Corporate Social Responsibility and Green Aircraft Technology: the Bombardier Perspective

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Bombardier Aerospace

UTIAS_MITACS International Workshop on Aviation and Climate Change
University of Toronto Institute for Aerospace Studies
May 30, 2008

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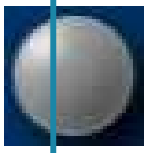
Agenda



Environmental Awareness

Bombardier's Approach to Address the Environmental Concerns

How is Bombardier positioned today?

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Bombardier Inc. Overview

- Corporate office based in Montréal, Canada
- Workforce of 59,760 people worldwide as at January 31, 2008
- Revenues of $17.5 billion for fiscal year ended January 31, 2008
- More than 96% of revenues generated outside Canada
- Listed on the Toronto Stock Exchange (BBD)

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Overview: fields of activity

Aerospace

F08 revenues: $9.7 billion
55% of total revenues
Backlog: $22.7 billion*
Employees: 28,100*

Transportation

F08 revenues: $7.8 billion
45% of total revenues
Backlog: $30.9 billion*
Employees: 31,485*

*As at January 31, 2008

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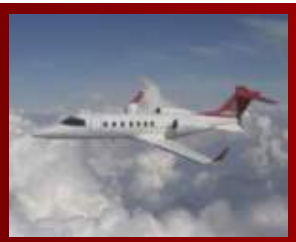
Bombardier's Business Aircraft portfolio is centred on three families

LEARJET FAMILY



Learjet 40 XR

Learjet 45 XR

Learjet 60 XR

CHALLENGER FAMILY

Challenger 300

Challenger 605

Challenger 850

GLOBAL FAMILY

Bombardier Global 5000

Global Express XRS

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Bombardier regional aircraft

Q100/200

Q300

Q400

CRJ200

CRJ700

CRJ900/705

CRJ1000

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Bombardier amphibious aircraft

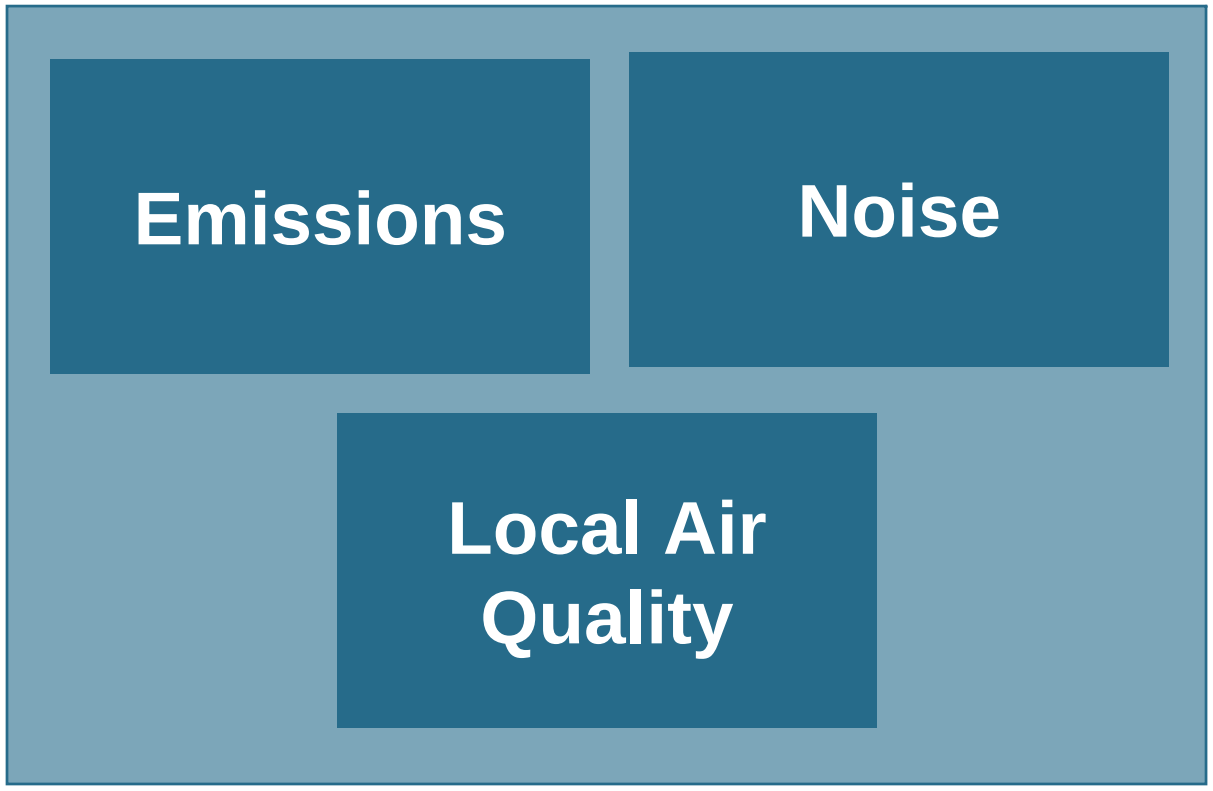
- **The world's most productive firefighting aircraft in service**
- **The *Bombardier 415* aircraft can also be configured for a wide range of multi-mission capabilities:**
  - Search and rescue
  - Maritime patrol
  - Law enforcement
  - Environmental control

The Environment – Who are the stakeholders?

