SUMMIT

TRAINING OF ENGINEERS AND SPECIALISTS
FOR THE AEROSPACE INDUSTRY

NOVEMBER 26, 2008

ÉCOLE DE TECHNOLOGIE SUPÉRIEURE

Towards a better educational partnership between industry and university

REPORT

SUMMIT ON TRAINING OF ENGINEERS AND SPECIALISTS FOR THE AEROSPACE INDUSTRY

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of Metropolitan Montréal

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Aéro Montréal would like to thank the **DRAKKAR HUMAN RESOURCES** Montréal team who coordinated the drafting of this report and who supported the work of the Summit on Training of Engineers and Specialist, with the cooperation of **DELOITTE**. Drakkar Human Resources, your partner in the optimisation of human capital. AAA Canada, subsidiary of Drakkar and Assistance Aéronautique & Aérospatiale France, on-site manufacturing. Deloitte, professional services in audit, tax, financial advisory and consulting

We also want to thank the **Summit organizing committee** for preparing the conference and workshop themes.

President: Marius Paraschivoiu, Concordia University

Members :

- Patrick Champagne, Esterline CMC Electronics
- Isabelle Deschamps, ÉTS
- Jean Dubuc, L-3 Communications MAS (Canada)
- Hany Moustapha, Pratt & Whitney Canada
- Serge Tremblay, CAMAQ

Finally, we would like to thank members of **Aero Montréal's Innovation Working Group** whose work over the past two years led to the Summit.

President: Hany Moustapha, Pratt & Whitney Canada

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- Carlos Trindade, CRIAQ
- Jack Eric Vandenbroucke, ÉTS
- Normand Raymond, MDEIE (Observer)
- Dominique Leroy, Industry Canada (Observer)

1. FOREWORD

Message from the CEO

Our aerospace sector is at the very forefront of the key manufacturing sectors of Québec. It generates considerable economic activity, provides thousands of high-quality jobs for Quebecers – as demonstrated by its leadership in research and development – and is home to Canada's most prestigious research institutes, schools and universities involved in aerospace. In addition, our aerospace sector can draw on a very competitive pool of quality manpower to meet the needs of the industry, including tradespeople, technicians, specialists and engineers. In an age of increasingly knowledge-based economies, the availability of qualified manpower is crucial for our industry in maintaining its clear competitive advantage.

At the initiative of Aéro Montréal, the aerospace cluster of Metropolitan Montréal, the "*Summit on the Training of Engineers and Specialists for the Aerospace Industry*"[1] follows up on the *Aerospace Innovation Forum – Future Outlook* that was held in Montréal in December 2007. The Summit provided an opportunity to define the training programs that must be developed for the next generation of aerospace engineers and specialists in this province to help preserve the high level of skills and expertise that distinguishes our manpower pool.

The Summit is part of the overall efforts of the Cluster's Innovation Working Group, an industry task force made up of experts in engineering and research and development. Through such working groups, Aéro Montréal strives to work in a collaborative spirit and foster an environment favourable to the development and expansion of the aerospace industry so that it can continue to be an engine of the Canadian economy and a source of wealth creation for Montréal, Québec and Canada.

Suzanne M. Benoît
Chief Executive Officer
Aéro Montréal

Message from the Co-Presidents

The growth and vitality of Québec's aerospace industry flow from the vision and skills of its engineers and specialists. The sector employs more than 10,000 engineers and specialists,and for the past three years, has needed an average of over 800 new qualified engineers and specialists per year. Generally speaking, it has been able to draw on a pool of 11,000 new graduates in pure and applied sciences and benefits from the presence of seven renowned universities offering programs oriented to aerospace engineering. As impressive as this may be, we must ask whether our human capital and future generations are adequately equipped to meet the challenges faced by the aerospace industry in the 21st century? These challenges include demands to reduce the industry's environmental footprint, compliance with safety norms and certifications; continuous production improvements; increases in productivity and performance, and new practices in technological development. How should these new imperatives be reflected in the academic programs being offered by our universities and in continuous training within our businesses? The "*Summit on The Training of Engineers and Specialists for the Aerospace Industry*" and, more particularly, this year's theme "Towards a better educational partnership between industry and university" allowed our sector to address these fundamental questions looming in the future of our industry and universities.

François Caza
Vice President and Chief Engineer
Bombardier Aerospace

Christophe Guy
Chief Executive Officer
École Polytechnique de Montréal

[1] *Report on the Aerospace Innovation Forum, June 2008.*

2. EXECUTIVE SUMMARY

On November 26, 2008, the *Summit on the Training of Engineers and Specialists for the Aerospace Industry* was held on the initiative of Aéro Montréal, the Aerospace Cluster of Metropolitan Montréal. More than 125 representatives from the industry and higher education in Québec met under the theme Towards a better educational partnership between industry and university. They spent a day discussing the manpower needs of Québec's aerospace sector and on the conditions for joining forces to enhance university and company training programs.

The Summit's objectives were, on the one hand, to identify the aerospace industry's requirements in terms of specialized manpower and all the training programs already offered in Québec, and on the other hand, to propose concrete actions to improve current training.

Demand for specialized manpower, the needs of aircraft, engine, avionics and simulator manufacturers, university programs and two industry-university collaboration initiatives in Québec (Montréal Aerospace Institute and CRIAQ) were presented.

The morning session of the Summit featured seven presentations on the needs of specialized manpower for the industry as a whole as well as for its main sectors, and on university programs that complement institutions and organizations specializing in higher education.

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Summit participants underscored that the training of tomorrow's aerospace engineer needs to put more emphasis on systems integration multidisciplinary, multi-site and multicultural work; a high level of technical skills and a range of professional qualifications such as leadership, team spirit and commitment towards customers and shareholders. Tomorrow's agile engineer is a business-oriented engineer with global skills, i.e. an engineer able to focus on costs, to practice continuous process improvement within a "lean" company, capable of thinking in 3D, a risk manager skilled in systems engineering to integrate the product, manufacturing and customer support at the same time.

The presentations highlighted the fact that aerospace training for our Québec students has many strengths.

Six Québec university institutions offer a large number of training programs at the bachelor's and master's levels that set them apart, namely through the specializations offered and teaching methods (internships, cooperative approach): Concordia, Laval, McGill and Sherbrooke universities; Ecole de Technologie Supérieure (ETS) and École Polytechnique de Montréal (EPM). The Montréal Aerospace Institute (MAI) is a model of collaboration between the university and industry. MAI is a partnership between companies and the university world focusing on student training that ensures an industry presence on campuses. In addition, through their collaborative nature, CRIAQ projects bring together hundreds of researchers, specialists and students from seven universities and three Québec research centres, as well as a Canadian and international university network. Many students participate in each project.

Workshop discussions highlighted the need to tailor training programs to industrial realities. They suggested internships for students and encouraging university professors to obtain industrial experience by spending time in a company. To enhance training, companies should structure and share their in-house training courses with each other. A pressing need has emerged in airborne systems. There's a big gap in this area between the industry's needs and the number of potential graduates. The number of specialized majors should be increased by, for example, offering an avionics option in computer engineering. In addition, avionics courses require major improvement.

Québec universities do not have sufficient resources for higher education. Despite the appeal of a city like Montréal, it's difficult to attract the best talent from around the world due to a lack of financing (e.g. granting of scholorships). There is strong competition among the world's aerospace regions to attract very high quality students and workers. There isn't enough government financing for universities to hire more professors and reduce the student-teacher ratio. This would assure better quality training and an increase in projects.

The summit also identified the sector's key issues and related actions.

The **seven measures or actions** that were put forward during the summit are as follows:

1. **Encourage university-company and company-university exchanges by facilitating training through internships, the integration of professors into companies and joint research projects through CRIAQ or MAI.**
2. **Establish shared training programs that are recognized by all the partners for "in company" aerospace training (underway via MAI).**
3. **Develop concentrations in airborne systems (underway via CAMAQ).**
4. **Encourage more young people to consider a career in aerospace engineering by promoting the sector starting in high school (e.g. recent Aéro Montréal initiative).**
5. **Encourage more university students to continue their studies and ensure that these programs are better tailored to the industry's needs.**
6. **Improve training of engineers by emphasizing systems integration and the management of multidisciplinary teams, both in universities and companies.**
7. **Identify the various engineer profiles and specializations and make this classification available to define academic programs and reflect the industry's needs, for example the CDIO initiative.**

Other issues reviewed during the Summit included the promotion of local and international partnerships; the appointment of senior executives within companies to oversee in-house training; and the fact that SMEs are not sufficiently supported by universities.

Finally, Québec is very well situated over other international aerospace centres in terms of aerospace engineers and specialists training. First, there is a good balance among the number of graduates coming out of universities and the needs of companies for engineers; this balance should not be upended by demographic changes as long as the industry and universities maintain the same level of collaboration.

