs to remain a leader in satellite communications. —





ADAPTING TO CHANGE



“Today’s economy is favorable, with an average unemployment rate of 6%, one of the lowest in the last 40 years. We have very strong economic stability and a favorable fiscal system...Private investments are still somewhat of an issue, but with the tools that we have Investissement Québec is able to get a lot of leverage on the dollars spent. For our manufacturing initiative, every dollar generated two-and-a-half dollars of private investment. There is an appetite for innovation.”

- Pierre Gabriel Côté,
President and CEO,
Investissement Québec

Aerospace in Québec:

The case for an industrial policy

Within Canada's aerospace sector at large, Québec accounts for 60% of its share of GDP and 60% of exports. Competition for international market share is therefore fierce and, as companies are increasingly able to source suppliers and partners across the globe thanks to greater accessibility, this competition is also felt within the domestic market. It is therefore paramount that companies both large and small are able to offer a competitive set of products and services.

Most players that make up the Québec aerospace cluster recognize the intensity of international competition, not just from established players such as the United States, Western Europe and Brazil, but also from other large countries. "Countries such as China, Russia, India and Japan are hot on the heels of Canada in terms of aerospace," re-marked John Maris, president of Marinvent, which provides consulting, services, training, tools and IP to the industry. "Since only certifying bodies in Canada, Europe, the United States and Brazil are currently recognized worldwide, Canada has an advantage of a few years. However, since this barrier will only last so long, there is little stopping emerging countries reaching Canada's level of expertise."

Whilst both the federal and provincial government recognize this and have done much to support the industry, some argue that a proper aerospace industrial policy is needed to ensure the sector remains globally competitive.

Government support

The federal and provincial governments have shown their commitment to Québec's aerospace sector through various funding pledges and initiatives. "Québec's aerospace industry is critical to the economy," emphasized Dominique Anglade, Minister of Economy, Science and Innovation, Government of Québec. "Aerospace is a key area of focus for economic development because it aligns with three main pillars that must be met for economic growth: entrepreneurship, advanced manufacturing and exports. For example, aerospace comprises the highest concentration of R&D out of any other industry and is the number one export driver, which is key considering exports (40% to the rest of Canada and 60% internationally) account for 50% of Québec's GDP. The sector also employs 40,000 people and Bombardier alone is the largest aeronautics company in Canada. For these reasons, the government has launched industrial strategies over the years to support the industry and has recently made unprecedented investments into developing the sector, particularly focusing on innovation."

Ahead of the Paris Air Show in June of this year, the federal Ministry of Innovation, Science and Economic Development announced a C\$2.2 million contribution, through Canada Economic Development for Quebec Regions (CED), to six aerospace companies that provide highly spe-

cialized equipment to the sector. In February 2017, the federal government also announced it was supporting Bombardier with C\$372.5 million in repayable contributions to fund R&D for the new Global 7000 business jet and ongoing activities related to the development of the company's C Series aircraft. This comes in addition to the US\$1 billion invested by the Québec government into Bombardier's C Series in return for a 49.5% stake.

Alongside these public spending pledges, there are a plethora of government funded programs, institutions and policies that support Québec's aerospace sector. Canada's Industrial and Technological Benefits (ITB) policy mandates that companies that are awarded defense procurement contracts from the federal government must make investments in Canada equal to 100% of the value of the contract. Beneficiaries of this policy include Mannarino Systems and Software, an engineering firm that supplies mission-critical equipment to the aerospace and defense sectors, which is receiving a C\$10 million investment-loan for, among other things, proprietary software systems for aircraft.

Meanwhile, the Strategic Aerospace and Defense Initiative (SADI) provides repayable contributions to support research and development (R&D) projects in the aerospace, space, defense and security sectors. Furthermore, the government funds R&D programs for the sector through organizations such as the Consortium for Aero-

space Research and Innovation in Canada (CARIC) and, in Québec specifically, the Consortium for Research and Innovation in Aerospace in Québec (CRIAQ).

At the provincial level, Québec's Ministry of Economy, Science and Innovation recently published its 'Québec Aerospace Strategy' for 2016 to 2022, where it committed to C\$510 million in government contributions and drew up a 10-point plan for the industry's adaption to global trends. Key elements include attracting Tier 1 and 2 suppliers, transitioning to Industry 4.0 and boosting exports. As well as owning a 49.5% stake in Bombardier's C Series program, Québec's government recently provided a C\$45 million loan to MDA to set up a center of excellence for satellites. The Province also helps SMEs transition to advanced manufacturing processes, contributing C\$400 million of funding across 240 projects, for example.

Government support is broadly recognized as essential for the industry. The prominent global position of the industry indicates that this support has been effective to date and local companies generally seem to be well supported. Nevertheless, global dynamics are rapidly changing and the industry will need to continue to adapt or risk falling behind. "In order to compete with emerging economies, it is essential that governments offer support to aerospace companies to level the playing field," noted Chris O'Neil, president and COO of Mecaer America.

In need of a plan

Currently, there is no overarching industrial policy which joins all of the multitude of initiatives together. Some in the industry believe the government needs to employ a more cohesive and coordinated plan if the industry is to continue on its positive trajectory relative to other rising stars worldwide. The absence of such thinking could arguably hurt the industry in tangible ways. For example, it is widely accepted that

government investment into large players is essential as they are too big to fail, particularly when they are a true driving force for the local industry. However, these larger players must focus on their margins and it makes little sense for them to source suppliers in-country if there are more cost-effective solutions further afield. For this reason, many players, including Québec's OEMs, rationally invest where costs are lower rather than in the region. "The solution is for the government to break the loop by creating an aerospace policy that encourages a more strategic investment distribution across the whole sector to encourage SME to grow and prosper," commented Maris.

Another area in which industrial policy could play a key role but is currently lacking is in bringing about integration of services within Québec's supply chain, a key demand of the OEMs. The best approach, however, is still somewhat unclear. Many stakeholders believe consolidation is the answer; others argue in favor of a consortium model, where suppliers partner on large orders and integrate their capabilities. Whilst consolidation is a longstanding trend in the industry, it will take a long time for new Tier 1s and 2s to form. Another approach would be the attraction of Tier 1 integrators from abroad, which is an area of focus for Aero Montréal and the Québec government. "Many companies are currently too small, typically with revenue at around C\$20 million. They must consolidate to form larger companies in order to compete. However, the process is particularly long given the entrepreneurial nature of these companies, which often means owners are unwilling to relinquish control," remarked Jean Wilhelmy, senior vice-president, Aerospace, at Fonds de solidarité FTQ.

OEMs tend not to favor consortium models as they prefer to hold one entity accountable per contract. "As part of a wider industrial policy, government entities such as the Business Development Bank of Canada (BDC) and Export Development

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Companies are not sufficiently incentivized to keep their operations in Canada over lower-cost jurisdictions. It is the government's role to provide the right incentives for a vibrant aerospace industry in Canada. We have witnessed the decline of the aerospace industry in other countries, such as the United Kingdom, due to a lack of government policy to support the sector's competitiveness. We do not want this to happen to Canada.

- John Maris,
President,
Marinvent



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Canada (EDC) should take on non-core risks which SMEs do not have the resources to manage," Maris suggested.

Under such a scenario, OEMs would have confidence in a consortium's ability to deliver.

Therefore, whilst the government is committed to helping the industry, a more strategic approach could significantly help the sector. "We have witnessed the decline of the aerospace industry in other countries, such as the United Kingdom, due to a lack of government policy to support the sector's competitiveness. We do not want this to happen to Canada," concluded Maris.

Whilst the outlook for Québec's aerospace industry remains undoubtedly positive for the foreseeable future, a proper industrial policy could be key in ensuring the sustained prominence of the sector internationally. —

100% of Nothing

By Phil Cole, VP Business Development, Marinvent

Collaboration and consortia have been well established for many years in the Canadian aerospace market, with R&D consortia such as CRIAQ, CARIC and GARDN admirably demonstrating the ability to collectively solve problems and share intellectual property access between universities, research institutions, SMEs and larger “sponsor” organizations.

However, most models focus on individual big “R”, little “d” R&D projects and do not translate into the creation of wealth for SMEs. Neither do they establish enduring ties between SMEs to capitalize on bringing profitable new products and services to market.

So why is it so difficult for Canadian aerospace SMEs to grow and thrive in a country where aerospace is clearly a recognized priority and where collaboration is already a norm?

Today’s global aerospace industry is characterized by continued consolidation of the supply chain, translating into fewer opportunities for smaller companies with niche products and services. Put simply, the OEMs and Tier 1 integrators around the world are looking to outsource larger and larger pieces of their product lifecycle. In so doing, they are forging enduring relationships with suppliers who are able to offer more turnkey deliverables for which it is easier to justify the value and share the risk. If a customer has a choice between outsourcing US\$100 million of its costs to a single supplier of a subsystem (wherever they are in the world) through a single commercial vehicle or outsourcing US\$1 million each to 100 SMEs, each requiring its own commercial vehicle, point of contact and management overhead, it is abundantly clear that the SMEs are out of luck.

One key challenge is that, due to the entrepreneurial nature of Canada’s SMEs, some

smaller companies would prefer to have 100% of a niche market than tackle a market that is 100 times larger and share the proceeds with their competitors through a consortium.

Canadian aerospace SMEs have three choices: Continue to act alone and end up with 100% of nothing; look to be acquired to survive; find a way to band together in order to collectively share in larger contracts by offering more value to customers through consortia.

The Canadian Government has recognized this fact and has recently launched the Innovation Superclusters Initiative, which specifically targets projects that will create jobs and new SMEs through commercialization of products and services in consortia. This is a fundamental shift away from funding pure early stage R&D towards generating sustainable wealth and prosperity and it is a very welcome move.

The obvious question raised by SMEs when considering the consortium option is: ***are the OEMs and Tier 1s ready to contract with a consortium of SMEs?***

This is a very big question indeed and it is true that consortia have not yet established a workable environment to make this an easy choice for customers.

A typical supplier contract (even those with our own Government) has clauses within it that few SMEs can service adequately. For instance, the protection of the customer in the event of non-delivery, late delivery or delivery of a non-performing product. Customers want to see a commercial organization with deep enough pockets to rectify the problem or pay liquidated damages under such circumstances.

In a consortium model, one of the members must be large enough and willing to bear this commercial risk on behalf of the other members—which does not happen—or a third

party organization is required to underwrite the consortium. The only appropriate organization would be a Government-backed entity such as the Canadian Crown Corporation (CCC), the Business Development Bank of Canada (BDC) or Export Development Canada (EDC). Until simple rules have been established allowing a consortium to obtain such commercial assistance, we are likely to continue fighting a losing battle in an aerospace market which is incredibly risk-averse.

The good news is that this idea is already in development. The Aerospace Industries Association of Canada (AIAC) under its Small Business Working Group is putting together a document that will provide SMEs with practical advice on forming consortia. Part of the preparatory work on this document included very positive discussions with BDC and EDC with respect to treating consortia differently.

There is, however, still one enduring problem that must be overcome; the conservative nature of Canadian aerospace SMEs. It is incredibly difficult to convince a private entrepreneur that has built a company from scratch over 20 years that they should “risk” that investment by changing the way they work. What is worse is to ask them to give up having 100% control of their products and services and to accept a majority consortium decision. They may have 100% of a small niche market today, but in time that niche will be swallowed by a supplier that can satisfy demand and offer more besides, at which point our conservative SME will face having 100% of nothing.

A piece of advice for any SMEs considering forming a consortium: Look first to the SMEs that appear as much like you as possible. These are your competitors today but, if you can find a way to collaborate, you will be much stronger together. —

The consortium model could work if OEMs can be convinced that SMEs can take on the liability for contracts. EDC's mandate is to help small companies get all the financing they can get from banks but we know that banks' risk appetite is limited. Therefore, we are here to add capacity to the banks from a financial standpoint, reduce risks and help the companies in the way that they are structured.



- Alexandre Faria,
VP Business Development, Export Development Canada (EDC)

For many years now, OEMs have expressed the desire to work with fewer suppliers. This has led to increased pressure on some SMEs to consolidate or, as a minimum, associate themselves with Tier 1 suppliers. Initially, SMEs believed that this action by the OEMs would be detrimental to them. However, with time, everyone has found their 'niche' and we now see consortium form for specific projects. These consortia only remain together for the time of a project. This flexibility is very good for the industry.



- Jacques Comtois,
Vice President and General Manager, L-3 Communications MAS

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The Canadian government is definitely trying hard to change the dynamic in Canada's aerospace industry by encouraging companies to collaborate more. Due to the entrepreneurial nature of Canada's SMEs, some smaller companies would prefer to have 100% of a niche market than tackle a market that is 100 times larger and share the proceeds with their competitors through a consortium. In addition, whilst research consortia are easily formed and therefore the most common form of consortium, commercial projects are much more complicated.



