



GO BEYOND

PRATT & WHITNEY FUTURE OF ELECTRIC PROPULSION

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SEPTEMBER 2023

POWERING
SUSTAINABLE
AVIATION™

SMARTER.
CLEANER.
GREENER.

POWERING SUSTAINABLE AVIATION

THE PRATT & WHITNEY APPROACH

Smarter Technology

Leverage GTF technology

Hybrid-electric propulsion

Digitization



Cleaner Fuel

Sustainable Aviation Fuel +

Hydrogen propulsion



Greener Business

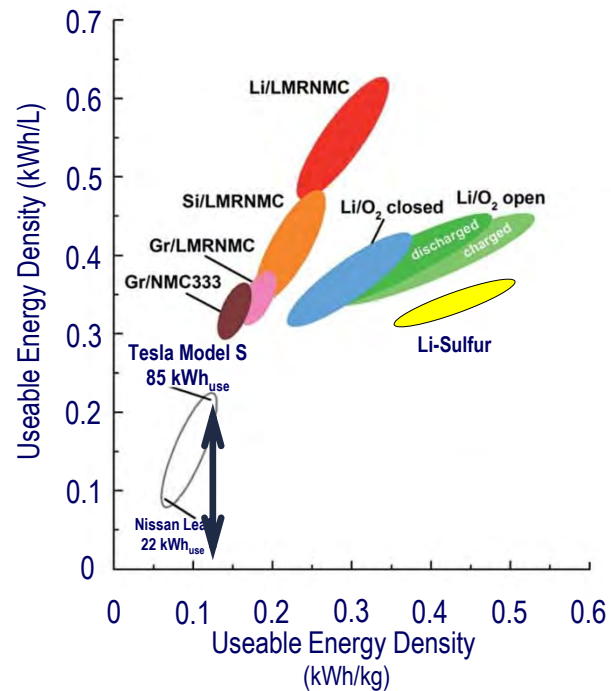
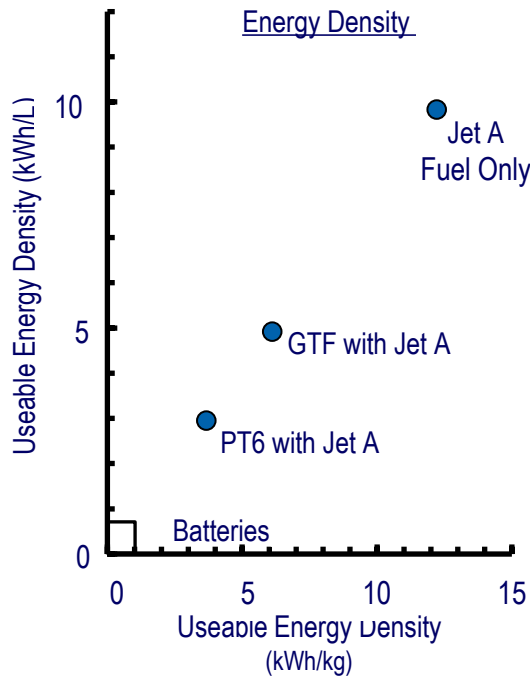
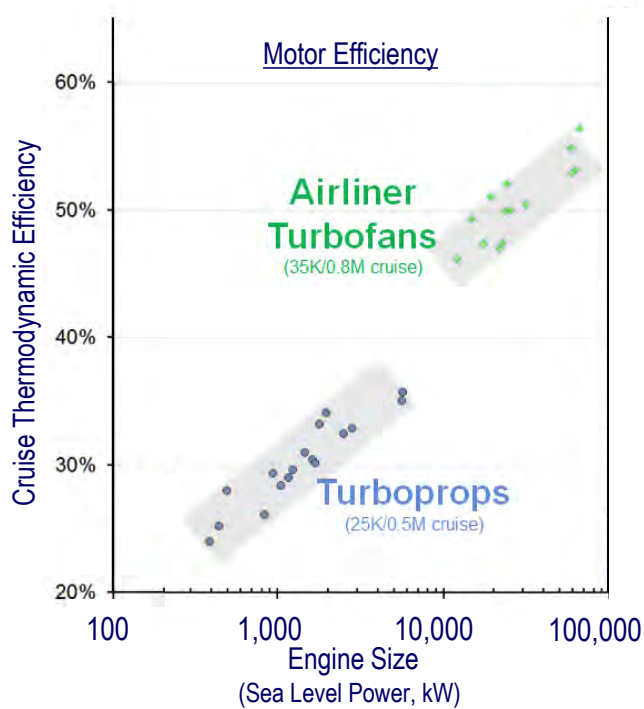
Continual reduction in environmental footprint

