

Bombardier Strategic Technology: Preparing the Future of Business and Commercial Aviation



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Future Major Platforms
Canada's model for future global positioning
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Forward-looking Statements

This presentation includes forward-looking statements. Forward-looking statements generally can be identified by the use of forward-looking terminology such as “may”, “will”, “expect”, “intend”, “estimate”, “anticipate”, “plan”, “foresee”, “believe” or “continue” or the negatives of these terms or variations of them or similar terminology. By their nature, forward-looking statements require Bombardier Inc. (the “Corporation”) to make assumptions and are subject to important known and unknown risks and uncertainties, which may cause the Corporation’s actual results in future periods to differ materially from forecasted results. While the Corporation considers its assumptions to be reasonable and appropriate based on current information available, there is a risk that they may not be accurate. For additional information with respect to the assumptions underlying the forward-looking statements made in this presentation, please refer to the respective sections of the Corporation’s aerospace segment (“Aerospace”) and the Corporation’s transportation segment (“Transportation”) in the F06 MD&A.

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SUMMARY

- **Preamble**
 - Aerospace Industry, a priority for Canada
 - Specific Aspects of the Aerospace Industry
 - The New Competitive Landscape
 - Canada Aerospace Industry Needs
- **Key criteria for being on Future Major Platforms**
- **Aerospace Technology Innovation Chain: Europe and Canada**
 - Why an FMP Technology Demonstrators Program
 - Objectives of the FMP Technology Demonstrators Program
- **Bombardier Aerospace Leadership in National Technology Collaborative Programs**
 - CRIAQ, CAETRM, GARDN, FMP
- **Technology Demonstrator: Composite structures for Aircraft Fuselages**
 - Top Level Objectives
 - Technologies to be demonstrated
 - Potential Collaborators
 - Benefits of the Project
- **Conclusions**

Aerospace: A Priority for Canada

- **Specific Aspects of the Aerospace Industry**
 - Safety Considerations and Regulation
 - Product Lifetime
 - Intensive Capital Needs
- **The New Competitive Landscape:**
 - Globalization
 - The Environment
- **Canada's Aerospace Industry Needs**
 - Strengthened Canadian Original Equipment Manufacturers
 - Improved SME's and Equipment Manufacturers Competitive Position on Future Major Platforms

Canada Aerospace Industry in Numbers

- **400 firms, 83 000 employees, \$23.6 billion in 2008**
- The country's leading advanced technology exporter (more than 80% of output is exported)
- Global market leaders in regional and business aircraft, avionics, commercial helicopters, aircraft engines, flight simulation, landing gear and space systems
- Globally competitive suppliers for structures, electronics, systems, communications and maintenance, repair and overhaul



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Specific Aspects of the Aerospace Industry

- **Safety Considerations and Regulations**
 - Lead to long and expensive aircraft development cycles: 5 to 10 years to develop and validate new technology before selection on an aircraft program
 - Example: composites, more electric systems, advanced navigation systems
- **Product Lifetime**
 - Aircraft remain in service for 20 to 30 years
 - Technologies implemented today will affect the environment for the next 40 years
- **Intensive Capital Needs**
 - Launch of a new product requires intensive capital investment
 - It is therefore crucial to reduce the risks of introducing new technology, hence the absolute need for a *technology demonstration phase*

The New Competitive Landscape

■ Globalization: Increased Competition

- Strengthened Traditional Competitors: USA, Western Europe, Russia, Brazil, Japan
- Emerging Countries: China, India, South-Korea; low-cost and well supported by government infrastructure programs
- To strive in this new competitive environment, Europe and the USA are changing the game and establishing strong and durable product discriminators
 - Launch of technologically advanced new platforms (composites, more electric aircraft, integrated avionics) with the emphasis on protecting the environment

■ The Environment

- Public opinion and the new environmental regulations require the development of aircraft with a lower environmental footprint

To remain competitive, the Canadian Aerospace Industry must be positioned for this technological change