- Phil Cole,
VP Business Development, Marinvent

Québec does not have enough Tier 1s and we need to encourage Tier 3 and 4 companies to work together to fill that gap. This could be achieved through consortiums or joint ventures, not necessarily mergers. Consortiums are not commonly seen in Québec as companies are wary about partnering with competitors. However, there have been some positive developments, including through the MACH FAB 4.0 Initiative in which SMEs work together to develop automation technology. This is why an organization such as Aéro Montréal plays a catalyzing role.



-Suzanne M. Benoît,
President, Aéro Montréal

Québec's Aerospace 4.0: A Solution to Cost Pressures?

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Aerospace companies globally have faced a number of challenges in recent years which continue to shape the industry. Competition from lower-cost jurisdictions has become more pronounced and, as the world has become smaller through increased accessibility and communication, geographical advantages are diminishing. With China expected to become the dominant aviation market in the future, IATA projects the expected number of passengers flying to, from or within China to reach 1.3 billion by 2035 and expects India's market to triple over the same time period. For large companies, lean cost structures and streamlined supply chains are more important than ever to pursue global leadership positions, whilst suppliers must be cost-competitive in order to win contracts.

Used as an umbrella term for new(ish) technologies, "Industry 4.0" is a term uttered by many but generally lacking a solid definition. "There is a danger that Industry 4.0 could be viewed as 'Industry 3.0' on steroids, simply automation and digitization of manufacturing processes with bigger computers in order to produce things better, faster and cheaper," said Stephen Yue, Lorne Trotter Chair in Aerospace Engineering and director at McGill University's Institute for Aerospace Engineering. "Production optimization is a continuous process; there is no need to label something that is naturally evolving. One major difference of 4.0 versus 3.0 is that it

does not involve only manufacturing, but digitally links together all aspects and associated technologies of the business, from ordering to delivery, and maybe beyond."

The uptake of technologies facilitating automation, digitization, robotics, artificial intelligence, additive manufacturing and a general progression towards the Internet of Things has certainly increased, which is particularly notable in an industry that is historically conservative. "Automation is the future of our North American operations," commented Maria Della Posta, senior vice president at Pratt & Whitney Canada (P&WC). "With currency fluctuations and market pressure on manufacturing and production costs, advanced manufacturing is part of our strategy to be globally competitive. Our transformation gives us the precision, quality and ability to address materials and shapes in a way that heightens product performance as well. Floor space availability is another advantage: we can now machine more parts with fewer machines."

P&WC's Mirabel Aerospace Centre is the first in the industry with a fully horizontal moving assembly line for its PW800 engine, allowing the height of the engine to be adjusted up and down and rotated during assembly. "This caters to our employees' ergonomics as each of them is always working at the most suitable height," highlighted Della Posta. "Our Mirabel operations are highly automated, designed around lean principles and the facility it-

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As an industry, we are well positioned to take advantage of these technologies, which are very much integrated into the innovation agendas of the Canadian and Québec governments to ensure we leverage as much as possible. There will be much tighter coordination going forward to develop these technologies and increase their implementation.

- Cynthia Garneau,
President,
Bell Helicopter Textron Canada



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self was awarded the Leadership in Energy and Environmental Design (LEED) Gold certification. It features a passive solar wall and energy efficient lighting that maximizes the use of natural light, a highly reflective roof that reduces heat is-

land effects as well as systems that reduce water consumption by 40%.”

P&WC has been pursuing its automation journey for the past four years, moving from robotization of key components in its advanced manufacturing centers to fully-functioning centers producing at a much more rapid rate. The three new manufacturing lines in Québec and those in Poland feature fully-automated cells with less human intervention and now require only a couple of operators. The company is also pushing towards predictive maintenance.

Other processes with potential advantages include additive manufacturing. “Additive manufacturing in particular is a very interesting technology for our product,” commented Gilles Labbé, president and CEO at Héroux-Devtek, which specializes in landing gear and actuation systems. “In the forging of products, a very long lead time is required for building and obtaining parts from the supplier, plus the subsequent machining can result in wasting 80% of the material. Additive manufacturing reduces the long lead time and can reduce the material cost and waste by large amounts. It is now proven, with GE as a good example, that the additive manufacturing process can design lighter and more reliable components at a lesser cost. Additive manufacturing will become more and more present in our industry and will be a game changer.”

Héroux-Devtek’s work on its contract for the Boeing 777 aircraft landing gear also involved an investment of over US\$110 million on equipment and capacity, including installation of flexible manufacturing systems (FMS) to automate the process, meaning one employee can run four or five pieces of equipment simultaneously. The company also plans to be the first to employ robotics to paint these landing gear parts.

Alongside clear benefits for multinationals and large players looking for a bigger share of international markets, SMEs will also likely need to follow suit in order to be considered competitive suppliers.

SME implementation: a longer-term view

Amid increasing cost pressure from the top of the value chain and a desire to simplify supply chains, SMEs must adapt in order to stay afloat. Consolidation is inevitable as customers show preference for integrated service offerings from their suppliers; SMEs, whilst previously holding an advantage in terms of flexibility and specialized expertise, struggle to compete.

However, although promises of increased efficiency, quality and production volume are appealing, concerns remain over whether companies can support the required investment. Many SMEs not only lack the investment power, but also the production volumes required to justify the initial cost. “In contrast to the automotive industry, which has product cycles of three to four years and high throughput volumes, aerospace contracts run for up to 25 years and are low in volume,” highlighted Michael Muldoon, director of aerospace operations at Radix Inc. “This means that once SMEs have won an order and attained necessary approvals they have little incentive to change their work flows. Other countries such as the United Kingdom, Singapore and lower cost regions are adopting automation more rapidly than Canada. Québec needs to change this to avoid being left behind.”

According to John Nassr, president at ICAM Technologies, a specialist in CNC post-processing and machine tool simulation, scalability is the answer for SMEs: “We start them off with either pure G-Code machine solutions or pure post-processing. We then gradually bring them up to the complete automation solution. Customers have reported that they have achieved a 15% reduction in programming time and a 10 to 15% reduction in cycle time with our automation solution. Considering the price of a 5X CNC machine, these two reductions are equivalent to the solution paying for itself in less than a year.”

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Robotics is really the Wild West. In the past, manufacturing required machines to have a one-to-one relationship with the task. For the first time in history, we have robots with more dimensions than the task. Companies are now moving away from dedicated equipment towards more flexible automation.

**- Chahe Bakmazjian,
Business Team Leader, Robotmaster,
Hypertherm Robotic Software Inc.**



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ICAM’s R&D focuses on merging the world of robotics and CNC machining. “Robots are typically cheap and good at repetitive motions but they have a lower quality of rigidity than CNC machines,” stressed Nassr. “Combining both would produce the best of both worlds. Large software providers are developing complex, expensive software to program and provide robot simulation. The ICAM solution, on the other hand, offers complete configuration with SIEMENS, CATIA and other big players while staying within the PLM global data management. Therefore, instead of having to constantly use expensive specific modules for CAD/CAM vendors, regular 5-axis machining is usually enough to link with the ICAM solution and drive CNC machines as well as robots.” ICAM plans to focus on making its software easier for inexperienced users to

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Compared with more prescriptive lean manufacturing methods, Industry 4.0 is more of a philosophy on how to approach manufacturing. Companies need to look at where they can make most improvement and apply principles from this philosophy. The prices for the components Radix purchases to develop its systems are coming down, which has a positive knock-on effect in making our own products more accessible. For example, a 3D scanner now costs under C\$10,000 whereas not long ago they cost approximately C\$100,000.

- Michael Muldoon,
Director of Aerospace Operations,
Radix Inc.



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implement and is training its international network of resellers to offer the same services as in Canada, increasing the company's global reach.

While there might be more flexible and scalable packages available, SMEs wanting to implement these new technologies extensively will likely require external financial support. In addition, increasing throughput volumes to justify implementation is required, which will likely mean increasing presence in export markets. However, SMEs may initially suffer from a competitive standpoint by not being able to offer these technological advantages in the first place. “SMEs can definitely be

more competitive if are willing to invest in innovation,” commented Real Julien, president at J2 Procurement, a consulting firm specializing in supply chain management. “The game is no longer the bigger against the smaller; the game is now the faster against the slower. If some SMEs are not open to getting help outside their walls, they will, unfortunately but definitely, stunt the growth of their business. One of the biggest barriers will be our OEMs. If their supply chain strategy continues to progress towards lower costs, SMEs may not be willing or able to invest in automation or Industry 4.0.”

The Québec government's intention to address this challenge is apparent in its 2017-18 budget, which indicates planned investment of C\$100 million over five years to develop Montréal as an artificial intelligence (AI) ‘supercluster’. At a national level, the federal government's 2017-18 budget also shows focus on innovation, proposing the establishment of a new department, Innovation Canada, which will distribute investment of up to C\$950 million into a number of ‘superclusters’ over the same five-year period. The 2017 federal budget also allocates C\$125 million towards a national AI strategy of which Québec will certainly play a leading role. As the only aerospace hub globally with advanced AI capabilities, the potential for application and development is immense.

In addition to financial aid, there has been a focus on the implementation of these technologies by the region's primary aerospace association. To support SMEs with their transition to Industry 4.0, Aéro Montréal launched the MACH FAB 4.0 initiative, aimed at the more advanced companies involved in the previously established MACH program, which focuses on developing supplier competitiveness. “Through adopting Industry 4.0 processes, SMEs become more digitally connected with their clients, which is a strong incentive for adopting these technologies,” outlined Aéro Montréal's president, Suzanne M. Benoît. “Companies that do not

adopt these new processes will struggle unless they have a technological niche. Transition to Industry 4.0 supposes a new business model for many companies and a comprehension of the necessity to innovate—this can be a challenge. Our role is to ensure SMEs' awareness of the importance to make the shift to 4.0 and to identify solution providers to support them in that shift.”

Investissement Québec, a government arm for economic development, also launched an Industry 4.0 initiative, now in its second year, which includes financing for small companies as well as non-financial solutions such as labor support. Barring the initial investment, the advantages offered to companies in driving down costs are blatant; support in the implementation phase, both financially and non-financially, will therefore provide a springboard for the increased competitiveness of these companies.

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Automation is completely changing the industry...Automation means engineers and a shop workers alike can set their focus on high value-added tasks. Everyone is more efficient and greater value is created in their respective roles.

- Mark Makoukji,
Managing Partner,
P3 Group



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Training for implementation

As companies begin to integrate new technologies out of necessity as much as for competitive advantage, the very nature of the work undertaken will change. Existing employees will therefore need to be trained and new employees must be prepared accordingly. Although some concerns may be raised around potential job loss, general consensus is that whilst the nature of certain roles may change, robotics and other new technologies will enhance performance across various aspects rather than replace any need for human judgement.

As universities continue to position themselves as partners to industry and play a more proactive role in securing practical experience for students, they will be integral in the training of new talent to support these technology trends. “There are also many opportunities within Industry 4.0, or “Aerospace 4.0,” highlighted Dr. Hany Moustapha, professor and director at AÉROÉTS, Pratt & Whitney Canada (P&WC) Chair in propulsion systems at École de technologie supérieure (ÉTS) and senior research fellow at P&WC. “A key challenge is to demystify these concepts, for which we are offering short courses and presentations at ÉTS. Industry 4.0 encompasses entire processes and we will therefore need to develop these capabilities within the workforce. As well as supporting our students, we will continue to work with companies of all shapes and sizes.”

ÉTS prides itself on its strong industry links; by placing more than 3,000 interns at companies every year, the university ensures its students have the practical experience preferred and often demanded by companies. In addition, ÉTS conducts 70% of research activities in collaboration with industry, a huge leap from the Canadian average of 25%.

Whilst many of these new technologies are perhaps in line with younger generations more accustomed to interfacing with tablets and applications, many existing

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The key is to merge human expertise and judgement with the use of robotics to maximize the task performance; we are not yet ready to replace humans entirely. With surface inspection, for example, the robot will be able to identify a defect and present it to the inspector. When looking at a part, 99.9% of the surface may be good, and a defect can be extremely difficult for a human to catch—they may not catch it at all. The robot will present the defect and require a judgement call.

- Jean-François Dupont,
CEO,
AV&R



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workers may face challenges due to shifting requirements in their day-to-day roles. Effective implementation is a primary concern for companies as the full extent of advantages will otherwise not be realized. “One of the main challenges is providing an interface to present a complex problem in an easy-to-grasp manner,” explained Chahe Bakmazjian, business team leader at Robotmaster, Hypertherm Robotic Software Inc. “We are catering to

people with task expertise that might not have expertise in the software and technology involved in the robotized process. In essence, we are bridging that gap. If huge amounts of training are required, some of the gains of the new process are thrown out the window because the sheer effort of programming and validating that robot erodes some of the profitability.”