Secondly, inter-university and industry-university collaboration is well developed, and has been for more than two decades, as reflected by a wide range of initiatives such as CAMAQ's joint masters in aerospace engineering that brings together 6 universities and more than 12 companies, the MAI with 3 university aerospace institutes and more than 20 enterprises, CDIO or CRIAQ's aerospace student forums.

Companies, just like universities, want and are ready to work together to enhance their collaboration and better respond to the sector's need for specialized manpower within the context of increasing international competition. The challenge is to maintain the momentum of all the initiatives taken to date. The seven measures identified during the summit will allow, through concrete actions, to accelerate this collaboration and strengthen our university programs in line with the new requirements of the dynamic aerospace sector.

The *Summit on the Training of Engineers and Specialists for the Aerospace Industry*, an initiative of Aéro Montréal, the Aerospace Cluster of Metropolitan Montréal, was held on November 26, 2008. More than 125 representatives from the industry and higher education in Québec met under the theme Towards a better educational partnership between industry and university. They spent a day discussing the Québec aerospace sector's manpower needs and ways to pool their efforts to better develop the quality and quantity of university and company training programs for the next generation of engineers and specialists in the industry.

The morning session of the Summit featured seven presentations on the industry's specialized manpower needs, including those of its main sectors of activity – aircraft, engineer, avionics systems and simulator manufacturers – as well as on university programs that complement higher education institutes and specialized organizations.

AEROSPACE HIGHER EDUCATION IN QUÉBEC AT A GLANCE

Higher education in aerospace

- 6 universities train the engineers and specialists of tomorrow through quality programs tailored to industrial realities. Three institutes complement this training through internships.

- A close relationship with the industry's innovation capacity to ensure constant alignment between the programs offered and the processes and technologies used by the industry.
- Various in-house continuous education programs to meet companies' direct needs.

List of universities, specialized institutes and organizations

- **Engineering schools:** École Polytechnique de Montréal, École de Technologie Supérieure, Concordia University, Laval University, McGill University, Sherbrooke University and the University of Québec at Chicoutimi (research only).
- **Institutes:** Concordia Institute of Aerospace Design and Innovation (CIADI), Institut d'Innovation et de Conception en Aérospatiale de Polytechnique (IICAP), Institut de Conception et d'Innovation en aérospatiale (ICIA) and École de Technologie Supérieure.
- **Specialized organizations:** Consortium for Research and Innovation in Aerospace in Québec (CRIAQ), Comité sectoriel de main-d'œuvre en aérospatiale au Québec (CAMAQ).

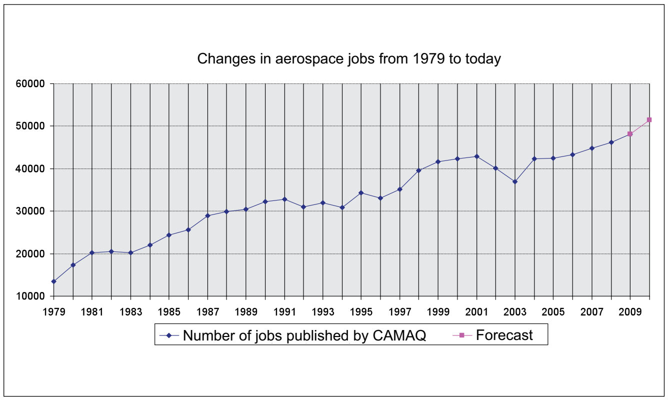
3.1 The demand for a specialized workforce

Serge Tremblay from CAMAQ - Comité sectoriel de main-d'œuvre en aérospatiale – noted that the data for specialist jobs in engineering cited in the presentation are drawn from the CAMAQ 2008-2010 census conducted in fall 2008 among the 210 aerospace companies recognized by the Québec Ministry of Economic Development, Innovation and Export Trade.

Aerospace is one of the most globalized activities on the planet. Since the Second World War, the rate of growth of commercial aviation, measured in terms of numbers of travelers taking an airplane every day in the world, has increased steadily. This increase is expected to continue, at least over the coming decades. Thanks to this constant growth in world aviation, Québec's aerospace sector has seen its business increase by an average of 9.5% annually since 1984.

The number of jobs in the sector has set pace with this historic growth rate, as illustrated by the graphic below. In 2008, Québec had 46,168 jobs in aerospace. At the end of 2009, this should surpass 50,000.

Figure 1 : Changes in Québec aerospace jobs since 1979



In 2008, the total number of scientists employed in the industry in Québec was 10,335 or 22% of all aerospace jobs. Of this number, 8,247 work in large companies and 2,088 in small and medium size companies.

For some selected years, the following chart shows the number of students enrolled in engineering school faculties in Québec.

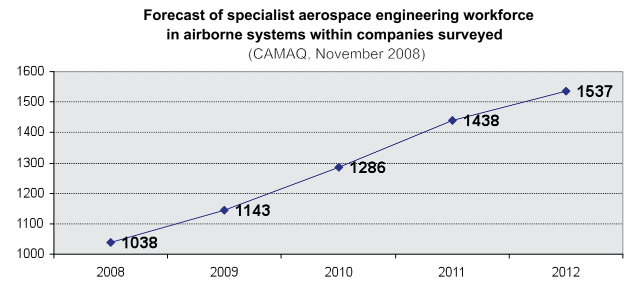
Chart 1: Change in enrolment in engineering faculties and schools in Québec

Year	Engineering (all disciplines)		Electrical Engineering		Mechanical Engineering	
	Total Number	Annual Change	Number	Annual Change	Number	Annual Change
1984	N/A	NA	3 114	NA	2 820	NA
1994	13 387	NA	3 361	0,8%	3 416	2,1%
2004	19 266	4,4%	4 591	3,7%	5 291	5,5%
2007	18 395	-1,5%	2 856	-12,6%	5 038	-1,6%

From 2004 to 2007, this data indicates a decline of 1.5% in the total number of student enrolments in Engineering, all disciplines together, with a drop of 1.6% in mechanical engineering and a significant decline of 12.6% in electrical engineering.

The number of mechanical engineering graduates should be sufficient to respond to the quantitative recruitment needs of the industry. But while sciences and information technologies occupy a growing place in aerospace – avionics and simulation – there's a risk of a shortage of Québec university graduates in these fields. A recent CAMAQ survey of airborne aerospace engineering systems (see following graphic) shows that the 1,038 specialists in 2008 will decline to 1,537 in five years. This forecast demonstrates a major challenge that requires special attention.

Figure 2 : Workforce forecast for aerospace engineering specialists in airborne systems



***Companies surveyed**: Canadian Space Agency, Air Data, Bell Helicopter, Bombardier Aerospace, CAE, CS Canada, Dassault Systèmes, Esterline CMC Electronics, Héroux-Devtek, L-3 Communications MAS, Mannarino Software and Systems, Marinvent, MDA Espace, Pratt & Whitney Canada and Thales Avionics Canada.

This latest data on airborne systems manpower indicates that more high level IT specialists will need to be recruited from abroad in the coming years. The number of engineers and specialists recruited from abroad has already been growing since 2003. This growth suggests a trend towards a greater cultural diversification among expert engineers and specialists in the industry.

Another demographic characteristic: the average mean age of aerospace science personnel tends to be slightly below that of the industry's employee population in general. However, in SMEs, this category of personnel is younger. It is on average around 32 years while the average age of all other employees in the same SMEs is 38 years.

In conclusion, we can simply say that, despite turmoil in the global industry and some clouds on the horizon for Québec's aerospace industry, our industry is doing relatively well in terms of manpower.

3.2 The demand for a specialized workforce

Under the heading *In aerospace engineering, invest in our future*, an overview of the needs of aircraft manufacturers was made jointly by Mr. **Guy Lambert**, Vice President, Commercial Helicopters Engineering, Bell Helicopter Textron Canada, and Mr. **Fassi Kafyeke**, Director, Strategic Technology and Senior Engineering Advisor, Bombardier Aerospace.

Bell Helicopter Textron Canada

Mr. Lambert first noted that there is a wide variety of professional careers available in aerospace engineering, both at Bell and Bombardier. And they are available in many engineering disciplines: advanced design, aerodynamics, dynamics, systems engineering, structural design, propulsion, new materials, experimental engineering, project management, supply chain, etc.

In 2008, of Bell's 2,213 total employees, 381 were in the engineering function. They include the majority of university specialists, although others are also found in many other units of the company. Among these, research and development plays a critical role; its quality assures the company's ability to continue to compete.

Among the competencies and skills required

- Design, including a host of skills in design, analysis, manufacturing and customer support, as well as certification of new aircraft.
  - Includes use of CADCAM (CATIA) and structural analysis software (NASTRAN, PATRAN, ANSYS), and other software specialized in the analysis of helicopters.
- Design
  - Structural and mechanical, hydraulic, electrical and avionics.
- Analysis
  - Static, dynamic and fatigue structures, aerodynamics, materials.
- Flight tests
  - Instrumentation, development and certification, real-time data acquisition.
- Laboratory
  - Full support for in-house and global manufacturing.
  - Development of components using leading edge materials.
- Technology research
- Manufacturing engineering.