Canada Aerospace Industry Needs

- **Strengthened Canadian Original Equipment Manufacturers**
 - Strengthen Existing Canadian Aerospace Innovation Networks (Institute for Aerospace Research, national and provincial research consortia)
 - Complete the Chain of Innovation by Establishing a Canadian Technology Demonstrator Framework Program
- **Improved SME's and Equipment Manufacturers Competitive Position on Future Major Platforms**
 - Insure Participation of SME's in Technology Demonstrator Programs
 - Increase the potential of selection of Canadian Suppliers on new domestic and international platforms

Technology demonstrator programs were launched in Europe and the USA to support to their OEMs, SMEs and Equipment Manufacturers

Key Criteria / capabilities for Suppliers To be on Bombardier and other OEM's Future Platforms

(1 of 2)

- **Commercial considerations**
 - Financial health
 - Competitiveness of offer (Total Life Cycle Cost)
- **Technical capabilities**
 - Design competencies
 - Simulation/test capabilities
 - R&D capabilities
- **Operations/Manufacturing capabilities**
 - Quality and on time delivery focus
 - Lean manufacturing
 - Robust processes
- **Program Management skills:**
 - Change management
 - (technical, manpower, process)
 - On Site support

*To be
Strengthened by
FMP Technology
Demonstrator
Program*

Key Criteria / capabilities for Suppliers

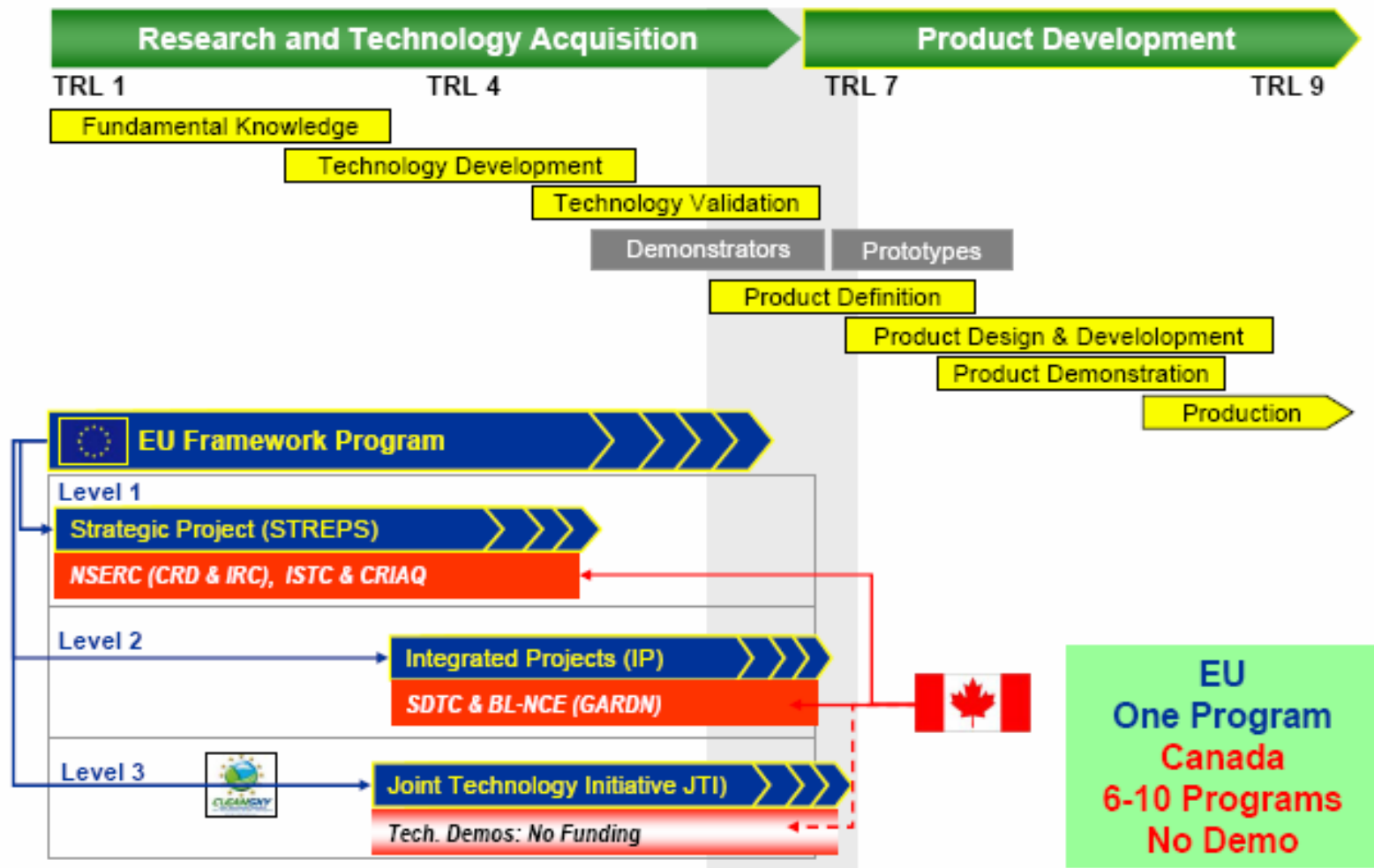
To be on Bombardier and other OEM's Future Platforms