- **An airport neighbour?**
- **A national regulator?**
- **An airport authority?**
- **Us as Bombardier employees?**
- **The travelling customer?**
- **The airline?**
- **The media?**
- **Greenpeace, Friends of the Earth or other environmental NGO's?**
- **Etc., etc.**

Who's interest is the most important?

The main contributing factors between aviation and the environment



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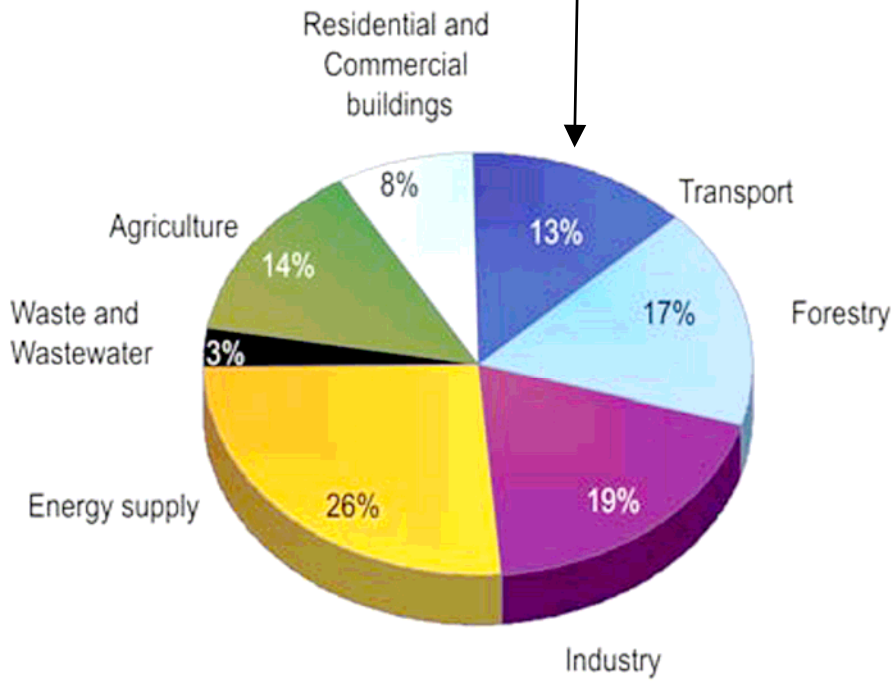
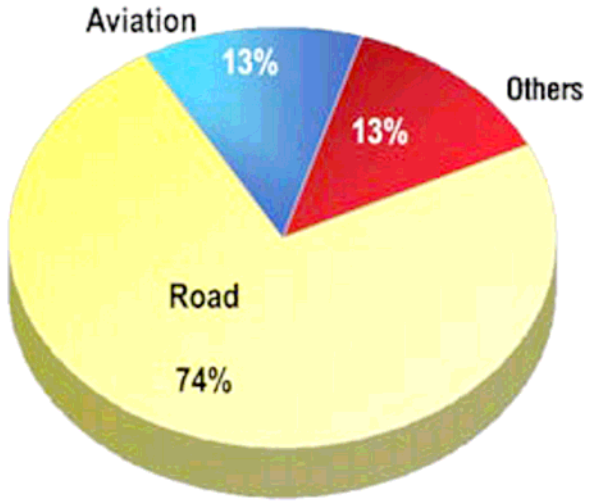
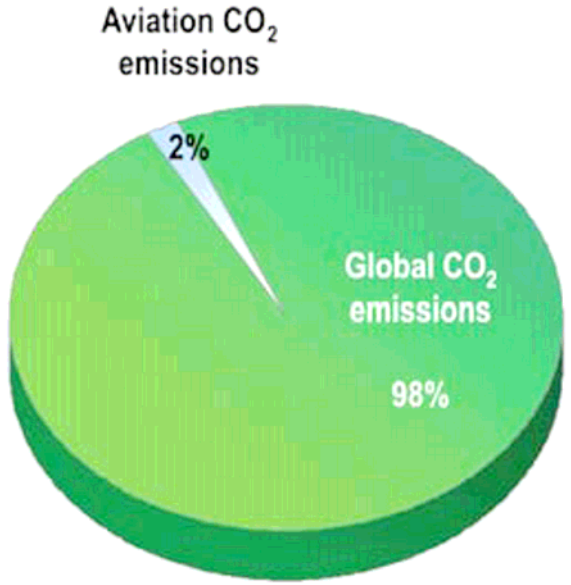
1. Global Emissions

Aviation is included in the transport sector



Global GHG by Sector, 2004 (IPCC)





