

Low Emission Aviation Program (LEAP)

Transitioning towards a “net-zero” future for aviation

Pervez Canteenwalla, Program Leader





- 18msq.km with six time zones
- 160 million PAX (2019)
- 100,000 employees
- \$24B in GDP (2021)
- #1 Canada manufacturing sector for R&D intensity

WHAT WE DO



**WE ADVANCE
SCIENTIFIC
AND TECHNICAL
KNOWLEDGE**

**WE SUPPORT
GOVERNMENT
POLICY
OBJECTIVES**

**WE SUPPORT
BUSINESS
INNOVATION**

Two primary streams of activity

1) Research performer (national labs)



14 research centres



24 laboratory locations



126 major R&D facilities



\$871.1M total expenditures



1,187 peer-reviewed publications



\$169.8M total revenues



1,035 R&D clients



14 collaborative programs



1,855 active patents (441 patent families)

2) Advice and funding to SME innovation projects

Industrial Research Assistance Program (NRC IRAP)

262

ITAs

106

locations

\$468M

Gs&Cs funding invested in SMEs

3,657

total firms funded

11,198

advisory services to unfunded firms

Macro Summary Results (2020-21)



NRC Research Centres

DIGITAL TECHNOLOGIES

- Digital Technologies

EMERGING TECHNOLOGIES

- Advanced Electronics and Photonics
- Herzberg Astronomy and Astrophysics
- **Metrology**
- Nanotechnology
- **Security and Disruptive Technologies**

ENGINEERING

- Construction
- **Energy, Mining and Environment**
- Ocean, Coastal and River Engineering

LIFE SCIENCES

- Aquatic and Crop Resource Development
- Human Health Therapeutics
- **Medical Devices**

TRANSPORTATION AND MANUFACTURING

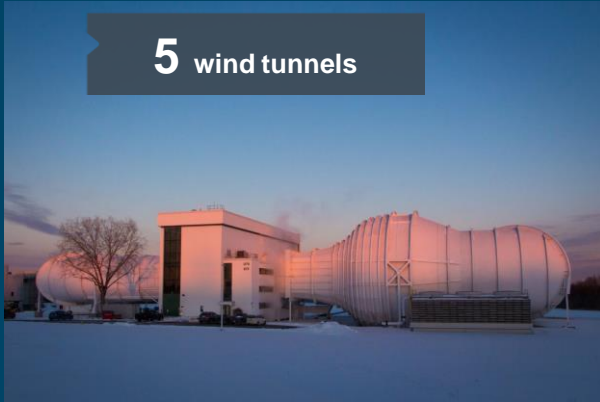
- **Aerospace**
- **Automotive and Surface Transportation**

LEAP leverages non-aerospace expertise from across NRC

Aerospace Research Centre Facilities



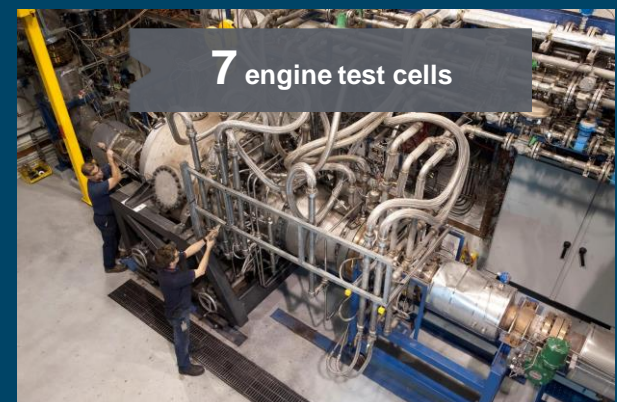
5 wind tunnels



Aerospace Manufacturing Facilities



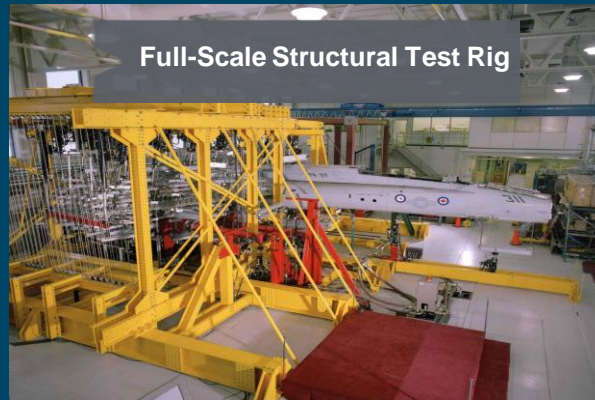
7 engine test cells



9 Research Aircraft



Full-Scale Structural Test Rig



Centre for Air Travel Research



Aerospace Specialization and Focus Areas

Aero RC offers **deep experience and capabilities** in:



Structures
and materials



Aerospace
manufacturing



Aerodynamics



Propulsion



Flight research

Focus Areas and Programs



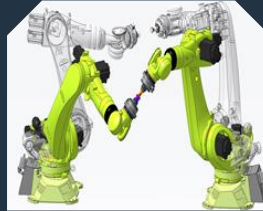
Low Emission
Aviation



Integrated Aerial
Mobility



Aeronautical Product
Development &
Certification



Advanced Digital
Aerospace
Manufacturing

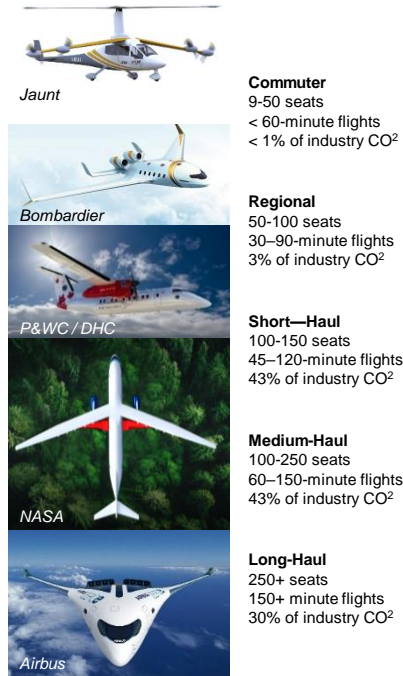


Defence
Technology
Sustainment



Air Travel
Research

One Size Doesn't Fit All








	2022	2025	2030	2035	2040	2045	2050
1 MW	SAF	Electric or hydrogen fuel cell and/or SAF	Electric or hydrogen fuel cell and/or SAF	Electric or hydrogen fuel cell and/or SAF	Electric or hydrogen fuel cell and/or SAF	Electric or hydrogen fuel cell and/or SAF	Electric or hydrogen fuel cell and/or SAF
	SAF	SAF	Electric or hydrogen fuel cell and/or SAF	Electric or hydrogen fuel cell and/or SAF	Electric or hydrogen fuel cell and/or SAF	Electric or hydrogen fuel cell and/or SAF	Electric or hydrogen fuel cell and/or SAF
	SAF	SAF	SAF	SAF potentially some hydrogen	Hydrogen and/of SAF	Hydrogen and/of SAF	Hydrogen and/of SAF
	SAF	SAF	SAF	SAF	SAF	SAF	SAF potentially some hydrogen
100 MW	SAF	SAF	SAF	SAF	SAF	SAF	SAF

