NASA Electric Aircraft Testbed (NEAT)

Summary of Capabilities
Version 1.0 February, 2020

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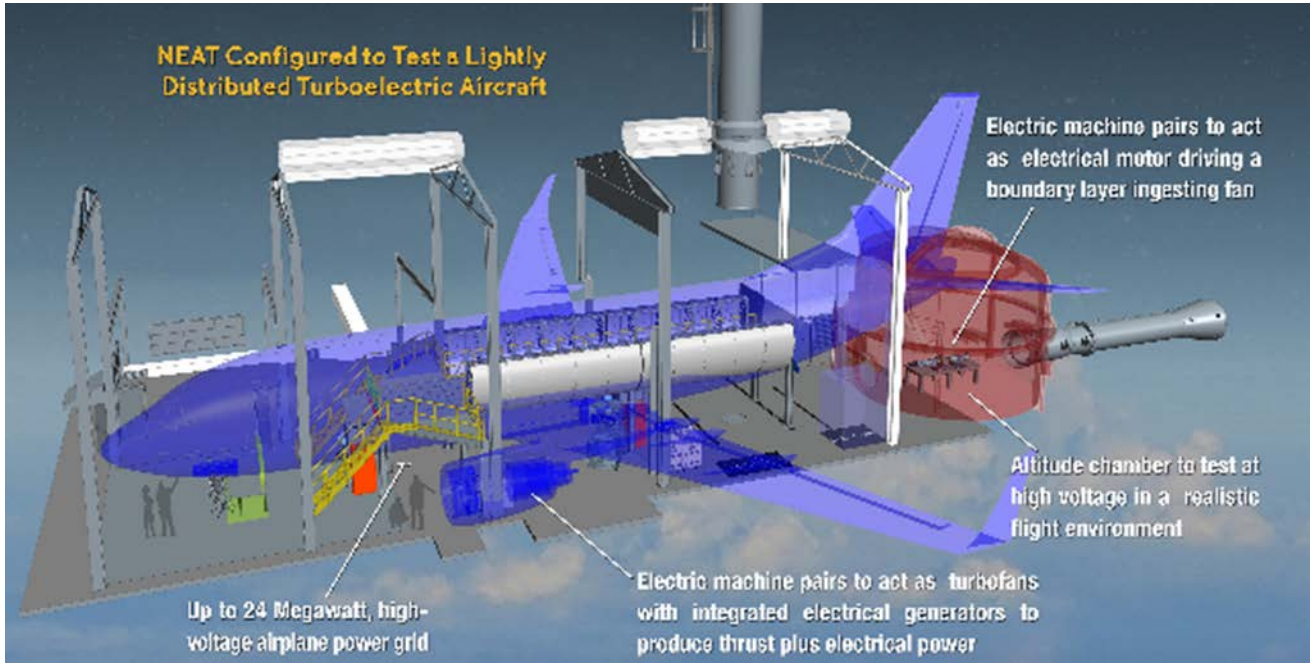
NASA Electric Aircraft Testbed (NEAT)

- Being developed to enable end-to-end development and testing of the electric portion of MW-scale electric aircraft powertrain systems
- Designed with a reconfigurable architecture that industry, academia, and Government can utilize to further mature electric aircraft technologies.

Capability

- Power up to 12 MW (more if regenerating)
- Cooling tower with 950 kW cooling capacity (additional chillers, etc. can be used as well)
- Altitude (up to 60,000 feet pressure)