Source: ICAO 2007

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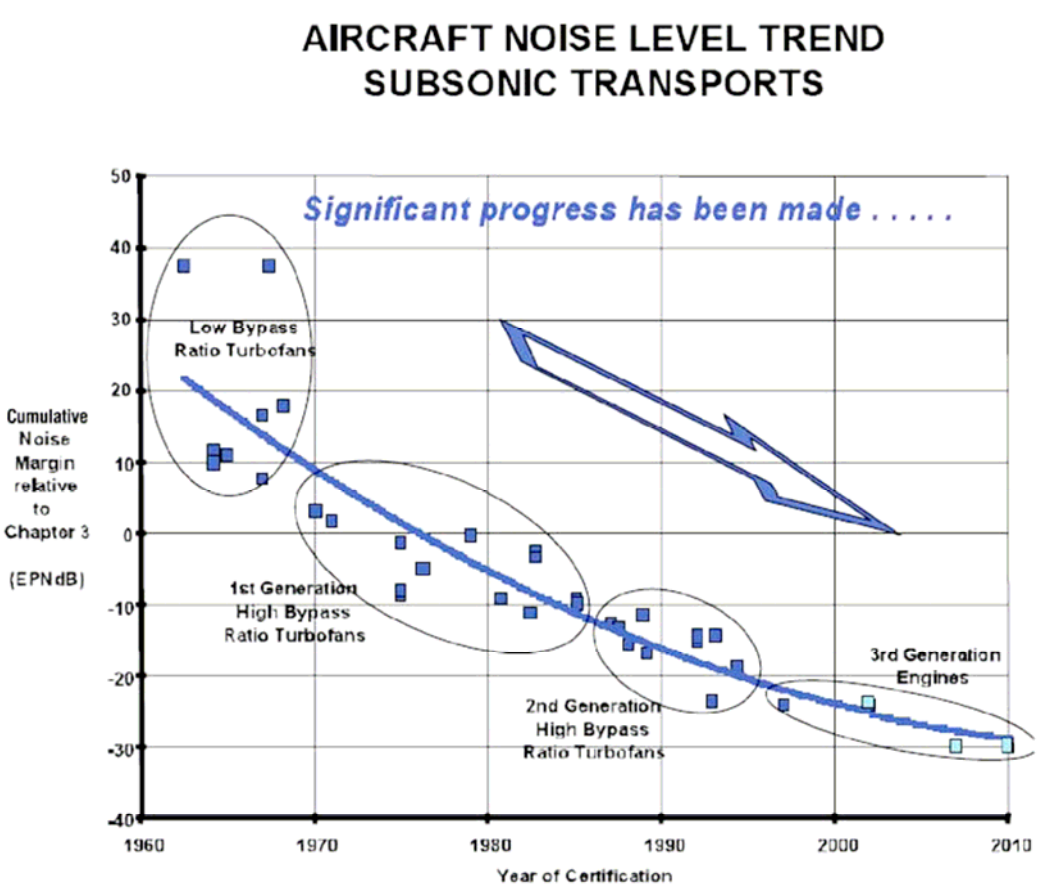
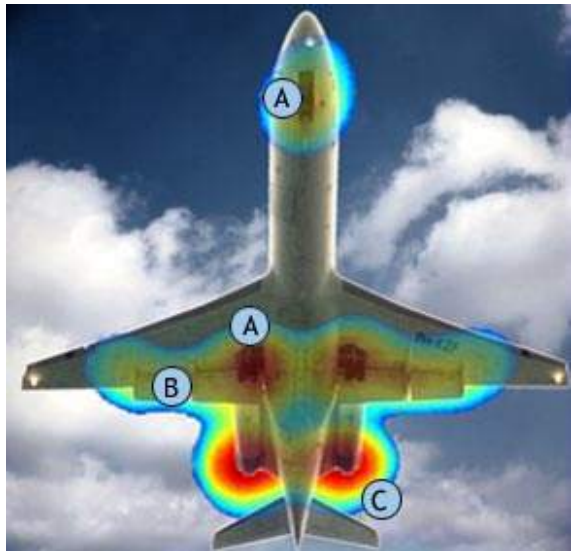
2. Noise – The Balanced Approach

- Noise was aviations' first real encounter with environmental groups, perceived as being the main issue (it's still an issue today!).
- Aircraft today are approximately 75% quieter than 40 years ago





Main Noise Sources

- Undercarriage
- Flaps & Slats
- Engines

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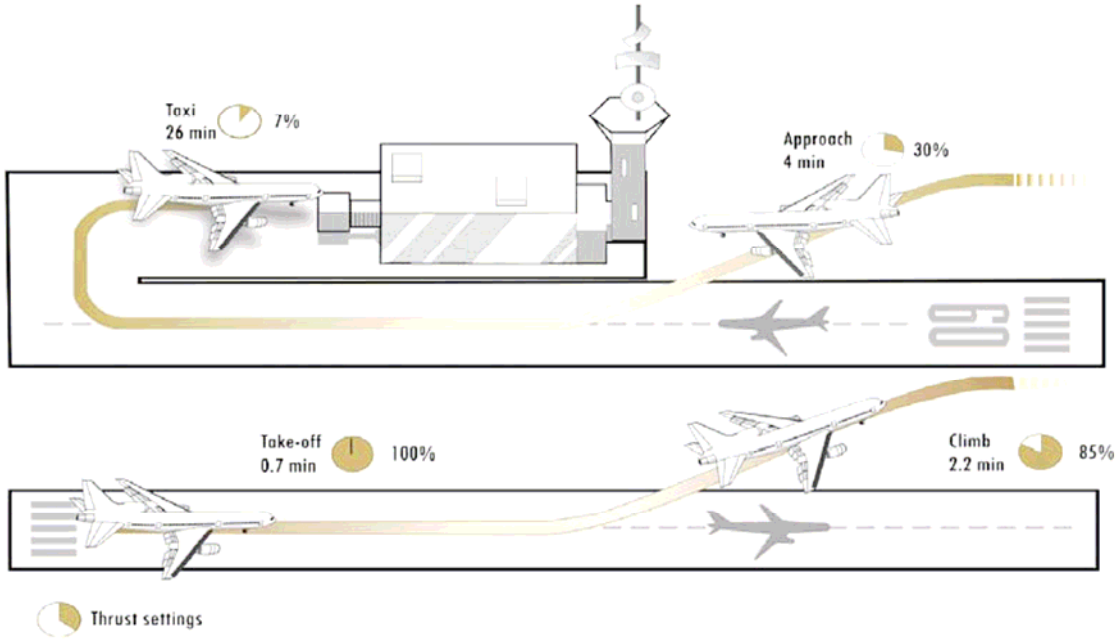
3. Local Air Quality (LAQ)

- LAQ refers to the effects of aircraft operations (landing and take-off) on local air quality around airports and up to a level of 3,000ft.
- LAQ includes operation of airside equipment, APU's, general airport transport infrastructure, waste management etc.
- Other gases emitted including sulphur oxides (SOx), carbon monoxide (CO), unburned hydrocarbons and smoke.



