## NASA SBIR 2008 Phase I Solicitation

### X8 Protection Systems

The Thermal Protection System (TPS) protects a spacecraft from the severe heating encountered during hypersonic flight through a planetary atmosphere. In general, there are two classes of TPS: reusable and ablative. Typically, reusable TPS applications are limited to relatively mild entry environments like that of Space Shuttle. No change in the mass or properties of the TPS material results from entry with a significant amount of energy being re-radiated from the heated surface and the remainder conducted into the TPS material. Typically, a surface coating with high emissivity (to maximize the amount of energy re-radiated) and with low surface catalycity (to minimize convective heating by suppressing surface recombination of dissociated boundary layer species) is employed. The primary insulation has low thermal conductivity to minimize the mass of material required to insulate the primary structure. Ablative TPS materials, in contrast, accommodate high heating rates and heat loads through phase change and mass loss. All NASA planetary entry probes to date have used ablative TPS. Most ablative TPS materials are reinforced composites employing organic resins as binders. When heated, the resin pyrolyzes producing gaseous products that are heated as they percolate toward the surface thus transferring some energy from the solid to the gas. Additionally, the injection of the pyrolysis gases into the boundary layer alters the boundary layer properties resulting in reduced convective heating. However, the gases may undergo chemical reactions with the boundary layer gases that could return heat to the surface. Furthermore, chemical reactions between the surface material and boundary layer species can result in consumption of the surface material leading to surface recession. Those reactions can be endothermic (vaporization, sublimation) or exothermic (oxidation) and will have an important impact on net energy to the surface. Clearly, in comparison to reusable TPS materials, the interaction of ablative TPS materials with the surrounding gas environment is much more complex as there are many more mechanisms to accommodate the entry heating. NASA has successfully tackled the complexity of thermal protection systems for numerous missions to inner and outer planets in our solar system in the past; the knowledge gained has been invaluable but incomplete. Future missions will be more demanding. Better performing ablative TPS than currently available is needed to satisfy requirements of the most severe CEV missions, e.g., Mars Landing with 8 km/s entry and Mars Sample Return with 12-15 km/s entry.

## Subtopics

### X8.01 Detachable, Human-Rated, Ablative Environmentally Compliant TPS

**Lead Center: ARC**

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

The technologies described below support the goal of developing higher performance TPS materials and integrated entry systems architectures for higher performance CEV as well as future Exploration missions.

Development of TPS materials for maximum reliability and survivability with minimized mass requirements, under severe combined convective and radiative heating, including development of acreage materials, adhesives, joints, penetrations, deployables, inflatables and seals.

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. This leads to higher fidelity design tools, risk reduction, decreased heat shield mass and a direct payload increase.

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 themselves have the proper integrity and are free of voids or defects.

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 density charring ablators.

Advances in Multidisciplinary Design Optimization (MDO) are sought specifically in application to address combined aerothermal environments, material response, vehicle shape, vehicle size, aerodynamic stability, mass, and cross-range, characterizing the entry vehicle design problem.

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

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