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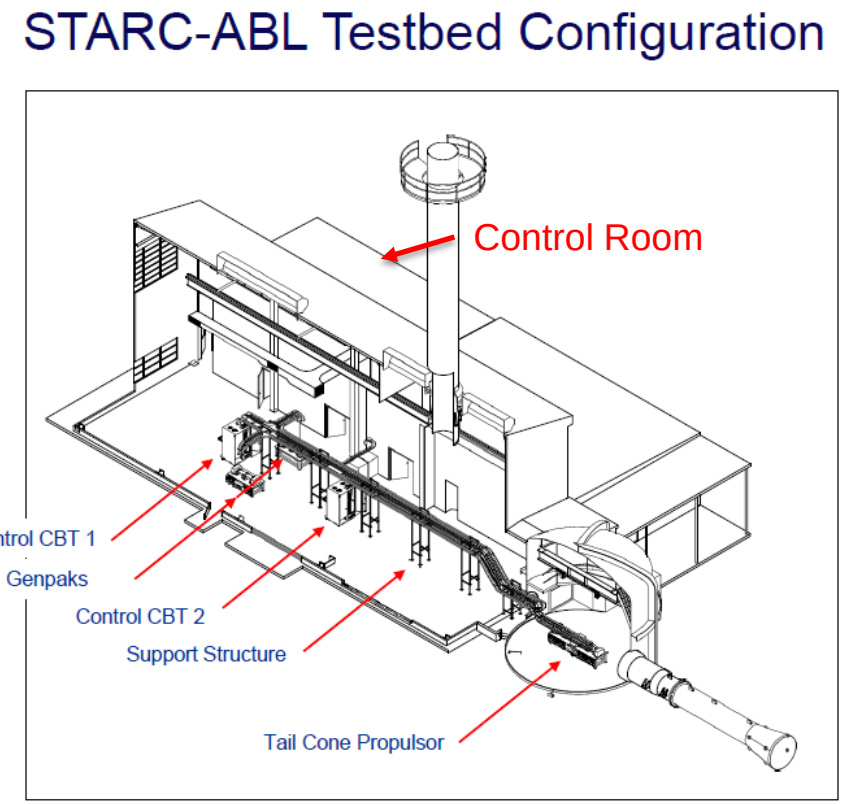
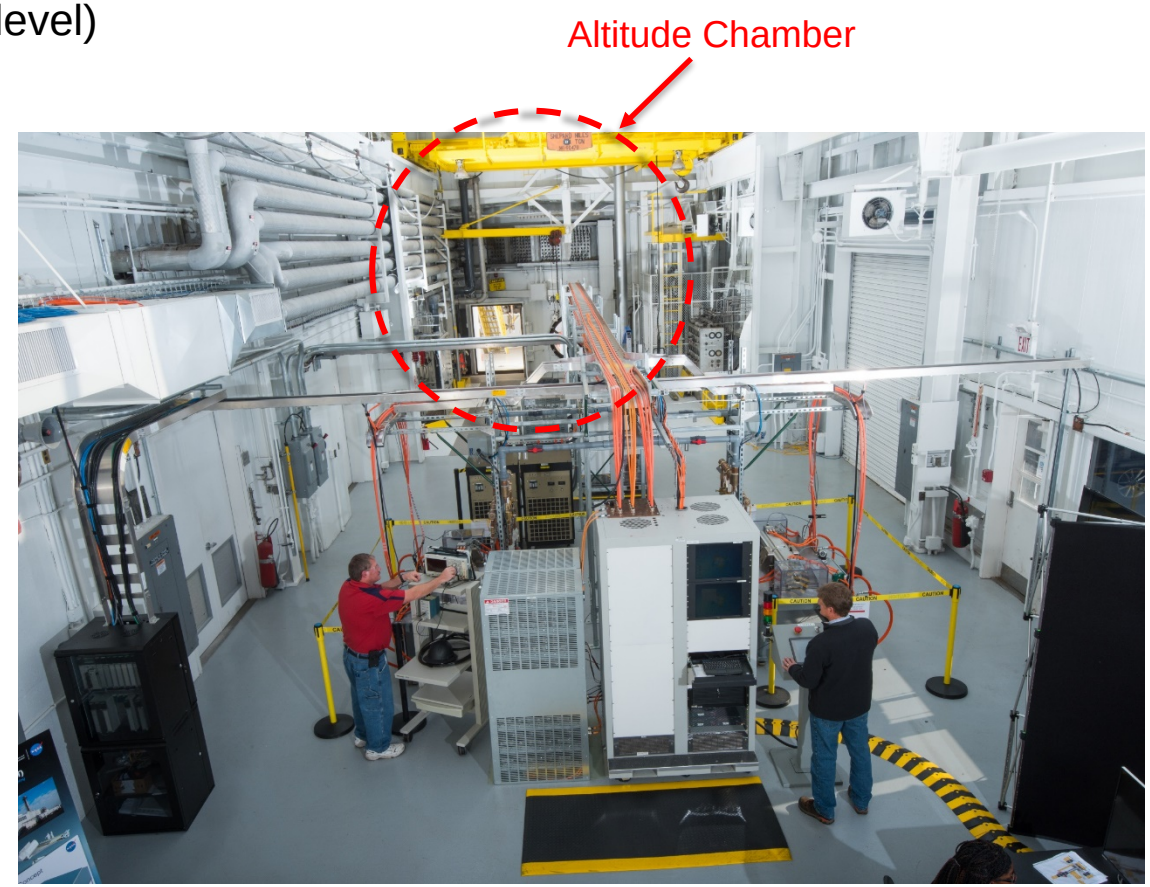
Main Test Area

