NASA SBIR 2022 Phase I Solicitation

Z1.05  Lunar and Planetary Surface Power Management and Distribution

Lead Center: GRC

Participating Center(s): GSFC, JSC

Scope Title
Innovative Ways to Transmit Power over Long Distances for Lunar and Mars 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 effort 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 largest and highest power (100 kW) space power distribution system, with eight interleaved microgrids providing power functions similar to a terrestrial power utility. Planetary bases will be similar to the ISS, with expectations of storage, science, and habitation modules and multiple power sources, but at higher power levels and with longer distribution networks providing interconnection. In order to enable high-power (>100 kW) 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, connectors, wireless sensors, 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 ranging from -153 to 123 °C for lunar applications and -125 to 80 °C 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 that 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 Electrified Aircraft Propulsion Technology. 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 direct current (DC)-to-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.

Distribution components of a three-phase/1,200-Hz permanent magnet alternator, 480-VAC to 650-VDC power management and distribution with direct drive to Hall thrusters. Key components of the distribution include rotary alternators and alternating current (AC) transmission, including alternator voltage, step-up/step-down transformers, and rectifiers.
NOTE: See Subtopic Z203, Mechanisms for Extreme Environments, 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- to 10-kW range.

Expected TRL or TRL Range at completion of the Project
3 to 6

Primary Technology Taxonomy
Level 1
TX 03 Aerospace Power and Energy Storage

Level 2
TX 03.3 Power Management and Distribution

Desired Deliverables of Phase I and Phase II
Research Analysis Prototype Hardware
Desired Deliverables Description
Typically, deliverables under Phase I proposals are geared toward a technology concept with associated analysis and design. A final report usually suffices in summarizing the work, but a prototype is preferred. 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 that will be encountered. Operability in environments subject to temperature swings will be a critical requirement for 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. To enable a new Mars transportation capability for human exploration, new technology development must be started soon to address the unique needs of a mixed alternating current/direct current (AC/DC) space-rated power system to prove feasibility and provide realistic performance metrics for detailed vehicle design concepts and mission trade studies.

Relevance / Science Traceability
This subtopic would directly address a remaining technology gap in the lunar and Mars surface mission concepts and Mars human transportation needs. There are potential infusion opportunities with SMD (Science Mission Directorate), Commercial Lander Payload Services (CLPS), HEOMD (Human Exploration and Operations Mission Directorate), and Flexible Lunar Architecture for Exploration (FLARE). 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.

References
The Global Exploration Roadmap, January 2018:
https://www.nasa.gov/sites/default/files/atoms/files/ger_2018_small_mobi...
Space Policy Directive-1, Reinvigorating America's Human Space Exploration Program, December 11, 2017:
https://www.federalregister.gov/documents/2017/12/14/2017-27160/reinvigo...