Active optical debris detection:

Highly accurate position determination of space debris orbits

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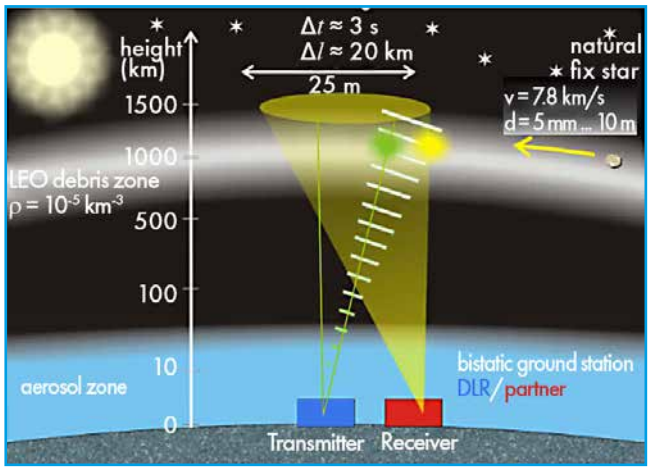
Application Note

A first step to minimizing the risk of space debris colliding with space assets is the precise determination of the position of their orbits. 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 or less in 3 dimensions, which can be used for accurate orbit determination.



The general concept is depicted in Fig. 1. Space debris objects are first recognized by passive optical means using solar illumination. Afterwards, they are illuminated by an intense, highly repetitive, ns-pulsed, 532 nm time-of-flight (TOF) illumination laser.

Backscattered photons are detected with single photon detectors mounted in the receiver telescope. In about 80 passes, space debris objects of approx. 1 m in size were consistently monitored over distances of up to 2500 km at the Satellite Laser Ranging Station in Graz, Austria. Normally, the return rate is variable and the typical ranging accuracy is about 3 m rms. In this case, a variation from the two-line-element (TLE)-based object positions of 5 km along track and 1 km cross track was measured.

DLR operates a dedicated, remotely controlled orbital debris research observatory equipped with a 17" reflector telescope (PlaneWave CDK 17) and a highly accurate telescope mount (Astelco NTM-500).

This allows accurate tracking of low-earth orbit (LEO) objects in leap frog and continuous mode. The smallest visible objects to be observed in tracking mode are cube satellites of 10 cm in dimension. Tracking accuracy in closed-loop mode is approx. 2 arcsecs, which corresponds to 10 meters at a distance of 1000 km.

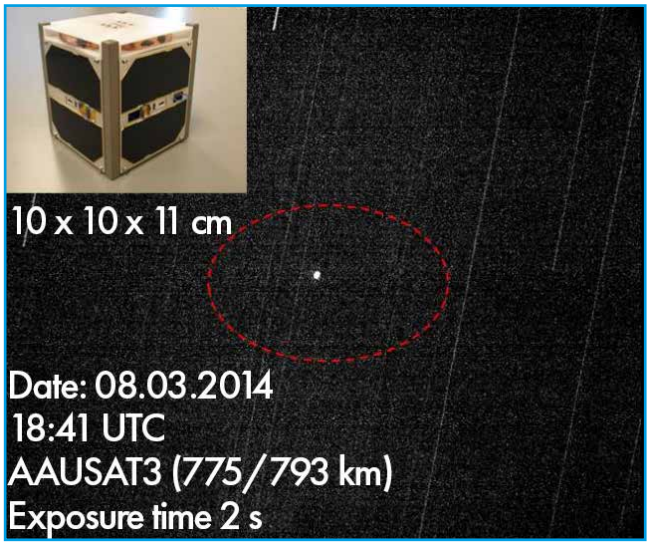


Fig. 2 shows a frame taken from a cube sat using an sCMOS camera (Zyla-5.5-CL10 from Andor Technology) with an exposure time of 2 secs in continuous tracking mode.

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

Sources

"DLR/FrankEppler" www.dlr.de/dlr/desktopdefault.aspx/tabid-10176/372_read-8026/#/gallery/12159
http://elib.dlr.de/94157/1/Riede%20DLR_1.pdf

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