Robotmaster, founded in 1996 as Jabez Technologies and acquired by Hypertherm in 2015, continues to develop industrial robot programming technologies. The company’s newly rewritten software, Robotmaster v7, is scheduled for release in 2017 and is based on an entirely new architecture considered to suit the industry’s needs over the next five or six years at least.

Generally, the industry is demanding greater versatility in its workforce and implementation of robots and new technologies require a different kind of manpower. In combination with arising knowledge gaps as new technology is introduced, training will be required both to bring existing employees up to speed and to prepare new employees appropriately.

Industry 4.0 in the future

Industry 4.0 presents a means to achieve results that were not previously achievable. The advantages of automating certain processes, for example, are clear; higher accuracy, shorter lead times and generally increased efficiency are just some of the incentives to invest. However, the investment required may knock out some players if they cannot keep up with their competitors.

For an industry that exports such a huge majority of its production, it is in the region’s interest to support the technological transformation of its companies. Remaining competitive at an international level is paramount and implementation of automation and digitization processes are a giant step in closing the gap with low-cost jurisdictions. —

Jean-François Dupont

CEO
AV&R



AV&R is an engineering firm specializing in automation, vision and robotics with a history dating back to 1994.

Have there been any developments since we met in 2015, particularly as companies increase their uptake of automation technologies?

Automation is currently a buzzword in the industry. A lot of AV&R's attraction stems from companies needing to lower costs, for which the main driver is coming from the OEMs. Because the new engines on the market have been sold at cost or even at a loss per unit, the next years will be marked by cost reduction, and there is only one way to reduce cost: automation. In the past, OEMs were moving production to lower-cost countries but the new performance requirements and tolerances make it impossible to carry out these processes manually any longer. Even low-cost environments are now required to automate processes and the amount of investment needed is roughly the same or sometimes higher due to the highly qualified workforce required to operate the system. We are particularly focused on the aircraft engine, surface finishing and surface inspection. The future will center around Industry 4.0, and we believe our position in the market is very strong to facilitate this move: our systems are deployed on the ground, connecting all parts, we know the exact variations in process, the type of defects, part profiles, and are able to populate all the software used. We are the chain to connect all the information and centralize it in the cloud.

Québec is also home to a variety of SMEs which lack such high levels of investment capital. How great a barrier will cost be to these smaller companies and can they remain competitive?

Automation has long been easily deployed in plants with high throughput volumes. If a company has only small batches, it is much more difficult to automate its processes. In aerospace, the volumes are not yet high enough to demand the same levels of precision as in automotive production and a greater flexibility is demanded to accommodate a greater variation in the parts. Because of this, we have invested a lot of money to adapt the system to accept variations, which brings the possibility of implementation to smaller companies.

What are some of the results companies can expect to see through the automation of surface inspection?

The key is to merge human expertise and judgement with the use of robotics to maximize the task performance. The robot will present the defect and require a judgement call.

We are currently developing a solution with Rolls Royce and will deploy our first inspection system at the AMRC in Sheffield. Quality is a clear benefit of this kind of solution and also helps the inspector focus their knowledge on the decision at hand.

How will AV&R utilize new technologies to maximize efficiency in testing over the life of an aircraft?

We will be able to follow the complete life of a part—we digitalize the surface of the part so we know exactly where the potential defects are. Following a cycle, we will re-inspect the parts during the maintenance overhaul and compare the surfaces with the originals. This will allow us to monitor any deterioration and predict defects over the life of a part. In our extensive database, we will then be able to find where all these parts are involved and will be able to ground only the one plane with a potential defect. Normally, an engine is verified with all tests done on a computer with parts modelled after their initial design. All simulation parts are perfect. We will be able to simulate the real engine, recreating its real performance.

What are AV&R's main objectives going forward?

Due to agreements with some key customers, we will be opening some offices outside Canada, initially in France and the United Kingdom, and potentially in the United States depending on any changes to NAFTA. However, it is already much more difficult for us to cross the border and send engineers over. Previously, the United States was a local market for us.

Airlines order planes that will be delivered in five to ten years. Since AV&R offers solutions to automate the production of these planes' engines to the motorists, we are currently operating off their backlog, which will keep us busy for at least five years. —



Chahe Bakmazjian

Business Team Leader, Robotmaster
HYPERTHERM ROBOTIC SOFTWARE INC.

Now operating as Hypertherm's Robotic Software Team, Robotmaster develops industrial robot programming technologies that enable versatile and profitable robotic solutions for manufacturing applications.

Robotmaster was founded in 1996 as Jabez Technologies and acquired by Hypertherm in 2015. What were the motivations behind the acquisition on each side?

Hypertherm wanted a stake in our technology as a Horizon 3 opportunity. As a hardware company, they had understood that in this new economy it is really the technology that will be adding tremendous value to a complete solution.

Because we had been growing extremely fast (above 60% per year) there was a lot of operational and administrative work that needed to be done which was taking up the majority of my time. Hypertherm was a match made in heaven due to its functional teams behind the scenes offering behind-the-scenes support whilst maintaining independently-run business teams to execute strategy.

With the launch of Robotmaster v7 on the horizon, how does this software address the developments in the automation and robotics landscape?

Robotmaster v7 is a completely rewritten software, not a new version. We realized that old architecture is not going to do justice to this new economy and took everything we knew and put it to the test. Instead of creating an incremental change, we forecast the use of robots in the future and sought to create an architecture suited to the needs we currently see, at least for the next five or six years.

Could you elaborate on the software itself and its aerospace applications?

There are two areas of operation with very different needs. The first is on the structural side and the second is on the engine and its components. On the engine component side, we cater to deburring, surface treatments and applications such as plasma or cold spray. On the blade itself, we cater to grinding, remanufacturing, and so on. On the fuselage and airframe, the biggest application we cater to is drilling and riveting. Another application would be trimming of composite parts.

Drilling and riveting of airframes is generally done using CNC-type dedicated machines created around the assembly of a tubular structure that can only drill and rivet one hole at a time. With the demand for flexibility, OEM's such as Boeing are moving towards robots. Robots can have cells of eight or more robots working a couple of regions at a time, doubling or even quadrupling the speed. Since robots are more complex and not easy to program, there is a technology gap, which is where we come in.

Does the Robotmaster software integrate well with other aspects of Industry 4.0?

Very much so. We realized that most current architectures are not suited to what Industry 4.0 entails and offers. Therefore, in our v7 product design, we looked at the principles and tenets of Industry 4.0 to create an architecture that will enable Industry 4.0-type behavior.

Industry 4.0 is really about connecting a smart plant. The scope of our vision is not at a plant level but at a cell level. However, our philosophy is that if a single cell contains suitable attributes required by Industry 4.0 and that cell is smart, then that smart cell will create a smarter factory. Without smart cells and only connectivity, the factory is connected but not necessarily smart. With regard to IoT, the current trend is more towards gathering the data rather than deciding what to do with it. Our architecture allows full and real-time access to information as well as any interventions by processing that information.

What are the next steps for the company?

We will release the new product in 2017. Robots are here to stay. They have their unique challenges and our goal is to be the bridge between the user and the robot. We are trying to narrow that gap to enable utilization to full potential. One area in which we have a great deal of interest is deep learning and machine learning. Our goal is not to keep pushing a snapshot of this technology; we believe there is a better business case to keep innovating and make it easier and easier for people to exploit a robot, which means we will be somewhat competing against ourselves as we go forward. —

Vito Marone

President

**BUILDIT SOFTWARE
& SOLUTIONS LTD.**



Could you provide an overview of BuildIT's main activities?

BuildIT delivers 3D metrology solutions for inspection, assembly and alignment. We automate and simplify workflows through our software, enabling employees with little training to conduct very precise inspections. Our primary customer base comprises large aerospace companies such as Airbus, BAE Systems and Bombardier. Our flagship product is the BuildIT platform, which is where the company's name comes from.

In July 2016, BuildIT was acquired by Faro Technologies (Faro). How will this affect the focus and scope of the company?

Faro is a world leader in computer-aided measurement and imaging devices and software. A key focus for Faro is to offer more solu-

tions rather than products and it therefore acquired BuildIT due to its highly configurable and automatable services. The acquisition will increase BuildIT's capacity to grow due to it giving us more international reach. We now also have a bigger budget, new devices and hardware technology that BuildIT can use to help design even better software.

How accessible is your software to SMEs who are under cost pressure?

BuildIT understands that improving productivity requires upfront investment. We therefore start by offering smaller workflow automation services. Most SMEs start by purchasing measurement equipment software. From this, they can create their own macros to take measurements, which can reduce the time it takes to take measurements from one hour to five minutes. After they have benefitted from this technology, they can scale up their automation by purchasing a more comprehensive package from BuildIT.

What are BuildIT's key goals for the next three to five years?

BuildIT wants to expand and be known internationally in new markets such as Asia. As part of that goal, we want to expand our automation and configurability capabilities so that BuildIT can regularly deliver projects around the world. —

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Michael Muldoon

Director of

Aerospace Operations
RADIX INC.



Could you provide an overview of the company's main activities and products?

Radix provides software which enables companies to visualize, collect data and provide traceability on a person's work activities, such as inspection, in order to improve their production efficiency. We fill a gap in the market for companies that still have people-based tasks but are open to using some automation to improve the efficiency of those tasks. Aside from Radix, AIS comprises a mold making division and a tooling division. Radix was brought into the group to differentiate AIS in the market place and inject new technology into the company. Two of our main products are Tool Tracker and Inspect Tracker. Tool Tracker addresses error-proofing needs and provides complete traceability in a manual fastening sta-

tion. Inspect Tracker is an integrated, vision-based system where workers use a simple, handheld pointer.

Radix also offers custom solutions for end-of-line vision inspection through the use of collaborative robots.

What advantages can Radix offer its clients?

Radix's tools save clients time and improve process efficiency. For example, Inspect Tracker can reduce inspection time by 50% and results in more accurate data and ultimately improves the quality of the products our clients produce. It also improves their own client communication through the data collected by our tools and shared with other systems.

What are Radix's key goals for the future?

Radix aims to grow its aerospace division from 10% to 25% of the company's business. Québec remains a key area of focus but other regions are more advanced in their manufacturing processes, such as the United States and some countries in Europe. Québec's government is helping jolt local companies into becoming more innovative. —

If Québec wants to keep its place as the third-largest aerospace hub in the world, we need to look at what the industry is demanding today. It is pushing for more automation, innovation, R&D, additive manufacturing, composites and digitalization. This change does not put Québec in jeopardy, but we need to think about how we will survive and keep our place in the new environment. It is a question we need to ask ourselves every day. Québec and Canada have a great R&D ecosystem. We have a strong university network and research centers, but the support needs to be industry-led. As the industry, we are in the best position to identify and address the need.



- Alain Ouellette,
Operations Director,
GE Aviation

One struggle of Québec companies is automation. It is a priority for the Québec government and they are encouraging companies to invest in automation in order to stay competitive. Our companies are very innovative with new ideas but they need to invest in more efficient processes. Right now, we use a lot of laborers and labor costs come into play for worldwide competition. Automation is one of the keys to making the region more competitive as it will reduce the cost gap with other lower-cost countries.



- Alexandre Faria,
VP Business Development,
Export Development Canada (EDC)

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We welcome these technologies because they are essential. The aerospace supply chain is now international. Therefore, in order to compete, we need to implement automation as much as we can. We are one of the first companies that entered into the Industry 4.0 program and we have several projects. Becoming more automated is essential for us and is definitely the next step considering the challenges around manpower.



- Sylvain Bedard,
CEO,
Sonaca Montréal

If SMEs do not implement these technologies, they will not survive—labor in Québec is too expensive. Automation reflects a broader shift in the workforce due to technological advancements which are unstoppable. Previously, around 80% of employees worked on the production line and 20% worked in office based jobs; now this ratio is being reversed.



- Guillermo Alonso,
President,
Alta Precision





RESEARCH AND DEVELOPMENT



“There are powerful disruptive technologies coming into play such as 3D printing, robotics and more broadly Industry 4.0, which are evolving fast. Companies will have to adapt or be swept aside.”

- André Viau,
Portfolio Manager, Aerospace Industry,
Fonds de solidarité FTQ

Banding Together: Québec's Innovation Ecosystem

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Having emerged as the pinnacle of Canada's aerospace industry, it is apparent that beyond the driving force of the OEMs, Québec's key to success lies in its high number of innovative SMEs and collaborative approach to innovation. Research organizations such as the Consortium for Research and Innovation in Aerospace in Québec (CRIAQ) and the national Consortium for Aerospace Research and Innovation in Canada (CARIC) support programs and bridge gaps between universities, SMEs and larger players. Associations such as Aéro Montréal and the Aerospace Industries Association of Canada (AIAC) also seek to coordinate the industry and encourage collaboration to drive innovation. "Canada is first in civil flight simulation, first in small engine production, second in business and regional aircraft production and third in overall civil aviation production," noted Jim Quick, AIAC's president and CEO. "Globally, we are ranked number one in strategic importance to overall manufacturing for our country, number three in terms of R&D intensity, and number five in terms of GDP contribution...We are not like other aerospace nations, which often have supply chains that are very focused on their own national needs. We do not build

aircraft for Canada; we build them for the globe."

