ASCEND—Aviation-class **S**ynergistically **C**ooled **E**lectric-motors with i**N**tegrated **D**rives

PROJECT DESCRIPTIONS

Raytheon Technologies Research Center – East Hartford, CT

Ultra-Light, inTegrated, Reliable, Aviation-class, Co-Optimized Motor & Power converter with Advanced Cooling Technology (ULTRA-COMPACT) - $2,330,137

The Raytheon Technologies Research Center proposes ULTRA-COMPACT to improve the electric-to-shaft power electric drive train and demonstrate feasibility of a turbo-electric distributed propulsion-based electrified aircraft propulsion system. The ULTRA-COMPACT electric propulsion system leverages: (1) high-speed Permanent Magnet machines, (2) a series-parallel, multi-level silicon carbide (SiC) based motor drive topology, (3) an integrated and actively controlled thermal management system that provides coolant directly to the motor windings and power converter, and (4) a high-power density gearbox using lightweight composite.

Marquette University – Milwaukee, WI

High Power Density Motor Equipped with Additively Manufactured Windings Integrated with Advanced Cooling and Modular Integrated Power Electronics- $1,600,000

Marquette University and its partners are developing the next generation of electric drivetrains for aerospace propulsion. The proposed system consists of a high-power density motor enabled by (1) an additively manufactured winding and a novel thermal management scheme, (2) a modular power electronics topology, and (3) tight system integration and shared thermal management between the motor and power electronics to meet or exceed system-level targets. In the project's first phase, the team will develop concepts and tradeoff studies and perform sub-component/component testing and risk retirement. Phase two will focus on component procurement, system integration, and verification testing of the technology.

General Electric Global Research – Niskayuna, NY

Electric Flightworthy Lightweight Integrated Thermally-Enhanced powertrain System (eFLITES) for Narrow-body Commercial Aircraft - $2,300,000

General Electric Global Research will develop a 2MW fully integrated all-electric aircraft powertrain and demonstrate a 350 kW lab-scale prototype to enable zero carbon emission narrow-body commercial aircraft with all-electric propulsion. The technology is supported by several key innovations such as a high-voltage, direct-drive, synchronous permanent-magnet motor with transformational embedded cooling of the windings using supercritical carbon dioxide and high-temperature, high-voltage electrical insulation; a modular inverter fully integrated into the motor to reduce component count with high-temperature, low-loss SiC inverter modules; and an ultracompact thermal management system that services the motor and inverter. The design and use of novel manufacturing techniques will lead to significant mass reduction and thus increase in specific power density while maintaining a very high electrical-to-mechanical energy conversion efficiency.

Honeywell – Torrance, CA

Advanced Electric Propulsion System (AEPS) - $1,800,000

Honeywell Aerospace proposes to develop a novel high-voltage 500 kW advanced electric propulsion system (AEPS) with a high efficiency and a high-power density. The cost-effective AEPS will include a highly effective and innovative thermal management system. This system will use high-speed air flow from the aircraft propulsor wash to cool the power electronics and the motor via an innovative heat sink integrated into the AEPS housing that minimizes the thermal resistance. Other key innovations enable overall machine weight reduction without compromising efficiency, such as the use of high-performance windings, which increases the copper fill factor for increased machine efficiency and thermal and electric conductivities. The AEPS also uses an integrated, direct drive permanent magnet electric motor and a motor drive (power and control electronics) with common chassis and cooling systems for enhanced performance.

University of California, Santa Cruz – Santa Cruz, CA

Flux-Switching Machine Based All-Electric Power Train for Future Aircraft - $854,495

Power density and efficiency are crucial to electric propulsion for future aviation systems. The University of California, Santa Cruz proposes a novel all-electric power train. Each aspect of the proposed power train encompasses unique technology. The machinery relies on a flux-switching motor with superconducting field coils which has been shown to be smaller and lighter than conventional designs. The electronics are based on state-of-the-art multilevel inverter technology leading to improved efficiency and lower electromagnetic noise. The cooling technology is a hybrid system containing ultralight cryogenics as well as traditional air cooling methods. The development of the all-electric power train involves an aggressive design schedule and creation of a manufacturing plan that engages U.S. suppliers.

Texas A&M Engineering Experiment Station – College Station, TX

Multi-Physical Co-Design of Next Generation Axial Motors for Aerospace Applications - $1,300,000

Texas A&M will focus on the design, fabrication, and testing of a lightweight and ultra-efficient electric powertrain for aircraft propulsion to reduce the energy costs and emissions of aviation. The team's technology will reach peak power density and efficiency via (1) an axial flux motor with lightweight carbon fiber reinforced structural material, (2) a GaN multilevel inverter, (3) a thermally conductive nanocomposite electrical insulation, and (4) a two-phase thermal management system with zeolite thermal energy storage to absorb the excess heat generated during takeoff. Each subsystem is designed for tight integration with the other subsystems to minimize weight.

Hyper Tech Research Inc. – Columbus, OH

Cryo Thermal Management of High Power Density Motors and Drives - $2,910,479

Hyper Tech Research Inc., aims to design and demonstrate a multi-MW, high-efficiency, and high-power density integrated electric propulsion motor, drive, and thermal management system that meets the performance requirements of future hybrid electric, single-aisle passenger aircraft. The proposed technology incorporates an advanced and high-performance induction electric machine with a novel advanced thermal management techniques for synergistic cooling that safely uses cryogenic bio-LNG as the energy source for power generation and a large thermal-battery cooling system to provide a highly compact, light, and efficient thermal management system capability throughout all the different flight phases of a commercial narrow-body aircraft. If successful, the system will allow for a cost-effective motor capable of operating at a higher current density compared with existing conventional non-cryogenic motors without using superconductors.

Wright Electric – Albany, NY

2nd Generation Motor for Large Electric Aircraft Propulsion Systems - $647,039

Wright Electric will design engine systems that use cutting-edge innovations in integrated cooling, power electronics, and rotor design. The design will create a high-efficiency, high-performance motor without

sacrificing safety or the use of existing manufacturing techniques. The team plans to use an aggressive cooling strategy coupled with a high frequency inverter. In phase one of the project, the team will create a detailed design and subcomponent testing of this system. In phase two, it will build and demonstrate this system. The unique innovations across the electric engine will continue the development of aircraft flying entirely on electric power.

Advanced Magnet Lab, Inc. – Melbourne, FL

High Power Density Dual Rotor Permanent Magnet Motor with Integrated Cooling and Drive for Aircraft Propulsion - $655,354

Advanced Magnet Lab (AML) seeks to develop high-power density permanent magnet motors. When coupled to an integrated SiC drive, these motors will enable an overall specific power beyond 12 kW/kg. The proposed concept relies on (1) the tight integration of a high-power density dual-rotor permanent magnet rotor based on "continuous flux directed" magnets (PM-360^{TM}) currently under development at AML, (2) high-power density SiC power converters, and (3) a shared closed-loop cooling system rejecting the heat in the propulsion ducted fan air stream.