(2 of 2)

- **Corporate Social responsibility**
 - Adherence to Bombardier's Supplier Code Of Conduct
 - Commit to the principles of United Nations Global Compact
 - Certified OHSAS 18001 or equivalent; ISO 14001 or equivalent
 - Participate in a CSR network
- **Aftermarket capabilities**
 - Technical support
 - Service centers availability
- **Support of marketing & sales activity**
- **Quality**
 - Affiliation with international organizations (NADCAP, IAQG...)
 - AS9100 approved; Certified to a recognized QMS
 - Approved by a government regulatory agency

Aerospace Technology Innovation Chain

A Comparison of the European and Canadian Systems



TRL: Technology Readiness Level

Why an FMP Technology Demonstrator Program?

- **The Canadian Aerospace Industry invests continuously in Research and Development**
- **The rhythm of R&D investments, affected by the economic slow-down, must be strengthened to respond to the growing challenges of Globalization and the Environment Imperative**
- **There is a need to improve Canadian SMEs competitiveness in order to increase Canadian Contents on Future Platforms**
- **A new program is needed to fill the growing gap between the needs of the OEMs and the capacity of the Canadian Supply Chain to fill these needs**

In Canada, there is currently no Framework Program to support aerospace technology demonstration, as can be found in most other major aerospace countries

Objectives of the FMP Technology Demonstrators Program

- **Bring new technologies to Readiness level 7 by 2014 for application to new platforms beginning in 2017**
- **Reinforce the Canadian supply chain and increase Canadian export**
- **Cater to the technology needs of Canadian SME's through collaboration between Canadian OEM's, SME's and equipment manufacturers; this partnership will also help develop the processes needed to apply successfully these new technologies**
- **Develop Highly Qualified Personnel for the Aerospace Industry; universities will be associated to the FMP technology demonstrator programs**

Maintain Canada's competitive position in a rapidly changing world market

Bombardier Aerospace Leadership in National Technology Collaborative Programs

- A founding and key member of CRIAQ (Consortium pour la Recherche Industrielle au Quebec)
 - Bombardier is leading or participating in 31 collaborative research programs involving 6 OEM's, 13 SME's, 4 equipment manufacturers, the national research council and several universities in Canada

MEMBERSHIP

Industries (36)	
Universities Research Centres (13)	
Associate (7)	



Bombardier Aerospace Leadership in National Technology Collaborative Programs

Co-chair of the CAETRM (Canadian Aviation Environment Technology Road Map) with the National Research Council;
 The Roadmap identified key technologies to be demonstrated in the FMP program

- **Bombardier Aerospace**
- **NRC - CNRC**
- **Air Canada**
- **OAC**
- **AQA**
- **Pratt & Whitney Canada**
- **Bell Helicopter Textron Canada Inc.**
- **Rolls-Royce Ltd.**
- **CRIAQ**
- **Standard Aero**
- **Aero Montreal**
- **Industry Canada**
- **AIAC**
- **Messier-Dowty**
- **Transport Canada**