More than 70% of all Canadian aerospace R&D is carried out in the Greater Montréal area, representing an investment of approximately US\$700 million a year. When it comes to commercial entities, Bombardier is Canada's top R&D investor, investing more than C\$6 billion into R&D over the past 10 years. However, significant portion of overall investment comes from financial support offered by a number of Québec's associations and both the provincial and federal governments. For example, 2016 saw 21 new collaborative research projects supported by CRIAQ with a total value of C\$26.9 million. More broadly, CRIAQ has also launched a Digital Aerospace project to fuel discussion on the convergence of aerospace and digital technology to determine R&D needs and translate them into development priorities over defined time frames. In addition to CRIAQ, other internationally-renowned research bodies include the Institut Nationale d'Optique (INO), the NRC Aerospace Manufacturing Technology Centre, Defence Research and Development Canada - Valcartier (DRDC) and the Centre technologique en aérospatiale (CTA).

R&D consortiums are typically formed

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One of the major trends in the aerospace industry is the democratization of innovation where all companies, including smaller ones, have access to technologies that will enable them to create innovative products...SMEs often face challenges in finding financing for their products.

They also need to validate their products quickly so that their limited resources will not go fruitless. In addition, SMEs sometimes do not have the capacity to commercialize their products and need the support of companies like MAYA so that they can focus on product development.

- Marc Lafontaine,
Vice President,
Maya Simulation Ltd.



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around a particular challenge or area of improvement; CRIAQ is also trying to approach program selection more strategically in this way. "Most of CRIAQ's projects have been bottom-up programs creating technology according to companies' needs," explained Denis Faubert, president and CEO at CRIAQ. "However, we are starting to move towards incorporating new technology research into structured programs. We want to pursue projects in big fields such as advanced manufacturing, clean tech, and numerical technology, which includes artificial intelligence."

Also following this approach is Aéro Montréal, which launched the Coalition for Greener Aircraft program, SA2GE (Smart Affordable Green Aircraft), in 2011, for example. The program aims to address climate change and compliance with new environmental regulations. "Environmental impacts, including on climate change, are an opportunity

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Because our projects do not extend beyond TRL 6, we have been trying to create bridges between our program and ones that can further assist companies, without a gap in support if possible. We are also trying to be more strategic... We are also trying to transform ourselves into something of an R&D brokerage service, offering more research programs than just our own. Even if the CRIAQ program does not fit a company's needs, we want to be able to support them in their application to other programs. Additionally, we have become much more proactive in reaching out to companies in other clusters, such as TechnoMontréal and Prompt. This is important for the future to be able to inject technologies from other networks into aerospace products.



- Denis Faubert,
President & CEO,
Consortium for Research and
Innovation in Aerospace in Quebec (CRIAQ)

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for aviation to play a leadership role,” commented Suzanne M. Benoît, Aéro Montréal’s president. “We had great success with this initiative, with 27 SMEs, five universities and four R&D centers collaborating. The Québec government and private companies contributed C\$150 million in five R&D projects. Héroux-Devtek, for example, worked on a project to launch more environmentally-friendly surface treatment technologies. Advancements of this sort will place them in a strong position on new generations of aircraft with the OEMs.”

Aéro Montréal launched phase two of the program in 2016, with five projects selected. As part of its Québec Aerospace Strategy, the Québec Government has allocated funding of up to C\$65 million for this second phase of the project, which will total upwards of C\$130 million in public and private funding by 2021.

In many instances, programs are led by large companies, such as Québec’s OEMs and Tier 1s. In line with increasing tendencies to outsource non-core functions and looking outwards for specialized expertise, larger companies are more and more receptive to joining forces with external organizations. Pratt & Whitney Canada (P&WC), for example, has more than 23 ongoing university agreements

in Canada and projects with CARIC, CRIAQ and GARDN. “With the support of the Canadian government, we are also working with the aerospace cluster to create a consortium with themes related to advanced manufacturing and digitization,” noted Maria Della Posta, senior vice president at P&WC. “Additionally, we work with more than 1,300 suppliers in Canada. In collaboration with the federal government, we have put in place a program to help suppliers gain aerospace accreditation. We derive a lot of value from these collaborations, and we try to give as much back to the community as possible.” Bombardier, Canada’s largest investor into R&D, also looks to its surrounding ecosystem to drive innovation forward, actively participating in almost 20 collaborative projects with universities, SMEs and other industry players. “These types of projects are crucial to help adapt R&D concepts into commercially viable solutions and to improve our global competitiveness,” commented Olivier Marcil, vice president, external relations at Bombardier. “In today’s fast-evolving economy, innovation goes beyond academic collaboration. SMEs are creating new innovative technologies and collaboration between them and established global companies has become

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essential to address customer needs. At Bombardier, we are creating opportunities to foster this type of collaboration.”

Referencing the MACH initiative, deployed in 2011 under Bombardier’s mentorship to encourage collaboration between large businesses and SMEs in Québec’s aerospace supply chain and thereby increase competitiveness, Marcil continued: “Today, more than 55 suppliers have been involved in the program and more than 600 improvement projects have been completed. This type of collaboration not only creates value for the industry at large, but also helps us build a world-class supply chain to compete in any environment.”

Alongside contributions to major projects and its own internal R&D, Bombardier also assembled a pan-Canadian consortium and launched Project Horizon, a collaborative project focusing on the development of innovative aircraft technologies. With partners including the Canadian National Research Council and five Canadian universities, the consortium aims to develop advanced electric systems to replace heavier pneumatic and hydraulic systems found in some aircraft. Another area of focus is electronic interfaces that will allow aircraft computers to perform tasks without pilot input, replacing conventional mechanical flight controls.

Whilst it is often a natural fit for the industry giants to take the reins on collaborative projects, there are of course exceptions to the leadership model. For example, phase two of the SA2GE program, in which Bombardier is also involved, is in fact led by SME Teraxion.

More generally, well established companies are increasingly looking to universities and startups as a source of breakthrough technologies and proprietary processes. A key challenge within the innovation ecosystem is therefore the commercialization of this research to capture value addition rather than passing the program on at a low technology readiness level (TRL). CRIAQ is very much focused on this evolution from applied research with a low TRL to mid-TRL demonstration programs. In conjunction with CARIC, CRIAQ now funds the work of companies as well as universities. “Although there has been some concern over losing university involvement because higher TRLs

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If Québec wants to keep its place as the third-largest aerospace hub in the world, we need to look at what the industry is demanding today. It is pushing for more automation, innovation, R&D, additive manufacturing, composites and digitalization. This change does not put Québec in jeopardy, but we need to think about how we will survive and keep our place in the new environment. It is a question we need to ask ourselves every day. Québec and Canada have a great R&D ecosystem. We have a strong university network and research centers, but the support needs to be industry-led. As the industry, we are in the best position to identify and address the need.



- Alain Ouellette,
Operations Director,
GE Aviation

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generally involve less applied research, we maintain our strong involvement with universities,” assured Faubert. “In terms of current funding dynamics, about 35% of the total project value goes to SMEs, about 30% to universities and about 20% to large companies.”

Government support and financing

Whilst some companies have large R&D budgets and the available resources to launch large projects, others require external support such as that offered by CRIAQ and the government. On the subject of government support of innovation, Michel Farley, president and CEO of Varitron Technologies, commented: They have done a lot to help industry, including through funding to spur innovation in manufacturing processes and to help companies export. Investissement Québec has a stake of approximately 28% in Varitron and funding from the government will help the company market itself in the United States and secure more business there. Other companies in Québec should also use this funding to jump start their innovation and export strategies, something which is especially important as some owners of SMEs are unwilling to invest their own resources as they are nearing retirement.”

Varitron is among the top five Electronics manufacturing services (EMS) corporations in Canada, focusing on printed circuit board assembly and electronic engineering services for a variety of industries. The company has recently started to investigate the potential of printable inks and is also working on a new cooling technology for electronics.

Towards the end of 2016, the Honorable Navdeep Bains, Minister of Innovation, Science and Economic Development for the federal government, announced an investment of up to C\$54 million in a consortium of 15 Canadian companies and academic institutions for cutting-edge electrical systems and advanced aerodynamic systems. This funding will be delivered under the Technology Demonstration Program, which supports collaborative research and early stage projects. The consortium will be led by Bombardier, with other Québec-based partners including Thales, Liebherr, OPAL-RT, McGill University and Polytechnique Montréal.

Québec’s aerospace industry is a prime example of the benefits of collaboration in driving innovation. By financially supporting the breakthrough innovation stemming from smaller companies and universities in particular, the government will ensure that the industry remains at the cutting-edge of technology into the future. —



Denis Faubert

President & CEO
**CONSORTIUM FOR
RESEARCH AND INNOVATION
IN AEROSPACE IN QUEBEC
(CRIAQ)**

This year is CRIAQ's 15th anniversary. What are the updates since we met in 2015?

Since 2015, the nature of CRIAQ's programs has evolved from applied research with a low technology readiness level (TRL) to mid-TRL demonstration programs. Before 2014, all CRIAQ projects were focused on TRL 2, 3 and 4—early stages in the innovation cycle. Since 2014, two-thirds of CRIAQ projects in Québec are TRL 4, 5, and 6. With the national Consortium for Aerospace Research and

Innovation in Canada (CARIC), we can now fund the work of companies as well as universities. Although there has been some concern over losing university involvement because higher TRLs generally involve less applied research, we maintain our strong involvement with universities. In terms of current funding dynamics, about 35% of the total project value goes to SMEs, about 30% to universities and about 20% to large companies.

Because our projects do not extend beyond TRL 6, we have been trying to create bridges between our program and ones that can further assist companies, without a gap in support if possible. We are also trying to be more strategic. Most of CRIAQ's projects have been bottom-up programs creating technology according to companies' needs. However, we are starting to move towards incorporating new technology research into structured programs. We want to pursue projects in big fields such as advanced manufacturing, clean tech, and numerical technology, which includes artificial intelligence. We are also trying to transform ourselves into something of an R&D brokerage service, offering more research programs than just our own. Even if the CRIAQ program does not fit a company's needs, we want to be able to support them in their application to other programs. Additionally, we have become much more proactive in reaching out to companies in other clusters, such as TechnoMontréal and Prompt. This is important for the future to be able to inject technologies from other networks into aerospace products.

Historically, there has been a lack of willingness to collaborate with potential competitors. Is this attitude now changing?

There is no lack of good will from anyone. However, it is much easier to have competitors work together in a pre-competitive environment, for TRL 3 and below. Beyond TRL 4, when getting closer to commercial products, there is more vertical collaboration between the OEM and its supply chain.

Could you elaborate on the general funding model for CRIAQ's projects?

The industry partner generally covers

their costs and we at least match it. The maximum stacking limit of government programs in a project is 75% and, by combining various sources, we can reach that amount in some cases. The IP is defined in the funding agreement at the start of the project.

There is a gap between universities and industry when it comes to training. Is supporting students in gaining practical experience an area of focus for CRIAQ?

We seek to bridge this gap in two ways. Firstly, we work a lot with our partner, Mitacs Canada. Mitacs funds internships so, where possible, we try to incorporate this option into our projects to take students from laboratories to the industry. Secondly, we work with McGill University on its AeroCREATE program, which seeks to complement students' curriculum with work or studies in IP subject matter. 80% of McGill's internships occur through CRIAQ projects.

How do you expect CRIAQ's role in Québec's ecosystem to evolve over the coming years?

Our core mission is to build Québec's research network system through a more strategic orientation; growing our network internationally, increasing visibility of SMEs and increasing collaboration with other communities. Over the next five years, we want to at least double the international component of our programs to about 25% and would like 25% of our programs to be top-down as opposed to bottom-up. We also want 20% of our programs to be led by SMEs, which we should achieve more quickly. We are monitoring these targets and are making good progress so far.

CARIC, with the support of CRIAQ, is also leading an industry-driven proposal (Project MOST21) in the Superclusters competition that will encompass aerospace, ground mobility, advanced manufacturing and numerical technology. Similarly, we hope the findings of the Numerical Aerospace study will result in the structuring of a program at CRIAQ for numerical technology. This is the most important new development for us to plan for in order to stay ahead of the curve and exploit these technologies commercially. —

Innovation finds new roots

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Image courtesy of Concordia University

Many of Québec's universities have longstanding relationships with industry. As the aerospace industry demands more practical experience from recent graduates, internships and co-op programs are viewed as essential tools to properly prepare students for their first jobs. More recently, however, the industry has also acknowledged universities to be valuable partners in early-stage R&D and a primary source of breakthrough innovation.