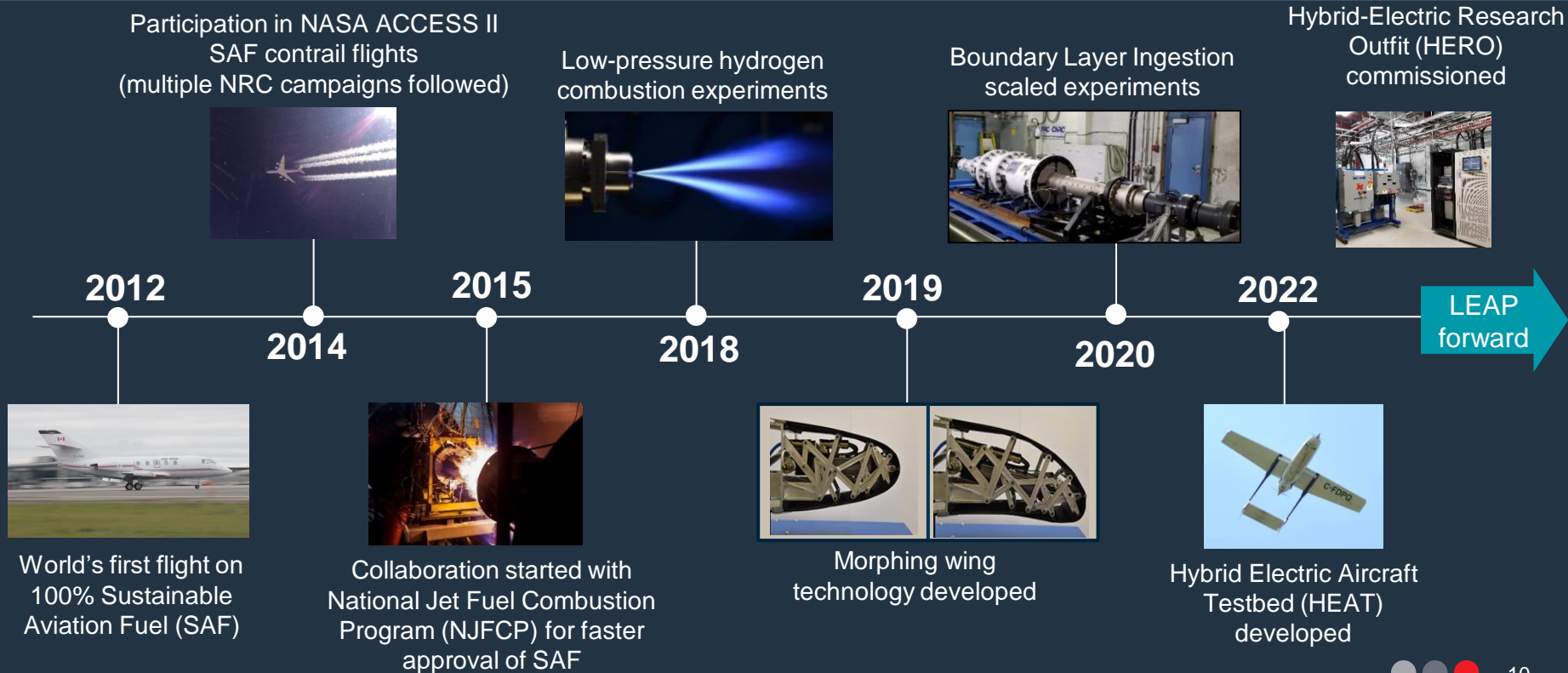
27% of CO₂ emissions

73% of CO₂ emissions

*Assumes that electrical grid and/or hydrogen production are "green".
 Source: [Air Transport Action Group's \(ATAG\) Waypoint 2050 – A vision of net-zero aviation by mid-century](#)

		State of the Art		Need for Larger Aircraft
	BATTERY	~170 Wh/kg	x4	>700 Wh/kg
	MOTORS	~2.5 MW & 5 kW/kg	x2	>5 MW & 13 kW/kg with >98% efficiency
	SAF	~\$5/L	÷5	~\$1/L
	NOVEL AIRCRAFT CONFIGURATIONS	Lab-scale demo		Flight demonstrators
	H2 STORAGE EFFICIENCY (mass of fuel / total mass of tank + fuel)	~14.5% (liquid)	x2	>35%

Sustainable Aviation at the NRC – The past decade



Low Emission Aviation Program (LEAP)

Focus Areas

Vision: To accelerate the transition to “Net-Zero” for Canada’s aviation industry and strengthen our position as a clean tech leader.

Develop, evaluate, and integrate low emission technologies safely into aviation applications

Aircraft
Technology
Integration



Advancement of technologies of the electric engine to improve its performance and reliability as well as methods for integration in the aircraft, testing and certification

Electrical
Systems



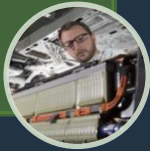
Demonstrate the integration and safe operation of key enabling ground and on-board technologies for hydrogen, H2-mixtures, and SAF based propulsion & power generation systems that meet the stringent technical, safety, and regulatory requirements of airborne applications

Clean Fuel
Technologies



Advancement of safety and suitability of battery technologies to enable aircraft electrification

