Politecnico di Milano – Department of Aerospace Science and Technology
Modeling and Simulation of Aerospace Systems – AY 2019/2020 (F. Topputo)

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Solar Array Drive Assembly for LUMIO

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 far-side. LUMIO is one of the two winners 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.

LUMIO envisages a 12U CubeSat form-factor placed in a halo orbit at Earth-Moon L2, carrying the LUMIO-Cam, a miniaturized optical instrument capable of detecting light flashes in the visible spectrum. LUMIO demonstrates our recently enabled capability to perform lunar science and exploration with a shoebox-sized space system.

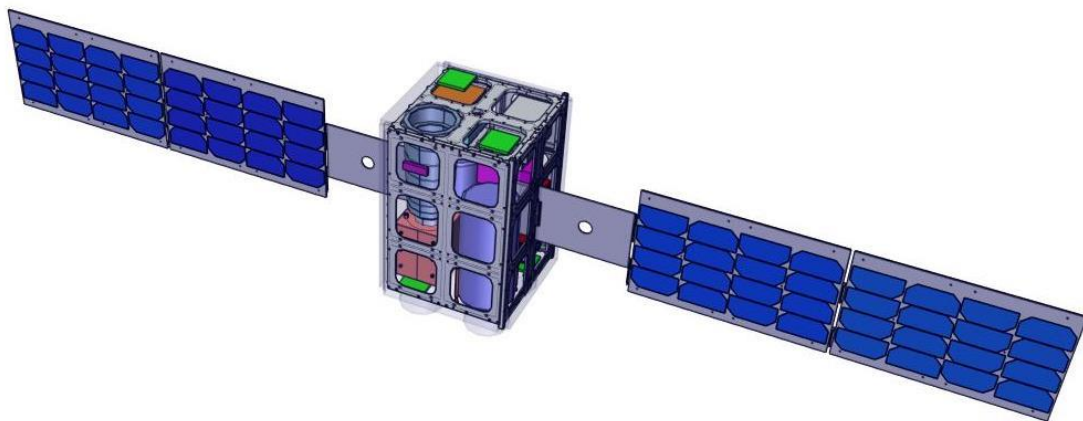
Figure 1: Artist's impression of LUMIO.

Figure 2: LUMIO Configuration

1. Tasks

With reference to LUMIO CubeSat in Figure 2,

1. Set up the electromechanical model for the Solar Array Drive Assembly (SADA) coupled with a thermal model for the spacecraft;

2. Carry out a dynamic simulation for a full orbit and show the system response, considering solar panels tracking the Sun.

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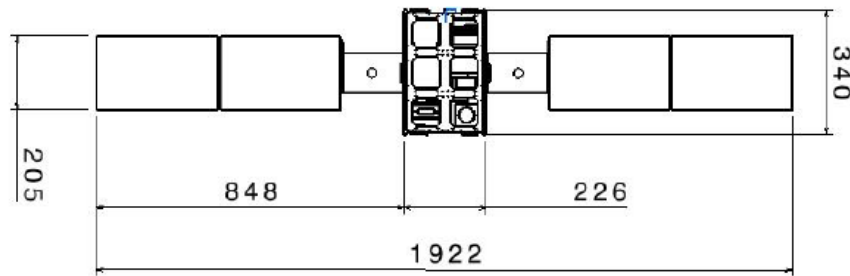
2. Physical parameters

Figure 3: LUMIO Dimensions

Solar Panels

- 4 panels (2 left and 2 right) in a 4x4 cell configuration
- Dimensions: from Figure 3, each panel has length 325mm, thickness 5 mm
- Mass = 500g each panel

Stepper motor

- Two phase, 20 step per revolution
- Terminal resistance: 13.6 Ω
- Terminal inductance: 2 mH
- Back-EMF amplitude: 0.53 Vs
- Gearhead reduction 4:1

Structure

- Material: Aluminum
- Total weight: 2 kg

Orbital mechanics

- LUMIO trajectory will be provided in an agreed format

3. Guidelines

Write the model equations for the stepper motor and the mechanical equations related to the solar panel movements.

Derive the spacecraft thermal model using at least 10 lumps (1 for each face, 2 for each solar wing). Remember that the P/L boresight always points the Moon and solar panels track the Sun.

Integrate the coupled equations. Note that the stepper motor cannot track continuously the Sun.

> ➢ ***Introduce and justify all the other missing data****. Modify parameters above if needed.*

4. References

1. F. Topputo et al*. LUMIO: Characterizing Lunar Meteoroid Impacts with a CubeSat*. 69th International Astronautical Congress, Bremen, 2018.
2. P. Sundaramoorthy et al. *System design of LUMIO: A CubeSat at Earth-Moon L2 for observing lunar meteoroid impacts*. 69th International Astronautical Congress, Bremen, 2018.
3. Takashi Kenjo. *Stepping motors and their microprocessor controls*. Clarendon Press, 1984.

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4. K. Balakrishnan, B. Umamaheswari, and K. Latha. *Estimation of rotor position and speed for Hybrid Stepper Motor under various phase excitation schemes and compensated resonance*. 2011 International Conference on Power Engineering, Energy and Electrical Drives. 2011, pp. 1–6. doi: 10.1109/PowerEng.2011.6036488.
5. Fabio Santoni et al. *An innovative deployable solar panel system for Cubesats*. Acta Astronautica 95 (2014), pp. 210–217.
6. Fabio Santoni et al. *An orientable solar panel system for nanospacecraft*. Acta Astronautica 101 (2014), pp. 120–128.
7. D.W. Jones and Reston Condit. *Stepping motor fundamentals*. Microchip Technology Inc, 2004.