NASA SBIR 2019 Phase I Solicitation

S4.04 Extreme Environments Technology

Lead Center: JPL

Participating Center(s): GRC, GSFC, LaRC

Technology Area: TA4 Robotics, Telerobotics and Autonomous Systems

This subtopic addresses NASA's need to develop technologies for producing space systems that can operate without environmental protection housings in the extreme environments of NASA missions. Key performance parameters of interest are survivability and operation under the following conditions:

Â Very low temperature environments (Example: temperatures on the surface of MoonÂ as low as -180Â° C).

- Combination of low temperature and radiation environments (Example: surface conditions at Europa of -180Â° C with very high radiation).
- Very high temperature, high pressure and chemically corrosive environments (Example:Â Venus surface conditions, which include very high pressure of 93 bar and extreme temperatures of 485Â° C).

Â NASA is interested in expanding its ability to explore the deep atmospheres and surfaces of the Moon, planets, asteroids, and comets through the use of long-lived (days or weeks) balloons and landers. Survivability in extreme high temperatures and high pressures is also required for deep atmospheric probes to the giant planets. Proposals are sought for technologies that are suitable for remote sensing applications at cryogenic temperatures, and in-situ atmospheric and surface explorations in the high temperature, high pressure environment at the Venusian surface (485Â° C, 93 bar), or in low-temperature environments such as those of Titan (-180Â° C), Europa (-220Â° C), Ganymede (-200Â° C), Mars, the Moon, asteroids, comets and other small bodies. Also, Europa-Jupiter missions may have a mission life of 10 years and the radiation environment is estimated at 2.9 Mega-rad total ionizing dose (TID) behind 0.1 inch thick aluminum. Proposals are sought for technologies that enable NASA's long duration missions to extreme wide-temperature and cosmic radiation environments. High reliability, ease of maintenance, low volume, low mass, and low out-gassing characteristics are highly desirable. Special interest lies in development of the following technologies that are suitable for the environments discussed above:

Â Wide temperature range precision mechanisms i.e., beam steering, scanner, linear and tilting multi-axis mechanisms.

- Radiation-tolerant/radiation-hardened low-power, low-noise, mixed-signal mechanism control electronics for precision actuators and sensors.
- Wide temperature range feedback sensors with sub-arc-second/nanometer precision.
- Long life, long stroke, low power, and high torque/force actuators with sub-arc-second/nanometer precision.
- Long life bearings/tribological surfaces/lubricants.

- High temperature energy storage systems. High-temperature actuators and gear boxes for robotic arms and other mechanisms.
- Long life high temperature electronics (including components, circuits and tools) and high temperature electronic packaging.
- Low-power and wide-operating-temperature radiation-tolerant/radiation-hardened RF electronics.
- Radiation-tolerant/radiation-hardened low-power/ultra-low power, wide-operating-temperature, low-noise mixed-signal electronics for space-borne systems such as guidance and navigation avionics and instruments.
- Radiation-tolerant/radiation-hardened power electronics.
- Radiation-tolerant/radiation-hardened electronics packaging (including, shielding, passives, connectors, wiring harness and materials used in advanced electronics assembly).

Â Research should be conducted to demonstrate technical feasibility during Phase I and show a path toward a Phase II hardware demonstration, and when possible, deliver a demonstration unit for functional and environmental testing at the completion of the Phase II contract.

Â There is a high relevance to NASA's Science Mission Directorate (SMD). As mentioned above, low temperature survivability is required for surface missions to Titan, Europa, Ganymede, small bodies and comets. Mars diurnal temperatures range from -120Â° C to +20Â° C. For the Europa Clipper baseline concept, with a mission life of 10 years, the radiation environment is estimated at 2.9 Mega-rad total ionizing dose (TID) behind 100 mil thick aluminum. Lunar equatorial region temperatures swing from -180Â° C to +130Â° C during the lunar day/night cycle, and shadowed lunar pole temperatures can drop to -230Â° C. Advanced technologies for high temperature systems (electronics, electro-mechanical and mechanical) and pressure vessels are needed to ensure NASA can meet its long duration (days instead of hours) life target for its missions in high temperature and high pressure environments.

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

Â The expected Technology Readiness Level (TRL) range at completion of this project is 3 to 5.Â Â

Â **References:**

Â Proceedings of the Extreme Environment Sessions of the IEEE Aerospace Conference. https://www.aeroconf.org/

- Proceedings of the meetings of the Venus Exploration Analysis Group (VEXAG). https://www.lpi.usra.edu/vexag/
- Proceedings of the meetings of the Outer Planet Assessment Group (OPAG). https://www.lpi.usra.edu/opag/