Collaboration Strategy for Staff Training

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Agenda

- Bombardier Products
- Engineering at Bombardier: a Wide Variety of Disciplines
- University Collaborations
- The Changing Role of Engineering
- Bombardier Engineering University
- Conclusions and Way Forward
Bombardier Fields of activity

**Aerospace**

F09 revenues: $10.0 billion
51% of total revenues
Backlog: $23.5 billion*
Employees: 32,500*

*As at January 31, 2009

**Transportation**

F09 revenues: $9.8 billion
49% of total revenues
Backlog: $24.7 billion*
Employees: 34,200*

*As at January 31, 2009
Bombardier’s Business Aircraft portfolio is centred on three families:

**LEARJET FAMILY**
- Learjet 40 XR
- Learjet 45 XR
- Learjet 60 XR
- Learjet 85

**CHALLENGER FAMILY**
- Challenger 300
- Challenger 605
- Challenger 850

**GLOBAL FAMILY**
- Bombardier Global 5000
- Global Express XRS

Learjet, Learjet 40, Learjet 45, Learjet 60, Learjet 85, Challenger, Challenger 300, Challenger 605, Challenger 850, Global, Global 5000, Global Express, XR and XRS are trademarks of Bombardier Inc. or its subsidiaries.
Bombardier’s Commercial Aircraft portfolio is aligned with current market trends

**Turboprops**

- Q400 and Q400 NextGen

**Regional jets**

- CRJ700 NextGen
- CRJ900 NextGen
- CRJ1000 NextGen

**Single-aisle mainline jets**

- CSeries CS100/CS300

Q-Series aircraft: 1,034 ordered, 942 delivered.

CRJ Series: 1,673 ordered, 1,569 delivered.

CRJ, CRJ700, CRJ900, CRJ1000, CS100, CS300, CSeries, NextGen and Q400 are trademarks of Bombardier Inc. or its subsidiaries.
CSERIES • Design and Technologies Focused On Optimization

- Best in Class Cabin Comfort and Flexibility
- Superior Field Performance & Range Flexibility
- 70% Advanced Materials
- Advanced Flight Deck FBW with Side Sticks
- Integrated Avionics & Optimized Systems
- Electric Brakes
- Pratt & Whitney PurePower™ PW1000G

Pratt & Whitney
Engineering Disciplines at Bombardier
A wide variety of engineering careers available

- Advanced Design
- Advanced Aerodynamics
- Flight Sciences
- Dynamics and Loads
- Systems Engineering
- Propulsion
- Structural Design
- Weights
- Stress
- Materials and Processes
- Experimental Engineering

- Quality Assurance
- Airworthiness
- Product Life Cycle Management
- Customization
- Operations Liaison
- Project Management
- Sourcing and Supply Chain
Aerodynamic Development

CFD
• Aircraft Aerodynamic Design
• Power-plant Integration
• Prediction of Lift and Drag
• Aerodynamic Loads

Wind Tunnel Testing
• Design Validation
• Performance Verification
• Aerodynamic Data

Flight Testing
• Final Design Validation
• Handling Qualities
• Airworthiness Approval
Structure Design

- Structural Design and Systems Installation
- Service Engineering
- Master Lines
- Stress
- Weights and Balance
- Liaison Engineering
- Nomenclature
- Interior Design / Customization
Materials and Process

Microscopic Surface Examination

Microscopic examination is the study of the surface of metals and alloys by scanning electron microscopy (SEM)
University Collaboration: An answer to talent shortage

- Growing needs for skilled people threatens new products development.
- University programs contribute to mitigate this risk by:
  - Bringing students to the Aerospace sector
  - Developing competencies among students, to answer our technical needs
  - Bringing future Engineers to work closely with Industry, thus offering us the opportunity to hire candidates with the right skills to work on specific projects.
Bombardier University programs address all levels of expertise

**Example: Montreal University Programs**

<table>
<thead>
<tr>
<th>Expertise</th>
<th>Programs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PhD</strong></td>
<td>Bourse en Milieu de Pratique&lt;br&gt;<strong>→ Innovation / Advanced Research Engineers</strong></td>
</tr>
<tr>
<td><strong>M. Sc.</strong></td>
<td>Bourse en Milieu Pratique&lt;br&gt;CIMGAS (Comité Industrie/universités sur la Maîtrise en Génie Aéronautique et Spatial)&lt;br&gt;<strong>→ Advanced Research Engineers</strong></td>
</tr>
<tr>
<td><strong>Bachelor</strong></td>
<td>Polytechnique Montreal&lt;br&gt;Carleton Case Studies: Design reviews&lt;br&gt;Montreal Aerospace Institute&lt;br&gt;<strong>→ Product Development Engineers</strong></td>
</tr>
<tr>
<td><strong>Collegial / Technical</strong></td>
<td>École Nationale d'Aérotechnique / Centre Aero Technique&lt;br&gt;<strong>→ Methods / Supervisory technicians</strong></td>
</tr>
<tr>
<td><strong>Secondary</strong></td>
<td>École des Métiers (CAMAQ)&lt;br&gt;<strong>→ Specialized workers</strong></td>
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</tbody>
</table>
Bombardier Contribution to Aerospace Engineering Education

