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DESIGN AND ANALYSIS OF A 3U CUBESAT-BASED ROVER FOR MOON SURFACE EXPLORATION

Abstract

As interest in Moon exploration grows, low-cost scientific missions are being explored to make Moon exploration more accessible to universities and small research institutions. Traditional moon rovers require significant resources, limiting access to moon surface exploration. This study is part of the LUNEX and EuroMoonMars initiative, focusing on advancing low-cost lunar exploration technologies. One promising solution is to adapt the standardized low-cost systems developed for low-Earth orbit (LEO), which endure similar environmental conditions, and extend their qualifications for Moon exploration. The CubeSat platform, widely regarded as the most successful standardized platform for LEO low-cost missions in recent decades, can potentially be adapted for low-cost Moon surface exploration. This study introduces a CubeSat-based rover design which utilizes a standard 3U CubeSat as the baseline, with hyperspectral camera as the primary payload for moon surface observation. A CubeSat-based rover is a compact, modular robotic vehicle which directly integrates CubeSat technology onto a mobile rover platform, enabling it to conduct scientific experiments on the Moon surface. The proposed rover design aims to extend CubeSat technology to meet the requirements of Moon surface missions, including extreme temperature fluctuations, Moon landing impact load, and Moon regolith interactions under low gravity. A comprehensive analysis of the rover's performance under simulated Moon surface conditions is presented in this study, including wheel-soil interaction analysis, rover stability analysis, and structural finite element analysis under load conditions from launch to landing and operating on the Moon. Experimental tests under simulated lunar conditions were also conducted on the CubeSat-based rover design and are presented in this study to validate the structural analysis results and the design's functionality. The results of these

analyses and experimental tests demonstrate that a CubeSat-based rover can meet the requirements of a small-scale moon surface observation mission. Additionally, comparison with past moon surface exploration missions shows the cost-effectiveness of the CubeSat-based rover platform. The study also provides useful insights into the feasibility of adopting CubeSat-based rovers as low-cost platforms for lunar surface exploration missions.