Attachment 1
24 Sep 2021

Experiments, Prototypes, Research, and Evaluation Supporting Systems (EXPRESS)

RXC Structural Materials Division Open Advanced Research Announcement (ARA) with Competitive Calls

1. Statement of Objective/Needs:

Air Force Research Laboratory, Materials & Manufacturing Directorate is soliciting white papers and potentially technical and cost proposals under this announcement that support the needs of its Structural Materials and Applications mission in the following areas:

The experimentation, evaluation, and assessment of materials and processes technology for Air Force and Space Force applications aimed at meeting validated systems requirements or to sustain and/or modernize installations or operations required for general research, development, test, and evaluation.

The demonstration of new and improved materials (including procedures, instructions/manuals, and familiarization training) in Air Force and Space Force system specific applications (including development of subsystems and components (experimental prototypes) and/or efforts to reduce risk to systems, and/or efforts to integrate subsystems and components into experimental system prototypes for field experiments and/or tests in a simulated environment or realistic operating environment) and/or development efforts to upgrade fielded or nearing production systems.

The transition of materials and processes to Air Force and Space Force Systems to ensure the required capabilities are available to enable the best supplies are available for the national defense are of interest.

Descriptors of Materials and Manufacturing Directorate technology interests are presented below on the basis of both Structural Materials Needs and Air Force and Space Force application area needs. The term "Demonstration" is used below as short hand to cover the full breath of experimentation, evaluation, and assessment, demonstration, risk reduction, and technology transition described above.

a. Structural Materials Needs:

***Ceramics and Ceramic Matrix Composites Materials and Processes*:** The objective of Ceramic Materials and Processes research is the demonstration of advanced high-temperature constituents for fiber-reinforced ceramic-matrix composites (CMCs) and an understanding of their behavior in relevant service environments. Demonstration of advanced constituents and composites to allow systems applications of next-generation fiber reinforced structural ceramic materials and processing and process models for a range of air and space applications

including turbine engine and scramjet engine hot-section components and thermal protection systems for hypersonic vehicles is sought.

Polymer Matrix Composites Materials and Processes: Demonstration in laboratory, and/or relevant environments, and/or actual applications is required of new polymer matrix composite materials and processing (PMC M&P) technologies for Air Force and Space Force propulsion and structural applications to enable systems with more "reach" due to lighter-weight and higher-temperature structural components; more "affordability" from predictive, optimized, and agile processing methods; more "sustainability" from rapid insertion of robust materials with better as-manufactured performance baselines; and more "survivability" from electromagnetic energy and laser threats through multiscale functional materials.

Composites Certification: The scope of the advanced structural airframe materials, process, and lifing tools to support composites certification covers exploratory through developmental research in understanding and prediction of composite behavior in representative Air Force and Space Force System environments. Areas of interest include demonstration of: Constitutive models and the ability to analyze highly tailored Air Force system structures are needed to improve design, maintenance, and performance of Air Force and Space Force Systems. The tailoring and demonstration of turn-key predictive, physics-based simulation tools for the prediction of structural composite damage evolution and behaviors across multiple scales is desired.

Metallic Materials and Processes: Advanced propulsion concepts require demonstration of metallic materials that withstand higher operating temperatures for longer times at higher stresses and in more aggressive environments relative to existing alloys. Further, many of the intended applications involve thin structural gauges and advanced heat-exchanger configurations. Future systems for access to space and hypersonic delivery are calling for the development and demonstration of advanced metallic thermal protection systems (TPS) and high-temperature airframe structures. The high temperature metals sub-competency focuses on the Air Force's and Space Force's affordable mission & sustainment needs, leading critical-path development efforts needed to achieve "true" retirement for cause in rotating applications.

Characterization, Sensing, and Analytics: The mission of Characterization, Sensing, and Analytics is to deliver material and damage characterization technologies that assure maximum reliability, availability and safety of Air Force and Space Force Systems. This includes demonstration of technologies addressing needs in the areas of nondestructive evaluation/inspection (NDE/I) and characterization of materials of interest to the aircraft structures, turbine engine, and specialty coatings communities within the Air Force and Space Force. The characterization, sensing, and analytics (CSA) team requires demonstration of next generation sensing technologies for materials and damage state characterization to enable future sustainment and maintenance strategies such as Condition-based Maintenance plus Prognosis (CBM+).

The objectives of the ARA efforts in CSA includes demonstrating advanced NDE/NDI methods and instrumentation for complex multilayer metallic structures with minimal or no disassembly and demonstrating advanced state of the art NDE/NDI for composite structural designs, included coated composite designs.

b. AIR FORCE Application Needs:

***Propulsion*:** Demonstration of advanced materials technologies are sought that enable higher operating efficiencies, enhanced performance, increased range, affordable manufacturability, and sustainability. In order to achieve improved efficiency and performance, materials technologies are required to enable higher operating temperatures, resulting in higher thermodynamic efficiency. Additional enhancement in efficiency is achieved through materials solutions that reduce engine weight, without reducing thrust. Activities are therefore sought to demonstrate materials technologies with higher temperature capability and/or reduced weight for applications such as ducts, rotors, blades and airfoils, integrated rotating structures, vanes, shrouds, nozzles, and combustor liners. Demonstration technologies could target advancements in polymer matrix composites (PMC), metals, ceramic and CMC, and coatings.

