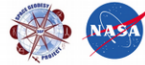


Session 6: Characteristics of Retroreflector Arrays



Conclusions



Thermal-Optical Performance of the GPS III Laser Retroreflector Array

S. M. Merkowitz, J. Crow, J. Esper, E. D. Hoffman, D. Steinfeld, S. Wall
NASA Goddard Space Flight Center

P. Lyons
Sigma Space Corporation

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21st International Workshop on Laser Ranging

November 7, 2018

- ◆ Demonstrated the GPS-LRA meets the ILRS cross section requirement over the range of SLR incidence angles.
- ◆ The cross section remains stable throughout the full range of solar incidence, including past the breakthrough angle.
- ◆ Full thermal-optical performance verification will be performed over the coming weeks, including:
 - Cold Test - soak the array to -18°C
 - Transient Test - sweeping through solar beam at orbital speeds
 - Deliberate Gradient Test - thermal gradients generated across the LRA with heaters

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Characterization of the optical performance of COTS laser retroreflectors for ASI-INFN Joint Projects

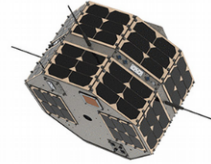
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G. Delle Monache ★, M. Di Paolo Emilio ★ L. Ioppi ★, O. Luongo ★, M. Maiello ★,
M. Muccino ★, F. Pasquali ☐, M. Petrassi ★, L. Porcelli ★, L. Salvatori ★, M. Tantalò ★,
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- ASI-CGS: planning to laser range to new satellites for space geodesy and gravitational physics studies.
- INFN-LNF's SCF_Lab: working on laboratory solar-orbital-thermo-vacuum-optical characterisation ("SCF-Test") of COTS retroreflectors for future missions
 - Results to come starting from early 2019.
- Results will help to optimize retroreflector arrays design and manufacturing reducing the costs
- SCF_Lab is a space R&D infrastructure open to further collaboration.

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kHz SLR Application on the Attitude Analysis of TechnoSat

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Conclusion & Summary

- ❑ **Easier: more sides, higher repetition rate**
- ❑ **Assumptions have been compared to onboard gyroscope**
- ❑ **TechnoSat experiment is convinced that COTS (Commercial-off-the-shelf) CCR bring**
 - Ø10mm CCR is fully sufficient for SLR ranging to LEO --24 stations were able to get returns;
 - Traditional benefits of SLR, -- orbit determination;
 - "Ahead of time" data production, -- attitude determination during/after the life time of satellite;
 - Significantly low cost for space activities -- few tens of dollars;
- ❑ **All SLR data need to be analysed steps more --- higher time/degree resolution**
 - Time when the face changes
 - Time of Max. or Min. pk-pk
 - Value of RMS vs. geometry distance projection

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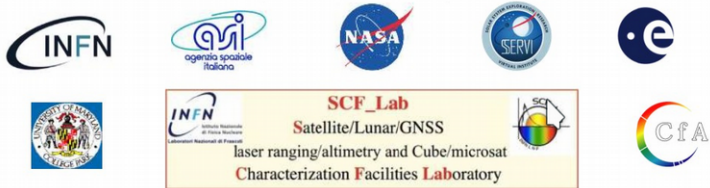
Microreflectors for Mars, Phobos/Deimos and Asteroids/Comets

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Conclusions and Outlooks

Mars space-qualified microreflector such as INRRI, LaRRI and LaRA will lead to:

- Mars Geophysical Networks (MGN)
- Accurate positioning of landing-roving
- Absolute mars-location of the rover site at end-of-life
- Lasercomm test & diagnostics.
- Atmospheric trace species detection by lidar on orbiter
- Lidar-based landing next to Mars 2020 for sample return

Phobos/Deimos microreflector together with INRRI, LaRRI and LaRA will lead to:

- Laser-ranging between Mars's moons and laser-equipped satellites orbiting around Mars
- Enhanced tests of General Relativity at 1.5 AU

On Asteroids/Comets COSPHERA

- will be dropped/landed on NEOs, as in missions like the ESA candidate Hera.
- will supports laser ranging by orbiters, laser altimetry, performing ToF laser ranging (by the μ Lidar on board Hera)

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Session 6: Characteristics of Retroreflector Arrays

21st International Workshop on Laser Ranging
«Laser Ranging for Sustainable Millimeter Geoscience»
Canberra, Australia, November 05 – 09, 2018

Experimental determination of photometric characteristics of the BLITS-M satellite

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JSC «Research and production corporation «Precision systems and instruments»



Summary

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1. The star magnitude at the point of observation, due to the reflection of solar radiation from the hemisphere with an interference mirror coating, does not depend on the phase angle and the rotation of the satellite around its axis. The range of magnitude, depending on the zenith angle, is from 10,5^m to 11,5^m.
2. The star magnitude at the observation point, due to the incidence of solar radiation on the transmissive (uncoated) hemisphere, depends on the phase angle and the rotation angle of the satellite around its axis. The magnitude in this case varies from 10,8^m to 12,6^m at zenith angle $z = 0^\circ$ and from 11,8^m to 13,8^m at $z = 60^\circ$.

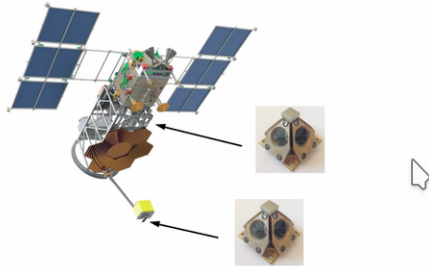
As a result, we expect that there will be no major problems with the detection of the BLITS-M.

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Retroreflector complexes to determinate the coordinates of SC moving parts

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JSC «Research and production corporation «Precision systems and instruments»



Summary

1. The retroreflector complexes of the SC make it possible to determine the coordinates of the movable SC parts and to clarify its orientation, in particular, during an emergency operation.
2. The results of laser ranging of the SC Lomonosov allow us to recommend the installation of the RRS "Pyramid" on the LEO spacecraft as part of retroreflector complex for different tasks. Such non-expensive retroreflector complexes allow to identification of spacecraft, which may be defined as space debris.
3. Three RRSs with different polarization characteristics should be installed on the SC for the clarification and monitoring of spatial orientation. In order to divide the range differences between RRSs, the polarization state of the laser radiation should alternate change from *right* to *left* circular during the laser ranging session.