Local orbit uncertainty reduction in follow-up passes based on single-pass debris laser ranging

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Laser ranging is a promising concept to complement future activities in space surveillance and tracking, e.g. by contributing to orbit determination of space debris. Commonly, Two-Line Elements (TLEs) are used to predict angles and ranges for operational tracking. Due to their inherently large uncertainties, the targets must be acquired visually, e.g. by using a finder telescope. Therefore, appropriate illumination conditions are required and blind tracking is impossible. However, as estimating space debris orbits and their associated uncertainties is typically a data-sparse problem, effort should be made to maximize the data yield. In this regard, we show how orbit prediction uncertainty of TLEs can be reduced using single-pass observations to facilitate faster object acquisition or even blind tracking in follow-up passes. We build on a previously developed framework of statistically consistent data fusion of TLE and laser ranging data, which additionally employs a-priori information on object-specific properties and a realistic process noise model. Based on that, we present conditions and requirements for blind tracking - amongst others on pass geometry, temporal spacing of first and follow-up pass, tracking accuracy and the additional use of angular observations. Eventually, we validate our findings using real laser ranging data.