UNDERSTANDING COMPONENT/MATERIALS PERFORMANCE IN THE LUNAR ENVIRONMENT.

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Introduction: The lunar surface is projected to be one of the most difficult for 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 that need to operate for extended periods. Near surface transport of fine dust particles and a propensity for it to be electrostatically attached to surfaces and repel physical removal by brushing, create an environment quickly capable of degrading the performance of systems that ultimately leads to premature system failure.

Man's desire to have a 'permanent' presence on the Moon has led to considerable interest and possible commercialization activities both from US and International partners [1], and in-situ, resource utilization (ISRU) promises to be a critical 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 [2], 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 similar environments to those 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: In an effort to provide experimental data that can be used to characterize the performance of materials/systems such as motors, actuators and small robots for instance, as well as electrostatic repulsion experiments and plasma material interactions, Southern Research has developed and instrumented a thermal vacuum chamber capable of operating at cryogenic temperatures into which simulated regolith can be introduced to mimic operating on the lunar surface. The chamber, which contains a simulated regolith base approximately 60cm by 90cm in size can routinely cycle between 100K and 400K through the use of a LN_2 shroud and directional lamp heating above the bed, while maintaining a vacuum in the 10^{-6} torr range. The chamber (Figure 1) supports a wide 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 communications link allows direct communication with small robotic platforms and robust testing of systems. In addition to small robotic platforms such as PUFFER [3] other NASA investments in power and thermal systems seek to address nighttime survival. For specialized testing, smaller volumes of the chamber can be reduced in temperature to 20K to 30K allowing for characterization such as battery degradation through the lunar night.

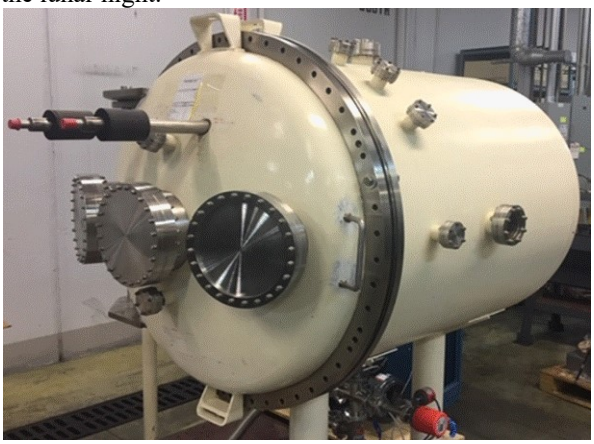

Figure 1. Chamber for material/system characterization

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 and new coatings being developed by NASA for future permanent and long-duration mission applications will be characterized together with electrostatic dust repulsion systems and technologies.

References:

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[2] D.Hendrickson (2018) *As above*.
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