Batteries in
Aviation



Modeling & Simulation



Technology Demonstrator



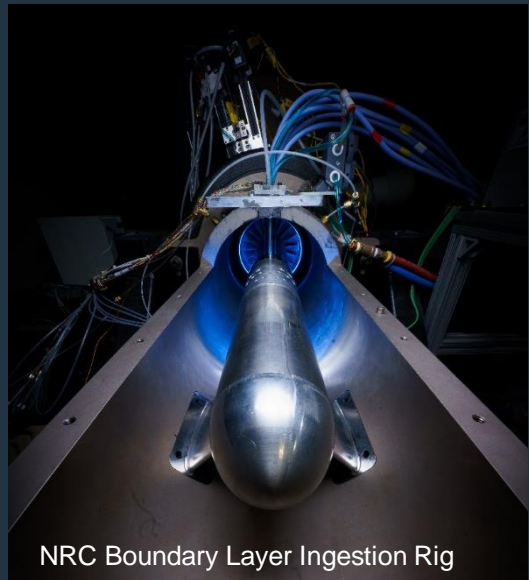
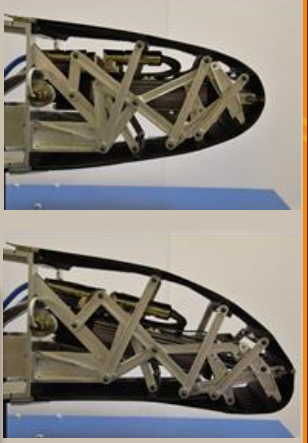
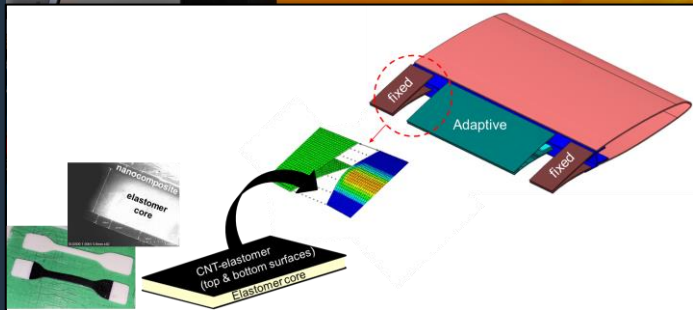
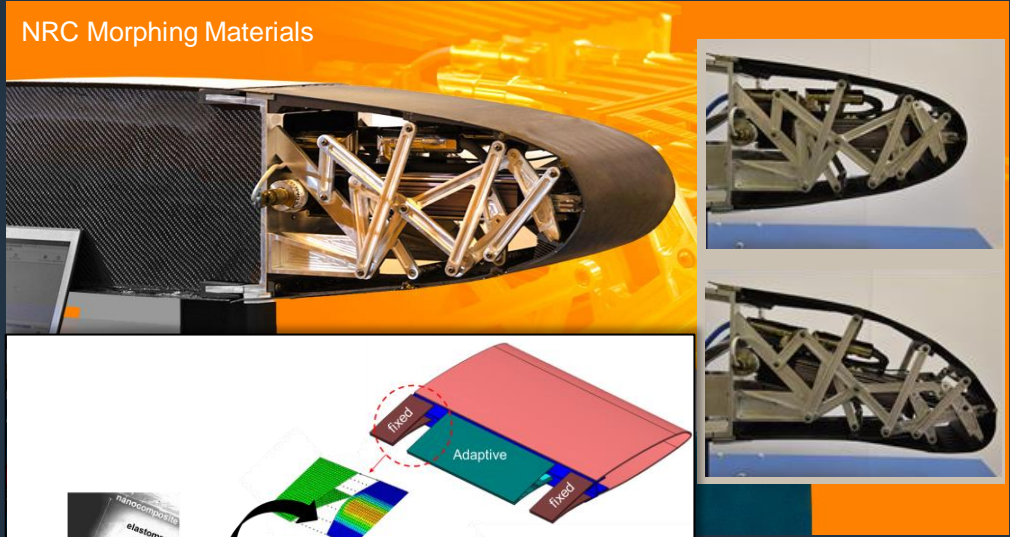
Safety & Certification

Aircraft Technology Integration

Technology Performance & Emission Assessments (SAF, H2, electric)

Next Generation Aircraft Configurations

Technology Demonstrators



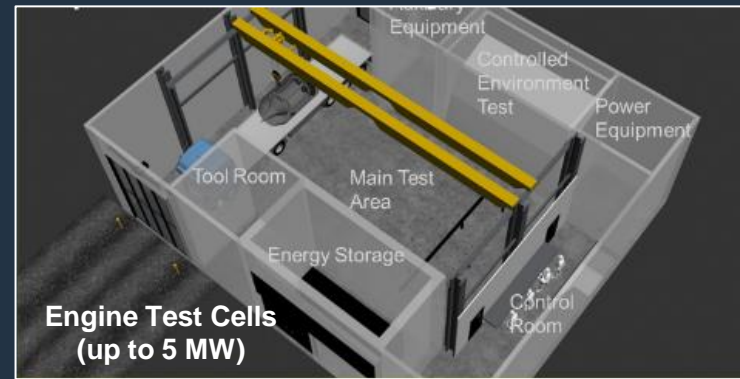
Electrical Systems

Hybrid-Electric Demonstrations

Reliability, Safety and Certification

Efficient High-Power Electrical Propulsion Technology Advancement

Proposed MW-scale facilities for HE system development



Clean Fuel Technologies

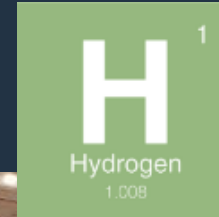
Hydrogen Storage Systems & Operations

Hydrogen Safety & Certification

Fuel Cell Propulsion

SAF and Hydrogen Combustion Technologies

Hydrogen Investigations



National Research Council Canada • Conseil national de recherches Canada • SIEMENS ENERGY • McGill

