Environmental Testbed Development to Evaluate Power Distribution Materials in Electrified Aircraft (EA)

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Introduction

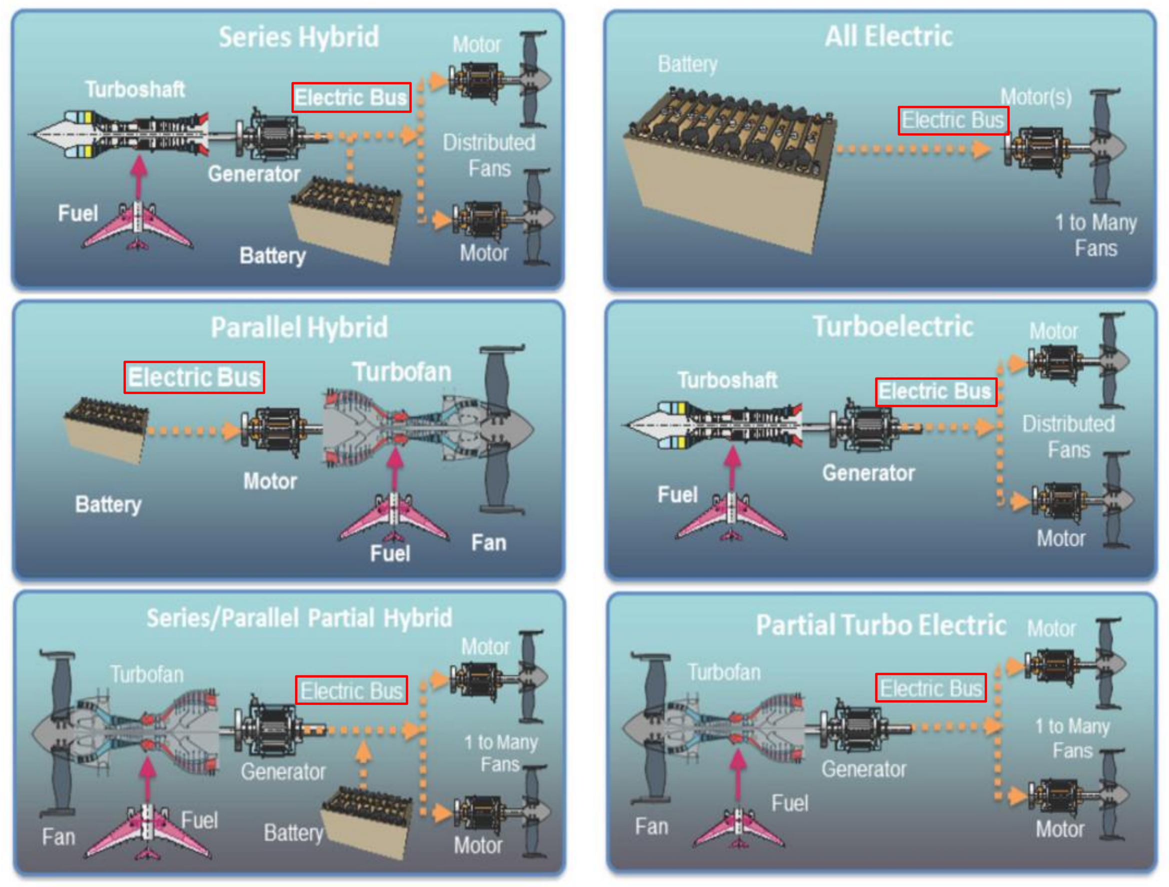

Fig. 1: Proposed configuration for EP systems. James L. Felder "NASA Hybrid Electric Propulsion Systems Structures,"

