

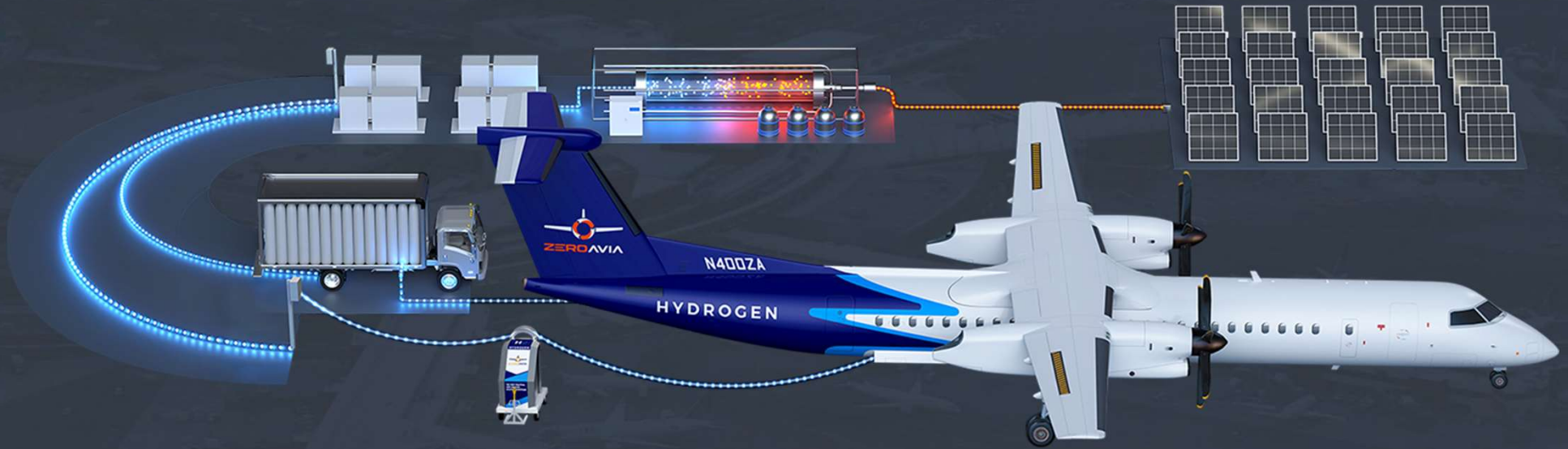
Scaling Hydrogen-Electric Propulsion for Large Aircraft

ZEROAVIA



Vision: Hydrogen-Electric Engine in Every Aircraft

ZEROAVIA



Iterate and learn fast to certify first



Lower barriers to accelerate adoption



Scale quickly, leveraging key technologies



Lead and orchestrate the infrastructure strategy



Explore new and expand in existing target markets

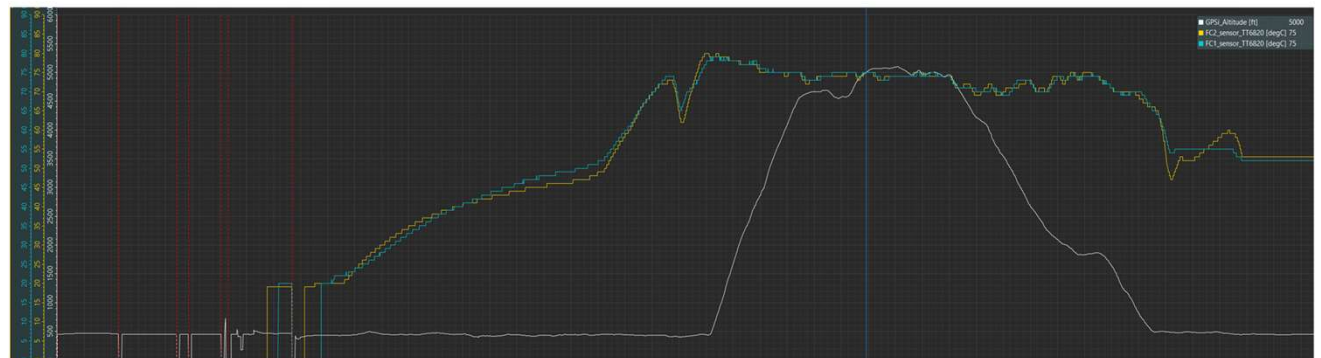
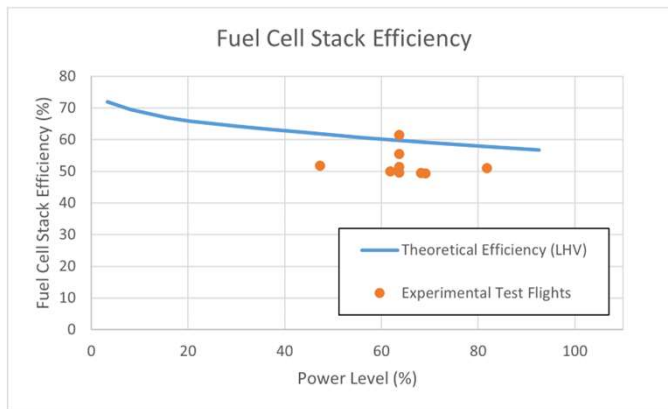
Flight Test Program

