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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 from a lunar mother spacecraft in a low inclination lunar orbit and to reach without human intervention his final destination orbit close to the Moon-Earth L2 point, where science can be carried out. Being the destination orbit always in view from Earth (despite a distance of sixty to eighty thousand kilometers), Direct-to-Earth communication was added to the mission as a mean to reduce risk and allow independent verification of several of the innovative technologies that would be demonstrated, first of all autonomous navigation. A detailed link budget analysis will be presented for all mission phases for both the link with the mother spacecraft in low lunar orbit and the link with Earth. Beside defining the achievable data transfer, we will focus also on evaluating the available ground stations to better evaluate mission cost with respect to science return. Radio-navigation performances will also be evaluated to estimate the position and relative velocity accuracy, given also the limited performances available for the on-board navigation transponder. This will help also better defining the on-board autonomous navigation system, constraining the total error budget. Further strategies, such as beacon tones, will be evaluated to lower the overall operational cost by employing continuous monitoring with a low performances ground station and, only when needed, perform high speed downlink using a deep-space class ground station. This strategy is considered of extreme importance, especially for small missions, to allow opportunistic operations on high gain antennas, given their very busy schedule.