

INFLUENCE OF ATMOSPHERIC TURBULENCE ON PLANETARY TRANSCEIVER LASER RANGING.

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Introduction: We investigate the influence of atmospheric turbulence on the performance of the uplink of a planetary transceiver laser ranging system using a single photon detector. We numerically combine the influence of turbulence in the mean intensity profile variations, scintillation, beam-wander induced pointing errors [1],[2] and stochastic time-of-flight variations [3]. Thereby, we map the intensity variations due to turbulence to variations in the probability distribution of the arrival time of the 1st photon in a laser pulse, which influences the range measurement error probability distribution..The turbulence models are applied to assess the influence on single-pass range accuracy and precision statistics, as well as the parameter estimation quality of a Phobos Laser Ranging (PLR) mission [4].

Range measurement errors: The difference in range measurement error between weak and strong turbulence is 3-4 mm in a PLR concept. This indicates that turbulence is a potentially important contributor to the error budget of interplanetary laser ranging missions, which aim at mm-level accuracy and precision. The single-shot precision is generally weakly influenced by turbulence, but strong turbulence is found to cause a strong decrease in detected pulse fraction, reducing normal point precision. We show that a trade-off between range accuracy and precision must be made when selecting laser system parameters, which is influenced by atmospheric turbulence effects. By consistently operating at the single-photon signal strength level, accuracy variations can be largely removed, at the expense of normal point precision, due to the reduced detection probability.

Parameter estimation influence We perform parameter estimations of Phobos initial state and observation biases using simulated measurements with and without turbulence, using a daily periodic turbulence strength model. We show that the parameter estimation quality is degraded significantly below that of the turbulence-free case only in the presence of strong turbulence.

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References:

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