SLR link budget and retroreflector optical cross section evaluation

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The network of satellite laser ranging stations is expanding every year, which is partly driven by new applications such as space traffic management as well as new companies that commercialize the technology.

For the design of new ground segments, it is important to find the balance between an optimization of the link budget, e.g., through the utilization of high-power lasers, large telescopes, etc., and the mass, the volume, and the overall costs of such systems. A key uncertainty in the estimation of the link budget is the optical cross section of the satellites that are equipped with retroreflectors.

The objective of this study is the derivation of the practical “in-orbit” optical cross section from Satellite Laser Ranging (SLR) measurements with a given link budget model. In addition, theoretical values are determined from a state-of-the-art analytical approach that was proposed by Degnan. The results of both methods are compared with literature values, which were computed via diffraction theory.

The analysis is accomplished using the historical normal point data that was published by the EUROLAS Data Center (EDC) and the data that was obtained from our system, namely the miniSLR®. The data comprises a selection of satellites in various orbit altitudes and single 25 photon operating ground segments. The optical cross sections are derived from the link budget equation under consideration of atmospheric-, system specific-, and free space losses.

The findings show that the theoretical values reflect the literature values for single retroreflectors or arrays. However, larger deviations are found for spherical satellites. The derived practical optical cross sections are in the range of two orders of magnitude to the theoretical values. Additionally, a relative constant bias between the individual stations is found. This indicates that these stations over- or underestimate their available system specifications.