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Bombardier Aerospace Leadership in National Technology Collaborative Programs



- **A founding and key member of GARDN (Green Aviation Research and Development Network), a new federally sponsored business-led network of centers of excellence**
 - In this network, Bombardier is collaborating with 5 companies and 7 universities

The Canadian Aerospace Industry has a long tradition of collaborative research and Bombardier's role has been pivotal in many of these associations

GARDN Eight Research Themes



Emissions

Noise



Icing

Aircraft
Operations

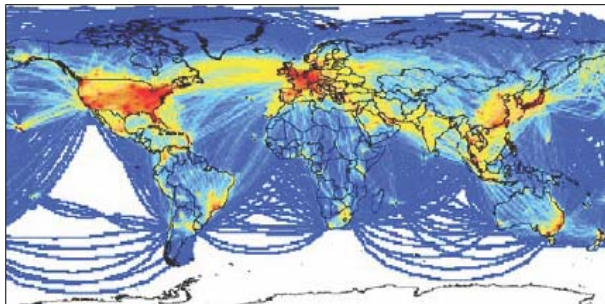
Performance

Alternative
Fuels

Product Life Cycle
Management



Materials &
Manufacturing
Processes



Bombardier Aerospace Leadership in Future Major Platform Technology Roadmap

- **Member of the FMP technology committee**
- **Proposed the SAGE concept for future platforms**
- **Helped build the table of FMP technologies**

SAGE: Identifying future aviation technology drivers

The aircraft of the future will be:

SMART Systems	<ul style="list-style-type: none">▪ Integrated and intelligent systems,▪ Air transport system optimization▪ Enhanced passenger comfort
AFFORDABLE Initial and Operating Cost	<ul style="list-style-type: none">▪ To build: design, manufacturing and materials▪ To operate: reduced fuel consumption, maintenance and navigation fees
GREEN Environmentally Friendly	<ul style="list-style-type: none">▪ 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	<ul style="list-style-type: none">▪ Advanced aero concepts , Advanced materials, more electric airframe▪ Power management systems, Integrated thermal management of propulsion system, Value added innovative design

CAETRM: Technology Needs and Capability

Canadian Aviation Environmental Technology RoadMap

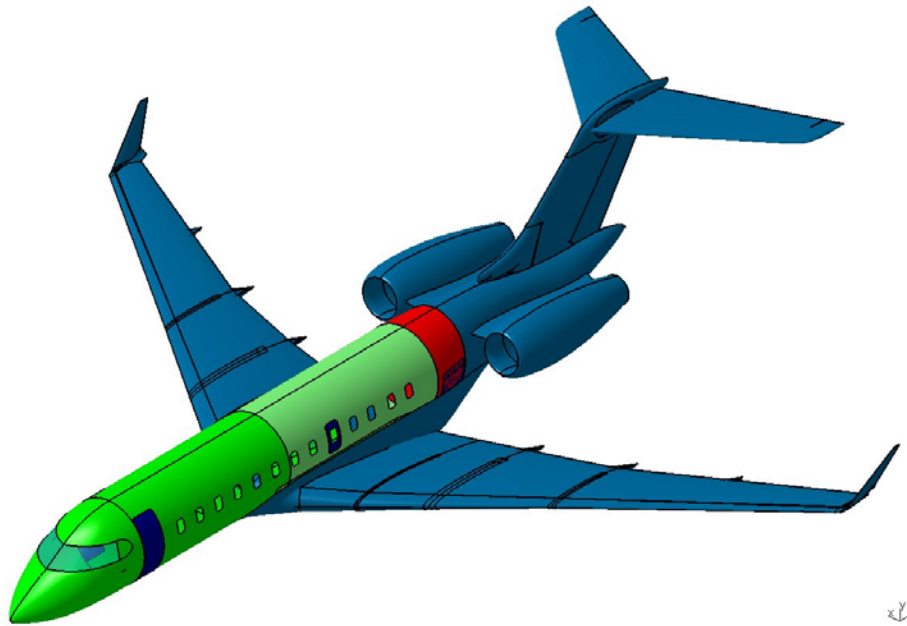
Product Development	Manufacturing	Environment	Advanced Materials	Avionics	More Intelligent Systems	More Electric Systems	Human Performance Augmentation
Future configuration development	Special processes		High temperature alloys	In flight entertainment Diagnostics	Network centric	Engine technologies	Remote operators
Quality systems and processes	Intelligent manufacturing		Metallics	In flight business	Adaptive systems		Environmental databases
Logistics system integration	RFID		Metal Matrix Composites	Open platforms / Landing aids	Autonomous systems		
			Multi-functional	Display systems Adaptive over life cycle	Air transport system optimization		
Multi-disciplinary design optimization	Agile	Noxious emissions reductions	Low cost manufacturing	Systems integration			Advanced diagnostics
Lean engineering	Automated fibre placement	Alternative fuels	High temp. composites				Integrated Electronic Tech Manuals
	Machining		Hybrids				
			Ceramic Matrix Composites				
Integrated design and manufacturing	Lean	Noise emissions reduction	Liquid composite moulding				
Virtual prototyping, testing & integration	Robotics	Fuel burn	Advanced metallic alloys				
Life analysis	Inspection and Repair	Materials of Concern	Coatings				
Prognostics and health management	Joining						
Advanced product development strategy	Near net shape manufacturing		Thermosets	Augmented / synthetic vision systems	Sensors	Electric power generation & distribution	Synthetic training environments
	Advanced assembly processes		Thermoplastics	Fly by wire/light	Morphing systems	Actuation	Human machine interface
			Nano materials			Power management	
						Environmental control systems	

