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WHITE PAPER
GLOBAL SUPPLY CHAIN SUMMIT 2017

"From Vision to Reality: Breaking Through the World of 4.0"

Prepared by Aéro Montréal

June 19, 2017

AÉRO MONTRÉAL
Grappe aérospatiale du Québec

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1. PRESIDENT'S MESSAGE

The aerospace industry's manufacturing landscape is changing dramatically to transition to Industry 4.0, which integrates all production processes through an intensive use of digital tools[1]. For more than a decade, Aéro Montréal has worked tirelessly to support SMEs in Québec's aerospace industry. Along with various stakeholders in our cluster, we are now focusing our efforts on transforming SMEs into innovative SMEs, ready to respond effectively to the new global technological environment and to OEMs' new competitive demands.

As the flagship event of International Aerospace Week 2017, **Aéro Montréal's 4th Global Supply Chain Summit** was an unparalleled success, full of discussions and learning. Nearly 500 participants benefited from quality programming centered on Industry 4.0 and its concrete impacts for our companies. The theme of **From Vision to Reality: Breaking Through the World of 4.0** is of great interest to all aerospace players, especially our SMEs, because this digital transformation is essential to improve their positioning in the global value chain.

Aéro Montréal would like to thank our guests who honoured us with their presence:

- The Honorable Marc GARNEAU, Canadian Minister of Transport;

- Mrs. Christine ST-PIERRE, Québec Minister of International Relations and La Francophonie; and

- Mr. Denis CODERRE, Mayor of Montréal.

We would also like to thank Hélène V. GAGNON, Chair of the Board of Directors of Aéro Montréal and Vice-President, Public Affairs and Global Communications, CAE, for playing a leading role in prompting discussions and helping to expertly synthesize the concrete ideas presented by participants. Her contribution clearly enabled the Summit to achieve its objectives.

With the organizing committee of the Global Supply Chain Summit, we prepared this event focusing on two specific objectives:

1. to ensure that SMEs understand the concept of Industry 4.0 and how to integrate it successfully into their business model;

2. to enable SMEs, through partners and solution providers, to be supported in this transformation.

The speakers shared their experiences and case studies to illustrate the concept of 4.0, its integration in their company, and its degree of maturity. In addition, a **4.0 Demo Zone** brought together 24 solution providers offering the resources needed to implement the digital shift in our companies. We would like to thank Emploi-Québec for making the **4.0 Demo Zone** possible. Emploi-Québec is a leading partner that is committed to our industry's 4.0 transition. It is actively supporting the training of a skilled and specialized workforce without which the transition to the plant of the future would not be possible.

[1] Source: "Industrie 4.0. Les défis de la transformation numérique du modèle industriel allemande." Authors: Dorothée Kohler and Jean-Daniel Weisz. La documentation Française, 2015.

We would like to underscore the involvement of the Government of Québec, which is working alongside Aéro Montréal to support SMEs in taking this shift. We are proud to be pursuing the **MACH FAB 4.0** initiative, previously announced in the 2016-2026 Québec Aerospace Strategy. Over the next five years, this program aims to support 50 SMEs in the aerospace sector in their transition to the industry of the future.

This White Paper has been prepared in this context: in addition to reporting on the Global Supply Chain Summit, we have highlighted the steps that should be followed in implementing 4.0 in companies. We are confident that this document will contribute to increasing the competitiveness of the Québec supply chain by positioning it as a leader in the journey to 4.0.

Suzanne M. Benoit, MBA
President

2. Executive Summary

The fourth industrial revolution is taking shape before our eyes and changing the way all industrial sectors operate. All the technologies on which Industry 4.0 is built already exist and are being integrated into the process. The aerospace industry's manufacturing landscape is also changing dramatically to make this digital shift. Most of Canada's aerospace sector activities are in Québec, especially in the Greater Montréal area. As the aerospace capital of Canada, Montréal is also aiming to become a *supercluster* of artificial intelligence (AI). This cluster will contribute significantly to ensuring that companies in the aerospace industry successfully shift to 4.0. An innovation hub, the aerospace industry is being actively supported by both the federal and provincial governments.

With the advent of the Industry of the Future, companies are digitizing their physical assets and integrating them into digital ecosystems, throughout the value chain. This is allowing for huge amounts of data to be collected and analyzed in real time. Once in place, 4.0 enables companies to be more innovative and to respond more quickly to their customers' needs while achieving greater operational efficiencies. With lower operating costs, better management of lead times, higher quality products, and reduced product development cycles, the performance and competitiveness of companies are significantly improved.

In a highly competitive environment, a global supply chain, evolving technologies and increasingly complex products, companies in the aerospace industry have no choice but to transform themselves, to share best practices, and to adapt to disruptive technologies. Prime contractors, like subcontractors, have responsibilities in the implementation of 4.0. For a subcontracting SME, taking this digital shift means adapting to this reality by rethinking its business model. Mutual trust, transparency, data sharing and connectivity through an open architecture are essential for these partners to move forward, together, with a view to improving efficiency and innovation. The interconnection of the supply chain makes it possible to optimize the overall performance of all the players in the aerospace sector.

Today's company needs to anticipate the upheavals of tomorrow, rather than just suffer them. The evolution of digital technologies requires the organization to adopt a digital culture. With digitization, some tasks are eliminated, but the resources freed up can be allocated to tasks and responsibilities with higher added value. Emphasis should be placed on employee training and skills development to successfully transform from within. On the other hand, tools exist to assess the company's digital maturity, enabling it to identify gaps and draw up an action plan.

Many levers are available in Québec to facilitate the transition of SMEs to Industry 4.0. **MACH FAB 4.0** is a program that supports and finances SMEs' digital transition. In addition, the training and recruitment of talent are major levers in planning manpower needs. Many training programs are available and the **emploi.aeroportail.ca** site enables companies and job seekers to access a centralized database. On the other hand, support provided by experts allows any company wishing to take the 4.0 shift to ensure that projects respond to strategic issues and generate returns on investment. The Aéro Montréal **4.0 Demo Zone** enabled Summit participants to meet solution providers and learn about the resources needed to implement the industry of the future in their organization.

Québec SMEs are in a unique position to seize the opportunities offered by the fourth industrial revolution. However, they must act now by taking a clear-cut approach with concrete steps: develop a strategy based on digital maturity; carry out pilot projects; determine the organizational, human, financial and technological resources required; master data analysis; adapt the entire company to this new culture; and use its ecosystem to develop partnerships.

3. Context

Most of Canada's aerospace activities are in Québec. The aerospace industry is a hotbed of innovation where companies are investing one dollar out of every five in research and development. In 2016, more than 70% of Canadian aerospace R&D took place in the Montréal area.

Both the federal and provincial governments actively support the aerospace industry through a variety of mechanisms. Both levels also provided concrete measures to support innovation within their respective 2017 budgets. The Canadian government is fully aware that an industry that is so vital to the economy must remain at the forefront of innovation, while the Québec government, in the same vein, is strengthening the innovation capacity of Québec companies.

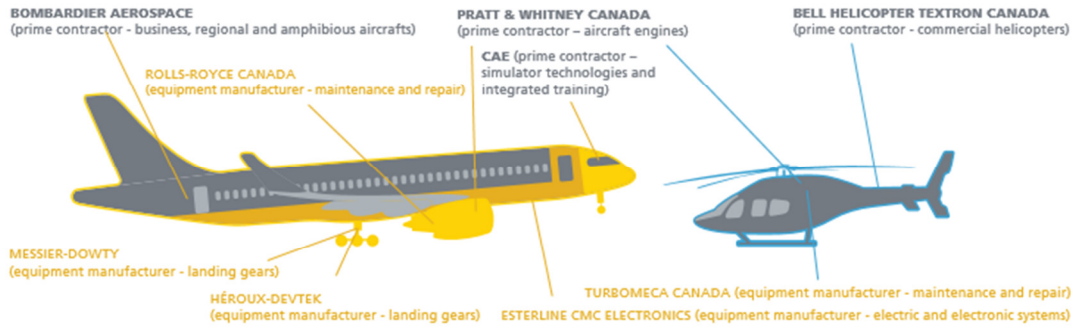
As the capital of Canada's aerospace industry and third largest aeronautical centre in the world, after Seattle and Toulouse, Montréal is also aiming to become a *supercluster* of artificial intelligence. This cluster will strongly contribute to the success of companies in the aerospace industry.

3.1 The aerospace industry in Québec[2]

The aerospace industry is one of the Québec economy's most dynamic sectors. Recognized as one of the main engines of growth and wealth creation for all of Québec, this sector is a strategic asset in Québec's economy while being a source of great pride. More than 205 companies and more than half of the industry's jobs in Canada are located in Québec.

The Québec aerospace sector employs about 40,000 people. This sector is centered around four major companies: Bombardier, Bell Helicopter Textron Canada, CAE and Pratt & Whitney Canada. These OEMs are supported by 11 Tier 1 suppliers, major equipment suppliers and maintenance specialists, and 188 subcontractors.

Figure 1: Greater Montréal's aerospace industry: a complete network[3]



[2] Source: "Reinventing the Horizon, 2016-2026." Québec Aerospace Strategy.

[3] Source: "The aerospace industry in Greater Montréal." Montréal International.

The industry can count on a high-level education system offering a variety of aerospace programs to ensure quality training for its workforce. This includes high-quality educational institutions providing secondary, college and university education and graduate studies. Among them are the École nationale d'aérotechnique (ÉNA), the École des métiers de l'aérospatiale de Montréal (ÉMAM), the Montréal Aerospace Institutes (MAI), which include the six universities active in aerospace research, and more than 10 highly-regarded public and parapublic research centres[4].

Aéro Montréal, which brings together Québec's aerospace cluster, ensures the cohesion and mobilization of this community to support the growth and visibility of the sector on the world stage. Two organizations support Aéro Montréal with specific mandates: the Comité sectorial de main-d'oeuvre en aérospatiale du Québec (CAMAQ), which responds to the needs of companies and workers in the industry, and the Consortium for Research and Innovation in Aerospace in Québec (CRIAQ), which optimizes collaborative research between universities and the industry.

In addition, prestigious international aviation organizations have their headquarters in Montréal: the International Civil Aviation Organization (ICAO), the International Air Transport Association (IATA), and the International Federation of Airline Pilots' Associations.

> *"Québec's economic development is based on three main pillars: 1. Entrepreneurship, 2. Innovative manufacturing, 3. Exports. [ ] The aerospace industry is highly aligned with these three pillars."*
>
> **Dominique Anglade**
> **Québec Minister of Economy, Science and Innovation; Minister responsible for the Digital Strategy**

3.2 Federal government involvement

The aerospace industry is directly involved in enhancing Canada's global competitiveness through its innovative companies.