Among students to be hired, key research skills being sought are primarily in design and analysis.

Hired students face many major industrial challenges. They have to contribute to reducing the cost of acquiring and operating new aircraft despite a constant increase in navigation and environmental standards. They have to help increase the company's customers competitiveness and maintain helicopters market share amongst all transportation solutions. By using advanced technologies, engineers must also enhance the performance, functionality and reliability of new aircraft as well as make them greener, without compromising safety. While doing this, they need to focus on optimizing and continuously transforming manufacturing processes through automation, robotics and "green" processes.

Bombardier Aerospace

Under the heading The engineer of tomorrow in aerospace, Mr. Kafyeke began his presentation by providing the following context:

- In aerospace manufacturing, the business is changing quickly. The emphasis will now be on systems integration and structures.
- The work environments of engineers are increasingly diversifying. They are multidisciplinary, multi-site and multicultural.
- In addition to a solid base of technical skills, the engineer must also hold professional qualifications. The critical skills that will set him apart are among others: leadership, team spirit, accountability towards customers and shareholders.

According to Mr. Kafyeke, the industry today needs an "agile engineer." He is a "business engineer" able to focus on costs ("Value Engineering"), to practice process innovation within a lean company, capable of thinking tridimensionally, able to understand and manage risks, knowledgeable about engineering systems to integrate-integrate-integrate and have global competencies.

In 2009, Bombardier Aerospace's hiring plans will require 500 engineers and future engineers, including 70 post-graduates (masters and doctorates), and about 200 interns.

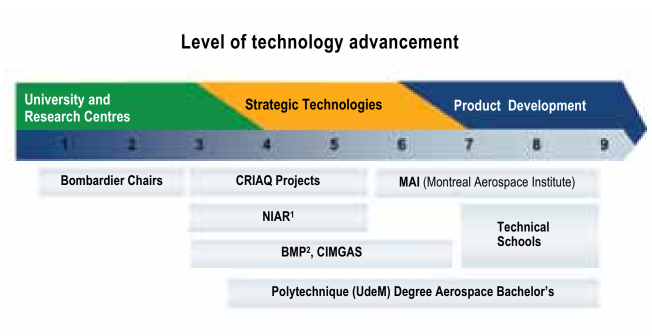
They will face the following challenges: new composite materials; the integration of complex systems; virtual simulation and environmental design. In the same vein, there are new and increasing needs in industrial engineering, supply chain and industrial processes. Also, there is a need to implement international partnerships in countries with diversified cultures.

In addition, with demographic curves showing an aging workforce, efforts are needed in continuing education to improve employees' qualifications. Moreover, efficient knowledge management is critical to maintaining the company's excellence.

Collaboration with universities is a response to the emerging shortage of talent. This shortage jeopardizes the deployment of new products. University training programs can help respond to the growing need for qualified personnel. They can mitigate this anticipated shortage in several ways: by encouraging students to choose a career in aerospace; by developing students' technical skills in line with the needs of aerospace; by encouraging future engineers to collaborate closely with the industry to give the company the opportunity to hire employees with sufficient work qualifications, on specific projects.

The following graphic explains Bombardier's reason for partnering with the education community, universities and research centres. In a way, these initiatives extend the company's innovation resources beyond its walls.

Figure 3 : Innovation resources



Without including investments in university chairs, contributions of various kinds to institutions and research-training organizations, and aid for student activities, Bombardier Aerospace's contributions in supporting public educational programs are numerous, diversified and at all levels of expertise and study.

- For example, the company provides scholarships for doctoral and masters students in the field through CIMGAS *(Comité Industrie/universités sur la Maîtrise en Génie Aéronautique et Spatial)*. Similar initiatives target bachelor's students enrolled at École Polytechnique and Carleton University, college level technical training at École nationale d'aérotechnique (ÉNA) and, finally, at the high school level at École des métiers de l'aérospatiale de Montréal (ÉMAM).
- In addition, Bombardier Aerospace makes a direct contribution to aerospace engineering training; 18 company engineers are currently giving courses.
- Also, Bombardier Aerospace supports the implementation of a bachelor's degree in aerospace engineering in the fields of structures, systems and virtual environment, while covering the basic engineering disciplines focused on aircraft – conceptual design, aerodynamics, performance, stability and controls. Thanks to its participation, this initiative will begin in 2009. Another diploma, integrating 5 years of bachelor's and master's studies, covers the leading edge fields of composite structures or fluid dynamics systems.
- Finally, Bombardier Aerospace has committed its support for the joint CIMGAS master's program.

Directed at the industry, the following suggestions were made for improving educational programs:

- Encourage more direct company involvement in the educational process. For example, training courses on real projects instead of simulated ones, or even through summer internships based on real industrial technology requirements (R&D) rather than simulations – the CIADI model.
- Allow for carrying out projects in environments that are as "true to life" as possible – example, the Virtual environment project approach.
- Take actions always keeping in mind the future requirements of an industry in evolution.
- In conclusion, Bombardier Aerospace's relations with the university are essential to meet its needs for qualified personnel and technical know-how development. Bombardier's Strategic Technologies Group helps to manage complex relations with universities to ensure that good partnerships emerge.

3.3 The needs of engine manufacturers

Under the heading *Future Skills Needs for Gas Turbine Engineers*, the presentation by Mr. **Walter Di Bartolomeo**, Vice President, Engineering, Pratt & Whitney Canada, highlighted the manpower needs and challenges facing the gas engine industry.

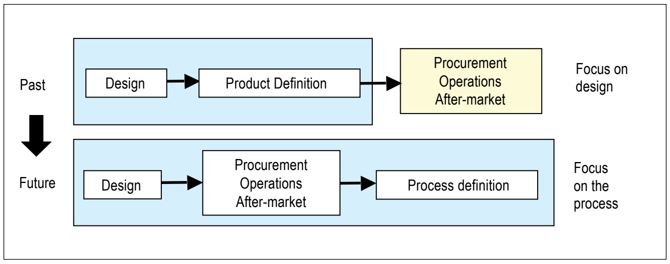
To define the future skills requirements of new engineers, one has to look at the current and future evolution of aircraft engines. In broad lines, this evolution has the following features:

- The range of products is increasingly diversifying; for gas turbines, the number of engine families has increased from 2 to 11.
- The price structure is becoming fixed, for a fixed price per product, instead of a base price plus a varying cost according to requirements.
- Global facilities, spread over all continents, serve a global customer base. The market forecasts show growth of more than 60% in Asia, more than 20%

in North and South America and more than 10% in Europe and Australia.

- Isolated companies are being replaced by partnerships with traditional suppliers as well as traditional competitors.
- The computer is revolutionizing the management of schedules and data. Design is increasingly computerized. More powerful computers are being used, from design by CAO to supporting tests, using advanced analytical tools. So much so that the time required to design a new engine has dropped from 5 to 3 years.
- The following graphic illustrates the remarkable transformation underway in the engineer's work process. In the past, engineering tasks were focused on product design. In the future, process definition will be the main focus of the engineer.

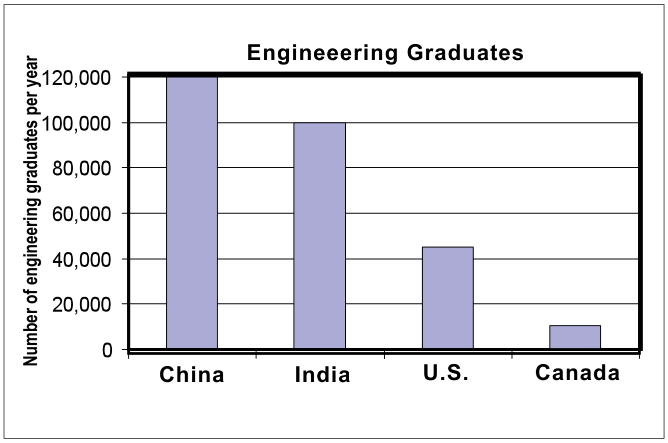
Figure 4 : Transformation of the engineer's work process



- Environmental protection is leading to the green engine: composed of as many green materials as possible; manufacture and services based on green processes; involvement of green partners and suppliers; the lowest possible noise; the lowest possible emissions; design with human factors in mind; efficient metals; designed for reliable service; reuse and recycling.

In the coming years, a host of demographic factors will affect the aerospace workforce. The overall trend of an aging population will affect the industry. By 2016, 50% of North American aerospace engineers will be eligible for retirement. In terms of engineers' training, the challenge involves not only their replacement but also knowledge retention – knowledge management and best practices. In engineering at Pratt & Whitney, 34% of engineers have less than 10 years experience while their average age is 44 years.