University spin-offs are increasingly finding success, in high demand due to their possession of a specialized capability or first-in-class technology, and the universities themselves are increasing their capabilities for higher technology readiness levels (TRLs) to capture more value. By playing a more integral role in the later-stage development of technologies, they are better able to play a significant role on research platforms alongside commercial entities.

Particularly developed along these lines is Sherbrooke University. "We are what we can call an "integrated chain of innovation";" commented Richard Arès, associate Dean of engineering & general manager of the university's Interdisciplinary Institute for Technological Innovation (3IT). "In the world of electronics, robotics and information technology, we cover the whole chain of TRL 1 to 9. Therefore, we can be partners with industry from the very early work all the way to market."

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Our industry is very well supported by research and academic institutes across the country, and the role they play will continue increasing. We now have more tools involving research institutions and universities, such as the CARIC and GARDN networks, and a higher degree of interface between industry and academia than we have ever had before. These new and stronger relationships should lead to increased exports, commercialization, and growth in the industry.



- Jim Quick,
President & CEO,
AIAC

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Equally notable are the large number of startup companies born out of the university's research. "In terms of entrepreneurship, the University of Sherbrooke has the highest number of spin-offs by far," highlighted Arès. "We have a company-creation accelerator (ACET), an organization dedicated to helping startups launch, progress faster and have a bigger chance of success through funding, networking, coaching and training. For some time, the Québec ecosystem created about a dozen companies a year. This organization has created more than 70 companies in the last four years, entering the leagues of spin-off universities like Ryerson University and UBC." Sherbrooke University's target is to multiply its level of partnerships with industry by 10.

Funding and support

As well as securing more practical experience for students to work on 'real world' solutions, by securing closer ties with surrounding companies universities also benefit from greater access to funding. By positioning themselves as partners to industry, universities are more likely to have the visibility to partake in externally-funded research programs, even if the funding is not provided by industry. "Industry contributes a relatively small amount to funding for research, with government-funded research bodies typically providing around 80% of the funding," said Louis Laberge Lebel, assistant professor at Polytechnique Montréal's Department of Mechanical Engineering. "Companies are usually focused on short-term cost savings, meaning the scope of research is quite narrow. It would be beneficial if companies were more open to partnering with universities on fundamental research that could lead to the next big technological advances."

As well as working for more than 10 years on a large project with Safran towards the goal of making parts for the LEAP-X engine, Polytechnique Montréal was also involved in the production of a fire-resistant carbon fiber composite by-pass duct for aircraft engines with P&WC. The university is also working on several projects with CRIAQ, CARIC and NSERC. —

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There are probably three times as many projects with industry compared to 10 years ago. However, civil aviation companies have limited resources to fund research and therefore we will likely continue to rely on government funding for projects we are involved in.

- Prof. Aouni Lakis,
Director,
Aerospace Innovation and
Design Institute (IICAP),
Polytechnique Montréal



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Contributing to the economy of the province is of prime importance for Concordia. A key element of this is the availability of highly qualified personnel (HQP), which the university helps provide. Without doubt, Québec has the strongest aerospace engineering talent pool in Canada, perhaps even globally. Concordia is proud to contribute to the province's niche in aerospace.

- Amir Asif,
Dean,
Faculty of Engineering and
Computer Science,
Concordia University



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AEROSPACE 4.0™: TOWARDS A SMART AND DIGITAL ENTERPRISE

ÉTS offers an integrated research and education program to support the aerospace industry in implementing Industry 4.0 technologies.

RESEARCH Decades of experience in applied engineering research coupled with industry projects allow ÉTS professors to provide innovative solutions in areas such as: <ul style="list-style-type: none"> • Robotics • Additive manufacturing • Intelligent Manufacturing Systems (IMS) and Multidisciplinary Factory Optimization (MFO) • Multidisciplinary Design Optimization (MDO) and product development simulation • Smart supply chain and logistics - Product Lifecycle Management (PLM) • Advanced predictive maintenance systems 	EDUCATION Professionals who need to familiarize themselves with Industry 4.0 technologies can attend lectures and workshops with leading experts in topics such as: <ul style="list-style-type: none"> • Artificial Intelligence • Big data: reliability, variability, sharing and security • Collaborative robotics • Additive manufacturing • Modeling and simulation of machining processes • Multidisciplinary design and optimization • Virtual development testing
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ÉTS
Engineering for Industry



Dr. Hany Moustapha

Professor and Director, AÉROÉTS,
P&WC Chair in Propulsion System,
**ÉCOLE DE TECHNOLOGIE
SUPÉRIEURE (ÉTS)**
and Senior Research Fellow
**PRATT & WHITNEY CANADA
(P&WC)**

ÉTS is focused on engineering across a variety of industries. How has the university developed, and what are the key focus areas in terms of its student offering?

Aerospace is the number one area at ÉTS. Of 170 professors, we have close to 56 professors across different departments working in aerospace, so almost one third of our workforce. AÉROÉTS is a community within ÉTS, rather than a distinct department, and spans the various departments, such as mechanical engineering, electrical engineering and computer science. Within aerospace, ÉTS' main strength is manufacturing and material – we have a large critical mass of professors in this area. The second core strength is avionics, which includes controls, drones and navigation. Nevertheless, we also have extensive expertise across other areas including emissions, design optimization, simulation, fluid dynamics, and so on. We cover all research areas.

We are the only university in Canada that only hires professors with industrial experience. Cumulatively, our 56 professors involved in aerospace have about 350 years' practical industry experience. ÉTS is number one in Canada in terms of graduating engineers, graduating between 750 and 800 engineers per year. All of our students come from a technical college, so they are very hands-on. ÉTS has approximately 10,000 students, including 8,000 at undergraduate level and 2,000 at graduate level, and of those, 3,000 are yearly co-op students. In aerospace, we have more than 500 co-op students per year, which amounts to more than the rest of the aerospace co-op students at Canadian universities combined.

ÉTS has very strong industry links, placing more than 3,000 interns at companies every year and conducting 70% of research activities in collaboration with industry. Could you elaborate on this relationship?

The Canadian average for the percentage of research conducted by engineering faculties in collaboration with industry is 25%, so our activities sit at almost triple the average. The relationship is extremely strong, and we have partnerships with between 50 and 60 of the 250 aerospace companies in Québec, in addition to international companies.

How strong is Québec's talent pool?

We have no shortage of talent, although it was an issue some 15 to 20 years ago. The

collaboration between industry and universities is now extremely strong. The result is near self-sufficiency when it comes to talent. Equally, there is a lot of movement and rotation between companies, even in management positions. Canada will need 10,000 aerospace engineers over the next 10 years, so the demand for talent will continue to be strong.

In 2015, you noted that fuel consumption has been a great area of focus for ÉTS. As travel and by extension emissions increase, how is this area developing?

The key topic of the moment is the environment. Projections for new aircraft over the next 10 years sit at 2,000 per year. With additional aircraft and flights comes an increasing challenge around the environment, emissions and noise pollution. Preference for blended wing body (BWB) aircraft is increasing. Electric and hybrid propulsion is another popular area of research and development.

Are there any particularly notable projects in which ÉTS is involved?

We are working on a very big project with Siemens, which is a total enterprise Industry 4.0 integrated R&D program and involves other universities working together as a consortium. We have a 25-year partnership with McGill and often collaborate with other universities on large-scale contracts such as this one.

There is also the Center for Aerospace Professional Education (CAPE), a partnership with McGill, which is the only professional education body for aerospace in Canada, and the second in North America alongside Kansas University. We also have the Montreal Aerospace Institute (MAI), a combination of six Québec universities.

What are the objectives for ÉTS going forward with regard to aerospace?

The Siemens contract will be a big area of focus for us because it involves so many players and so many parties within ÉTS, including both professors and students. There are also many opportunities within Industry 4.0, or "Aerospace 4.0". A key challenge is to demystify these concepts, for which we are offering short courses and presentations at ÉTS. Industry 4.0 encompasses entire processes and we will therefore need to develop these capabilities within the workforce. —

Amir Asif & Isabelle Dostaler

AA: Dean, Faculty of Engineering and Computer Science

ID: Professor, Management,
John Molson School of Business
CONCORDIA UNIVERSITY



AA



ID

Concordia University is a public university located in Montréal, offering a bachelor's and master's program in aerospace engineering. The John Molson School of Business is the university's business school.

How important is aerospace teaching and research to Concordia?

AA: Since Montreal is a major hub for aerospace engineering research and development activities, aerospace has always been important to Concordia and we continue to strengthen our expertise and links with the industry. For many years we have offered a professional master's degree program in aerospace engineering and an aerospace specialization within the undergraduate mechanical engineering program. We have always had close ties with major aerospace companies such as Bombardier, Pratt & Whitney Canada, Bell Helicopter, Siemens (Rolls Royce), and a number of SMEs.

How does Concordia facilitate student participation in the industry?

AA: Concordia offers three main ways for its students to contribute: the co-op program, internships and apprenticeships. Since the establishment of Concordia's Institute of Aerospace Design & Innovation (CIADI) in 2002, the university has placed about 1500 undergraduate students on internships in the aerospace industry. About 500 of these students are working as full time employees with the companies where they worked as interns. Over the years, the feedback from the industry has been that, while they value the program, it takes too long to train graduates to be productive in the workplace. In consultation with aerospace industry, Concordia therefore launched the BEng in Aerospace Engineering in 2016. The curriculum

focuses on developing the "right" skills so graduates can contribute from day one of their placements. An innovative feature of the program is an apprenticeship component that places students in different departments of the same company over four years of their studies. The industry is contributing financially toward the apprenticeship program, which is also supported through an NSERC Chair in Aerospace Design Engineering (NCADE) whose role it is to incorporate engineering design and hands-on practical experience for our students.

How are you preparing students for Industry 4.0?

AA: A key part of Industry 4.0 is cyber-physical system technology that connects objects from physical and virtual worlds through an "internet-of-things" framework. Both cyber-physical systems and internet-of-things are active research areas in the faculty. Concordia has a strong background in associated fields, including virtual reality, communication networks, artificial intelligence, data analytics and systems software, and was one of the first universities to offer an undergraduate degree in software engineering.

The business school launched an aviation think tank in September 2016. Could you elaborate on its purpose?

ID: The think tank serves as a neutral platform for industry professionals and researchers to focus on a deeper, more nuanced understanding of the aviation sector. The impetus for it came from the former CEO of Air Canada and IATA, Pierre Jean Jeannot, who is the chairman of our advisory board. Major projects so far include a large research contract from the Québec government to develop a strategy for air regional transporta-

tion in the province.

Concordia boasts a wealth of research collaborations with industry. Could you describe any particularly interesting research projects?

AA: We are working on NSERC funded projects that address industry needs. Within aerospace engineering, the research includes avionics, instrumentation and control, combustion and propulsion, materials and structures, surface engineering, renewable energy as well as aerospace design and simulation. We collaborate with the industry on research into aerospace robotics and have ongoing research in collaboration with the industry on integration advanced electromagnetics in aerospace design. Underpinning these projects is the fact that Concordia has a very progressive intellectual property (IP) policy that encourages both researchers and industry to invest time and money into projects.

What are your key objectives for the next five years with regard to aerospace?

AA: The faculty has just developed its strategic plan. We aspire to be one of the top engineering schools in Canada. As part of this, we want to foster niches in strategic areas such as aerospace engineering and to continue to develop academic and research programs in next generation technologies working directly with industry.

ID: In line with the university's core values, we want to embrace the world through aerospace and for Montréal to be the world's top aerospace hub. With regards to the aviation think tank, our immediate objective is to secure more input and financial support from the industry in order to conduct research that will help design sound aviation policy and business practice. —

Stephen Yue

Lorne Trottier Chair in
Aerospace Engineering and Director
**MCGILL INSTITUTE FOR
AEROSPACE ENGINEERING,
MCGILL UNIVERSITY**



Could you give an overview of McGill's Institute for Aerospace Engineering (MIAE)?

The institute was formed in 2010 to support student access to internships generated by the Montreal Aerospace Institute (MAI), which is made up of the main aerospace companies, plus the various institutes at McGill, ÉTS, Concordia, Sherbrooke, Laval and École Polytechnique de Montréal. McGill has about 300 undergraduates available for these internships and gets around 70 to 80 internships a year. By bringing together the aerospace engineering professors, the institute is also a way for industry to have greater visibility on the different McGill research themes, and vice versa. The MIAE also funds students to participate in the McGill Engineering Faculty SURE (Summer Undergraduate Research in

Engineering) program, which offers paid opportunities for undergraduates to work as researchers for professors in the summer months. In addition, the MIAE administers the CREATE program, which prepares graduate students, selected from the aforementioned aerospace institutes, for entry into the industry through industry oriented training programs.

