NASA SBIR 2014 Phase I Solicitation

H8 High Efficiency Space Power Systems

This topic solicits technology for power systems to be used for the human exploration of space. Power system needs consistent with human spaceflight include:

- Fuel cells compatible with methane-fueled landers, and electrolyzers and fuel cells compatible with materials extracted from lunar regolith and/or the Martian soil or atmosphere.
- Nuclear fission systems to power electric spacecraft and/or surface space power systems.

Solid oxide technology is of interest for fuel cells and electrolyzers to enable:

- The operation of fuel cells using hydrocarbon reactants, including methane and fuels generated on-site at the Moon or Mars.
- Electrolysis systems capable of generating oxygen by electrolyzing CO_2 (from the Mars atmosphere, trash processing, life support, or volatiles released from soils), and/or water from either extraterrestrial soils or from life support systems.

Both component and system level technologies are of interest. Technologies to enable space-based nuclear fission systems are sought for three power classes:

- Kilowatt-class to support robotic missions as precursors to human exploration.
- 10 kWe-class power conversion devices and 400-500K radiators to support large surface power and 100 kWe-class electric propulsion vehicles.
- 100 kWe-class power conversion devices, >500K radiators, and high temperature fuels, materials, and heat transport to support MW-class electric vehicles.

Subtopics

H8.01 Solid Oxide Fuel Cells and Electrolyzers

Lead Center: GRC

Participating Center(s): JSC

Solid oxide technology for fuel cells and electrolyzers to enable:

- The operation of fuel cells using hydrocarbon reactants, including methane and ISRU-generated fuels.

- Electrolysis systems capable of electrolyzing CO_2 from the Mars atmosphere, and/or water from the Mars surface to generate oxygen, or to recover oxygen from CO_2 and water from crew respiration for life support.

Both component and system level technologies are of interest.

Technologies are sought that improve the durability, efficiency, and reliability of solid oxide fuel systems capable of internal reforming of hydrocarbon fuels. Hydrocarbon fuels of interest include methane and fuels generated by processing lunar and Mars soils. Primary solid oxide components and systems of interest are:

- Solid oxide cell, stack, materials and system development for operation on unreformed methane in designs scalable to 1 to 3 kW at maturity. There is a strong preference for high power density configurations, e.g., planar.
- Solid oxide cells and stacks must startup with a minimal amount of water and then be capable of sustained operation on pure methane.
- Development of hermetic sealing materials for ceramic to ceramic interconnect or ceramic to metal interconnect stacks capable of thermal cycling. Data for the proposed seals materials and sealing scheme/design should be included in the proposal.
- Development of catalysts for direct internal reforming of methane. Provide single cell performance data on dry methane for the one or more of the proposed anode compositions.

Proposed technologies should demonstrate the following characteristics:

- Systems are expected to operate as specified after at least 20 thermal cycles during Phase I and the heat up rate must be stated in the proposal.
- The developed systems are expected to operate as specified after at least 500 hours of steady state operation on propellant-grade methane and oxygen with 2500 hours expected of a mature system. System should startup “dry” or with a minimal amount of water, but after reaching operating conditions an amount of water/H_2 consistent with what can be obtained from anode recycle can be used. Amounts must be justified in the proposal.
- Minimal cooling required for power applications. Cooling in the final application will be provided by means of conduction through the stack to a radiator exposed to space and/or by anode exhaust flow.

Research should be conducted to demonstrate technical feasibility during Phase I and show a path toward a Phase II hardware demonstration. Emphasis should be on demonstrating technical feasibility, prototype hardware (2-4 cell stacks preferred), conceptual designs and implementation approaches.

H8.02 Space Nuclear Power Systems

Lead Center: GRC

Participating Center(s): JPL, JSC, MSFC

NASA is developing fission power system technology for future space exploration applications using a stepwise approach. Initial small fission systems are envisioned in the 1 to 10 kWe range that utilize cast uranium metal fuel and heat pipe cooling coupled to static or dynamic power conversion. Follow-on systems could produce 10s or 100s of kilowatts utilizing a pin-type uranium fueled reactor with pumped liquid metal cooling, dynamic power conversion, and high temperature radiators. The anticipated design life for these systems is 8 to 15 years with no maintenance. Candidate mission applications include power sources for robotic precursors, human outposts on the moon or Mars, and nuclear electric propulsion (NEP) vehicles. NASA is planning a variety of nuclear and non-nuclear system ground tests to validate technologies required to transfer reactor heat, convert the heat into electricity, reject waste heat, process the electrical output, and demonstrate overall system performance.

The primary goals for the early systems are low cost, high reliability, and long life. Proposals are solicited that could help supplement or augment the planned NASA system testing. Specific areas for development include:

- 800-1000 K heat transport technology for reactor cooling (liquid metal heat pipes, liquid metal pumps).
- 1-10 kWe-class power conversion technology (thermoelectric, Stirling, Brayton).
- 400-500 K heat rejection technology for waste heat removal (water heat pipes, composite radiators, water pumps).

The early systems are expected to provide the foundation for later systems in the multi-hundred kilowatt or megawatt range that utilize higher operating temperatures, alternative materials, and advanced components to improve system performance. Specific areas for development include:

- 100 kWe-class power conversion technologies.
- Waste heat rejection technologies for 500 K and above.
- High temperature reactor fuels, structural materials and heat transport technologies.

Expected deliverables include monthly and final reports, analytical models, and experimental hardware. Phase I activities should focus on analytical validation of technical feasibility including conceptual designs and trade studies with supporting coupon/component level testing. Phase II activities should emphasize experimental testing using prototype hardware in a subsystem context under relevant operating conditions to demonstrate technology readiness.