NASA SBIR 2019 Phase I Solicitation

Z1.03 Kilowatt-Class Energy Conversion for Small Fission Reactors

Lead Center: GRC

Participating Center(s): JPL

Technology Area: TA3 Space Power and Energy Storage

NASA is considering the use of kilowatt class Fission Power Systems for surface missions to the moon and Mars. This technology directly aligns with the Space Technology Mission Directorate (STMD) roadmap for space power and energy storage and could be infused into the Kilopower Project to enhance performance or reliability. Current work in fission power systems is focused on the Kilopower project which uses a highly enriched Uranium-Molybdenum reactor core with a Beryllium oxide reflector. Depleted uranium, tungsten, and lithium hydride provide shielding of gamma rays and neutrons to the power conversion system, control electronics, payload, and habitat. Heat is removed from the core at approximately 800° C using sodium heat pipes and delivered to the power conversion system. Waste heat is removed from the power conversion system at approximately 100 to 200° C using water heat pipes coupled to aluminum or composite radiator panels. The Kilopower project targets the 1-10 kW electrical power range with most previous work focused on a demonstration of the 1 kWe design. The current solicitation is focused on innovations that enable the scaling of the 1 kWe design to 10 kWe, with a specific focus on surface power applications. Areas of interest include:

- Robust, efficient, highly reliable, and long-life thermal-to-electric power conversion, controller, and PMAD technology. Power conversion can consist of multiple lower power units which could be combined to create 10 kW of electric power. Stirling, Brayton, and thermoelectric convertors that can be coupled to Kilopower reactors are of interest.
- Reduction in shield mass through increased distance from core with mass effective Power Management and Distribution (PMAD) and transmission or lightweight possibly retractable booms.
- Radiation shield materials selection, design, and fabrication for mixed neutron and gamma environments, with consideration for mass effectiveness, manufacturability, and cost.
- Radiation tolerant electronics designed to withstand an induced radiation environment in addition to the ambient environment in space. Target dose tolerance ranges for fission power system electronics are between 1E11 to 1E13 n/cm^2 total neutron fluence, and between 100 kRad(Si) and 1000kRad(Si) total ionizing gamma dose.

Proposed concepts must identify, compare, and contrast advantages over key metrics pertinent to the technology concept.

The desired deliverables are primarily a prototype hardware to demonstrate concept feasibility. The appropriate research and analysis required to develop the hardware is also desired. The expected TRL for this project is 3 to 5.

NASA has plans to purchase services for delivery of payloads to the Moon through the Commercial Lunar Payload Services (CLPS) contract. Under this subtopic, proposals may include efforts to develop payloads for flight demonstration of relevant technologies in the lunar environment. The CLPS payload accommodations are yet to be precisely defined, however at least for early missions, proposed payloads should not exceed 15 kilograms in mass and not require more than 8 watts of continuous power. Smaller, simpler, and more self-sufficient payloads are more likely to be accommodated. Commercial payload delivery services may begin as early as 2020 and flight opportunities are expected to continue well into the future. In future years it is expected that payloads of higher mass and with higher power requirements might be accommodated. Selection for award under this solicitation will not guarantee selection for a lunar flight opportunity.

References:

- https://www.nasa.gov/directorates/spacetech/kilopower
- Gibson, M.A., et al., "The Kilopwer Reactor Using Stirling TechnologY (KRUSTY) Nuclear Ground Test Results and Lessons Learned," AIAA P&E 2018, AIAA-2018-4973.
- Mason, Lee S., "A Comparison of Energy Conversion Technologies for Space Nuclear Power Systems," AIAA P&E 2018, AIAA-2018-4977.
- Chaiken, M.F., et al., "Radiation Tolerance Testing of Electronics for Space Fission Power Systems," Nuclear and Emerging Technologies for Space 2018, Paper No. 24146.
- Gibson, M.A., et al., "NASA's Kilopower Reactor Development and the Path to Higher Power Missions," 2017 IEEE Aerospace Conference, 4-11 March 2017, Big Sky, MT.
- Mason, Lee S., et al., "A Small Fission Power System for NASA Planetary Science Missions," NASA/TM--2011-217099.