Composites in Canada

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National Research Council Canada | Conseil national de recherches Canada

Canada

Presentation Outline

- Some Canadian innovations in history
- Canadian aerospace sector and strategic importance of composites
- Aerospace composites innovators in Canada
- Canadian innovation system
- Innovation in action – AFP demonstrator

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Canadian Inventions…. Some important ones

- Telephone (1876)
- Standard Time (1878)
- Variable-pitch Propeller (1922)
- Insulin (1923)
- Electron Microscope (1937)
- Heart Pacemaker (1950)
- IMax Movie System (1968)
- JAVA (1994)
- Blackberry (1999)

Canadian Inventions….
Some less prominent ones

- Zipper (1913)
- Wonderbra (1935)
- Jolly Jumper (1959)
- Abdominizer (1984)
- Poutine (?)

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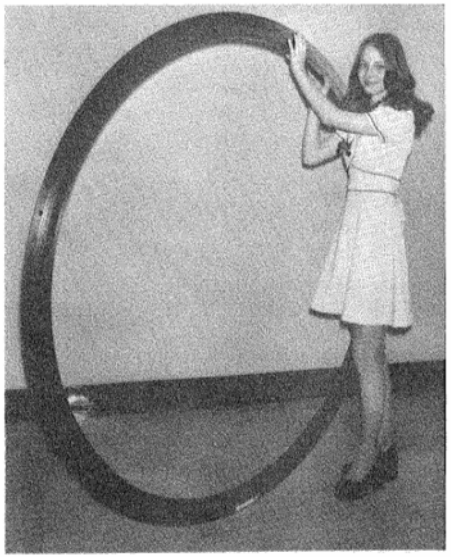
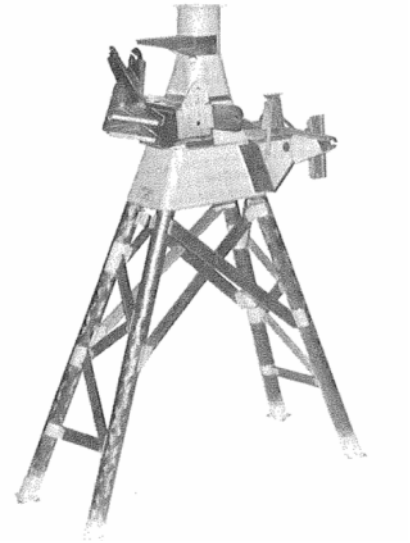
Canadian Inventions….
Some very “Canadian” ones

- Rotary Railroad Snowplow (1869)
- Electric Car Heater (1890)
- Snowblower (1925)
- Retractable Beer Carton Handle (1957)
- Snowmobile (J-A Bombardier, 1958)
- Hockey Goalie Mask (1960)

Some early composites applications in Canada



1974: Momentum Wheel Rim – carbon fibre / epoxy for satellite attitude control



Early 1970s Satcom Antenna - Kevlar fibre composite

Bristol Aerospace - Winnipeg

1981: Canadarm1 - Graphite fibre composite

2001: Canadarm2 (SSRMS) – Carbon fibre / PEEK (not early but I like it…)

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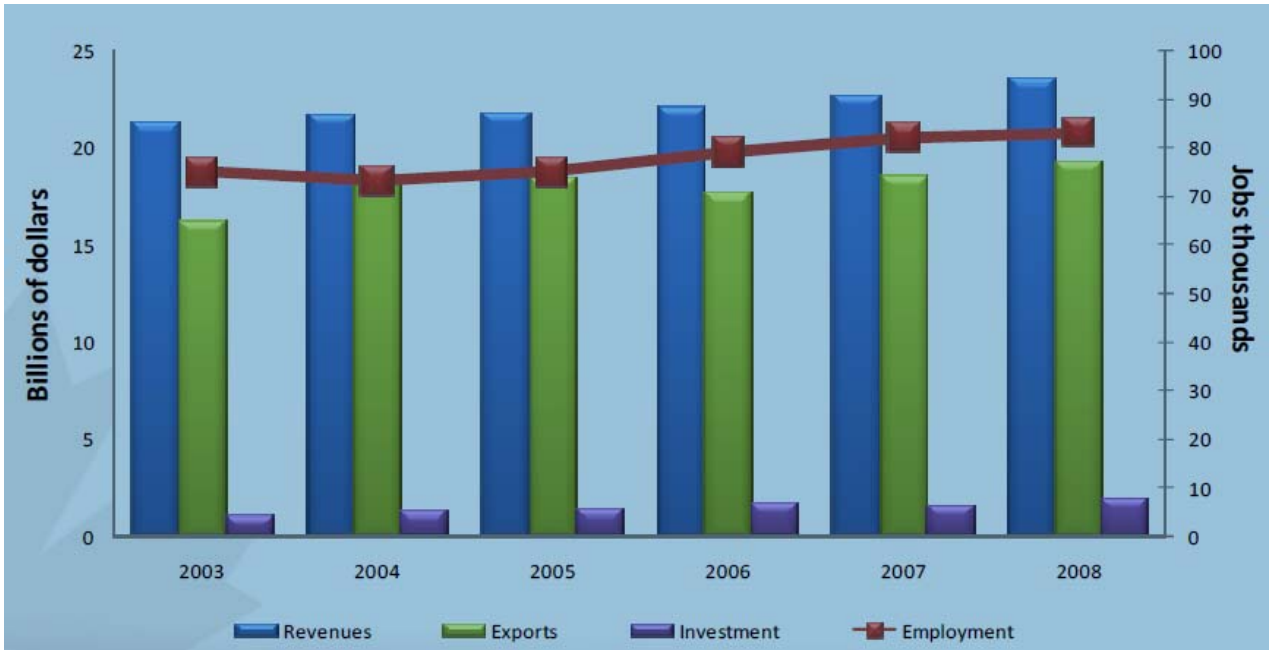
Canada's aerospace industry is a key economic driver…

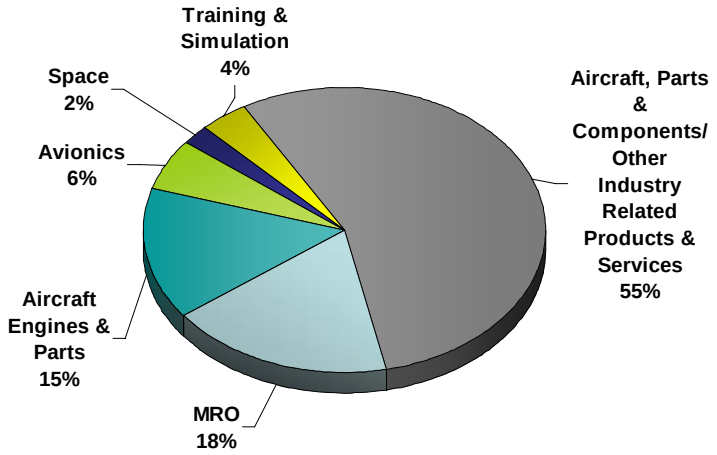
- Civil and defence sales of $23.6 billion in 2008.
- Well-integrated into the global aerospace industry, 82% output exported.
- 11% of all Canadian industrial R&D spending; $1.2 billion in 2006.
- Over 400 firms with over 83,000 employees. 32,000 prof/tech



… and a Strong International Competitor

- 5th in world aerospace sales and employment after US, UK, France and Germany.
- 3rd in world civil aircraft production after US and France.
- Highly oriented to commercial markets
  - 78% of industry output for civil use, *cf.* 44% in USA.
- Several major foreign firms established in Canada.
- Has 5% share of both global aerospace sales and employment.

Canada's Aerospace Products (2008)



Source: Aerospace Industries Association of Canada

Global Leadership (% of global market share)

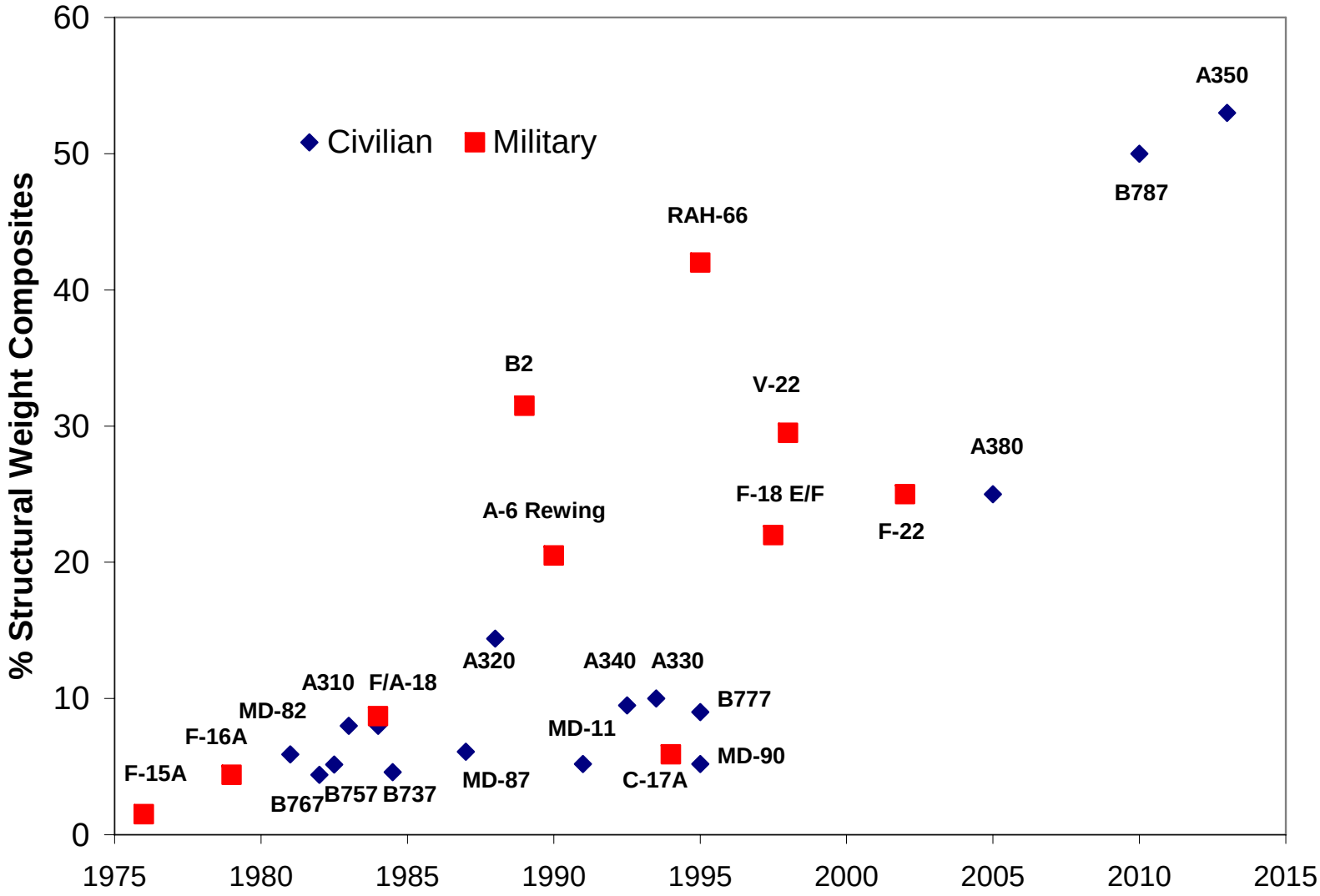
	Regional Aircraft	47%
	Small gas turbine engines	34%
	Visual simulation equipment	70%
	Aircraft environmental control systems	60%
	New large aircraft landing gear	60%
	Civil helicopters	14%