- Test area large enough for 737-class electric powertrain (sea level)
- Pictures show NEAT in 2017 STARC-ABL configuration
  - 500 kW subscale, simplified electrical architecture
  - Sea Level (chamber used for horizontal space only)





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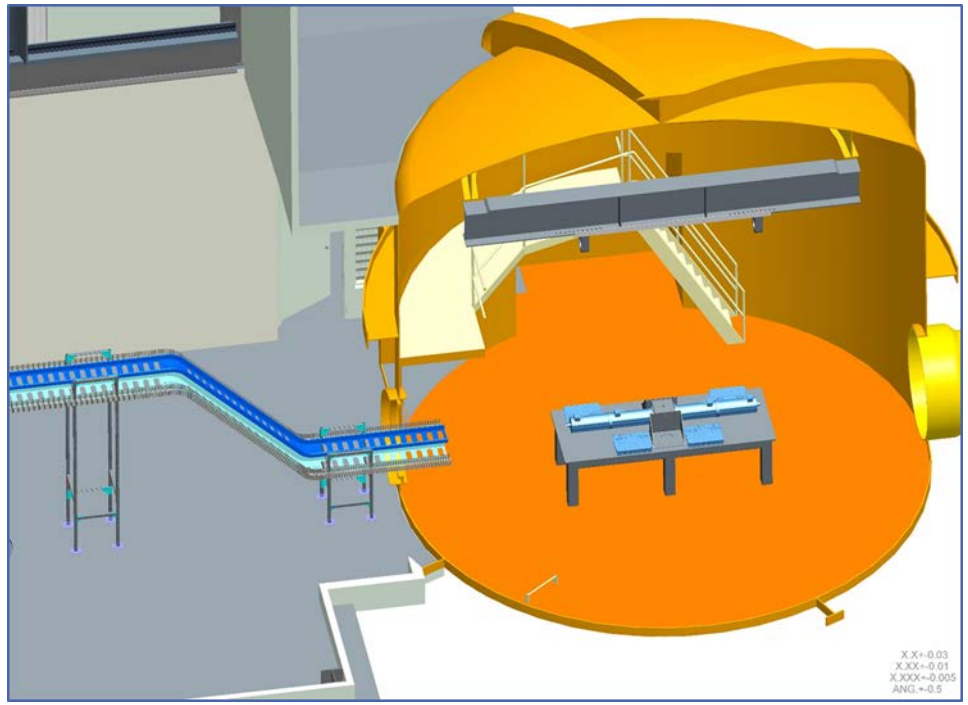
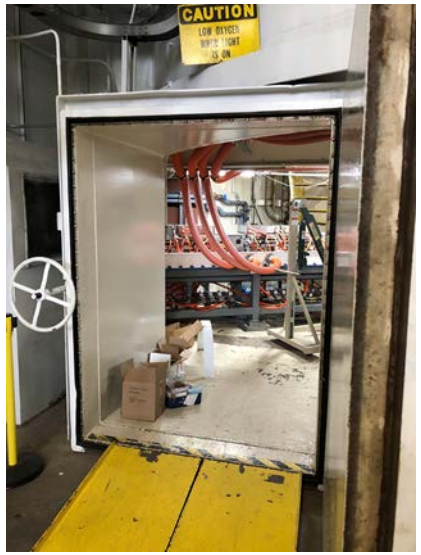
Altitude Chamber

- Altitude Chamber adjacent to main test area
  - 25 ft diameter X 21 ft high, cylindrical steel shell chamber
  - Reinforced concrete floor
  - Access:
    - Access door (7 ft tall x 6 ft wide)
    - 48” bulkhead open to main test area
    - 65” bulkhead open to outside
    - Other plates and flanges
  - Operated at 60,000 ft (15 minute pump down)