World-class turbine airfoil facility in Asheville, North Carolina



ENERGY DENSITY

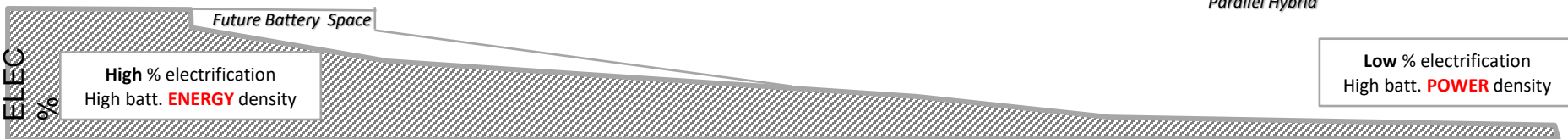
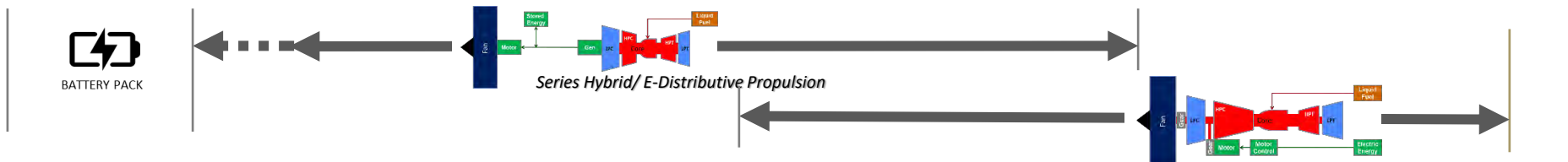
THE CHALLENGE FOR BATTERY AND HYBRID POWERED AIRCRAFT



ELECTRIC PROPULSION LANDSCAPE

RTX IS DEVELOPING SCALABLE & ADAPTABLE TECHNOLOGIES TO ENABLE ELECTRIFICATION ACROSS ALL MAJOR PLATFORM NEEDS

RTX Portfolio



RTX is developing scalable hybrid electric technology

PREPARING FOR THE FUTURE OF AEROSPACE

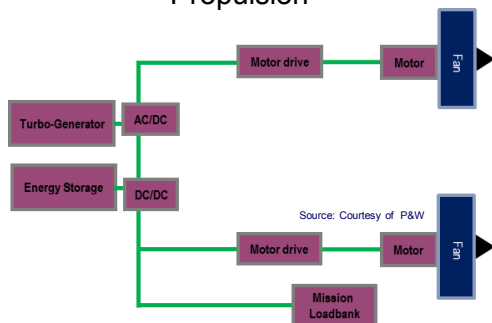
THREE DEMONSTRATORS TO DEVELOP TECHNOLOGY & VALIDATE END-TO-END SYSTEM INTEGRATION OPERATION ACROSS ALL MAJOR PLATFORM NEEDS

Key Features and Technologies:

- >540 VDC Systems
- Adaptive Multi-Effector Propulsion Controls
- Modular Large Commercial Lithium-Ion Batteries
- Scalable & Modular Electric Machines & Power Electronics

STEP-TECH

100-750 kW End to End Distributed Propulsion

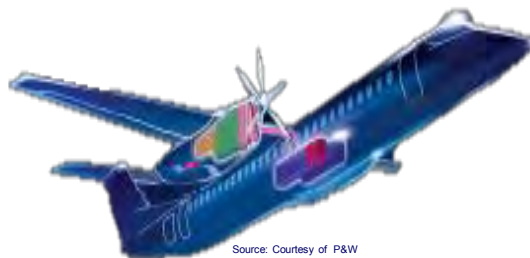


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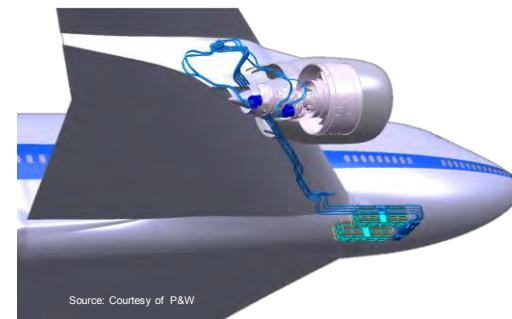
Next Generation Regional Turboprop