- NASA is pursuing the development of electrified propulsion (EP) technologies to improve air transportation in terms of *efficiency*, *affordability*, and *sustainability*.
- The power requirements are expected to reach 20 megawatts for large EP commercial airliners.
- A key challenge is transmission and distribution of the high voltage (~20 kilovolts) needed for some EP systems.
- This is a challenge because the risk of electrical failure in aircraft at high altitude (low pressure) due to **corona discharge** and other forms of partial discharge increases significantly when voltages exceed 327 V.
- Corona discharge is a form of partial discharge in which gaseous molecules are ionized by strong electric fields.
- Corona discharge is known to lead to *aging* in adjacent materials.
- Aging is a leading cause of electrical failure in electrical insulation materials. In particular, aging from electrical, vibrational, and thermal stresses decrease the *performance life* of insulation materials.
- There are currently no test standards or equipment that can effectively age materials under high altitude, voltage and frequency conditions. This poster proposes a design for a test system including an environmental chamber that can simulate the environment of future EP systems for aging tests.

Project Goals

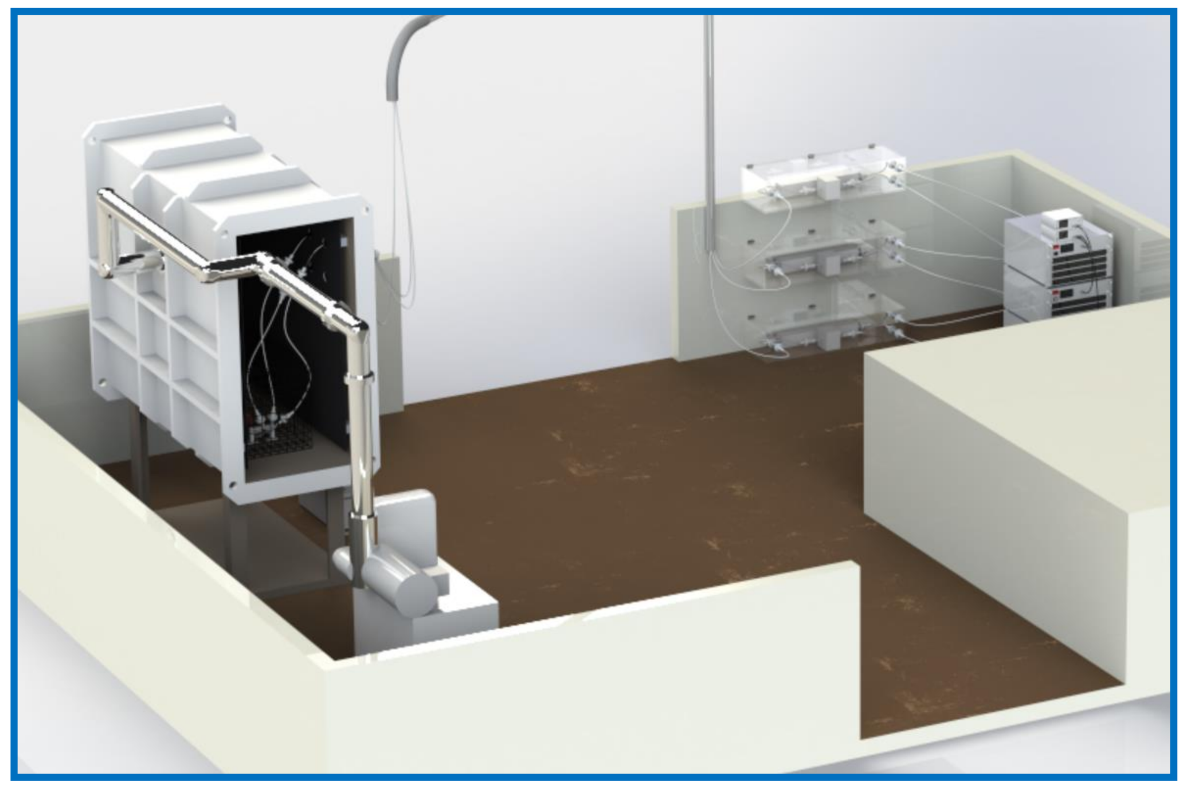

Fig. 2: Rendering of the Testbed System Configured for VF-9

- **Begin designing a testbed that can simulate an inflight environment for testing electrical power distribution equipment:**
  - Identify target specifications.
  - Select necessary subsystems.
  - Identify and communicate with potential vendors.
  - Perform cost analyses of various configurations.
  - Design methods of integrating subsystems.
  - Draft 3D models using CAD software.

