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GROUND-BASED LASER MOMENTUM TRANSFER CONCEPT FOR SPACE DEBRIS COLLISION AVOIDANCE

Abstract

Satellite laser ranging (SLR) is a well-established technology within the scientific community used since the early 1960s to precisely measure distances. The technology evolved in support of the geodetic research striving for high accuracy measurements which nowadays is achieved by means of high repetition, low energy pulse lasers used in combination of satellites equipped with retroreflectors. The achieved accuracy allowed not only for quality improvement of orbit determination products but also remote estimation of the attitude of the observed target.

The SLR technique constitutes a highly accurate, relatively cheap alternative to radars for the tracking of orbiting targets. In the last decade, the successful tracking of resident space objects, not equipped with retroreflectors, made SLR a fundamental and appealing technique also in the space debris domain.

In this study, we will introduce a step forward - thanks to the availability of commercial high power (> 10 kW) continuous wave (CW) lasers - which consists in the setup of a network of ground stations able to efficiently contribute to space debris collision avoidance manoeuvres in the low Earth orbit (LEO).

This paper will summarize the achievements of a conceptual study on ground-based laser momentum transfer to LEO space debris performed by a consortium under the guidance of the German Aerospace Center (DLR) funded by the European Space Agency (ESA) in the frame of the ESA Space Safety Programme.

The study was carried out approaching the problem from an astrodynamical, physical, technological and legal point of view. The required tracking precision and the fundamental physics of the laser momentum transfer (LMT) were studied to evaluate the achievable thrust on LEO debris objects with commercially available components. An astrodynamical analysis was carried out to assess the efficiency of the imposed thrust and the consequences on the probability of collision in LEO. In the paper we will report the outcomes of the study which allowed us to define: the requirements of a laser tracking and momentum transfer (LTMT) station, the minimum size of an LTMT network for LEO collision avoidance operation, the current technological challenges, and gaps to be filled before its implementation.