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ROBOTIC MISSION DESIGN FOR PRELIMINARY MINERAL EXPLORATION IN THE PERIPHERAL LUNAR PERMANENTLY SHADOWED REGIONS

Abstract

Shallow surface ice deposits in the small peripheral lunar permanently shadowed regions (PSRs) are one of the most interesting potential targets for near-term space resource utilization (SRU). This is due to a combination of ingredients: high-quality remote sensing data from the Lunar Reconnaissance Orbiter, upcoming surface exploration by the VIPER rover and other international partners, and upcoming low-cost access via the NASA CLPS (Commercial Lunar Payload Services) program. Accessing these surface deposits will both build out the basic technologies needed to operate in and around the lunar PSRs and allow the use of ISRU as a building block for more ambitious operations in cislunar space and near-Earth asteroids.

For this to proceed, the space resources community now needs detailed information about the specific, spatial distribution of water in areas of interest. In the terminology of terrestrial mineral exploration, the expected water deposits on the lunar poles are a mineral resource. We would like to identify ore reserves, concentrated regions of water ice with known grade and extent that can be viably extracted.

Identifying these regions of interest will require detailed mapping by robotic missions using both remote sensing and direct drilling and chemical sampling of the subsurface regolith. In this work, we simulate such a mission to understand the requirements and constraints of lunar mineral exploration work. Using simulated families of subsurface water distributions, we conduct Monte Carlo simulation of exploration missions to understand the impact of rover endurance, sensor selection, and sampling topology.

Using this simulated sampling data, combined with standard geostatistical estimation techniques, we argue that the distribution of water in small PSRs can be readily determined by lightweight robotic exploration to an accuracy to within terrestrial standards for preliminary feasibility studies. Through this approach, we aim to identify high-priority target PSRs for development missions. By careful mapping of a range of promising locations, these missions will aim to identify unusually high-yield, easy-to-access sites, suitable for preliminary SRU pilot projects.