Key to FMP/SAGE

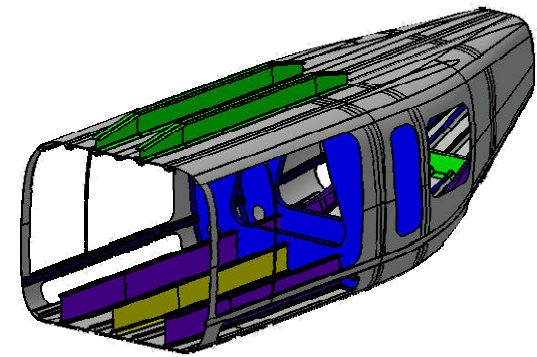
Proficiency in Canada

↳ These technologies will be part of the future **Strategic Technology Portfolio**.

FMP Technology Demonstration: Composite Structures for Aircraft Fuselages



Fixed Wing Airplanes



Helicopters

Composites Technology Demonstrator

- **Design, build and test demonstrator for Composite Fuselages for a fixed wing aircraft or a helicopter using Automated Fiber Placement**
- **This project will focus on developing composite structure technologies applicable to an airplane fuselage or a helicopter fuselage.**
- **Objectives:**
 - Build on technologies developed separately by OEMs and NRC
 - Exploit NRC AFP facility
 - Develop SMEs in composite technologies
 - Demonstrate technologies to TRL Level 6
 - Prepare Canadian OEMs and SMEs for bidding on composite FMP

Top level - Project Objectives

- **Design and Manufacture a full scale fuselage test article**
 - **Develop Automated Fibre Placement as a core technology**
 - **Develop composite airframe ancillary technologies**
 - **Supply chain development for affordable and competitive composite structures**
 - **Enhancement of composite pressure vessel design and manufacturing skills**
- ✓ Demonstrate *TRL 7* by Q4-2013 for AFP technology

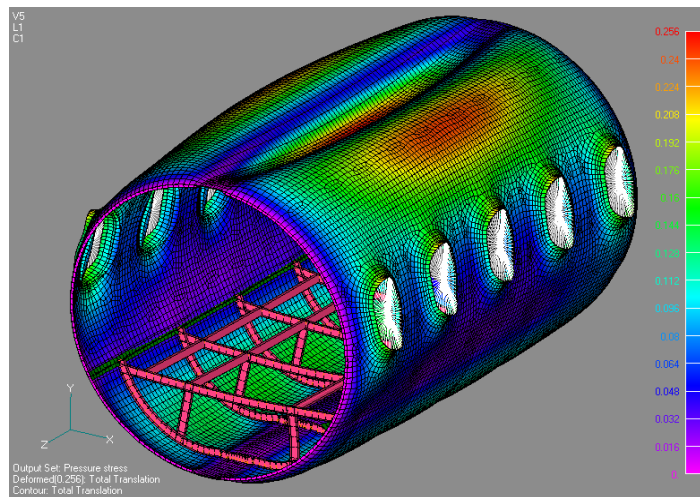
Composites Technologies to be Demonstrated

