The SBIR topic area of Lightweight Spacecraft Materials and Structures centers on developing lightweight inflatable structures, solar array structures, and advanced manufacturing technologies for metallic materials. Applications are expected to include space exploration vehicles including launch vehicles, crewed vehicles, and surface and habitat systems, and solar electric propulsion tugs. The subtopic Expandable/Deployable Structures solicits innovative concepts to support the development of lightweight-structure technologies that would be viable solutions to high packaging efficiency, and of deployment mechanisms. Technologies are needed to minimize launch mass, volume and costs, while maintaining the required structural performance for the loads and environments. Of particular interest for expandable/inflatable systems are high-tenacity fibrous materials for the restraint layer of inflatable structures, and bladder materials with limited air permeation and good flexure properties at low temperatures. Analysis and test methods that verify the performance of highly loaded inflated structures are highly desired. For large solar arrays systems, mass-efficient solar array designs with a scalable path from 20-30 kW up to 300 kW and beyond are needed. Advanced analysis and test techniques to ensure reliable deployment of large solar array structures are of special interest. Novel design and packaging concepts, analysis techniques, and both ground and in-space test methods are sought for large deployable solar arrays as well as for individual components such as lightweight booms, ribs, or frames; flexible substrate materials; and mechanisms. The overall objective of the subtopic on Advanced Manufacturing and Material Development for Lightweight Metallic Structures is to advance technology readiness levels of lightweight metals and manufacturing techniques for launch vehicles and in-space applications resulting in structures having affordable, reliable, predictable performance with reduced costs. Proposals are sought that offer innovative manufacturing processes and/or materials to locally increase the stiffness and strength of structural elements added to NNS components. Manufacturing methods of interest include additive manufacturing methods that employ wire feedstock, fusion and friction stir welding. Of specific interest in materials are advances in aluminum wire and tape feedstock materials, including customized alloy chemistry and metal matrix composites (MMCs) incorporating either discontinuous or continuous reinforcements. Of specific interest in manufacturing and processing are proposals that address issues such as residual stress and distortion control, post-deposition processing to develop service mechanical properties, and energy source/reinforcement interactions. Research under this topic should be conducted to demonstrate technical feasibility during Phase I and show a path toward a Phase II hardware demonstration, and when possible, deliver a full-scale demonstration unit for functional and environmental testing at the completion of the Phase II contract.

Subtopics

H5.01 Expandable/Deployable Structures

Lead Center: LaRC
Participating Center(s): JSC

The SBIR subtopic area of Lightweight Expandable/Deployable Structures solicits innovative concepts to support the development of primary pressurized inflatable modules or large solar array structures for space exploration environments. Concepts should illustrate simple designs, low launch-to-deployed dimension ratios, efficient packaging and deployment techniques. Robustness, damage tolerance, and minor repair capabilities should also be considered in concept submittals. Development of advanced analysis and test methods that verify the performance of highly loaded inflated structures or large solar array systems are highly desired.

Of particular interest for expandable/inflatable systems are high-tenacity fibrous materials for the restraint layer of inflatable structures. Proposed materials should have well-characterized long-term creep behavior or a characterization plan for determination thereof. Also of significant interest are bladder materials with an air permeation rate no greater than 1.5 cc/100 in$^2$/day/atm that remain sufficiently flexible at -50 °F to be deployed on orbit without external heating. Permeation rate should show no increase upon fold/flex testing at -50 °F.

For large solar arrays systems, mass-efficient solar array designs with a scalable path from 20-30 kW up to 300 kW and beyond are needed. Advanced analysis and test techniques to ensure reliable deployment of large solar array structures are of special interest. Novel design and packaging concepts, analysis techniques, and both ground and in-space test methods are sought for large deployable solar arrays as well as for individual components such as lightweight booms, ribs, or frames; flexible substrate materials; and mechanisms.

Technology Readiness Levels (TRL) of 3 to 4 or higher are sought.

Potential NASA Customers include:

- International Space Station.
- Advanced Exploration Systems - Deep Space Habitat.
- Office of Chief Technology - Game Changing Technology Division, and Technology Demonstration Missions.

H5.02 Advanced Manufacturing and Material Development for Lightweight Metallic Structures

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

The overall objective of this subtopic is to advance technology readiness levels of lightweight metals and manufacturing techniques for launch vehicles and in-space applications resulting in structures having affordable, reliable, predictable performance with reduced costs.
The current state-of-the-art for fabrication of launch vehicle structure is multi-piece welded and riveted construction to assemble parts that are heavily machined from thick wrought products. Fabrication of single-piece launch vehicle structure using near-net shape (NNS) manufacturing methods can reduce mass and cost while increasing safety and reliability, primarily through elimination of welds and parasitic weld land weight and reduction in the number of manufacturing steps. However, to fully realize the benefits of these NNS manufactured components, methods to add structural elements and/or locally enhance material properties of these structural elements are needed. Structural elements added by welding or deposited by additive manufacturing methods typically have dissimilar microstructures and reduced mechanical properties compared with the NNS fabricated component. Materials of construction are typically aluminum and aluminum lithium (Al-Li) alloys. Some examples where this technology would be applied include adding stiffeners to thin-walled single-piece monocoque shells such as cylinders, bulkheads, domes, and frustums, and for reinforcing cut outs and windows.

Proposals are sought that offer innovative manufacturing processes and/or materials to locally increase the stiffness and strength of structural elements added to NNS components. Manufacturing methods of interest include additive manufacturing methods that employ wire feedstock, fusion and friction stir welding. Of specific interest in materials are advances in aluminum wire and tape feedstock materials, including customized alloy chemistry and metal matrix composites (MMCs) incorporating either discontinuous or continuous reinforcements. Of specific interest in manufacturing and processing are proposals that address issues such as residual stress and distortion control, post-deposition processing to develop service mechanical properties, and energy source / reinforcement interactions.

Research should be conducted to demonstrate technical feasibility in Phase I and show a path toward demonstration in Phase II of material fabrication and/or manufacturing process improvement. When possible proposals should include delivery of sample material for test and evaluation by NASA and/or a component demonstration article.

Technology Readiness Levels (TRL) of 4 to 6 or higher are sought.

Potential NASA Customers include:

- Office of Chief Technology - Integrated Manufacturing Modeling with Experiment.
- Space Launch System.
- Multi Purpose Crew Vehicle.
- Fundamental Aeronautics - Fixed Wing, High Speed, Aerosciences Projects.