IAF SPACE EXPLORATION SYMPOSIUM (A3)
Moon Exploration – Part 3 (2C)

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AUTONOMOUS IN-SITU RESOURCE UTILIZATION OF LUNAR WATER ICE ENABLED BY A PERMANENTLY OPERATING LUNAR EXPLORATION ROVER (POLER)

Abstract

As humanity aims to return and stay on the Moon, one of the key enablers for a permanent settlement will be in-situ resource utilization (ISRU). Mining local water ice and converting it into rocket propellant is one of the key drivers for developing lunar infrastructure. Recent discoveries reveal the highest concentrations of water ice near the lunar polar regions and inside its craters.

To expand the capabilities of exploring the lunar poles and mining local water ice, this study proposes a scientific long-duration mission of a Permanently Operating Lunar Exploration Rover (POLER). It will serve three primary purposes:

- Design, develop, test, and demonstrate lunar water ice mining technologies serving as building blocks for ISRU.
- Gather scientific data in Permanently Shadowed Regions (PSR) at the lunar poles.
- Leverage long-term integration and interoperability within a larger ecosystem of lunar infrastructure.

Following a holistic mission and systems-based approach, an initial review of state of the art ISRU technologies creates the basis for a comprehensive trade-off analysis resulting in a top-level system architecture. Key criteria for system trades include environmental constraints in PSRs, power and performance requirements and scientific value. Iterative sizing calculations analyze the feasibility of a single integrated system versus "robotic staging" docking to secondary payloads. Scalability, modularity and interoperability of the system aims at long-term extension to robotic swarm operations within a lunar ISRU ecosystem.

Operating autonomously within craters and PSRs dramatically increases the difficulty of this mission. Extremely low temperatures, lack of sunlight, energy generation and storage, loss of communication line of sight, electrostatic lunar dust and rough terrain navigation are only some challenges POLER is designed to overcome. Stable in-situ power supply enables POLER to permanently survive and operate within these extreme conditions. Via electrolysis, an internal unit splits water into molecular oxygen and hydrogen. A unique POLER feature is its ability to lower a secondary cabled and retractable module inside the craters. This unlocks a wide range of applications for analyzing unexplored regions at a level of detail never achieved before and for accessing regions of the Moon with high concentrations of water ice.

Ultimately, POLER demonstrates key space exploration capabilities by leveraging ISRU and gaining a better understanding of the Moon and its resources, contributing to humanity's strive to become a multi-planetary species.

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