- AFP monolithic laminates with integral hat stiffeners
- AFP over honeycomb core
- AFP with autoclave curing material
- AFP with Out Of Autoclave curing material
- Primary bonded joints
- NDI for primary bonded joints
- Liquid composite molding technologies
- Compression molding technologies
- OOA adhesive curing (conductive heating)
- ATL and hot draping technologies
- Low cost tooling
- Closed cavity molding
- Materials development and characterization



Technology Advancement

- **Analysis, Simulation & Structural testing**
 - Develop Stress/Design tools methodology
 - Stress analysis methodology for structural bonding joints / splices
 - Damage scenario for sandwich construction

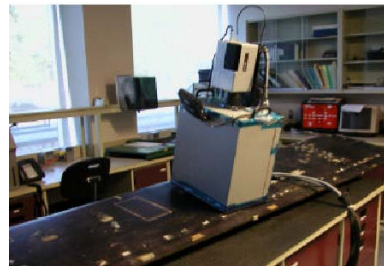


Master composite structure behavior

Technology Advancement

■ Manufacturing & Quality

- AFP manufacturing process
- Co-cured and co-bonded large assembly
- Validate Out-Of-Autoclave process
- NDI technologies for sandwich construction and bonded joints
- Large scale repair of sandwich construction
- Bonding process and quality control
- Metallic/composite/composite adhesive process and quality control
- Infusion process for detail parts

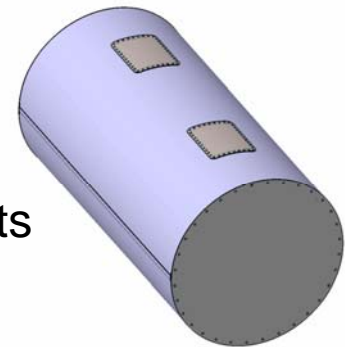


Select the optimum manufacturing process

Technology Advancement

▪ Systems testing

- Validate acoustic/thermal benefits
- Validate EMI/HIRF protection and lightning direct effects
- Validate flammability certification requirements
- (SHM) Structural Health Monitoring for composite application
- Dissimilar materials and environmental protection