Source: Aerospace Industries Association of Canada, Teal Group, 2006

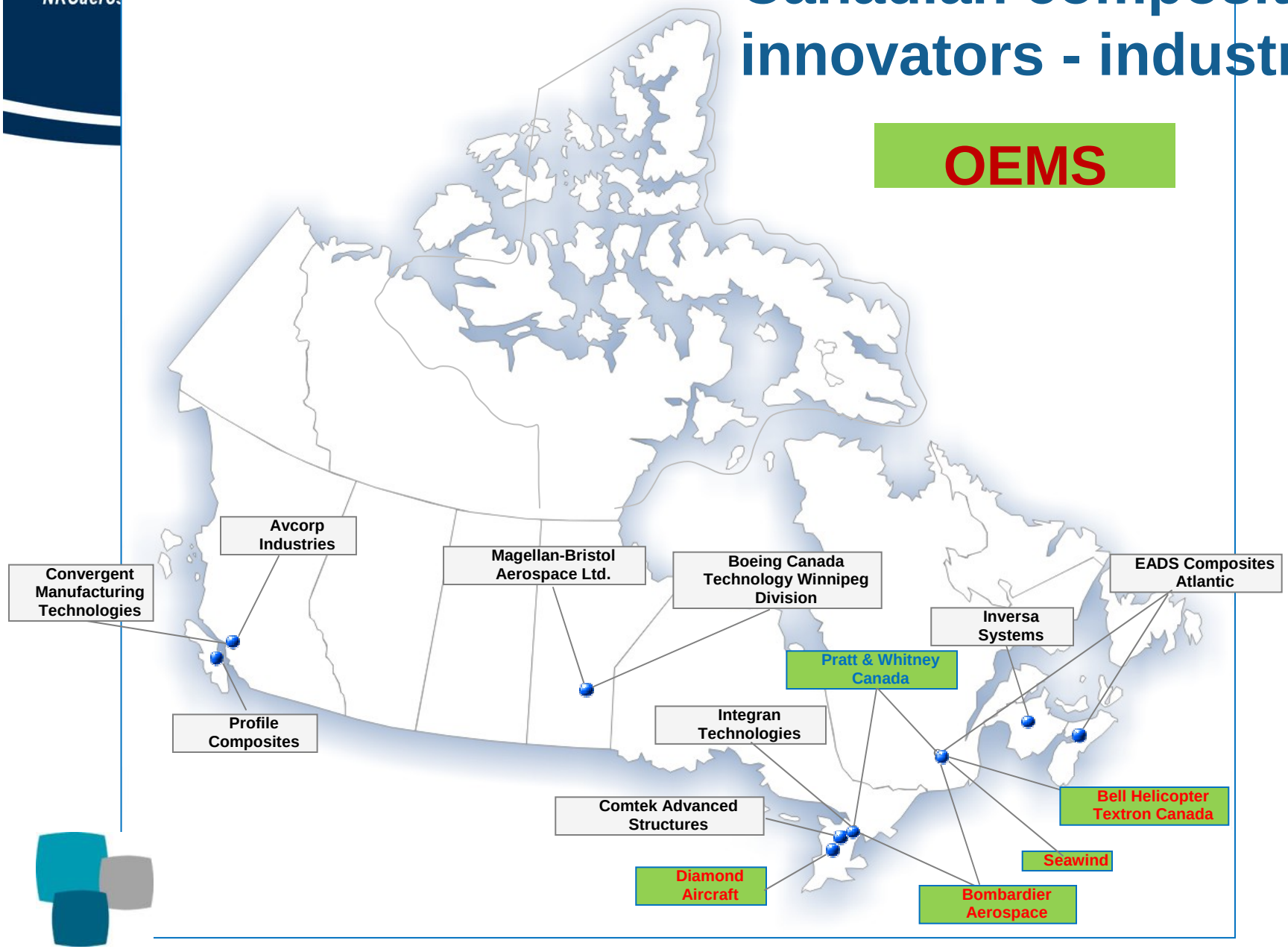
Composites are a High Priority for Canadian Aerospace

- Canadian activities in advanced composites have grown steadily, but relatively slowly over the years
- Significant acceleration since 2000 mirroring growth of composite structures in civil aviation
- Several industry reviews have identified strategic importance of composites to the Canadian aerospace industry
  - 2003 Industry Canada / NRC Competitive Technology Intelligence project undertaken to develop roadmap for aerospace composites technology
  - Industry review of NRC Aerospace programs in 2004 identified Composites as the number 1 strategic technology for the sector (for 2005 – 2010)
  - On-going Future Major Platforms initiative has identified composite materials and related manufacturing processes as critical strategic technologies
- Significant on-going investments by Canadian and provincial governments since 2000 in composites-related infrastructure, research and technology development (R&TD) programs

Growth in Composites Usage in Aircraft Structures



Canadian composites innovators - industry



Seawind Corporation
Montreal, Quebec

- Pennsylvania-based parent now selling Seawind kit aircraft
- Development of FAR 23 certified Seawind 300C Amphibian being undertaken just outside Montreal
- All composite (Glass/Vinyl ester, undergoing flight testing at NRC)
- Target certification date: June 2010

Diamond Aircraft Industries
London, Ontario

- Subsidiary of Diamond Aircraft Industries GmbH of Austria
- Founded in 1992 as Dimona, became Diamond Aircraft in 1996
- Produces several models of all-composite small aircraft out of 250,000 ft^2 production facility in London

DA42 Twin Star

- Light twin-engine utility and trainer aircraft
- Introduced 2004

D-Jet

- 5-seat, single-engine jet aircraft
- Carbon fibre composite structure
- Now undergoing certification out of London facility

Bell Helicopter Textron Canada
Montreal, Quebec

- Canadian division of Bell Helicopter Textron
- Plant opened in 1986, now 2200 employees in Quebec
- As BHT's commercial helicopters division is major producer of civilian helicopters, with 7 different models
- Major user of BMI matrix carbon fibre composites
- Long been sophisticated producer of composites for own use
- Recently been increasing composite technology development investments (example later in presentation)

Bell 407

Bell 429

Bombardier Aerospace
Montreal, Quebec

- Canada's largest aerospace company, 3rd largest OEM in world
- Global express empennage was first primary composite structure certified by Canadian OEM
- Significant recent investments in composites R&D in Montreal

Bombardier C-series

- Will include 46% composite materials
- Al/Li fuselage
- Wings, empennage composite
- Entry into service in 2013

Learjet 85

- First all - composite FAR 25 business jet
- Developed in Montreal, wing and fuselage to be made in Mexico, assembly in Wichita
- Material system for the overall airframe is a low-pressure oven-cured "out-of-autoclave"
- Entry into service in 2013

Canadian composites innovators - industry

Composites Fabricators

Lunenburg, Nova Scotia and Montreal

- Company was founded in 1987 in Lunenburg, Nova Scotia
- Now a subsidiary of EADS Sogerma Services with production and test facilities in Nova Scotia and Montreal,
- Is a leader in the design, analysis and development of advanced composite structures for the aeronautics, defence and space markets.
- Facilities for manufacturing, testing and prototyping
- Integrated capabilities from design & analysis, manufacturing & assembly, to NDI and testing

COMPOSITES ATLANTIC LIMITED
GROUP EADS SOGERMA

COMPOSITES ATLANTIC LIMITED
GROUP EADS SOGERMA

SAMPE Booth 1503

- Wide range of processes, including:
  - Hand lay-up with autoclave/oven curing
  - Liquid Composites Moulding (LCM)
  - Filament / tape winding
  - Compression moulding
  - Thermoforming
  - Automated Fibre Placement
- Invest heavily in product and process development
- Large customer base including Airbus, Boeing, Bombardier, Cessna, Honeywell, MDA, Northrop-Grumman, Goodrich and Spirit.

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COMTEK
Advanced Structures

Burlington, Ontario

- Subsidiary of Avcorp Industries (Vancouver, BC)
- Specializes in design, manufacture and maintenance of advanced composite structures for regional and business aircraft
- Extensive experience in design-build programs
- Maintains an active and innovative technology development program
- Notable capabilities in certification, manufacturing & process development, reverse engineering, materials engineering, material & component testing

A380 evacuation system components

Honeycomb sandwich floors

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COMTEK
Advanced Structures

High Temperature Composites – Engine Inner Bypass Fairing

- Used unique modified cyanate ester resins to achieve both high Tg and toughness, along with a proprietary low cost VARTM type process
- Comtek built prototype composite fairings using low cost UD carbon fabric and two different resin mixes, were manufactured by Comtek
- High-temperature engine tests by well-known aero-engine company gave excellent results
- Fairings resulted in large weight reduction while being cost competitive with aluminum parts

Comparison with OEM duct segment

Installed on test engine

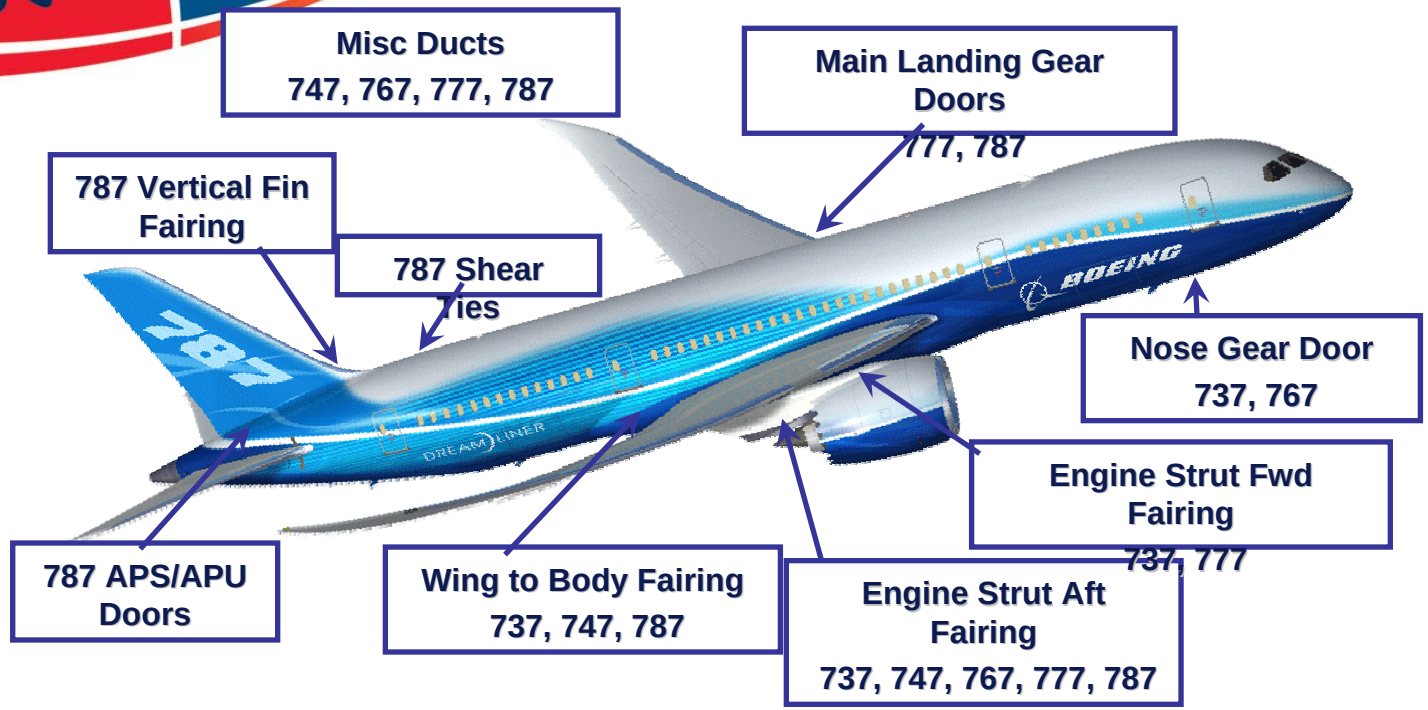
Bristol Aerospace (Magellan) Winnipeg, Manitoba

- Tier 1 and 2 manufacturer producing aircraft structures since 1930s
- Long history in composite materials and structures for aircraft and space structures - first began working with composites in 1960s
- About 100,000 ft2 dedicated space in Winnipeg producing composite components for Boeing, Rolls Royce, Augusta Westland
- Contracted supplier to Lockheed and BAE Systems for epoxy and BMI parts and structures for JSF
  - **First qualified international JSF partner for composites**

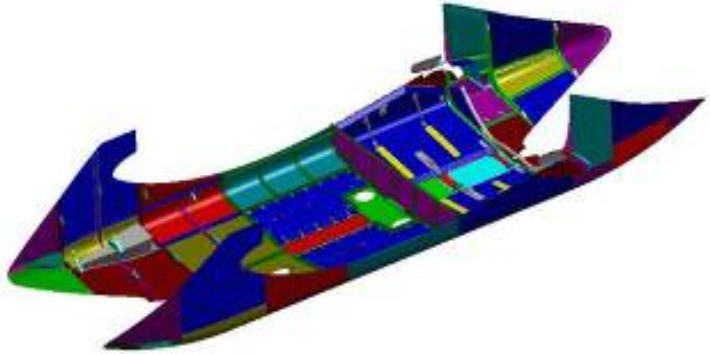
Boeing Canada Technology Winnipeg (Manitoba) Division

