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Author: Mr. Prem Sundaramoorthy
Delft University of Technology (TU Delft), The Netherlands, P.P.Sundaramoorthy@tudelft.nl

Dr. Francesco Topputo
Politecnico di Milano, Italy, francesco.topputo@polimi.it
Dr. Mauro Massari
Politecnico di Milano, Italy, mauro.massari@polimi.it
Dr. James Douglas Biggs
Politecnico di Milano, Italy, jamesdouglas.biggs@polimi.it
Dr. Pierluigi Di Lizia
Politecnico di Milano, Italy, pierluigi.dilizia@polimi.it
Dr. Diogene Alessandro Dei Tos
Politecnico di Milano, Italy, diogenealessandro.deitos@polimi.it
Mr. Karthik Venkatesh Mani
Politecnico di Milano, Italy, karthikvenkatesh.mani@polimi.it
Mr. Simone Ceccherini
Politecnico di Milano, Italy, simone.ceccherini@polimi.it
Mr. Vittorio Franzese
Politecnico di Milano, Italy, vittorio.franzese@mail.polimi.it
Dr. Angelo Cervone
Delft University of Technology (TU Delft), The Netherlands, a.cervone@tudelft.nl
Dr. Stefano Speretta
Delft University of Technology (TU Delft), The Netherlands, s.speretta@tudelft.nl
Ms. Samiksha Mestry
Delft University of Technology (TU Delft), The Netherlands, s.s.mestry@tudelft.nl
Mr. Mathijs Van de Poel
Delft University of Technology (TU Delft), Belgium, mathijs.vandepoel@gmail.com
Mr. Sean Pepper
Delft University of Technology (TU Delft), The Netherlands, S.M.Pepper@student.tudelft.nl
Mr. Ron Noomen
Delft University of Technology (TU Delft), The Netherlands, r.noomen@tudelft.nl
Dr. Anton Ivanov
Skolkovo Institute of Science and Technology, Russian Federation, a.ivanov2@skoltech.ru
Mr. Demetrio Labate
Leonardo Spa, Italy, demetrio.labate@leonardocompany.com
Mr. Arnoud Jochemsen
Science [&] Technology AS, Norway, jochemsen@stcorp.no
Prof. Roberto Furfaro
University of Arizona, United States, robertof@email.arizona.edu
Dr. Vishnu Reddy
University of Arizona, United States, reddy@lpl.arizona.edu
Mr. Kevin Jacquinot

University of Arizona, United States, jacquinot@email.arizona.edu
Dr. Roger Walker
European Space Agency (ESA), The Netherlands, Roger.Walker@esa.int
Mr. Johan Vennekens
ESA - European Space Agency, The Netherlands, Johan.Vennekens@esa.int
Ms. Ana Cipriano
European Space Agency (ESA), The Netherlands, ana.cipriano@esa.int

SYSTEM DESIGN OF LUMIO: A CUBESAT AT EARTH-MOON L2 FOR OBSERVING LUNAR METEOROID IMPACTS

Abstract

The Earth-Moon system is constantly being bombarded by a significant number of meteoroids with different sizes and velocities. Observation of the lunar surface impacts will enable characterization of the lunar meteoroid flux, which is similar to that of the Earth, and provide more detailed information on meteoroid size, velocity, temporal and spatial distribution. The Lunar Meteoroid Impact Observer (LUMIO) is a CubeSat mission at Earth-Moon L2 to observe, quantify, and characterise these meteoroid impacts by detecting their flashes on the lunar farside. LUMIO is one of the two winners of ESA's LUCE (Lunar CubeSat for Exploration) SysNova competition, and as such is being considered by ESA for implementation in the near future. This paper will present the design of the LUMIO spacecraft that will host the payload to capture the meteoroid flashes on the lunar surface. Key system challenges, trade-offs and consequent design iterations are discussed. The final design yields a feasible spacecraft budget and configuration that enables the LUMIO mission to be realized by 2023.

The spacecraft is a 12U form-factor CubeSat, with a mass of less than 22 kg. A zero-redundancy and COTS based approach has been adopted for the spacecraft design. A strong emphasis has been placed on realizing high onboard autonomy. A novel and autonomous navigation strategy that uses optical observations of the Earth and the Moon is proposed for navigation around the moon and beyond. The payload and navigation are the key drivers of the pointing requirements. Pointing requirements is achieved through reaction wheels, IMUs, star trackers, and fine sun sensors. A hybrid micro-propulsion system is included for orbital control, de-tumbling, and reaction wheel desaturation. Steady solar power availability is ensured with a one-axis solar array drive assembly in combination with an innovative attitude algorithm. Communication with Earth is through the Lunar Orbiter with a low bandwidth UHF link, which places high constraints on the data throughput. An onboard payload data processor has been designed that compresses the science data to a fraction of the raw data with no loss in information.

The paper will conclude with the key findings of a concurrent design review of the LUMIO spacecraft design that was performed at ESA/ESTEC concurrent design facility. The main discrepancies and incremental design changes are outlined along with feasibility and risk of the iterated design.