Continuing SAF Investigations

Blowoff
(Jet-A, $\phi = 0.35$)



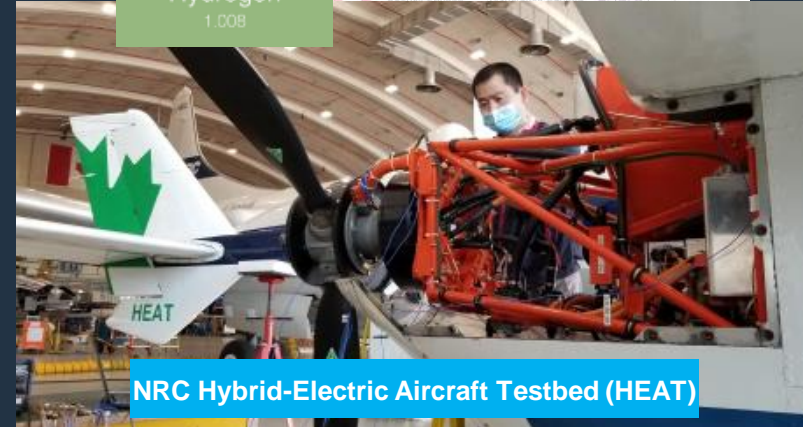
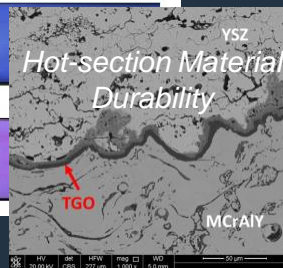
Stable flame
(Jet-A, $\phi = 0.53$)



Flashback
(Jet-A, $\phi = 0.65$)



Afterburner effects



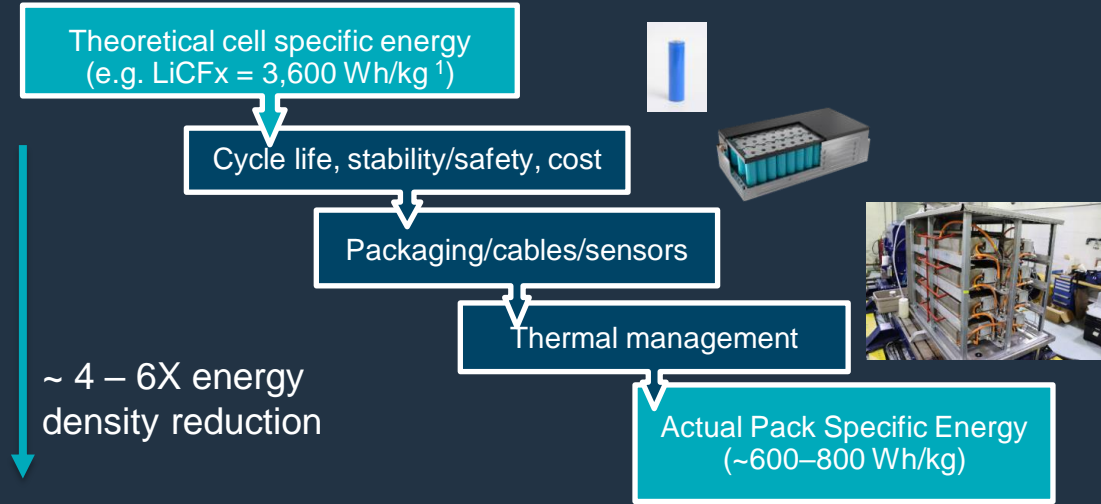
NRC Hybrid-Electric Aircraft Testbed (HEAT)

Batteries in Aviation

Battery Performance & Technology Demonstration

Battery Management & Health

Certification Methodologies



Battery Performance and Abuse Testing

HEAT II Battery Thermal Runaway Safety System Validated

January 2020



**Iteration 1:
Large Scale Loss
of Containment**

One year later: February 2021



**Iteration 3:
Thermal Runaway
Completely Contained**

Industry



Will take a multi-sectoral approach with all stakeholders involved (fuel/electricity producers, airports, regulators, OEMs, etc.) from industry, academia, and government.



Government



Academia





Thank you

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