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Preliminary design of a laser retroreflector payload for the MARTINLARA mission

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Introduction

The MARTINLARA Program is a research project funded by the Community of Madrid with the objective of developing a space mission on board a nanosatellite that integrates technologies for space use in various scientific applications. Among its five main objectives, the demonstration of various space-oriented functional technologies includes onboard retroreflectors (RR) that act as a space segment of a SLR system.

GeosIGN, the group of Space Geodesy of the National Geographic Institute of Spain (IGN), is developing the RR-based payload for conducting in-orbit validation experiments of space technologies based on RR integration for SLR.

This poster provides an overview of its current status.

MARTINLARA Program

Along its Phase 1 (2019-2022), after defining the Mission Requirements, a baseline for the mission orbit (LEO down-dusk orbit at 400-500 km), and platform (12U CubeSat) have been fixed.

This has contributed to produce the System Requirements Document (SRD), preliminary designs for the spacecraft, payloads, and auxiliary subsystems, and, finally, the Preliminary Design Definition.

GEOSIGN is in charge of carrying out the specification, design, acquisition and distribution of the RRs in the nanosatellite structure. The following aspects will be investigated: shape, size, optimal number and position of the RR on the platform.

Payload Preliminary Design

Two possible concepts have been proposed:

Concept 1. POD: LRA in the satellite nadir face

For Precise Orbit Determination (POD) purposes on the basis of SLR observations, at least one RR shall be visible at all times. Three basic Laser RR Array (LRA) designs are widely used in LEO missions for SLR [1].

The selected design is a pyramidal LRA of small dimensions, with four RRs arranged at 45º (tbc) with respect to the base of the pyramid.

- Each individual RR will have a clear aperture diameter of 7.5 mm, made in fused silica, with silver coating on its back faces, an ARC coating in the front face, and the dihedral angle small enough to deal with the velocity aberration of the orbit.
- The assembly mount (pyramid) will be made of aluminium.
- The assembly will be mounted on the nadir face of the platform. The diagonal of the pyramid base will be aligned with the along track direction of the platform (tbc), which guarantees that only two prisms contribute to the retro reflection of the signal from the station.

All the components will be COTS.

Fig. 1. Concept 1. LRA unassembled/assembled, its orientation with respect the along-track direction, and its position on the nadir face of a 6U CubeSat platform (former platform baseline).

Concept 1 backup. POD: LRA in the satellite nadir face

Beyond the potential flexibilities that could be introduced in that design, if required for reasons of area, volume, or weight budgets, an alternative concept has been identified that should fulfil the functional requirements for Concept 1: a minimal array of three corner cube RRs, proposed by ETH Zurich for the Astrocast CubeSat mission [2]. Its visibility from ground stations is not guaranteed for all possible satellite passes at all zenith distances (up to 70º).

Concept 2. Attitude determination: individual RRs on all the faces of the platform

Satellite attitude determination from SLR observations has been demonstrated for nanosatellites with the TechnoSat mission [3], as well as object identification/discrimination within a 4-satellite constellation of CubeSats in the S-NET mission [4]. For these purposes, the visible surfaces of the main body of the satellite (solar panels excluded), must mount at least one RR, the signal of which will generate a time-varying pattern in the full-rate SLR data that can be exploited to obtain information about the satellite attitude state.

In this configuration, individual RRs are distributed on every visible face of the platform. The number of RRs on each face must be different, to ensure the generation of an unique pattern in the SLR data. The baseline configuration would be a group of ten individual RRs distributed along the side faces of the platform.

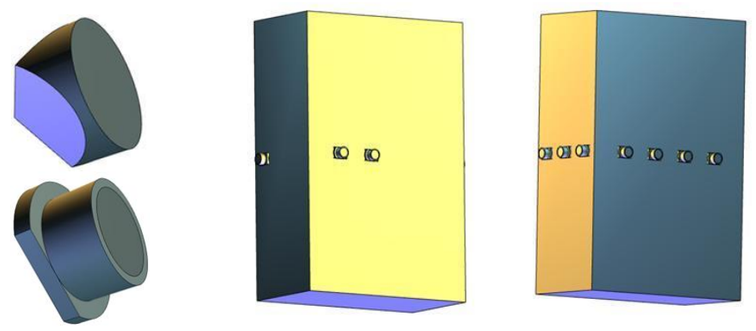

Fig. 2 . Concept 2. Individual RR unassembled/assembled, and their positions on the a 6U CubeSat platform.

An additional concept for Space Debris Tracking is also under study but still at a preliminary phase.

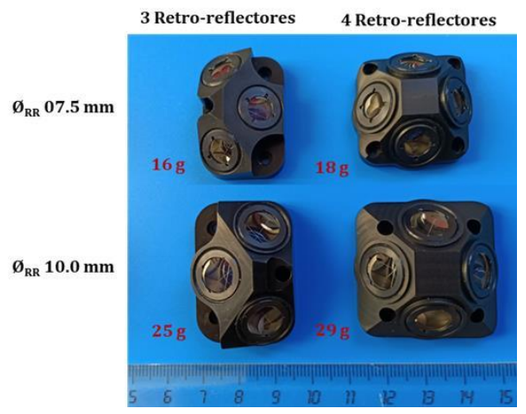

Fig. 3. For Concept 1, representative development models of optical performance, mass, and volume have been manufactured, mainly for optical characterization purposes, but also to increase in-house fabrication and assembly skills. Two RR diameters have been used, 7.5 mm and 10.0 mm.

Conclusions & Future Work

A. Along the Phase 01 of the MARTINLARA Project, several concepts for a LRA for SLR have been preliminary designed.

B. After completing the System Requirements Review (SRR), Phase 02 (4 years) will start. During it, the payloads Qualification Models, which are intended to be flight ones, will be designed, manufactured, assembled and verified.

C. A dedicated optical setup will be consolidated to characterise the LRA optical performance.

[1] Satellite laser ranging to low Earth orbiters: orbit and network validation, Daniel Arnold, 2018
[2] Requirements for CubeSats: the Astrocast CubeSat Mission, Markus Rothacher, 2017
[3] kHz SLR application on the attitude analysis of TechnoSat, P. Wang – 2018
[4] NanoSatellite Mission S-NET, P Wang – 2018