Space: Spaceframe concepts demand complex, lightweight, load-bearing three-dimensional structures that can withstand launch loads. Similarly, space vehicle propulsion systems seek to identify component (impellers, cryo-pumps, nozzles, bearings) materials that reduce weight while fully meeting operational needs. Often space structural components do more than carry load and are multifunctional, requiring the optimization and consideration of non-structural properties as part of materials invention and development. Activities to demonstrate novel, lightweight materials and/or processes that address such needs are sought.

***Hypersonics and Thermal Protection*:** New materials must be evaluated to validate performance in the extreme environment in order to fill technical gaps. The materials need to be robust, reproducible, and affordable. High temperatures ranging from 1100 degree F to over 2400 degree F, limit the material options that can be considered. Demonstration of materials and process (M&P) technology options are needed to reduce the risks associated with M&P acquisition decisions for future hypersonic vehicles. Vehicle concepts span the spectrum from expendable to reusable, boost glide to air-breathing propulsion; all placing different demands on the materials selected. All material systems are of interest as well as hybrid concepts. Joining, attachments, integration, insulation and seals are also areas of interest.

Munitions: Advanced munitions require new materials, processes, and performance understanding to support structural design in both the conventional and hypersonic regimes. Structural component performance in the areas of penetrating capability, enhanced fragmentation, weight reduction (cases and control surfaces), and

propulsion efficiency drive future munitions capability. Solutions incorporating the demonstration of the following are of interest: novel metals, ceramics, and polymer matrix composite manufacturing processes, hybridization and location specific tailoring of the properties of parts to optimize for function, NDI methods for quality inspection after manufacture, and the development and validation (using novel test techniques) of predictive performance models/simulations for munitions' unique, high strain rate performance environments.

Advanced Material Characterization: The demonstration of novel microstructure and properties characterization tools and research methodologies is necessary to advance the state of the art in materials science. Tools and techniques that support systems application of integrated computational materials science and engineering such as automated data acquisition, multiscale structural performance characterization techniques and apparatus, microstructural (chemistry, orientation, shape, residual stress), characterization techniques and apparatus (destructive and nondestructive), remote testing, and data analytics/management are therefore sought.

Combat Availability: Demonstration of emerging technologies and methods to inspect aging and diverse structures are of interest, as well as innovative sensor manipulation methods to place inspection probes on or within aircraft structures to aid inspectors in their inspection task. Tools and techniques that support airframe sustainment such as advanced sensor development, automated data acquisition/processing, inspection reliability, remote sensing/testing, and data analysis/management are of strong interest. Technology advancement and demonstration shall be derived with the Air Force depot and field application environment in mind.

Airframe: Hardened and Multifunctional Structures:

Hardened Structures: Demonstration of polymer and non-polymer matrix (including Ultra-High Temperature Ceramics (UHTCs)) composite materials and processes that meet current and future Air Force and Space Force System needs are of interest. This includes matrix materials, fibers, preforms, and other reinforcement materials, interfaces, processes, and the supporting computational tools.

Multifunctional Structures: The Air Force is continuously challenged with developing capabilities to better design, develop, fabricate, characterize, and assess the performance of new and emerging multifunctional materials. Therefore, the demonstration of novel design tools; advanced sensing technologies; advanced data collection, fusion, processing and analysis techniques; advanced evaluation and validation methods; as well as inspection protocols and procedures for these materials is of interest. Demonstration of modeling and simulation tools to design, characterize, and optimize sensor response to the materials of interest are also highly desirable.

Resilient Electromagnetic and Thermo-loaded Structures: Electromagnetic (EM) and thermo-loaded resilient materials are required for personnel, airborne systems, EO/IR & RF sensors, space assets, and ground support systems. Demonstration of Material solutions and development for counter high power microwave (HPM), counter electromagnetic pulse (EMP), lightning protection, and high voltage electrostatic discharges from space charge build-up from geomagnetic events on spacecraft are desired.

Operations Security (OPSEC) Requirements: The contractor shall participate in all activities associated with the disciplines of the organization's Industrial Security, Information Security, Personnel Security, Operations Security (OPSEC), and Antiterrorism programs, following appropriate measures in each program as required for this particular contract. Security measures are required to reduce program vulnerability from successful adversary collection, exploitation of critical information, and violations of export control requirements. The prime contractor shall ensure all subcontractors, if applicable, conform to these requirements as required by the prime contractor.

Program Protection Plan (PPP): Any potential critical program information (CPI) generated as part of this effort will be reviewed to determine the need for a PPP or to be included as part of an existing PPP.