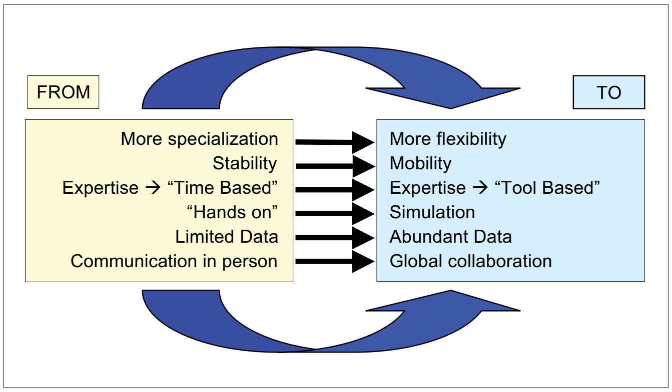
Figure 5 : Number of engineering graduates per year



Regarding the succession of new engineers, this graphic compares the number of annual engineering graduates for four countries : China, India, United States and Canada. The number of engineering graduates is increasing in China and declining in Europe and Russia. They are stable in Canada, but the total number is low. Globally in North America, the industry will need 20,000 new aerospace engineers while universities are producing 16,000.

The challenge of recruiting the best talents in engineering is influenced by the choice of this type of career by students. Canadian engineering graduates prefer generalist positions, and are less inclined to specialize, while the industry needs both multidisciplinary and specialized engineers. In addition, they have high professional expectations. In the 2000s, the industry is promoting process-innovation-integration while the engineering field requires global integration for engineers (global integrator). The graphic below summarizes certain aspects of this professional evolution

Figure 6 : Evolution of the engineering profession



The key drivers that will need to coexist are as follows:

- Integration by mastering the systems engineering discipline.
- Change of cost paradigm through Value Engineering.
- Innovation in technology and processes, and also its social aspect.
- Risk definition and management.
- The ability to think globally in a high mobility context, to understand different cultures and languages, and to leverage partnerships.

The following recommendations for engineer training in the engine field were proposed:

- The battle for talent by recruiting from other companies is no longer sustainable. For each company, obtaining an adequate share of talents requires establishing strategic industry alliances in terms of, among others: retention and recruitment; increasing the proportion of women engineers; more efforts in continuous training; maintaining the “grey talent” for a while longer; capturing “tribal knowledge” and using global talent at a distance.
- The university must deliver solid technical training that lies at the heart of engineering practices. On the one hand, the new engineer must master *Design systems* (Ansys, CATIA) and *Generic techniques* (fatigue, damage tolerance, basic controls, experimental design, quality measurement and risk analysis). On the other hand, he must also learn *Activities management* (time, contract, process, project), Communication (technical presentations, reports, good business writing) and *Legal* (intellectual property, export regulations and certification).

In conclusion,

- Changes in the industry and workforce challenges require better planning for all aspects of the gas turbine engineering profession.
- The demographic reality is here to stay.
- Knowledge management and best practices are essential.
- Global skills are indispensable.
- The industry is increasingly taking the lead in training and teaching partnerships.

3.4 The needs in avionics and simulation systems

The presentation of Mr. **Patrick Champagne**, Vice President, Engineering, Esterline CMC Electronics, covered the avionics, simulation and airborne systems sector.

Briefly speaking, this industrial sector is composed of architects and airborne systems, avionics manufacturers, simulator manufacturers, aircraft control equipment manufacturers, airborne software system suppliers for aviation and mechanical subsystem equipment suppliers. The following companies are the main players: Esterline CMC Electronics, the aeronautical division of Thales Canada, CAE, L-3 Communications MAS, Adacel and Manmarino Software and Systems..

Two challenges were highlighted.

- The sector is dominated by medium and small sized companies that do not have the capacity to rapidly acquire the skills the sector needs.
- There is little university training at the undergraduate level fully adapted to these companies’ needs.
    - The aerospace institutes are responding in part to this need by offering more apprenticeships than structured training;
    - Related aerospace master’s programs serve too few students.

The sector’s business environment is evolving as follows: aircraft manufacturers are reducing the number of suppliers; these are climbing up the industry value chain because they need to deliver complete and increasingly integrated systems; critical and coupled – for example, Integrated Modular Avionics (IMA) of the Boeing 787 and A380; the same suppliers must contribute to the objectives of the aircraft maker in terms of weight and volume, in reducing environmental impacts and in increasing the economic value for the end customer; aircraft manufacturers are demanding innovative and mature solutions that limit their risks and customers are expecting shorter development cycles at reduced development costs.

The volume of software content is increasing in all the solutions being developed. This results in a shortage of specialized resources in Montréal since they are being solicited by other industries (telecoms, video games, online multimedia) that appear to be more dynamic. Already, certain large airborne systems are already primarily software driven - FMS, CDS. OEMs are demanding that large software systems result in an increased level of avionics integration. The challenge lies in bringing together a high level of performance with integrity of execution of these software elements. This software features increasingly critical functions. Rigor and validation, in software development and complex electronic platforms are increasing from the start. As a result, the tools and processes for increasing productivity are becoming more complex (for example, coding automation and verification).

The sector's business is also impacted by other global business factors. With regards to competitiveness, large pools of outsourced resources with low hourly wages are available in Asia (India and China). Unstable exchange rates also affect contractual risks. Finally, there is a growing convergence between military and civil certification requirements.

KEY COMPETENCIES

a) Systems engineering

- ARP4754, airborne systems certification
- ARP4761, airborne systems safety analysis process
- Ergonomics and human-machine interface
- TC/FAA/EASA - DE / DER / DAR certification
- Tools and processes
- Reliability, maintainability, safety (RM&S)
- Helicopters and fixed wing test pilots
- Aerodynamics and modeling
- Aircraft systems/avionics systems:
  - ARINC and RTCA standards
  - 1553 - Military standards, night vision as an example
  - TSO, ETSO
  - Compact PCI, AFDX, CAN Bus, etc.

b) Software

- Software development standards (DO-178B/C)
- Architecture, languages:
  - OS real time
  - C language, C++ et ADA
  - Model-based Development
  - Airborne systems architecture
  - Real time software for management systems and air traffic simulation
  - Voice recognition

c) Electronic material

- DO-160E/F - environmental qualification avionics norms
- DO-254 - complex electronic material development norms

d) Simulation

- Objects-structured software that runs in parallel on a multi-computer network and on multi-core microprocessor.
- Graphics software to achieve 3D visualization and graphic animation

e) Others

- Mechanical subsystems – landing gear, flight controls
- Mechanical design and industrialization

3.5 University programs

The next presentation was made by Mr. **Clément Fortin**, Professor and Director of Mechanical Engineering at École Polytechnique de Montréal. He first described the undergraduate and master's aerospace engineering programs offered by Québec universities. Then, after making certain observations, he gave an overview of equivalent foreign programs he gave an overview of equivalent foreign programs. Finally, the engineers' training for the 21st century was put into perspective by a description of the CDIO initiative.

Undergraduate programs

Six Québec universities offer a large number of undergraduate training programs.

- As part of its mechanical engineering program, Sherbrooke University offers a 24-credit major in aerospace, half in mandatory courses and the other half in projects divided into 3 courses.
- McGill University's "B.Eng in Mechanical engineering" offers an aeronautical major composed of 5 courses, 2 mandatory and 3 optional courses out of 7 choices.

- In its mechanical engineering program, Laval University offers a major in aeronautics and aerospace composed of 4 courses, with 12 mandatory credits.
- École de Technologie Supérieure (ETS) offers two programs in aerospace engineering. The first is a mechanical engineering program, Aeronautical design (15 elective credits), and a second program in automated production in aeronautical manufacturing (18 elective credits).
- École Polytechnique de Montréal offers several programs related to aerospace. The mechanical engineering program include a 30-credit major in aeronautical engineering – including 9 credits for projects, 4 options of 2 courses and 1 project of 6 credits (stress, virtual environment, fluids, systems) – and an 18-credit Orientation in space techniques – including a 6-credit project. The electrical engineering program also offers a 30-credit major in Avionics – 6 courses and projects, including virtual environment.

  Finally, in September 2009 a new 120-credit aerospace engineering program will be composed of 4 projects of 15 credits and 4 orientations of 12 credits plus a project of 6 credits (stress, virtual environment, space technologies, and airborne systems). Based around CDIO, it is offered in collaboration with Bombardier Aerospace and ÉNA.
- Concordia University offers a "B. Eng in Mechanical engineering" with options (15.5 credits): in "Thermo-fluid" and propulsion (choice of 12 courses); in aerospace and vehicle systems (choice of 19 courses); and soon an aerospace option in 5 other engineering programs.

Master's in aerospace engineering

Training at the master's level has been around since the 1990s in collaboration with CAMAQ. Six universities contribute: Concordia, École Polytechnique, ETS, Laval, McGill and Sherbrooke. In addition, it is supported by at least 12 companies, among others: Bombardier Aerospace, Bell Helicopter Textron Canada, CAE, CMC, Pratt & Whitney Canada and Thales. A number of courses are designed and given by industry experts and feature case studies and internships.