Imaging System

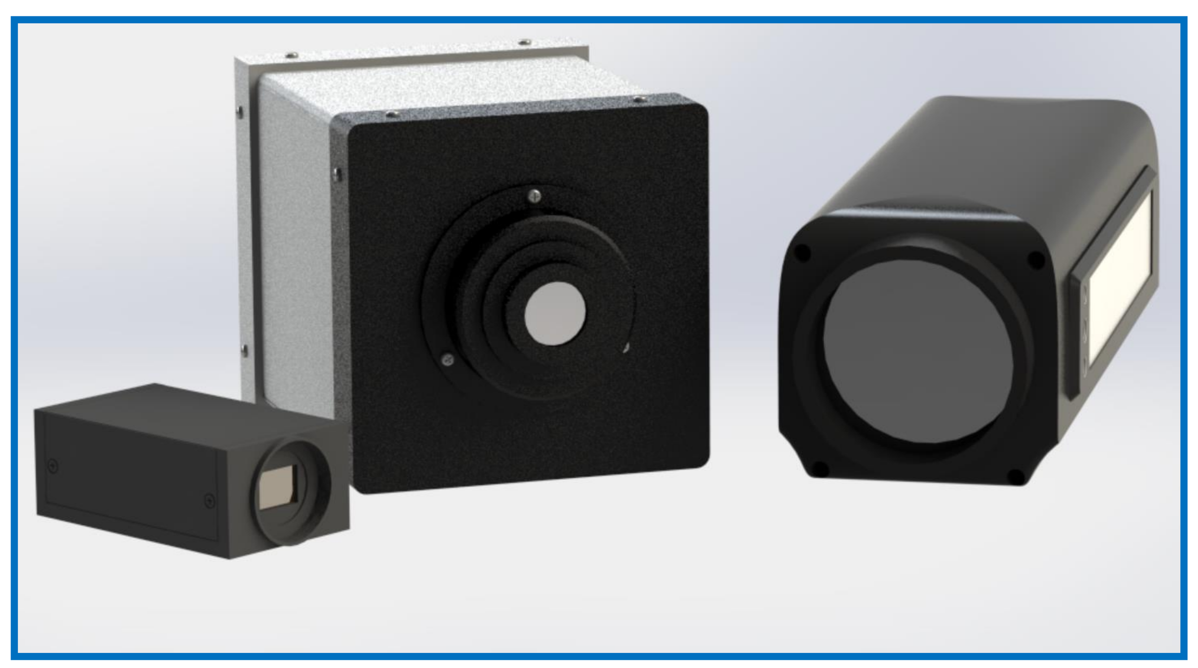

Fig. 3: Rendering of Potential Imaging System Components

- Thermal long wave IR imaging (5 – 15 μm).
- UV imaging (200 nm – visible) for corona detection.
- Window materials
- Field of view

Vibration System

Fig. 4: Rendering of the Vibration System

- Replicate inflight mechanical stresses on cables and bus bars
- Electrodynamic shaker
- Control hardware and amplifier
- Temperature and magnetic considerations
- Mounting components with sufficient rigidity

