Interreg
Sudoe

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Research and innovation

Preliminary design challenge

Mission requirements

NANOSTAR consortium

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SMALL SATELLITE FLY-BY MISSION TO THE MOON

The search for the presence of lunar water has attracted considerable attention and motivated several recent lunar missions, largely because of water's usefulness in rendering long-term lunar habitation feasible. Liquid water cannot persist on the Moon's surface, while water vapor is quickly decomposed by the sunlight and hydrogen quickly lost to the outer space. However, scientists have conjectured since the 1960s that water ice could survive in cold, permanently shadowed craters at the Moon's poles. Water molecules have also been detected in the thin layer of gases above the lunar surface [1].

The goal of this Space Mission Design competition is then to predesign **a small satellite fly-by mission to the Moon**, with some science data acquisition during the periselenium pass, e.g. from altitudes above the Moon's surface as low as 100 km. This **science demonstrator** mission shall feature a minimal onboard payload consisting of an optical camera to take a few pictures of the lunar soil. Additional payloads (e.g. spectrometers) can be proposed and included in the preliminary design, and shall be considered positively in the evaluation process.

Your team's objective is to propose a feasible solution to this challenge, which includes performing the **requirement flow-down** of the mission, **defining and sizing all the relevant subsystems**, carrying out the **mission analysis**, estimating the **performance of your system**, and justifying that your solution **satisfies all top-level mission requirements and deals with the constraints**. Refer to ECSS-E-ST-10C for more information on the requested level of detail of the above-defined activities; notwithstanding this, further detail level will be considered positively in the evaluation.

The expected output of your work includes a report and a presentation explaining your solution and an IDM-CIC file containing the 3D model of the spacecraft with a characterization (in terms of mass and position) of all its subsystems and individual components. See the NANOSTAR Student booklet for more information on the expected deliverables, and the rules of the Preliminary design challenge.

TOP-LEVEL MISSION REQUIREMENTS

The following list includes the top-level mission requirements and constraints that must be verified by all proposed designs:

- MR001. The system shall carry and activate safely the **main science payload** described below, for the maximum time around the periselenium pass, thus maximizing the total amount of science data received on Earth. *Additional payloads (e.g. technological demonstrators) can be included if they do not have a detrimental effect on the operation of the main one and the system can correctly support their operation. This will be considered positively in the evaluation of the project.*
- MR002. The altitude of the periselenium pass <u>**shall**</u> **not be higher than 100 km** (minimum periselenium altitude can be freely chosen, although it should be defined according to a risk trade-off analysis)
- MR003. **At least one Moon's flyby** <u>shall</u> be performed. *Additional Moon flybys will be considered positively in the evaluation of the project.*

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MR004. The **science data** obtained by the main science payload <u>shall</u> be transmitted to Earth within the mission timeframe.

MR005. The satellite <u>shall</u> be capable of performing the mission objectives, considering the **space environment** constraints.

MR006. The satellite <u>shall</u> guarantee the correct pointing of the main science payload during the flyby(s).

MR007. The **satellite volume <u>shall not</u> exceed 27U**. *A smaller volume will be considered positively in the evaluation of the project.*

MR008. The **mission duration from launch to end-of-life <u>shall not</u> exceed 5 years**. *A shorter duration will be considered positively in the evaluation of the project.*

MR009. Ground segment(s) <u>shall</u> rely only on the tracking stations of the **ESA network**

MR010. The uplink and downlink frequencies <u>shall</u> be in the **S, L, UHF, X or C bands**.

MAIN SCIENCE PAYLOAD CHARACTERISTICS

The main science payload of the small satellite carries at least an optical camera and its characteristics and requirements are described below:

- The payload is a box of **1 kg** and takes **1U** of volume
- The payload has an **optical camera on its exterior side whose field of view is a cone of 20 deg half angle**, which must not be occluded by other objects.
- The payload consumes a **total power of 5 W**, when turned ON. The payload has no power consumption when turned OFF. The consumed power is dissipated as heat inside the payload.
- A **pointing accuracy of 0.5 deg** must be ensured during the payload operation.
- When operating, the payload produces **10 MB of data per fly-by**, which must be transmitted to the Earth within the mission timeline. A larger amount of produced data can be considered, provided that the telecommunications system is sized to transmit it back to Earth within the mission timeframe.
- The payload must never point directly toward the Sun when operating
- The payload has good internal thermal conductivity and can be treated as an isothermal box. The temperature operating range is **-10 to +30 ºC** when in operation, and **-20 to +40 ºC** when not operating.
- The exterior wall of the payload, where the camera is, has the following **optical properties** $\varepsilon_{IR} = 0.6$ (emissivity for IR radiation) and $\alpha_{SUN} = 0.3$ (absorptivity for solar radiation).
- The main science payload is considered as a box having Al equivalent shielding of 0.8 mm in the six directions.

ADDITIONAL INFORMATION

- Student teams **do not need to consider launcher availability**.
- The **launcher injects the nanosatellite into GTO** (Geostationary Transfer Orbit) at a free inclination.

- System simplicity and risk will be part of the items considered in the evaluation of the project.

REFERENCES

[1] A. Colaprete, P. Schultz, J. Heldmann, D. Wooden, M. Shirley, K. Ennico, and D. Goldstein, *Detection of water in the LCROSS ejecta plume*. *science*, Vol. *330*(6003), pages 463-468, 2010