The federal government's commitment, in its 2017 budget, to support innovation and build *superclusters* is critical to the industry's development. This commitment benefits the entire Québec aerospace supply chain, allowing it to stand out from the global competition and contribute to the country's economy.

The 2017 Federal Budget prioritizes innovation, the digital shift and skills development, challenges directly related to the transition of SMEs to Industry 4.0. These companies will see their access to various programs simplified by the Strategic Innovation Fund.

[4] Source: "Propelling the talents of aerospace towards Industry 4.0" Aéro Talents White Paper, 2016.

*"In our budget for 2017, we are proposing to spend $1.26 billion over five years on the creation of a **Strategic Innovation Fund**. Some programs that already exist, such as the Strategic Aerospace and Defence Initiative, will be consolidated into this fund. The budget also proposes a new high-tech procurement program called Innovative Solutions Canada. [] The budget also allocates $6 million over three years to support business growth by promoting regulatory harmonization with Canada's trading partners."*

The Hon. Marc Garneau
Minister of Transport, federal government

3.3 Québec government involvement

The Government of Québec has been supporting Aéro Montréal since its creation in 2006 and, in particular, for the past seven years through the MACH Initiative. Implemented to support the strategic growth of Québec's aerospace industry over the long term, MACH is working with companies in the sector to promote collaboration and innovation within the supply chain. To date, this initiative has enabled 60 SME-suppliers to be supported by their sponsors in more than 600 projects related to the performance of their supply chain. In 2017, an additional 10 SMEs will be integrated into the program in a fifth cohort and new projects will be launched over the next three years. As a result, nearly $4 million in new public funding has been announced over the past 12 months to support these projects.

"Industry 4.0 is a driving force behind Québec's economic growth and is raising our profile among the international community. [] Québec is building its future on innovation and creativity. [] Québec's aerospace strategy provides a concrete response to the challenges facing the industry."

Christine St-Pierre
Minister of International Relations and la Francophonie, Government of Québec

The rapidly evolving global environment led the Government of Québec to recently strengthen its aerospace industry strategy so that it can continue its growth and achieve its full potential. The 2016-2026 Québec Aerospace Strategy, developed following a major consultation with industry players, revolves around four key drivers[5]:

1. strengthen and diversify the industry's structure;
2. foster the industry's growth by supporting projects and investing in the workforce;
3. support SMEs in their development; and
4. focus on innovation.

The third driver of the Strategy is entirely devoted to aerospace SMEs and aims especially to help these companies successfully complete their transition to Industry 4.0. To this end, three measures will help to develop an innovative manufacturing sector:

- **Supporting SMEs in their journey to Industry 4.0: MACH FAB 4.0.**

  The MAB FAB 4.0 initiative will support 50 SMEs in the aerospace sector in their transition to the digital enterprise of the future. Based on the MACH Initiative, the aim of this measure is

[5] Source: "Reinventing the Horizon, 2016-2026." Québec Aerospace Strategy

to promote the implementation of digital technologies and advanced manufacturing in participating SMEs. Implementation of this new initiative will be the responsibility of Aéro Montréal. The investment will be $19 million over five years: a $9.5 million contribution from the Government of Québec, plus an equivalent contribution from the private sector.

- Intervention squads specialized in the digital sector.

These squads will accompany SMEs by performing a diagnostic and developing a strategic plan. The Strategy provides resources of almost $4 million over the next five years for this measure.

- Supporting investments for the transition to Industry 4.0.

This measure will support SMEs who have carried out a diagnostic and strategic planning exercise within the framework of MACH FAB 4.0 or with the support of the specialized intervention squads in the digital sector. The financial support will especially apply to the acquisition of equipment and software required to execute digital transformation projects and improve competitiveness.

- **Investissement Québec's ESSOR program:** This program is administered jointly by Investissement Québec and the Ministry of the Economy, Science and Innovation. ESSOR is designed for entrepreneurs looking for financing to carry out a major long-term development project.

Figure 2: ESSOR, the solution tailored to your projects [6]

[6] Source: http://www.investquebec.com/quebec/en/financial-products/all-our-solutions/essor.html

"Québec's aerospace strategy will promote the transition to Industry 4.0, stimulate exports, encourage innovation, product development and new processes."

Dominique Anglade
Minister of Economy, Science and Innovation,
Minister responsible for the Digital Strategy
Government of Québec

3.4 Montréal: the 4.0 platform

Montréal is an international city that is celebrating its 375th anniversary this year. Dynamic, it has a community of start-ups dedicated to creativity and innovation and a large pool of skilled labour. In this regard, Montréal was elected the best city in the world in which to study, according to *QS Best Student Cities 2017*[7].

Recognized as one of the three world aerospace capitals, Montréal is also consolidating its position as a platform for 4.0 and artificial intelligence. With more than 200 researchers in this field, the metropolis is considered a hub of artificial intelligence. Montréal has the world's largest Deep Learning Lab), a leading field of artificial intelligence. Yoshua Bengio, a researcher at the University of Montréal and considered one of the world's foremost experts in deep learning, co-founded Element AI. The objective of this venture is to bridge the gap between entrepreneurs, large companies and artificial intelligence researchers and then create dozens of start-up companies and hundreds of jobs in artificial intelligence.

IT giants have taken up residence in Montréal and are investing in the city, such as Google and Microsoft. The latter has just bought the Maluuba start-up, one of the jewels of artificial intelligence, with McGill University and the University of Montréal.

Recently, the Québec Industrial Research Centre and Festo, an Industry 4.0 global giant, announced the first cyber-physical laboratory in Canada in the Saint-Laurent borough in Montréal to accelerate the digital transformation of innovative manufacturers[8].

"Montréal is a city that will allow you to operate your companies, be part of the solution and look for great partners to help you grow."

Denis Coderre
Mayor of Montréal

[7] Source: https://www.topuniversities.com/best-student-cities
[8] Source: http://www.fil-information.gouv.qc.ca/Pages/Article.aspx?idArticle=2504203818

4. Demystification of concept 4.0

The advent of the fourth industrial revolution - or the digital revolution - requires the intensive use of technologies, instantaneous transmission of information, and horizontal integration within companies. The interconnected machines in manufacturing plants communicate in real time, not only with each other but also with products, humans, various departments of the company, and suppliers and customers. This results in a tearing down and significant reduction in working in silos for existing production processes. In short, a reorganization of the value chain by merging the digital and "real" world of the plants.

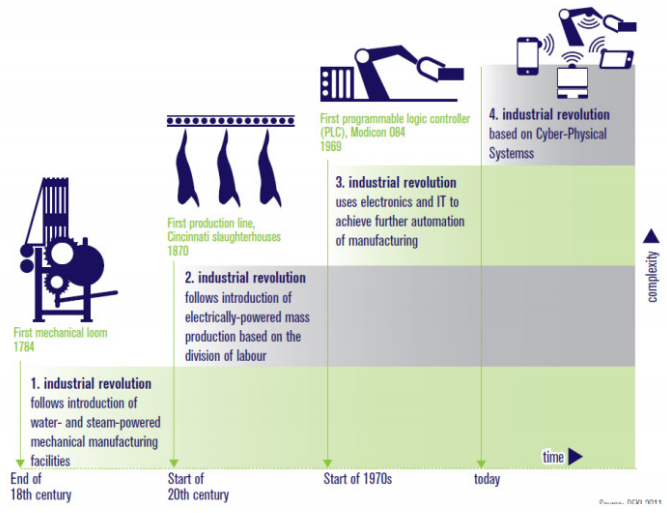
> "Industry *4.0 does not only involve plants but affects the entire company.*"
>
> **Hany Moustapha**
> **Professor and Director, AÉROÉTS**

4.1 Industry 4.0: Origins and Objectives

In 2011, Germany became the first country to implement an industrial policy centered on this connected plant concept. In Germany, the implementation of the Industry 4.0 project was based on three convictions[9]:

- the country's economic future depends on industry;
- maintain international leadership in equipment markets;
- anticipate the impact of information technologies on production processes to take advantage of the opportunities they offer.

Figure 3: Evolution of industrial history[10]



By naturally following the evolution of industrial history, Industry 4.0 is bringing advances in technologies and advances in the way work is organized.

ts and integrating them into digital
mers[11].

[9] Source: "Industrie 4.0. Les défis de la transformation numérique du modèle industriel allemande." Authors: Dorothée Kohler and Jean-Daniel Weisz. La documentation Française, 2015.
[10] Idem.

The primary objective of Industry 4.0 is not more automation, but more intelligence in the networking of machines, between themselves and with humans[12]. In the new 4.0 plant, technologies of plant 3.0[13] are used by integrating interconnected and autonomous tools, managed by artificial intelligence. This enables a better exploitation of data and a decentralization of decision-making.

> *"Technologies allow us to bring the Internet and computers closer to production processes, breaking down the barriers between vendors, various departments, the production process, suppliers and customers."*
>
> **Éric Leduc**
> **Chief Transformation and Procurement Officer, Microsoft Canada**

Connected systems will collect enormous amounts of data that can be analyzed in real time; this is called Management of Big Data. This information, once exploited, allows for optimization of production, the performance of predictive maintenance, better traceability, and the development of new products or services.

The machines no longer only do what they are programmed for. They also provide real-time data. This information facilitates better decision making and enhances production efficiency.

Industry 4.0 constantly optimizes the necessary resources: energy, raw materials, machines and time spent by employees operating the machines. For a company, this optimization allows for greater flexibility in meeting individual needs - from limited series to customized unit production - maximizing value creation for customers.

Users will have increasingly democratic access to advanced technologies, whether in terms of simplified use or more affordable costs. With cloud services for storing their data, companies no longer need to invest in information technology infrastructure.

[11] Source: http://www.pwc.com/ca/fr/industries/industry-4-0.html

[12] Source: "Industrie 4.0. Les défis de la transformation numérique du modèle industriel allemande." Authors: Dorothée Kohler and Jean-Daniel Weisz. La documentation Française, 2015.

[13] The third industrial revolution. Graphic p.13

4.2 Technologies at the service of 4.0

The technologies for the emergence of Industry 4.0 already exist. What makes Industry 4.0 a revolution is their interaction via connected processes and equipment. Machines have been communicating with humans for a long time, but there is currently a boom in the development of these technologies and in the integration of all these innovations within companies[14].

Figure 4: Technologies used in Industry 4.0

Other technologies could further enrich this graphic, such as inter-machine communication and artificial intelligence. New technologies will also be added in the future.

Excerpt of the presentation by Hany Moustapha
Professor and Director, AÉROÉTS

In Industry 4.0, interconnected and stand-alone devices, managed by artificial intelligence, are being added to assembly lines and robots to make decisions or generate alerts[15]. A set of techniques that enable machines to perform tasks and solve problems normally reserved for humans, artificial intelligence draws inspiration from the human brain. Artificial intelligence will play a key role in the digital transformation of companies. As for deep learning, it is a technology based on artificial neural networks allowing a program to understand spoken language or to recognize the content of an image. Deep learning pushes the limits of artificial intelligence.

