OPTICAL TECHNOLOGIES FOR SPACE SITUATIONAL AWARENESS

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ABSTRACT

Rapid growth of space industry lead to an increasing number of small satellites and CubeSats deployment. The benefits of increasing satellite coverage lead to the inevitable congestion of orbits potentially taking to catastrophic collisions and resulting in space debris that could pose a threat to other spacecraft, to the International Space Station and to life on Earth. TNO, the Netherlands Organization for Applied Scientific Research, in collaboration with the universities is studying methods and designing optical instrumentation for space situational awareness capable of cooperative and non-cooperative identification of satellites that could be possible operated from ground or in orbit.

Keywords: Satellite Ranging, Swarm Satellite, Cooperative Identification, Spectropolarimetry.

1 INTRODUCTION

Technologies for Space Situational Awareness are urged by recent events of collision of artificial debris with satellites and the greatly increased need of collision avoidance maneuvers. The space environment could greatly benefit from methods and techniques to keep track and identify, from ground and in orbit, the increasing population of Cubesats (and satellites in general) and the constellations made of hundreds of NanoSats more and more frequently deployed.

TNO is currently investigating the design of optical instrumentation which could offer peculiar characteristics like high angular resolution and power efficiency. Optical instruments can be complementary to existing infrastructure, from both the ground perspective (optical communication, laser ranging, astronomy ground stations) and space (imaging payload piggybacking on different missions). The focus on the activities performed is on the identification of satellite, characterization of orbiting bodies and rendez-vous with orbital objects.

2 MAIN SEGMENTS

Current investigated paths could be divided in two main segments: the ground and space segment. For the ground segment the activities cover the cooperative identification of satellites by means of Satellite License Plates (SLP), and the characterization of orbiting bodies by means of spectropolarimetric (SPM) instruments. The activities of TNO on the space segment are currently mainly focused on system design of Light Detection And Ranging (LiDAR) and/or imaging systems for identification of satellites and objects in space-to-space configuration.

3 SATELLITE LICENSE PLATE

The SLP technique [1] is a method complementary to standard satellite laser ranging. In this case the goal is not only to measure the distance of the satellite from the ground station, but also to identify the satellite under observation. The cooperative identification is established upon mounting a specific retroreflecting tag on satellites. The tag is embedded with a unique spectral signature which can be interrogated from ground. From a technology point of view the SLP derives from a conventional satellite laser ranging (SLR) architecture and therefore the two techniques can complement each other, delivering additional information and sharing the ground station infrastructure.

4 SPECTROPOLARIMETRY

SPM techniques [2] are conventionally used in the optical community to retrieve information about material characteristics of the observed scene, by extracting spectral and polarization information from the light collected. The same approach can be used to extract spectral and polarization information from the sun light scattered by an orbiting object. Differently from SLP this technique does not require any active interrogation, and therefore can also be integrated in existing astronomy observatory without major modification in the infrastructure. The current efforts from TNO are directed towards the modelling of the SPM response of satellite, and the design of optical instrument which allows to perform full-Stokes polarimetry to be integrated in an optical ground station.

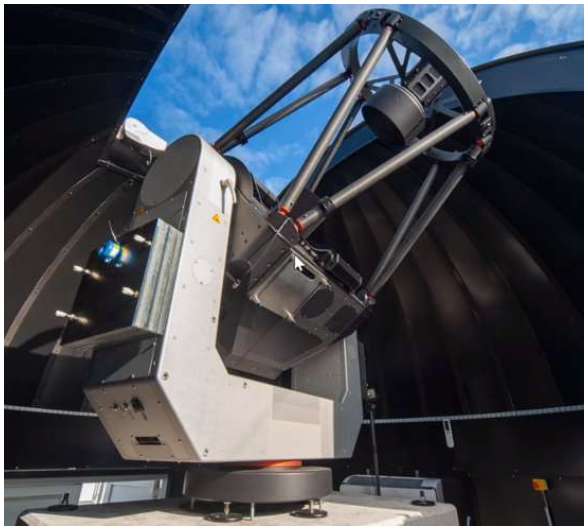

Figure 4-1 At TNO it is planned to use the 0.8 m aperture telescope in The Hague to test the SLP and SPM optical instruments with CubeSats in low earth orbit.

5 LiDAR FOR SATELLITE RENDEZ-VOUS

A system design concept for a LiDAR to be on-board of satellites for space bodies rendez-vous is currently under study at TNO. This LiDAR could be part of a suite of instruments, like cameras, RADARs, embarked on satellite which offer Space Situational Awareness (SSA) services from space. The current LiDAR concept, developed with a commercial partner, OMMATIDIA LIDAR S.L., would be based on Photonic Integrated Circuit (PIC) technology, facilitating the integration and the durability of the sensor.

6 CONCLUSIONS

TNO commitment is to cover an important role in the development of optical instrumentation aimed at the SSA domain. The plan is to develop a ground-to-ground demonstrator for SLP and launch the flying target in 2023, followed by an in-orbit demonstrator for target measurement (in low earth orbit) using the 0.8 m aperture telescope located at the TNO tower in The Hague. The SPM breadboard will be developed in 2023 in collaboration with Dutch universities: activities of characterization of the instrument and laboratory tests to characterize strategic targets will precede the in-orbit demonstrator planned for the late 2023. The breadboard and the ground-to-ground demonstrator development of LiDAR will be a parallel activity aimed at launching a sensor for in-orbit debris detection in 2025.

7 REFERENCES

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