1 MW 50% Parallel Hybrid Turboprop



Next Generation Single Aisle

>MW Dual Channel Mild Parallel Hybrid Turbofan

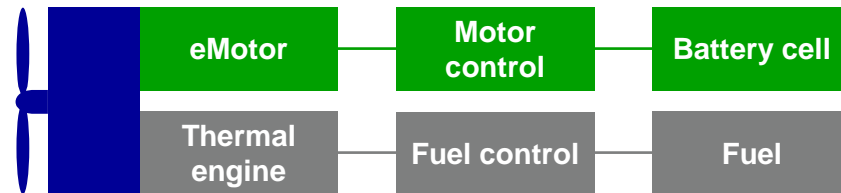


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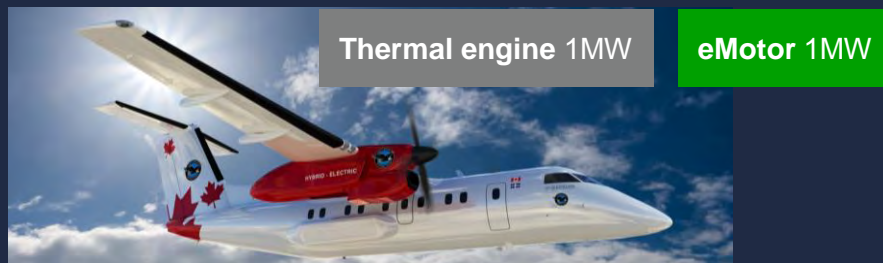
HYBRID-ELECTRIC PROPULSION

OPTIMIZING EFFICIENCY THROUGHOUT THE FLIGHT CYCLE

Thermal Engine +
Electrical motor
combined into
a common control engine



Engine power split between
fuel and battery cell at different
mission points



Targeting 30% lower mission fuel burn and emissions

HYBRID-ELECTRIC SINGLE AISLE AIRCRAFT DEMONSTRATOR

OPTIMIZE GAS TURBINE WITH ELECTRICAL TRANSIENT MANAGEMENT

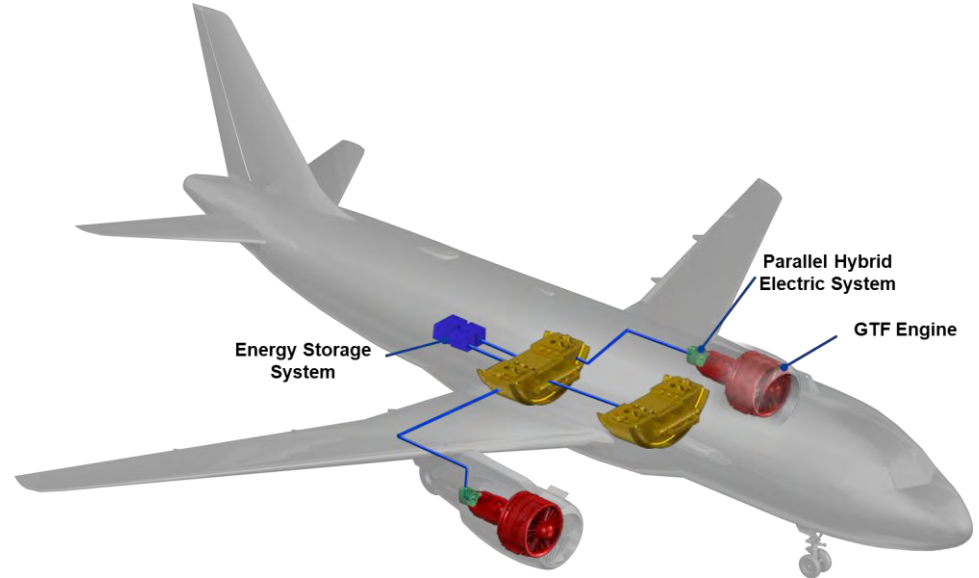
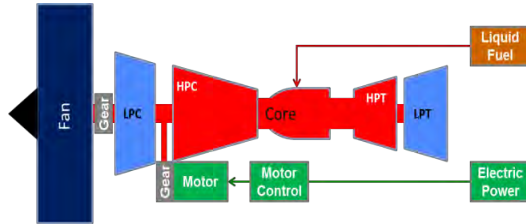
Mild parallel hybrid propulsion system