- Courses are given by BA Engineers: 18 Engineers involved
- Submission of projects for a Bachelor degree in Aerospace Engineering,
  - Addresses BA needs: Specialization in Structures, Systems and Virtual Environment, while covering the basic engineering disciplines with emphasis on aircraft (conceptual design, aerodynamics, performance, stability and control)
  - Integrated Bachelor-Master degree in 5 years to cater for advanced fields: Composite structures or Computational Fluid Dynamics
- Continuing support to the joint Master in Aerospace Engineering program (CIMGAS)
**Why Do We Collaborate with Universities?**

**Corporate Responsibility:**

“… We also provide training and professional development, **while partnering with schools and universities** to promote education in the engineering and transportation fields.”

Source: Corporate Responsibility Roadmap - May 2007

**1. Developing Talent** in University to support BA’s human resource needs.

**2. Sustaining an outside Innovation reservoir** to feed our R&D projects.

**3. Leveraging Research and Development Programs**

**Strategic Technology Vision:**

“To develop and align Competitive Technologies with our Aircraft programs through excellence in People, Innovation, and Commitment “

- **Continuous contact with Universities** (formal & informal):
  - Contributes to maintaining a spirit of innovation among Bombardier people
  - Bring external view on our work: Out of the box ideas that will trigger innovation among our Engineers.
  - Act as a think tank for future projects
Collaborative Research and Development
Awareness Research: University Chairs

- **McGill**: Multi-Disciplinary Analysis and Design of Aerospace Systems, Prof. W.G. Habashi
  - Bombardier, Bell, CAE
  - Junior Chair: Prof. S. Nadarajah, Aerodynamic Shape Optimization
- **Sherbrooke**: Aviation Acoustics, Profs. N. Atalla and A. Berry
  - Bombardier, P&W, Bell
- **Polytechnique**: Integrated Design for Efficient Aircraft, Prof. J-Y Trépanier
- **University of Toronto**: Endowed Chair to UTIAS

- **Intellectual Property**: NSERC guidelines, IP belongs to party which contributes or joint IP, industry receives royalty-free non-revocable licence, exclusive in its field of operation
- **Management**: funded for 5 years by the Bombardier foundation; technical review by Bombardier Aerospace staff twice a year.
- Supported by National Science and Engineering Research Council (NSERC)
Collaborative Research and Development
Technology Development

National Science and Engineering Council (NSERC) CRD research

Montreal Aerospace Institute (MAI) stages

Bourses en Milieu de Pratique (BMP) stages

Mathematics of Information Technology and Complex Systems Inc. (MITACS) Internships
(Accelerate Canada – Accelerate Quebec)

Consortium for Research and Innovation in Aerospace in Quebec (CRIAQ)

Green Aviation Research and Development Network consortium (GARDN)
Collaborative Research and Development
Technology Development – NSERC CRD Research

- Contract between industry and one professor;

- **Intellectual Property:** NSERC guidelines, IP belongs to party which contributed or joint IP, industry receives royalty-free non-revocable licence, exclusive in its field of operation;

- **Management:** Typically 3-4 years in duration, trains ~5 Graduate students;

- Works well to build/maintain critical mass in University lab, in addition to other types of funded research.

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National Science and Engineering Council (NSERC) CRD research
Collaborative Research and Development

Technology Development – Montreal Aerospace Institute Stages

- Summer internship positions (500 hrs/4 months);
- Involves most Montreal aerospace firms with Concordia, ETS, Laval, McGill, Polytechnique and Sherbrooke;
- **Management**: run by a University/Industry board;
- **Intellectual Property**: already negotiated: ownership to Industry;
- Program is used by Strategic Technology Office as demonstration program within Core Engineering:
  - Strategic technology paid stages offered in Core Engineering Departments
  - Enables departments to foster ties with students/universities;
  - Program often successful: Departments extend internships with their own budgets;
Collaborative Research and Development
Technology Development – Bourses en Milieu de Pratique (BMP)

- Started in 2007 by MDEIE (Ministère du Développement Économique, Innovation et Exportation) after consultation with industry;
- Master (2 years) and Ph.D. (3 years) programs to be performed mostly in industry, through joint university-industry student supervision;
- Subjects defined by academia or industry;
- Industry commits to 1/3 of the student stipend, with provincial and federal governments providing the same amount each;
- Intellectual Property negotiated following topic ownership (NSERC rules for Ph.D.)