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How Will Change be Driven?

- **Improvements within aviation will come from several sources**
  - Driven by industry, technology progression and commitments
  - Increasing customer requirements
  - Regulated by various governments, joint projects and programs
- **Current Worldwide Environmental Drivers in the Aerospace Industry**
  - ***Europe:*** Advisory Council for Aeronautics Research in Europe - ACARE 2001 (currently seen as the industry standard)
  - ***United States:*** First National Plan for Aeronautics Research Development and Infrastructure – December 2007
  - ***Canada:*** Canadian Environmental Technology Road Map (December 2008); Future Major Platform Framework (proposed for 2009)

Bombardier's Role in the Aviation System

- **As part of the Aviation System, Bombardier has a responsibility towards bringing solutions to market that integrate and improve the system.**
- **The customer now demands a more environmentally efficient aircraft as well as lower cash operating costs.**
- **Bombardier is committed to reducing the environmental impact of its entire operation**

Bombardier has begun to address these concerns with various Strategic Initiatives

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Environmental Strategic Initiatives

1. Creation of Environmental Working Groups

- The Environment is a key part of our Corporate Responsibility commitment; which includes contribution from all disciplines; Engineering, Supply Chain, Communities, etc.
- Within Engineering, an Internal Network has been created to bring together all the Environmental expertise to move forward.

2. R&D Program Initiatives

- Develop innovative technologies to address noise, emissions and local air quality.

3. External Technology Collaborative Programs

- Lead the Canadian Environmental Technology Road Map
- Participating in consortiums to address environmental concerns;
  - European Framework Programs
  - CAEWG: Canadian Aviation Environmental Working Group
  - CRIAQ: Consortium for Research and Innovation in Aerospace in Quebec
  - SAGE: Smart, Affordable, Green and Efficient program

Agenda

Environmental Awareness

Bombardier's Approach to Address the Environmental Concerns

→ R&D Program Initiatives

→ External Technology Collaborative Programs

How is Bombardier positioned today?

Designing Environment into the Aircraft

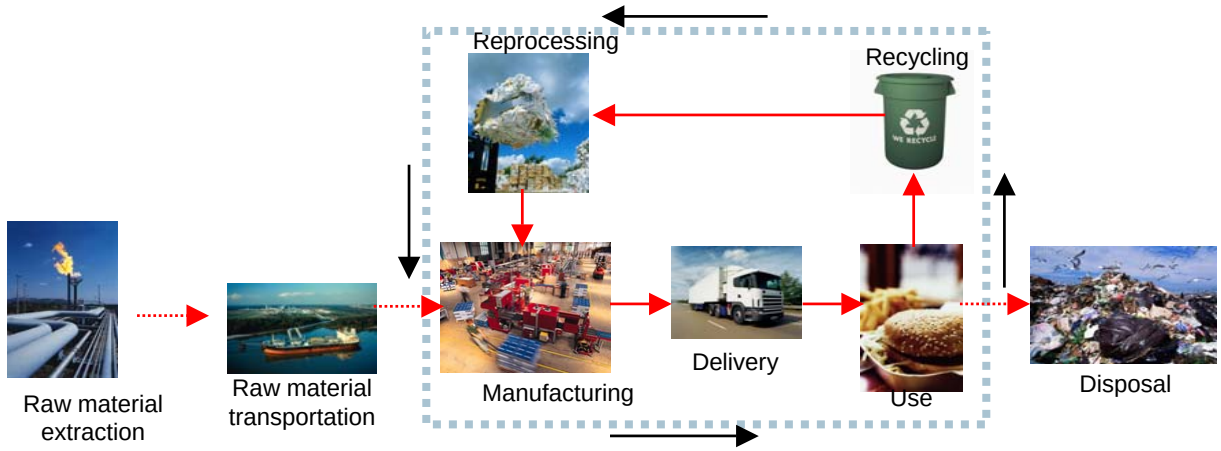
- **Consider the Environmental Life Cycle for the entire Aviation System**
  - Design, Manufacture, Operation, End of Life

  And will also include: Supply chain, distribution and maintenance
- **Incorporating Design for Environment**

  Product designed, built, used and disposed of with least impact to the environment (Fuel burn, etc.)

