SBIR/STTR

Small Business Innovation Research / Small Business Technology Transfer

NASA SBIR 2020 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

Scope Description

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

1) Very low temperature environments (e.g., temperatures at the surface of Titan and of other Ocean Worlds as low as -180 deg C; and in permanently shadowed craters on the Moon), or

2) Combination of low temperature and radiation environments (e.g., surface conditions at Europa of -180 deg C with very high radiation), or

3) Very high temperature, high pressure and chemically corrosive environments (e.g., Venus surface conditions having very high pressure and temperature of 486 deg C).

NASA is interested in expanding its ability to explore the deep atmospheres and surfaces of 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 atmospheres), 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:

- Wide temperature range precision mechanisms, e.g., 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-arcsecond/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
- 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 electronic packaging (including shielding, passives, connectors, wiring harness and materials used in advanced electronics assembly)

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.

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 will vary depending on the particular service provider and mission characteristics. Additional information on the CLPS program and providers can be found at this link: https://www.nasa.gov/content/commercial-lunar-payload-services. CLPS missions will typically carry multiple payloads for multiple customers. Smaller, simpler, and more self-sufficient payloads are more easily accommodated and would be more likely to be considered for a NASA-sponsored flight opportunity. 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 larger and more complex payloads will be accommodated. Selection for award under this solicitation will not guarantee selection for a lunar flight opportunity.

References

1. Proceedings of the Extreme Environment Sessions of the IEEE Aerospace Conference. https://www.aeroconf.org/ or via IEEE *Xplore* Digital Library
2. Proceedings of the meetings of the Venus Exploration Analysis Group (VEXAG). https://www.lpi.usra.edu/vexag/
3. Proceedings of the meetings of the Outer Planet Assessment Group (OPAG). https://www.lpi.usra.edu/opag/

Expected TRL or TRL range at completion of the project: 3 to 5

Desired Deliverables of Phase II

Prototype, Hardware

Desired Deliverables Description

Deliverables include proof of concept working prototypes that demonstrate the innovations defined in the proposal and enable direct operation in extreme environments.

State of the Art and Critical Gaps

Future NASA missions to high priority targets in our solar system will require systems that have to operate at extreme environmental conditions. NASA missions to the surfaces of Europa and other Ocean Worlds bodies will be exposed to temperatures as low as -180 deg C and radiation levels that are at megarad levels. Operation in permanently shadowed craters on the Moon is also a region of particular interest. In addition, NASA missions to the Venus surface and deep atmospheric probes to Jupiter or Saturn will be exposed to high temperatures, high pressures, and chemically corrosive environments.

Current state-of-practice for development of space systems for the above missions is to place hardware developed with conventional technologies into bulky and power-inefficient environmentally protected housings. The use of environmental protection housing will severely increase the mass of the space system, limit the life of the mission and the corresponding science return. This solicitation seeks to change the state of the practice by support technologies that will enable development of lightweight, highly efficient systems that can readily survive and operate in these extreme environments without the need for the environmental protection systems.

Relevance / Science Traceability

Relevance to SMD (Science Mission Directorate) is high.

Low temperature survivability is required for surface missions to Titan (-180 deg C), Europa (-220 deg C), Ganymede (-200 deg C), small bodies and comets. Mars diurnal temperatures range from -120 deg C to +20 deg C. For the Europa Clipper baseline concept, with a mission life of 10 years, the radiation environment is estimated at 2.9 megarad total ionizing dose (TID) behind 100 mil thick aluminum. Lunar equatorial region temperatures swing from -180 deg C to +130 deg C during the lunar day/night cycle, and shadowed lunar pole temperatures can drop to -230 deg 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 science missions which operate in high temperature and high pressure environments.