0.5 MW Electric Machines on core

1 MW Electric Machines on low spool

1KV battery and distribution

System control and protection

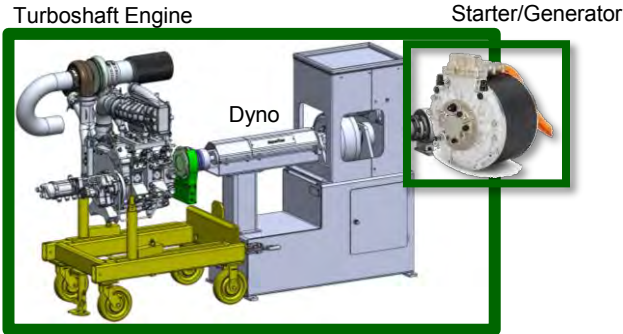


Aircraft-level solution that is 3-5% more efficient than current technologies

STEP-TECH HYBRID ELECTRIC GROUND DEMONSTRATION LAYOUT

LEVERAGING EXISTING RTRC TEST FACILITIES AND INFRASTRUCTURE

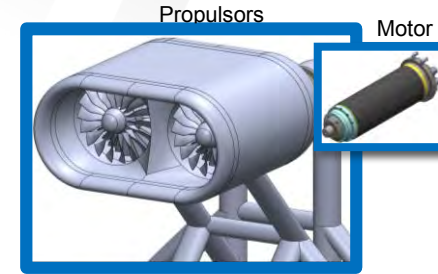
Jet Burner Stand



Juice Box



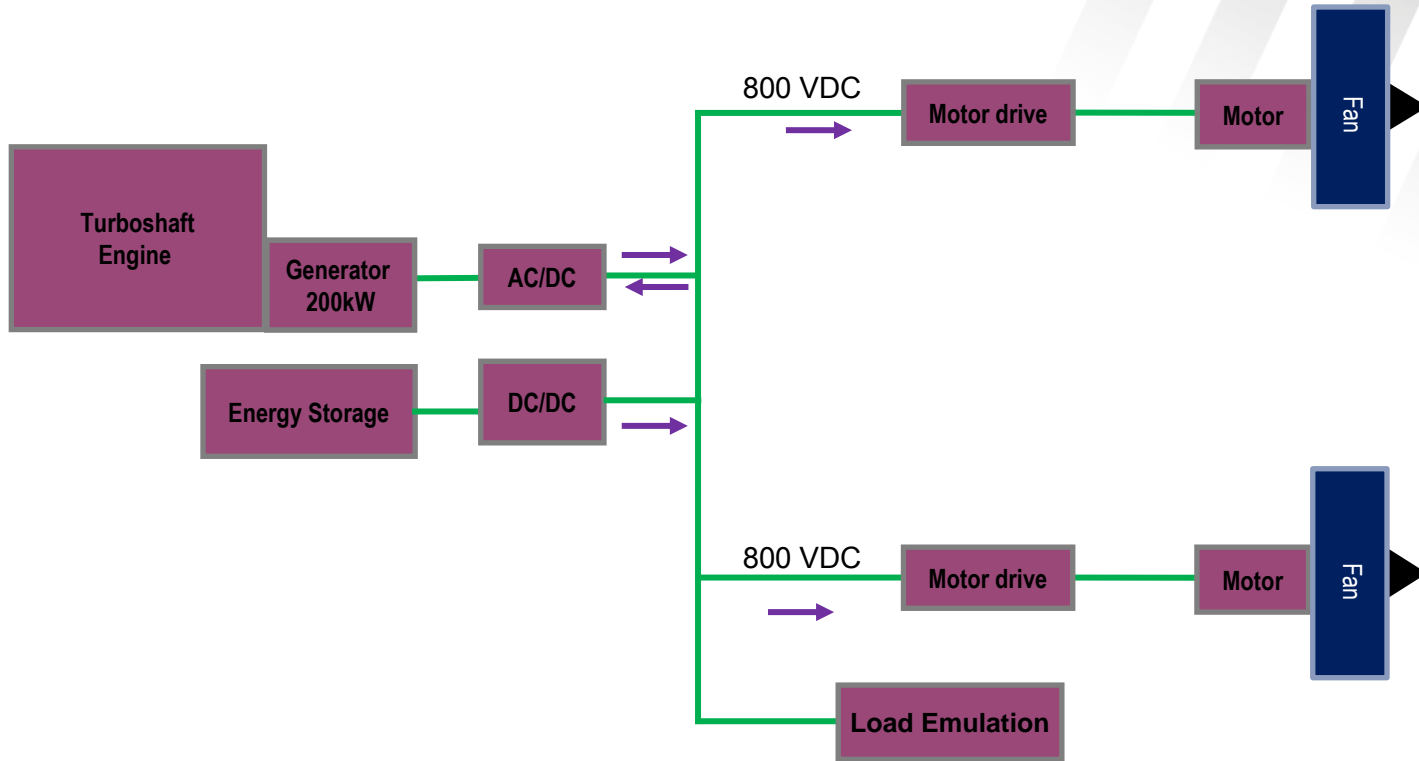
Acoustic Wind Tunnel



System Integration Across 3 Lab Locations with Representative Distances for Aircraft Integration

