NASA SBIR 2020 Phase I Solicitation

Z1.05 Lunar & Planetary Surface Power Management & Distribution

Lead Center: GRC

Participating Center(s): GSFC, JSC

Technology Area: TA3 Space Power and Energy Storage

Scope Title

Innovative ways to transmit high power for lunar & Mars surface missions

Scope Description

The Global Exploration Roadmap (January 2018) and the Space Policy Directive (December 2017) detail NASA's plans for future human-rated space missions. A major factor in this involves establishing bases on the lunar surface and eventually Mars. Surface power for bases is envisioned to be located remotely from the habitat modules and must be efficiently transferred over significant distances. The International Space Station (ISS) has the highest power (100kW), and largest space power distribution system with eight interleaved micro-grids providing power functions similar to a terrestrial power utility. Planetary bases will be similar to the ISS with expectations of multiple power sources, storage, science, and habitation modules, but at higher power levels and with longer distribution networks providing interconnection. In order to enable high power (>100kW) and longer distribution systems on the surface of the moon or Mars, NASA is in need of innovative technologies in the areas of lower mass/higher efficiency power electronic regulators, switchgear, cabling, connectors, wireless sensors, power beaming, power scavenging, and power management control. The technologies of interest would need to operate in extreme temperature environments, including lunar night, and could experience temperature changes from -153C to 123C for lunar applications, and -125C to 80C for Mars bases. In addition to temperature extremes, technologies would need to withstand (have minimal degradation from) lunar dust/regolith, Mars dust storms, and space radiation levels.

While this subtopic would directly address the lunar and Mars base initiatives, technologies developed could also benefit other NASA Mission Directorates including SMD (Science Mission Directorate) and ARMD (Aeronautics Research Mission Directorate). Specific projects which could find value in the technologies developed herein include Gateway, In-Situ Resource Utilization (ISRU), Advanced Modular Power Systems (AMPS), In-Space Electric Propulsion (ISP), planetary exploration, and Hybrid Gas Electric Propulsion. The power levels may be different, but the technology concepts could be similar, especially when dealing with temperature extremes and the need for electronics with higher power density and efficiency.

Specific technologies of interest would need to address the lunar or Mars environment, and include:

- Application of wide bandgap electronics in DC-DC isolating converters with wide temperature (-70ºC to 150ºC), high power density (>2 kW/kg), high efficiency (>96%) power electronics and associated drivers for

voltage regulation.
- Low mass, highly conductive wires and terminations that provide reliable small gauges for long distance power transmission in the 1-10kW range, low mass insulation materials with increased dielectric breakdown strength and void reductions with 600 V or greater ratings, and low loss/low mass shielding.
- Power beaming concepts to enable highly efficient flexible/mobile power transfer in the 100-1,000W range, including the fusion of power/communication/navigation.

(See Z13.02 - Dust Tolerant Mechanismssubtopic to propose power connection/termination related technologies that are impervious to environmental dust and enable robotic deployment, such as robotically-enabled high voltage connectors and/or near-field wireless power transfer in the 1-10kW range.)

References

The Global Exploration Roadmap, January 2018:
https://www.nasa.gov/sites/default/files/atoms/files/ger_2018_small_mobile.pdf

Space Policy Directive, December 2017: https://www.nasa.gov/topics/moon-to-mars/overview

Expected TRL or TRL range at completion of the project 3 to 6

Desired Deliverables of Phase II

Prototype, Analysis, Hardware, Research

Desired Deliverables Description

Typically, deliverables under Phase I proposals are geared towards a technology concept with associated analysis and design. A final report usually suffices in summarizing the work. Phase II hardware prototypes will have opportunities for infusion into NASA technology testbeds and commercial landers.

State of the Art and Critical Gaps

While high power terrestrial distribution systems exist, there is no equivalent to a lunar or planetary base. Unique challenges must be overcome in order to enable a realistic power architecture for these future applications, especially when dealing with the environmental extremes which will be encountered. The temperature swings will be a critical requirement on any technology developed, from power converters to cabling or power beaming concepts. In addition, proposals will have to consider lunar regolith and Mars dust storms.

Relevance / Science Traceability

This subtopic would directly address the lunar and Mars surface initiatives. There are potential infusion opportunities with SMD (Science Mission Directorate) Commercial Lander Payload Services and HEOMD (Human Exploration and Operations Mission Directorate) Flexible Lunar Exploration (FLEx) Landers. In addition, technologies developed could benefit other NASA missions including Gateway. The power levels may be different, but the technology concepts could be similar, especially when dealing with temperature extremes.