- Part of Boeing Commercial Airplane's Fabrication Division, supporting all current airplane models
- Canada's largest producer of advanced composites for aircraft, with about 1400 people and 747,000 ft^2 of fabrication and assembly space.
- Started operations in 1971, making low-complexity fibreglass panels.
  - Expanded operations and complexity of structures to primary and complex secondary structures
  - Now Tier 1 supplier for 787-8
- Some Boeing Winnipeg processes:
  - Autoclave processing, core forming, complex structure assembly
  - Machine-assisted lamination and hot drape forming

Boeing Winnipeg Product Walk Around



787 Main Landing Gear Door



787 Wing to Body Fairing

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Profile Composites

Sidney British Columbia

- Highly innovative small company, designing, developing and producing composite products for several industry sectors
- Technologies and Capabilities
  - Out-of-autoclave
  - Liquid (closed) moulding, RTM and VARTM
  - Hot-tool press and bladder molding
  - In-house complex metal RTM tooling design and fabrication
- Major Partners
  - A&P Technologies; NCMS; Bayer; Toray Carbon Fibers; Camosun College; University of Victoria; NASA White Sands; NRC/HIA

All-Carbon A/C Float

RTM Carbon/Ep Propeller

Carbon/Magnesium Hybrid Door w/ Battelle PNNL

Carbon/Ti Wheelchair for US VA

Current development activities

- Ultra-light, all composite UAVs
- Accelerated manufacturing of wind-turbine blade components
- High-rate production of hydrogen/natural gas storage tanks
  - 20 minute cycle times, with in-situ cure and health monitoring
- High-volume production for 17x15-m radio antenna reflectors



RTM High-Pressure COPV
Profile Composites Technology Lead
Winner 2009 JEC-Paris Composites Innovation Award for Transportation
Rapid Manufacturing of High-Pressure Carbon Composite Storage Tanks
Partners: A&P, Bayer, NASA, NCMS, Toray CFA




35-foot Hi-Precision Radio Antenna
NRC – DRAO Lead Organization
Winner 2009 JEC-Asia Composites Innovation Award for Aerospace
Cost-effective infusion Manufacturing of Kevlar/Carbon Composite Structures for Very Large One-Piece Reflectors

Antenna Reflectors for the Square Kilometre Array

- Composite radio telescope development has been ongoing at NRC/HIA Dominion Radio Observatory (DRAO) since 2006
- DRAO contributing to Square Kilometer Array (SKA) radio telescope project, developing Composite Antenna Reflectors, up to 15 m dia.
  - More than 1000 of these structures would be required for SKA!
- Composites offer high stiffness and high thermal stability.
- Liquid moulding offers a cost-effective approach for mass-production
- A 10m demonstrator (Mk1) showed the potential of materials, design and fabrication method, but had problems with dimensional control
- Profile Composites worked with DRAO to develop MkII design / process
- Now working on design / process development for high-volume production of 15 m reflector version

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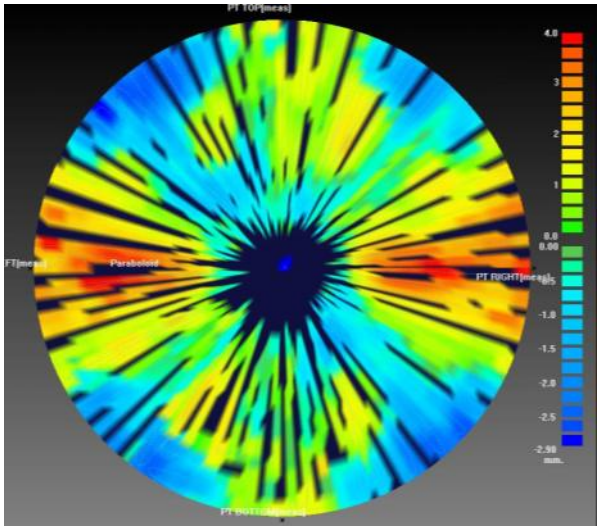
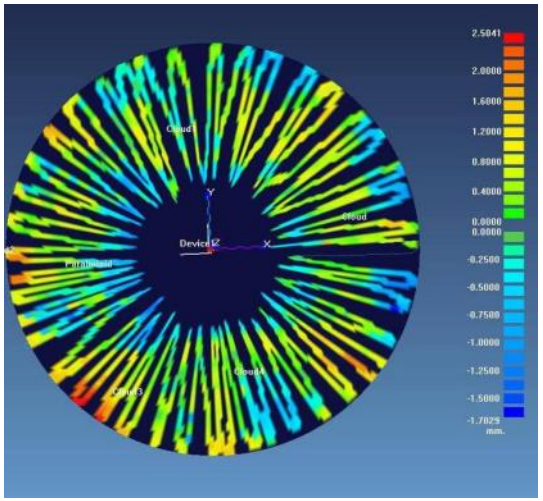
Composite Antenna Reflectors: Process Improvement with Profile Composites

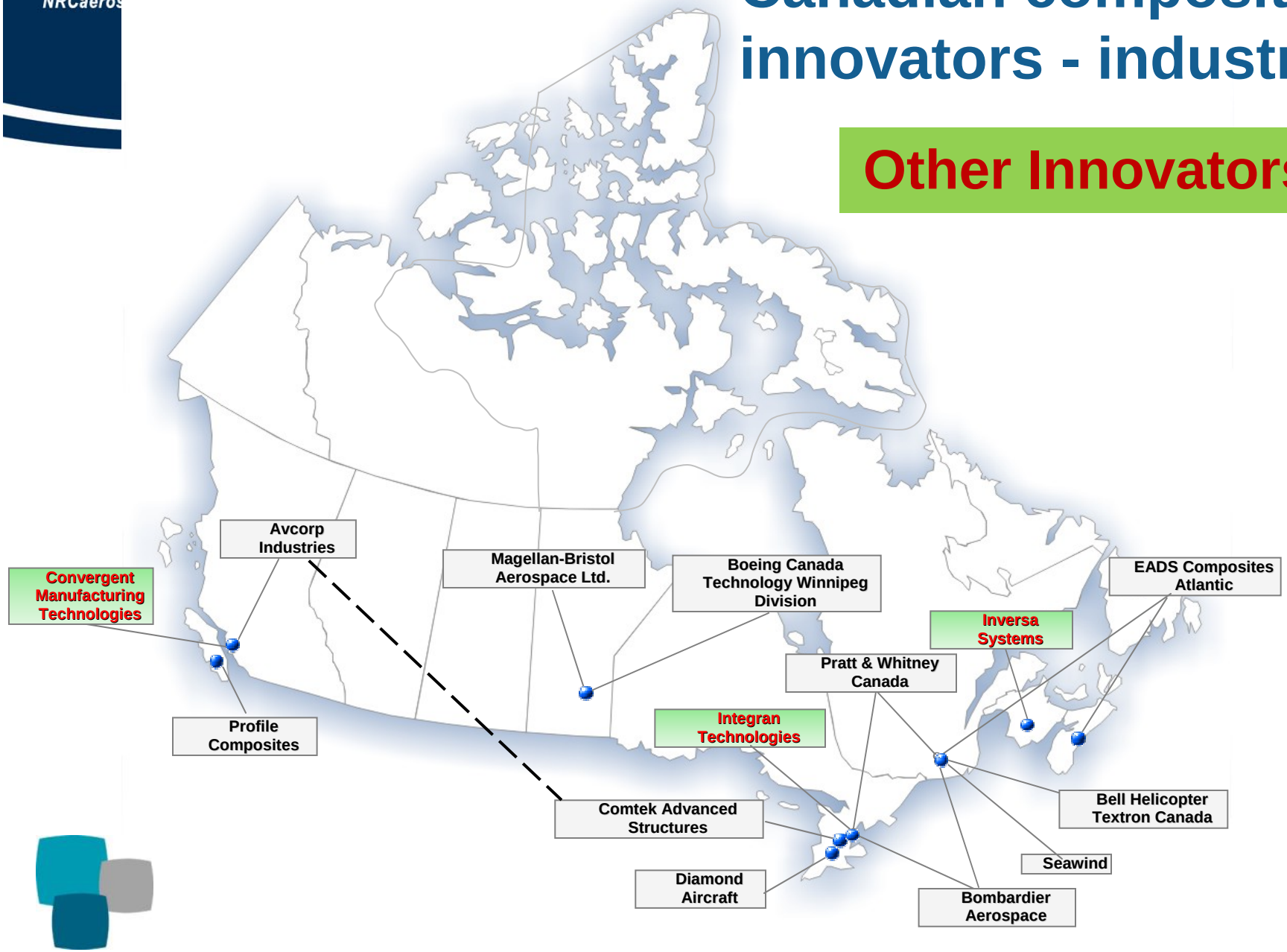




Significant improvement in dimensional tolerances and ease of fabrication of MkII (right) versus MkI (left). All objectives achieved.

Canadian composites innovators - industry

Other Innovators



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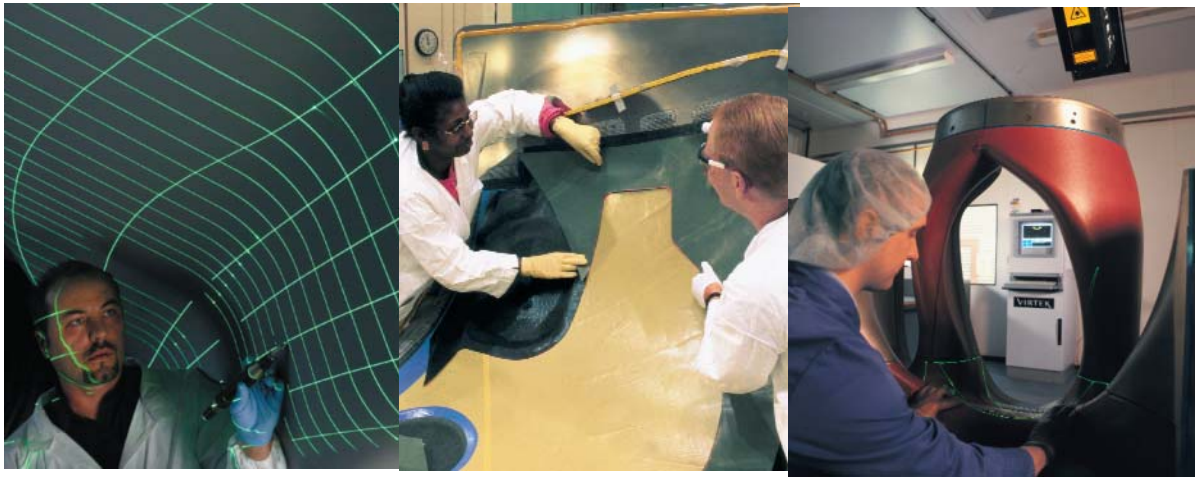
Virtek
Waterloo, Ontario

SAMPE Booth 512

- Founded in 1986 in Waterloo
- Owned by Gerber Technology, a Gerber Scientific company
- Core competency is driving a laser beam quickly and accurately
- Have developed a broad portfolio of patents and wide range of products for several sectors including aerospace
- World leaders in laser projection for composite ply alignment and assembly processes



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inversa SYSTEMS

Specialty inspection services

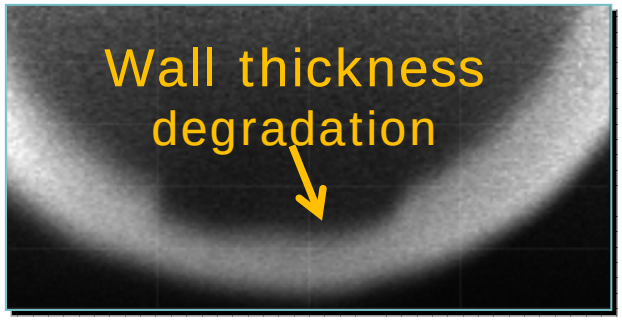
Developed Backscatter Computed Tomography technology

- Portable device
- Single-side access

Industrial composite application: Fiberglass Reinforced Plastic (FRP) structures in chemical plants