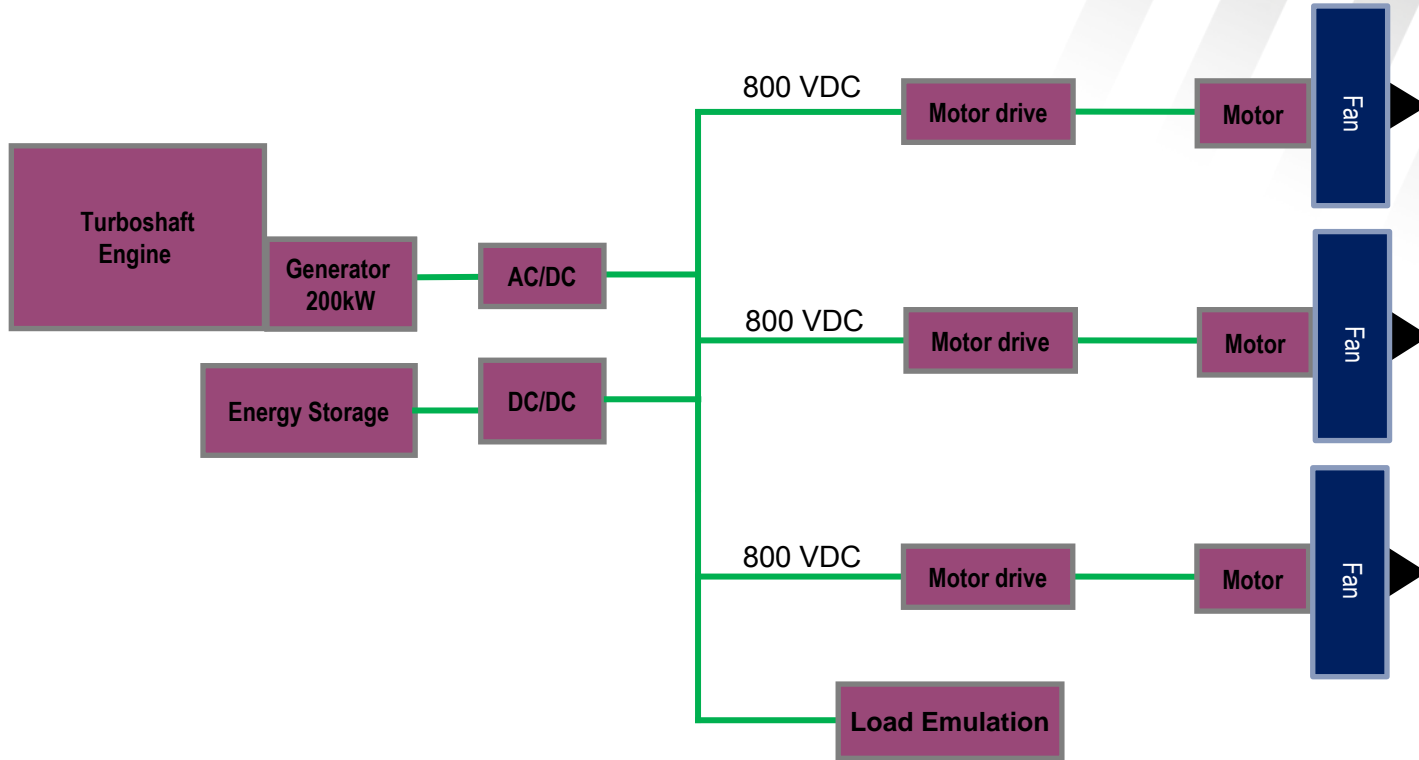
STEP-TECH ARCHITECTURE

VERSATILE SCALABLE & MODULAR ARCHITECTURE