Strong R&D programs are crucial to the future of Québec's aerospace industry. What key research initiatives in aerospace engineering is the university involved with?

If a company has a research program they want to lead, we encourage them to partner with our professors. For example, Professors Nadarajah and Hubert work closely with Bombardier on many projects, and McGill is involved in many CRIAQ (Consortium de Recherche et D'innovation en Aérospatiale au Québec) projects. There is also an emerging large scale effort with an OEM partnering with McGill, ETS and Concordia, focusing on manufacturing.

How does McGill position itself to attract the best students?

Most students come to McGill because of its reputation. McGill does not offer an aerospace specific degree program, but for students who are aerospace focused, the MIAE provides excellent access to the aerospace industry. McGill is also establishing a faculty-wide aerospace minor so that students of all engineering disciplines can have an aerospace orientation within their major engineering degree program. —

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Prof. Aouni Lakis & Wissem Maazoun

AL: Director, Aerospace Innovation
and Design Institute (IICAP)
WM: Business development specialist
**MITACS &
POLYTECHNIQUE MONTRÉAL**



AL



WM

To what extent does the university cater to aerospace?

AL: Polytechnique provides a joint Masters in Aerospace Engineering with six engineering faculties at different universities in Québec, including McGill, Concordia, Sherbrooke, ÉTS and Laval. As part of the degree, each student is required to complete two internships with the industry and engineers from the sector provide courses which focus on industrial applications of engineering theory. The program is extremely popular, with around 80 students every year.

In what ways does Polytechnique ensure that students have access to practical experience with industry?

AL: We have established relationships with Bombardier, Pratt & Whitney Canada (P&WC), Bell Helicopter, Siemens, CAE, Sfran, GE Aviation and many other companies. As part of the NSERC CREATE program, for example, select PhD students complete a four- to eight-month internship in industry and receive training on soft skills by aerospace companies. In addition, IICAP works as a conduit between students and the industry by finding suitable internship opportunities for undergraduate, masters and PhD students.

WM: Alongside IICAP, Mitacs works with Polytechnique and other universities as a 'human bridge' between industry and universities. Masters, PhD students, and postdocs obtain internships through this organization and focus on research that addresses problems companies are trying to solve.

What are the key objectives for the university in developing its industry ties over the next few years?

WM: We are in a position in which there is very good collaboration between industry and the university. Professors are open to doing more joint research projects and a key goal of ours is to deepen collaboration with industry. —

Serge Beaudoin & Richard Arès

SB: Business Partnerships Director
RA: Associate Dean of Engineering &
General Manager of 3IT
UNIVERSITY OF SHERBROOKE



SB



RA

The University of Sherbrooke hosts over 40,701 students. Could you briefly introduce the university and its main areas of academic focus?

SB: We have eight faculties: Administration, Education, Engineering, Law, Letters and Humanities, Medicine and Health Sciences, Science, and Sports and Physical Education. University of Sherbrooke is characterized by its co-op teaching. We have 45 programs where students are alternating study sessions with paid internships ("stages") in the workplace to complement the knowledge developed at the university with a practical work experience.

In research, we are striving to create and deliver value throughout the research journey, not only at the end. With 1,400 researchers, six institutes, 35 research centers, and 71 research chairs, our first priority when partnering with companies is training our students in real environments.

In engineering, we mostly teach our students through projects in which they combine course sessions with a separate working environment session. These internships bring us closer to our industry partners.

RA: We were the first francophone university and the second university in North America to put this type of training together. Every year, we have 4,500 work terms to find with over 1,000 different companies. We have developed and become recognized for our project- and problem-based learning, which is applied across Education, Medicine and Engineering. As soon as our students begin university, they are immediately put into practical situations where they must solve problems. A good example of an aeronautical project conducted by our students would definitely be the Epervier acrobatic plane. This plane was entirely designed and built by our engineering bachelor students and it is now part of the Canada Aviation and Space Museum exhibit.

Sherbrooke also collaborates with other research institutions. Could you elaborate on some of the models you work with?

RA: We developed a specific vision of how to collaborate with industry. The first important aspect is IP. We proposed "crowd-researching", where the industry can post problems or challenges on Web platforms and researchers can bid on and propose

solutions. The industrial partner can then choose a preferred solution, after which they can engage with the researchers and fund the program.

There can also be a great deal of friction between industry and universities over IP during collaborations, which can reduce the efficiency of the project as both parties are afraid of losing the IP or control. We are experimenting with a new model which focuses on transferring the IP to the commercial actor as quickly and seamlessly as possible. Since 90% of our ecosystem deals with very small companies, financial transfer is complicated due to lack of capital. We are therefore exploring other ways for IP to be paid back in order to secure return for the academics.

SB: Sherbrooke University's IP culture is very open. We are recognized as being very easy to deal with.

Talking about collaboration with the industry, if you are aware of the MITACS program, in which students work at the partner's facility 50% of the time and spend 50% of the internship at the university, according to MITACS 2016-2017 activity report, Sherbrooke is number-one in the number of Accelerate internship in Québec and second in Canada.

Could you provide a specific example of a research project currently underway?

SB: One of our researchers, Pr Patrice Masson, is currently undertaking a mechatronics project on the continuous monitoring of aircraft structures using ultrasound. By distributing sensors throughout the structure of a plane, real-time data on the aircraft structure can be produced. We also have very good young researchers working on drones with industrial and governmental partners. In smaller companies, students can create something completely new; companies are often dependent on the expertise we transfer to them.

What are the objectives of the university over the next few years?

SB: Our strategy revolves around innovation, partnerships and entrepreneurship. Our target is to multiply the level of partnerships we have with the industry by 10. We plan to achieve this by assessing partners' needs, finding the expertise, matching them up with the right research team, and following the partnership relation to maximize the impact of a project. —





LICENSE TO FLY: TRAINING QUÉBEC'S WORKFORCE



“Over the last 15 years, the industry has greatly matured, particularly in terms of collaboration. The result is near self-sufficiency when it comes to talent. Equally, there is a lot of movement and rotation between companies, even in management positions. Canada will need 10,000 aerospace engineers over the next 10 years, so the demand for talent will continue to be strong.”

- Dr. Hany Moustapha,
Professor and Director,
AÉROÉTS, P&WC Chair in Propulsion System,
École de technologie supérieure (ÉTS) and Senior Research Fellow,
Pratt & Whitney Canada (P&WC)

Developing the Talent Pool: Keeping up with Demand

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The quality of Québec's workforce is cited by many as one of the region's key advantages. Prominent universities include the École de technologie supérieure (ÉTS), Concordia, McGill, the Polytechnique de Montréal and Sherbrooke. As many industry leaders and skilled workers reach retirement, however, there is extremely high demand on the talent pool. Meanwhile, with the uptake in Industry 4.0 technologies and new processes, the nature of many jobs is changing, calling for additional training of existing employees to facilitate the transition.

According to the Comité sectoriel de main d'oeuvre en aérospatiale du Québec (CAMAQ), the Québec Aerospace Workforce Sector Committee, the region will need 10,000 new aerospace employees over the next 10 years and a further 23,000 to replace workers leaving the workforce. "21 years out of the last 30 saw a growth in aerospace manpower needs," said Nathalie Paré, Executive Director, Comité sectoriel de main d'oeuvre en aérospatiale du Québec (CAMAQ). "Overall, manpower needs have grown by 2.13% annually over these thirty years. Extrapolating from this for the next 10 years, Québec needs 10,000 new aerospace employees and 23,000 to replace workers leaving the workforce."

CAMAQ's mission is to ensure the aerospace industry has the right quantity and quality of manpower and to make sure that the training system is responsive to the needs of industry.

With a large number of qualified technicians and engineers retiring, demand for talent is strong but attracting new students to the industry can be challenging. "Companies are struggling to find the right talent and sometimes have to search internationally for it," said Jean Wilhelmy, senior vice president for aerospace, construction, services and transportation at Fonds de solidarité FTQ. "There are not enough younger people pursuing the technical skills needed by the industry."

Meanwhile, companies are increasingly demanding more practical experience from potential new recruits. Universities are therefore having to adapt their models to prepare students for the in-

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The Montréal aerospace cluster is one of the world's three major aerospace centers, along with Seattle and Toulouse.

This gives us access to an excellent pool of skilled labor generated by the extensive infrastructure of Québec universities, collaborative research centers, aerospace educational institutions, government support programs, as well as a wide range of local suppliers and service providers that target the real needs of the aerospace industry.

- Denis Gangi,
President,
Rolls-Royce Canada



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dustry. “Traditionally, education was the province of universities and industry took over the training of these educated students,” stated Professor Stephen Yue, Lorne Trottier Chair in Aerospace Engineering and director at McGill Institute for Aerospace Engineering, McGill University. “However, industry now desires that the university increases its role in the development of what is currently termed ‘graduate attributes’, which includes things like soft skills, as well as training in industry-specific tools, such as specific software.”

Organizations such as CAMAQ aim to bridge this gap. CRIAQ, for example, works a great deal with Mitacs Canada, which funds internships, and also works with McGill on its AeroCREATE program, which seeks to complement students’ curriculum with work or studies in IP subject matter. CRIAQ also recently formed an alliance with the Canadian Aeronautics and Space Institute (CASI) to publicize its work, give students visibility and allow them to interact with the industrial community.

The advantages of close industry ties extend well beyond student benefits, attracting financial support for university research programs and providing breakthrough innovation and early-stage development capabilities to companies. Organizations such as the Montréal Aerospace Institute (MAI) and the Comité sectoriel de main d’œuvre en aérospatiale du Québec (CAMAQ) seek to develop talent at the university level and support training in the form of internships and other initiatives.

For example, CAMAQ’s ‘Your 1st Job in Aerospace’ initiative encourages businesses to provide training to new graduates through financial supplements. “Businesses need to provide training on their specific requirements to new graduates, which can lead to lost production time for them as they have to devote limited resources to training,” explained Paré. “The Canadian government therefore provided C\$4.2 million for the three-year program and CAMAQ finances 50% of participating companies’ salary costs of the new graduates. CAMAQ has received very good feedback

from the industry because it allows them to properly coach new graduates at a lower cost.”

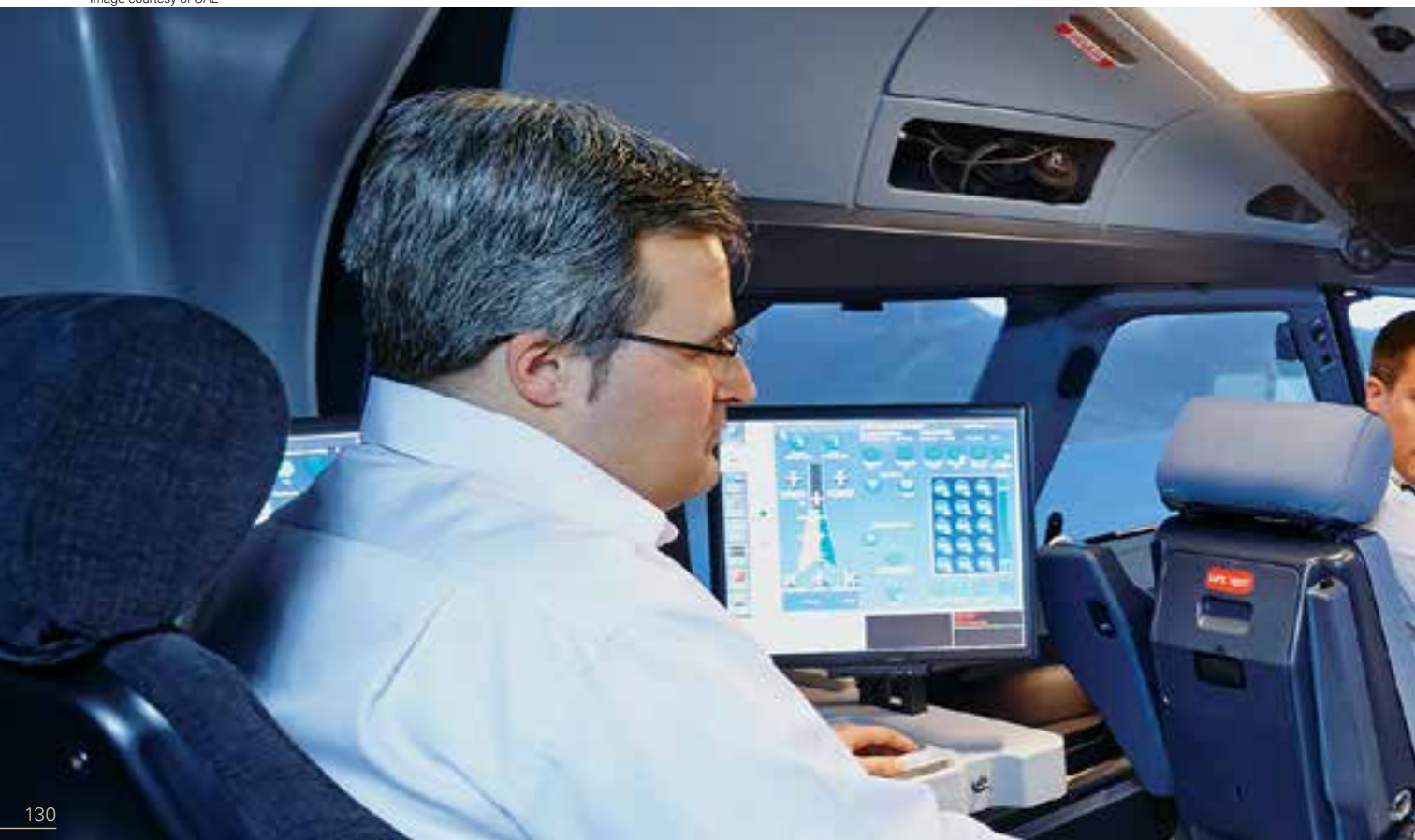
Universities have also become more proactive in fostering industry relationships themselves to secure more practical experience for students. Sherbrooke University, for example, is recognized for its co-op teaching and boasts 1,400 researchers, six institutes, 34 research centers and 50 to 60 additional research groups. “Every year, we have 4,500 work terms to find with over 1,000 different companies,” noted Richard Ares, associate Dean of Engineering and general manager of 3IT at the University of Sherbrooke. “As soon as our students begin university, they are immediately put into practical situations where they must solve problems. We are leaders in applying these programs to Engineering and our projects are much more ambitious than any other Engineering projects in other universities across North America.”