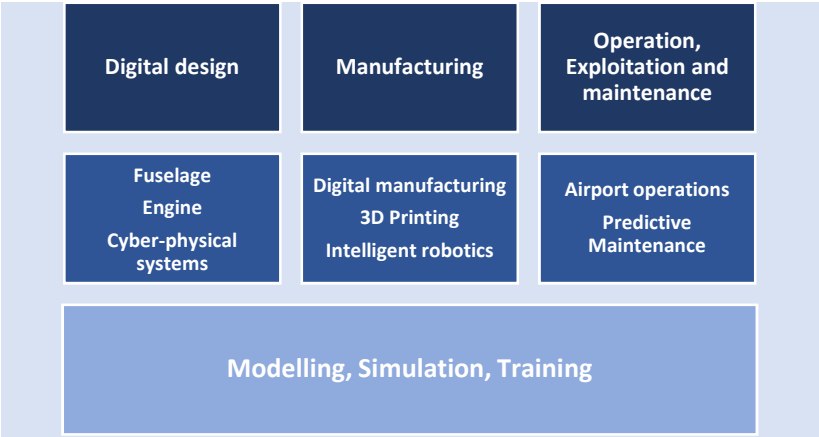
> *"By relying on data trends, artificial intelligence is the ability to process information that humans would not be able to see."*
>
> **Naomi Goldapple**
> **Program Director, Element AI**

[14] Source: http://affaires.lapresse.ca/portfolio/ingenieurs/201611/03/01-5037337-industrie-40-les-donnees-au-service-du-genie.php
[15] Source: http://www.lapresse.ca/le-soleil/affaires/techno/201611/13/01-5040840-revolution-numerique-pour-le-monde-industriel.php

4.3 Applications of artificial intelligence in the aerospace industry

Artificial intelligence applications are numerous and in highly varied sectors. The automation of the aerospace industry is a complex issue, especially since safety is essential. However, there are many opportunities for automation and these are increasing thanks to artificial intelligence.

Figure 5: AI applications in various aerospace fields



An example is GE Aviation in Bromont. “In aircraft engine repair processes, artificial intelligence allows the robot to understand the context, to identify anomalies and see where they are located. The robot can make the right decisions, more efficiently than humans, for repair,” says John Karigiannis, senior researcher at GE Aviation’s Global R&D Center for Automation and Robotics. In the same way, “robots, thanks to artificial intelligence, ensure seamless quality control during the building of engines,” he adds.

The Watson artificial intelligence computer program designed by IBM found a correlation between temperature and brake wear on the A350 XWB that enabled Airbus to perform preventive maintenance, avoiding costly delays for aviation companies. This aircraft has about 50,000 sensors on board that provide half a terabyte of data daily. AI makes it possible to discover correlations and problems that human beings could not have discerned with as much ease and speed[16].

AI enables the aerospace industry to reduce human risk, lower costs, increase production speed and improve the quality of finished products. Virtual test benches are revolutionizing ways to test engines. “We now do most of the tests virtually, then some real ones, which greatly minimizes costs,” explains Hany Moustapha[17]. In the short to medium term, aircraft inspections could conceivably be performed by drones[18].

The aerospace industry has much to gain from advances in artificial intelligence. The opposite is also true: aerospace is undoubtedly a sector that will enable the artificial intelligence sector. As

[16] Information from the presentation of Naomi Goldapple, ELEMENT AI

[17] Source: http://affaires.lapresse.ca/portfolio/ingenieurs/201611/03/01-5037337-industrie-40-les-donnees-au-service-du-genie.php

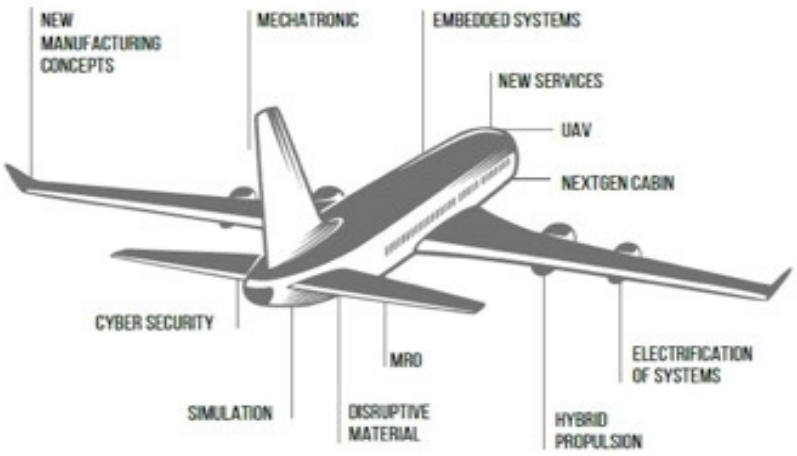
[18] Source: http://ici.radio-canada.ca/nouvelle/1018950/automatisation-revolution-technologique-bouleversement-monde-travail-robot-execution-tache

a precision industry, aerospace industry is enabling AI to optimize and develop its own systems by offering it a real-life field of expertise and testing.

4.4 *Start-ups* that disrupt models

The world of information technology is interested in the aerospace industry and vice versa.

Figure 6: Emerging areas of aerospace



Excerpt of the presentation by Van Espahbodi
Co-founder, Starburst Accelerator

All kinds of innovation can contribute to the evolution of the industry: materials, processes, customer experience, digitization, business models, etc. There are emerging areas of the aerospace sector in which start-ups are developing new technologies.

Starburst Accelerator is a new global incubator model, based on an open model, and rooted in collaboration between large groups and start-ups. The partner companies, OEMs, pay an annual subscription fee allowing them to participate in selection committees of candidate start-ups that propose innovative technologies. In 2016, Starburst Accelerator represented 300 start-ups, linking them with major groups.

> *"When you think of our industry just ten years ago ... the technological changes are huge. So, imagine us in another ten years! By adequately taking the digital shift, technologies can lead your company to very lucrative business opportunities."*
>
> **Joseph C. Anselmo**
> **Editor in Chief, Aviation Week & Space Technology**

5. Impact of 4.0 on the supply chain

As with other industries, aerospace has evolved considerably over the past two decades. A new ultra-competitive environment, customers with more and more power and choice, and a global supply chain are emerging challenges facing the industry. Moreover, changing technologies and increasingly complex products are being added to these challenges.

In this context, it is essential that companies in the sector transform themselves, collaborate, share best practices and adapt to the breakthrough technologies characteristic of Industry 4.0. OEMs, as well as the subcontractors, have responsibilities in the implementation of 4.0.

> *"In the global context, supply chain management is at the forefront of multiple challenges. This is especially true in the aerospace industry. Not only because of the nature of the products we manufacture, but also because of our environmental footprint and the increasing complexity of our supply chain.*
>
> *Looking at the value chain of our industry - from the raw material extractor that can be located in any part of the world to the passenger who wants to travel from point A to point B - the element shared by every member of the value chain is that he sees the world from three perspectives: reliability, accessibility and sustainability.*
>
> *To meet these three requirements, how we provide our professional services, how we maintain our relationships, and how we engage each level of our supply chain is essential.*
>
> *To achieve this, one of the key success factors is to understand this dynamic industry, the aerospace industry, and to understand how to integrate continuous improvements and breakthrough technologies such as Industry 4.0 into it.*
>
> **Jim Vounassis**
> **Chief of Transformation and Procurement, Bombardier Inc.**

> *"The pace at which transformations are taking place in our industry will accelerate and we cannot stop it. The decisions we make now, the investments we make in strategies and technologies, will have a considerable impact for the future."*
>
> **Graham Warwick**
> **Managing Editor, Technology, Aviation Week & Space Technology**

5.1 The challenges of OEMs

The aerospace industry is facing an exponential growth in commercial aviation due to a doubling of air traffic every 15 years[19]. On the new, highly competitive global chessboard, large companies in the sector are constantly looking for new ways to reduce their costs. Faced with the challenges of improving returns and the resulting increased production rates, these companies must consider reorganizing their operations with connected and flexible plants throughout their supply chain.

They therefore face a dual challenge: to integrate technologies harmoniously into their own production environment, while convincing their strategic suppliers to engage in 4.0 and in the transformation of their production system. The OEM will, for example, encourage its subcontractors to review their quality and delivery processes so that the systems are linked and able to exchange actionable information. As a result, 4.0 is causing upheavals on various levels of the supply chain.

The connected company can now exploit data usage available thanks to the digitization of connected equipment and devices. We are witnessing a migration from the creation of value for a company to places where the customer data usage is recovered and exploited[20]. For example, a typical 4.0 plant combines automated manufacturing systems, sensors that collect information, the operator and transmitter, product lifecycle management software, and emerging advanced manufacturing technologies[21].

> *"The Bombardier plant in Montréal is responsible, among other things, for the construction of the rear fuselage of the CSeries. The aluminum-lithium alloy reduces aircraft weight, optimizes production costs and reduces their environmental footprint. Automated processes using robots are the key to saving money on raw materials and achieving the best stability in manufacturing. Thanks to its precision, the robot allows for a great flexibility while eliminating human risk.*
>
> **Jean-Philippe Marouzé**
> **Director - Product and Advanced Composite Value Chain, Bombardier**

Let us cite as another example the aircraft engine manufacturer Rolls Royce[22]. With the digitization of connected equipment and devices, and the use of data from sensors that emit thousands of signals, Rolls Royce recognized the opportunity to develop new services. By providing valuable information to its customers - on engine performance, flight path or strategic weather data - the company enables them to optimize fuel consumption, generating tens of dollars millions of dollars in savings a year.

[19] Source: "Manufacturing's Coming Revolution.". Anthony L. Velocci. Aviation Week & Space Technology, January 9-22, 2017.

[20] Source: "Industrie 4.0. Les défis de la transformation numérique du modèle industriel allemande. Authors: Dorothée Kohler and Jean-Daniel Weisz. La documentation Française, 2015.

[21] Source: "Reinventing the Horizon, 2016-2026." Québec Aerospace Strategy, p.40.

[22] Presentation Éric Leduc, Chief Transformation and Procurement Officer, Microsoft Canada.