→ For example, Designing in recyclability

Changing the way we think about the use of raw materials and introducing the recyclability loop



→ Towards Greener Aircraft

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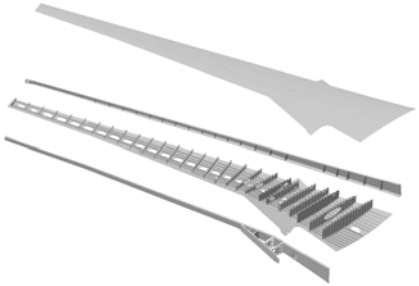
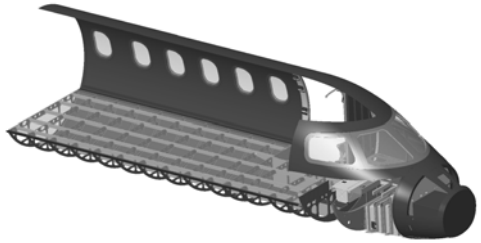
Composite Technology





- **Strategy:**
  - Develop composite technology for future aircraft platforms to reduce weight.
  - Lighter structures will consume less fuel, thereby reducing emissions.

"Le premier avion en materiaux composites"
La Presse, January 23, 2008

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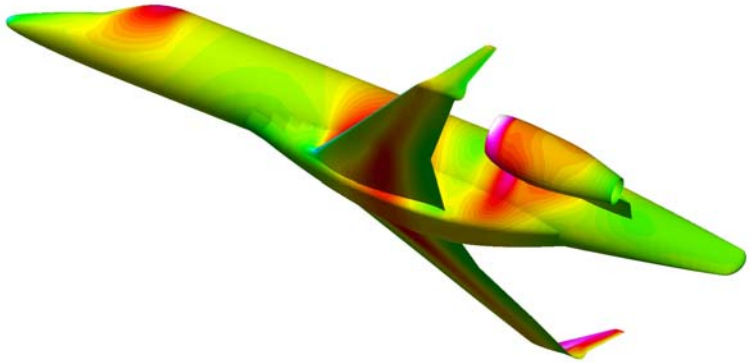
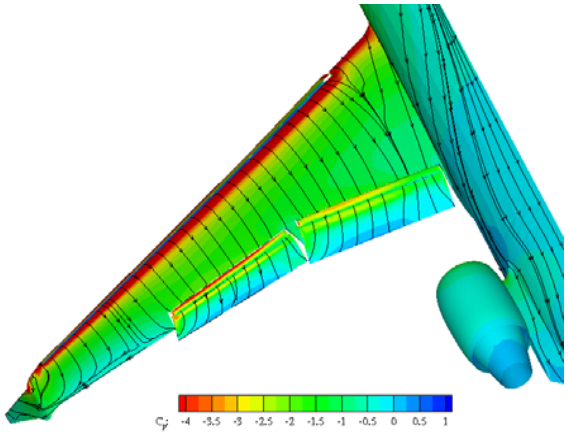
Advanced Aerodynamics Research

- **Objectives**
  - Develop innovative aircraft aerodynamic configurations to reduce drag that can help to reduce emissions.





Cruise: Learjet 85 wing design optimization using High-fidelity methods

Take off and landing: More accurate drag predictions for complete aircraft configurations with extended high-lift devices

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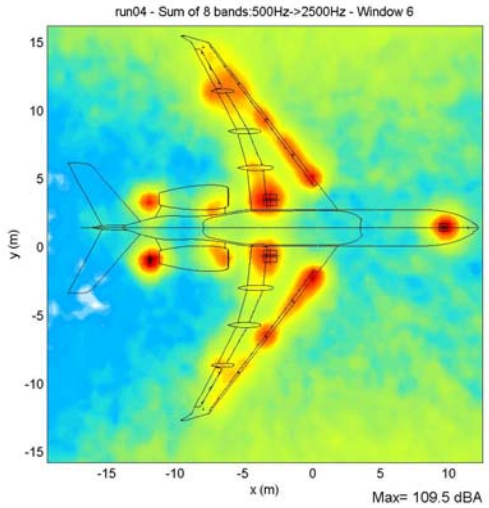
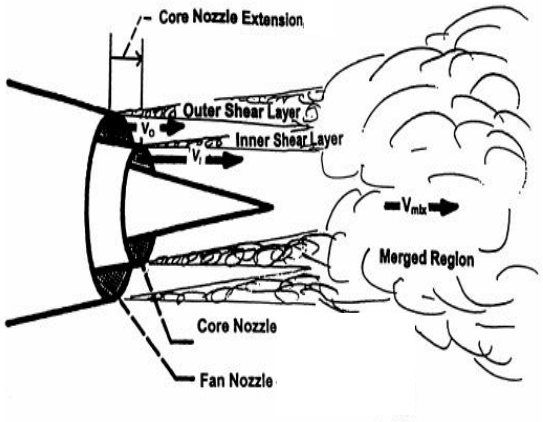
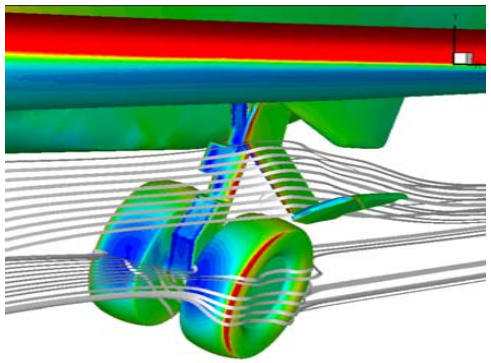
Acoustics Technology

- **Community Noise Prediction**
  - Developed aircraft noise source identification method using ground-based microphone array for flying aircraft.
  - Developed and validated aircraft community noise prediction methods for calculating airframe and engine noise.







