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MAPPING LUNAR TRANSIENT PHENOMENA WITH A CUBESAT CONSTELLATION: MOTHS MISSION CONCEPT AND DESIGN

Abstract

The increasing interest in space beyond Earth orbit has led to the development of innovative and miniaturized space systems and technologies. Particularly, small satellite missions for deep space exploration offer accessible and low-cost solutions to realize in-orbit testing and to settle new international collaborations for research activities. Thanks to their flexibility, fast implementation and increasing reliability, small satellites can be employed to conduct scientific exploration missions on outer planets and celestial bodies in the solar system, such as the Moon surface's observations and its craters studies. In this framework, a student team from S5Lab (Sapienza Space System and Space Surveillance Laboratory), at Sapienza University of Rome, developed the MOTHS mission (Moon Observation Through Hyperspectral Satellites). MOTHS is a 6U CubeSat Moon constellation, deployed on two orbital planes, and designed entirely using COTS components. The mission was developed with the primary objective of studying and analyzing Transient Lunar Phenomena (TLP). The importance of the mission lies in the necessity of conducting an in-depth study of the TLPs, which have thus far only been detected and analysed through observation performed from Earth. These phenomena are strongly related to various events happening in the Moon environment such as Argon, Radon and Polonium outgassing, making crucial their understanding for future lunar landing sites and lunar settlements establishment. The TLPs are phenomena that appear on the surface of the moon and consist of short-lived changes in light, colour and appearance on the surface of the moon, which can range from foggy patches to permanent changes in the lunar landscape. To study the TLP and all the related effects, the MOTHS primary payload consists of a hyperspectral camera equipped with a CMOS sensor payload which enables the detection of the TLPs and of the outgassing phenomena, specifically targeting gases such as Argon, Radon, and Polonium. Moreover, to support in-situ resource utilization (ISRU), such as rover and lander, MOTHS is equipped with a GNSS receiver together with its integrated patch antenna as a secondary payload. This payload will enable the exploitation of the MOTHS constellation as a relay system for future lunar navigation satellite systems (LNSS). In this paper, after the description of the mission concept and the mission analysis, the satellite design will be analysed, focusing on the hyperspectral payload and the GNSS system. Furthermore, it explores the possibility of synergic collaborations with future lunar human exploration activities.