5.2 The challenges of suppliers

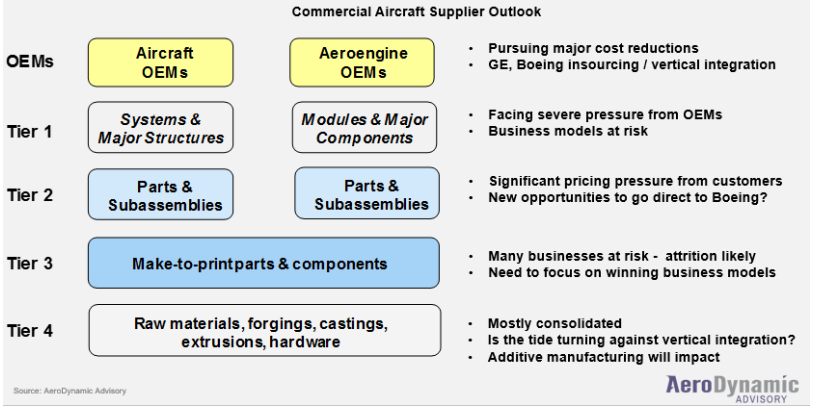
In this context, the SMEs supplying OEMs are experiencing profound changes in their environment since they are an integral part of the production process, with increasingly globalized supply chains and more intense competition. OEMs want to reduce the number of subcontractors and give those left with more responsibility for designing, manufacturing and assembling complete systems.

The nature of the relationship between OEMs and their subcontractors is changing considerably. These SMEs are increasingly seen as partners for their customers and must make changes to integrate into this competitive environment. Taking the 4.0 shift means that a subcontracting SME can adapt to this reality by rethinking its business model if it wishes to remain the supplier of its OEM.

According to Aéro Montréal's SME Mapping[23] project, these companies nevertheless need concrete information and transparency from OEMs in order to be able to build their new strategy in a sound manner. They must have a good understanding of the supply strategies of the OEMs. The transparency of the latter is a major issue that will have to be resolved quickly. It is on this condition that SMEs and OEMs will emerge as winners from the digital shift in the global value chain.

Companies situated between OEMs and smaller SMEs have a role to play in the spread of digitization within the industry.

Figure 7: The impacts of Industry 4.0 on the supply chain



Excerpt of the presentation by Kevin Michaels
CEO, AeroDynamic

[23] Mapping SME: this Aéro Montréal project is in progress and aims to identify trends, issues and needs by providing an overview of Québec SMEs in the aerospace sector.

5.3 Changing supply chain

Aerospace SMEs need to become more integrated into the global supply chain. This presence in international markets depends, among other things, on their successful transition to Industry 4.0. Companies must work together, between customers and subcontractors, and between teams throughout the value chain. Collaboration is paramount considering the speed with which technological transformations take place.

> *"This shift will inevitably take place and companies have no choice but to undertake it if they want to stay in the race over the long term. The two questions that suppliers must ask themselves today are: what is your vision and where do you want to go? What are you going to do to make sure you get there?"*
>
> **Anthony L. Velocci**
> **Ex-Editor-in-chief, Aviation Week & Space Technology**

With Industry 4.0, radical changes are taking place along the value chain and networking is at the heart of value creation.

For subcontractors, Industry 4.0 means faster customer response times, resulting in improved service levels. Like OEMs, SME suppliers will then move towards a services-oriented business model.

> *"We need to ensure that our suppliers respond as quickly as possible to our requests. We have to provide a certain leadership to the players in our supply chain. Investments and support are needed among suppliers who can help us."*
>
> **Jill Christenson**
> **Sr. Manager Supplier Management Aircraft Materials & Structures Strategy, The Boeing Company**

Many project managers are investing time and money to implement projects in partnership with their subcontractors, in a spirit of collaboration. In doing so, suppliers occasionally have to forgo short-term profits in order to invest in digital solutions that will allow them to remain a strategic partner with their customers in the coming years. They must also think about a new business model and a new work organization, representing sources of uncertainty and a constraint for these SMEs.

Mutual trust, transparency, data sharing and connectivity through an open architecture are essential for these partners to move forward together in a perspective of efficiency, profitability and innovation.

One of the key factors for successful data sharing is interoperability. And this interoperability necessarily involves opening and sharing platforms, standards and protocols[24]. Open and, of course, secure technologies play an important role in building a foundation for ensuring productivity. The evolution of digital technologies has improved management tools while the emergence of connected and intelligent equipment has allowed for the emergence of new performance indicators and, consequently, value-added information for companies.

[24] Source: https://www.industrie-techno.com/l-industrie-4-0-sera-open-source-ou-ne-sera-pas.45567

"We realized five years ago that we had to raise the quality of our products while reducing our production costs. As we moved to Industry 4.0, we had to adapt to new ways of doing business. Our entire business model has changed. The first step we took was to transform our corporate culture while preparing our employees at all levels for this profound change in mindset, through communication and training. All our ways of doing and thinking had to be changed: how we worked, how we thought about quality, production, data."

Tim Beatty
President, Bullen Ultrasonics

What are the questions that SME managers should ask themselves before undertaking the shift? One must first ask how Industry 4.0 in production can generate gains and new competitive advantages.

Modifications to equipment are necessary so that they communicate with each other, regardless of the make and the date of manufacture. They must also be modular to be able to produce small batches according to OEM orders. This transformation requires investment in technologies, computer-aided design, training and many trials and errors in learning how to optimize new processes. The analysis of data provided by the equipment becomes the next step in the transition to Industry 4.0. And throughout this learning process, employee training plays a key role.

Figure 8: The challenges and scope of a company shifting to 4.0[25]

[25] Source: ©Design and production KOHLER Consulting & Coaching

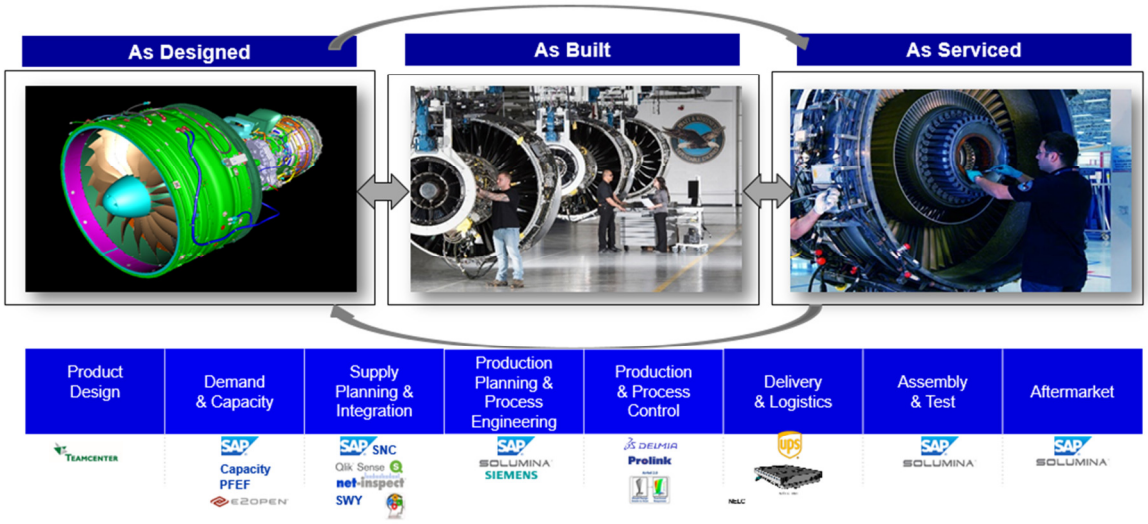
5.4 Optimizing performance through interconnection

The complexity of supply chain management has increased significantly.

In this context, it is imperative that the OEM accompany and support its suppliers in their shift towards Industry 4.0, whether in terms of advice or risk management. At the same time, by integrating with its suppliers, the latter allow them to access information in real time.

For example, Pratt & Whitney will be outsourcing 80% of its next generation of engines, up from 55% currently. The company has implemented proactive risk management for its supply base, handling more than 90,000 risks daily, with risks reported by thousands of data and leading indicators from multiple sources. The smart factory and the digital enterprise are the cornerstone of data collection.

Figure 9: Visibility and connection from start to finish



Excerpt of presentation by Shane Eddy
Senior Vice President, Operations, Pratt & Whitney

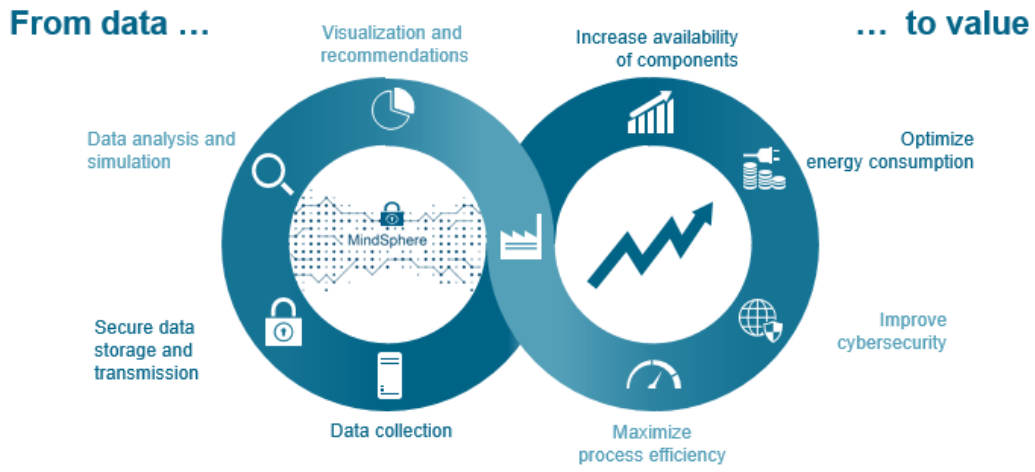
> *"All of the actions currently being undertaken in the aerospace industry with respect to 4.0 must result in a benefit to customers. They want perfect quality, especially in this industry, timely delivery and low costs. The investments made by some of our suppliers in 4.0 have allowed them to be on our list of suppliers for our next generation of engines. Currently, 50% of our suppliers are performing well. And with the increasing complexity of our operations, all our suppliers will have to perform well."*
>
> ***Shane Eddy***
> ***Senior Vice President, Operations, Pratt & Whitney***

5.5 Creation of value by exploiting data usage

> *"With Industry 4.0, we're going back to crafts. And what is a craftsman? He is a person who creates value. We need value creation on a large scale. This is what big companies are looking for and it is a fantastic opportunity for SMEs."*
>
> **Jeff Z. Gazidis**
> **Director, Aerospace, Siemens Canada**

With the digitization of equipment and connected devices, the company can exploit transmitted data usage. We are witnessing a migration from the creation of company value to places where customer data usage is collected and exploited[26]. This data allows the end customer to accomplish his mission more effectively.

