THE AMERICAN MODELICA **CONFERENCE** 2018

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National Research Council Canada

Conseil national de recherches Canada

MOTIVATION

- "Fully electric" and "more electric" aircraft are coming
- Driven by initiatives to reduce global greenhouse emissions
 - EPA
 - CleanSky initiative (EU)
- Big players + acquisitions + venture capital + research
 - Boeing
 - Airbus
 - NASA
 - ...
- Need tools with appropriate multi-physics and flexibility to support development of electric aircraft



The long road to an electric airplane motor ZDNet - Sep 27, 2018 Redmond-based magniX, an electric propulsion company working on an emissions free airplane engine, today announced successful tests of ... MagniX Takes Step Toward Giving Small Workhorse Planes An ... In-Depth - Forbes - Sep 27, 2018

View all



HES unveils plans for regional hydrogen-electric passenger aircrafts gasworld - 9 hours ago Designed as a zero-emissions aircraft, Element One merges HES'... fuel cell technologies with a distributed electric aircraft propulsion design.



Electric planes? Zero-emission future is zooming in The Seattle Times - Sep 11, 2018 The effects of electric aircraft will be profound. While flying has declined to only a minuscule share of our travel within the 1,000-mile range, ...



Meet The World's First Hydrogen-Electric Passenger Aircraft: Element .. InsideEVs - Oct 3, 2018

Singapore's HES Energy Systems presents the Element One, the world's first regional hydrogen-electric passenger aircraft. The ultra-light ...

World's first hydrogen-electric passenger plane to take off in 2025 The Star Online - Oct 3, 2018 View all



MagniX Hits Milestone for All-Electric Aircraft Motors Robb Report - Sep 27, 2018 Much digital ink has been spilled over the past year writing about electric vertical takeoff and landing vehicles (eVTOLs), which promise fast, ...



How the promise of electric power could transform aviation Financial Times - Sep 17, 2018 Last year, more electric aviation projects were announced than in all of the previous nine years, according to consultants Roland Berger. Of the ...



The NRC at a Glance

National Research Council Canada



Three key roles:

Business innovation Federal policy mandates Advancing knowledge

- 3,700 scientists, engineers, technicians, and other specialists, including 255 SME technology advisors
- Manages 178 buildings (equivalent to 354 NHL hockey rinks) in 72 locations
- \$1B annual expenditure (2016/17) including \$271M in funding for SMEs



Last year we worked with

- **7,900** SMEs (advice including Concierge)
- 3,500 SMEs (funding)
- 1,000 companies (R&D collaborations)
- 152 hospitals
- 72 colleges and universities
- 34 federal departments
- 39 provincial/municipal governments
- 36 countries

NRC CNRC

About NRC Aerospace Research Center

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NRC·CNRC

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NRC Hybrid Electric Aircraft Activities

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Sustainable Mobility Systems (SiMS) Physical Demonstrator Virtual Demonstrator Hybrid Electric Aircraft Testbed (HEAT) Cessna Skymaster - Electric propulsion test-hed Rear engine to be retrofitted with electric motor

- <u>SiMS</u>: A multi-disciplinary virtual prototyping tool that will support the development of hybrid-electric aircraft, including component characterization, optimization, trade studies, performance evaluation, and failure modes and effects
- <u>**HEAT</u>**: An airborne electric propulsion test-bed demonstrator that will be used to evaluate various hybrid-electric propulsion systems / configurations and gather experimental data to inform evolving certification requirements.</u>

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analysis.

NRC Hybrid Electric Aircraft Activities

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- Initially, SiMS will act as a virtual prototyping tool for the design and development of the HEAT physical demonstrator.
- In turn, HEAT will provide data to validate or tune system and component level models used by SiMS.
- Together, these systems will provide a dedicated research platform to advance hybrid-electric aircraft development and support certification.

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NASA X-57



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PURPOSE

- Implement flexible, modular, hybrid-electric aircraft modeling architecture to support virtual and physical demonstrator by National Research Council of Canada (NRC)
- Demonstrate architecture based on NASA X-57
- Highlight model-based development path that mimics X-57 development from baseline conventional to X-57 electric aircraft variant
- Demonstrate integrated multi-physics models that describe aircraft dynamics and performance, electrical, mechanical, and thermal system dynamics



AIRCRAFT DYNAMICS LIBRARY

- Template-based approach for design and analysis of aircraft and subsystems
- Multi-physics representation of all major subsystems
- 6DOF representation of aircraft flight dynamics using aircraft geometry and distributed mass and inertia of individual subsystems
- Powerful sizing model







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POWER TEMPLATE



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P2006T MODEL (MOD1)



- Twin-engine four-seat general aviation aircraft
- High wing and twin Rotax 912 S3 100 hp four cylinder internal combustion engines.
- Engines drive two-bladed constant speed propellers.
- Nominal specifications include a maximum cruise speed of 77 m/s (150 kt), 1239 km range, and fuel consumption of 17 L/h (4.5 gal/hr) per engine



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P2006T TO X-57

- X-57 = heavily modified Tecnam P2006T
- Developed as part of the Leading Edge Asynchronous Propeller Technology (LEAPTech) project, initiated in 2014
- X-57 features two wing tip cruise motors and six small electric motors distributed along the leading edge of each wing
- X-57 wing optimized for high-speed cruise condition with substantially reduced area and increased aspect ratio
- To produce the necessary lift at lower speeds of take-off and landing, trailing edge flap is deflected, and motors are operated to increase wing flow velocity and lift
- Lift augmentation propellers fold snugly along the motor nacelles when not in use during cruise to reduce drag





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X-57 ELECTRIC POWERTRAIN





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X-57 ELECTRIC POWERTRAIN







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CONCLUSIONS

- Multi-physics modeling approach that captures mechanical, electrical, and thermal dynamics
- Framework for rapid model variant development and for performing a range of analyses of multi-domain systems
- Analyses ranging from electric powertrain test benches to integrated electric aircraft performance focusing on Mod 1 to Mod 3 of X-57 project for cruise efficiency demonstration.
- Underlying framework, power train model architecture, and new electrification model templates have been developed and demonstrated
 - Will be used to support continued advancement of the NRC virtual (SiMS) and physical (HEAT) demonstrator systems

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FUTURE WORK

• From cruise to full operating envelope





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THANK YOU