- Concordia University's master's features a number of general courses of 12 credits, including a choice of 12 courses. It is comprised of specialized courses accounting for 24 credits: aeronautics and propulsion, choice of 14 courses; avionics and controls, choice of 19 courses; structures and materials, choice of 13 courses; and space engineering, 2 courses. In aerospace, case studies (1 course of 3 credits) and company internships (6 credits) are used and external courses in universities account for 6 credits (2 courses).
- École Polytechnique's department of mechanical engineering offers a basic course of 9/12 credits (choice of 8 courses), a specialized course of 15/24 credits (4 specialties): aeronautics and propulsion, 8 courses; avionics and controls, 16 courses; structures and materials, 10 courses; and space technology, 14 courses. Training in virtual environment accounts for 3 courses, plus a project. Case study courses (2) earn 3/6 credits; internship(s) or projects (3) totalling 6/12 credits. Courses taken outside École Polytechnique de Montréal account for 6 credits (2 courses).
- At ETS, master's level training offers two mandatory basic activities for everyone (6 credits): introduction to aeronautics, 3 credits; introduction to avionics, 3 credits; case study, 3 credits; and company internship, 6 credits. Also, there are two profiles: Fabrication and aeronautic production (15-18 credits) with a specialization in virtual environment and Systems and avionics (15-18 credits). There are two mandatory activities per profile worth 6 credits. Courses taken outside ETS earn 6 credits, 2 courses. Beginning in September 2009, the Aeronautic fabrication and production profile will become Aeronautic design and fabrication.
- Laval University's master's features a choice of 15 courses, worth 12 or 13 basic credits, with several fields of specialization: aeronautics and propulsion, 8 courses; avionics, 10 courses; structures and materials, 8 courses; and space technology, 13 courses. Two majors – Aerospace Engineering and Virtual Environment – are also available with internships and case studies. Courses taken outside the university earn 6 credits, 2 courses.
- McGill University's master's features 12 credits of common core courses, 3 case study credits, a company internship of 6 credits, advanced courses for 6 credits taken in another university, and advanced courses at McGill University for the remaining credits.
- Sherbrooke University's master's offers two majors: the route consisting of company internships or the virtual environment route. The company internships route includes 9 credits of mandatory pedagogical

activities (an internship of 6 credits and a case study of 3 credits); 36 credits of pedagogical activities as an option (a base course of 3 credits), optional courses – choice of 6 courses of 12 to 18 credits and specialized courses with an orientation in structures and materials – a choice of 14 courses in structures and materials, and a choice of 10 courses in aeronautics and propulsion. Finally, the student must take two courses (6 credits) outside Sherbrooke University. The virtual environment route offers 12 credits of mandatory courses in a virtual environment at École Polytechnique de Montréal and 33 optional credits in pedagogical activities.

- The Virtual environment option is offered by companies – Bombardier Aerospace, Bell Helicopter Textron Canada and Pratt & Whitney Canada - by CAMAQ and has been available in six universities since 1999. This option won the Conference Board of Canada prize in 2001 for industry-university collaboration. The PLM environment is used to represent the industrial milieu in an academic environment: configuration management, numeric modelling and securized industrial data. Two courses are offered: Project management in aeronautical engineering (engineering systems, certification, risks, quality assurance in product development, advanced development, FMEA), and Product development in a virtual environment (design process, numeric modelling, configuration management, concurrent engineering, PLM, PDM, MPM).

Training abroad

A review of training programs allows for a few key observations.

- The total duration of studies abroad is 12 years (plus 4 years, plus 30 credits Master's degree – LMD type) and 13 years in Québec (plus 4 years, plus 45 master's credits). Since the Bologne Accords of 1999, the LMD formula has spread throughout European universities and is already influencing the rest of the world. The average total duration of studies leading to a university degree tends to take a year less than here. There is growing pressure on the Québec educational system given fierce global competition to attract and retain the best students and graduates.
- Overall, here are some brief comments: the training environment is oriented towards research. Everywhere, the biggest difficulty is resistance to change. There is more space oriented training in the United States than in Europe. There is little training in systems integration and global design.

The CDIO reference point (Conceive-Design-Implement-Operate)

An international meeting of participants in the CDIO initiative was held during the first week of November 2008. The workshop focused on aerospace needs in the United States. Boeing, Lockheed-Martin, Northrop-Grumman, GE Aircraft Engines and Orbital Dynamics attended. CDIO has become a university and industrial collaboration network that is constantly growing.

Why CDIO?

For most of the 20th century, engineering training programs were based primarily on practical lessons learned on the job. Courses given by practicing engineers were centred on real problem resolution. However, scientific and technical knowledge has increased tremendously, especially during the final years of the 20th century. Engineering training has emphasized engineering science to the detriment of the sharing of practices.

In recent years, the industrial community realized that graduates, while technically well trained, lacked concrete qualifications in terms of true to life technological situations. Several major companies, including Boeing, developed lists of qualifications being sought and acquired by engineers it wanted to hire. To encourage American engineering schools to better respond to the real needs of companies and rethink their teaching methods, ABET[2] stated its training criteria for graduating engineers. Faced with a gap between the practice and science of engineering, MIT's CDIO Initiative aims to meet the challenge of contributing in a real way to the reform of engineering training.

The goal of CDIO is to educate students in terms of:

- Mastering a practical, in-depth knowledge of fundamental technical principles;
- Taking leadership in creating and operating new products, processes and systems;
- Understanding the strategic importance and impact of technology research and development on society.

[2] *The Accreditation Board of Engineering and Technology (ABET) in the U.S., is an organization in charge of accreditation of university programs in applied sciences, in technology, etc.*

The overall conclusion of the workshop is the need for university training in aerospace that provides more room for **system design** and **business context**, as well as the acquisition of **leadership** skills and thinking **multi-dimensionally**. Engineering training programs need to be adjusted so that, among other things, graduates can better **understand the engineering of systems with complex added value, adapt to a team-based industrial environment composed of experienced individuals, and in-depth thinking.**

An evaluation of the CDIO initiative by a Bombardier participant

- The most important asset of an engineering-based organization is its skilled employees.
- The industry is changing to adapt to a new environment; the university must also adapt to the changing needs; an initiative like CDIO is very encouraging.
- Universities must train leaders, integrators and innovators; not only people who know more, but people who know how to do more with what they know.

The presentation concluded with the observation that engineers' training is at a crossroads. It's important to review training at the doctorate level in terms of the needs of the industry rather than those of the university.

3.6 The Montréal Aerospace Institute

Under the heading, A Model of University-Industry Collaboration for Students Training, Mr. **Hany Moustapha**, Senior Manager, Technology Programs, Pratt & Whitney Canada, presented the activities of the Montréal Aerospace Institute (MAI).

The institute brings together undergraduate students from CIADI (Concordia), ICIA (ETS) and IICAP (École Polytechnique de Montréal). From Québec, Canada and abroad, dozens of partners from the industry (companies, universities, schools, research centres, public organizations and industrial organizations) contribute in different ways to the MAI.

MAI's Mission

- Training of undergraduate students
- Training initiatives through real projects (PBL)
- Real industrial training programs
- Prepare students to integrate into the industry
- Raise aerospace awareness
- Networking
- Mentoring

The MAI is an initiative driven since 2002 by the aerospace industry. It is a partnership between industry and the university world, oriented towards student training, on the one hand, to train a specialized and performing workforce, and on the other hand, to ensure a company presence on campuses.

The Project Based Learning approach is encouraged. This is a teaching initiative in which apprenticeships involve carrying out a real project.

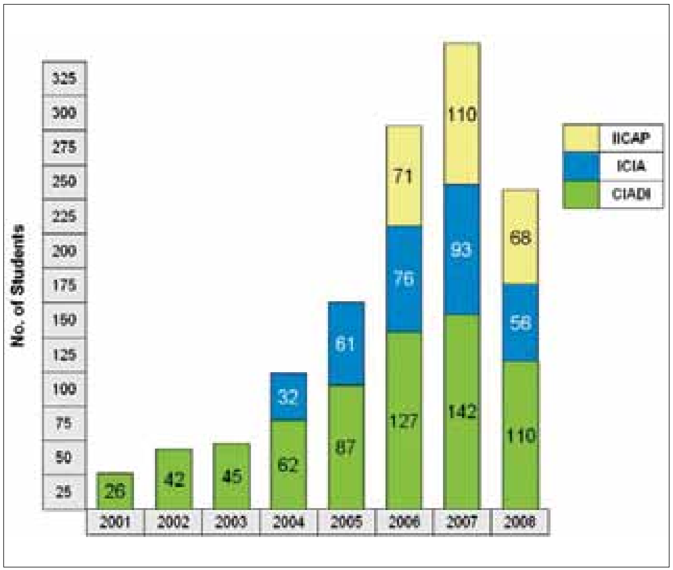
- Students devote 500 to 1,000 hours to a study project.
- The execution and supervision of the project is done both in companies and the university, jointly and/or alternatively.
- There is great flexibility in working conditions: place, schedule, part-time, etc.
- All the student projects are visible to the entire aerospace industry.
- Mentoring is done by step meetings, monitoring and evaluation.
- An evaluation database and CVs of the best students are available to the entire industry.
- A network matching students and aerospace companies is put in place.
- The company also has a need to use CATIA, MATLAB, etc.
- International projects are possible through "CIADI GLOBAL."
- Organized company visits are held.
- Access is assured to a library, postings, material, conferences, workshops, forums, etc.