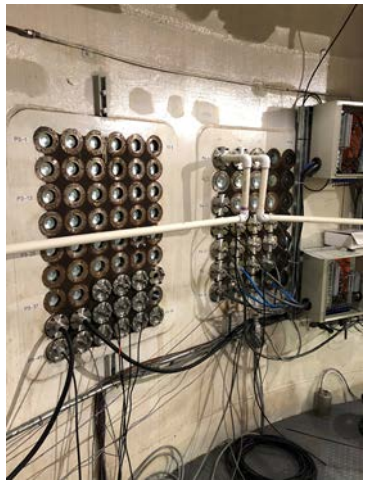


Layout Drawing showing interior of chamber

48” Bulkhead



Access Door



Instrumentation connections into altitude chamber

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Facility Support

- Cooling
  - Relied in past on rented cooling
  - Recently added dedicated cooling in external pump building
  - System designed to provide up to 400 gpm of cooling water at approximately 90˚ F.
- Instrument Air and Gearbox Pressurization Systems
  - 120 CFM @ 100PSIG
  - Dew point: -40ºF
  - Provides air to gearbox and other equipment
- Facility PLCs, Data Acquisition, etc
  - Data acquisition system currently configured for NASA use, not as protected “customer data” typically provided in a research facility

Cooling System

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Electrical Power

- External Power source
  - 12 MVA available at 4160 VAC
  - 3 MVA of 3-phase, 480VAC transformed to date for testbed use
  - Further transformer upgrades made when additional power is required, up to the full 12 MVA
- Available voltages (converted for testbed use)
  - Total of 550 kW of bidirectional DC power
    - 2 Arbin units
    - Each is 275 kW, 0-700V DC, 0-275 A
  - Total of 1500 kW DC power
    - 6 Magna units, can be wired in series or parallel
    - Each unit is 250 kW, 0-700 VDC, 0-357 A

Magna Power Supplies behind barricade

Arbin Bidirectional Power Supplies

Aerial View of Power Bus

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Electrical Power

- Load Banks
  - 2 MW of DC load banks
  - 2 units, each is 1 MW, stored outdoors
- Facility ground loop
- Batteries
  - Arbin units can be used as battery simulators
  - Planning to incorporate batteries, but none have been tested to date
  - Working with GRC battery organization and SMEs to safely accommodate in near future

Resistive Load Banks

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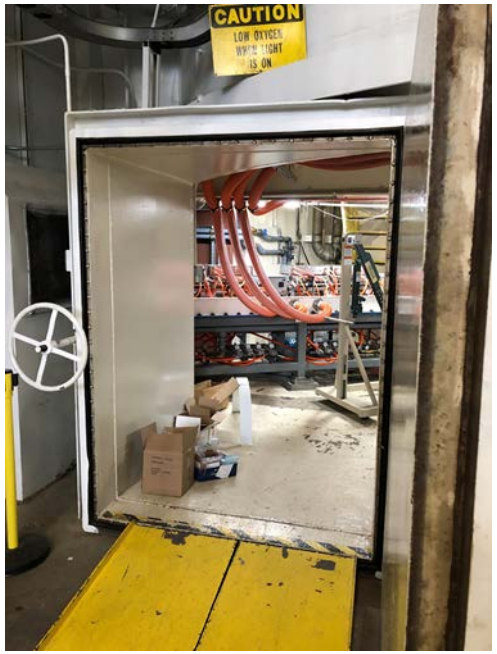
Electrical Machine Testing

- Foresee need to incorporate MW machines in powertrain configurations, and to potentially test promising machines at altitude
- COTS machines and drives can be configured as dynamometer
  - Up to 10 250 kW Parker motors on single shaft can be strung together
  - Two 1 MW strings possible with existing equipment
  - Mechanical Layout shows that two strings can fit in altitude chamber
  - Protective shroud used to keep at 1 ATM while under vacuum
- Have two 3:1 gearboxes
  - Intended to accommodate different operating speeds for powertrain components
  - Gearboxes capable of 1 MW each
  - COTS machines can operate up to 7000 rpm when attached to gearbox, higher when not attached

MW dyno in protective shroud, lid up (1 ATM)



MW dyno in altitude chamber

Lufkin 3:1 Gearbox

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Safety

- All NEAT tests subject to NASA's safety process
  - NEAT is under purview of the Area 9 Safety Committee
  - Safety Review and Safety Permit application process
  - Qualified operators only permitted during run phase

- High Voltage Precautions in use
  - All high V cabling out of reach and barricaded
  - Power supplies have built-in overvoltage and overcurrent features
  - Inverters have built-in trip points
  - Ground fault monitoring
  - Operations rules and facility alarms, interlocks and shutdowns in use

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Potential Partnering

- NEAT was conceived of as a reconfigurable testbed for use by NASA and its partners
- Testing has been conducted with research partners with the goal of advancing US competitiveness in EAP
- NEAT has not operated as a “pay for use” test asset to date
- Cost
  - No daily cost available to date
  - Each configuration has been unique, and can require design modifications to current electrical system
  - However, expenditures are known, and a price estimate can be created for a specific configuration and test duration