The goals of this topic are to develop high-performance materials, fabrics, modular vehicle structural concepts, and mechanical components for exploration systems. Major technology drivers include reducing system cost, mass, and launch volume; enabling the construction of space and surface infrastructure from modular elements; extending the performance and lifetime of systems operating in extreme environments; and providing systems with integrated diagnostic and adaptive capabilities. This topic is responsible for basic technology level research, development, and testing through experimental and/or analytical validation of novel materials and structural concepts for a wide range of exploration applications. The three subtopics include Advanced Materials and Mechanisms, Structures and Habitats, and Nanotechnology.

Subtopics

X2.01 Advanced Materials

Lead Center: LaRC
Participating Center(s): GRC, MSFC

Technology areas included in this subtopic are high performance, super lightweight structural materials, space-durable materials, multifunctional materials, and flexible material systems. Materials of interest include ceramics, metals, polymers, and their composites as well as coatings for erosion resistance and environmental protection. Proposals with innovative and revolutionary ideas in the area of advanced materials are sought for explorations applications such as:

- Flexible fabrics and thermal insulation for spacesuits and habitats;
- High strength-to-weight and high temperature composite materials for lightweight vehicle structures and power and propulsion systems;
- Self-healing materials to repair damage to spacesuits, habitats, and wire insulation electronics, sensing, and actuators for monitoring system health and adapting to changing mission conditions;
- Flexible fabrics relevant to mission needs such as inflatable systems for ballutes, habitats, airbags, parachutes, and suits;
Innovative approaches to materials systems yielding durable, lightweight, flexible films and fabrics.

X2.02 Structures and Habitats

Lead Center: LaRC

Participating Center(s): AFRC, JSC, MSFC

This subtopic solicits innovative structural concepts, materials, and assembly techniques that support the development of modular space systems. Also needed is a criteria to judge the different concepts in terms of impact on the overall performance and weight. Structural concepts can include inflatable, erectable, deployable, or easily connected modules to create large space structures utilizing membranes, composites, or other material concepts. Modular units can provide reconfigurable structures, such as multiple-energy configurations using cables and linkages, compliant structures or mechanisms that adapt to varying surfaces, or multi-purpose integrated structures, such as load-bearing modular power distribution, thermal management, or radiation protection systems. Additionally, this subtopic includes research related to novel rotating devices, actuators, tribology, and seals. It further includes intelligent structural, electrical, and fluid interfaces to enable the assembly (or ‘self-assembly’) of modular systems.

Of particular interest are inflatable structures and habitats to minimize launch volume and costs. Large inflatable structures can be folded into compact packages for launch, pressurized for deployment once in space, and rigidized after deployment so that internal pressure is not required to maintain structural stiffness and shape.

New concepts, materials, and methods for in-space structures and habitats to enable humans to safely and effectively live and work in space are needed. Specifically, structures or habitats with integral radiation shielding, impact shielding, thermal management, and integral diagnostics/health monitoring capabilities are of interest as well as high strength-to-weight materials (e.g., foamed materials), structural elements, and beams that can be deployed or fabricated in situ. Development of smart and multifunctional modular structures, including the use of embedded sensors and actuators, is encouraged.

Also solicited are assembly technologies such as innovative connectors for joining and/or bonding techniques, module positioning and alignment concepts, component deployment or erection concepts, and component/module inspection and verification techniques. Structures and materials that support reconfigurable modular architectures are also solicited.

Modeling and structural testing techniques and analyses that support the design of modular structural concepts or their assembly are of interest. Two areas are of particular interest: one is controls-structures interaction (CSI) techniques and the second is hybrid-test and physics based-modeling approaches. Application of advanced controls-structures interaction (CSI) techniques for measuring and controlling structural dynamics and geometry are important. Solutions for incorporation of CSI techniques for controlling such inflatable structures are also highly desirable. On hybrid modeling, ways to integrate test and physics-based models for cases where the physics-based models are not sufficient is also desirable.
X2.03 Nanostructured Materials

Lead Center: ARC

Participating Center(s): JSC, LaRC

The applications of advances in Nanotechnology are anticipated to have a profound impact on NASA’s future missions by offering significant advantages in terms of cost affordability and reliability from multifunctional materials. Nanotechnology enables systems performance beyond those expected from conventional materials. While many fundamental findings are reported in the literature, there is a strong need to focus efforts on the demonstration of real benefits provided by nanostructured material systems.

It is especially interesting to meet exploration challenges with the development of high strength-to-weight and multi-functionality possible from the unique combinations of desirable properties of the nano-structured materials. The promise of high strength-to-weight, multi-functional, nano-structured materials has led to intense interest in developing them for near-term applications for human spaceflight and exploration.

Nano-structured materials of interest include, but are not limited to, the utilization of single wall, carbon, nanotube-based composites, ceramic nanofibers, and bio/nano-inspired materials and composites.

Due to the size scale and fundamental physical properties of the structures involved, a successful proposal for applications development should demonstrate a mature understanding of nano-material synthesis and material quality, as well as incorporate the development and use of new characterization methodologies to fully assess the impact of the nano-structured materials upon a given matrix or system.

The specific focus of this subtopic will include, but not be limited to:

- New materials for structures and components offering significant mass reduction and increased strength with improved thermal conductivity, low permeability, low density, and improved damage tolerance through self-repairing mechanisms;
- Application of nano-structured materials to self-healing and self-repair materials and concepts;
- Nano-structured materials offering enhanced radiation protection;
- Development of nano-material systems that are resistant to large thermal fluctuations, radiation, electrostatic charging, abrasion, and micrometeoroid debris damage;
- Nano-materials for energy generation, storage, and distribution.