BCT Scanner

Inspection of FRP Pipe



CT Image

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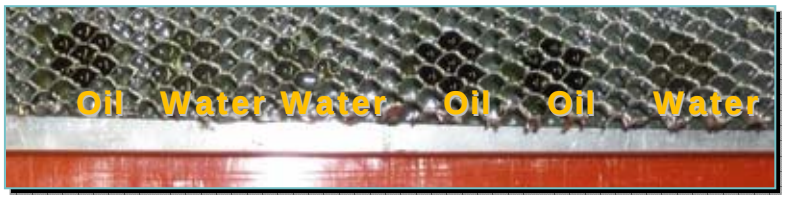
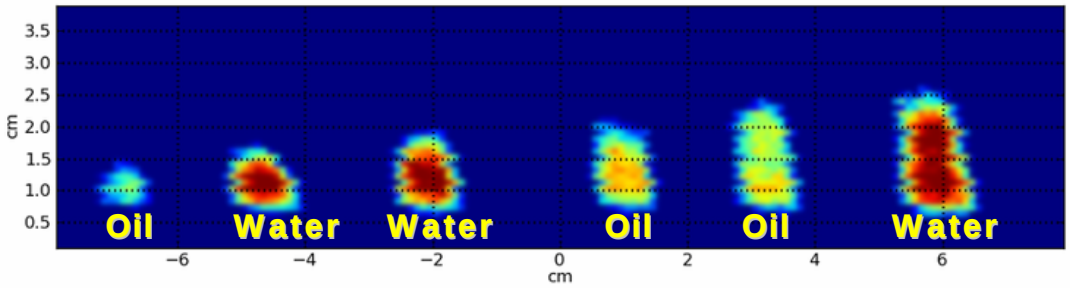
inversa SYSTEMS

Example Aerospace Application: Fluid Ingress in Honeycomb

- Carbon/epoxy face-sheet section bonded to aluminum honeycomb with various volumes of oil and water
- Single-side and portable inspection through carbon/epoxy face-sheet
- BCT can distinguish oil (yellow) from water (red)
- Provides fluid volume and location measurement



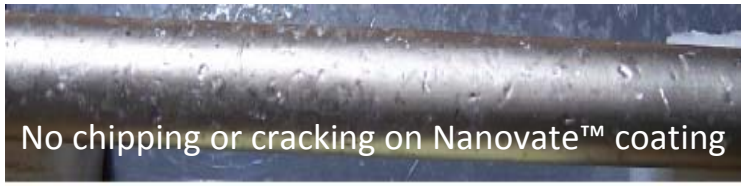


Integran Technologies Inc
Toronto, Ontario

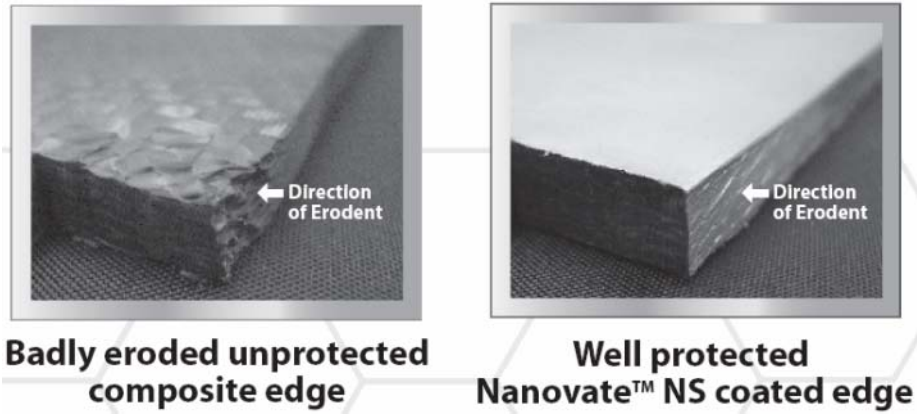
High-performance metallic coatings for composites

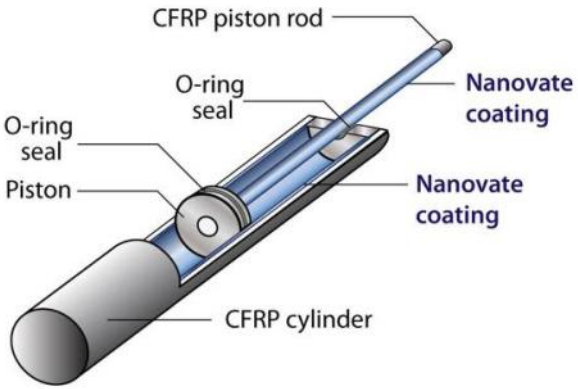
- Nanovate™ NS metallic coating protects composites with low weight penalty
- Increases impact damage tolerance, improves erosion protection and reduces wear/ abrasion

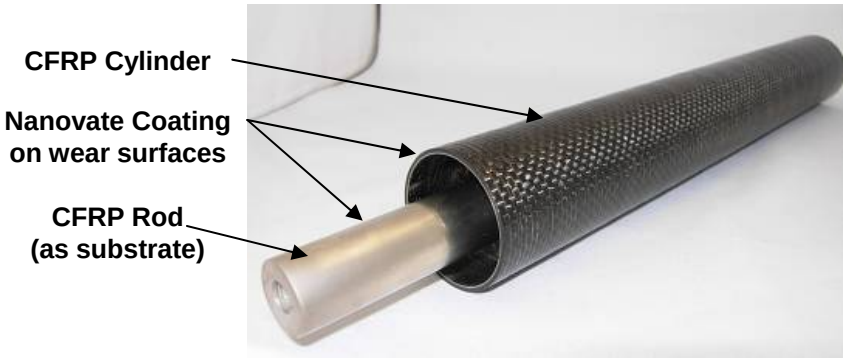
Impact Resistance



Erosion Protection







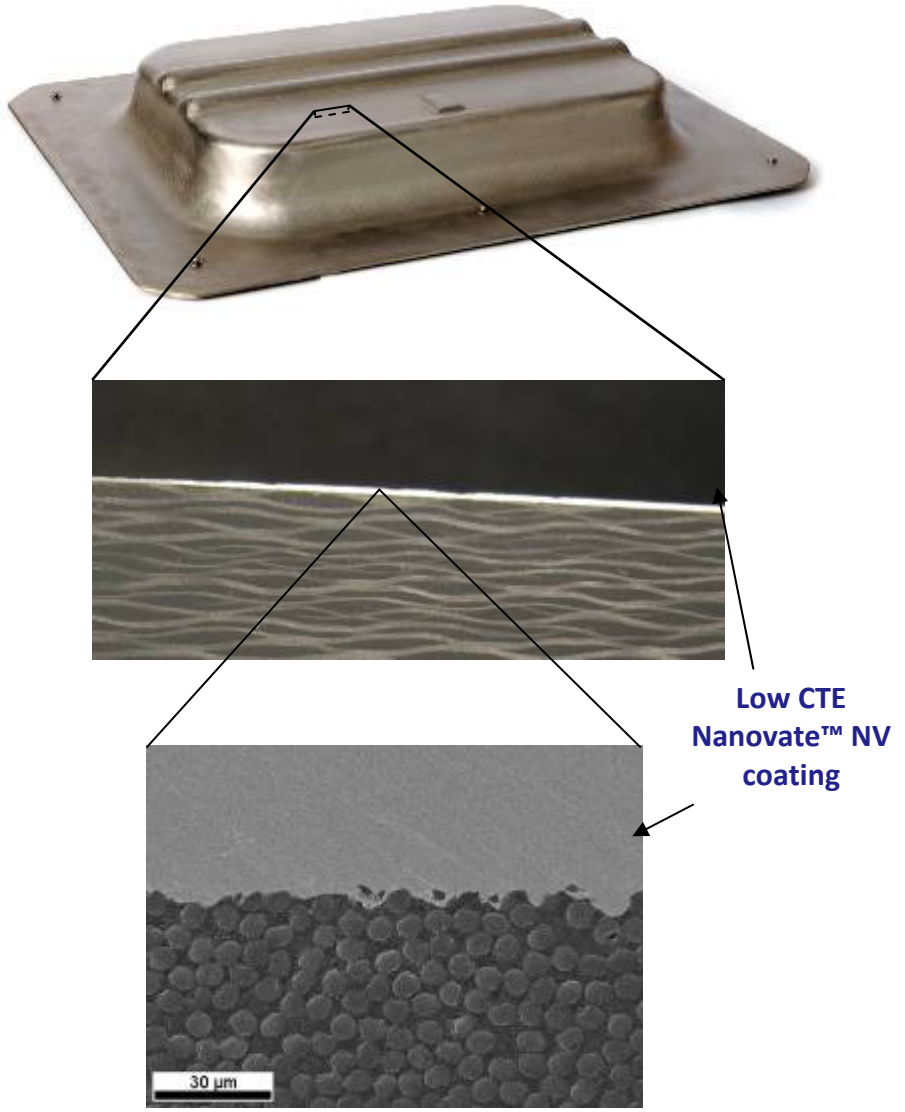
Integran Technologies Inc

SAMPE Booth 1606

When applied to tooling, Nanovate™ NS metallic coating…

- Increases durability of by adding hard, low CTE surface coating
- This reduces manufacturing wear and tear and vacuum leaks
- Lower thermal mass and lower cost than Invar tools

- Undergoing joint development with ACG (UK) to complete validation



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CONVERGENT
MANUFACTURING TECHNOLOGIES

Vancouver, BC

REDUCING RISK IN COMPOSITES PROCESSING

- UBC spin-off (1998)
- World leader in efficient process design support tools
- International clientele and partnerships
- Extensive applications experience
  - New *product* development support
  - New *material* development support
  - New *process* development support

Created to bridge the gap between fundamentals and application in a still-maturing technology area

Gave process modelling seminar at SAMPE 2010

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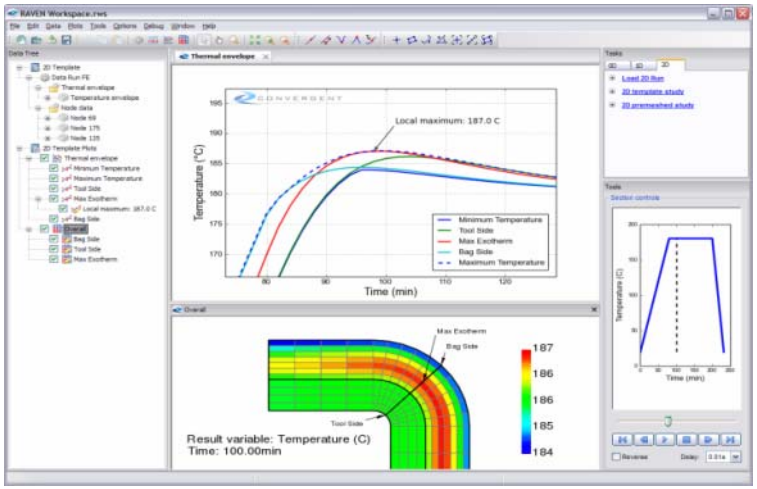
NRCaerospace

CONVERGENT
MANUFACTURING TECHNOLOGIES

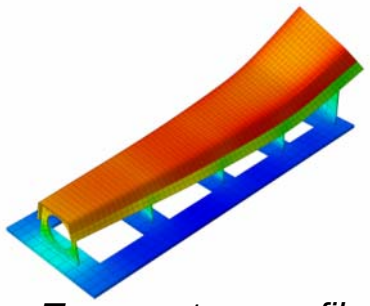
SAMPE Booth 222

REDUCING RISK IN COMPOSITES PROCESSING

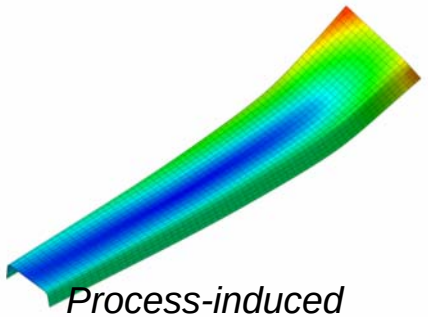
- SOFTWARE
  - Easy to use: $RAVEN_3$
  - FEM: COMPRO/CCA
  - Customer specific modules
- SERVICES
  - Full program support
  - Training and technical consulting
  - Materials, process, and facilities characterization
  - Proprietary R&D



