



## NASA SBIR 2009 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, noise, lift, drag, durability, and emissions. This subtopic is also a subtopic for the "Low-Cost and Reliable Access to Space (LCRATS)" topic. Proposals to this subtopic may gain additional consideration to the extent that they effectively address the LCRATS topic (See topic O5 under the Space Operations Mission Directorate). In general, the technologies of interest cover four research themes:

- **Fundamental materials development, processing and characterization** - new approaches to enhance the durability, processability, and reliability of advanced materials (metals, ceramics, polymers, composites, hybrids and coatings) with an emphasis on multifunctional and adaptive materials and structural concepts. In particular, proposals are sought in:
  - Textile ceramic matrix composite materials and structures and environmental barrier coatings capable of multi-use at 2700°F or greater for air vehicle propulsion and airframe applications.
  - 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.
  - Development of joining and integration technologies including fasteners and/or chemical joining methods for ceramic-to-ceramic, metal-to-metal, and metal-to-ceramic materials.
  - Development of variable stiffness materials to support adaptive, multifunctional structures concepts.
- **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 structures that integrate novel materials, mechanism design, and structural subcomponent design into systems level designs.
- Life prediction tools for textile ceramic 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 preform structures in either a relaxed or compressed deformation state are of particular interest.
- **Computational materials development tools** - methods to predict properties of both airframe and propulsion materials based upon chemistry and process for conventional as well as nanostructured, multifunctional and adaptive materials.
  - Ab-initio methods that enable the development of refractory composite coating for multi-use at temperatures greater than 3000°F in an air environments.
  - Quantum chemistry, molecular dynamics, and mesoscale models for the design, characterization and optimization of ablation materials for radiation heating, thermal re-radiation, and catalytic effects.
- **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:
  - Microadaptive flow control for use in robust, efficient, low mass actuators with broad bandwidths. The identification and development of actuators that can operate in harsh environments (600-800°F) experienced in gas turbine engine compressors with the following features: (1) operational frequencies of 1000 to 10,000 Hz, (2) stroke or displacement >100μm, (3) capable of exerting forces >200 lbs.
  - Piezoelectric devices with the ability to convert strain energy into useable electric energy that can be integrated into aircraft designs for energy harvesting and or vibration damping including application to aircraft engine fan and compressor rotor blades. Requirement for these devices are power densities greater than or equal to 0.1 mW/cm<sup>2</sup>. Novel approaches are sought to enable piezoelectric devices to operate in engine environment including typical stresses of fan/compressor blades and to have the durability for engine application.
  - Miniature thermoelectric devices for powering RF sensors for use in turbine engine compressors. Devices must be capable of operating at temperatures up to 600°C in oxidizing environments and capable of achieving power densities greater than or equal to 0.1 mW/cm<sup>2</sup>. Prototype device demonstration is required showing functionality at 600° in air for 100 hours and delivering power output in excess of 10W/cm<sup>2</sup>.
  - Materials to support wireless sensing and actuating multifunctional structures.
  - Manufacturing and fabrication technologies leading to the development of lightweight structurally integrated thermal protection systems for space access and planetary entry, including high temperature honeycombs, hat-stiffeners, rigid fibrous and foam insulators.

- 
- Advanced material and component technologies to enable the development of mechanical and electrical drive system to distribute power from a single engine core to drive multiple propulsive fans, in particular, AC-tolerant, low loss ( 1.5 T field and 500 Hz electrical frequency; and high efficiency (= 30% of Carnot), low mass (
  - Novel structural design strategies for integrated fan cases that combine hardwall composite cases for blade containment with acoustic treatments. Concepts are also sought that also integrate the case with the fan inlet to maximize structural, acoustic attenuation and weight benefits.