Sherbrooke University is particularly well regarded by industry for its open IP culture and entrepreneurial environment. The academic institution has created more than 70 spin-off companies in the last four years and its Interdisciplinary Institute For Technological Innovation (3IT) accelerates technology transfer in several sectors, covering technology readiness level (TRL) 1 through TRL 9.

Many of Québec’s universities also work with Mitacs, a national, not-for-profit organization founded in 1999 to design and deliver research and training programs in Canada. Over the past 15 years, Mitacs has supported more than 10,000 research internships and trained more than 19,000 students. Montréal is also home to the Center for Aerospace Professional Education (CAPE), a partnership between McGill and ÉTS, which is the only professional education body for aerospace in Canada, and the second in North America alongside Kansas University.

There is also the Center for Aerospace Professional Education (CAPE), a partnership between ÉTS and McGill and the only professional education body for aerospace in Canada, and the second

Image courtesy of CAE



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The ecosystem is strong but we are all competing for manpower. Whilst the academic programs are fantastic, the challenge lies in attracting people into these programs, especially women. There are not enough students graduating to meet current market demand. Those that apply to school often obtain job offers before they finish their programs.

- Sylvain Bedard,
CEO,
Sonaca Montréal



in North America alongside Kansas University. In addition, six Québec universities have combined to form the Montréal Aerospace Institute (MAI), created to address the aerospace industry's future needs for engineering highly qualified personnel (HQP).

Virtual training

Particularly when it comes to pilot training, simulated environments are an essential tool and training systems are currently in high demand. IATA forecasts indicate a growth in passenger trips by more than 4% annually over the next 10 years; the commercial aviation industry is therefore set to double over the next 20 years. At Paris Air Show, CAE unveiled its first CAE Airline Pilot Demand Outlook, which forecast the need for 255,000 new airline pilots over the next 10 years, further highlighting that 50% of those set to fly the world's commercial aircraft in 10 years have not yet started to train.

CAE is a global leader in training for the civil aviation and works with over 300 airlines, training more than 120,000 pilots annually at every career phase. The company plans to meet this rising demand for new and innovative pilot career pathways and training systems. “CAE's secret sauce has always been its culture of innovation,” highlighted Marc Parent, CAE's president and CEO. “We have invested more than C\$1.3 billion in R&D over the past 10 years and we continue to invest heavily today—not only in developing the latest technologies but also in our training differentiators: instructors, courseware, products and processes. One of

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the key elements will be how we leverage existing technologies and big data to create training programs that are tailored to the specific needs of each pilot. We call that adaptive training. If the data shows that the pilot has problems in landing with crosswinds, for example, the training program will focus on this aspect until it is mastered.”

Over the years, CAE has helped create the standards that are the basis of pilot training today and will likely continue to shape the future of training. Presagis, a division of CAE, specializes in virtual reality, artificial intelligence and human-machine software solutions for aerospace and defense. “Presagis has three core areas of critical expertise,” noted Jean-Michel Brière, general manager at Presagis. “The first is virtual reality; we can create a virtual environment for almost any customer. The second is artificial intelligence—our systems that allow the creation of life in virtual environments. The third is human-machine interface. Drawing on these areas of expertise, we sell support to help customers create the next generation of systems. For example, we have developed touch in our tools for the cockpit, and customers are using our system to create the next generation of cockpit display systems. We also regularly work with real-time avionic systems. Despite our size, we are recognized in the industry as being experts in our fields.”

One of Presagis’ branches assimilates the virtual training environment into a real cockpit platform to bring simulation into aircraft, removing the cost incurred by having all aircraft flying at the same time during training. Virtual training for missions elsewhere in the world also increases safety and security. —

“

Particularly in Montréal, we have close relationships with universities such as Concordia and McGill for occasional research programs and internships. We make extensive use of these connections to help students get real-world work experience. We primarily provide the training tools for companies to train their staff. However, nearly two years ago, Adacel was awarded part of a contract to provide air traffic control instructors that train controllers in the FAA. We have about 47 employees in the field using our simulator equipment to train air traffic control students.

- Gary Pearson,
CEO,
Adacel



”

Nathalie Paré

Executive Director

COMITÉ SECTORIEL DE MAIN D'OEUVRE EN AÉROSPATIALE DU QUÉBEC (CAMAQ)



What are CAMAQ's core mission and main activities?

CAMAQ's mission is to make sure the aerospace industry has the right quantity and quality of manpower and to make sure that the training system is responsive to the needs of industry. Every year, CAMAQ conducts a survey of companies' needs and then collaborates with schools to make sure they are meeting those needs. CAMAQ works closely with the Montréal Aerospace Trades School (École des métiers de l'aérospatiale de Montréal) and the National Aerospace School (École nationale d'aérotechnique), both technical trade schools. CAMAQ also coordinates a joint master's program in collaboration with McGill, Concordia, ÉTS, Polytechnique, Laval and Sherbrooke.

What key trends you have observed through your annual surveys?

21 years out of the last 30 saw a growth in aerospace manpower needs. Overall, manpower needs have grown by 2.13% annually over these thirty years. Extrapolating from this for the next 10 years, Québec needs 10,000 new aerospace employees and 23,000 to replace workers leaving the workforce.

Can Québec's educational infrastructure as it currently stands cope with this demand?

In short, yes. Because the industry and educational institutes are so well integrated, schools are very adaptive to demand. Our survey forecasts labor needs for the next one to three years and has a 95% to 98% response rate. We provide data on industry needs for scientific workers, technicians and professional and administrative

workers. CAMAQ also enquires after recruitment challenges and particular training requirements; for example, if they need more mechanical engineers as opposed to computer engineers. In addition, CAMAQ collects data on how many new graduates are required versus experienced hires. Usually it is about 50:50. Using this data, each year CAMAQ makes recommendations to schools to make sure they are graduating enough of the right types of students.

What particular skills are employers demanding from candidates?

Generally, they want their workforce to be more versatile. For example, they must be able to do some crafting, some robotics and some analysis. Employees need to know what is happening before and after their role in the production process. Business is also transitioning to Industry 4.0, for which labor competency needs are still not well defined. CAMAQ is working to help define these and to help schools better prepare students. Soft skills like analysis, comprehension and teamwork are also more in demand and critical.

Do you see Industry 4.0 as a threat to the workforce or something which will help it advance?

The effects will not be less manpower, but a different kind of manpower. Rather than robots replacing humans, employees will need to learn new skills to work with these machines. Industry 4.0 will therefore help workers to achieve more.

Companies are demanding that graduates have more industry experience before they are hired. What solutions do

you favor to help students be more prepared when entering the industry?

By working closely with both industry and schools, CAMAQ helps ensure students are industry ready. The good thing is that industry and educational institutes are very well integrated. However, companies sometimes have to devote limited resources to training which can lead to lost production time. That is why in May 2016 we launched the program 'Your 1st job in Aerospace' to help companies provide training on their specific requirements to new graduates and to help 200 new graduates get their first experience in aerospace. The Canadian government therefore provided C\$4.2 million for the three year program and CAMAQ finances 50% of participating companies' salary costs of the new graduates. CAMAQ has received very good feedback from the industry on this initiative because it allows them to properly coach new graduates at a lower cost. In addition, the students get the experience they need to acquire their first job in aerospace.

What are the key goals for CAMAQ in the next three to five years?

CAMAQ is launching a detailed interactive map showing all the different stakeholders involved in training in Québec, which we are very excited about. CAMAQ is also working on an initiative to keep seniors in the industry for longer. Next year, CAMAQ is launching its recommendations on new competencies that are required for labor to adapt to Industry 4.0. CAMAQ's main focus will be to continue to help define the manpower needs of the aerospace industry and to be a reliable conduit between companies and schools. —



George Karam

Vice President & General Manager
TRU SIMULATION + TRAINING

TRU simulation is a manufacturer of flight simulators and training solutions for civil and military markets

Previously Mechtronix, TRU Simulation + Training is a Textron Inc. company. Could you briefly introduce TRU and its relationship to Textron?

TRU is the simulation and training arm of Textron. We have a strong pedigree in the products and services we offer, which has helped Textron with its strategic move into the area of simulation and training. Our business addresses a number of areas in simulation equipment and training. In terms of commercial air transport, our focus is the provision, design and supply of simulation equipment. As for business aviation and rotary wings, we provide our customers with equipment and training too, especially Textron customers. Addi-

tionally, TRU has a strong military presence in simulation and mission and maintenance.

TRU has always been and will continue to be focused on innovation and putting forth new technologies, such as TRU Horizon.

Could you provide some more information on TRU Horizon?

TRU Horizon is a technology that allows for a simplified distributed I/O that can support the use of aircraft Line-Replaceable Units (LRUs) in our simulators. TRU Horizon is the third generation of solutions with benefits such as ease of maintenance, lower cost of operation and fewer spare-part requirements. Instead of the traditional complex wiring and connections in aircraft, TRU Horizon simplifies the overall architecture and setup of the simulator behind the panels. Our customers are often impressed with how clean and tidy our simulators are as well as how easy it is to maintain and troubleshoot any issues in the cockpit.

Our philosophy has always been that one size does not fit all and having flexibility in our solution means offering our customers a range of services.

What are some of the newest innovations being implemented on the simulation front?

TRU will remain current in visual systems technology as it continues to rapidly improve in fidelity and projector technology. Parallel to that is the full-flight simulator project we recently completed for Viking, a Canadian aircraft OEM. This technology provides additional visual channels to facilitate pilot training and docking maneuvers which traditional simulators do not have.

Are there any considerations or requirements in line with changing technology in the cockpit?

Aircraft are evolving, evident in new innovation from the aircraft OEMs. For example, Boeing's new 777X aircraft has cockpit displays with touchscreen technology. Being Boeing's chosen supplier for this aircraft, we will be implementing this technology on our simulators to ensure they mirror the aircraft.

Additionally, in non-aircraft-specific systems, such as the Instructor Operating Station, we are ensuring that we continuously

introduce new features that will augment the training capabilities for the instructors and the crew.

Could you elaborate on TRU's maintenance simulation training offering?

We are actively involved in virtual reality to support training for flight crew and a number of Textron aircraft platforms. We are investing in a lot of new technologies in this area, and we are applying many of these technologies to the solutions we offer to our military customers.

Are there any key differences in requirement between commercial and military customers?

A new area that has been relevant for the commercial world is in upset prevention and recovery training. We are working hand-in-hand with the aircraft OEMs to ensure we incorporate this training into our simulation offerings. The military side has its own requirements, but we are equally attentive to our end users in that area.

Have there been any notable developments in aircraft connectivity that have impacted TRU's solutions?

We are expending resources on connectivity so that we can collect data from our operating simulators during training sessions and feed it back to support competency-based training. As a company, TRU has been a big supporter of evidence-based training. We work with a number of airlines around the world to allow them to implement evidence-based training within competency-based training. Instead of focusing on repetitive mechanical tasks, the focus is on the experience gained through operation of the aircraft and data collected from the simulator, then feeding it back to the training structure and having an adaptive training philosophy.