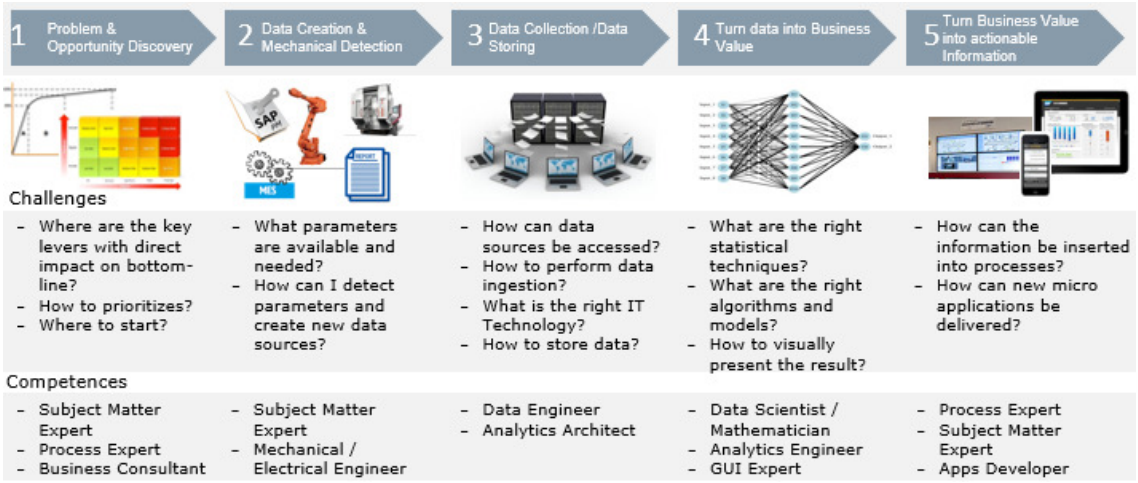
Figure 10: Creation of value from data



Excerpt of the presentation by Jeff Z. Gazidis
Director, Aerospace, Siemens Canada

[26] Source: "Industrie 4.0. Les défis de la transformation numérique du modèle industriel allemande." Authors: Dorothée Kohler and Jean-Daniel Weisz. La documentation Française, 2015.

Figure 11: 5 steps to transforming data into actionable information



Excerpt of the presentation by Jeff Z. Gazidis
Director, Aerospace, Siemens Canada

6. Integration of 4.0 in SMEs

Today's company needs to anticipate the upheavals of tomorrow, rather than just be subjected to them. Like the previous industrial revolutions, this new era will be accompanied by social, human and productivity advances. According to various sources, and contrary to preconceived notions, this new era will be accompanied by the creation of value-added jobs. Scientific and technical progress only makes sense if it improves the human condition.

> *"With the 4.0 shift we've taken, we've been able to double our revenues in the last three years because our prices have dropped and demand has increased. Our customers are also more competitive in the markets. Tasks have been transformed and we have retained all our employees by training them in their new responsibilities."*
>
> **Tim Beatty**
> **President, Bullen Ultrasonics**

Industry 4.0 is a driver of transformation in the aerospace industry and is being achieved via the Big Data revolution. This revolution is based on the ability of companies to analyze data and take advantage of them in terms of innovation, production, commercial relations and, ultimately, profit margins[27]. It's not the bigger fish eating the little fish... but the faster ones eating the slowest![28]

6.1 Humans at the heart of 4.0

With the advent of Industry 4.0, some tasks are being eliminated. But the resources freed up can be allocated to tasks and responsibilities with higher added value. The challenges of digitization on employment and the organization of work are real. However, in Germany, where it all began, players tend to favour a pragmatic and local approach aimed at identifying, in a tangible way, digital impact zones in the plant[29]. Several studies have been conducted in this country to determine the impact of Industry 4.0: machines will not replace man. Agility, ease of adaptation and training are the watchwords. Digitization will allow for more autonomy with more attractive and scalable tasks, including for less skilled positions.

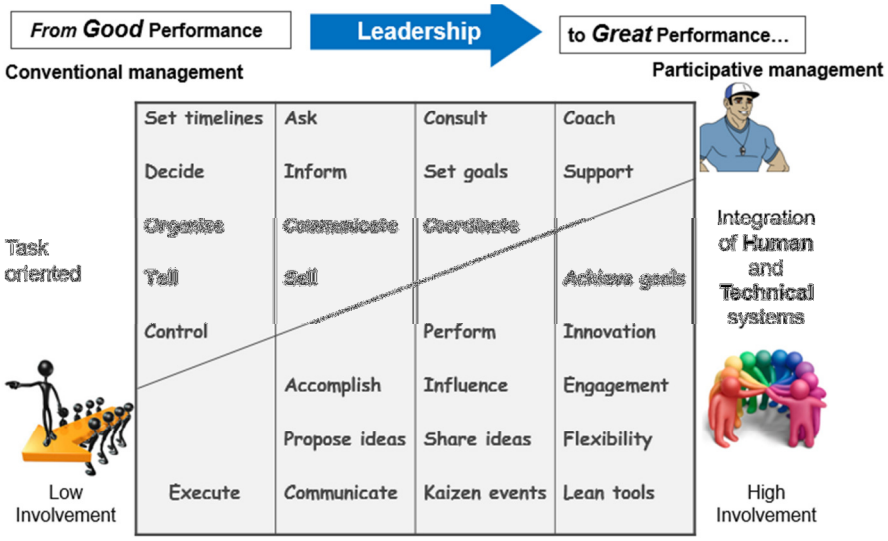
[27] Source: "Industrie 4.0. Les défis de la transformation numérique du modèle industriel allemande." Authors: Dorothée Kohler and Jean-Daniel Weisz. La documentation Française, 2015.
[28] Idem.
[29] Idem.

GE Aviation, Bromont Plant: A culture of participative management

GE Aviation is a world leader among aviation service providers and a leading producer of aircraft engines. The Bromont plant, with a portfolio of 800 products used in cutting-edge aircraft engines, has achieved a true digital transformation of its operations. This digitization has enabled its customers to be better served and all its subcontractors to considerably reduce parts cycle time while improving their quality. Aircraft engine manufacture and repair processes have been automated. The first robots appeared in 1983. In 2013, the company inaugurated its research and development centre in robotics, automation and instrumentation. With more than 500 digitally controlled machines and nearly 200 robots, the Bromont plant currently has a production capacity of more than 60,000 aircraft engine compressor blades per week.

In 2016, GE Bromont manufactured 3.3 million parts, which would have been impossible without automation and robotics. The human being was at the heart of this transformation towards digitization. GE Bromont ensures that priority is placed on employees. With high-tech manufacturing that is growing rapidly, the Bromont plant champions teamwork. The non-unionized workplace is characterized by participatory management. Teams are autonomous and dynamic. They drive continuous improvement by encouraging each member to give their best and in turn offer the best possible product. Each decision is taken as a team by the employees involved who are an integral part of the processes. Employees identify problems, find solutions and implement them. By doing so, they develop technical and relational skills.

Figure 12: Management model of the GE Aviation plant in Bromont



Excerpt of the presentation by Johanne Jolicoeur
Senior Manager, Human Resources, GE Aviation Canada

With robotization of the plant, concrete results quickly emerged:

- reduced risk of accidents and injuries;
- enrichment of tasks with flexible and versatile operators and engaged employees;
- improved working conditions (e.g. balanced shifts, automation of repetitive tasks);
- improved parts quality;
- reduced production cycle time and increased productivity (continuous improvement);
- increased capacity and bigger product portfolio.

> *"The important thing is to have a balance between humans and technologies. You can have the best technology in the world, but if your employees are not engaged in the process and mobilized, your technology strategy will fail.*
>
> *By improving productivity through robotization we are finding ways to access other markets by offering new products. This message has always helped us when the company faced resistance to change."*
>
> **Johanne Jolicoeur**
> **Senior Manager, Human Resources, GE Aviation Canada**

6.2 Training employees to ensure a culture of transformation[30]

Emphasis should be placed on training employees and the acquisition of generic skills to successfully transform within a company. Trades will change with the digitization of the value chain. We need to ensure that companies have a strong pool of workers and a new generation of people whose skills will become more and more specialized.

The challenges directly related to training are numerous: the adaptability of production to new technologies; access for companies and educational institutions to financing to invest in state-of-the-art equipment; training integrated with the real needs of companies; awareness programs for young people in science and technology; acquisition of new skills; knowledge transfer; and more efficient management of resources.

In recent years there has been a genuine collaboration between industry and the educational community, resulting in more and more targeted programs and enhanced R&D projects. However, there is still a great deal of work to be done to ensure that the needs of companies are matched with the training adapted to 4.0 workers.

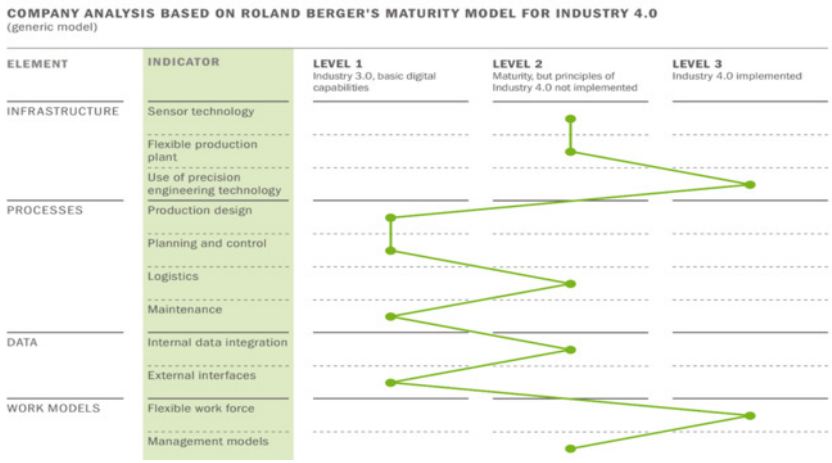
[30] Source: "Propelling the talents of aerospace towards Industry 4.0." Aéro Talents White Paper, 2016.

6.3 Measuring the success of 4.0 implementation in a company

The evolution of digital technologies requires that the organization fosters a digital culture. To remain competitive, it is necessary to evaluate the technologies present and to note the current situation in the company, to determine the steps to be taken, and to develop an action plan. In other words, it is crucial to start now, regardless of the size of the digital assets, the level of mastery of the tools, the degree of maturity of each of the technologies and, overall, the digital maturity of the organization[31].

Several models exist when dealing with a company's digital maturity.

