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NOVEL LUNAR MISSION ARCHITECTURE DESIGN: DEPLOYMENT OF A PROTOTYPE COMPLETELY AUTONOMOUS OXYGEN PRODUCTION FACILITY ON THE MOON

Abstract

The Moon, an imminent frontier for human exploration and settlement, necessitates advancements in spacefaring capabilities, with in-situ resource utilization (ISRU) emerging as a pivotal enabler for sustainable lunar habitation. Globally, substantial efforts are directed towards developing ISRU systems, primarily focused on the extraction and utilization of local resources within lunar regolith. Presently, these endeavors are concentrated on advancing the underlying technologies, with prototype systems predominantly confined to laboratory or field testbeds. However, the transition to fully operational space-system implementations of these ISRU testbeds is a current inquiry that stands to profoundly influence the success and scope of future lunar exploration missions. How will the ISRU systems be deployed on the lunar surface? What other lunar assets will be required for these ISRU systems? What will be the architecture of the lunar mission deploying the first ISRU plant? What other space systems will be required?

The current research answers the above questions and presents a comprehensive lunar mission architecture design study, with the aim to deploy the first completely autonomous oxygen production facility on the lunar south pole. The primary objective is to establish a self-sustaining and self-deployable oxygen production system, a crucial step towards enabling human presence on the Moon.

The mission architecture comprises a Launch Vehicle, Lunar Lander, Lunar Rover, In-Situ Resource Utilization (ISRU) Plant, and Lunar Power systems. The distinctive and novel aspect of this mission design is its complete autonomy, requiring no human intervention or reliance on pre-deployed lunar assets. The Lunar Lander, a fully autonomous spacecraft, is equipped with an integrated ISRU Plant, solar arrays for power generation, and serves as a communication hub between lunar assets and Earth. The Rover, tasked with excavating lunar regolith, transports the material to the Lander for oxygen extraction. The mission sets forth specific objectives to be achieved by 2030, including the autonomous deployment of the Lander and lunar assets, the production of a minimum of 1000 kg of oxygen by the ISRU plant, and the storage of the produced oxygen for up to one year. Crucially, the mission is designed to operate independently without relying on other lunar assets.

This mission design study lays the foundation for a pioneering endeavor to establish a self-sufficient oxygen production system on the Moon. By meeting the specified mission requirements, including the storage of oxygen for future manned lunar missions, this concept becomes a cornerstone for the development of permanent lunar settlements.