Institute of
Technical Physics

Active-optical debris detection: A means for highly accurate position determination of space debris orbits

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Introduction

A first step in the mitigation of collisional risk of space debris to space assets is the precise determination of their orbits in case of an upcoming possible collision. At the Institute of Technical Physics, technologies are developed which combine laser ranging and passive optical tracking.

The goal is to achieve precise orbital data of space debris with a resolution of 10 m and less in 3 dimensions.

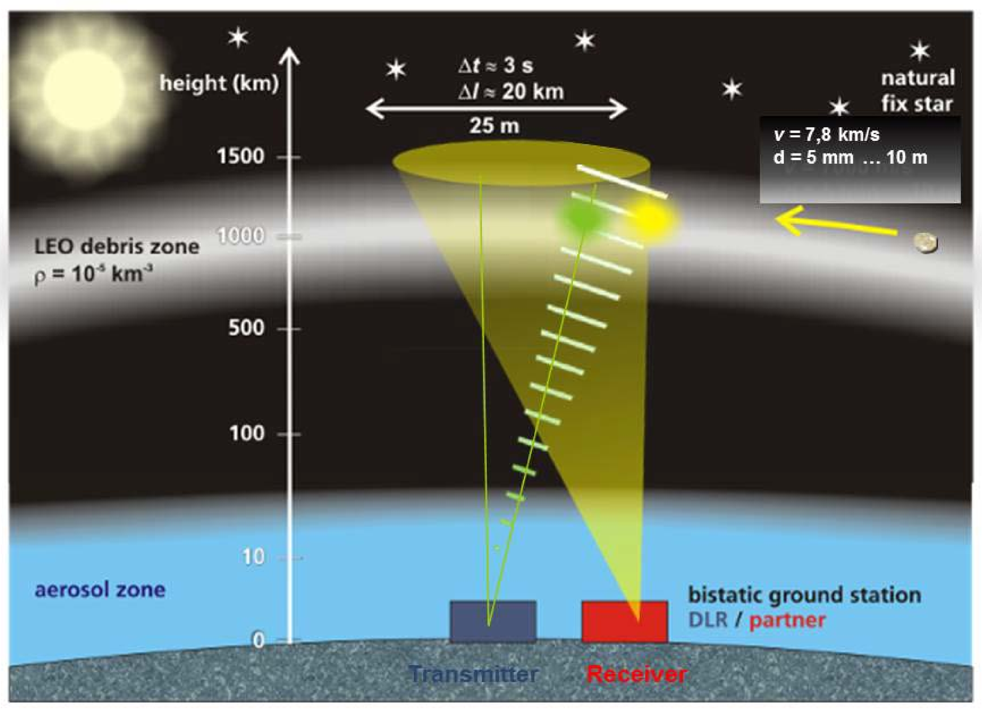

Fig. 1 General detection concept.

The general concept is depicted in Fig.1 where the space debris object is recognized by passive-optical means using solar illumination and afterwards illuminated by an intense highly repetitive Time-of-Flight illumination laser. Backscattered photons are detected with single photon detectors mounted in the receiver telescope.
A typical ranging chart is displayed in the Fig. 2.