**Benefits:**
- For University: increase industrial hire of M.Sc. and Ph.D. graduates
- For Industry: increase innovation capability by hiring staff trained for research

**Bourses en Milieu de Pratique (BMP) stages**
Collaborative Research and Development
Technology Development – MITACS Internships (Accelerate Canada)

- 4-month internships in technical field, renewable once or twice;
- Company pays $1/2 with government matching the other half; stage can be extended to one year if necessary
- Post-graduate students only;
- Very low application overhead, response within 1 month;
- Intellectual Property generally to Industry;
- Usually works best as technology transfer from students working on other R&D projects, at the end of their studies.

Mathematics of Information Technology and Complex Systems Inc. (MITACS) Internships
(Accelerate Canada – Accelerate Quebec)
Collaborative Research and Development

Technology Development – CRIAQ Projects

- Consortium de Recherche et d’Innovation en Aérospatiale au Québec;
  - National Collaborative Projects: minimum 2 Universities and 2 Industries (can include National Laboratories like NRC);
  - International Collaborative Projects: minimum one university, one industry in Canada, one university, one industry abroad;

- Intellectual Property already negotiated;

**Benefits**

- Allows students to participate in large projects (coordination, timetable, deliverables);
- Provides extensive leverage (up to 7 times if several industrial partners):
  - 25% Industry, 25% CRIAQ, 50% NSERC
- A key element of the aerospace innovation system in Québec.

Consortium for Research and Innovation in Aerospace in Quebec (CRIAQ)
Collaborative Research and Development
GARDN (Green Aviation Research and Development Program)

- A new federally sponsored Business-Led Network of Centers of Excellence
- GARDN mission is to promote the protection of the environment and support the competitive excellence of Canadian aeronautical products and services, the economic success of the member companies and the development and training of highly qualified personnel in the aerospace environmental field.
Managing our future through the university collaboration network
The Changing Role of the Engineer

- The airplane manufacturing business is changing
  - Emphasis is on integration of systems and structures
- Engineers are called to work in very diversified environments
  - Multi-disciplinary environment
  - Multi-site environment
  - Multi-cultural environment
- The engineer is assumed to have strong technical skills
  - Soft skills are the critical discriminator: leadership, team spirit, commitment to customers and shareholder
- An Increasing need for project managers.
- A new emphasis on technology development to bring innovative products to the market.
Today’s Industry Needs: The Agile Engineer

- “Business” engineers
- Focus on Cost: Value Engineering
- Process innovation – Lean Enterprise
- Three-dimensional thinking
- Risk definition and management
- Integrate, integrate and integrate:
  - Systems engineering
Does the industry need specialists or generalists?

Is there any difference between a B.Eng Mechanical or a B.Eng Aerospace?

Do aircraft and engine Manufacturers need B.Eng Industrial and B.Eng Electrical engineers?

What is the average age of engineers and scientists working for the aerospace industry?

Do we have to worry about the growing number of retirements?

If you could add a course to the B.Eng. Mechanical degree what would it be?

What additional training should be added to the Montreal Aerospace Institutes?
Some suggestions for improving the curriculum

- **More involvement from Industry in the education process**
  - Real life projects, not simulated
  - Summer stages based on real industry technology needs (R&D) instead of simulations (CIADI model)

- **Allow projects to run in real-life or very near real-life environments**
  - Example: the Virtual Environment Project

- **Stay abreast of future evolution of industry needs**
Bombardier Engineering University

- In 2008, BA faced a large workforce ramp-up to cater for three launched programs, CRJ-1000, CSeries and Learjet-85, and prepare for other possible programs: Model 170 (GX derivative) and Model 127 (Challenger replacement);

- At the same time, other airframe manufacturers were also launching new aircraft programs; this led to a severe shortage of experienced aerospace engineers;

- There was a need to provide newly hired less experienced aerospace engineers and non-aerospace engineers with the training needed to bring them to the level needed to be productive;

- The Bombardier Engineering University (BEU) was set up to cater for this need and, at the same time, to regroup several engineering training programs that were not properly harmonized
In order to support properly Bombardier Aerospace business priorities and in the face of severe skill shortages, there is a need to invest in the proper **technical training** of our staff.

Bombardier Engineering University activities include:

1. University Programs & Courses
2. The Aerospace Knowledge Center
3. The Conferences & Working Groups central repository
4. Professional Development Programs & Engineering Training Programs
5. The New Graduates and Partners Program
Conclusions

- Bombardier has achieved a position of leader in Regional and Business aviation through sustained technology development and product innovation.

- An extensive network of national and international collaborations, is crucial in the first two phases; government support for collaborative university-industry R&D is essential.

- University Relations are essential to support our internal needs for skilled personnel and technical knowledge.

- The role of engineers is changing and university programs must change to adjust to the new realities. A University-Industry summit was organized in 2008 to address these issues.

- In the face of severe skill shortages, Bombardier has strengthened its internal training program by regrouping them in the “Bombardier Engineering University”.