Corona Discharge System

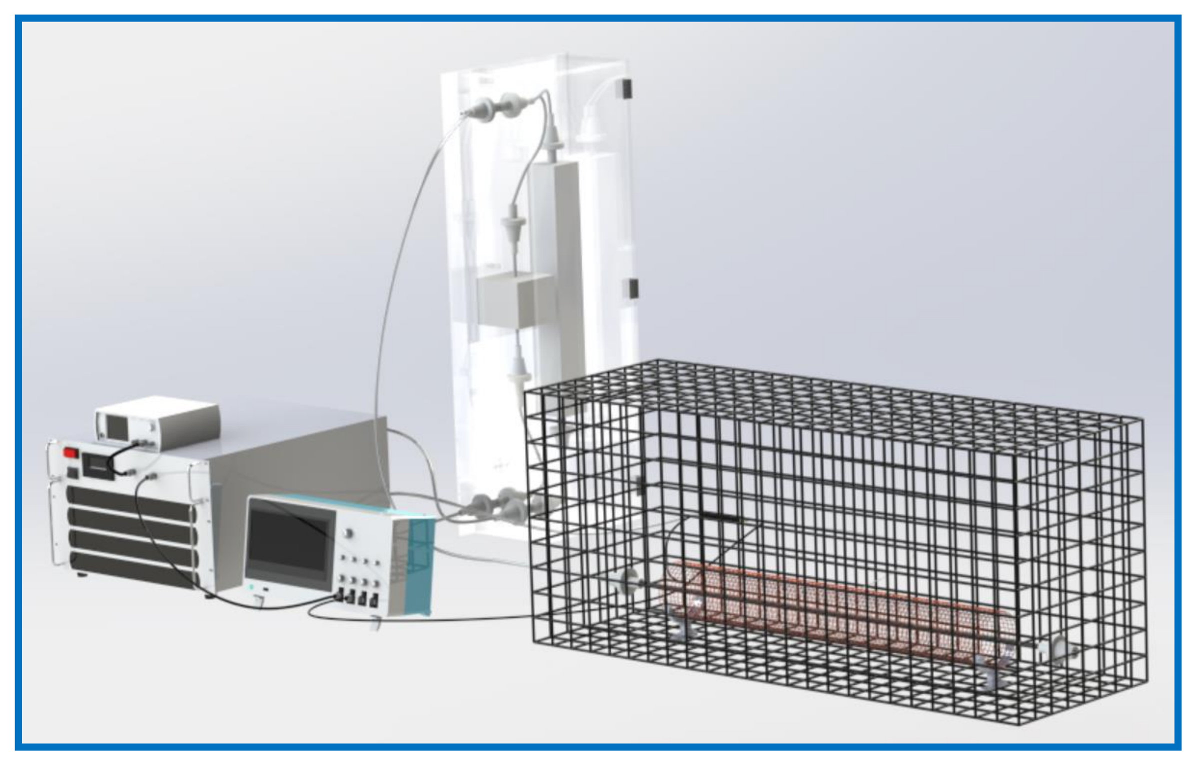

Fig. 5: Rendering of the Corona Discharge System (Configured for single-phase power).

- Must be capable of applying three phase power at up to 20 kV and 4 kHz.
- Waveform generator connected to three separate high voltage amplifiers.
- Conformal passive electrode for uniform electrical field.
- Electrical corona detection.
- System grounds and faraday cage.

