



NASA SBIR 2011 Phase I Solicitation

X9.01 Ablative Thermal Protection Systems

Lead Center: ARC

Participating Center(s): GRC, JPL, JSC, LaRC

The technologies described below support the goal of developing higher performance ablative TPS materials for future Exploration missions. Developments are sought for ablative TPS materials and heat shield systems that exhibit maximum robustness, reliability and survivability while maintaining minimum mass requirements, and are capable of enduring severe combined convective and radiative heating, including: development of acreage (main body, non-leading edge) materials, adhesives, joints, penetrations, and seals. Three classes of materials will be required:

- One class of materials, for Mars aerocapture and entry for a rigid mid L/D (lift to drag ratio) shaped vehicle, will need to survive a dual heating exposure, with the first at heat fluxes of 400-500 W/cm² (primarily convective) and integrated heat loads of up to 55 kJ/cm², and the second at heat fluxes of 100-200 W/cm² and integrated heat loads of up to 25 kJ/cm². These materials or material systems must improve on the current state-of-the-art recession rates of 0.25 mm/s at heating rates of 200 W/cm² and pressures of 0.3 atm and improve on the state-of-the-art areal mass of 1.0 g/cm² required to maintain a bondline temperature below 250Å°C
- The second class of materials, for Mars aerocapture and entry for a hypersonic deployable aerodynamic decelerator, will need to survive a dual heating exposure, with the first at heat fluxes of 100-200 W/cm² (primarily convective) and integrated heat loads of 10 kJ/cm² and the second at heat fluxes of 30-50 W/cm² and heat loads of 5 kJ/cm². These materials may be either flexible or deployable.
- The third class of materials, for Mars return, will need to survive heat fluxes of 1500-2500 W/cm², with radiation contributing up to 75% of that flux, and integrated heat loads from 75-150 kJ/cm². These materials, or material systems must improve on the current state-of-the-art recession rates of 1.00 mm/s at heating rates of 200 W/cm² and pressures of 0.3 atm and improve on the state-of-the-art areal mass of 4.0 g/cm², required to maintain a bondline temperature below 250Å°C.

In-situ heat flux sensors and surface recession diagnostics tools are needed for flight systems to provide better traceability from the modeling and design tools to actual performance. The resultant data will lead to higher fidelity design tools, risk reduction, decreased heat shield mass and increases in direct payload. The heat flux sensors should be accurate within 20%, surface recession diagnostic sensors should be accurate within 10%, and any temperature sensors should be accurate within 5% of actual values.

Non Destructive Evaluation (NDE) tools are sought to verify design requirements are met during manufacturing and assembly of the heat shield, e.g., verifying that anisotropic materials have been installed in their proper orientation, that the bondline as well as the TPS materials have the proper integrity and are free of voids or defects. Void and/or defect detection requirements will depend upon the materials being inspected. Typical internal void detection requirements are on the order of 6-mm, and bondline defect detection requirements are on the order of 25.4-mm by 25.4-mm by the thickness of the adhesive.

Advances are sought in ablation modeling, including radiation, convection, gas surface interactions, pyrolysis, coking, and charring. There is a specific need for improved models for low and mid density as well as multi-layered charring ablators (with different chemical composition in each layer). Consideration of the non-equilibrium states of the pyrolysis gases and the surface thermochemistry, as well as the potential to couple the resulting models to a computational fluid dynamics solver, should be included in the modeling efforts.

Technology Readiness Levels (TRL) of 2-3 or higher are sought.