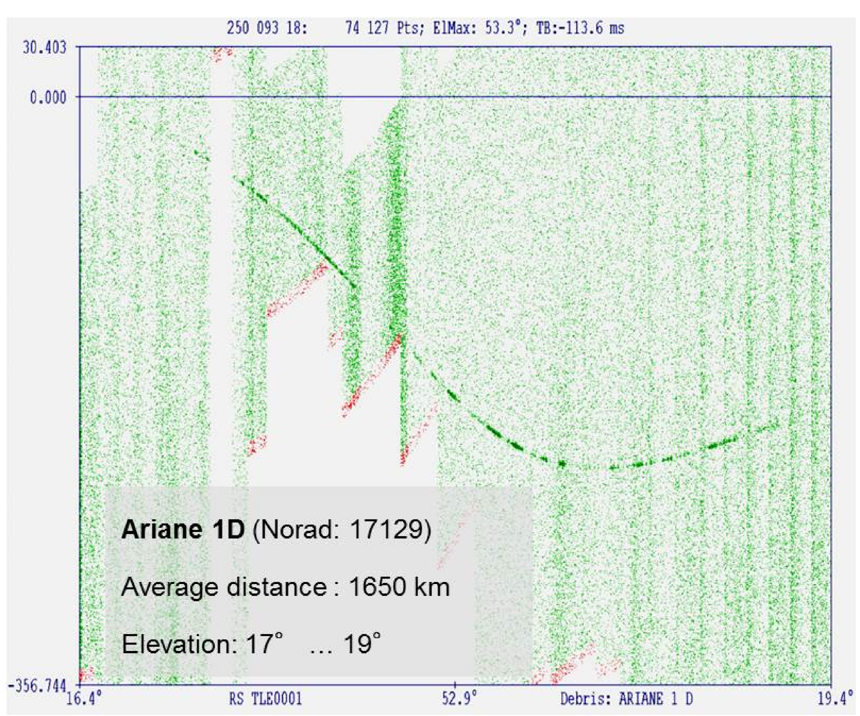

Fig. 2 Ranging chart from Ariane R/B (from G. Kirchner, Graz).

Successful demonstration of laser ranging on space debris was performed in campaigns at the SLR station Graz-Lustbühel with ns pulsed lasers operating at 532 nm. In ~ 80 debris passes, space debris objects of size on the order of 1 m were consistently monitored over distances of up to 2500 km. Typical is a variable return rate and a ranging accuracy of ~ 3 m rms. A variation from the TLE based object positions of 5 km along track and 1 km cross track was measured.

Orbital debris research observatory

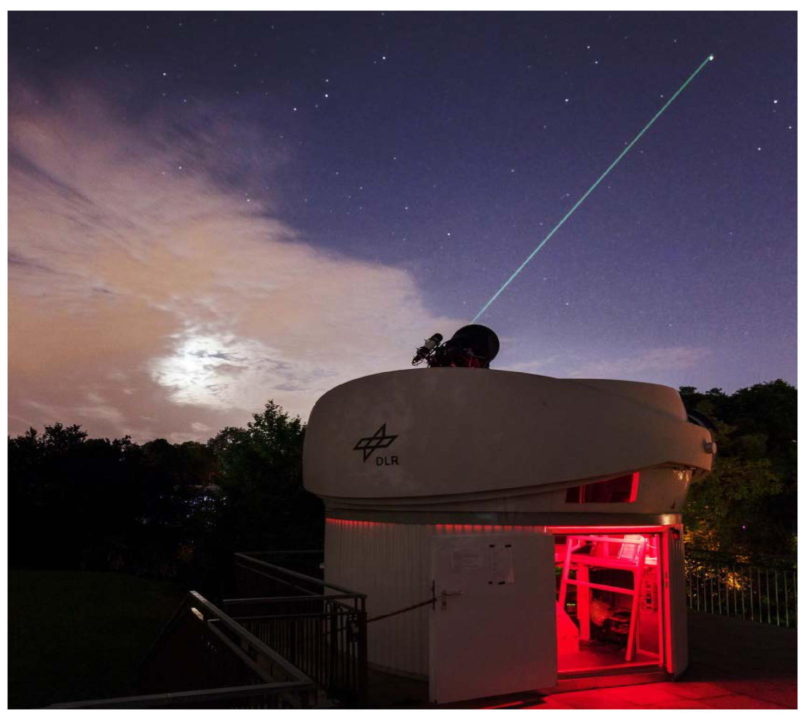

Fig. 3 DLR space debris observatory.

DLR is operating a dedicated remote controlled obital debris research observatory equipped with a 17" reflector telescope (PlaneWave CDK 17) and a highly accurate telescope mount (Astelco NTM-500). Accurate tracking of LEO objects in leap frog and continuous tracking mode are possible. The smallest visible objects are cube sats of 10 cm dimensions being observed in tracking mode. The tracking accuracy in closed-loop mode is ~ 2 arcsecs, corresponding to 10 m at a distance of 1000 km.

In Fig. 4 is shown a frame taken from a cube sat using an sCMOS camera (ANDOR Zyla) with an exposure time of 2 secs in continuous tracking mode.

