NASA SBIR 2019 Phase I Solicitation

A1.07 Propulsion Efficiency - Propulsion Materials and Structures

Lead Center: GRC

Participating Center(s): GRC

Technology Area: TA12 Materials, Structures, Mechanical Systems and Manufacturing

Materials and Structures research and development are a key contributorÂ to NASAâ€™sÂ Aeronautics Research Mission Directorate (ARMD), impacting the development of advanced propulsion systems for Next Generation aircraft.Â Proposals are sought for advanced materials and structures technologies that will be enabling for new propulsion systems for subsonic transport vehicles with high levels of thermal, transmission, and propulsive efficiency.

For future aircraft with hybrid electric or all electric propulsion systems, advanced materials technology is needed for power components including electric machines and power cables. Integrated computational and experimental approaches are needed that can reduce the time necessary for development, testing, and validation of new materials systems and components. Advanced high-pressure-ratio compact gas turbine engines will include components of sufficiently compact size so that new approaches to processing and advanced manufacturing will be needed. Temperature capability, thermo-mechanical performance, environmental durability, reliability and cost-effectiveness

are important considerations.

Â The increased use of various types of modeling to improve R&D effectiveness and enable more rapid and revolutionary materials design has been identified as critical. NASA recently sponsored a study to define a potential 25-year goal for integrated, multiscale modeling of materials and systems to accelerate the pace and reduce the expense of innovation in future aeronautical systems. Through a series of surveys, workshops, and validation exercises, this study identified critical cultural changes and gaps facing the multiscale modeling community. The results of this study were published in a NASA report [Vision 2040: A Roadmap for Integrated, Multiscale Modeling and Simulation of Materials and Systems, NASA/CR-2018-219771]. Some of the critical gaps identified in this report are:Â

- Under-development of physics-based models that link length and time scales
- Inability to conduct real time characterization at appropriate length and time scales
- Lack of optimization methods that bridge scales
- Lack of models that compute input sensitivities and propagate uncertainties
- Lack of verification and validation methods and dataÂ

Proposals emphasizing modeling can address topics which shall advance gaps in the Vision 2040 report. The range of topics could include data management, data analytics, machine learning, linkage and integration across spatiotemporal scales, and characterization of materials over their lifecycle. Proposals may address any material class associated with aeronautics propulsion, multiscale modeling and measurements, multiscale optimization methods, and verification and validation of models and methods. However, approaches should rely on iterative, predictive methods which integrate experiments and simulations to describe the behavior and response of materials at various length and time scales.

Specific technology areas of interest this year include:Â

- Computational materials and multiscale modeling tools, including methods to predict properties, and/or durability of propulsion materials based upon chemistry and processing for conventional as well as functionally-graded, nanostructured, multifunctional and adaptive materials.
- Robust and efficient methods/tools to design and model advanced propulsion system materials and structures at all scale levels, including approaches that are adaptable for a multi-scale framework.
- Multiscale design tools that integrate novel materials, mechanism design, and structural subcomponent design into system level designs.
- Advancing technology for ceramic matrix composites (CMCs) and their environmental barrier coatings (EBCs) for gas turbine engine components operating at 1482Â° C (2700Â° F) or higher. Focus areas include increased thermomechanical durability, increased resistance to environmental interactions, cost-effectiveness of processing and manufacturing, and improved approaches to component fabrication and integration. Computational tools and integrated experimental/computational methods are sought, including models/tools to predict degradation and failure mechanisms.
- Additive Manufacturing and other advanced processing/manufacturing approaches for propulsion systemÂ structural components or materials to enable improved engine efficiency through decreasing weight and/or improving component design, properties and performance.
- Soft magnetic material with high magnetic saturation and/or lower losses for 100 â€“ 300 kHz operation, hard magnetic materials with an energy product greater than neodymium iron boron, conductors with a specific resistivity less than copper or aluminum, and cable insulation materials with increased dielectric breakdown strength, and significantly higher thermal conductivity (â‰¥ 1W/mÂ·K) and resistance to ageing effects such as corona, ozone, humidity and dust operating at greater than 3kV.
- Novel materials systems and structures to enable functionality, such as power harvesting, thermal management, self-sensing, and actuation. Approaches may include use of nanotechnology and novel processing to tailor and control properties such as thermal conductivity, electrical conductivity, thermoelectric response, microstructure and porosity, and shape memory behavior.
- Design and development of unique materials such as shape memory alloys and high entropy alloys for aeronautics structures and components.
- Propulsion aeromechanics, damping devices, and analysis and mistuning analysis for turbomachinery rotating blades.Â

The expected technology readiness level (TRL) range at completion of the project isÂ 2 to 4.

NASAâ€™s intent is to select proposals that have the potential to move a critical technology beyond Phase II SBIR funding and transition it to Phase III, where NASAâ€™s ARMD programs, Other Government Agencies, or a commercial entity in the aeronautics sector can fund further maturation as needed, leading to actual usage. Each proposed topic area could yield a different deliverable. Some Phase IIs will yield models supported with experimental data, some can yield software related to a model that was developed, some will yield a material system or subcomponent that has been demonstrated to have better properties/performance (ability to operate at a higher temperature, carry more current, modeling tools for incorporation in software, etc.). The goal is to have funded proposals yield products that enable enhanced propulsion systems (with the possibility that additional funding via Phase III required to reach this goal), and the technology is of strong interest to NASA and/or commercial entities.Â

References:Â

- Vision 2040: A Roadmap for Integrated, Multiscale Modeling and Simulation of Materials and Systems, NASA/CR-2018-219771Â https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20180002010.pdf
- NASA Hybrid Gas-Electric Propulsion (HGEP) Subproject: Â https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20170004515.pdf

- Hybrid Electric Propulsion:
    - https://www1.grc.nasa.gov/aeronautics/hep/Â Â
    - https://www.grc.nasa.gov/www/cdtb/aboutus/workshop2016/HybridElectricPropulsionReportOut-LCCPCDRoadmapWorkshop.pdf
- NASA Transformational Tools and Technologies (TTT) Project:Â https://www.nasa.gov/aeroresearch/programs/tacp/ttt/descriptionÂ Â
- NASA Convergent Aeronautics Solutions (CAS) Project:
    - https://www.nasa.gov/aeroresearch/programs/tacp/casÂ Â
    - https://nari.arc.nasa.gov/Â Â
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    - https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20170006909.pdf