



## NASA SBIR 2015 Phase I Solicitation

### H5.02 Extreme Temperature Structures

Lead Center: MSFC

Participating Center(s): LaRC

This subtopic seeks to develop innovative low cost and lightweight structures for cryogenic and elevated temperature environments. The storage of cryogenic propellants and the high temperature environment during atmospheric entry require advanced materials to provide low mass, affordable, and reliable solutions. The development of durable and affordable material systems is critical to technology advances and to enabling future launch and atmospheric entry vehicles. The subtopic focuses on two main areas: highly damage-tolerant composite materials for use in cryogenic storage applications and high temperature composite materials for hot structures applications. Proposals to each area will be considered separately.

- *Cryogenic Storage Applications* - The focus of this area is to yield material systems and manufacturing processes which enable the capability to store and transfer cryogenic propellants (liquid oxygen & liquid hydrogen) to orbit. Operating temperature ranges for these fluids are  $-183^{\circ}\text{C}$  to  $-253^{\circ}\text{C}$ . Specific areas include:
  - Composite systems to be used in the construction of storage vessels or ductwork for cryogenic propellants. Performance metrics for cryogenic applications include: temperature dependent properties (fracture toughness, strength, coefficient of thermal expansion), resistance to permeability and micro-cracking under cryogenic thermal and biaxial stress state cycling.
  - Reliable hatch or access door sealing technique/mechanism for cryogenic composite structures. Concepts must address seal systems for both composite to composite and composite to metal applications. Techniques must consider scale up and manufacturability factors.
- *Hot Structures* - The focus of this area is the development of cost effective, environmentally durable and manufacturable material systems capable of operating at temperatures from  $1500^{\circ}\text{C}$  to  $3000^{\circ}\text{C}$ , while maintaining structural integrity. Significant reductions in vehicle weight can be achieved with the application of hot structures, which do not require parasitic thermal protection systems. This area seeks innovative technologies in one or more of the following:
  - Light-weight, low-cost, composite material systems that include continuous fibers.
  - Significant improvements of in-plane and thru the thickness mechanical properties, compared to current high temperature laminated composites.
  - Decreased processing time and increased consistency for high temperature materials.
  - Improvement in potential reusability for multiple missions.
  - Low conductivity, low thermal expansion, high impact resistance.

For all above technologies, research, testing, and analysis should be conducted to demonstrate technical feasibility during Phase I and show a path towards Phase II hardware demonstration. Emphasis should be on the delivery of a manufacturing demonstration unit for NASA testing at the completion of the Phase II contract.

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*Phase I Deliverables* - Test coupons and characterization samples for demonstrating the proposed material product. Matrix of verification/characterization testing to be performed at the end of Phase II.

*Phase II Deliverables* - Test coupons and manufacturing demonstration unit for proposed material product. A full report of the material development process will be provided along with the results of the conducted verification matrix from Phase I. Opportunities and plans should also be identified and summarized for potential commercialization.

References:

- Anon, "Final Report of the X-33 Liquid Hydrogen Tank Test Investigation Team"; National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama 35812, May 2000.
- Glass, D. E. "Ceramic Matrix Composites (CMC) Thermal Protection Systems (TPS) and Hot Structures for Hypersonic Vehicles"; 15th AIAA International Space Planes and Hypersonic Systems and Technologies Conference, Dayton, Ohio, AIAA-2008-2682, April 2008. (<http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/20080017096.pdf>)