Space Debris

The increasing amount of space debris in orbit around Earth poses a great threat to active satellites. With a velocity of approximately 7 km/s, even collisions with tiny particles with a few millimetres of diameter can lead to severe damage on space objects. In addition, larger satellites or rocket bodies that do not burn up completely during re-entry can impact on Earth's surface. Any approach in counteracting the large amount of space debris requires a profound knowledge of the orbit and the behaviour during re-entry. Enhancing radar tracking, satellite laser ranging (SLR) is an excellent method to improve orbit predictions up to the order of a few meters. The SLR station Graz with its worldwide-recognised unique competence is currently working on various topics concerning space debris science.

Bi- and multi-static space debris laser ranging: "Bi-static" or "multi-static" measurements are conducted in Graz since 2013 together with different SLR stations across Europe: One or more stations send laser pulses towards space debris, using lasers at different wavelengths. The diffuse reflection – no retro-reflectors are required – is spread across Europe and can be detected by other SLR stations using single-photon avalanche detectors. Such joint measurements improve the orbit prediction accuracy drastically.

Stare & Chase: Within "Stare and Chase" experiments optical observations of space debris targets are used to determine pointing directions while analysing the stellar background. Only from these measurements and without other a-priori orbital knowledge, orbit predictions are calculated and immediately used to track and range to these targets within the same pass.

Spin period and attitude determination of satellites and space debris: From kHz SLR data, detailed information on the spin period and spin attitude of rotating satellites and space debris can be gained. In addition to – and independent from SLR measurements –sunlight reflected from space debris has been utilised since 2015 to acquire light curves with single-photon detectors. A light curve represents the intensity of reflected sunlight during a full spin period of a satellite.

Daylight space debris laser ranging: Recently, the first successful daylight space debris laser ranging has been achieved. The reflected sunlight of rocket bodies is visualized against the blue daylight sky to correct inaccurate orbit predictions in real-time. Orbit predictions of space debris objects based on Two Line Elements (TLE) are usually only accurate to within a few kilometres. Before the actual SLR search routine can be started space debris objects have to be centred within the field of view of the SLR station. The object has to be optically detected with an additional telescope using a larger field of view. First daylight space debris laser ranging results pave the way to significantly increasing the potential observation times improving the predictions in case of conjunctions or future removal missions.

In the context of these activities, we would like to stress Austria's commitment and active support to implementing the *Guidelines for the Long-term Sustainability of Outer Space Activities*, in this case in particular *Guideline B.3 "Promote the collection, sharing and dissemination of space debris monitoring information"* as part of the Guidelines addressing *Safety of Space Operations.*

Finally, we would like to inform you that *Mr. Michael Steindorfer* from the *Space Research Institute of the Austrian Academy of Sciences* will deliver a technical presentation on 12 February during the afternoon session with more details on these activities in Austria.