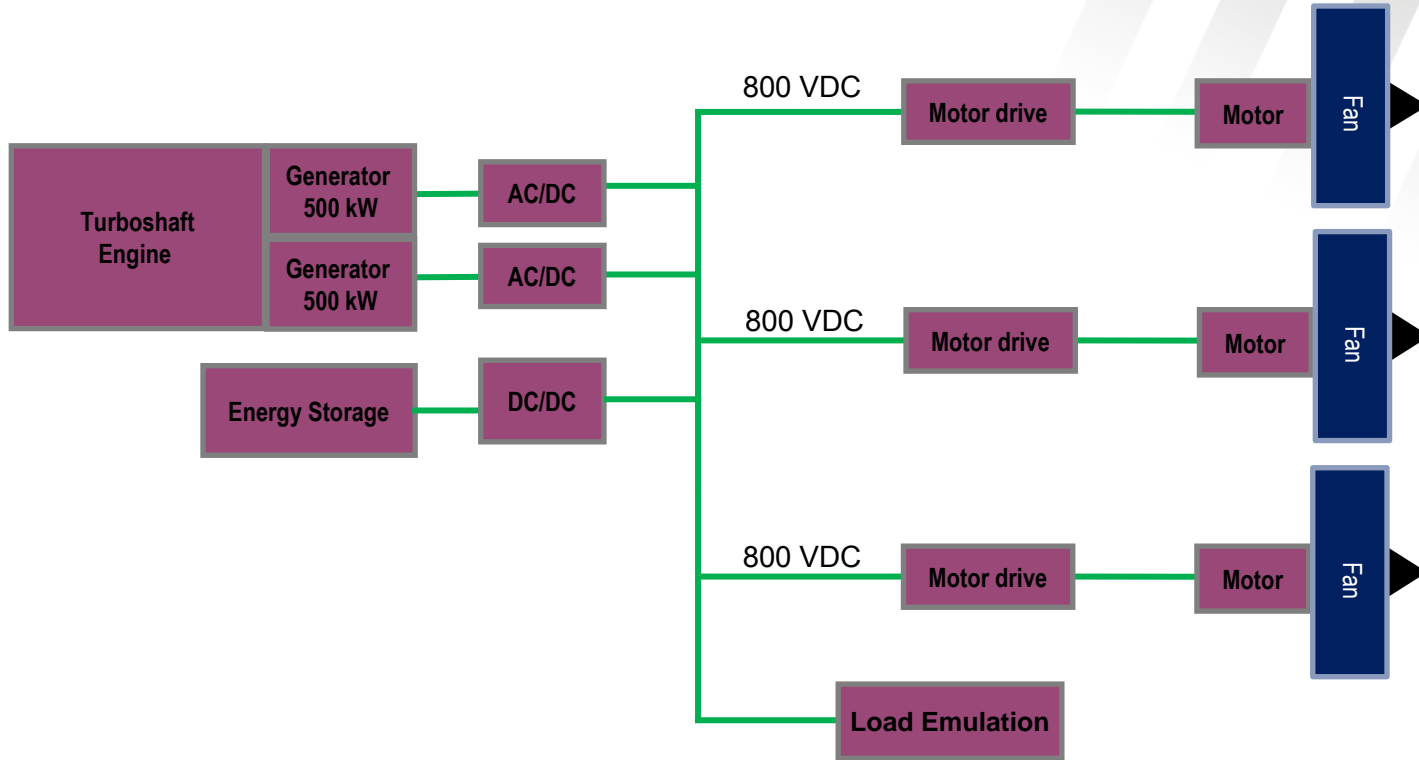
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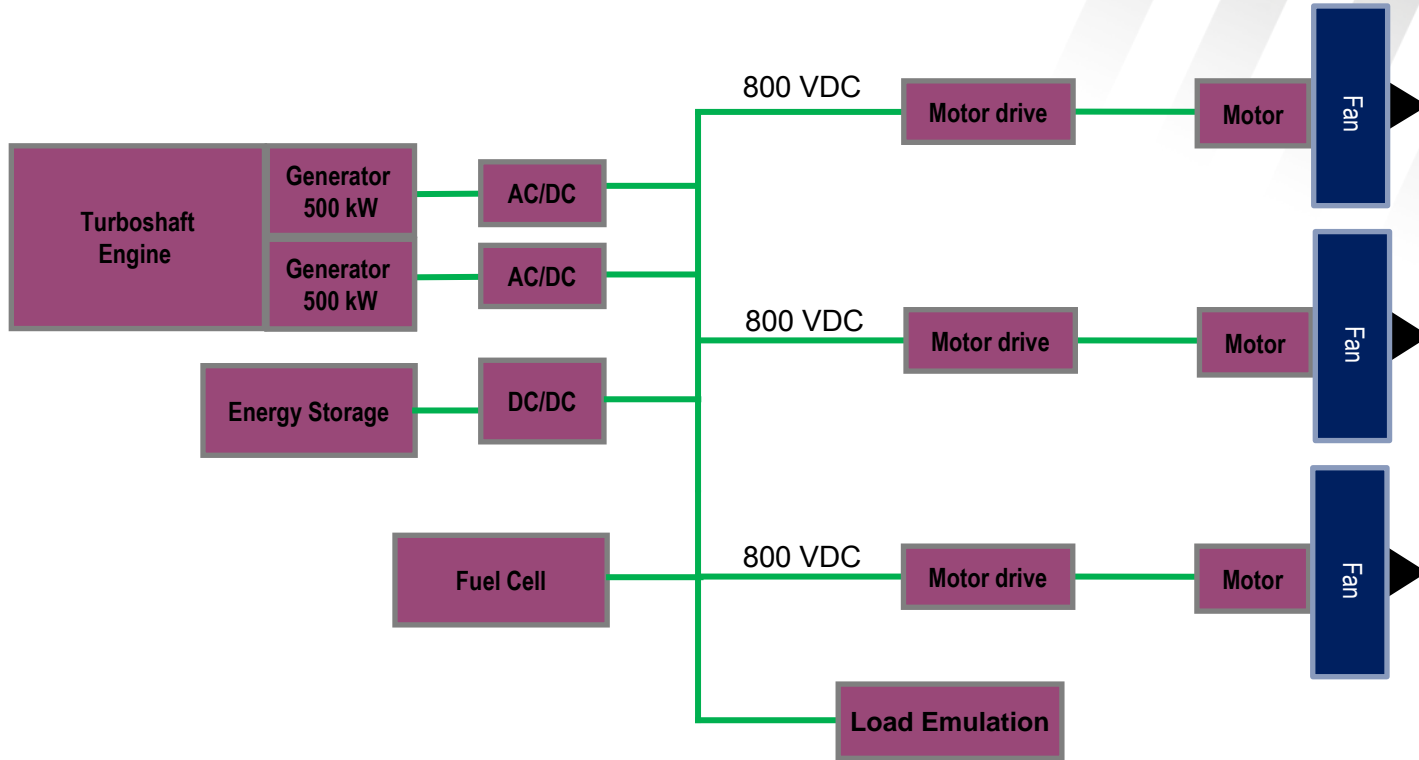
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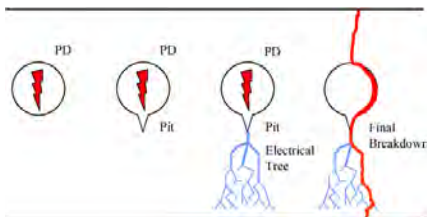
STEP-TECH ARCHITECTURE