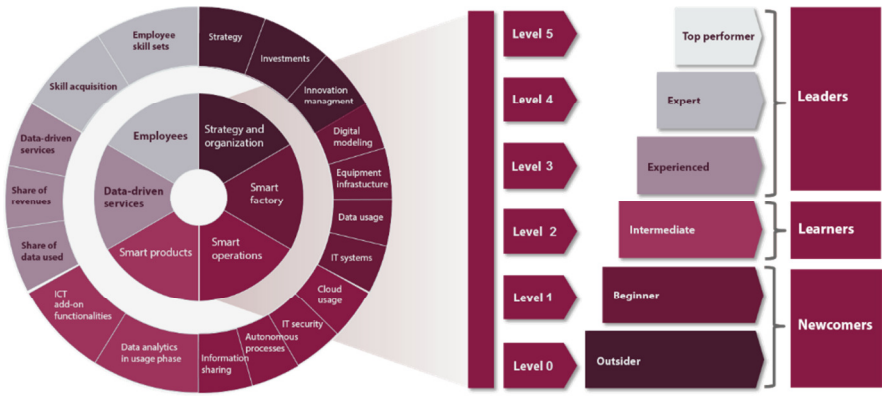
Figure 13: Roland Berger's Digital maturity model for Industry 4.0



Excerpt of the presentation by Hany Moustapha
Professor and Director, AÉROÉTS

In this model, the notion of digital maturity is associated with several factors: infrastructure, processes, data and working methods.

Figure 14: *Readiness* Model for Industry 4.0 of the German Engineering Federation



Excerpt of the presentation by Yves Proteau
Co-president, APN

[31] Source: "Roadmap, Industry 4.0." Québec Digital Strategy, 2016.

The Readiness model is an online evaluation model[32] enabling a company to measure its degree of maturity related to Industry 4.0 in six key areas: Strategy and Organization, Factory, Operations, Products, Services, and Employees.

The École de technologie supérieure (ÉTS) in Montréal is participating in the creation of a new maturity index, "Aerospace 4.0," in conjunction with Concordia University. The German firm Siemens will contribute know-how gathered in its home country.

[32] Online model: https://www.industrie40-readiness.de/?lang=en

7. Key factors in successfully implementing 4.0

Québec SMEs are in a unique position to seize the opportunities generated by the fourth industrial revolution. However, they must act quickly while following a number of steps necessary for the implementation of 4.0.

Figure 15: The successful digital roadmap[33][34]

Diagnostic and development of a 4.0 strategy

The first step is to perform a diagnosis of the company's maturity by taking into account all the services and steps of the value chain to identify business opportunities and strategic positioning. It is then up to the leaders to develop a 4.0 roadmap aligned with the company's overall strategy.

Carrying out pilot projects

To make the 4.0 strategy credible, to motivate teams, and to facilitate change, it is necessary to start its implementation through projects that can ensure a rapid return on investment. Collaboration with external stakeholders is strongly advised to maximize its chances of success. The transition to industry 4.0 is a step-by-step process. The SME should not try to achieve everything, right away, and should not try to integrate all the technologies. It is important to carefully select and implement technologies that are useful to one's own reality and needs.

Identification of required measures

Once the first pilot projects have been completed, four strategic areas must be considered:

- Organizational structure: innovation laboratory, centres of excellence, committees.
- People: investing in new talent with high added value.
- Processes: new collaboration models, data security.
- Technology: the choice of technologies to invest in.

[33] Source: http://www.pwc.com/ca/fr/industries/industry-4-0.html

[34] Source: "6 étapes incontournables pour digitaliser une entreprise industrielle." Author: Océane Lauro. October 17, 2016.

Mastering data analysis

Data support decision-making while improving a company's products and services. It will be crucial to develop a strategy in this area by focusing on predictive analysis and forecasting, automatic feedback and employee connectivity. Firstly, it is important for the SME to take the time to select the data it wishes to exploit from the set of available data. The next step is to provide the right data to the right person at the right time.

Transformation of a company to a digital enterprise

To carry out this large-scale project, company managers must support this new corporate culture by demonstrating leadership. The 4.0 transition can only be achieved through a strong commitment and engagement from management.

Using the ecosystem

The company can pull on external players and strike partnerships when it does not have all the skills and agility needed internally.

8. Concrete levers of Industry 4.0 for Québec's aerospace industry

Many levers are available in Québec to facilitate the transition of SMEs to Industry 4.0. Aéro Montréal's MACH FAB 4.0 initiative supports and finances the digital transition of SMEs. Many training programs are available in Québec. Solution providers are a major asset for companies in their transition.

8.1 MACH FAB 4.0 Initiative

The MACH FAB 4.0 initiative, included in the 2016-2026 Québec Aerospace Strategy, is a $19 million project, including $9.5 million in public funding. It will help support 50 SMEs in Québec's aerospace industry in transitioning to the company of the future. Implementation of this initiative is the responsibility of Aéro Montréal[35]. The main partners involved in this project are AEROÉTS, CEFRIO and Sous-traitance industrielle Québec (STIQ).

MACH FAB 4.0 is a tailor-made support program designed for SMEs. The projects supported by the MAB FAB 4.0 initiative are geared towards the intelligence and fluidity of production as well as advanced manufacturing. This program constitutes a major lever in supporting and financing SMEs in their digital transition. They can carry out projects over a period of six months to two years.

Because of this program, Québec's aerospace SMEs will become more integrated into the global supply chain and increase their presence in export markets.

The kinds of projects underway as part of the MACH FAB 4.0 initiative include:

- Real-time production management.
- Optimization of the production cycle using simulation to determine the best machine sequencing.
- Use of data collection to perform preventive maintenance of manufacturing equipment.
- Connection to the OEM's resource management systems to enable real-time information exchange.

[35] Contact: Martin-Charles Boucher M.Eng., Project Manager, MACH FAB 4.0 Program, Supply Chain. martin-charles.boucher@aeroMontréal.ca

8.2 Training

The Aéro Talents White Paper prepared by Aéro Montréal in 2016[36] provides a summary of the programs and initiatives of all the partners in Québec's aerospace cluster.

• **"Aerospace 4.0"** Created by AÉROÉTS in 2016, "Aerospace 4.0" is an integrated research, education and continuing education program designed to meet the needs of Industry 4.0 in the aerospace sector. This program includes an R&D component and an education and training component.

  o Research and development component: this component brings together several institutions and research centres to carry out structuring research and development projects on Industry 4.0 technologies for the aerospace sector. This initiative will focus on the entire company to achieve a "Smart Digital Enterprise."

  o Education and training component: This component mobilizes AEROÉTS resources to develop various continuing and short-term training that will prepare aerospace workers for the new skills required by Industry 4.0. These training courses can be given to specialized workers, technicians, engineers and professionals, in particular through AéroFormation.

• **"AéroFormation"** is a consortium created in 2013 between the École des métiers de l'aérospatiale de Montréal (ÉMAM) and the Centre for Aerospace Professional Education (CAPE - McGill University and ÉTS) in partnership with Aéro Montréal, the Comité sectoriel de main-d'oeuvre en aérospatiale (CAMAQ) and Emploi-Québec de l'Ile-de-Montréal. The objective of AéroFormation is to develop various continuing and short-term courses to prepare specialized workers, technicians and engineers for the new skills required by Industry 4.0. In 2016, Aéro Montréal renewed its partnership with AéroFormation.

- **The Montréal Aerospace Institutes** (MAI) Established in 2001, the Montréal Aerospace Institutes aims to better prepare undergraduate students through industrial projects, internships, mentoring, training courses, industrial visits, internships abroad, etc. Each year, approximately 300 students are chosen from Concordia, ÉTS, Polytechnique, McGill, Sherbrooke and Laval universities. Most graduates are hired by MAI member companies. In its new mission, the MAI is aiming to double the number of students in five years, expand access to SMEs, and to act as the academic spokesperson for aerospace education and training.

[36] The full document is available here: https://www.aeromontréal.ca/rapports-et-documents.html

8.3 Talent recruitment[37]

In the context of the 4.0 shift, the recruitment of talent in companies is a major challenge and an important lever. There is a need to retrain employees, change organizational models and pursue strategic recruitment, all while planning future workforce needs.

Recently, Aéro Montréal launched **jobs.aeroportail.ca**, an initiative allowing companies and job seekers to access a centralized database of jobs available in the aerospace industry in Québec. This is a section of the aeroportail.ca, a digital ecosystem that provides simple, centralized and dynamic information on the sector, including available training.

[37] This section is available in the Aéro Talents White Paper: https://www.aeroMontréal.ca/rapports-et-documents.html

8.4 Solution providers

Support provided by consultants enables any company wishing to take the 4.0 shift to ensure that projects respond to strategic issues and generate returns on investment. Suppliers contribute, each in their own way, to the innovation and productivity of manufacturing companies.

As part of the 2017 Global Supply Chain Summit, Aéro Montréal, with the support of Emploi Québec, created the **4.0 Demo Zone**. This Zone enabled Summit participants to find solution providers and the resources needed to implement Industry 4.0 in their organization. This area was organized in such a way as to simplify participants' search by creating areas based on type of technology and by having visitors navigate a path similar to the one recommended for the journey from a traditional factory to the factory of the future.

Some of the solution providers in the **4.0 Demo Zone** participated in a panel discussion (Merkur, VKS, and Radix) to present their solutions and share success stories. The Poka start-up and the Canadian subsidiary of giant Siemens also presented their respective technologies.

A- Support, Financing, Training Area

- **CNRC**: More intelligent manufacturing technologies
  https://www.nrc-cnrc.gc.ca/eng/index.html

  National Research Council Canada (NRC), the country's leading research organization, supports industrial innovation, the advancement of knowledge, technology development and the carrying out of government mandates.

- **NSERC**: Your innovation partner
  http://www.nserc-crsng.gc.ca/index_eng.asp

  The Natural Sciences and Engineering Research Council of Canada works with a university or college research team to help organizations achieve their operational goals, solve problems and achieve results.

- **MACH FAB 4.0**[38]
  https://www.aeromontreal.ca/machfab_en.html

  The MACH FAB 4.0 initiative aims to promote the transition of SMEs to Industry 4.0, to improve the competitiveness and productivity of SMEs, and to implement digital and advanced manufacturing technologies.

[38] See Chapter 7.1 pg. 31 on the MACH FAB 4.0 Initiative

B- Big Data, Interconnexion Area

- **CENTRIS TECHNOLOGIES**: Complete solutions for needs in automation, industrial software and Industry 4.0.
  http://centristech.com/en/home

  Centris Technologies offers specialized know-how and cutting-edge products for industrial automation and "Industry 4.0" software development. Centris Technologies employs a rigorous development process, keeping total quality as its ultimate goal.

- **FACILITÉ INFORMATIQUE**: IT Consulting Services, BI, Big Data, SAP, S1000D
  https://www.facilite.com/index.aspx

  The mission of the Facilité Informatique group is to offer advisory services, expert advice and solutions in information technology.

- **MEMEX**: Measuring manufacturing excellence
  http://www.memexoee.com/

  MEMEX provides manufacturers with products that enable manufacturing machines to communicate with each other and with production management systems.