$RAVEN_3$ software



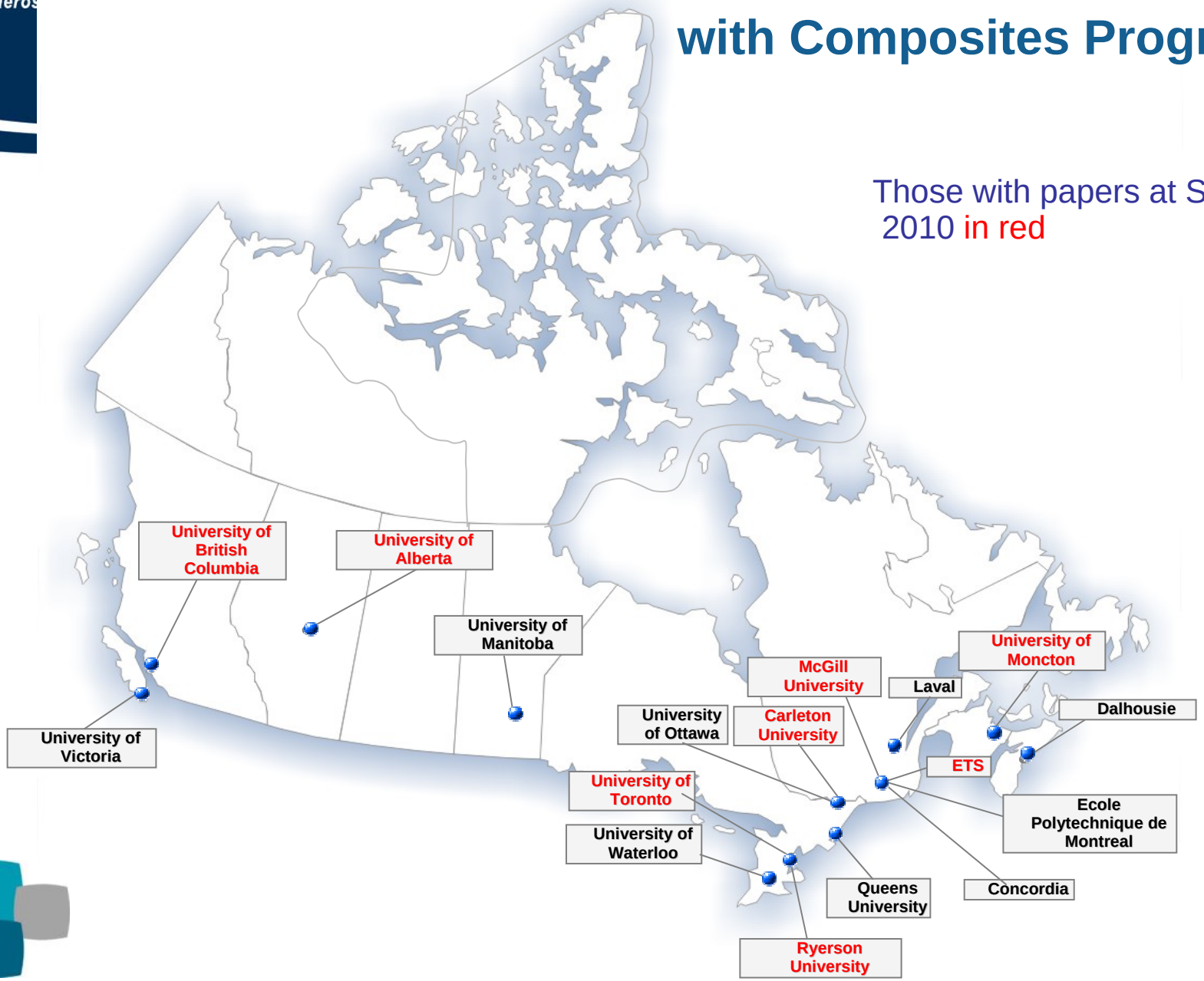
Temperature profile during cure



Process-induced deformations

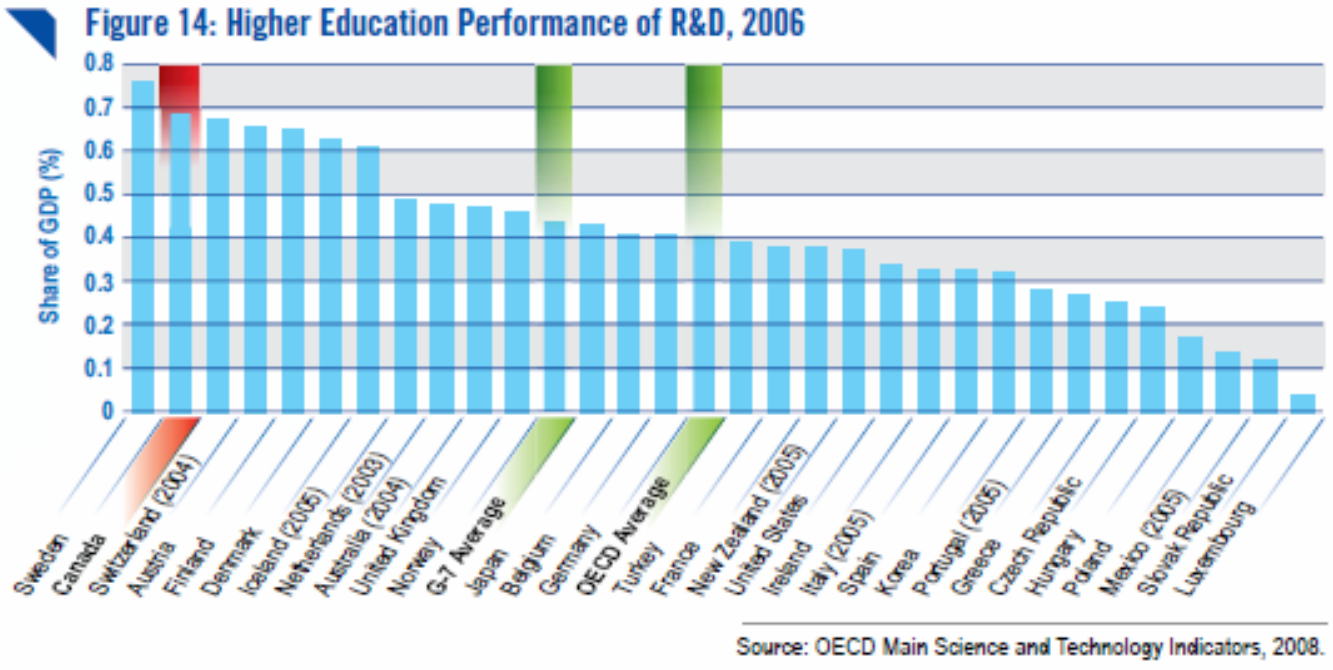
Some Canadian Universities with Composites Programs

Those with papers at SAMPE 2010 in red



Canadian Universities and Composites

- Canadian investment in university-based R&D is high compared to international norms
- Investment in university research in advanced composites has grown rapidly in recent years



Canadian Universities and Composites

- Canada has world-class university research programs in advanced composites from coast-to-coast
- Many universities have excellent linkages with the Canadian and international aerospace and automotive industries, including those in British Columbia and, especially, in Montreal.
- Canada is very active in organizing international composites-related conferences, including SAMPE 2010, for which SAMPE Eastern Canada is the co-sponsor..
- Second Joint ASC-CACSMA Conference, Montreal, September 26-28, 2011 (www.cacsma.ca)
- 19th International Conference of Composite Materials, ICCM-19, Montreal, 2013 (watch www.cacsma.ca)

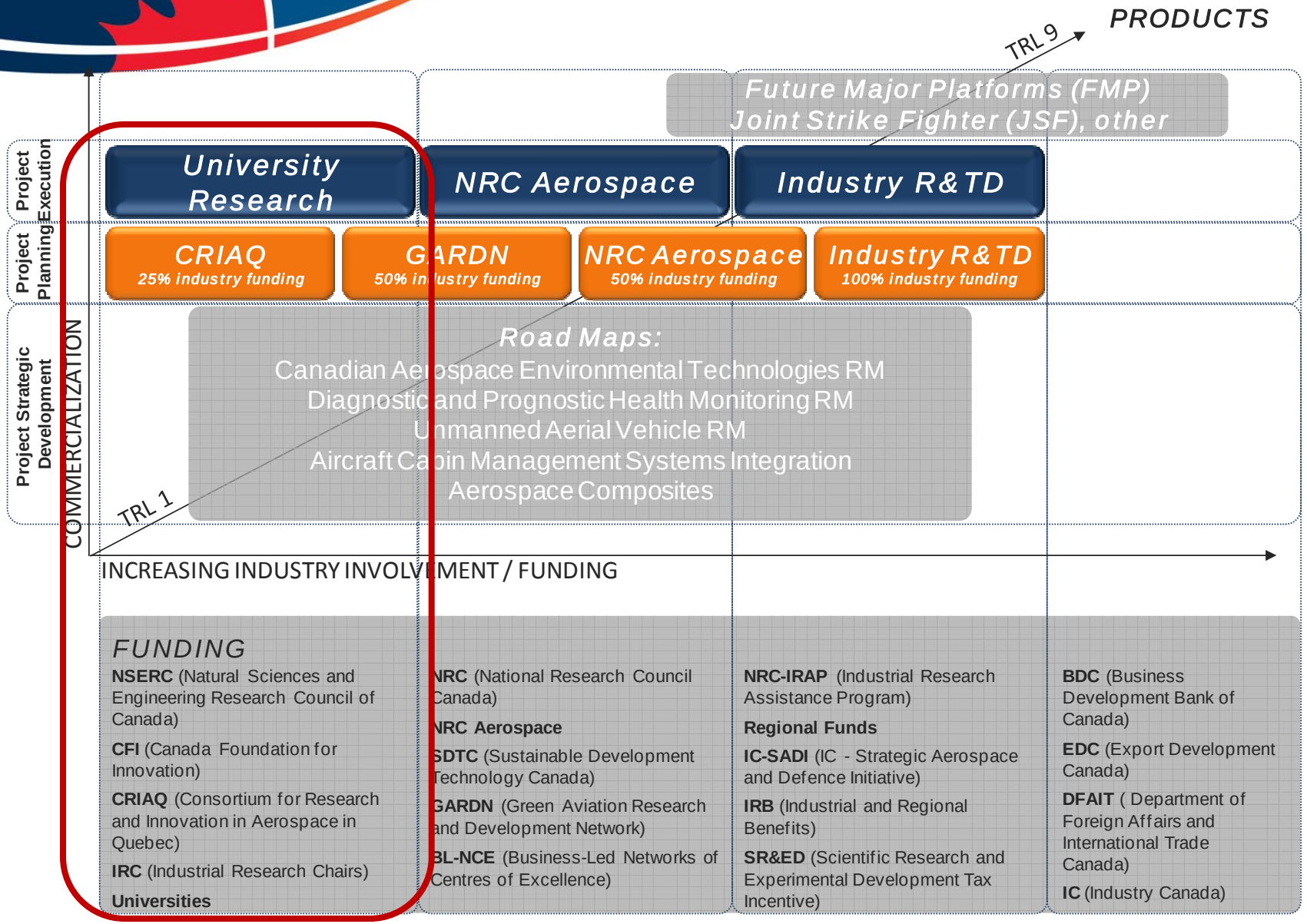
Canadian Universities at SAMPE 2010

- Some of the areas of research being presented at SAMPE 2010 include (by session name):
  - Process modelling
  - Nanocomposites
  - Liquid moulding
  - Space Applications
  - Structural Health Monitoring and Nondestructive Characterization
  - Design and Analysis
  - Novel Architectures, Hybrids, & Coatings
  - Out-of-autoclave
  - Thermoplastic Composites
  - Automated Fiber Placement
- Wednesday, Featured Lecture 2:00 – 2:50 PM, Room 307-308, “Natural Materials”, Mohini Sain, U of Toronto

The Canadian Innovation System: Supporting R&TD

- The Canadian innovation system provides support from basic research (low TRL) through to product development and productionization (high TRL)
- Increasing levels of funding have been made available in recent years aimed at the strategic aerospace sector, including composite materials and manufacturing
- Support for composites R&D has also come from various “green” programs, including those aimed at bio-based materials
- Also key to the composites innovation system are government-funded organizations with the mandate to “bridge the gap” between low TRL and high TRL activities

