NASA SBIR 2014 Phase I Solicitation

H5.03 Advanced Fabrication and Manufacturing of Polymer Matrix Composite (PMC) Structures

Lead Center: MSFC

Participating Center(s): LaRC

The subtopic area for Polymer Matrix Composite (PMC) Materials and Manufacturing concentrates on developing lightweight structures, using advanced materials technologies and new manufacturing processes. The objective of the subtopic is to advance technology readiness levels of PMC materials and manufacturing for launch vehicles and in-space applications resulting in structures having affordable, reliable and predictable performance. The subtopic will address two areas, manufacturing of structures and highly damage-tolerant materials for use in cryogenic environments. Proposals to each area will be considered separately. Areas of interest include: advances in PMC materials for large-scale structures and for in-space applications; innovative automated manufacturing processes (e.g., fiber placement); advanced non-autoclave curing; damage-tolerant/repairable structures; low-cost, durable tooling; high temperature PMC materials for high performance composite structures (high temperature applications); and materials with high resistance to micro cracking at cryogenic temperatures. Reliable, affordable, and practical joining techniques for large segmented composite structures are desired.

Lightweight structures and PMC materials have been identified as a critical need for launch vehicles since the reduction of structural mass translates directly to vehicle additional performance, reduced cost, and increased payload mass capacity. Reliable large-scale (approximately 8 meters or greater in diameter) PMC structures will be critical to the "heavy lift" of America's next-generation space fleet. The capability to transfer and store for long-term propellant, particularly cryogenic propellants in orbit, can significantly increase the nation's ability to conduct complex and extended exploration missions beyond Earth's orbit. The use of PMC materials for cryotanks offers the potential of significant weight savings. Applications include storage of cryogenic propellants on an Earth Departure Stage, a lunar or asteroid descent vehicle, long-term cryogen storage on the Moon, and propellant tanks for a heavy lift launch vehicle. Consideration shall be made for manufacturability in the sense of either using out of autoclave cure or autoclave cure and, in made in sections, novel and reliable approaches to join sections of composite structures to take advantage of the high strength to weight properties so that the joining methods do not significantly increase the complexity or weight of the overall structure. Novel approaches from cradle to grave will be considered in the sense that these very large structures required robust and lightweight tooling and transportation methods for minimal modifications to existing facilities and use of existing transportation or minimal modifications to such infrastructures.

Performance metrics for manufacturing structures include: achieving adequate structural and weight performance; manufacturing and life cycle affordability analysis; verifiable practices for scale-up; validation of confidence in design, materials performance, and manufacturing processes; low-cost, durable tooling; and quantitative risk reduction capability. Research should be conducted to demonstrate novel approaches, technical feasibility, and basic performance characterization for polymer matrix composite structures or low-cost, durable tooling during Phase I, and show a path toward a Phase II design allowables and prototype demonstration. Emphasis should be on demonstrable manufacturing technology that can be scaled up for very large structures.

Performance metrics for materials developed for cryotanks are: temperature-dependent material properties including strength, modulus, CTE, and fracture toughness; and demonstrated improved resistance over present SOA of multi-directional laminates to microcracking under cryogenic temperature cycling. Initial property characterization would be done at the coupon level in Phase I. Generation of design allowables, characterization of long-term material durability, and fabrication of larger panels would be part of follow-on efforts.

High temperature polymer matrices for high performance composite structures (high temperature applications) with ease of manufacturing using the current composite manufacturing techniques.