- 10 Flights completed
- Flight speeds up to 150kt IAS
- Altitude expanded to 5000 ft
- Various Ambient Temperatures (Jan – Jul 2023)
- No Fuel Cell Failures
- No In-flight shutdowns of Hydrogen-Electric Propulsion



Key Results

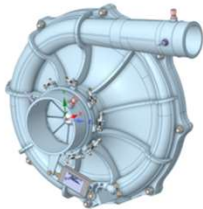
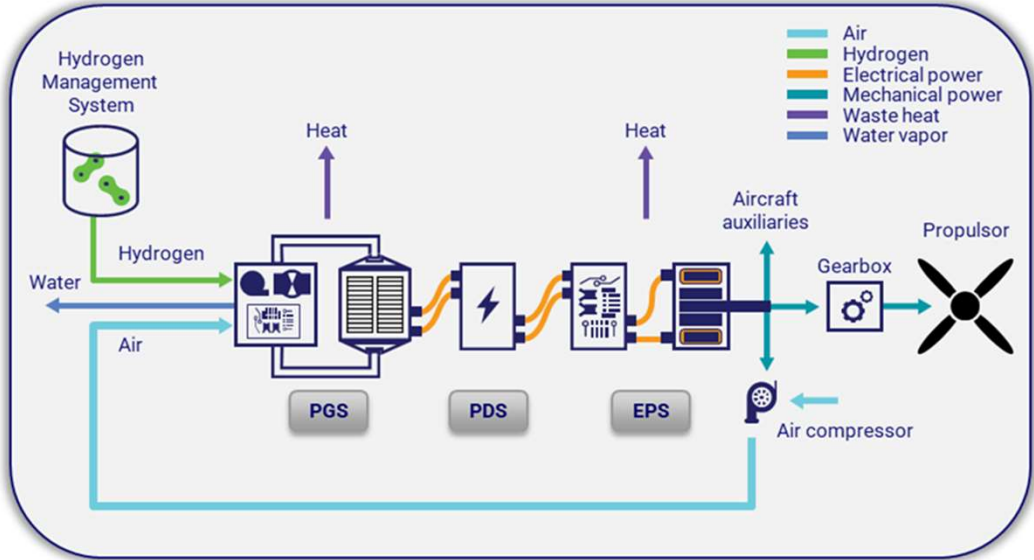
- Fuel Cell Efficiencies
- Thermal Performance
- System dynamics



ZA2000 MW Class Powertrain for 40 – 80 seat regional turboprop class aircraft



System overview



Motor: 750kw continuous / 900kW peak @ 20,000 RPM:

- In-house team + top partners
- High cooling efficiency with advanced proprietary cooling concept
- High power density
- Fully Aerospace Std. compliant (DO160-G, et.al)

Inverter: 200kW unit (commonality with ZA-600)

- High Power Density
- Fully Aerospace Std. Compliant (DO178C, DO254, DO160G)
- Common cooling with E-Motor
- Integrated with Motor, or Remote mount



2 x HyperCore motors (1.8MW) tested Utilised ZeroAvia's HyperTruck test bed

- High-power, high-speed motor technologies, applicable to 40 -80 seat regional turboprop size aircraft
- System modularity, using two motors on same shaft
- Understanding and measurement of system dynamics
- Calibration of physical, electrical models
- Cooling and thermal validation



ZA2000 PGS approach: HTPEM Fuel Cell Stack Technology

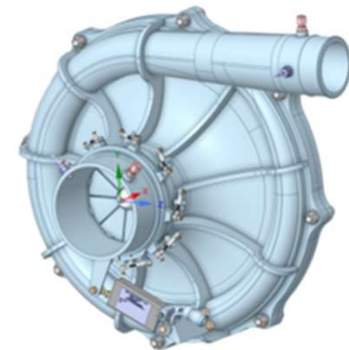
Fuel Cell Stacks:

- In-House HTPEM Technology (160°C - 180 °C)
- Air-Cooled Concept (Simplified BoP)
- High specific power at system level
- Robust Membrane Technology



Balance of Plant (BoP):

- In-House Design Turbomachinery (Compressor, Turbine)
- Qualified H2 components (leverage ZA600 program)

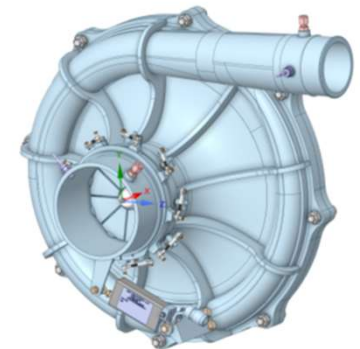
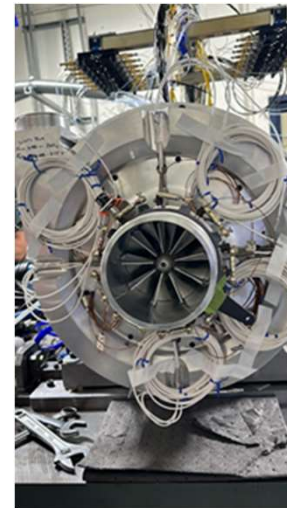


Prototype Fuel Cell Stacks:

- First Small-Scale Stack Developed and Tested
- Second Generation Small-Scale Stack on Test (planned for flight demonstration, Q1 2024)
- Design and Development of Scale-Up version underway

Balance of Plant (BoP):

- In-House Designed Compressor built and tested: Qualification planned 2024)
- H2 components leveraged from ZA600 program, where applicable.