- A database of graduating students' CVs is accessible to the entire industry.
- Students can win entrance scholarships (CIADI).

For students, MAI ensures income and a chance to include real projects on their CVs, as well as to have the opportunity to apply for a job in aerospace. For graduate students, this allows them to better know the industry ("readiness"). For their part, companies are able to execute a project at an efficient cost, to train onsite prior to hiring, and have access to a recruitment pool.

In 2008, 234 students from Québec (see graphic below), by their involvement in projects, had the oppurtunity to enhance their higher training in aerospace and facilitate hiring by companies thanks to the Institute.

Figure 7 : Evolution of students in Montréal's three aerospace institutes.



In the future, MAI aims to integrate its activities with graduate students and business schools. It also intends to cooperate with a company incubator.

3.7 CRIAQ's role in training student researchers

The presentation of Mr. **André Bazergui,** President and CEO of CRIAQ (Consortium for Research and Innovation in Aerospace in Québec), highlighted the activities of the organization since its creation in 2002.

Currently, CRIAQ has 52 members from companies (32), universities and research centres (13), as well as associations (7). The Consortium manages pre-competitive research in aerospace where a minimum of 25% of the cost of projects led by universities is assumed by company partners while the rest is financed from universities' own funds. This partnership, which is enjoying growing membership from the aerospace industry, assures the success of the collaborative formula based on research-innovation-training. All the projects have a link and/or practical component with industrial reality. All the partners, students, universities, research centres and companies play a role.

CRIAQ's Mission

- Enhance the aerospace industry's competitiveness and improve the knowledge pool through enhanced student training

Objectives

- Collaborative research via partnerships
- Innovation
- Training
- Promotion
- National and international collaborations

Since its beginnings, CRIAQ has contributed to establishing more than 45 research projects of which 12 have now been successfully completed and 6 involve international collaborations. In addition, 40 new projects are under preparation.

Through their collaborative nature, CRIAQ projects necessarily regroup university researchers and research centres that work closely with industry specialists. Together, they supervise many students per project, not only at the doctoral and master's level but also at the undergraduate level thanks to CRIAQ's Initiation to Research Program. So we find students in all the projects as shown in the chart next page.

Chart 2: Number of participating students in CRIAQ projects

Students	*06-07*	**07-08**
Post-doc	*8*	**14**
Ph.D.	*25*	**54**
M.Sc.A.	*41*	**87**
B.Sc.A interns	*6*	**62**

As the accompanying chart shows, in one year the number of participating students in projects jumped from a total of 80 in 2006-2007 to 217 in 2007-2008 and 71% held at least a master's degree.

In addition, CRIAQ provides strong support to a number of aerospace student activities. With financial support from FQRNT, it is the main partner of the Aerospace Student Forums. As part of preparing the next generation, it offers an internships program for undergraduate students in research teams (PIRA) and collaborates in CAMAQ's training initiatives. It sponsors teams that participate in aerospace competitions. It offers scholarships for practical training.

Finally, CRIAQ is involved in international student exchange programs. It aims to help attract the best students in the aerospace world to Québec. Moreover, it supports the possibility of our researchers, industrial partners and students to participate in international opportunities for leading edge activities.

In the afternoon, Summit participants were invited to attend workshops, held in two sessions of two workshops each that were held simultaneously. The first session, ***Workshops on undergraduate education***, featured a workshop on undergraduate training as it relates to *Aircraft and engine manufacturers* and a second on *Avionics and simulation systems*. In the second session, ***Workshops on continuous education***, the first dealt with *Education in the industry* and the second, *Post-graduate education.*

Undergraduate training workshops

4.1 Aircraft and engine manufacturers

The workshop on the theme *Undergraduate education* as it relates to *Aircraft and engine manufacturers* had Mr. **Robert Clive Fews**, Manager, Technology, Bell Helicopter Textron Canada, and Mr. **Marius Paraschivoiu**, Associate Professor, Department of Mechanical and Industrial Engineering, Concordia University as moderators.

Regarding the qualifications needed by the next generation of engineers, the first discussions attempted to answer the following question: does the industry need specialists or generalists?

The workshop quickly reached a consensus on the need for the industry to have two types of engineers who are complementary. Over time, it is possible for an engineer, with experience and continuous training, to develop these two professional skills. To do so, it is important to teach future engineers to adapt by "learning to learn." It remains open how an individual can acquire the two skills.

The participants also discussed the need for teaching to better adapt to industrial reality through the sharing of various practical skills ("professionals"). One of these is to learn teamwork right from the beginning universities. Among the suggestions made, the workshop selected the utilization of the internships approach for all the training programs. Another suggested giving teachers hands-on experience through company internships during their sabbaticals or their summer vacations. Some schools and faculties already encourage industrial experience among their teachers.

In terms of professional qualifications, creativity, a passion for working on aircraft and leadership were mentioned. Another interesting comment was that, while there seem to be few problems regarding conception or design, the same can't be said for manufacturing where weaknesses exist.

Thirdly, the workshop reviewed the impact of an aging population on the aerospace engineering community. However, questions were raised as to the accuracy and detail of available statistics measuring and characterizing forecasted industry manpower supply and demand. In this regard, in addition to the demographic challenges, there is also a lack of accurate data for airborne aerospace systems (e.g. avionics) and university enrolments and graduates per specialty that work in the industry. There is a need for more efforts in this area.

The workshop agreed that in the short term, universities will be able to respond to the demand for new engineers. However, there is a shortage of experienced engineers in the industry. This is particularly worrisome for the medium and long term. Demographics have several implications in terms of manpower: retirees, low birth rate, decline in women enrolment in school streams leading to engineering, and a higher school dropout rate among boys than girls, who commit less to science and technical careers, many engineers from here leave to work abroad (Europe, United States, South America), etc. On this last point, participants suggested that aerospace be promoted starting early in high school to give young people a taste for working in the airplane industry.

4.2 Avionics and simulation systems

Ms. **Ruxandra Botez**, professor in the automated production engineering department of École de Technologie Supérieure, and Mr. **Philippe Molaret**, Technical Manager and Vice President, Engineering at Thales Canada, were moderators of the *Avionics and simulation systems* workshop.

At the start of the session, a series of questions were posted on a screen. The first related to avionics while the other concerned aerospace engineering training in general.

Avionics systems

First, there's a great need for airborne systems training, a strategic area where there is strong international competition. However, there is a large gap between the needs required by the avionics and simulation industry and the number of potential graduates.

- Regarding the avionics manpower market, there is a dual need for more detailed data on the supply of graduates and their required qualifications, as well as on the accuracy of measuring industrial demand.
- More specialized majors are needed: for example in computer engineering with an avionics option. But while there is perhaps a need to create more aerospace specialties through new specialized majors, there is also a strong risk of losing students to more generic streams.
- Systems engineering is a long-term competency. Systems engineering training should focus more on the why, not only the how. The vision system is “a large vision system”.
- Even for specialists hired with an electrical engineering degree, some 7-10 years in a company are needed to train an engineer to the right level of expertise in airborne avionics systems. Through adapted university programs, we need to be able to cut in half this apprenticeship time within a company.
- The simulation discipline needs to be better structured to be better taught.
  - To work eventually with simulators, students must understand all the avionics systems, not only their software component.
  - For existing programs, there is a large focus on creating through simulation yet little focus is put on using the discipline.
  - At ETS simulation is done in MATLAB.
- For recruitment in the simulation field, aerospace is competing directly with the video game sector which is hiring many of these kinds of graduates.
- The fad of gaining knowledge by using tools like CATIA could rather quickly outdate specialists who use such tools exclusively.
- More courses should be given by professionals and scientists from the industry.
- There is a need for more teaching about stringent aviation standards and regulations.
- Companies should donate recent equipment to university labs.

Aerospace engineering training in general

- It would be useful to better identify aerospace engineering training needs by updating a must-have competencies repository: what people to be trained need to be able to do, under what conditions, with what tools, etc.
  - There is a lack of data as to the number of annual undergraduates.
  - Our industry must better understand major trends and regulations.
- Affirm clearly that the university is a business whose product is a student and the customer is the company.
- Emulate the International Institute of Telecommunications (IIT) in ICT, a common industrial training ground that is well equipped for students and employees to perform internships.
- University training must mirror industrial realities.
  - Encourage work internships in companies for teachers during their sabbaticals.
  - Cooperative internships in the industry are an important training mechanism.
- Regarding the mechanism of industrial chairs, it is difficult, if not impossible, for an SME to finance this type of research and get closer to universities. The industry needs to think about this.

Attracting young people to aerospace

By the time young people enter CEGEP, it is too late to convince them to commit to a career in aerospace. ADRIQ demonstrated that action needs to be taken early in high school. The choice of advanced mathematics courses is made in the third year of high school. The field needs to be explained to young people starting in high school to spark interest among them regarding the choice of what they should take in college.