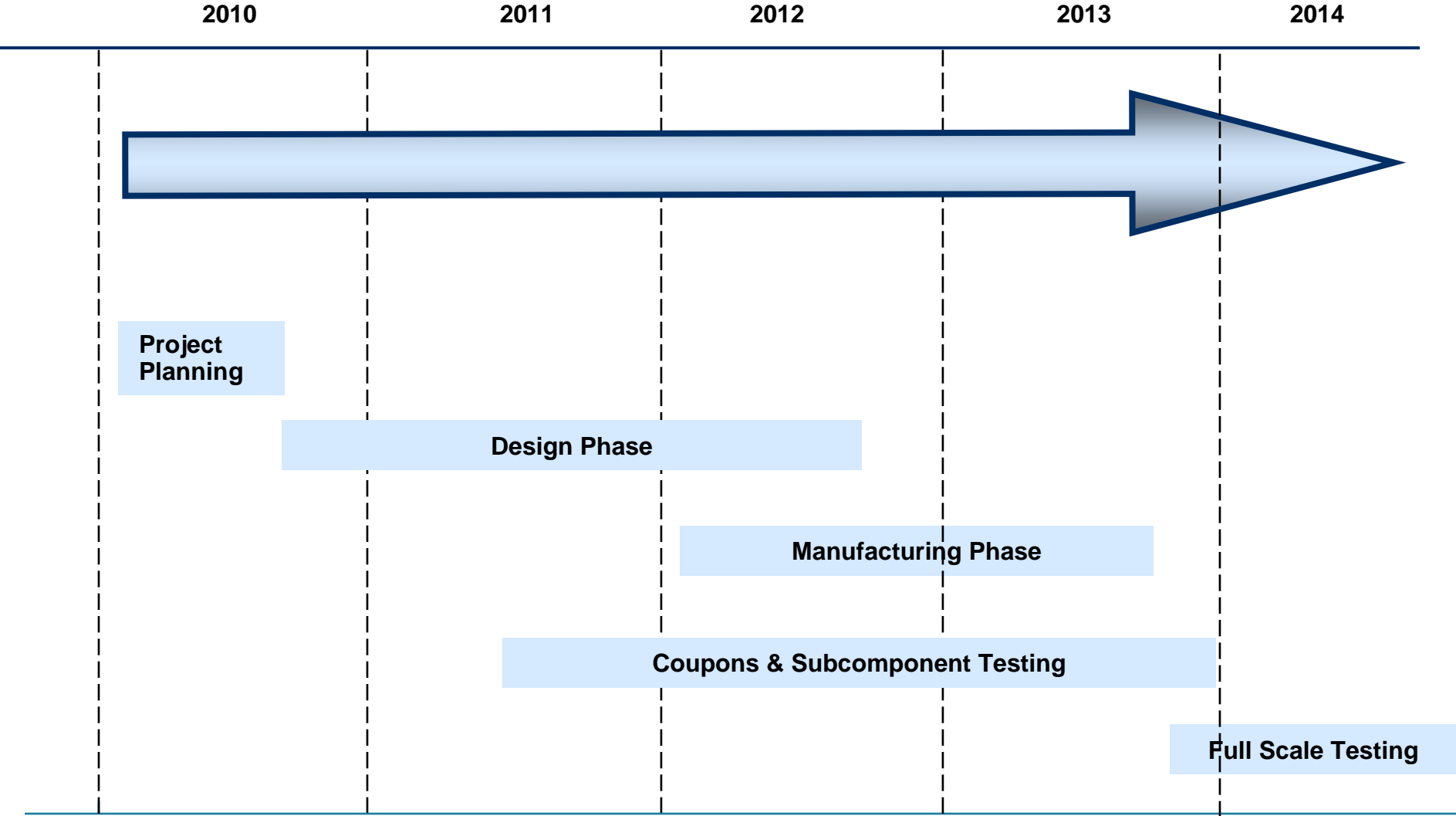


Find systems solutions for composite structure

Potential Collaborators

- Bell Helicopter
- Pratt and Whitney Canada
- Bombardier Aerospace
- Composite Atlantic Ltd.
- Delastek
- Avior
- FDC
- Avcorp
- Comtec
- Bristol Magellan
- Universities
- CTA
- Composite research center
Manitoba
- NRC-AMTC
- NRC-SMPL
- NRC-IMI

Timeline - FMP Collaborative Project



Benefits of the Project

- **Allow Canadian suppliers to acquire Tier 1 integrator capabilities by participating in new technology demonstration programs in close association with major Canadian OEMs.**
- **Allow the Canadian aerospace industry to move from the traditional sheet metal manufacturing technology to a new technology that will become standard on future aircraft.**
- **Complete the innovation cycle by extending the universities research and development (TRL 1 to 4) results into the demonstration phase (TRL 5 to 7).**

Conclusions

- **The aerospace industry continuously invests in technology innovation. A partnership with the government in a national R&D framework program will accelerate the rhythm of new technology demonstration and maintain Canada's competitive position in the world**
- **The Aerospace Industries Association of Canada has submitted a report highlighting the need for a technology demonstrator program**
- **Demonstrators are needed in various fields:**
 - Aircraft composite structures
 - More Electric Aircraft systems and engines
 - Integrated Avionics and Advanced Vision Systems
- **A national framework program will allow also collaboration of Canadian OEMs, SMEs and equipment manufacturers with major R&D programs in other major aerospace countries**
- **Bombardier Aerospace is ready to partner with Canadian suppliers and lead major collaborative technology demonstration programs**



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