



## NASA STTR 2019 Phase I Solicitation

### T15.03 Electrified Aircraft Propulsion Energy Storage

Lead Center: GRC

Participating Center(s): AFRC, LaRC

Technology Area: TA15 Aeronautics

Proposals are sought for the development of enabling rechargeable batteries (or other types of energy storage) for Electrified Aircraft Propulsion (EAP). Two paths to improved battery performance are sought:

- Innovative thermal, structural, and electrical integration that reduce the mass fraction added when scaling from a battery cell to an integrated battery.
- Battery chemistry improvements that substantially enhance useable energy density, cycle life, life cycle cost, and safety.

This subtopic seeks technologies in the Technology Readiness Level (TRL) range 1 to 4 via partnerships between academic institutions and small businesses. Small businesses interested in proposing TRL 3-6 energy storage ideas should apply to SBIR subtopic A1.04 - Electrified Aircraft Propulsion.

Batteries and other energy storage systems with some combination of some or all of the following performance levels at the integrated battery pack level are sought (see below for additional details on these metrics):

- Specific energy > 400Whr/kg at the system level.
- Cycle life > 10,000 cycles.
- Prime flight quality and safety.
- Cost effective enough to close electric air services at a profit.

Battery pack level energy density means the amount of useable energy after derating for depth of discharge, cycle life, C rate limits, thermal constraints, and any other applicable limit to energy that can be used during the mission divided by the mass of the battery package (including the structure, safety devices, battery management system, and thermal management parts that are mounted to the battery). This will typically require cell level energy densities in the range to 600-800 W-hr/kg along with an innovative combination of those cells into a battery system. Alternate electrical energy storage approaches will also be considered.

All-electric conventional and vertical takeoff research vehicles that can carry one or two people have been demonstrated. In order to achieve commercial viability, improvements in batteries are required for the aircraft to have sufficient range, safety, and operational economics for regular service. Markets needs span urban air mobility (UAM), thin/short haul aviation, and commercial air transport vehicles which use EAP. 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.

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- **Specific Energy:** Approximately a factor of 2 improvement is needed. Current assessment of battery specific energy requirements for all-electric operations are in the 300-400 Wh/kg at the installed/pack level (installed means after derating for depth of discharge limit, cycle life, battery management, packaging, and thermal environment). This assumes the ability to quickly recharge between flights. Current state of the art (SOA) is about ? 160-170 Wh/kg (pack level). Li-ion batteries are nearing practical maximums so new chemistry(s) or energy storage types are likely required to meet all-electric UAM mission needs. All electric helicopters and regional passenger aircraft will likely need 600Wh/kg and 500-700Wh/kg (cell level) respectively. Approximately 30-40% Wh/kg is lost when cells are integrated into packs and installed.
  - **Cycle Life:** A substantial improvement is needed. Current SOA is 1500-3000 cycles which lasts about 3 months for UAM.
  - **Prime Flight Quality and Safety:** The expected reliability of an aviation system is probably a few orders of magnitude higher than an automotive application and safety considerations are a more significant driver – including time needed to get passengers out of danger. Discuss features and plans to ensure reliability.
  - **Cost:** Justify features of the technology and implementation, including comparisons to SOA alternatives, which aid in ensuring that the vehicle concept and overall operations can close profitably.

EAP is an area of strong and growing interest in NASA's Aeronautics Research Mission Directorate (ARMD). Energy storage is an enabling technology for the UAM and Thin Haul segments of the effort. There are emerging vehicle level efforts in UAM/On-Demand Mobility like 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.

NASA Projects working in the vehicle aspects of EAP include: Advanced Air Vehicles Program (AAVP)/Advanced Air Transport Technology (AATT) Projects, Integrated Aviation Systems Program (IASP)/ Flight Demonstrations & Capabilities (FDC) Project, AAVP/Revolutionary Vertical Lift Technology (RVLT) Project, and Transformative Aeronautics Concepts Program (TACP)/Convergent Aeronautics Solutions (CAS) Projects.

Key outcomes NASA intends to achieve in this research 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 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 EAP 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.

Deliverables most likely will include prototypes of energy storage units along with research and analysis addressing safety and cost considerations. In some cases, test data for safety may be a deliverable. Ideally, proposals would identify a technology pull area (with a market size estimate), how the proposed idea address the needs of the technology pull area, and then deliver a combination of analysis and prototypes that substantiate the idea's merit.

#### References:

- Electrified Aircraft Propulsion (EAP) is called out as a key part of Thrust 4 in the ARMD strategic plan: <https://www.nasa.gov/aeroresearch/strategy>
- NASA Urban Air Mobility (UAM): <https://ntrs.nasa.gov/search.jsp?R=20170006235>
- NASA X-57 Project: <https://www.nasa.gov/aeroresearch/X-57/technical/index.html>