



NASA STTR 2007 Phase I Solicitation

T3 Technologies for Space Exploration and Human Research

This topic seeks to solicit advanced innovative technologies and systems in space power and propulsion to fulfill our Nation's goal of space exploration. Space exploration will require the presence of humans on the planets and NASA will need to insure the general health of the astronauts through development of advanced biomedical sensors that will diagnose and monitor astronaut health. The above anticipated technologies should advance the state-of-the-art or feature enabling technologies to allow NASA to meet future exploration goals.

Subtopics

T3.01 Space Power and Propulsion

Lead Center: GRC

Development of innovative technologies and systems are sought that will result in robust, lightweight, ultra-high efficiency, lower cost, power and in-space propulsion systems that are long-lived in the relevant mission environment and that enable future missions. The technology developments being sought would, through highly-efficient generation and utilization of power and in-space propulsion, significantly increase the system performance.

Innovations are sought that will significantly improve the efficiency, mass specific power, operating temperature range, radiation hardness, stowed volume, flexibility/reconfigurability, and autonomy of space power systems. In power generation, advances are needed in photovoltaic cell structure including the incorporation of nanomaterials; module integration including monolithic interconnections and high-voltage operation; and array technologies including ultra-lightweight deployment techniques for flexible, thin-film modules, and concentrator techniques. In energy storage systems, advances are needed in batteries-primary and rechargeable-regenerative fuel cells. Advances are also needed in power management and distribution systems, power system control, and integrated health management.

Innovations are sought that will improve the capability of spacecraft propulsion systems. In solar electric propulsion technology, radioisotope electric propulsion advances are needed for ion, Hall, including cathodes, neutralizers, electrode-less plasma production, low-erosion materials, high-temperature permanent magnets, and power processing. Innovations are needed for xenon, krypton, and metal propellant storage and distribution systems. In small chemical propulsion technology, advances are sought for non-catalytic ignition methods for advanced monopropellants and high-temperature, reactive combustion chamber materials. Also, advances are sought for chemical, electrostatic, or electromagnetic miniature and precision propulsion systems.

T3.02 Bio-Technology and Life Support

Lead Center: GRC

The new Vision for Space Exploration (VSE) entails the eventual presence of humans on the planetary surfaces of both the Moon and Mars. The physiological effects of prolonged space exposure (to both the microgravity environment of interplanetary space as well as the reduced gravity environments of the Moon and Mars) need to be quantified in order minimize mission risk, as well as insure the general health of astronauts both in space and upon their return to Earth. Biomedical sensors to monitor astronaut health that maximize diagnostic capability while reducing up-mass and power requirements are of significant interest for exploration missions. For longer duration missions on the Moon and the journey to Mars, the astronauts' continued health maintenance and fitness evaluation for mission critical activities will need to be performed routinely. Similarly, medical diagnostics are required to evaluate acute events like fatigue fractures. As a result, there is an acknowledged need for compact, robust, multi-function diagnostic biomedical sensors to reduce levels of risk in exploration class missions. To fully quantify space-normal physiology, these biomedical sensors must be supplemented by advanced analytical tools, such as high-resolution microscopy and lab-on-a-chip instrumentation (for blood or urine analysis). In addition, computational models (incorporating the direct physiological data) are needed that allow comparison to 1G values and determination of secondary physiological quantities (e.g., cardiac dysrhythmia and renal stone formation, as related to measured calcium levels). These computational models will also enable physicians to predict, diagnose and treat pathologies that are either not present in a 1G environment or are induced by synergies with spaceflight stressors. Specific innovations required for this task include:

- Noninvasive or minimally invasive sensors to detect health parameters such as: metabolic rate, heart rate, ECG, oxygen consumption rate, CO₂ generation rate, core and/or skin temperature, radiation monitoring, oxygen saturation level, intra-cranial pressure, and ocular blood flow rates;
- Novel analytical capabilities such as high resolution microscopy and lab-on-a-chip analysis of blood and urine;
- Technologies for IV fluid mixing and medical grade water generation from the onboard potable water supply;
- Novel approaches to noninvasive measurement of cephalad fluid shift and bone density measurements on astronauts in space is desired to understand and mitigate adverse effects of space environment on astronaut health and performance.

Although the Moon and Mars differ vastly in their origins and near-surface environments, common to both is the ubiquitous presence of fine particulates in the surface regolith. The objectives of the VSE specify missions of unprecedented duration and complexity, posing new classes of technical and operational challenges. One such challenge is managing the effects arising from the finest particulate fractions, commonly referred to as dust. The detailed experiences afforded by the series of Apollo missions provide valuable insights into the problems attributable to Lunar dust. Both anecdotal descriptions provided in situ by the crew members and analysis after the fact provide a lengthy testimony to the numerous technical issues associated with dust. Innovative technologies are needed to monitor the presence of dust, separation of dust from the cabin environment, removal of dust from EVA suit and mitigation of any adverse effects on astronaut health. Specific innovations required include:

- Novel approaches (and instrumentation) for detecting the presence of fine particulates in the cabin and air-lock environments and effective regenerative technologies for removing them are required;
- Technologies to effectively and safely remove dust particles from EVA suits and from the surface of any equipment that needs to be transported from the Lunar surface into the cabin environment are needed;
- Technologies and novel approaches to mitigate any adverse effects of dust on the performance of life support equipment and processes are also needed.

Low mass, high reliability, robustness, low power consumption, long life, ease of usage and easy interface with the onboard data acquisition and control system are highly desirable attributes for all candidate technologies.