Space Debris Orbit Predictions using Bi-Static Laser Observations. Case Study: ENVISAT. H. Wirnsberger[1], O. Baur[1] and G. Kirchner[2], [1]Space Research Institute, Austrian Academy of Sciences, Schmiedlstrasse 6, 8042 Graz, Austria, (harald.wirnsberger@oeaw.ac.at, oliver.baur@oeaw.ac.at). [2]Space Research Institute, Austrian Academy of Sciences, Lustbuehelstrasse 46, 8042 Graz, Austria (georg.kirchner@oeaw.ac.at).

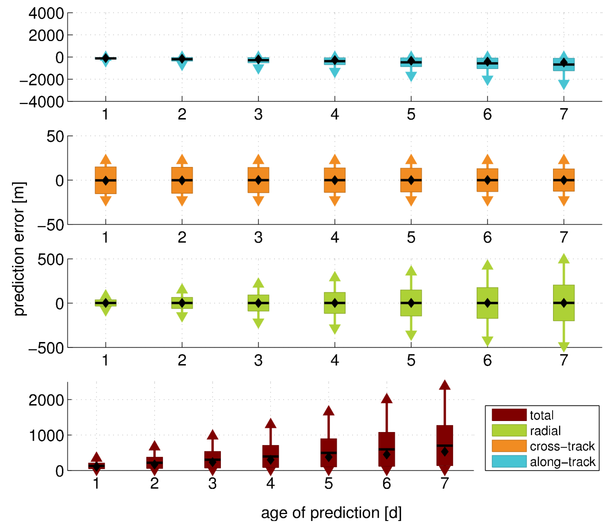
Introduction: Space debris objects in the Low Earth Orbit segment pose an increasing threat to all spacefaring nations. For collision avoidance measures or the removal of space debris, the quality of orbit predictions is one of the most relevant issues. Laser ranging opens the door to significantly improve the reliability and accuracy of space debris orbit predictions. The benefit of "conventional" two-way laser ranges for this purpose has recently been demonstrated, e.g., [1] and [3]. For the first time, in this contribution we focus on bi-static laser observations - a new observation type for orbit determination and prediction. Conceptionally, bi- or multi-static observations refer to the tracking of objects from an active SLR-station and the detection of diffusely reflected photons at one or more passive stations. In order to demonstrate the concept, in 2013 the SLR-station Wettzell detected photons emitted from the SLR-station Graz, diffusely reflected from debris objects.

Our investigations deal with orbit predictions of the defunct ENVISAT satellite, since it was possible to track 4 passes during the experimental bi-static measurement sessions. We found that the incorporation of bi-static laser observations can improve the prediction accuracy, against the background of sparse tracking data. As indicated by Figure 1, the improvements are about one order of magnitude compared to the results using "conventional" two-way laser ranges only. The results are based on laser tracking data during an observation period of 3 days from only one active SLR-station reflecting realistic space debris tracking scenarios. At a prediction age of three days, the total errors are at the level of 1000 m for two-way laser ranges only (Figure 1a), and 150 m for two-way laser ranges and additional bi-static observations (Figure 1b).

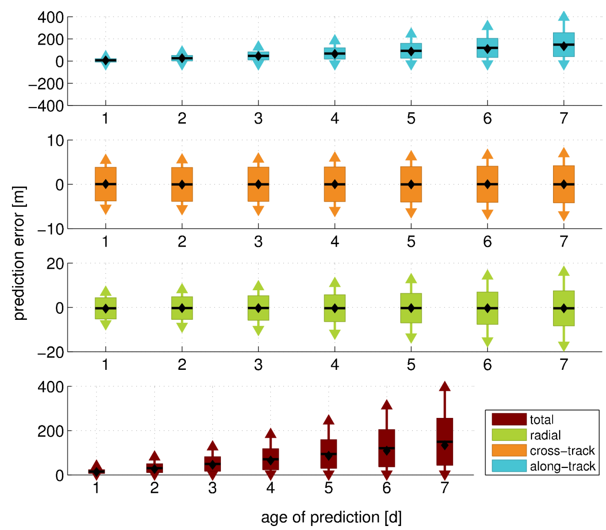
The number of laser observations to debris objects is very limited, caused by advanced tracking requirements (see [2], [4]). The concept of bi-static observations can improve this situation by the extension of the existing SLR-station network with a few receive-only units in the vicinity of transmitting stations. Thence the quality of space debris orbit predictions can be increased.

References:

[1] J. C. Bennett et al. (2013) ASR, 52, 1876-1887.
[2] G. Kirchner et al. (2013) ASR, 51, 21-24.
[3] J. Sang and J. C. Bennett (2014) ASR, 54, 119-124.
[4] Z.-P. Zhang et al. (2012) RAA, 12, 212- 218.



(a) two-way laser ranges Graz



(b) two-way laser ranges Graz + bi-static

Figure 1: Orbit prediction errors for ENVISAT with respect to an a posteriori determined reference orbit derived from two way laser ranges (acquired by 12 SLR-stations altogether). Box: two-sided standard deviation; black line: mean; black diamond: median; arrows: minimum and maximum values. Different scales apply.

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