NASA SBIR 2008 Phase I Solicitation

X6 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.Â 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.Â 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. Â Mission priorities include human-safe, reliable operation and high energy-density in a 0 â€“ 30Â°C and 0 â€“ 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.Â 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

X6.01 Fuel Cells for Surface Systems

Lead Center: GRC

Participating Center(s): JPL, JSC

Energy storage devices are required to enable future robotic and human exploration missions. Advanced primary fuel cell and regenerative fuel cell (RFC) energy storage systems are sought for Exploration mission applications, specifically descent for power for the Altair lander and stationary power for lunar surface bases. Technology advances that reduce the weight and volume, improve the efficiency, life, safety, system simplicity and reliability of fuel cell, electrolysis, and RFC systems are desired. The specific advancements of interest are outlined below:

Regenerative Fuel Cell (RFC) Systems: Primary fuel cells, water electrolyzers, and associated balance-of-plant hardware constitute a RFC system. Performance of fuel cell and electrolysis system functions through passive means and the elimination of as many ancillary components as possible have been identified as the most direct approach to achieving mission efficiency, life, and reliability goals. Specifically, technological advances are sought in the following areas:

- Static Cathode Water Vapor Feed Electrolysis Cell: Preliminary system studies have shown that static cathode feed electrolyzers have the most potential for system simplicity and the fewest number of ancillary components. Proton-exchange-membrane (PEM) electrolysis technology is sought that electrolyzes water vapor supplied to the hydrogen evolving electrode. The electrolysis cell should operate at balanced pressures up to 2000 psi and must not require circulation of hydrogen to transport the water to the electrolysis cell cathode. The exiting hydrogen and oxygen must not contain liquid water droplets, but may contain water vapor.
- Passive Fuel Cell or Electrolysis Cell Heat Removal/ Thermal Control: Passive thermal control of individual cells within a fuel cell or electrolysis stack has the potential to eliminate actively pumped liquid coolant loops. A highly thermally conductive heat pipe plate that is also electrically conductive is sought to passively remove the heat from the individual fuel cells or electrolysis cells within a cell stack. The flat plates that are sought should have a thermal conductivity exceeding 2000 W/m/K, a thickness of <= 0.050 inches, a resistivity of <= 0.2 ohm-cm, and a bulk density of <= 3 grams/cm^3.

- Fuel Cell/ Electrolysis Cell Voltage Monitor Application Specific Integrated Circuit (ASIC): A cell voltage monitoring ASIC has the potential to eliminate a number of discreet electrical components within a fuel cell, electrolysis, or RFC electrical control system. An ASIC is sought that monitors up to 48 differential cell voltages (0-2 VDC) with

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.

X6.02 Advanced Space-Rated Batteries

Lead Center: GRC

Participating Center(s): JPL, JSC

Advanced human-rated energy rechargeable batteries are required for future robotic and human exploration missions. Advanced Li-based battery systems are sought for use on Exploration mission applications including power for landers, rovers, and Extravehicular activities (EVA). Areas of emphasis include advanced component materials with the potential to achieve weight and volume performance improvements and safety advancements in human-rated systems.

Rechargeable lithium-based batteries 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 weight and volume improvements and safety advancements that contribute to the following cell level metrics:

- Specific energy of 300 Wh/kg @ C/2 discharge rate and 0Â°C;
- Energy density greater than 500 Wh/l;
- Calendar life of 5 years.

The cycle life requirements for these missions are relatively benign; the cycle life required at 100% Depth of Discharge (DOD) is in the range of 250 cycles.

Systems that combine all of the above characteristics and demonstrate a high degree of safety and reliability are desired. Innovative solutions that offer the cell level characteristics described above are of particular interest. Proposals are sought which address:

- Advanced cathodes with specific capacities >= 300 mAh/g at C/2 rate discharge and 0Â°C, and/or
- Advanced anodes with specific capacities >= 600 mAh/g at C/2 and 0Â°C with minimal irreversible capacity loss,
- Nonflammable electrolytes, and/or
- Electrolytes that are stable up to 5 volts.

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.