LH2 Aircraft Systems: Key Developments and Challenges

Storage Vessels

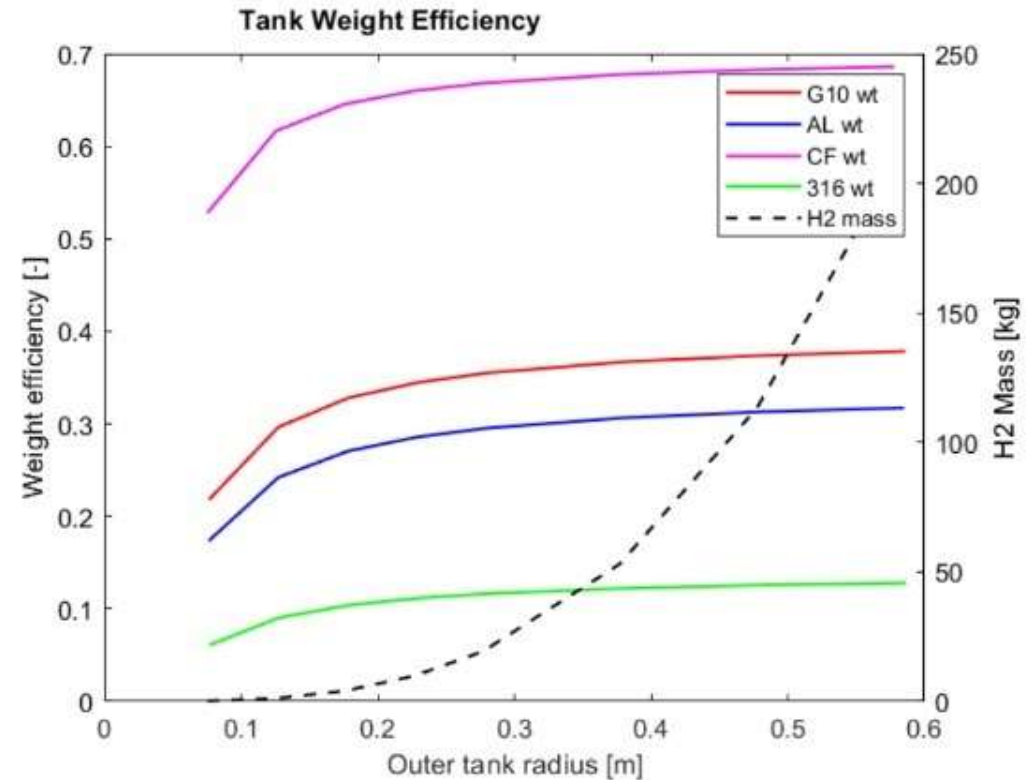
- Tank Materials (Weight and Lifetime)
- Advanced Insulation Techniques (Boiloff and Dormancy)
- Safety Systems (Reliability and Weight)

Transfer Systems

- Super-insulated Lines (Advanced Materials & Manufacturing)
- LH2 Pumps (Reliability and Weight)
- Valves (Reliability and Weight)
- Pressure Head System

Phase Change Systems

- Heat Exchangers / Vaporizers (Weight and Volume)
- Buffer Tanks (Weight and Volume)



Scaling Hydrogen Electric Propulsion for Large Aircraft

Proven LTPEM technology to reach high power density for ZA600 family powertrains for 10 – 19 Seat Aircraft

Vertical Integration, with full in-House ownership of HTPEM fuel cell, Electric Motor and Inverter Technologies

- ZA2000 – Regional Turboprop market (40-80 seats)
- Roadmap to higher power systems for single isle and beyond
- Vision: fully integrated, high-power density TurboCell engine for large aircraft



ZA600: Adapted Technology
100 – 750 kW
LTPEM Fuel Cells (~85°C)

- Superstack Concept
- Central Compressor
- In-House E-Motor + Inverter
- High Power Density System



ZA2000: In House HTPEM Technology
2 – 5 MW

HTPEM Fuel Cells (~180°C)

- Light Weight aluminum plates, Air-cooled Fuel Cell Stack
- High Pressure Operation
- Performance Improvements
- HyperCore EPS



ZA2000RJ
ZA10000
5 – 10 MW +

HTPEM Fuel Cells (~200°C)

- Next Gen Fuel Cells
- Advanced Thermal Systems
- Advanced EPS
- Integrated TurboCell Engine Concept

Thank you



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