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M3Or4A-06: A sustainable flight demonstrator using a retrofit high-temperature superconducting (HTS) brushless DC motor in an RC plane

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In the United States, the transportation sector was the largest contributor to CO2 emissions, responsible for ˜28% of the total in 2022, whereas the residential sector accounted for around 13%. While batteries are making significant progress in reducing emissions in the transportation and residential sectors, commercial aircraft remain a mode of transportation where electrification poses significant challenges with current technologies. To address the challenges of electrifying commercial aircraft, two innovations are necessary: (1) the development of new, carbon-neutral, readily available fuels and (2) innovative approaches to deliver power to propel the airplane. Electrified aircraft allow architectural enhancement to improve aerodynamic, propulsive, environmental, and power management efficiencies dramatically. Presently, the gross take-off power needed for a single-aisle 150-passenger aircraft is greater than 20MW. Electrifying aircraft with such power demands using conventional electrification technologies is extremely challenging. Hence, the next generation of technologies such as cryocooling, superconductivity, and power conversion systems (i.e. fuel cells, etc.) will play a crucial role in power generation, transmission, and propeller drivetrains. A ground-based demonstration of a cryocooled high-temperature superconductor (HTS) powertrain was previously presented at SciTech 2025 on an RC scale. The current work will focus on a first-of-its-kind RC plane flight demonstration using a liquid nitrogen (LN2) tank and an HTS conductor-based BLDC motor.
For the first prototype, we modified a battery-powered, twin-motor EC-1500 cargo-style RC airplane by installing a custom-built HTS motor in the nose of the aircraft, making it a tri-motor configuration. The key challenge was modifying an existing brushless DC motor (EFLM15650) by incorporating HTS windings in the stator. Another challenge was to design and integrate a cryogenic Thermal Management System (TMS) that includes a liquid nitrogen (LN2) tank on the airplane. The first HTS motor prototype was tested by immersing it inside an LN2 tank as proof of concept. A second round of systems testing showed the implementation of the motor in the nose of the EC-1500 RC airplane.

This paper will showcase an advanced science project undertaken at Greenwich High School and the University of Connecticut. It will validate the feasibility of a sustainable Radio-Controlled (RC) aircraft, propelled by an HTS brushless DC motor (peak power 600W) while using batteries and a fuel cell. The purpose is to develop flight demonstrators for future aviation technologies that will operate in a real-world environment while offering an affordable path for educational institutions. The focus of this paper is on creating a redundant TMS for the superconducting stator to operate as demonstrated in previous works. For the LN2 tank, a Styrofoam model created through CAD software will prevent the tank from caving, decrease the weight for better flight optimization, and allow for a more aerodynamic design that is flush with the aircraft fuselage. The jacket and rotor will be 3D printed with carbon fiber-reinforced filament, aiding structural rigidity and weight reduction. In previous designs, the PLA structures would bend and crack, which created challenges with the concentricity and integrity of the design. Lastly, to solve condensation issues, the shaft and bearings of the motor will be replaced with a thermally insulating material and self-lubricating material, such as garolite (G-10/FR4) or polyetheretherketone (PEEK).
Further testing will demonstrate the flight capabilities and characteristics of this motor and fuel cell via an onboard data acquisition system to measure motor performance and AC losses when operating under load. This supported the development of an affordable RC aircraft fleet of technology demonstrators for instructional and R&D purposes. Ongoing work, such as the NASA ULI Cheetah program, shows promise of efficient electric power trains with cryogenics and fuel cells. We aim for this effort to accelerate the technology transition into future commercial aircraft.

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