CRJ-700 Landing Gear

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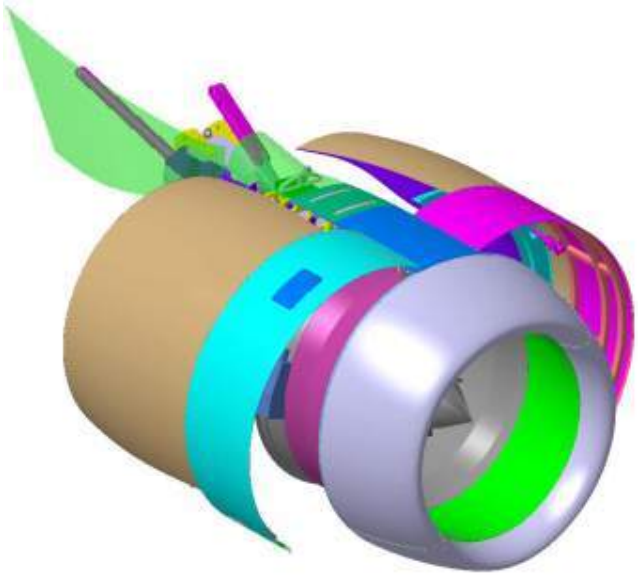
Nacelles Technology Development at Belfast

Collaborative UK / European Programs

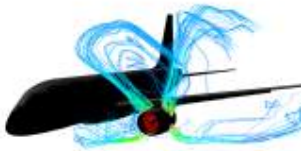
Environmentally Friendly Engine 2006-2011



- **Bombardier (Belfast) Lead for Powerplant WP**
- **<u>Industry:</u> Rolls Royce, Goodrich, HS Marstons, Smiths; <u>Universities:</u> Cambridge, Oxford, Loughborough, Sheffield, Birmingham, Belfast**

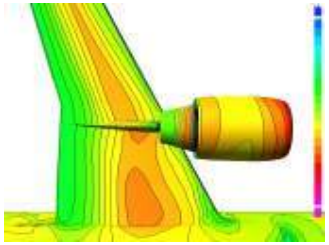
Low Weight Nacelle

- Innovative thrust reverser for high BPR engine
- Structural studies
- Material opportunity studies



Low Drag Nacelle

- Laminar flow control
- Surface coatings
- Flow control



Low Noise Nacelle

- Acoustic area yield
- Splice-less designs
- Advanced acoustic treatments

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CAEWG: Canadian Aviation Environmental Working Group

As part of the Aerospace Industry Association of Canada – AIAC

- A Joint Canadian initiative on Noise & Emissions Reductions
  - Reduced nacelle weight
  - Reduced nacelle aerodynamic drag
  - Improved attenuation of engine noise

- Business Led-Network Centre of Excellence
  - Private sector problem-driven research partnerships
  - Fund large-scale collaborative research networks
  - Enhance private sector innovation

Networks of Centres of Excellence of Canada | Réseaux de centres d'excellence du Canada

- Bombardier Research Potential
  - Acoustic Liners
  - Spliceless Inlets
  - Fan Chevrons
  - Increased Nacelle Length
  - Landing Gear Farings

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Consortium for Research and Innovation in Aerospace in Quebec - CRIAQ

R&D Themes

MANU	Manufacturing
COMP	Composites
ACOU	Vibro-Acoustics and Noise Control
MDO	Modeling, Simulation, Optimization, System Integration
LEAN	Supply Chain Optimization and Lean
PLM	Life Cycle Management
DPHM	Diagnostics, Prognostics, Health Monitoring
AVIO	Avionics and Control
ENV	**Environment, Safety, Icing**

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SAGE initiative
Canadian Aerospace Technology Demonstrators

- **SMART** Systems
  - Integrated and intelligent systems,
  - Air transport system optimization
  - Enhanced passenger comfort

- **AFFORDABLE** Initial and Operating Cost
  - To build: design, manufacturing and materials
  - To operate: reduced fuel consumption, maintenance and navigation fees

- **GREEN** - Environmentally Friendly
  - Reduced noise (5-10dB), CO2 (25%) and NOx (30%), Fuel consumption (25%), Materials of Concern (Chromium, etc)
  - Alternative fuel, Hazardous waste elimination, Green metrics for Eco Design

- **EFFICIENT** Performance and Operation
  - Advanced aero concepts , Advanced materials, more electric airframe
  - Power management systems, Integrated thermal management of propulsion system, Value added innovative design

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Technology Initiatives Overview

- **As a leader in Aerospace, Bombardier continuously develops in-house competencies in Aerodynamics, Acoustics, Materials, Structures and Systems, to answer these environmental challenges.**

- **We work together with institutions and industrial partners in Canada and across the world to address these concerns.**

Bombardier is in a unique position to bring together all of these important initiatives to introduce the aircraft of tomorrow.

Agenda

Environmental Awareness

Bombardier's Approach to Address the Environmental Concerns

How is Bombardier positioned today?