Aerospace Innovation in Canada



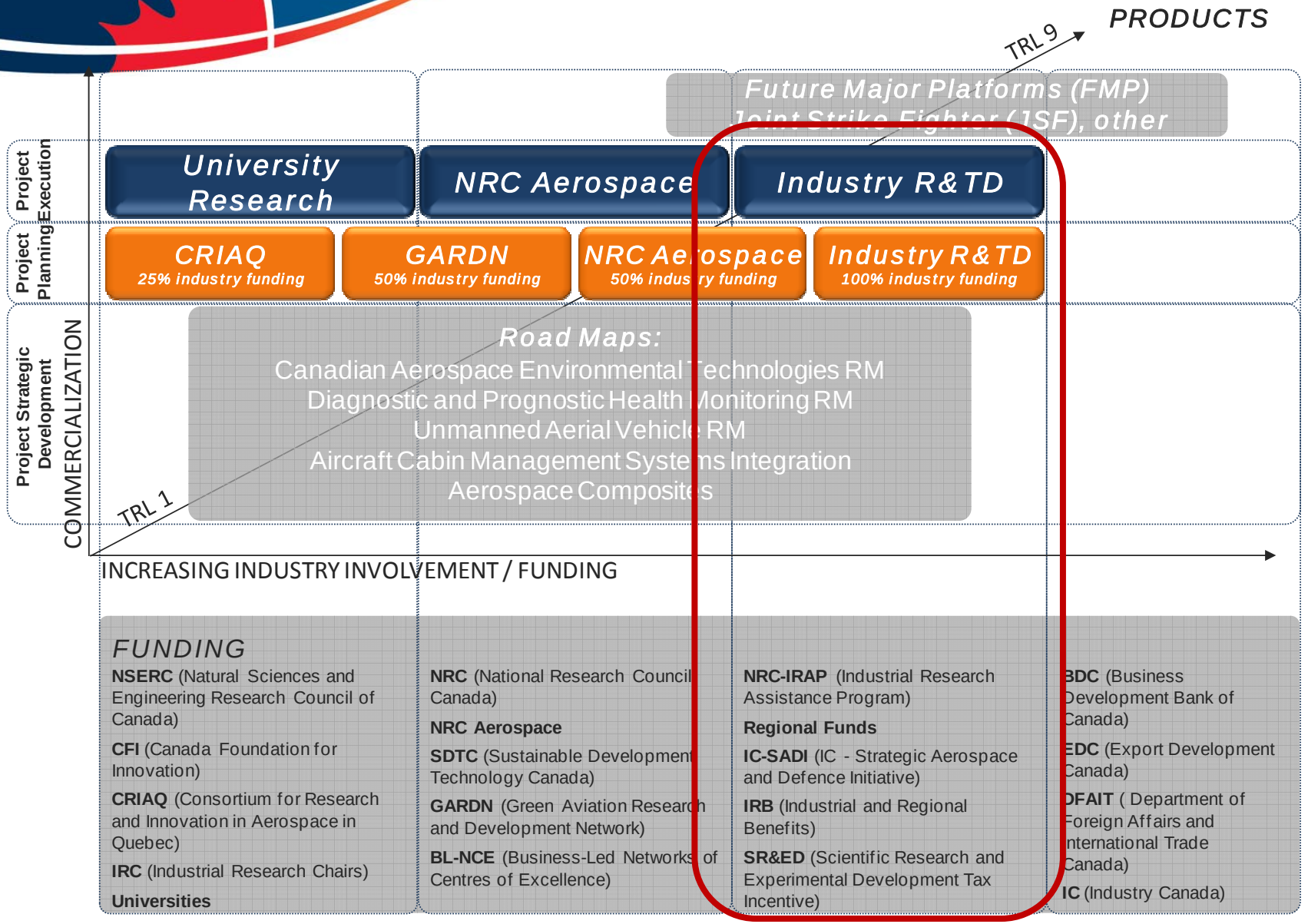
Innovation at Lower TRLs

- **NSERC** – Federal funding for University Research $400M invested annually in Discovery Grants, $300M in “innovation”

- **Canada Foundation for Innovation** - $600M annual funding primarily for innovation infrastructure in universities

- **CRIAQ** – Quebec-based innovation fund for pre-competitive generic-based industrial research (>25% industry contribution). $15M public funds invested over 6 years. Thrusts are:
  - **Composites**
  - Acoustics
  - DPHM
  - Environmental Issues
  - **Manufacturing**
  - MDO
  - Avionics
  - Life-Cycle Management

Aerospace Innovation in Canada



FUNDING

NSERC (Natural Sciences and Engineering Research Council of Canada)

CFI (Canada Foundation for Innovation)

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

IRC (Industrial Research Chairs)

Universities

NRC (National Research Council Canada)

NRC Aerospace

SDTC (Sustainable Development Technology Canada)

GARDN (Green Aviation Research and Development Network)

BL-NCE (Business-Led Networks of Centres of Excellence)

NRC-IRAP (Industrial Research Assistance Program)

Regional Funds

IC-SADI (IC - Strategic Aerospace and Defence Initiative)

IRB (Industrial and Regional Benefits)

SR&ED (Scientific Research and Experimental Development Tax Incentive)

BDC (Business Development Bank of Canada)

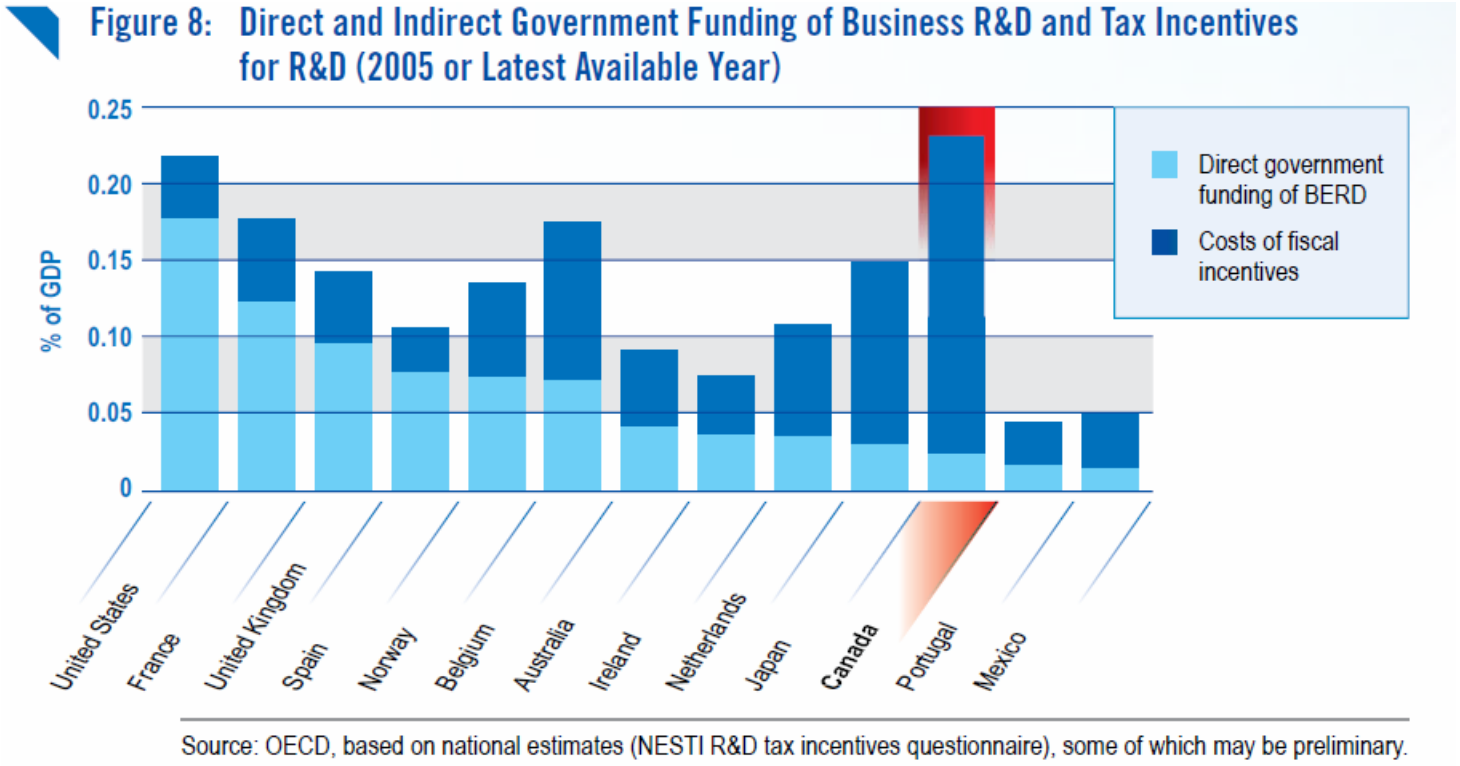
EDC (Export Development Canada)

DFAIT (Department of Foreign Affairs and International Trade Canada)

IC (Industry Canada)

Government Support for Industry R&D (high TRL)

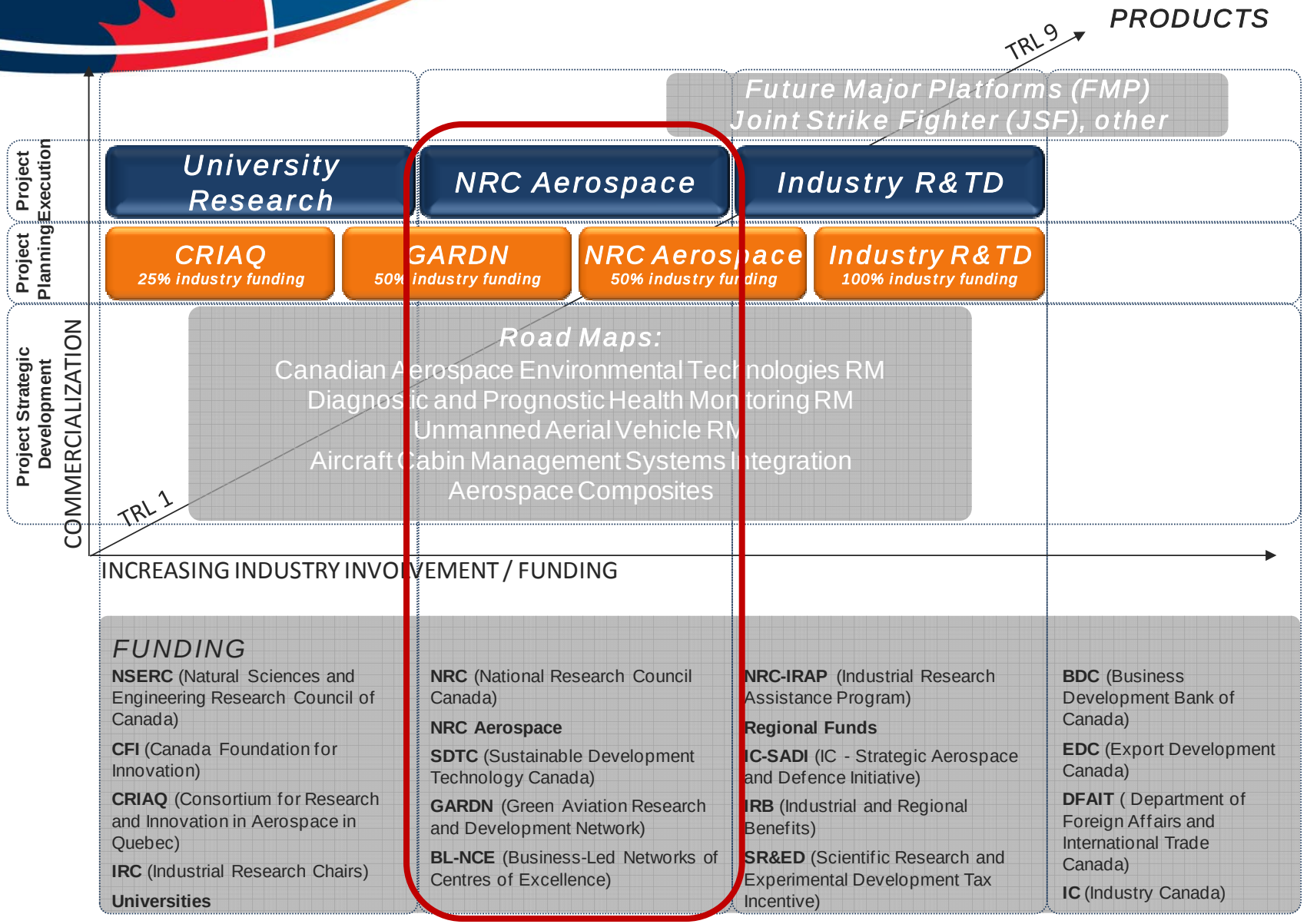
- Direct Canadian government support for Industry R&D is modest
- Total support, including incentives such as tax credits, is substantial