VERSATILE SCALABLE & MODULAR ARCHITECTURE



REGULATORY CHALLENGES

STANDARD METRICS AND REGULATIONS NEEDED TO ENSURE TARGETED INDUSTRY RESPONSE



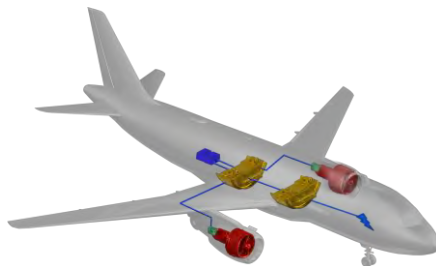
High Voltage & Battery Safety

Power Quality for High Voltage, Voltage Regulation

Arcing, Partial Discharge Corona Discharge safety

Standards for battery fire containment/mitigation (Chemistry based approach?)

Engagement with SAE AE-10 & AE 7



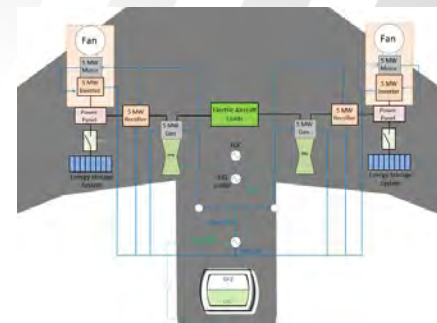
Parallel Hybrid Propulsion

Standards for integrated propulsion and powertrain controls

FAR 33 and 25 Impacts

Electromagnetic Hazards

Engagement with SAE E-40



LH2 Enabled Hybrid

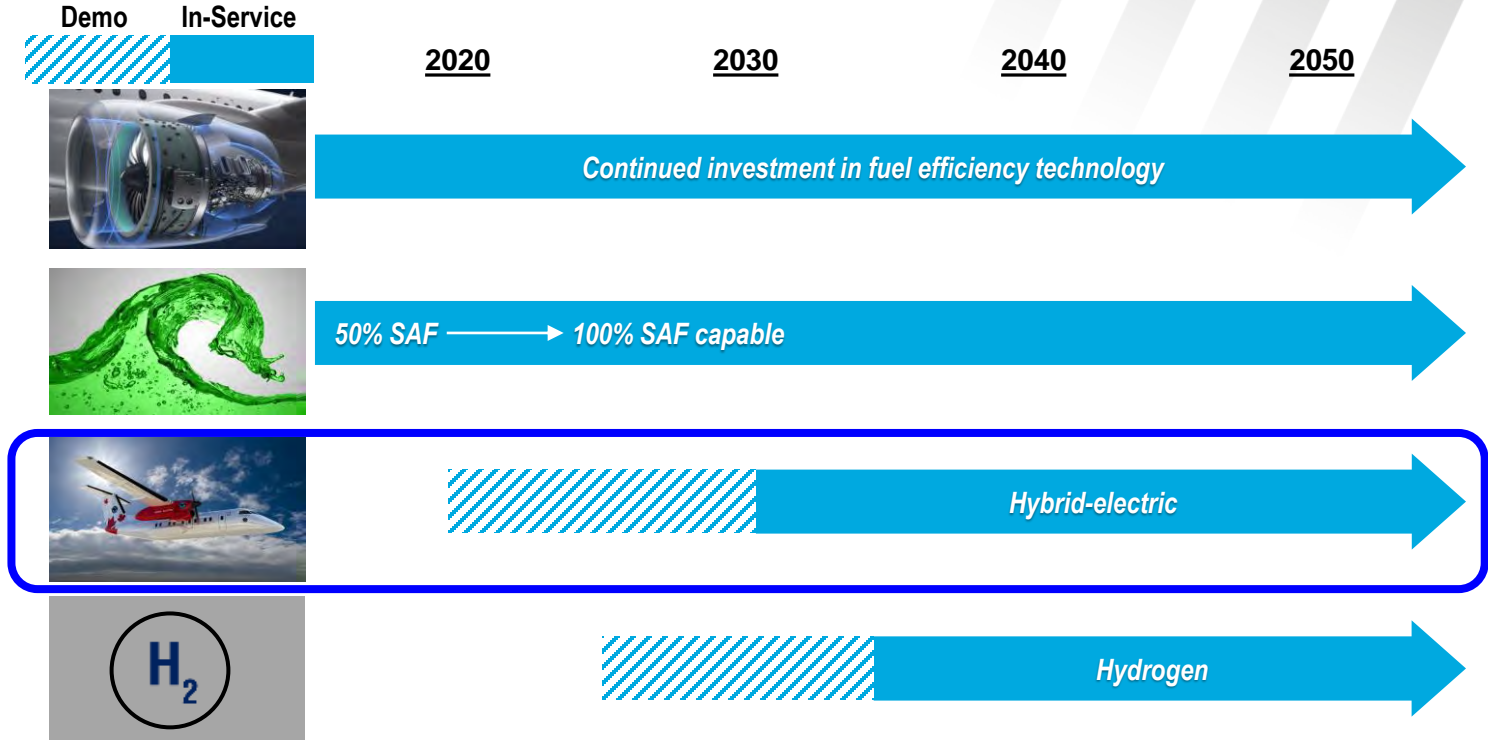
LH2 TMS Management and Safety

Standards for Superconducting Systems

Fuel cell integration

TECHNOLOGY PATHWAYS TO SUSTAINABLE AVIATION

MULTIPLE SOLUTIONS REQUIRED FOR NET ZERO





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POWERING SUSTAINABLE AVIATION™

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