NASA SBIR 2009 Phase I Solicitation

X7 Energy Generation and Storage

This topic includes technology development for batteries, fuel cells, regenerative fuel cells, and fission and isotopic power systems for the Altair lunar lander and surface operations on the Moon and Mars. Technologies developed must be infused into these Constellation program elements: primary fuel cells for the Altair lunar lander descent stage, secondary batteries for the Altair ascent stage, secondary batteries for extravehicular activities (EVA) suits, and regenerative fuel cells, fission and isotopic power systems on the Moon and Mars to power habitats, in situ resource production, and mobility systems. Specific technology goals and component needs are given in the sub-topics. General mission priorities for energy storage and generation include:

- EVA suits require secondary batteries sufficient to power all portable life support, communications, and electronics for an 8-hour mission with minimal volume. Battery operation required for six months and 100 recharge cycles with a shelf life of at least two years. Mission priorities include human-safe operation; 8-hr duration; high specific energy; and high energy-density.
- Secondary batteries for the Altair ascent stage require nominally 10 recharge cycles with 1.7 kW nominal power and 2 kW peak power, operating for 7 hours continuously. Mission priorities include human-safe, reliable operation and high energy-density in a 0 - 30Â°C and 0 - 1/6 gravity environment.
- The Altair descent stage requires a fuel cell with a nominal power level of 3 kW with 5.5 kW peak, operating for 220 hours continuously. Mission priorities include human-safe reliable operation; the ability to scavenge available fuel; and high energy-density.
- Regenerative fuel cells, which combine a fuel cell with a water electrolyzer, have been baselined for lunar surface system operations. Mission priorities include reliable, long-duration maintenance-free operation; human-safe operation; high specific-energy; and high system efficiency in a 0 - 100Â°C, 1/6 gravity environment.
- Architecture studies have identified nuclear power technology to effectively satisfy high power requirements for extended duration lunar surface missions. Nuclear power generation is especially attractive for missions with significant solar eclipse periods, including non-polar locations and inside lunar craters, as well as Mars outposts.
- Power systems for lunar rovers require human-safe operation; reliable, maintenance-free operation; and high specific-energy.

Subtopics

X7.01 Advanced Space Rated Batteries

Lead Center: GRC

Participating Center(s): JPL, JSC

Advanced battery systems are sought for use in Exploration mission applications including power for landers, rovers, and extravehicular activities. Areas of emphasis include advanced cell chemistries with the aggressive mass and volume performance improvements and safety advancements in human-rated systems over state-of the-art lithium-based systems. Rechargeable cell chemistries with advanced non-toxic anode and cathode materials and nonflammable electrolytes are of particular interest.

The focus of this solicitation is on advanced cell components and materials to provide mass and volume improvements and safety advancements that contribute to the following goals:

- Specific energy (cell level)>300 Wh/kg at C/2 and 0Â°C;
- Energy density (cell level)>600 Wh/l at C/2 and 0Â°C;
- Operating Temperature Range from 0Â°C to 30Â°C;
- Tolerance to abuse such as overcharge and over temperature conditions;
- Calendar life >5 years; cycle life 250 cycles at 100% depth of discharge.

Systems that combine all of the above characteristics and demonstrate a high degree of safety are desired. Cell safety devices such as shutdown separators, current limiting devices that inhibit or prevent thermal runaway, cell venting, and flame or fire; autonomous safety features that result in safe, non-flammable, non-hazardous operation especially for human-rated applications are of particular interest. Safety features that enhance the performance of high-power/high-rate cells that operate at >30Â°C discharge rates are also of interest.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase 2 contract.

X7.02 Surface Nuclear Power Systems

Lead Center: GRC

Participating Center(s): MSFC

NASA is interested in the development of highly advanced systems, subsystems and components for use with fission and isotopic systems to power habitats, resource production, and mobility systems on the Moon and Mars. Nuclear systems are anticipated to enable the long duration stay over the lunar night and for "global access" Mars missions. Initial planetary outpost power levels are anticipated to be between 30-50 kWe with anticipated growth to 100's kWe. Isotopic technologies that improve the utilization of a limited fuel supply and have extensibility to fission systems are sought. Performance goals include reducing overall system mass, volume and cost, and increasing safety and reliability.

