NASA SBIR 2006 Phase I Solicitation

S7.04 Chemical and Propellantless Propulsion for Deep Space

Lead Center: MSFC

Participating Center(s): GRC, GSFC, JSC

Spacecraft propulsion technology innovations are sought for future deep space science missions. Propulsion system functions for these missions include primary propulsion, maneuvering, planetary injection, and planetary descent and ascent. Innovations are needed to reduce spacecraft propulsion system mass, volume, and/or cost. Applicable propulsion technologies include advanced chemical, emerging technologies, and aerocapture.

Advanced Chemical Propulsion

Innovations in low-thrust chemical propulsion system technologies are sought for robotic, deep-space, scientific, mission applications. Delta V's for the missions of interest range from 1000 m/sec to 3000 m/sec. Advanced chemical propulsion technologies of interest are:

- Advanced material and component technology to enable development of bipropellant engines with Isp greater than 360 seconds, both pressure-fed and pump-fed, with chamber pressures ranging from 100 to 500 psia systems;
- Non-catalytic ignition technology and critical component materials (e.g., tank bladders, valve seats, and filters) for power-limited spacecraft using high-performance (Isp >275 s), high-density (>1 g/cc) monopropellant formulations.

Tether Technologies

Focus on technologies that support the development of tethers that can survive in the space environment. The near-Earth environment contains a significant amount of atomic oxygen (AO) formed by photo-dissociation of atmospheric oxygen. This AO attacks the chemical bonds of polymeric materials, which are desirable for their high specific tensile strength. Furthermore, ultraviolet radiation also attacks tether materials. A coating for a polymeric tether must be able to protect the tether against both effects. Coatings that can be uniformly applied after the fabrication of a multi-strand tether structure are especially desirable, because of the requirement that a space tether have a multitude of separate load paths in the event of a cut by an orbital debris particle. Certain materials (such as titanium oxide/zinc oxide) offer both ultraviolet radiation protection as well as atomic oxygen resistance. Tether technologies of interest are:
- Techniques and processes to coat and protect polymeric tether materials from offer both ultraviolet radiation protection as well as atomic oxygen resistance effects. Such coatings must be as thin as possible because of the importance in maintaining a high specific tensile strength in tether materials, although they must be able to adhere uniformly and reliably to tether materials, even in the face of winding and ground handling. Degradation to the strength characteristics of the tether generated by the coating process must be absolutely minimized.

**Aeroassist (Aerocapture)**

Aerocapture relies on the exchange of momentum with an atmosphere to achieve a decelerating thrust leading to orbit capture. This technique permits spacecraft to be launched from Earth at higher velocities, thus providing a shorter overall trip time. At the destination, the velocity is reduced by aerodynamic drag within the atmosphere. The aerocapture maneuver can be accomplished by utilizing either rigid or inflatable deceleration systems.

Preliminary analysis has shown that the inflatable decelerator concepts may provide mass reduction and improved packaging efficiency over a rigid aeroshell system. However, the TRL for these inflatable decelerators must be increased before an adequate comparison to traditional rigid aeroshells can be made. Current inflatable decelerator concepts are expected to be manufactured from thin film materials, elastomeric materials, and/or high temperature fabrics, stowed during transport and inflated prior to atmospheric entry for aerocapture applications at planetary destinations. Materials of particular interest include: polyimide thin films, polybenzobisoxazole (PBO) thin films, and ceramic fabrics. Prior to the aerocapture maneuver, the inflatable decelerator will be tightly stowed for many years (up to 10 years) in an uncontrolled space environment (-130°C) during transport to outer solar system destination. Before final atmospheric entry, the inflatable decelerator will be unstowed and inflated (cold GN₂). During the aerocapture maneuver, up to 24 hours after the inflation process is initiated, the inflatable decelerator will experience temperatures to 500°C (or higher).

**Low Temperature/High Temperature Structural Materials/Adhesives**

Development for Inflatable Deceleration Systems: This task focuses on the development and testing of structural materials/adhesives that can be utilized for aerocapture inflatable decelerator systems. This task should include:

- A thorough survey of the thin film polymer, elastomeric;
- A high temperature fabric trade space for materials that will maintain structural properties during the temperature extremes and long term space exposure experienced by inflatable decelerators;
- Investigation of the effects of various coatings, surface treatments, or impregnation processes to enhance material properties, which may include optical, mechanical, thermal or physical properties;
- A thorough survey of the adhesives trade space for materials that will maintain bond strength during the temperature extremes of long term space exposure and atmospheric entry experienced by inflatable decelerator systems must also be included.

Final deliverables should include selection criteria for final materials/adhesives, an evaluation of technology
readiness levels (TRL) of candidates, technology development and testing of candidates that require further TRL advancement.