SBIR/STTR

Small Business Innovation Research / Small Business Technology Transfer

NASA SBIR 2014 Phase I Solicitation

H7 Entry, Descent, and Landing Technologies

In order to explore other planets or return to Earth, NASA requires various technologies to facilitate entry, descent and landing. This topic, at this time, is supported by a single subtopic that calls for the development, modeling, testing, monitoring, and inspection of ablative thermal protection materials and/or systems that will support planetary entry. There is interest in ablative materials that can support aerocapture, requiring them to protect the spacecraft during two heating pulses. There is interest in developing flexible and/or deployable ablative materials. There is also interest in mid to high density composites that are capable replacements to chop-molded or tape-wrapped carbon phenolic composites that were used on Venus entry vehicles in the past. Work is needed on improved reinforcement materials for composites, as well as new formulations of polymers in composites. As new materials are developed, improved analytical tools are required to more accurately predict material response in entry conditions. Instrumentation for measuring the actual surface heating, in-depth temperatures, surface recession rates during testing and/or flight is required to verify the response of the materials and to monitor the health of flight hardware. Inspection of thermal protection material/aeroshell interfaces is critical to assure quality and is extremely difficult for porous, low density composites.

Subtopics

H7.01 Advanced Thermal Protection Systems Technologies

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 higher performance 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 capable of enduring severe combined convective and radiative heating. In addition, in order to adequately test and design with these materials, advancements in instrumentation, inspection, and modeling of ablative TPS materials is also sought.

- Areas of interest include improvements in the reinforcement materials or integration techniques such as joining or attachment for such materials as follows:
    - Advancements in carbon felts including thickness (>1.0-in), density (>0.10 g/cm^3), uniformity to use as reinforcement for high strain-to-failure ablative TPS materials.
    - Advancements in thin (~0.1-in) three dimensional woven carbon materials to act as stress bearing structure for deployable aeroshells. If advances in integration techniques are proposed, NASA may provide materials GFE to use in the development effort.
    - Advances in ceramic felts including thickness (>1.0-in) and uniformity to use as reinforcement for

    - flexible TPS in heating up to ~150 W/cm^2.
    - Advancements in thick (>1.0-in) three dimensional woven carbon materials to use as reinforcement for high heat flux mid-to-high density ablative TPS materials. If advances in integration techniques are proposed, NASA may provide materials GFE to use in the development effort.
- TPS Materials advancements sought in felts or woven materials impregnated with polymers and/or additives to improve ablation and insulative performance. Areas of interest include:
    - One class of materials, for planetary 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/cm^2 (primarily convective) and integrated heat loads of up to 55 kJ/cm^2, and the second at heat fluxes of 100-200 W/cm^2 and integrated heat loads of up to 25 kJ/cm^2. 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/cm^2 and pressures of 0.3 atm and improve on the state-of-the-art areal mass of 1.0 g/cm^2 required to maintain a bondline temperature below 250 ºC
    - The second class of materials, for planetary aerocapture and entry for a deployable aerodynamic decelerator, will need to survive a single or dual heating exposure, with the first (or single pulse) at heat fluxes of 50-150 W/cm^2 (primarily convective) and integrated heat loads of 10 kJ/cm^2 and the second at heat fluxes of 30-50 W/cm^2 and heat loads of 5 kJ/cm^2. These materials may be either flexible or deployable.
    - The third class of materials, for higher velocity (>11.5km/s) Earth return, will need to survive heat fluxes of 1500-2500 W/cm^2, with radiation contributing up to 75% of that flux, and integrated heat loads from 75-150 kJ/cm^2. 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 2000 W/cm^2 and pressures of 0.3 atm and improve on the state-of-the-art areal mass of 4.0 g/cm^2, required to maintain a bondline temperature below 250 ºC.
- Development of in-situ heat flux sensors, surface recession diagnostics, and in-depth or interface thermal response measurement devices for use on rigid and/or flexible ablative materials. 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 for evaluation of bondline and in-depth integrity for light weight rigid and/or flexible ablative materials. 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 for low and mid-density fiber based (woven or felt) ablative materials. 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.

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

For all above technologies, research should be conducted to demonstrate technical feasibility during Phase I and show a path towards Phase II hardware/software demonstration with delivery of a demonstration unit or software package for NASA testing at the completion of the Phase II contract.

Phase I Deliverables - Feasibility study, including simulations and measurements, proving the proposed approach to develop a given product (TRL 3). Small samples and initial test data may be provided to demonstrate feasibility. Development of the verification matrix of measurements to be performed at the end of Phase II, along with specific quantitative pass-fail ranges for each quantity listed.

Phase II Deliverables - Working engineering model of proposed product, along with full report of development and measurements, including populated verification matrix from Phase I (TRL 4-5). Opportunities and plans should also be identified and summarized for potential commercialization.