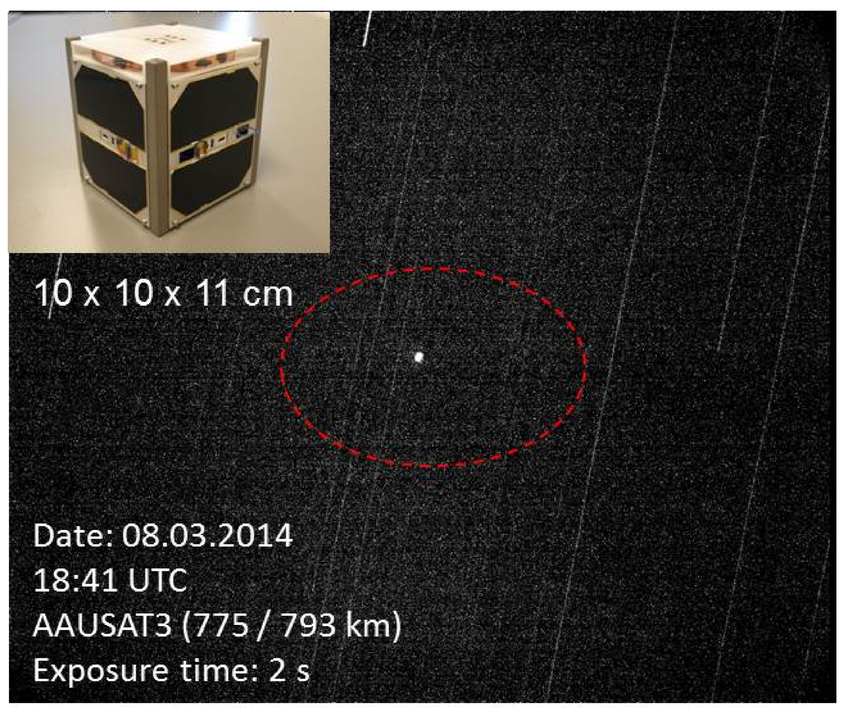

Fig. 4 Image of Cube Sat AAUSAT3. Fixed stars appear as tracks in the image.

The accurate continuous tracking is the prerequisite for implementing the laser technology into the current system. A small 0.3 mJ / 1 kHz Nd:YAG laser system is available for piggyback mounting and laser ranging tests on cooperative LEO objects. Permission for operation of the laser in aerospace region is available and a concept for aerospace security is being developed.

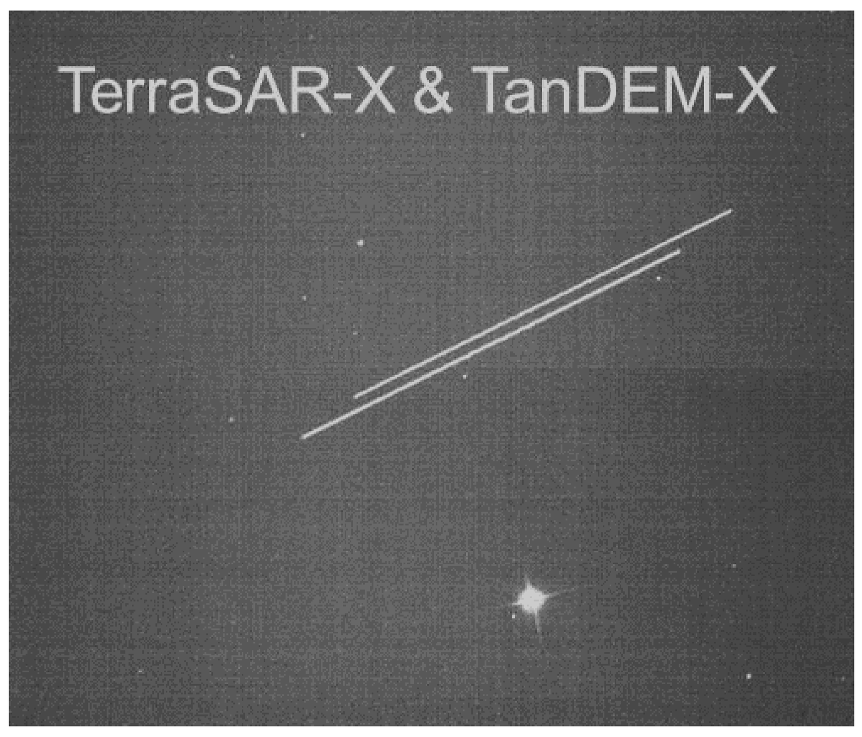

Fig. 5 TerraSAR-X TanDEM-X passage over Stuttgart monitored in leap frog mode.

Conclusion and outlook

Future development will concentrate on the positional determination of space debris objects by laser monitoring and analysis of the orbit accuracy based on theses measurements.

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