NASA SBIR 2022 Phase I Solicitation

A1.04 Electrified Aircraft Propulsion

Lead Center: GRC

Participating Center(s): AFRC, LaRC

Scope Title

Electrified Aircraft Propulsion (EAP)

Scope Description

Technical proposals are sought for the development of enabling power systems, that will be required for aircraft using turboelectric, hybrid-electric, or all-electric power generation as part of the propulsion system. This subtopic is targeted towards megawatt-class vehicles. For the 100- to 200-kW realm targeted to electric vertical takeoff and landing (eVTOL) vehicles, please go to subtopic A1.06: Vertical Lift Technology for Urban Air Mobility -Electric Motor Fault Mitigation Technology.

Specifically, novel developments are sought in these areas:

- Superconducting wire or cables compatible with the NASA High Efficiency Megawatt Motor (HEMM) and at a temperature of 62 K that have properties exceeding: engineering current density >205 A/mm$^2$, cost per performance <$1.10/(A-m)$, and shear stress in all three axis >20 MPa. Information on HEMM can be found in the publication “High Efficiency Megawatt Motor Preliminary Design”, Jansen et al. https://ntrs.nasa.gov/citations/20190029589
- Lightweight alternating current (AC) and direct current (DC) electrical fault management systems and protective devices (such as circuit breakers). Technology should scale to aircraft circuits operating in the 1,000- to 3,000-V range at 500 to 2,000 A. Prototypes can be built at the 100- to 500-V at 10- to 100-A range or at full scale. The circuit breaker technology proposals will be evaluated on the metrics of: speed to isolate circuit, specific power (kW/kg), and efficiency (1- (W loss/ W conducted)). The performance objective is to exceed 200 kW/kg and 99.5% at full scale.
- Converters (inverters/rectifiers) used to convert AC to AC frequency AC to DC. Technology should scale to aircraft circuits operating in the 1,000- to 3,000-V range at 500 to 2,000 A. Prototypes can be built at the 100- to 500-V at 10- to 100-A range or at full scale. The converters will be evaluated on the metrics of specific power (kW/kg) and efficiency with objective to exceed 20 kW/kg and 99.5% at full scale.
- Electric machines for aircraft propulsion used for direct-drive propulsion of fans or propellers or as generators coupled to internal combustion engines, turboprops, or turbofans. Technology should scale to aircraft applications in the 1- to 5-MW range. The electric machines will be evaluated on the metrics of: specific power (kW/kg) and efficiency with objective to exceed 20 kW/kg and 98% at full scale.

Expected TRL or TRL Range at completion of the Project
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 subtopic, 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 motors, distribution systems, and fault management. 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.

Technologies that address these gaps enable 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 the 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 Demonstration (EPFD) project to enable a megawatt-class aircraft.

Key outcomes NASA intends to achieve in this area are:

- Outcome for 2015 to 2025: Markets will begin to open for electrified small aircraft.
- Outcome for 2025 to 2035: Certified small-aircraft fleets enabled by EAP will provide new mobility options. The decade may also see initial application of EAP 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 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=20170006235