- **MERKUR**: Consulting engineering company for all industrial companies
  http://merkur.ca/

  Merkur supports its customers in enhancing their companies' performance, enabling them to stand out, be more competitive and ready to face the challenges of tomorrow.

During the panel discussion, Éric St-Laurent, Director, Technology Optimization at Merkur, presented five technologies that bring concrete solutions to companies.

o Operator assistance: The objective is to help an operator to retain the production sequences of 200 different products, for example, to reduce possible errors, contribute to knowledge management and accelerated training.
o Equipment connectivity: with connected equipment, the user can retrieve data in real time.
o Production monitoring: with collected data, the user can understand the performance, the challenges, control and communicate information; this information is a guarantee of continuous improvement and generates a leverage effect.
o Advanced automation: new automation possibilities increase productivity.
o Data Integration and Enhancement: Creates value and assists supervisors in their decision-making.

Pascal Vachon, Senior Advisor, Smart Factory, Merkur, stressed the importance of defining a global vision of the smart factory based on the unique issues at each company and implementing the strategy.

- **VKS**: VKS is a work instruction software for manufacturing companies
  http://fr.vksapp.com/

VKS is a work instruction software that enables manufacturing companies to move from a manual approach to a paperless, visual solution that targets industry-leading 4.0 and integrates it with the Internet of Things (IoT).

Ryan Zimmermann, Director of Business Development, presented the origin of digital work instruction software during the panel discussion. This tool has enabled several manufacturers to share best practices in operations and to monitor quality and productivity.

- **WORXIMITY**: smart factory technologies
  https://worximity.com/en/

  WORXIMITY allows a company to take control of its production and transform its production processes with information obtained in real time.

C- Automation, Robotics Area

- **ATOS**: A leader in the area of Big Data and cybersecurity
  https://atos.net

  Serving a global customer base, the Group is a leader in the field of Big Data, cybersecurity and digital workspace. It provides cloud services, infrastructure and data management, business solutions & platforms as well as transactional services.

- **GCTECH**: Practical machining solutions since 1988
  http://www.cgtech.com

  The VERICUT verification module detects program errors and easily verifies parts accuracy.

- **AUTOMATION MACHINE DESIGN RC INC:** Design and manufacturing of customized automated industrial equipment
  http://www.amdinc.ca

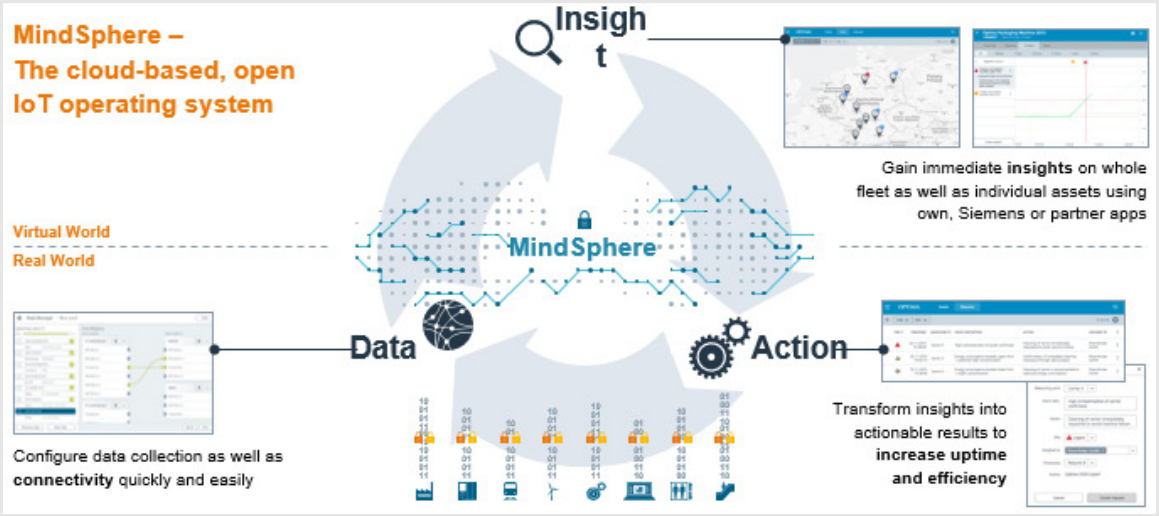
  Automation Machine Design Inc. (AMD) specializes in the design and manufacture of customized automated and robotic equipment, focusing on improving customer performance through increased productivity.

- **ROBOTICS DESIGN INC**: A leader in the field of modular robotic technology.
  http://www.amdinc.ca

  The company is composed of several divisions that share the mission of providing unique and innovative products to serve humanity and simplify life while protecting the environment.

- **SIEMENS**: A leader in cutting-edge technology
  http://www.siemens.com

Jeff Gazidis, Director, Aerospace, presented **MindSphere**. Designed as an open cloud-based IoT ecosystem, MindSphere enables industrial companies (customers, partners, suppliers) to improve the performance of their facilities by increasing the productivity of their machines and installations, optimizing the maintenance and cleaning of systems through the collection and analysis of large quantities of production data.



- **VALIANT CORP.**: Automated manufacturing and assembly systems.
  http://www.valiantcorp.com/

D- New Technologies Area

- **FUSIA IMPRESSION 3D MÉTAL INC**: FusiA is specialized in the additive manufacturing of metal parts and is a leader in the field of modular robotic technology. https://www.fusia.fr/

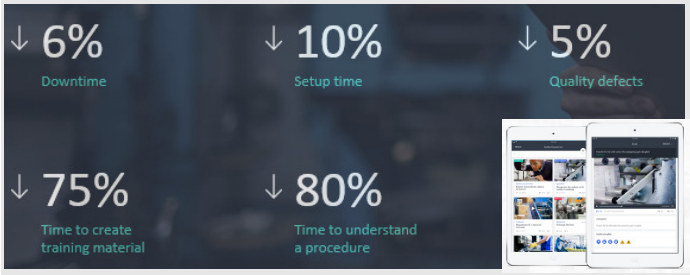
  The FusiA Group specializes in the additive manufacturing (3D printing) of metal parts. Through the FusiA Group and its subsidiaries, FusiA has more than 40 years of expertise in precision machining, enabling it to offer services from the research and design phases to production aligned with aeronautical standards. Its expertise in additive manufacturing allows it to produce prototype parts, from pre-series and series to complex geometries, certified for flight.

- **POKA**: Communications and training solutions for manufacturers. www.poka.io

Poka is a multiplatform application designed to collect all the data and procedures relating to a company.

Alexandre Leclerc, co-founder and president of Poka, introduced the start-up Poka, a social network for factories, and designed to be used by factory employees. Its ultimate goal is to ensure that employee knowledge can be systematically communicated through training videos and problem solving. This technology was first deployed in Biscuit Leclerc plants, Alexandre being the representative of the fifth generation Leclerc in the company.

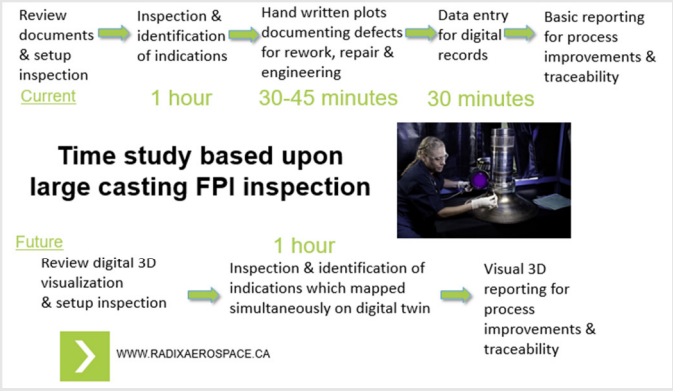
The practical benefits of using Poka for Biscuits Leclerc were reduced time for training preparation and understanding of procedures, as well as reduced downtimes, machine setup times and lower quality defects.



- **RADIX AEROSPACE**: Communications and training solutions for manufacturers. www.radixinc.ca

Radix provides world-class innovation, creating processes, products and systems that focus on results and quality, thereby improving the traceability and efficiency of production for its customers.

Mike Muldoon, Director, Aerospace Operations, introduced Radix's 3D Inspection Tracking technology, enabling customers to optimize their digitization process. Automation projects effectively influence productivity.



- **SAFRAN IDENTITY AND SECURITY**: A leader in biometrics and digital identity https://www.morpho.com

  Safran Identity & Security is a global leader in security and identity solutions for an increasingly digital and connected world (digital signature, identification, access control, identity, etc.).

- **TERVENE**:
  https://tervene.com/

  Tervene is a technology company that has developed an application that enables team leaders and foremen in the manufacturing industry to proactively monitor their operations, identify opportunities for improvement, and develop action plans.

- **VIRTUAL PROCESS**: System allowing for remote monitoring and control of a manufacturing plant in real time.

  http://www.virtual-process.com

  Virtual Process is a manufacturing execution system (MES) and performance management system (BPM) that streamlines and controls all manufacturing operations.

9. Conclusion and recommendations

The fourth edition of the Global Supply Chain Summit organized by Aéro Montréal paved the way for discussions and action to ensure that Québec's SMEs in the aerospace industry move from vision to reality and take concrete steps to embark on a journey to the future.

By dramatically changing the way products are designed and delivered to customers, Industry 4.0 is shaking up all industry sectors. Its impact on the aerospace sector promises to be considerable: better use of resources, increased productivity, reduced operating costs, superior product quality and, consequently, increased capacity to provide added value to customers. These are just some of the benefits for companies engaged in the digital transformation. In a context of international competition, SMEs that have innovated and started their transition to Industry 4.0 will be more competitive on the world stage, which allows them to keep their position as suppliers of choice to OEMs.

The Summit demonstrated that all the players in the sector, OEMs and all their suppliers, can truly benefit from working together to take advantage of this digital revolution already underway. Industry 4.0 will enable Québec to strengthen the already enviable position of its aerospace industry on the international stage.

Although there is still a long way to go and investments are needed to adopt digitization to their production processes, Québec SMEs in the aerospace industry have the opportunity to thrive further on the fertile ground of Montréal and Québec. Whether it is recruiting a skilled workforce, assessing the company's digital maturity, finding solution providers, experts or financing, the Québec aerospace cluster is mobilized to support these efforts to change and fully use all available levers for the transformation. As a global artificial intelligence hub, Montréal can provide the aerospace industry with the resources and expertise necessary for its digital transformation.

In this context, the following are the main recommendations for achieving the objectives and findings set out in this White Paper to accelerate the digital transformation in the Québec aerospace ecosystem:

- **Promote Business Process Innovation among SMEs**.

