



NASA SBIR 2011 Phase I Solicitation

A2.01 Materials and Structures for Future Aircraft

Lead Center: GRC

Participating Center(s): AFRC, ARC, LaRC

Advanced materials and structures technologies are needed in all four of the NASA Fundamental Aeronautics Program research thrusts (Subsonics Fixed Wing, Subsonics Rotary Wing, Supersonics, and Hypersonics) to enable the design and development of advanced future aircraft. Proposals are sought that address specific design and development challenges associated with airframe and propulsion systems. These proposals should be linked to improvements in aircraft performance indicators such as vehicle weight, fuel consumption, noise, lift, drag, durability, and emissions. In general, the technologies of interest cover five research themes:

Fundamental Materials Development, Processing and Characterization

Innovative approaches to enhance the durability, processability, performance and reliability of advanced materials (metals, ceramics, polymers, composites, nanostructured materials, hybrids and coatings). In particular, proposals are sought in:

- Advanced high temperature materials for aircraft engine and airframe components and thermal protection systems, including advanced blade and disk alloys, ceramics and CMCs, polymers and PMCs, nanostructured materials, hybrid materials and coatings to improve environmental durability.
- New adaptive materials such as piezoelectric ceramics, shape memory alloys, shape memory polymers, and variable stiffness materials and methods to integrate these materials into airframe and/or aircraft engine structures to change component shape, dampen vibrations, and/or attenuate acoustic transmission through the structure.
- Multifunctional materials and structural concepts for engine and airframe structures, such as novel approaches to power harvesting and thermal management, lightning strike mitigating, self-sensing, and materials for wireless sensing and actuation.
- New high strength fibers, in particular low density, high strength and stiffness carbon fibers.
- Innovative processing methods to reduce component manufacturing costs and improve damage tolerance, performance and reliability of ceramics, shape memory alloys, polymers, composites, and hybrids, nanostructured and multifunctional materials and coatings.

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- Development of joining and integration technologies including fasteners and/or chemical joining methods for ceramic-to-ceramic, metal-to-metal (with an emphasis on joining dissimilar forms of nickel base superalloys, e.g., powder metallurgy to cast or directionally solidified alloys), and metal-to-ceramic as well as solid state joining methods such as advanced friction stir welding.
 - Innovative methods for the evaluation of advanced materials and structural concepts (in particular multifunctional and/or adaptive) under simulated operating conditions, including combinations of electrical, thermal and mechanical loads.
 - Nondestructive evaluation (NDE) methods for the detection of as-fabricated flaws and in-service damage for textile polymeric, ceramic and metal matrix composites, nanostructured materials and hybrids. NDE methods that provide quantitative information on residual structural performance are preferred.

Structural Analysis Tools and Procedures

Robust and efficient design methods and tools for advanced materials and structural concepts (in particular multifunctional and/or adaptive components) including variable fidelity methods, uncertainty based design and optimization methods, multi-scale computational modeling, and multi-physics modeling and simulation tools. In particular, proposals are sought in:

- Multiscale design tools for aircraft and engine structures that integrate novel materials, mechanism design, and structural subcomponent design into systems level designs.
- Life prediction tools for textile composites including fiber architecture modeling methods that enable the development of physics-based hierarchical analysis methods. Fiber architecture models that address yarn-to-yarn and ply-to-ply interactions covering a wide range of textile perform structures in either a relaxed or compressed deformation state as well as tools to predict debonding and delamination of through thickness reinforced (stitched, z-pinned) composites are of particular interest.
- Tools to predict durability and damage tolerance of new material forms including metallic-composite hybrids, friction stir-welded metallic materials and powder metallurgy-formed materials.
- Meso scale tools to guide materials placement to enable tailored load paths in multifunctional structures for enhanced damage tolerance.

Computational Materials Development Tools

Methods to predict properties, damage tolerance, and/or durability of both airframe and propulsion materials, thermal protection systems and ablatives based upon chemistry and processing for conventional as well as functionally graded, nanostructured, multifunctional and adaptive materials. In particular proposals are sought in:

- Ab-initio methods that enable the development of coatings for multiple uses at temperatures above 3000°F in an air environment.
- Computational tool development for structure-property modeling of adaptive materials such as piezoelectric ceramics, shape memory alloys, shape memory polymers to characterize their physical and mechanical behavior under the influence of an external stimulus.

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- Computational and analytical tools to enable molecular design of polymeric and/nanostructured materials with tailored multifunctional characteristics.
 - Computational microstructural and thermodynamic analysis tools and technique development for designing new lightweight alloy compositions for subsonic airframe and engines from first principles, functionally graded (chemically or microstructurally) materials, and/or novel metals processing techniques to accelerate materials development and understanding of processing-structure-property relationships.
 - Software tools to predict temperature dependent phase chemistries, volume fractions, shape and size distributions, and lattice parameters of phases in a broad range of nickel and iron-nickel based superalloys. Toolset should utilize thermodynamic and kinetic databases and models that are fully accessible, which allow modifications and user-input to expand experimental databases and refine model predictions.

Advanced Structural Concepts

New concepts for airframe and propulsion components incorporating new light weight concepts as well as "smart" structural concepts such as those incorporating self-diagnostics with adaptive materials, multifunctional component concepts to reduce mass and improve durability and performance, lightweight, efficient drive systems and electric motors for use in advanced turboelectric propulsion systems for aircraft, and new concepts for robust thermal protection systems for high-mass planetary entry, descent and landing. In particular, proposals are sought in:

- Innovative structural concepts, materials, manufacturing and fabrication leading to reliable, entry descent and landing systems including deployable rigid and flexible heat shields and structurally integrated multifunctional systems. Of particular interest are high temperature honeycombs, hat stiffeners, rigid fibrous and foam insulators, as well as high temperature adhesives, films and fabrics for advanced flexible heat shields.
- New actuator concepts employing shape memory alloys.
- Advanced mechanical component technologies including self-lubricating coatings, oil-free bearings, and seals.
- Advanced material and component technologies to enable the development of mechanical and electrical drive system to enable the development of turboelectric propulsion systems, which utilize power from a single turbine engine generator to drive multiple propulsive fans. Innovative concepts are sought for AC-tolerant, low loss (1.5 T field and 500 Hz electrical frequency; and high efficiency (= 30% of Carnot), low mass (
- Novel structural designs for integrated fan cases that combine hardwall composite cases for blade containment with acoustic treatments as well as concepts that integrate the case with the fan inlet to maximize structural, acoustic attenuation and weight benefits.
- Innovative approaches to structural sensors for extreme environments (>1800Å°F) including the development and validation of improved methods (i.e., adhesives, plasma spraying techniques, etc.) for attaching sensors to advanced high-temperature materials as well as approaches to measure strain, temperature, heat flux and/or acceleration of structural components.