Environmental Regulation and Analysis System

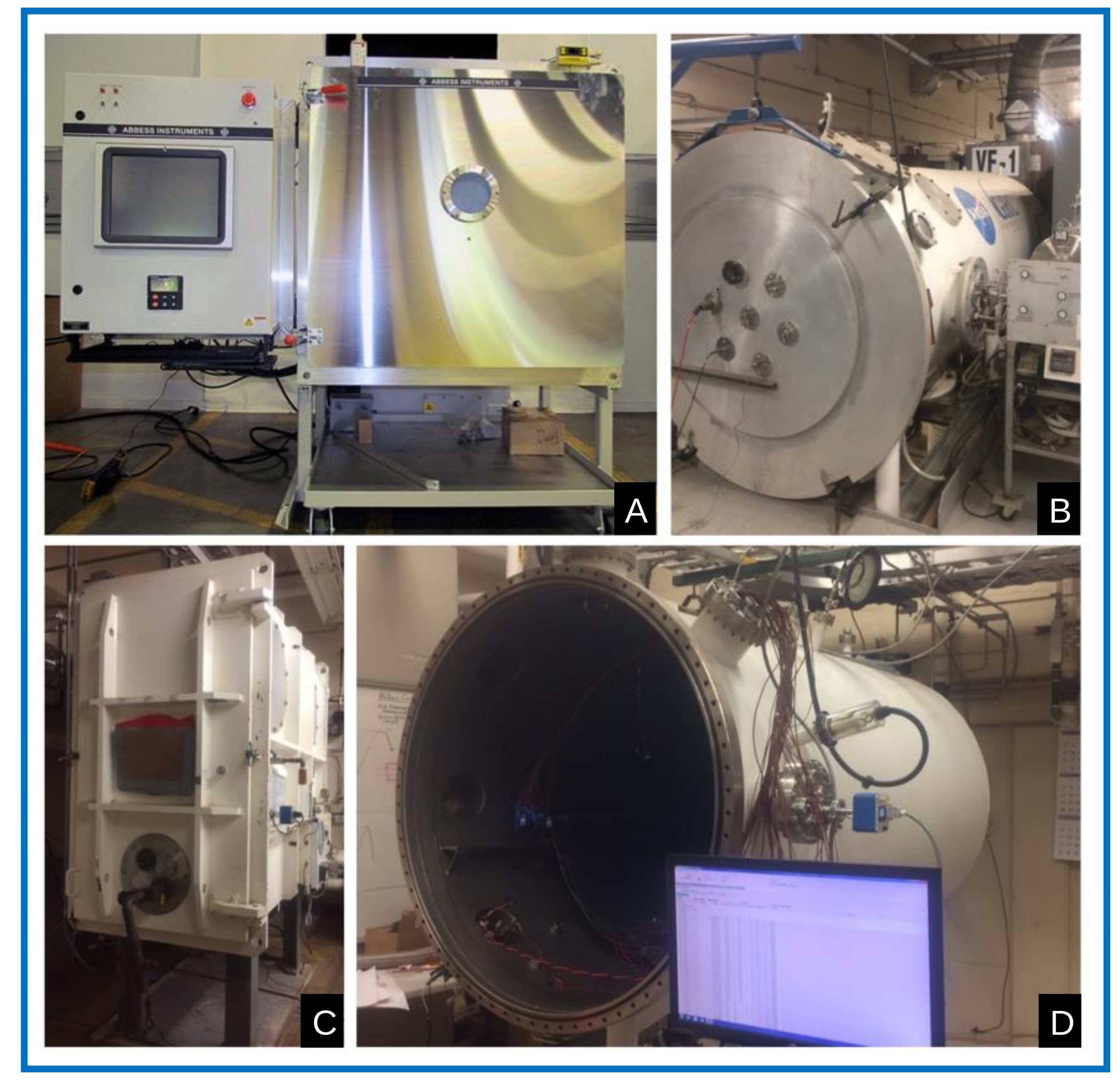

Fig. 6: Possible Chambers: A: New chamber built by Abbess B: VF-1 at GRC C: VF-9 at GRC D: VF-10 at GRC

- Simulation of sea level (1 atm) to 50,000 feet (0.1 atm).
- Temperatures from -60 to 200 degrees Celsius.
- Feedthroughs for power, thermocouples, and gas I/O.
- Mass spectrometer.
- Vacuum pumps.
- Repurposed or custom order.

Summary

A testbed that can successfully replicate inflight conditions for testing the damaging effects of corona discharge will be very valuable for the development of new materials for use in future electrified aircraft. This project has identified the necessary components for such a system, begun communication with potential vendors, and begun preliminary design work for integrating the various subsystems together. The test system will cost an estimated $300,000 if using a custom order chamber or $200,000 if using a modified repurposed chamber.