Combined Regolith Batteries and Vertical Solar Array Systems for Lunar Night Survival. N. W. Traeden[1] and H. J. Williams[1], [1]Honeybee Robotics, 2408 Lincoln Ave, Altadena, CA 91001, NWTraeden@honeybeerobotics.com

Introduction: In situ resource utilization has been proposed to decrease mass of a variety of elements needed to achieve Lunar Permanence, but many current architectures for overnight energy storage rely on materials brought exclusively from Earth such as batteries and fuel cells. Fuel cells are not infinitely scalable. Battery mass represents a large portion of mass for night surviving systems depending on existing technology, and batteries are a common cause for failure (up to 20%) [1]. Other technologies such as radioisotope heating units are too low TRL for immediate integration. A low mass, scalable, simple, readily available alternative to existing night survival technology is necessary. We propose a new system using Lunar regolith to store and slowly release thermal energy to survive the Lunar night.

Lunar regolith in vacuum is a highly insulative material, with a heat transfer coefficient of under 1.5 × 10-4 W/cm K even when fully densified [1]. To make use of Lunar regolith as a thermal mass for storing heat, the concept of Lunar thermal wadis was put forward by Balasubramaniam et al [3]. This concept proposed the use of materials with even lower thermal conductivity than regolith and included regolith melting as a potential element. The thermal wadi concept suffered from three major issues: difficulty introducing heat to large amounts of regolith without massive support equipment, requiring large amounts of special materials and losing some heat to phase change / recrystallization.

Terrestrial thermal energy storage (TES) systems are regularly used with concentrated solar power plants to smooth output [4]. Some recently developed systems capture energy from renewables during peak production times to provide grid area heating [5]. Some of the simplest TES systems store heat in the form of sensible energy; in which they raise the temperature of a stored medium, like mineral oil or silica sand. This energy is later extracted using heat exchange systems.

Honeybee has developed the Regolith Aided Night Survival System (RAiNSS), a new method, drawing on elements from these previously developed Lunar and terrestrial technologies: pumping heated gas in a closed system through a storage tank of collected Lunar regolith for thermal energy storage.

Honeybee Robotics has proven pneumatic stirring and transport of Lunar regolith to be an effective and well-established technique through the multiple CLPS missions [6]. One gram of pressurized gas can move over a kilogram of regolith in the low Lunar gravity. RAiNSS holds gas in a tank and preheats it using thermoelectric heaters wrapped around the tank. The gas is introduced into the closed regolith-holding container in direct contact with the regolith, stirring and heating it. This alleviates the thermal conductivity issues associated with transferring large amounts of heat to lunar regolith. Pumps move gas between the container and tank, repeating the process to increase regolith temperature to just below melting. During periods of darkness, cooled gas is used to extract heat from the regolith thermal mass to provide thermal energy to Lunar structures or habitats. In periods of inactivity the system pressure may be pulled back to vacuum to reduce thermal losses in the media.

To power this system, Honeybee will integrate its Lunar Array Mast and Power System (LAMPS). LAMPS is a deployable and stowable vertical solar array, scaled in its current iteration for 10kW at 15m tall and portable using a Lunar Terrain Vehicle. LAMPS is scalable in size and power, using modular solar panels in its arrays and a helical band actuator for its central boom that can shrink or grow with small hardware changes. Because both RAiNSS and LAMPS are highly scalable and potentially mobile, this system can serve as a lander-independent power and night survival system.

Conclusion: using RAiNSS and LAMPS, we have created a system for night survival with high TRL, low political risk technology, ready for a technology demonstration mission in the next five years.

References:

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