  4.0 technologies are well known for optimizing plant production and productivity. But their use needs to be extended more broadly to business process optimization. This can be done by interconnecting systems and facilitating transparency and sharing, in real time, information from all areas of the company, suppliers and customers. Therefore, financial partners must also adapt their solutions to support this more global and strategic transition of the company.

- **Encourage consolidation of the Québec aerospace sector through collaborative 4.0 projects**

The consolidation challenge is real in Québec and the digital transition that is taking place must be used as a springboard to foster collaboration and the consolidation of companies in the aerospace sector. SMEs have needs that are often common in terms of implementing 4.0 in their companies. In order to pool costs and benefit from a leverage effect, it is important to encourage and support SMEs through collaborative 4.0 projects. Through this pragmatic practice, SMEs will learn about partnerships. Step by step, this may encourage collaboration in other major projects that may lead to mergers, acquisitions or the creation of sales consortia. All these actions will eventually help SMEs achieve critical mass, which will allow them to join the supply chain and offer their customers complete sub-assemblies. This will ultimately lead to the consolidation and competitiveness of our industry and the positioning of Québec on the world stage through a global business transition.

- **Create accelerators to foster the implementation of artificial intelligence in companies to remain a world leader.**

  Canada, Québec and Montréal are taking a leading position in the development of artificial intelligence. Montréal has not only the largest concentration of experts on the subject but is also one of the three largest aerospace hubs in the world. These two conditions form a fertile breeding ground for the development and implementation of concrete projects within companies in the aerospace sector. These companies represent users of choice for AI technologies. To demystify this technology and facilitate its transfer, the development of accelerators in Québec to help companies take ownership of these breakthrough technologies would provide a true competitive advantage.

This document was produced under the supervision of Aéro Montréal's Supply Chain Working Group.

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Appendices

Appendix 1 – Our partners

Aéro Montréal thanks I Invest Canada – Community Initiatives (ICCI) for its support in preparing this White Paper, as well as the following partners:

Appendix 2 –Aéro Montréal Supply Chain Working Group

The Supply Chain Working Group's mandate is to ensure the planning and implementation of a concerted action plan with the objective of increasing the competitiveness of Quebec suppliers. It aims to therefore strengthen Québec's aerospace supply chain.

Working Group Champion:

- **Louis Marc Pinard**, Deputy General Manager and Director, Strategic Planning & Commercial, Arconic

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- **Mélanie Lussier**, Director, Market Development – SME / Supply Chain
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Appendix 3 –April 4 Program

Global Supply Chain Summit 2017

"From Vision To Reality: Breaking Through the World of 4.0"

Tuesday, April 4, 2017 at the Palais des congrès de Montréal

As we enter the 4th Industrial Revolution, which is leveraging interconnections between machines and interconnections between machines and humans, this 2017 edition of the Global Supply Chain Summit aims to help companies of all sizes in the aerospace sector to migrate towards Industry 4.0. Emphasis will be placed on demystifying the concept and presenting case studies to inspire and encourage our industry's transition.

Master of Ceremonies:

Hélène V. Gagnon, Vice President, Public Affairs and Global Communications, CAE and Chair of the Board, Aéro Montréal.

Time	Thematics [1]
7:00 a.m. – 8:00 a.m.	**Registration and Welcome**
8:00 a.m. – 8:15 a.m.	**Welcoming Remarks** ▪ Suzanne M. Benoît, President, Aéro Montréal
8:15 a.m. – 8:30 a.m.	**Opening Remarks by Ms. Christine St-Pierre, Minister of International Relations and La Francophonie of Québec**
8:30 a.m. – 8:40 a.m.	**Opening Presentation** *Joseph C. Anselmo will review general trends in the aerospace sector and introduce the day's agenda.* ▪ Joseph C. Anselmo, Editor-in-chief, Aviation Week & Space Technology
8:40 a.m – 8:50 a.m.	**Opening Speach by Bombardier** ▪ Jim Vounassis, Chief Transformation and Procurement Officer, Bombardier
8:50 a.m. – 9:25 a.m. *Panel*	**The Evolution and Impacts of 4.0** Moderator: **Hélène V. Gagnon**, Vice President, Public Affairs and Global Communications, CAE and Chair of the Board, Aéro Montréal. *It's time to demystify the term "4.0," to review the steps that have led to the 4th industrial revolution as a result of various breakthrough technologies. This panel will also underline why Montreal is becoming the new 4.0 hub.* ▪ Éric Leduc, Senior Sales Manager, Microsoft ▪ Naomi Goldapple, Program Director, Element AI
9:25 a.m. – 9:50 a.m. *Conference*	**The Impact of 4.0 on the Supply Chain** *Kevin Michaels will show us the changes that 4.0 has had on various levels of the supply chain.* ▪ Kevin Michaels, Managing Director, AeroDynamic
9:50 a.m. – 10:15 a.m. *Conference*	**State of the Art: When Robotics Optimize the Production of Aerospace structures** ▪ Jean-Philippe Marouzé, Director – Product and Advanced Composite Value Chain, Bombardier
10:15 a.m. – 10:30 a.m.	**Break**
10:30 a.m. – 11:25 a.m. *Case study presentation*	**Concrete Example of a Supply Chain in Transformation** Moderator: Graham Warwick, Managing Editor, Aviation Week & Space Technology *This panel will share lessons learned and explain the role companies are playing in a rapidly-changing supply chain.* ▪ Jill Christenson, Sr. Manager Supplier Management Aircraft Materials &Structures Strategy, The Boeing Company ▪ Anthony L. Velocci, Former Editor-in-chief of Aviation Week & Space Technology ▪ Tim Beatty, President, Bullen Ultrasonics
11:25 a.m. – 12:10 a.m. *Case study presentation*	**Assess and Measure your Transition to 4.0** *This panel will present the tools that will enable you to position yourself and measure the success of implementing 4.0 in your company.* ▪ Hany Moustapha, Professor and Director, AÉROÉTS ▪ Jeff Z. Gazidis, Aerospace Industry Manager, Siemens Canada ▪ Yves Proteau, Co-President, APN
12:10 a.m. – 1:45 p.m.	**Lunch in the Demo Zone 4.0**
1:45 p.m. – 2:15 p.m. *Conference*	**When Start-Ups disrupt the Models** *Van Espahbodi will show us how innovative start-ups are disrupting traditional operating concepts, acting in 4.0.* ▪ Van Espahbodi ,Co-Founder, Starburst Accelerator
2:15 p.m. – 2:45 p.m. *Conference*	**Optimize Performance through Interconnection!** *Shane Eddy will present the impact of industry 4.0 on the supply chain by showing how supply chain interconnection optimizes the overall performance of all players in the aerospace sector. He will cite the case of Pratt & Whitney, a leader in creating a digitalized relationship with its suppliers.* ▪ Shane Eddy, Senior Vice President Operations , Pratt & Whitney
2:45 p.m. – 3:15 p.m. *Conference*	**Humans, the Heart of 4.0** *GE Bromont, a leader in robotic plants, demonstrates how Humans are at the heart of industry 4.0. by giving priority to its employees in its digital journey.* ▪ Johanne Jolicoeur, Senior Manager, Human Resources, GE Aviation Bromont
3:15 p.m – 3:30 p.m.	**Break**
3:30 p.m. – 4:15 p.m. *Case study presentation* *Bilingual*	**Successful Transitions: Knowledge Sharing from other Sectors** *Companies from other sectors, Biscuits Leclerc and Lumenpulse will inspire us with their success stories, explaining why they have taken the journey and the improvements that have resulted.* ▪ Alexandre Leclerc, Cofounder & CEO, Poka ▪ Guy Beauséjour, Manufacturing Operations Director, Lumenpulse Lighting ▪ Harold Lebrun, Virtual-Chief Technology Officer, Virtual Process
4:15 p.m. – 5:00 p.m. *Panel* *Bilingual*	**Concrete Solutions that bring more than you think** *This very pragmatic panel will show you, step by step, the solutions available for your company to migrate to 4.0 (costs, ROI, benefits).* ▪ Éric St-Laurent, Director, Technological Optimization, Merkur ▪ Pascal Vachon, Senior Advisor, Merkur ▪ Ryan Zimermann, Director of Business Development, VKS ▪ Mike Muldoon, Director, Aerospace Operations, Radix
5:00 p.m. – 5:10 p.m.	**Closing Remarks** *Joseph C. Anselmo will summarize the key concepts exposed during the day, for a successful 4.0 transition of the supply chain.* ▪ Joseph C. Anselmo, Editor-in-chief, Aviation Week & Space Technology
5:15 p.m. – 7:30 p.m.	**Cocktail in the Demo Zone 4.0**

Appendix 4 – 4.0 Demo Zone

Bibliography/webography

- "Industrie 4.0. Les défis de la transformation numérique du modèle industriel allemand." Authors: Dorothée Kohler and Jean-Daniel Weisz. La documentation Française, 2015.
- "Reinventing the horizon, 2016-2026," Québec Aerospace Strategy.
- "Greater Montréal's aerospace industry." Montréal International.
- "Propelling the talents of aerospace towards Industry 4.0." Aéro Talents White Paper, 2016.
- "Best Student Cities 2017" (https://www.topuniversities.com/best-student-cities).
- " CRIQ and Festo will establish the first cyber-physical laboratory in Canada." (http://www.fil-information.gouv.qc.ca/Pages/Article.aspx?idArticle=2504203818)
- "Industry 4.0: Canada's manufacturing sector's opportunity to shine" (http://www.pwc.com/ca/fr/industries/industry-4-0.html)
- "Industry 4.0: data at the service of engineering" (http://affaires.lapresse.ca/portfolio/ingenieurs/201611/03/01-5037337-industrie-40-les-donnees-au-service-du-genie.php)
- "Digital revolution for the industrial world" (http://www.lapresse.ca/le-soleil/affaires/techno/201611/13/01-5040840-revolution-numerique-pour-le-monde-industriel.php)
- "Manufacturing's Coming Revolution." Anthony L. Velocci. Aviation Week & Space Technology, January 9-22, 2017.
- "Industry 4.0 will be, or won't be, open source." (https://www.industrie-techno.com/l-industrie-4-0-sera-open-source-ou-ne-sera-pas.45567)
- "GE Aviation: 115 new jobs at the Bromont plant" (http://www.lapresse.ca/la-voix-de-lest/actualites/201702/09/01-5068152-ge-aviation-115-nouveaux-emplois-a-lusine-de-bromont.php)
- "Industry 4.0 Roadmap." Québec Digital Strategy, 2016
- "How artificial intelligence is changing the job market" (http://ici.radio-canada.ca/nouvelle/1018950/automatisation-revolution-technologique-bouleversement-monde-travail-robot-execution-tache)
- "The solution adapted to your projects" http://www.investQuébec.com/Québec/fr/produits-financiers/toutes-nos-solutions/essor.html