SIMULATED COMPARATIVE ANALYSIS OF ONE- AND TWO-WAY PLANETARY LASER RANGING SYSTEMS

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Introduction: Laser ranging is an emerging technology for tracking interplanetary missions [1], offering improved range accuracy precision at the mm-cm level, a substantial improvement over existing DSN systems. In a one-way system, such as that currently being used on the LRO spacecraft [2], only an active detector is required on the spacecraft. For a two-way system, such as that tested by using the laser altimeter system on the MESSENGER spacecraft en route to Mercury [3], a laser transmitter system is additionally placed on the space segment, which will asynchronously fire laser pulses towards the ground stations.

System comparison: Both one- and two-way laser ranging systems have the potential to provide increased science return for planetary missions. Although the one-way system requires less hardware, clock errors on both the space and ground segments will accumulate over time, degrading the quality of the range measurements. For the two-way system, which requires a more extensive hardware package on the space segment, the range measurements are only sensitive to clock errors integrated over the two-way light time.

Simulation approach: We investigate the performance of both one- and two-way laser ranging systems by simulating their operation. We generate realizations of clock error time histories from Allan variance profiles, and use them to create range measurement error profiles. We subsequently perform the orbit determination process from this data to quantify the system's performance. For our simulations, we use two test cases: a lunar orbiter similar to LRO and a Phobos lander similar to the Phobos Laser Ranging concept [4]. We include the estimation of clock parameters over a number of arc lengths for our simulations of the one-way range system and use a variety of state arc durations for the lunar orbiter simulations. We perform Monte Carlo simulations and generate true error distributions for both missions for various combinations of clock and state arc length. Thereby, we study the optimal data analysis strategies for such missions and quantify the relative capabilities of the one- and two-way laser range systems.

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References:

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