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Moon Exploration – Part 2 (2B)

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ADVANCING UTILIZATION OF THE MOON THROUGH CRYOGENIC TECHNOLOGIES

Abstract

The next stage of exploration and utilization of the Moon will require us to operate in extremely cold environments well below -180 °C. Such capability will enable us to operate in the Permanently Shadowed Regions (PSRs) of the Moon. In addition, advancing such technology can also provide a multitude of benefits, including in the long-term preservation of living cells for safe-keeping on the Moon (a modern Lunar Ark) (Foing, 2004) (Diaz et al., 2021) and long-duration space travel. The objective of this paper is to explore the use of cryogenic applications and insulation technologies for lunar applications. Such an effort can facilitate the next stage of exploration and utilization of space. Our main applications are the conceptual design and analysis of a Lunar Robotic Ark housed inside a lunar lava-tube. A Lunar Robotic Ark can preserve Earth's rich bio-diversity in a locale that has remained pristine for 3-4 billion years and at a steady state of -25 °C. In these conditions we look to provide an estimation of the power required to maintain bio-matter at -196 °C and seeds at -180 °C. Operating at these very cold temperatures would sound like a burden, however we can exploit unique phenomenon such as superconductivity and quantum levitation to minimize material to material contact and heat transfer. To further evaluate the feasibility of the lunar robotic ark, we also need to determine the feasibility of transporting cryo-preserved material in transport cannisters from Earth to the Moon in at least 5 days. As a first step, we wish to determine feasibility of designing a transport cannister that maintains cryo-temperature for 5 days at LEO. For this we start with a 3U CubeSat that contains cryo-refrigeration system that uses a Stirling engine and insulation. Last but not least, exploring the PSR's of the Moon is a high-risk high-reward mission to prospect for water ice but also permanent locations to house a Lunar Robotic Ark. There needs to be sufficient water ice on the moon to enable development of a lunar base of any kind. PSR conditions present major challenges for operations of conventional landers and rovers. The best option is to provide a distributed low-cost solution. FemtoSats, a platform of less than 100 grams and smaller than a CubeSat can be scattered by the hundreds or thousands into a PSR and help first map the conditions and look for traces of water ice.