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 research thrusts to enable the design and development of advanced future aircraft. In general, technologies of interest that cover the four research thrusts (Subsonic Fixed Wing, Subsonic Rotary Wing, Supersonic, Hypersonic) include: fundamental materials development and characterization, multifunctional materials and structures development, structural health monitoring and damage assessment science, validated structural analysis tools, and computational materials development tools. More specific information on materials and structures technologies of interest in this program is given below.

Proposals are sought that address specific design and development challenges associated with airframe and propulsion systems and directly support improvements to future subsonic fixed wing aircraft. The potential impact of the proposed technologies should be linked to improvements in aircraft performance indicators such as vehicle weight, noise, lift, drag, lifetime, and emissions. Specific technology areas where contributions are sought include, but are not limited to the following:

- Advanced materials design concepts and processing development (e.g., multifunctional materials concepts, innovative approaches to damage tolerant lightweight structural materials, lightweight materials concepts to mitigate lightning strike damage, hybrid materials approaches to multifunctionality and/or improved durability and damage tolerance, and high-temperature materials for propulsion system applications);
- Design methods for material and structural concepts (in particular, multifunctional concepts) including variable fidelity methods, uncertainty based design and optimization methods, multi-scale computational methods, and multi-physics modeling and simulation tools;
- Adaptive materials and structures concepts (e.g., environmentally responsive materials and structures, intrinsically load/strain sensing materials and structures, active and/or highly flexible structures, shape memory and self-healing materials, innovative non-parasitic in situ methods to detect damage, impact and structural dynamics);
- Concepts and techniques for advanced multifunctional and/or adaptive material and structures characterization and evaluation (including combinations of thermal and mechanical loading environments);
- Identification, development and verification of degradation and failure mechanisms/criteria, residual strength (and other critical residual properties) and life prediction methods, and damage science design and analysis methods;
- Advanced materials fabrication and processing methods and joining and assembly methods, for ceramics, metals and polymers and/or hybrids of these materials;
- Tribological surface sciences, and mechanical components including oil-free bearings and seals technologies.
Supersonics aircraft require durable and reliable materials and structures to provide continuous operation at speeds in excess of Mach 2. Specific technology areas where contributions are sought include:

- Oxidative fail-safe CMC, CMC structures for liners and airfoils;
- Advanced engine containment prediction tools;
- High temperature shape memory alloys;
- Accelerated life prediction tools;
- Rapid design methods for aircraft structures;
- Novel hot acoustic absorber technologies are also of interest to address the sound problems with supersonic flights.

The ultra-high temperatures experienced by a hypersonic vehicle, coupled with storage challenges of advanced fuels requires advanced materials and structures technologies to enable safe reliable operation of the vehicles. Specific technology areas where contributions are sought include:

- Probabilistic design and lifing methods for high and cryogenic temperature materials;
- Design database development, structural joining techniques and characterization methods for advanced materials;
- Impact models for high and cryogenic temperature materials;
- Structurally integrated multifunctional thermal protection systems;
- Identification, development and verification of environmental and mechanical degradation and failure mechanisms, failure criteria, other design critical properties;
- Physics-based life prediction methods for advanced high temperature composites coupled with damage tolerant design and analysis methods;
- Computational materials development tools for durable high temperature materials;
- Development of composite material systems and coatings for significantly improved hypersonic environmental durability for increased mission lifetime;
- Development of durable structural sensor technology for extreme environments;
- Advanced thermal control structural and material systems through techniques to improve vehicle safety and decrease weight resulting from combined thermal and structural loads;
- Oxidation modeling;
- Modeling of high temperature composite structures manufacturing.