Higher TRL support

- Strategic Aerospace and Defence Initiative (SADI)
  - Launched April 2, 2007 under Industry Canada
  - Provided $900 million over 5 years to Canadian aerospace and defence industries in repayable contributions for strategic R&D projects (up to 30% of total eligible costs)
  - Additional $200 million funding was announced in 2009.
- Industrial Regional Benefits Policy (IRB)
- Leverages federal government procurement to generate long-term industrial and regional development
- Contractual commitment by prime contractors to place work in Canada equal to 100% of contract value
- Includes over 50 major procurements and >$20 billion CND in offset obligations
- Recent policy changes have increased flexibility, including providing significant leverage for R&D investments in Canada

Aerospace Innovation in Canada



FUNDING

NSERC (Natural Sciences and Engineering Research Council of Canada)

CFI (Canada Foundation for Innovation)

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

IRC (Industrial Research Chairs)

Universities

NRC (National Research Council Canada)

NRC Aerospace

SDTC (Sustainable Development Technology Canada)

GARDN (Green Aviation Research and Development Network)

BL-NCE (Business-Led Networks of Centres of Excellence)

NRC-IRAP (Industrial Research Assistance Program)

Regional Funds

IC-SADI (IC - Strategic Aerospace and Defence Initiative)

IRB (Industrial and Regional Benefits)

SR&ED (Scientific Research and Experimental Development Tax Incentive)

BDC (Business Development Bank of Canada)

EDC (Export Development Canada)

DFAIT (Department of Foreign Affairs and International Trade Canada)

IC (Industry Canada)

Mid TRL Support

NRC Industrial Research Assistance Program

- Program supporting R&D for small-to-medium enterprises (SMEs)
- Large network of Industrial Technology Advisors (ITAs) across Canada
- Provide a wide range of technical and business advisory services

Green Aviation Research and Development Network (GARDN)

- A business-led Network Centre of Excellence
- $12M funding over 4 years
- 50% industry contributions

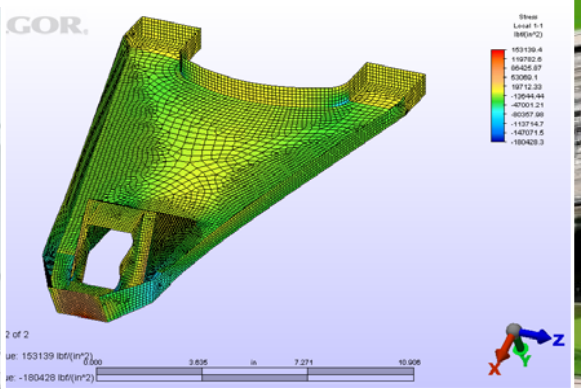
Government-supported R&TD Organizations

- Composites Innovation Centre
- National Research Council Canada - Research Programs

Composites Innovation Centre
Winnipeg, Manitoba

- Industry-led Not-For-Profit corporation, established in 2003
- Assist industry in development & commercialization of composite applications & technologies
- Catalyst for attracting new composite industry & start up companies in Manitoba & Western Canada. Very active on national and international level.
- Sectors supported: Aerospace, Ground Transportation, Civil Infrastructure and Industrial Applications
- Capabilities: Bio-materials, Composite Design, Processing, Testing, Prototyping, Recycling, Project Management
- Specialize in planning & coordinating collaborative projects of all sizes






Composites Innovation Centre
Winnipeg, Manitoba

International Collaborations (Non-client)

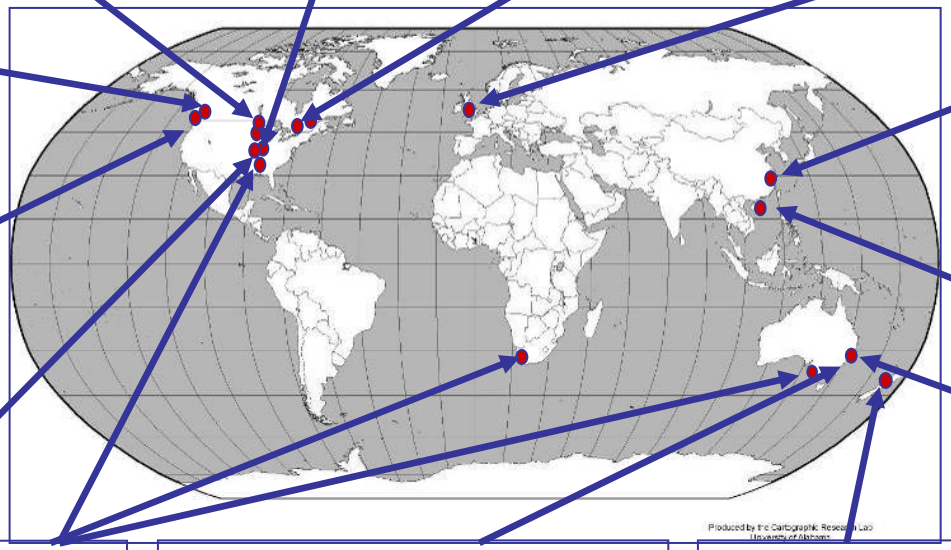
MOUs/Pending Agreements: RRC, University of Manitoba, Industrial Technology Centre

Boeing Supported Aerospace Consortium Development – St Louis

MOU National Research Council – IAR, IMI, AMTC

Technology Partnership Discussions – AMRC Sheffield, UK

Okanagan Composite Manufacturing Group – Programs / Collaborations



Research Centre of China Hemp Materials Discussions

University of British Columbia - Research Collaboration

MOU University of Hong Kong Science and Technology

MOU National Composite Center – Ohio, USA

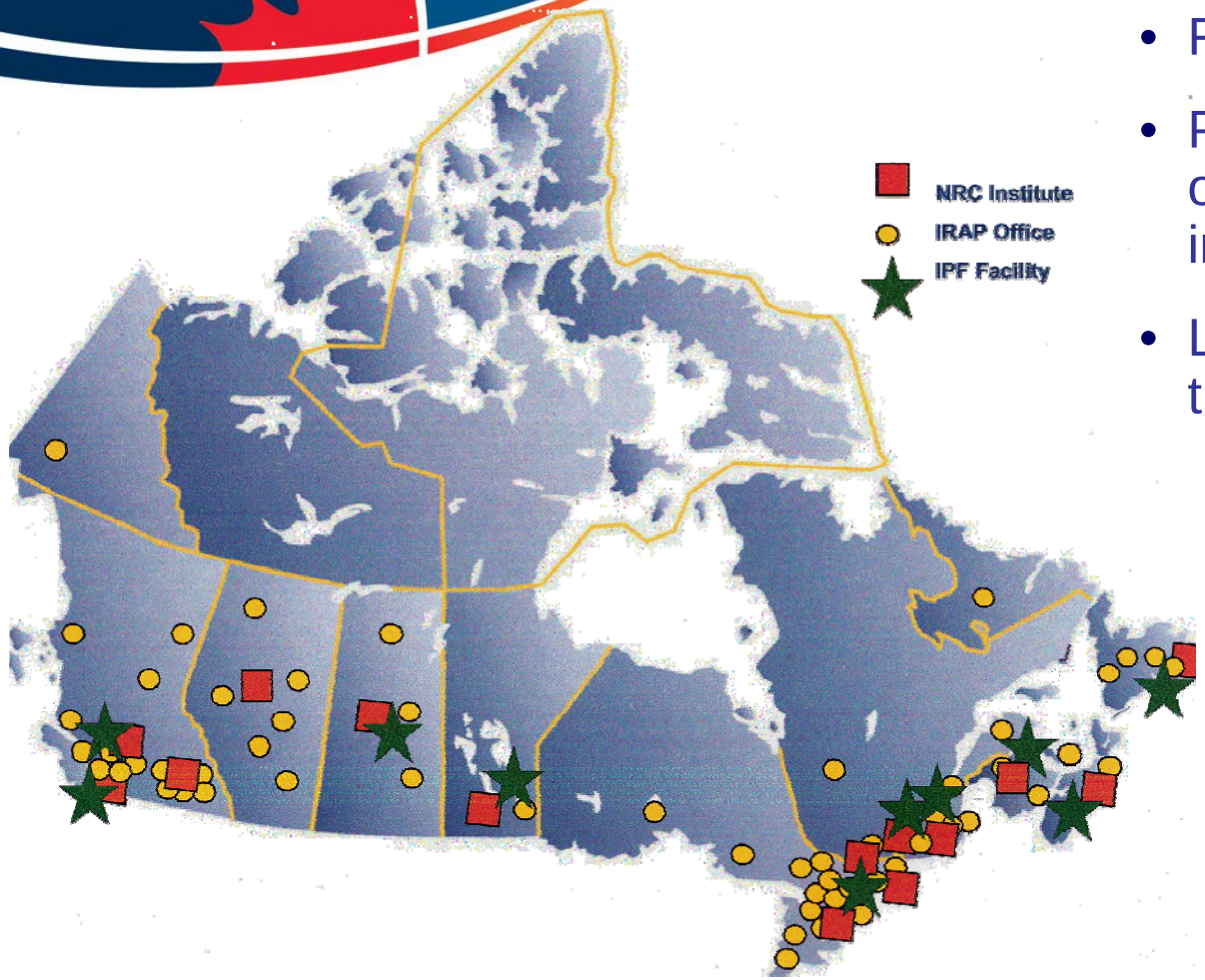
Queensland Universities – Professor sabbaticals

Biocomposites International Research Network Member

MOU – CRC-ACS Composite Centre - Melbourne

SCION Research Collaboration

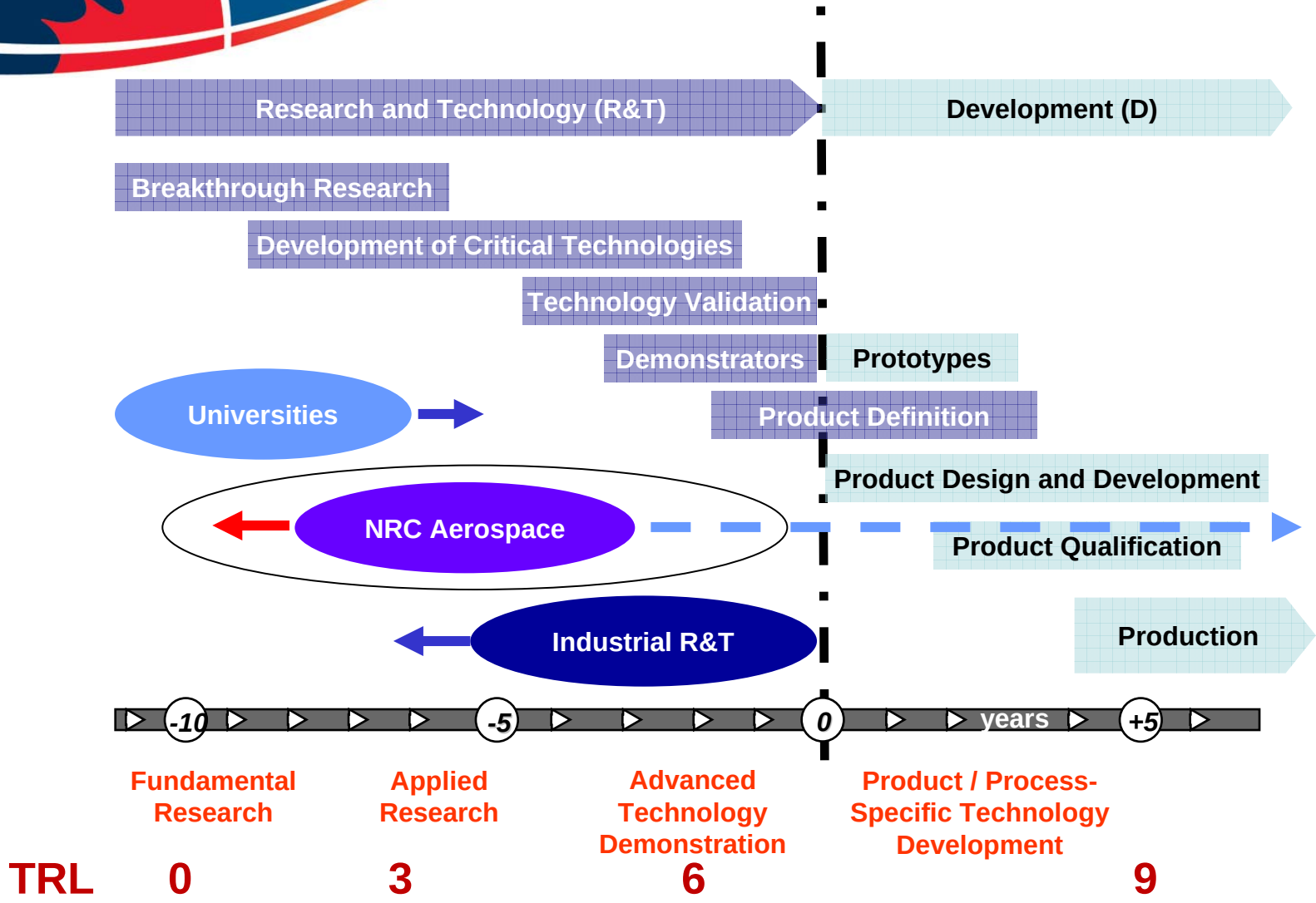
National Research Council Canada: A National Institution