Specific technology topics of interest are:

- High efficiency (>20%) power conversion at 900 K;
- Electrical power management, control and distribution (1-5 kV);
- High temperature, low mass (2) radiators, liquid metal/liquid metal and liquid metal/gas heat exchangers (>90% effectiveness) and electromagnetic pumps (>20% efficiency);
- Deployment systems/mechanisms for large radiators (~3m x 15m);
- High temperature (>900 K) materials or coatings compatible with local soil and atmospheric environments;
- Systems/technologies to mitigate planetary surface environments including dust accumulation, wind, planetary atmospheres, corrosive soils, etc.;
- System designs to provide autonomous control for 10-year operation, including sensor and control technologies;
- Radiation tolerant systems and materials enabling robust, long life operation.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase 2 contract.

X7.03 Fuel Cells for Surface Systems

Lead Center: GRC

Participating Center(s): JPL, JSC

Advanced primary fuel cell and regenerative fuel cell energy storage systems are baselined to provide descent power for the Altair lander and stationary power for lunar bases. Technology advances that reduce the weight and volume, improve the efficiency, life, safety, system simplicity and reliability of PEM fuel cell, electrolysis, and regenerative fuel cell systems are desired. Proposals are sought which address the following areas:

Advanced Conductive Fuel Cell Water Separator

Research directed towards improving the water separating capability of a planar separator internal to each fuel cell in a fuel cell stack. Proposals directed at developing such advanced separator materials must meet the following criteria to be considered relevant.

The separator:

- Must be wettable with water, and have a contact angle less than 30 degrees;
- Must allow water to penetrate and be transferred through the plane of the separator at a rate of at least 0.33 grams of water per hour per square centimeter of separator planar area;
- Must not permit gas vapor to penetrate through the separator up to at least 30 psid (i.e., a bubble pressure point of at least 30 psid);
- Must be electrically conductive, and have a resistivity of no more than 7.0 x 10^{-3} Ohm-cm;
- Ideally should be compatible with a fuel cell fabrication process step that occurs at 1000Â°C with a compressing force of at least 600 psi. (The separator will not need to operate at these conditions, but could be subjected to these conditions during fuel cell fabrication). This bullet is not a requirement but a desirable characteristic.

Hydrogen/Oxygen Dual Gas Pressure Regulator

Research directed towards improving the regulators that regulate hydrogen and oxygen gases down to a usable pressure for the fuel cell. The regulated pressure needs to be controlled so that the pressure differential between the gases is within a few psi. NASA is interested in developing a single mechanical component which functions as a dual gas regulator that can reliably regulate these gases from high pressure source (>500psi) down to

Advanced Electrocatalyst Materials for Fuel Cells and Electrolyzers

Research directed towards improving the kinetics of oxygen reduction and oxygen evolution. Nano-phase, high-surface area unsupported platinum-alloys, incorporating cobalt, nickel and iron are potential candidates for improving the kinetics of oxygen reduction. Oxides of ruthenium and iridium are particularly promising electrocatalysts for the oxygen evolution reaction. In addition to performance, the new materials must exhibit durability for over 10,000 hours of operation with no more than 20% loss in performance. Proposals directed at developing such advanced nano-phase materials, understanding composition/property relationships, and demonstrating their characteristics in operating fuel cells will be considered directly relevant to achieving the long-term goals of the Explorations Missions.

- Fuel cell MEA efficiency >75% (>0.92volts) @ 200 mA/cm^2;
- Electrolysis MEA efficiency >85% (2.

Research should be conducted to demonstrate technical feasibility during Phase 1 and show a path toward a Phase 2 hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase 2 contract.