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DESIGNING THE RADIO LINK FOR A LUNAR CUBESAT: THE LUMIO CASE

Abstract

The Lunar Meteoroid Impact Observer (LUMIO) is a mission designed to observe, quantify, and characterize the meteoroid impacts by detecting their flashes on the lunar far side. Earth-based lunar observations are restricted by weather, geometric and illumination conditions, while a lunar orbiter can improve the detection rate of lunar meteoroid impact flashes, as it would allow for longer monitoring periods. This paper will focus on the communications and radio navigation system of the mission, designed for the ESA roadmap for lunar exploration. LUMIO has been designed to operate autonomously after deployment in a eccentric lunar orbit and to reach, without human intervention, its final destination orbit close to the Moon-Earth L2 point, where the primary mission can be carried out. One of the mission goals is the demonstration of an autonomous optical navigation system whose performances have to be validated against a traditional radiometric direct-to-Earth link. Furthermore, other autonomous radio-navigation techniques involving an inter-satellite link have also been investigated and the feasibility for this mission has been established. A detailed link budget analysis has been presented for all mission phases for both the inter-satellite link (considering commercial Lunar data relay missions) and a traditional radio link with Earth. Beside defining the achievable data transfer and radio navigation performance, we focused also on evaluating the available ground stations to better evaluate mission cost with respect to science return. Radio-navigation performances have been also evaluated to estimate the position and relative velocity accuracy, given the power, mass, and volume constraints of a typical CubeSat mission. This helped better defining the on-board autonomous navigation system, constraining the total error budget for this mission and future ones. This mission will be run with a heavily constrained budget with respect to traditional agency-type scientific missions, relying as much as possible on commercial services to improve flexibility and limit costs. Several solutions, such as beacon tones, have been evaluated to lower the overall operational cost. Continuous monitoring with both a low performance ground station and an inter-satellite link has been considered to limit the usage of deep-space class ground stations to the minimum. This is considered of extreme importance, especially for small missions, to allow opportunistic operations on high gain antennas, given their availability and their high operational cost.