- Federal government agency
- Provides essential elements of national S&T infrastructure
- Labs and facilities across the country
  - 20 research institutes
  - Industrial Research Assistance Program
  - Industrial Partnership Facilities
  - CISTI (National Technical Library)

Staff: Approx. 4,300 employees; 1,500 visiting / guest workers
Total expenditures 2009-10: **$840 M**
Total Income 2009-10: **$160 M**

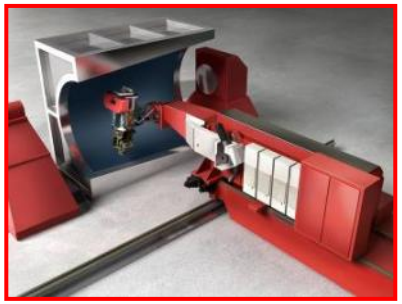
NRC role in the R&TD continuum

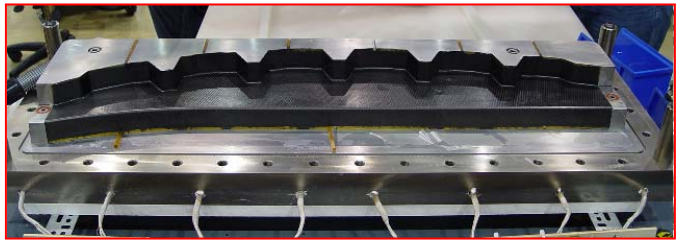


NRC Composites Activities

SAMPE Booth 635

- Canada's largest and most comprehensive composites R&TD program
- Major composites activities within **Institute for Aerospace Research** (Ottawa, Montreal) and **Industrial Materials Institute** (Montreal).
- Key areas of activity include:
  - Process automation, including automated fibre placement
  - Joining technologies (bonding and welding)
  - Conductive heating technologies
  - Liquid moulding technologies
  - Forming processes
  - Composites life-cycle management
  - Bio-derived and nano-modified polymers and composites
- Serve aerospace, defence, ground transportation and industrial sectors





NRC Activities in Bio-based Polymers and Composites

Platform

Polymers and bio-based composites

Technologies and materials

2000 → 2005 → 2006-10 →

Project Wood-PP

Natural fiber composites
Thermoplastic starch
PLA nanocomposites

National Bioproducts Program

Technology Group

Industrial Sectors

Ground transportation
Construction

- Packaging
- Biomedical
- Transportation
- Energy
- Sport
- Aerospace

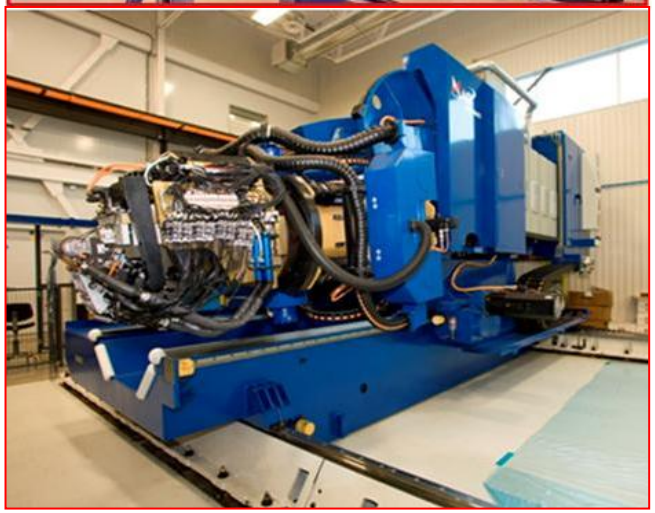
NRC Automated Fibre Placement Capabilities

ADC Machine

- Equipped with thermoset (1” band width) and thermoplastic (0.25” and 0.5” band width) heads
- Thermoset placement head for 8 tows of 0.125”
- Thermoplastic placement head for 1 tow of 0.25” or 0.5”
- Fiber placement programming system

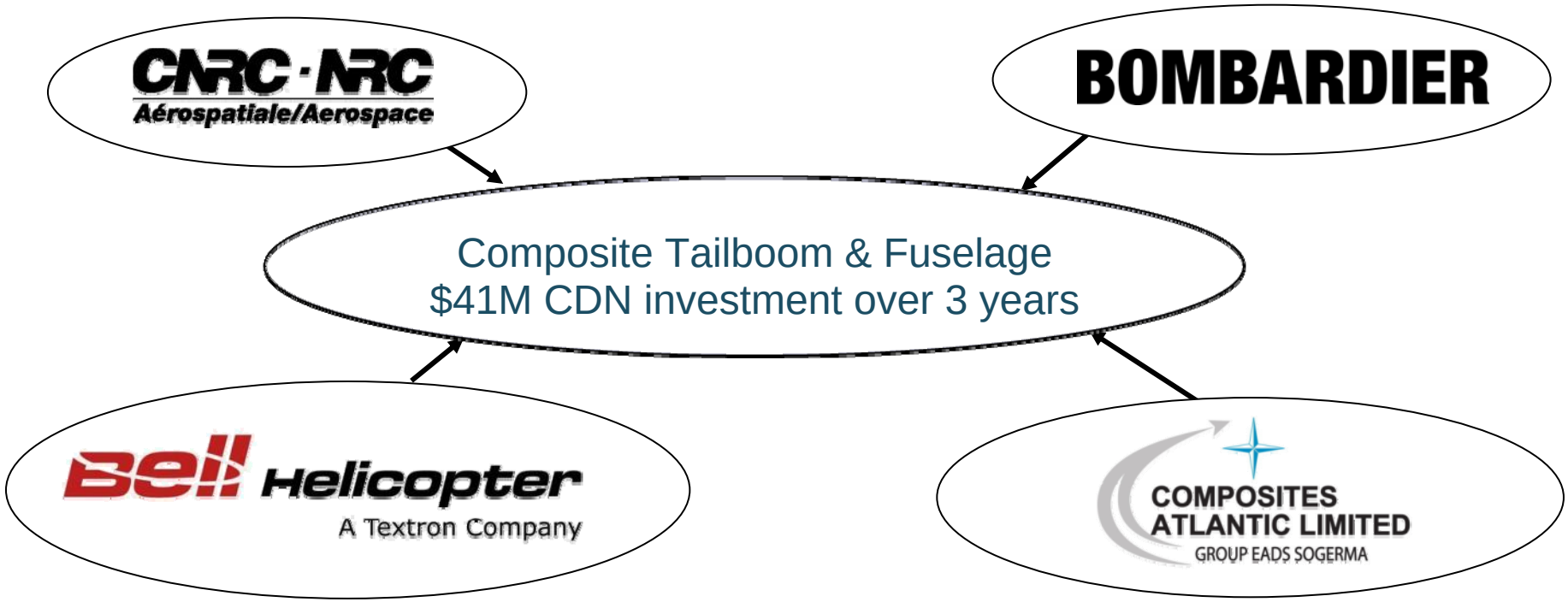
Cincinnati Machine Viper 4000,

- Equipped with a thermoset head
- Placement head for 32 tows of 0.125”
- Capable of handling IML and OML tools
- Fiber placement programming and simulation
- System commissioned in Montreal mid-2008
- NRC machine located at Composite Atlantic



AFP (Automated Fiber Placement) Demonstrator Project

- Collaborative Automated Fibre Placement technology demonstration project
- Partnership involving an SME (Composites Atlantic), OEMs (Bombardier and Bell Helicopter) and government (NRC)
- By far the largest composites demonstrator project ever conducted in Canada



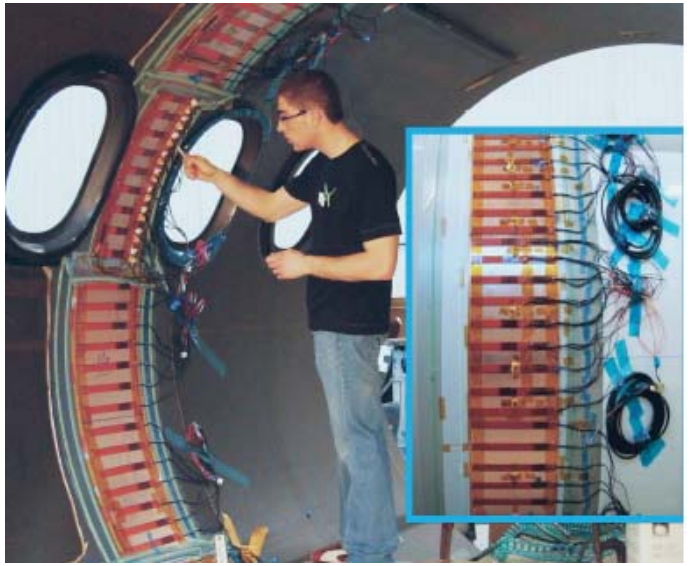
AFP (Automated Fiber Placement) Collaboration Phases

- Initial collaboration on all-composite helicopter tailboom demonstrator involved Bell Helicopter, Bombardier and NRC, using NRC's Automated Dynamics AFP machine.
- Follow-on collaboration on composite fuselage section, added Composites Atlantic and used NRC's Viper 4000 AFP machine (support from Development Economic Canada - DEC).
- Both demonstration projects functioned using an IPT approach with members from all participating organizations

Key Project Outcomes

- Both phases of activity were excellent technical successes and proved an excellent case study for collaborative technology development
- The knowledge and competencies developed by the participants will be foundational for the future of aerospace composites in Canada
- New phases of activity already being initiated

Sandwich fuselage shell with AFP slit tape material from Cytec



Out-of-autoclave radial adhesive joining of barrel sections using NRC heating technology

Wrap-up and Conclusion

- Canada has a long history of innovation and a world-class aerospace industry
- Canada started a bit slow in composites, but innovation across the spectrum has greatly accelerated in recent years
  - Driven by technology maturation, market forces and development of critical competencies across the country
  - Supported by accelerating government and industry investment, university research programs and a strong innovation infrastructure
- There are numerous mechanisms to support international involvement in the rapidly emerging composites sector. The NRC and our partners are eager and willing to engage with you – talk to us!

NRC·CNRC
NRCaerospace

Go Canada, Go!

NRC·CNRC
NRCaerospace

Some contacts…

Bell Helicopter Textron Canada Ltd.	www.bellhelicopter.com/
Boeing Canada Technology Winnipeg Division	www.boeing.ca
Bombardier Aerospace	www.bombardier.com
Bristol Aerospace Ltd.	www.bristol.ca
Composites Atlantic Ltd.	www.compositesatlantic.com (Booth 1503)
Composites Innovation Centre	www.compositesinnovation.ca
Comtek Advanced Structures	www.comtekadvanced.com
Convergent Manufacturing Technologies	www.convergent.ca (Booth 222)
Diamond Aircraft Industries	www.diamondair.com
Integran Technologies Inc.	www.integran.com (Booth 1606)
Inversa Systems	www.inversasystems.com
Profile Composites	www.profilecomposites.com
Seawind Corporation	www.seawind.net