Bombardier's Green Machines

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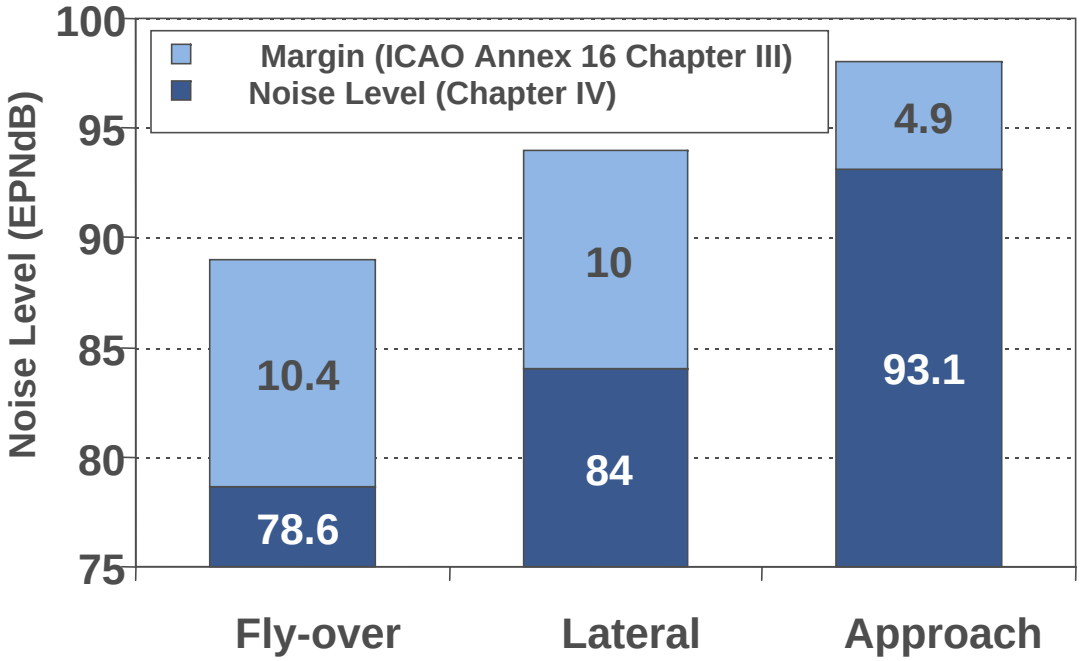
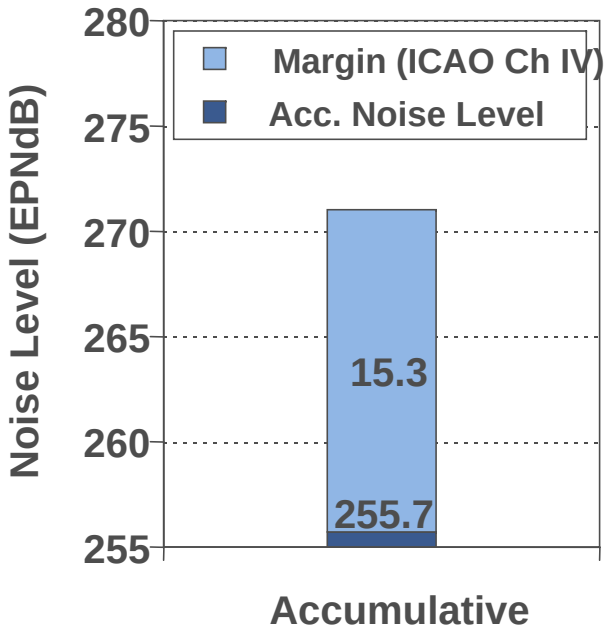
The highest weight Q400 has plenty of noise margin

Environmental compatibility
Q400 EHGW - Chapter IV Noise Levels





Note: Q400 with Reduced RPM landing

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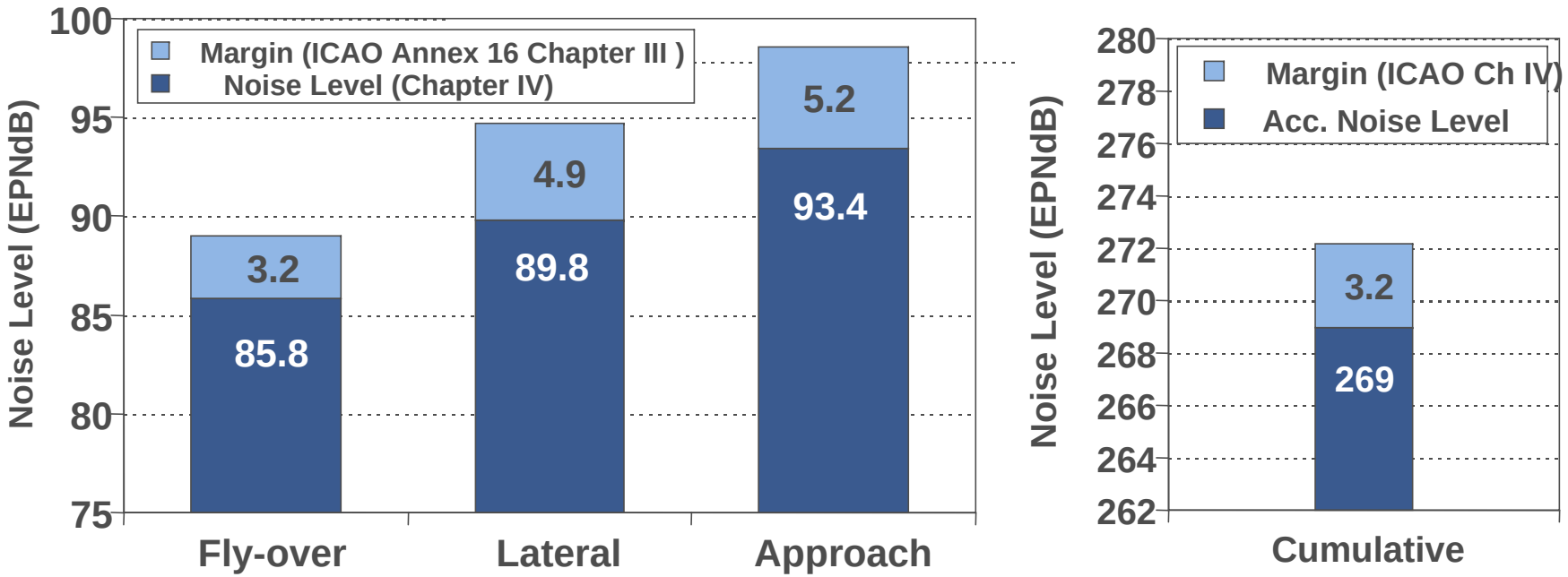
The CRJ1000 will be certified to Chapter IV with an expected margin of 3.2 EPNdB