What are the main objectives for the company going forward?

Our commercial air transport has doubled this year and we plan to continue growing aggressively going forward. We also plan to have a number of interns join TRU every semester. We are an attractive company to work for because of the exposure offered to new aviation technologies and the opportunity to develop solutions in collaboration with major international aircraft OEMs. —





THE FUTURE OF QUÉBEC'S AEROSPACE INDUSTRY



“We can always do more by raising our ambitions and having bigger dreams. The C-Series program will definitely spur growth in the industry. We have had a tough past few years, but with the strategy we have in place and the economic environment, Québec is now widely recognized as an exciting hub.”

- Dominique Anglade,
Minister of Economy, Science and Innovation,
Government of Québec

Québec's claim to global leadership

Québec's aerospace sector has all the makings of a global leader. From world-class OEMs to a competitive supplier network, the region's ecosystem is thriving due to a number of factors. Proficiency across various disciplines, most notably automation, robotics and artificial intelligence (AI) are key in ensuring the sector retains its prominent position internationally.

The importance placed on the province's aerospace industry as a key economic driver are clear. Examples of support from the federal government include a C\$2.2 million contribution, through Canada Economic Development for Quebec Regions (CED), to six aerospace companies that provide highly specialized equipment to the sector and C\$372.5 million in repayable contributions to Bombardier for its Global 7000 business jet and C Series aircraft.

Meanwhile, the Québec Ministry of Economy, Science and Innovation's recently-published 'Québec Aerospace Strategy' for 2016 to 2022 commits C\$510 million in government contributions to the sector and includes a 10-point plan for the industry's adaption to global trends. Focal points include the attraction of Tier 1 and 2 suppliers, the transition to Industry 4.0 and boosting exports. C\$400 million of funding has been allocated across 240 projects to help SMEs transition to advanced manufacturing, for example. As well as support for the province's SMEs, Québec's government has also shown substantial support for its prime contractors, with a US\$1 billion investment into Bombardier's C Series in return for a 49.5% stake and a recent C\$45 million loan to MDA to set up a center of excellence for satellites. In addition to funding allocations, there are also a number of policies and incentives in place to support Québec's aerospace sector.

Global dynamics are shifting and, as such, well-established industries are experiencing increased competition from lower-cost operating environments. Developing countries such as China and India are hot on the heels of established aerospace jurisdictions as they continue to invest heavily in their manufacturing sectors. Whilst the Americas and Europe may currently hold an advantage as home to the only certifying bodies currently recognized worldwide, the barrier is rapidly diminishing. In light of an increas-



ingly globalized operating environment, companies worldwide must compete internationally in order to obtain any business, also tying companies in with export markets as an all-important source of demand.

With Québec already exporting over 80% of its aerospace production, remaining competitive at an international level is paramount. Recognizing the importance of fostering a competitive supply chain, Québec's government is extremely focused on increasing the efficiency of its companies through the implementation of Industry 4.0 technologies. "In order to export, SMEs need to become top performers; to do this they need to invest in Industry 4.0 processes and in automation in particular," commented Dominique Anglade, Minister of Economy, Science and Innovation, Government of Québec. "For this reason, the Ministry launched the MACH-FAB 4.0 initiative with Aéro Montréal which focuses on helping SMEs transition to Industry 4.0. The Ministry also



Image courtesy of Bombardier

launched an export strategy in October 2016 and has a dedicated organization to support exports. Every time we travel internationally to events, we bring an aerospace team to promote exports from SMEs and to find forums for them to meet customers.”

Because companies are placing more emphasis than ever on efficiency and cost reduction, it is the engineering services segment that has arguably seen most rapid growth in an otherwise relatively slow market. Québec’s service companies are extremely well placed to take advantage of this uptick in demand due to the region’s longstanding prominence in R&D and process innovation. As a result, Québec’s aerospace sector will continue to narrow the cost gap with lower-cost countries.

Alongside a need for increased efficiency, increased consolidation in response to OEM pressures for more integrated service offerings will change the shape of Québec’s aerospace supply chain. SMEs unable to offer turnkey solutions will only be able

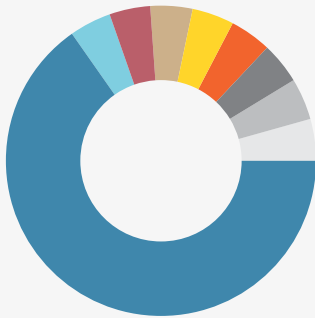
to survive if they have a unique product or will otherwise have to compete on price. Government support is therefore essential in supporting process innovation in SMEs in order to sustain a competitive aerospace SME network.

Going forward, as well as the focus on implementation of Industry 4.0 technologies, there will be a drive to attract more Tier 1 integrators to the region. “We need to bring more integrators to Québec, such as subsidiaries of large foreign companies,” emphasized Suzanne M. Benoît, President at Aéro Montréal. “This will bring opportunities for our SMEs and foster supply links with our OEMs.”

Québec has its sights set on global leadership and has the appropriate tools and strategies in place to meet its targets. Whilst the long-term future is less certain as international dynamics continue to shift, Québec’s aerospace sector is poised to adapt and ensure its position as a global forerunner. —

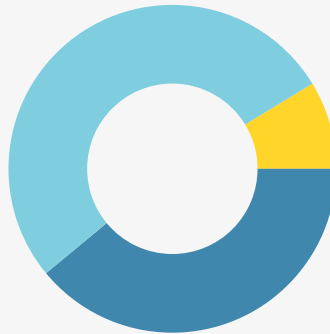
INFORMATION ABOUT YOUR COMPANY

1. Please indicate the type of company you represent within the aerospace industry



- Aeronautics
- R&D service provider in Optics & Photonics
- Engineering services
- All
- Education
- Financing
- Economic development agency
- University
- Services

2. The main sector in which you operate has a positive outlook



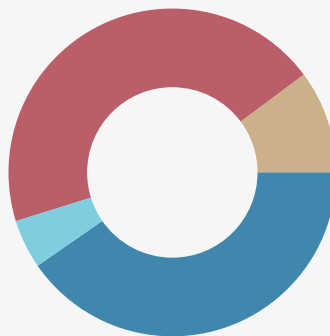
- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

3. Does your company serve only the national market?



- Yes
- No

4. If no, what other markets does your company serve?



- Europe
- Asia
- North America
- South America
- Australia
- Africa

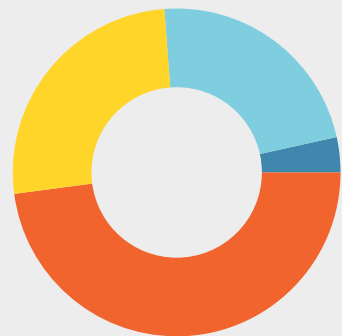
INDUSTRY CHALLENGES

1. Attracting investment to the sector's development is a challenge for the aerospace industry in Quebec



- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

2. There are limited resources available to support R&D efforts and innovation



- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

QUEBEC'S AEROSPACE INDUSTRY

1. The sector has extensive capabilities and the potential to be an international leader



● Strongly agree
● Agree
● Neither agree nor disagree
● Disagree
● Strongly disagree

2. The presence of prominent multinationals is beneficial to the surrounding industry



● Strongly agree
● Agree
● Neither agree nor disagree
● Disagree
● Strongly disagree

3. Relatively low business costs give Quebec's aerospace sector a strong competitive advantage



● Strongly agree
● Agree
● Neither agree nor disagree
● Disagree
● Strongly disagree

4. Companies within the aerospace industry are well supported by the local and national governments



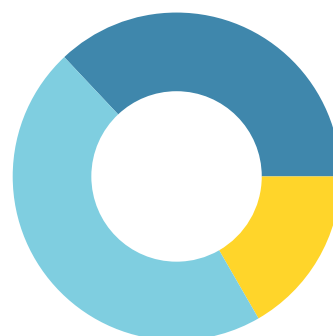
● Strongly agree
● Agree
● Neither agree nor disagree
● Disagree
● Strongly disagree

5. One of the key benefits of operating in Quebec is the access to skilled labor and research capabilities provided by universities



● Strongly agree
● Agree
● Neither agree nor disagree
● Disagree
● Strongly disagree

6. The tax framework is very supportive of businesses



● Strongly agree
● Agree
● Neither agree nor disagree
● Disagree
● Strongly disagree

With the leadership of the government, the industry, and the financial entities, the tools are available to move the industry forward and gain size where needed. Québec's aerospace cluster is operating in an extremely competitive global industry and it needs to continue evolving in this way in order to remain a key player.

- Alain Ricard,
Head of Transport Team,
Norton Rose Fulbright

Both the provincial and federal governments recognize that the majority of the industry's workforce is employed by SMEs and that they must therefore provide a healthy 'environment' to these companies by implementing sound and supportive policies. There are therefore a lot of positive steps being taken, such as the introduction of the Industrial Technological Benefits (ITB) policy by the Federal Government. Aéro Montréal has also increased the number of seats on its board of directors allocated to SMEs. L-3 has over 800 suppliers across Canada, so we definitely appreciate having a strong SME ecosystem. Small and Medium sized businesses tend to be lot more agile and efficient than organizations of a larger size. It is important that we continue to support SMEs as they do not only provide a lot of flexibility to our Industry but they are also very often incubators for research and new technology.

- Jacques Comtois,
Vice President and General Manager,
L-3 Communications MAS

Whilst government support of the Big Four OEMs is essential as they are too big to fail, the focus needs to extend to the SMEs to a greater extent to maintain Canada's competitiveness. The Big Four OEMs are public companies whose focus must be on reducing cost and time to market as a priority. Government funding, an integral component of a thriving industry, can therefore end up being rationally invested in lower-cost jurisdictions to create the best return on investment for shareholders. Ironically as a result, government investment in OEMs often does not lead to investment in Canada's SMEs but rather to increased offshoring for the industry as a whole. The solution is for the government to break the loop by creating an aerospace policy that encourages a more strategic investment distribution across the whole sector to encourage SMEs to grow and prosper.

- John Maris,
President,
and Phil Cole,
VP Business Development,
Marinvent and Cert Center Canada

The investments required for new equipment are very high and OEMs are asking suppliers to absorb more of the non-recurring costs of production such as software, workforce required and certification. Commercial banks do not typically finance these soft costs, so government support is critical... Initiatives such as MACH FAB 4.0 are also crucial to help companies transition to new processes... The outlook for the industry is strong—passenger and cargo volume is on the rise. We are in a winning industry; we just need to capitalize on its strength.

- Guillermo Alonso,
President,
Alta Precision

There are many good programs organized by institutions such as Aéro Montréal but the visibility is not high enough. Many SMEs do not have the time and resources to continuously seek and identify these programs. It would be beneficial if more resources were devoted to advertising such initiatives. We are grateful for the support Export Québec provides for companies like AMEC to promote their companies internationally at conferences such as NBAA.

- Geneviève Paré,
Business Development Director,
AMEC Usinage

Many SMEs suffer from the pressure on cost. This applies mainly to commercial programs, and all simple parts are outsourced to low-cost countries. However, positioning ourselves as a niche expert in complex products and gears where we have a lot of knowledge and know-how protects us from these trends...The more integrated we are, the better it is for the customer in terms of lead time and cost.

- Serge Audet,
General Manager,
ATLAS Aeronautik

Suppliers in Québec need to break out of the Québec bubble. It is a major challenge as this takes considerable time and investment. It makes sense for suppliers to diversify their customer and program base and move up the food chain towards more integrated structures, which will come from exports...The government is aware of the challenge; the clock is ticking on a lot of the smaller suppliers. Their reliance on a very local OEM customer base is a big vulnerability, so they need to penetrate international markets outside the Québec cluster. For the cluster to evolve, the smaller companies need to be supported in addressing these challenges. The Québec Government as well as Canada are very aggressive in helping to promote companies and assist them in penetrating new markets. Government officials are not sticking their heads in the sand and ignoring the problem.

- Stephen Kearns,
President & CEO,
Avior (Produits Intégrés)

Space is evolving very rapidly with the advent of new technologies leading to a large increase in available data and new countries entering into the industry, making it a very dynamic environment. The CSA wants to ensure that space continues to drive innovation and economic growth for the benefit of Canadians. We will therefore leverage all of the new economic and technological opportunities presented by the possibilities of cheaper, faster and more frequent space activity. We will ensure that the Canadian space sector is connected with our international partners so that it remains at the forefront of innovation. Finally, we want to maintain the skills capacity in terms of scientists and engineers to exploit these opportunities.

- Sylvain Laporte,
Chief Executive Officer,
Canadian Space Agency

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THANK YOU

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