EPSC Abstracts
Vol. 12, EPSC2018-320, 2018
European Planetary Science Congress 2018

Lunar Meteoroid Impact Observer (LUMIO): A CubeSat at Earth-Moon L2

F. Topputo(1), M. Massari(1), J. Biggs(1), P. Di Lizia(1), D. Dei Tos(1), K. Mani(1), S. Ceccherini(1), V. Franzese(1), A. Cervone(2), P. Sundaramoorthy(2), S. Speretta(2), S. Mestry(2), R. Noomen(2), A. Ivanov(3), D. Labate(4), A. Jochemsen(5), R. Furfaro(6), V. Reddy(6), K. Jacquinot(6), A. Cipriano(7), J. Vennekens(7), R. Walker(7), **C. Avdellidou**(7), D. Koschny (7)
(1) Politecnico di Milano, Milano, Italy, (2) TU Delft, Delft, The Netherlands, (3) École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland, (4) Leonardo, Airborne & Space System Division, Florence, Italy, (5) S[&]T Norway, Oslo, Norway, (6) University of Arizona, Tucson, AZ, United States, (7) ESA/ESTEC, Noordwijk, The Netherlands
(francesco.topputo@polimi.it)

Abstract

The Lunar Meteoroid Impact Observer (LUMIO) is a CubeSat mission to observe, quantify, and characterise the meteoroid impacts by detecting their flashes on the lunar farside. This complements the knowledge gathered by Earth-based observations of the lunar nearside, thus synthesising a global information on the lunar meteoroid environment. LUMIO is one of the two winner of ESA's LUCE (Lunar CubeSat for Exploration) SysNova competition, and as such it is being considered by ESA for implementation in the near future.

1. Scientific framework

Meteoroids are small Sun orbiting fragments of asteroids and comets, whose sizes range from micrometres to meters and masses from 10^{-15} to 10^{4} kg [1]. Their formation is a consequence of asteroids colliding with each other or with other bodies, comets releasing dust particles when close to the Sun and minor bodies shattering into individual fragments. Therefore, understanding meteoroids and associated phenomena can be valuable for the study of asteroids and comets themselves. Since the Earth and Moon are impacted by the same meteoroid streams and swarms, studying the meteoroid flux at the Moon can be useful, not only to understand the meteoroid flux impacting Earth, but also to improve the meteoroid models of the Solar System. Furthermore, understanding the meteoroid flux distribution at the Moon is also critical for future Moon surface missions, as it could help understand, for example, future lunar living areas.

In a lunar meteoroid impact, the kinetic energy of the impactor is partitioned into (i) the generation of a seismic wave, (ii) the excavation of a crater, (iii) the ejection of particles, and (iv) the emission of radiation. Any of these phenomena can be observed to detect impacts. The detection of lunar impact flashes is the most advantageous method as it yields an independent detection of meteoroid impacts, provides the most information about the impactor, and allows for the monitoring of a large Moon surface area.

The first unambiguous lunar meteoroid impact flashes were detected during 1999's Leonid meteoroid showers [2, 3], while the first redundant detection of sporadic impacts was only reported six years later [4]. Since then there have been several attempts for ground-based lunar observations with three programs to provide the majority of the detections (Spanish survey [5], NASA survey [6] and NELIOTA project [7]).

However, observing the lunar impacts with space-based assets, and especially on the lunar farside, yields a number of benefits over ground-based telescopes, namely: the absence of atmosphere, weather and earthshine, the increase of the observing hours, no restrictions on lunar longitudes and latitudes.

2. Description of the mission

The LUMIO mission utilises a CubeSat that carries the LUMIO-Cam, an optical instrument capable of detecting light flashes in the visible spectrum. On-board data processing is implemented to minimise data downlink, while still retaining relevant scientific data: only those images containing flashes are stored. The mission implements a sophisticated orbit design: LUMIO is placed on a halo orbit about Earth–Moon L2 where permanent full-disk observation of the lunar farside is made. This prevents having background noise due to Earthshine, and thus permits obtaining high-quality scientific products. Repetitive operations are foreseen, the orbit being in near 2:1 resonance with the Moon orbit. Innovative full-disk optical autonomous navigation is proposed, and its performances are assessed and quantified. The spacecraft is a 12U form-factor CubeSat, with <22 kg mass. Novel on-board micro-propulsion system for orbital control, de-tumbling, and RW desaturation is used. Steady solar power generation is achieved with solar array drive assembly and eclipse-free orbit. Accurate pointing is performed by using reaction wheels, IMU, start trackers, and fine sun sensors. Communication with the Lunar Orbiter is done in UHF band. Advanced thermal coating and resistance heater for thermal control, as well as lightweight structure with radiation shielding are considered.

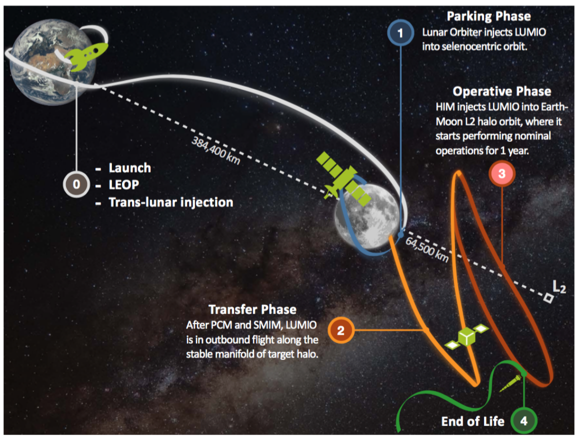

Figure 1: Outline of LUMIO mission.

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