Environmental compatibility
CRJ1000 ER* – Preliminary Chapter IV noise levels



* Targets per Chapter IV. Applicable to both Stnd 2% & Optional +5% Engine

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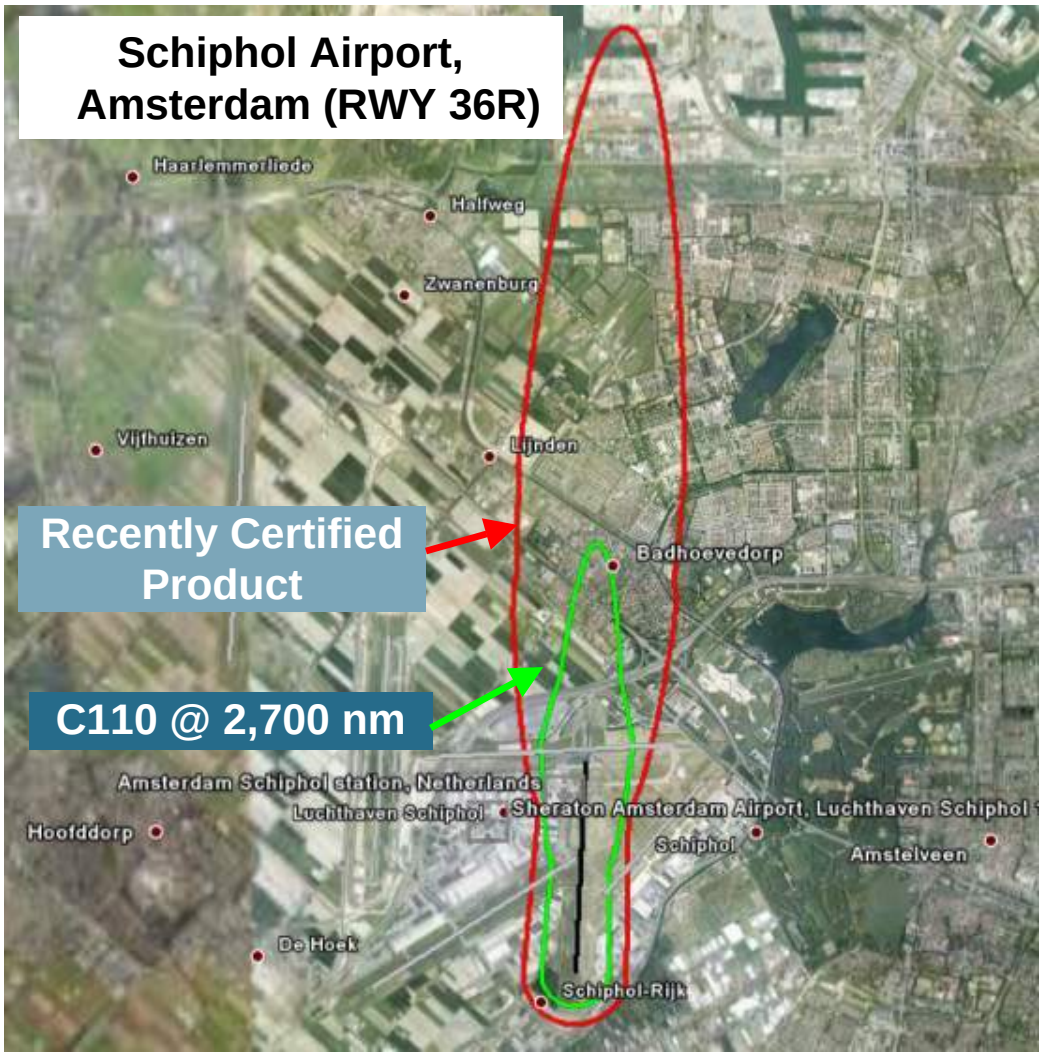
CSeries – The Community Environmental Solution

CSeries Quiet Footprint



dBA-A Weighted Sound Level; C110: MTOW 126,800 lb, Flaps 5 deg, MTOT 23,300 lbf; Competition RTOW 115,280 lb (TOFL limitation), MTOT 20,000 lbf, Flap 5 deg

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CSeries • A Game Changer in its Class

- ☑ Family of Aircraft with Full Commonality
- ☑ Environmentally Focused – 20 EPNdB Margin to Stage IV
- ☑ Total Life Cycle Cost Improvement
- ☑ 15% Better Cash Operating Costs – 20% Fuel Burn Advantage
- ☑ Widebody Comfort In A Single Aisle Aircraft
- ☑ Mature 99% at Entry Into Service
- ☑ Operational Flexibility – Short Field and Longer Range Performance

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