A1.04 Electrified Aircraft Propulsion

NASA SBIR 2021 Phase I Solicitation

Lead Center: GRC

Participating Center(s): AFRC, LaRC

Scope Title:

Electrified Aircraft Propulsion

Scope Description:

Proposals are sought for the development of energy storage, propulsion airframe integration, power distribution, thermal, tools/modeling approaches, electric machines, and electrical power conversion that will be required for aircraft that use turboelectric, hybrid electric, or all-electric power generation as part of the propulsion system. Turboelectric, hybrid electric, and all-electric power generation, as well as distributed propulsive power, have been identified as candidate transformative aircraft configurations with reduced fuel consumption/energy use and emissions. However, components and management methods for power generation, distribution, and conversion are not currently available in the high power ranges with the necessary efficiency, power density, electrical stability, and safety required for thin haul/short haul or transport-class aircraft. Novel developments are sought in:

- Energy storage systems with specific energy >400 Whr/kg at the system level under continuous 2C rate discharge conditions, with cycle life >10,000 cycles. Materials or strategies to promote rapid charging are desirable. This subtopic seeks energy solutions in the Technology Readiness Level (TRL) 3 to 5 range, appropriate for near-term applications.

- Lightweight electrical insulation materials/composites for high-altitude, high-voltage power transmission with dielectric breakdown strength (V/m) of the insulation minimally 2.5× that of the operating electric field stress at the conductor surface (operating voltages expected to be 1 to 20 kV), high resistivity at high temperature (>10⁸ up to 10³⁰ ?•cm), low dielectric dissipation factor (tan ?), insulation Class C with operating temperature performance 240 to 400 °C, moisture resistant, good mechanical properties (low creep under high-voltage stresses) and with thermal conductivity ?1 up to 10 W/m•K.

- Innovative tools for the design and analysis of airframe-integrated, high-performance distributed electric propulsion (DEP) inlet/fan systems and the resulting effect on: (1) distortion and swirl at the aerodynamic interface plane (AIP), (2) fan efficiency, stability, and structural robustness, and (3) operation of adjacent flow paths for DEP inlet/fan concepts and/or boundary layer ingestion (BLI) aircraft.

- Additive manufacturing processes and advanced materials for future generation MW-class electric motor designs and windings, which provide lower costs, compact designs (>25% volume reduction), lighter weight
 (>30% reduction), advanced cooling/improved thermal conductivity, multimaterials and/or greatly improved material or component properties that significantly contribute toward improved electric machine performance. Maintaining electrical insulating and lifetime properties over repetitive thermal cycling, along with being resistant to corona effects, is of interest.

**Expected TRL or TRL Range at completion of the Project:** 2 to 6

**Primary Technology Taxonomy:**
- Level 1: TX 01 Propulsion Systems
- Level 2: TX 01.3 Aero Propulsion

**Desired Deliverables of Phase I and Phase II:**

- Research
- Analysis
- Prototype
- Hardware
- Software

**Desired Deliverables Description:**

Deliverables vary considerably within the topic, but ideally proposals would identify a technology pull area (with a market size estimate), how the proposed idea addresses the needs of the technology pull area and then deliver a combination of analysis and prototypes that substantiate the idea’s merit. For Phase I, it is desirable that the proposed innovation clearly demonstrates that it is commercially feasible and addresses NASA’s needs. Deliverables for a Phase II should be focused on the maturation, development, and demonstration of the proposed technical innovation.

**State of the Art and Critical Gaps:**

The critical technical need is for lightweight, high-efficiency power distribution systems and energy storage that have flight-critical reliability. Typically, the weight needs to be reduced by a factor of 2 to 3 and efficiency needs to be improved. Higher efficiency reduces losses and makes thermal management more achievable in an aircraft. Another need for medium to large aircraft is the ability to operate at voltages above 600 V. This capability results in reduced weight, however, is called out specifically because it impacts all of the power system components.

Technologies that address these gaps enable Electrified Aircraft Propulsion (EAP) which enables new aircraft configurations and capabilities for the point-to-point on-demand mobility market and a new type of innovation for transport aircraft to reduce fuel consumption and emissions.

**Relevance / Science Traceability:**

EAP is an area of strong and growing interest in Aeronautics Research Mission Directorate (ARMD). There are emerging vehicle level efforts in Urban On-Demand Mobility, the X-57 electric airplane being built to demonstrate EAP advances applicable to thin and short haul aircraft markets and an ongoing technology development subproject to enable EAP for single aisle aircraft. Additionally, NASA is starting the new Electrified Powertrain Flight Demo (EPFD) project to enable a MW-class aircraft.

Key outcomes NASA intends to achieve in this area are:

- Outcome for 2015-2025: markets will begin to open for electrified small aircraft.
- Outcome for 2025-2035: certified small-aircraft fleets enabled by electrified aircraft propulsion will provide new mobility options. The decade may also see initial application of electrified aircraft propulsion on large aircraft.
• Outcome for >2035: The prevalence of small-aircraft fleets with electrified propulsion will provide improved economics, performance, safety, and environmental impact, while growth in fleet operations of large aircraft with cleaner, more efficient alternative propulsion systems that will substantially contribute to carbon reduction.

Projects working in the vehicle aspects of EAP include:

• Advanced Air Vehicles Program (AAVP)/Advanced Air Transport Technology (AATT) Project
• Integrated Aviation Systems Program (IASP)/Flight Demonstrations and Capabilities (FDC) Project
• AAVP/Revolutionary Vertical Lift Technology (RVLT) Project
• Transformative Aeronautics Concepts Program (TACP)/Convergent Aeronautics Solutions (CAS) Project
• TACP/Transformational Tools and Technologies (TTT) Project

References:

EAP is called out as a key part of Thrust 3 in the ARMD strategic plan: https://www.nasa.gov/aeroresearch/strategy

Overview of NASA's EAP Research for Large Subsonic Aircraft: https://ntrs.nasa.gov/search.jsp?R=2017006235