- Student motivation is very important. The industry needs to give equipment to allow for students to be trained on the right materials and software.
- The fact remains that the ENA’s dropout rate is 50%.

Workshops on continuous education

4.3 Training in industry

The workshop moderators on the theme Training in industry were Mr. **Hany Moustapha**, Senior Manager, Technology Programs, Pratt & Whitney Canada, and Mr. **Fassi Kafyeke**, Director, Strategic Technology and Senior Engineering Advisor, Bombardier Aerospace.

During the workshop, Mr. Moustapha presented his company's experience, describing the activities and successes of Pratt University in Longueuil.

During the session, participants made many comments related to the theme being discussed:

- The gaps between company demands and supply of university-trained manpower are relatively well known.
- Current and future in-house training courses are open to universities. Also, companies should share their training courses amongst themselves.
- Governments finance training programs but not advanced courses. There's a need to bring various individual courses together into the training programs.
- It would be desirable to make better use of the case study method practiced by management schools as a way of bringing engineer training closer to real industrial situations.
- We need to train mentors and not leave them to their own devices.
- Courses allowing students to enhance their skills should target existing engineers as well as new hires.
- It would be useful to collaborate more with SMEs in industrial training and precompetitive R&D to boost their level of innovation.
- It is important to organize more student visits (universities, colleges, high schools) on company sites such as the new Bombardier-CSeries industrial centre.

4.4 Post-Graduate

Mr. **Arun Misra**, Professor and Chair of the Mechanical Engineering department at McGill University, and Mr. **Peter Jarvis**, Chief Engineer, Civil Simulation Technologies at CAE, moderated the Post-graduates workshop. The session responded to a number of posted questions.

How can we bring university training closer to the realities of industry?

- At the inter-university master's in aeronautics level, company internships are the best solution for ensuring that university training better corresponds to companies' real industrial conditions.
- For master's, doctoral studies and research, another good formula is to have students carry out projects in the industry. The CRIAQ formula has proven successful.

Does post-graduate training cover all the disciplines required by the aerospace industry? Is there one discipline that should be favoured?

- Avionics and aircraft controls courses require major improvements.
- There's a need to increase the number of courses offered in aeronautics.

How does the existing inter-university master's program in aerospace engineering respond to the needs of the aerospace industry?

- At École Polytechnique de Montréal, it's possible to participate in a company internship or industry project. Among the 44 students participating in the program, 80% choose to intern in companies. There are 15 students at Concordia. However, it is difficult to find appropriate internships.
  - The Québec government agreed to support international internships only very recently.
- Training through research (master's and PhD) responds more to the needs of large companies. Other companies hire post-graduates to resolve complex and real problems. They need to be trained to deal with these.
  - Through their performance, these advanced graduates ensure the employability of undergraduates and college employees.

- Meeting deadlines is among the skills that need to be better developed.

Are we training enough students at the master's and doctoral levels? What are the main constraints for increasing the number of graduate students?

- The amount of financing is proportionate to the number of students admitted: 80% of graduate students come from abroad.
- At École Polytechnique de Montréal, all master's and doctorate programs are carried out with industry collaboration.
- Graduates do not encounter problems in finding a job; they are all finding jobs in the industry or in higher education.
- The workshop posed the following question: should there be the same diversity of disciplines at the doctoral level as the master's?
- A major change is needed. In Europe, which the rest of the world is following, three years of study are needed to obtain a doctorate. If we can't compete with that, there's no point in continuing our efforts.
- There is a lack of training in export control, ITAR regulations and intellectual property.

What is the proper relationship between the depth and scope of graduate programs?

- At this level, companies don't ask for in-depth expertise but rather an ability to enhance solutions. The doctoral student must show that he/she is able to solve real problems and not only to conduct research.
- We asked the following question: how many doctoral students are universities training? École Polytechnique de Montréal trains the largest number, with two thirds working on projects.

How will students be able to move from graduate research to the industry? What role does manpower with a doctorate degree play in the aerospace industry?

- Doctorate graduates all find jobs in the industry. It was noted that the problem is not their employability, but that PhD students have not acquired sufficient qualifications. For example, they have learned how to work alone. In a company, they have to work in teams. In particular, a large number of foreign students have not acquired the necessary qualifications before beginning their doctoral studies.

What role should the industry play in training graduate students in terms of course offerings and collaborative research?

- Pre-competitive research offers the best opportunities for industry and university collaboration.
- There is no reason for three universities to repeat the same aerodynamics course. We need more coordination among ourselves regarding expertise training. The Toulouse region in France is one example: it has one school for training PhDs.

Do Québec universities have enough resources – personnel, equipment and government financing – to allow them to offer quality post-graduate programs that respond to the industry's needs?

- Montréal is an appealing city, just like Sydney, Australia. The problem here is that we don't have enough financing to attract the best students from around the world, for example through the granting of scholarships. We need to support the CRIAQ initiative in this regard. We need more like it. We face strong competition to attract high quality foreign workers. Recent agreements recognizing foreign degrees are very positive and follow the lead of other countries, such as Australia.
- The current level of public financing, so important for universities, is inadequate.
  - Through increased financing, universities could hire more professors. This would reduce the number of students per teacher for an enhanced quality of training and allow for more industrial type projects to be conducted. Comparatively, Québec devotes only 60% of the total financing per university student that Ontario provides.
  - There is also a need to lighten the burden of teachers, who spend 30% of their time preparing bureaucratic applications for subsidies.

5. SUMMIT CONCLUSIONS

A few observations raised by the Summit

Summit participants underscored that the training of tomorrow's aerospace engineer needs to put more emphasis on systems integration; multidisciplinary, multi-site and multicultural work; a high level of technical skills and a range of professional qualifications such as leadership, team spirit and commitment towards customers and shareholders. Tomorrow's agile engineer is a business-oriented engineer with global skills, i.e. an engineer able to focus on costs, to practice continuous process improvement within a "lean" company, capable of thinking in 3D, a risk manager and skilled in systems engineering to integrate the product, manufacturing and customer support at the same time.

The presentations highlighted the fact that aerospace training for our Québec students has many strengths.

Six Québec university institutions offer a large number of training programs at the bachelor's and master's levels that set them apart, namely through the specializations offered and teaching methods (internships, cooperative approach): Concordia, Laval, McGill and Sherbrooke universities; Ecole de Technologie Supérieure and Polytechnique de Montréal. The Montréal Aerospace Institute is a model of collaboration between the university and industry. The Institute is a partnership between companies and the university world focusing on student training while ensuring an industry presence on campuses. In addition, through their collaborative nature, CRIAQ projects bring together hundreds of researchers, specialists and students from seven universities and three Québec research centres, as well as a Canadian and international university network.

Workshop discussions highlighted the need to tailor training programs to industrial realities. They suggested internships for students and encouraging university professors to obtain industrial experience by spending time in a company. To enhance training, companies should structure and share their in-house training courses with each other. A pressing need has emerged in airborne systems and a big gap exists between the industry's needs and the number of potential graduates. The number of specialized majors should be increased by, for example, offering an avionics option in computer engineering. In addition, avionics courses require major improvement.

Québec universities do not have sufficient resources for higher education. Despite the appeal of a city like Montréal, it's difficult to attract the best talent from around the world due to a lack of financing (e.g. granting of scholarships). There is strong competition among the world's aerospace regions to attract very high quality students and workers. There isn't enough government financing for universities to hire more professors and reduce the student-teacher ratio. This would assure better quality training and an increase in projects.

The summit also identified the sector's key issues and related actions. The **seven measures or actions** that were put forward during the summit are as follows:

1. **Encourage university-company and company-university exchanges by facilitating training through internships, the integration of professors into companies and joint research projects through CRIAQ or MAI;**

2. **Establish shared training programs that are recognized by all the partners for "in company" aerospace training (underway via MAI);**

3. **Develop majors in airborne systems (underway via CAMAQ);**

4. **Encourage more young people to consider a career in aerospace engineering by promoting the sector starting in high school (e.g. recent Aero Montréal initiatives);**

5. **Encourage more university students to continue their studies and ensure that these programs are better tailored to the industry's needs;**

6. **Improve training of engineers by emphasizing systems integration and the management of multidisciplinary teams, both in universities and companies;**

7. **Identify the various engineer profiles and specializations and make this classification available to define academic programs and reflect the industry's needs, for example the CDIO initiative.**

Regarding in-house training, some specific observations were cited:

- There are no government subsidies for individual courses but aid is allocated to courses leading to a degree. To encourage governments to provide financial assistance for industry training, existing courses could be brought into programs that are sufficiently generic so that they can evolve and bind to existing college and university degrees;

- Companies need to appoint an executive responsible for advanced training;

- Teachers should be able to participate in in-house company courses;

- It's important to view "knowledge management" as a key element in companies' long-term competitiveness;

- There is a lack of specific training relative to ITAR, Export Control and intellectual property.

