

CHARACTERIZING COMPONENT PERFORMANCE IN THE LUNAR ENVIRONMENT.

M.C.L.Patterson¹, J.Tucker¹, K.Carpenter² and A.Parness²,

¹Southern Research Institute, 757, Tom Martin Dr., Birmingham, AL. 35211 mpatterson@southernresearch.org; jtucker@southernresearch.org ²NASA Jet Propulsion Laboratory, 4800, Oak Grove Dr., Pasadena, CA. 91109 Karlind.C.Carpenter@jpl.nasa.gov; Aaron.Parness@jpl.nasa.gov

Introduction: The lunar surface is one of the most difficult planetary environments for the long-term operation of mechanical systems. Extremely low night temperatures for extended periods, severe thermal gradients, periodic charging and discharging of the near surface exosphere and the highly abrasive regolith represent unprecedented challenges for the design of systems, especially those that must last more than a few days. Near surface transport of fine dust particles and a propensity for it to be electrostatically attached to surfaces, causing it to repel physical removal by brushing, create an environment that can quickly degrade component performance and lead to premature system failure.

Man's desire to have a 'permanent' presence on the Moon has led to considerable interest, including commercialization activities, both from US and International partners [1]. In-situ, resource utilization (ISRU) has the potential to be an enabling and potentially lucrative business for those willing to invest and adopt the significant risk associated with the development of a new infrastructure on the lunar surface. With estimated costs of \$1.2M/kg to deliver payloads to the lunar surface [1], the need to understand how systems perform, develop mitigation strategies to reduce or eliminate problems and to be able to predict life performance estimates in this hostile environment, is of great importance. To this end, Southern Research and NASA's Jet Propulsion Laboratory have been working to establish a test environment that closely approximates environments that will be encountered on the Lunar surface where materials, components and selected systems can be characterized and possible degradation mechanisms, better understood.

Materials Characterization: To provide experimental data that can characterize the performance of materials/systems such as motors, small robots and actuators, as well as to conduct electrostatic repulsion experiments and observe plasma material interactions, Southern Research has developed and instrumented a thermal vacuum chamber capable of operating at cryogenic temperatures into which regolith can be introduced to simulate operating on the lunar surface. The chamber contains a regolith base approximately 60cm by 90cm in size. It can routinely cycle between 100K and 400K through the use of directional lamp heating above the regolith bed while maintaining a vacuum in

the 10^{-6} torr range. The chamber (Figure 1) can be configured for isothermal or cyclic thermal gradient operation and supports a range of sensing and diagnostic capabilities including video, thermal imagery, stereo digital image correlation (DIC), temperature, strain and load cells for characterizing electromechanical systems. A WiFi link allows communication with small robotic platforms and robust testing of systems. In addition to small robotic platforms such as PUFFER [2], NASA is also investing in power and thermal systems to address nighttime survival. For specialized testing, smaller volumes of the chamber can be reduced item-temperature to 20K to 30K allowing characterization of battery degradation through the lunar night.

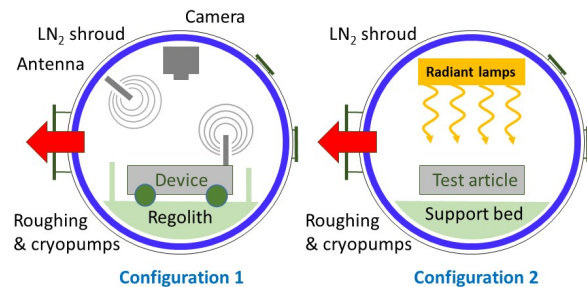


Figure 1. Typical Chamber Configurations

The chamber will be used to characterize tribological regolith mechanisms to help design for operating in the lunar regolith, identifying selection parameters for the component building blocks such as bearings, shafts, seals, and lubricants as well as critical design methods to protect those components. New materials like bulk metallic glass [3] and new coatings being developed by NASA for future permanent and long-duration mission applications will be characterized together with electrostatic dust repulsion systems.

References:

- [1] Panel Discussion "Working with Commercial Partners to Explore the Moon". (2018) *LEAG Annual Meeting, Nov. 15th 2018, USRA HQ, Columbia MD*
- [2] NASA Facts, "Space Technology Game Changing Development A-PUFFER: Autonomous Pop-Up Flat-Folding Explorer Robots" https://gameon.nasa.gov/gcd/files/2018/05/A-PUFFER_FS_180523.pdf
- [3] R.Dillon, "Game Changing Development, Bulk Metallic Glass Gears" NASA Facts, CL#16-3456 https://gameon.nasa.gov/gcd/files/2016/08/FS_BMGG_FS_160808.pdf