NASA SBIR 2016 Phase I Solicitation

H5.03 Multifunctional Materials and Structures: Integrated Structural Health Monitoring for Long Duration Habitats

Lead Center: LaRC

Participating Center(s): GRC, JSC, MSFC

Multifunctional and lightweight are critical attributes and technology themes required by deep space mission architectures. Multifunctional materials and structural systems will provide reductions in mass and volume for next generation vehicles. The NASA Technology Roadmap TA12, “Materials, Structures, Mechanical Systems, and Manufacturing” (http://www.nasa.gov/sites/default/files/atoms/files/2015_nasa_technology_roadmaps_ta_12_materials_structures_final.pdf), proposed Multifunctional Structures as one of their top 5 technical challenges, and the NRC review of the roadmap recommended it as the top priority in this area stating: “… To the extent that a structure can simultaneously perform additional functions, mission capability can be increased with decreased mass. Such multifunctional materials and structures will require new design analysis tools and might exhibit new failure modes; these should be understood for use in systems design and space systems operations.”

Some functional capabilities beyond structural that are in this multifunctional theme are insulating (thermal, acoustic, etc.), inflatable, protective (radiation and micrometeoroids and orbital debris), sensing, healing, in-situ inspectable (e.g., IVHM), actuating, integral cooling/heating, power generating (thermal-electric, photovoltaic, etc.), and so on.

Because of the broad scope possible in this SBIR subtopic, the intent is to vary its focus each year to address specific areas of multi-functionality:

- That have high payoff for a specific mission.
- That are broadly applicable to many missions.
- That could find broader applications outside of NASA which would allow for partnerships to leverage the development of these technologies.

For FY16, this SBIR subtopic seeks innovative, multifunctional approaches to integrating long-duration health monitoring capabilities within the range of candidate materials currently being investigated for space habitat long-duration mission concepts. These materials include, but are not limited to, thin-ply composites as well as the materials comprising the multiple soft-goods layers utilized in expandable space habitats, including the bladder, restraint and MMOD layers. Soft-goods materials, used in expandable habitats, may be packaged in an unloaded state for long periods of time prior to deployment, and then maintained at pressure for several years during a mission, while also being subjected to varying levels of thermal cycling. This creates a challenging set of conditions from which to predict the mechanical behavior of these structures over their operational life. NASA seeks the integration of robust, long-term sensing capabilities into the flexible materials (e.g., webbing, cordage, and woven fabrics) used in long-duration habitats, to provide health monitoring and evaluation of the structural integrity and properties of the multi-layer habitat structure throughout its mission life. The integration of the sensors would ideally be performed directly during manufacture; however, robust integration, post-fabrication, via non-destructive application, is also of interest. Ideally, the innovative sensing technology and integration approach should maintain the load-carrying capability or some other structural design requirement, and those technologies that enable weight reduction with similar or better structural performance when compared to traditional approaches will be considered. Sensing capabilities can include both the direct measurement of properties (strain, displacement, and load for example) and sensor fusion using multiple sensors to predict and locate critical damage areas and probable failure zones. The goal for long-duration space habitat design is fail-safe operation; providing monitoring and early prediction of failure onset via structural health monitoring and a benign, progressive failure architecture that allows for safe evacuation even at or after the first failure point.

In summary NASA seeks innovations in integrating structural health monitoring into materials for long-duration deep space habitats, including, but not limited to, state-of-the art thin-ply composites and soft-goods materials for expandable habitat structural concepts, during or after fabrication, to enable evaluation of structural properties and failure prediction over the duration of the habitat’s operational life.

Contractors should prove the feasibility of proposed innovations using suitable analyses and small scale tests in Phase I. In Phase II, significant testing/fabrication or software capabilities should be developed and demonstrated. A Technology Readiness Level (TRL) at the end of Phase II of 3-4 or higher is desired.