In addition, regarding exchanges between universities and the industry, some improvement opportunities were identified:

- It would be advantageous to promote the use of the case study method in engineering, similar to that practiced in management schools;
- Companies could make loans or donations of recent equipment to universities to ensure that students are well trained with the right tools;
- SMEs don't feel adequately supported by universities.

Finally, Québec is well situated over other international aerospace centres in terms of the training of aerospace engineers and specialists. First, there is a good balance among the number of graduates coming out of universities and the needs of companies for engineers; this balance should not be upended by demographic changes as long as the industry and universities maintain the same kevel of collaboration. Secondly, inter-university and industry-university collaboration is very developed, and has been for more than two decades, as reflected by a wide range of initiatives such as CAMAQ's joint masters in aerospace engineering that brings together 6 universities and more than 12 companies, MAI with 3 university aerospace institutes and more than 20 enterprises, CDIO or CRIAQ's aerospace student forums.

Companies, just like universities, want and are ready to work together to enhance their collaboration and better respond to the sector's need for specialized manpower within the context of increasing international competition. The challenge is to maintain the momentum of all the initiatives taken to date. The seven measures identified during the summit will allow, through concrete actions, to accelerate this collaboration and strengthen our university programs in line with the new requirements of the dynamic aerospace sector.

ANNEX A

Program

Presentations

The Demand for a Specialized Workforce

Serge Tremblay, Executive Director
CAMAQ

In his presentation, Mr. Tremblay will analyze the data obtained (Fall '08) during the CAMAQ 2008-2010 survey of specialized employment in engineering. This information, gathered from 210 aerospace companies recognized by the Ministry of Economic Development, Innovation and Export Trade of Québec (MDEIE), will be compared to that compiled during other periods of economic prosperity. The data gathered by the CAMAQ on registrations in engineering faculties, as well as the annual requirement for foreign labour in engineering, will be discussed.

The Needs of Aircraft Manufacturers

Guy Lambert, Vice President, Commercial Helicopters Engineering
Bell Helicopter Textron Canada

After a brief presentation of Bell Helicopter Textron Canada Ltd's history and products, we will overview the demographic of the company to better understand typical qualification requirements for the vertical lift rotocraft engineer. We will then review the role and expertise required in the industry to identify the skills and specialties of the aerospace engineer. We will conclude by looking at the future by examining the industry challenges, the tendancies and the qualifications of the engineer of tomorrow.

The Needs of Engine Manufacturers

Walter Di Bartolomeo, Vice President, Engineering
Pratt & Whitney Canada

The presentation will focus on several of the current and emerging workforce challenges that the gas turbine engine industry is facing. An evolution of the industry and its impact on the skill needs will be discussed, as well as the changing trends in global workforce distribution and expectations. Finally, best practices and further recommendations for training the next generation of gas turbine engineers will be presented.

The Needs in Avionics and Simulation Systems

Patrick Champagne, Vice President, Engineering
Esterline CMC Electronics

An overview of the sector will be offered, including avionics, embedded software, simulators and other equipment suppliers. Specific challenges facing the sector will be discussed, as well as the changing environmental picture: increased level of integration, evolution of standards, complexity of technologies, etc. Also to be covered: key competencies, from RTCA standards for software, firmware and environment, to systems integration and certification. The presentation will conclude with a needs forecast on required skills and quantities.

University Programs

Clément Fortin, Professor and Director, Department of Mechanical Engineering
École Polytechnique de Montréal

The presentation will first offer an overview of the training available in Québec universities, including both the training of engineers and those at higher levels. The master's in aerospace engineering instituted in collaboration with CAMAQ and offered by six Québec universities will be discussed, including the option of Virtual Environment. Some foreign programs will also be touched on. The CDIO initiative from the Aero/Astro department of MIT will be described, and its impact on the training of engineers for the 21st century will also be covered.

The Montréal Aerospace Institute

Hany Moustapha, Senior Manager, Technology Programs
Pratt & Whitney Canada

This umbrella organization for undergraduate students of Concordia/CIADI, ETS/ICIA and Poly/IICAP is an industry-led initiative. As an industry-university partnership, it aims to train students with a view to building a pool of specialized, high-performing manpower while maintaining industry visibility on campus. Since 2002, the Institute has helped ensure consistency in performance metrics, training courses, mentoring, recruitment, awards, international status, etc. Future plans include post-graduate teaching, the development of business schools and in particular becoming an incubator to provide the industry with specialized manpower.

CRIAQ's Role in the Training of Student Researchers

André Bazergui, President and Chief Executive Officer
Consortium for Research and Innovation in Aerospace in Québec (CRIAQ)

Since its creation in 2002, CRIAQ has helped set up more than 45 research projects, of which 12 have now been successfully concluded and 6 involve international collaborations. In addition, 40 new projects are in preparation. By their collaborative nature, the CRIAQ projects necessarily bring together researchers from universities and research centres who work closely with specialists from industry. Together they offer learning opportunities to a number of students, not only at the master's and doctorate levels, but also to undergraduates, thanks to the CRIAQ Research Initiation Program. The presentation will cover initiatives aimed at attracting the best students in the aerospace field. Also discussed will be the international aspect and the opportunities available to our researchers, their industrial partners and their students.

Workshops

Aircraft and Engine Manufacturers

Robert Clive Fews, Manager, Technology
Bell Helicopter Textron Canada
Marius Paraschivoiu, Associate Professor, Department of Mechanical and Industrial Engineering
Concordia University

The workshop on undergraduate programs related to the aircraft and engine manufacturers provides a platform where the participants can discuss the qualification needs of future aerospace engineers and specialists. First, the workshop will address the need of the industry. Second, the role of universities and industries in training is going to be examined. Third, participants should identify what can be improved

Training in Industry

Hany Moustapha, Senior Manager, Technology Programs
Pratt & Whitney Canada
Fassi Kafyeke, Director, Strategic Technology and Senior Engineering Advisor,
Bombardier Aerospace

This presentation will offer an overview of the training industry. We will present an analysis of current skill gaps and proficiency levels. We will also examine the university-style structure of the industry, and the types of courses and curricula that have been created. We will take a closer look at some experts on specific subjects, "train the trainer" style learning, and succession planning for specialists and generalists. Partnerships with universities and industry will also be discussed, as well as the new and expanded role of the Montréal Aerospace Institute.

Avionics and Simulation Systems

Ruxandra Botez, Professor, Department of Production Engineering
École de Technologie Supérieure
Philippe Molaret, Technical Manager and Vice President Engineering
Aircraft & Missions System, Aerospace Division
Thales Canada

Following the conferences dealing with the needs in scientific qualified labor force, this workshop is offering to dwell on the training theme for these resources issue: what are the training needs at the undergraduate level in aerospace engineering? The results of our exchanges will be summarized in the forum's closing presentation and will be used in a White Paper on the training required in the aerospace domain.

Postgraduate Programs

Arun Misra, Professor and Chair of the Department of Mechanical Engineering
McGill University
Peter Jarvis, Chief Engineer, Civil Simulation Technologies
CAE

The Workshop on Continuous Education – Postgraduate Programs will deal with opportunities available in Montréal-area universities for training in aerospace engineering at the Master's and Ph.D. levels. It will also examine if the local universities are satisfying the needs of the local aerospace industries effectively, and if there is any mismatch between the needs and services provided, what steps should be taken to remove this mismatch.

ANNEX B

List of charts and graphics

Charts

Graphics

ANNEXES C

Acronyms and abbreviations

ABET	Accreditation Board of Engineering and Technology
BMP	Bourse en milieu Pratique
CAMAQ	Comité sectoriel de main-d'œuvre en aérospatiale
CASI	Canadian Aeronautics and Space Institute
CDIO	Conceive Design Implement Operate
CIADI	Concordia's Institute for Aerospace Design and Innovation
CIMGAS	Comité Industrie/universités sur la Maîtrise en Génie Aéronautique et Spatial
CNRC	Centre National de Recherche Canada
CRIAQ	Consortium for Research and Innovation in Aerospace in Québec
CTFA	Centre des technologies de fabrication en aérospatiale
EMAS	Engineered Materials Arresting System
ÉNA	École Nationale d'Aérotechnique
EPM	École Polytechnique de Montréal
ETS	École de Technologie Supérieure
EU	European Union
ICIA	Institut de Conception et d'Innovation en aérospatiale (ETS)
IICAP	Institut d'Innovation et de Conception en Aérospatiale (École Polytechnique de Montréal)
IP	Intellectual Property
IRA	Institut de recherche aérospatiale
ICT	Information Technology and Communication
ITAR	International Traffic in Arms Regulations
MAI	Montreal Aerospace Institute
NIAR	National Institute for Aviation Research
OEM	Original Equipment Manufacturer
PLM	Product Lifecycle Management
SME	Small Medium Enterprise

SUMMIT

TRAINING OF ENGINEERS AND SPECIALISTS
FOR THE AEROSPACE INDUSTRY