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CONCEPT AND DESIGN OF AN AUTONOMOUS MICRO ROVER FOR LONG TERM LUNAR EXPLORATION

Abstract

Research on robotic lunar exploration has seen a broad revival, especially since the Google Lunar X-Prize increasingly brought private endeavors into play. This development is supported by national agencies with the aim of enabling long-term lunar infrastructure for in-situ operations and the establishment of a moon village. Thus, we assume that the demand and opportunities to explore the moon will increase greatly in the future. One challenge for effective exploration missions is developing a compact and lightweight robotic rover to reduce launch costs and open the possibility for secondary payload options. Existing micro rovers for exploration missions are clearly limited by their design for one day of sunlight and their low level of autonomy. For expanding the potential mission applications and range of use, an extension of lifetime could be reached by surviving the lunar night and providing a higher level of autonomy.

To address this objective, the paper presents a system design concept of a lightweight micro rover with long-term mission duration capabilities, derived from a multi-day lunar mission scenario at equatorial regions. Technical solutions are described, analyzed, and evaluated, with emphasis put on the harmonization of hardware selection due to a strictly limited budget in dimensions and power.

Two aspects have a significant impact on the rover and are analyzed particularly. First, the influence of the TCS and EPS on the rover's mechanical design. Second, the design of the GNC and OBDH subsystems since these are critical for the systems autonomy. To enable survivability at night, concepts for a thermal control system are discussed and evaluated, comprising innovative solution approaches using passive as well as active means of thermal control. Thermo-electric operation strategies additionally present a promising approach for supporting control efforts considering the tremendous variations in temperature and illumination. Furthermore, a low-power hardware and software architecture for the GNC is presented,

including a selection of sensors and the bus topology for the OBDH. An overview of conceivable scientific payloads will be provided as well as the integration of the subsystems in an enhanced mechanical concept for the chassis and the electronic compartment of the system.

A summary of the overall system performance will be given, highlighting the contribution to future robotic designs for advanced lunar exploration missions. The rover's demonstrator integration and testing of key-subsystems under lunar thermal and light conditions, simulated in an adapted TVAC chamber, is envisioned to be realized within the next two years.