NASA SBIR 2020 Phase I Solicitation

Z13.02 Dust Tolerant Mechanisms

Lead Center: KSC

Participating Center(s): GRC, JSC, LaRC

Technology Area: TA7 Human Exploration Destination Systems

Scope Title
Dust Tolerant Joints

Scope Description
A return to the Moon to extend human presence, pursue scientific activities, use the Moon to prepare for future human missions to Mars and expand Earth’s economic sphere, will require investment in developing new technologies and capabilities to achieve affordable and sustainable human exploration. From the operational experience gained and lessons learned during the Apollo missions, conducting long-term operations in the lunar environment will be a particular challenge, given the difficulties presented by the unique physical properties and other characteristics of lunar regolith, including dust. The Apollo missions and other lunar exploration have identified significant lunar dust-related problems that will challenge future mission success. Comprised of regolith particles ranging in size from tens of nanometers to microns, lunar dust is a manifestation of the complex interaction of the lunar soil with multiple mechanical, electrical and gravitational effects.

Mechanical systems will need to operate on the dusty surface of the moon for months to years. These systems will be exposed to the harsh regolith dust and will have little to no maintenance. This scope seeks technologies that will protect from or tolerate dust intrusion in the following areas:

- Rotary joints (steering, suspension, hinges, bearings, etc.)
- Linear joints (latches, shafts, restraint systems, landing gear, etc.)
- Static joints (quick disconnects, covers, airlocks, sample tools, etc.)

Successful solutions will enable operation in a lunar environment for 10 to 100 months with limited or no maintenance.

References
Expected TRL or TRL range at completion of the project: 2 to 6

Desired Deliverables of Phase II

Prototype, Analysis, Hardware, Software, Research

Desired Deliverables Description

Research should be conducted to demonstrate technical feasibility during Phase I and show a path toward Phase II demonstration with delivery of a demonstration package for NASA testing in operational test environments at the completion of the Phase II contract.

Phase I Deliverables - Research, identify and evaluate candidate technologies or concepts for dust tolerant mechanisms. Simulations or lab-level demonstrations are desirable. Deliverables must include a report to documenting findings.

Phase II Deliverables - Emphasis should be placed on developing, prototyping and demonstrating the technology under simulated operational conditions (regolith, thermal, vacuum). Deliverables shall include a report outlining the path showing how the technology could be matured and applied to mission-worthy systems, functional and performance test results and other associated documentation. Deliverable of a functional prototype is expected at the completion of the Phase II contract. The technology concept at the end of Phase II should be at a TRL of 6 or higher.

State of the Art and Critical Gaps

Previous solutions used in the Apollo program did not address the current need of long term usage. Terrestrial solutions often employ materials or methods that are incompatible with the lunar environment.

Critical Gaps:

- **Rotary joints**
  - Seals: Rotary joints are very common for actuation in dusty environments because of the widespread availability of rotary seals. Most of these seals however use elastomers that would off-gas and become brittle in a lunar environment. Solutions are needed that employ materials or non-traditional techniques that can operate in the lunar environment for an extended period of time (months to years).
  - Bearings: Regolith getting past the protective seals of rotary joints bearings is a common failure point. Bearings designs that are highly dust tolerant may be needed to reduce the risk of failures due to dust intrusion.

- **Linear joints**
  - Seals: Linear joints are less common in dusty environments because of the challenge of sealing the sliding joints. Similar to rotary seals, linear joint seals are often made from elastomers and would need to be modified to operate in a lunar environment. Solutions are needed that employ materials or non-traditional techniques that can operate in the lunar environment for an extended period of time (months to years).
  - Bearings: Regolith getting past the protective seals of linear joints bearings is a common failure point. Bearings designs that are highly dust tolerant may be needed to reduce the risk of failures due to dust intrusion.

- **Static joints**
  - Operations on the lunar surface will include assembly, construction, and Extra-Vehicular Activity (EVA) tasks. These tasks will involve the mating/demating of various structural, electrical, and fluid connections. Dust on the surface of these joints will impede their proper function and lead to failures. Solutions are needed to protect these joints from dust contamination (e.g. 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).
Dust will be one of the biggest challenges for operation on the lunar surface for the Artemis program.

“I think dust is probably one of our greatest inhibitors to a nominal operation on the Moon. I think we can overcome other physiological, physical or mechanical problems except dust.” Gene Cernan, Apollo 17 Technical Debrief.