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PRELIMINARY DESIGN AND MANUFACTURE OF PLANETARY EXPLORATION ROVERS BASED ON MISSION SCENARIOS

Abstract

Mission scenarios play a crucial role in planetary exploration, as they define the specifications for long-term survival, mobility technologies, and multi-joint manipulators of exploration rovers. In this study, Unmanned Exploration Laboratory(UEL) manufactured preliminary design of a versatile planetary exploration rovers capable of accommodating multiple mission requirements. The prototypes have been developed for two configurations: one equipped with a Surface Camera(SurfCam) for imaging planetary regolith particles provided by Korea Astronomy and Space Science Institute(KASI), and another outfitted with a gas chromatograph for in situ resource analysis of planetary regolith supplied by Korea Institute of Geoscience and Mineral Resources(KIGAM). For the KASI SurfCam rover, an elevation module that allows movements in increments of 0.01mm was installed at the front to enable the SurfCam to achieve the optimal focal distance. Moreover, a rocker differencing suspension was implemented to ensure that the SurfCam maintains a vertical orientation on uneven surfaces, and the rover was designed to weigh approximately 25kg. In the case of the KIGAM, gas chromatograph rover for In-Situ Resource Utilization(ISRU), a steering motor was integrated into the rocker differencing suspension to facilitate stable mobility and efficient collection and analysis of regolith samples on the planetary surface. Additionally, the internal space was optimized to accommodate the dimensions of the gas chromatograph. The rover's nominal weight is approximately 20kg, ensuring that the overall mass does not exceed 50kg even with the instrument installed. These cases emphasize each client who have specialized requirements for mission scenario-based preliminary designs to facilitate component selection. In collaboration with the Korea Aerospace Research Institute(KARI), a structural thermal model(STM) was developed to verify the thermal behavior of the rover under the extreme temperature conditions of the planetary surface ($-233\,^{\circ}$C to $123\,^{\circ}$C). Thermal analyses and simulations were performed, and based on the results, design modifications are underway to reduce the size of the rover's heat sink and effectively manage internal heat dissipation. It is going to be the development of thermal management systems capable of withstanding space environments. Efficient mobility algorithms and posture scenarios during mission operations are also critical for optimizing rover performance. Furthermore, the design must address weight distribution changes caused by the scientific operations of the multi-joint manipulator in low-gravity conditions. Long-term survival strategies must also account for temperature variations and energy constraints in planetary environments.