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Performance and Robustness against Jitter for Acquiring Optical Links in Space

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About the Study

Optical connections for inter-satellite communication at Low-Earth-Orbit (LEO) have been established between the NFIRE and TerraSAR-X satellites since 2007, achieving data rates in excess of 5 Gbit/s over distances of up to 6000 km. European Data Relay System EDRS deploys improved terminals with respect to those used in LEO to establish links between geostationary satellites using improved terminals compared to those used in LEO, more than 1000 established optical links per month Use to provide periodic data relay services to Sentinel 1 and 2 satellites. Future extensions of EDRS will add bridge distances of up to 80,000 km between quiescent nodes.

In addition to its application to communications, optical links are also used for accurate cosmic interference measurements to map the Earth's gravitational field. For example, the GRACEFO mission, which establishes an optical link between two spacecraft (SCs) at a distance of approximately 200 km. These connections allow small changes in inter-SC distances on the order of nanometers to be measured and provide information on the variations in the Earth's gravitational field. In the original plan for this mission, optical links were intended as an experimental demonstration, in addition to microwave links based on proven technology. Due to the excellent performance of optical links, they may serve as a base for use in future missions of this type.

Each transceiver transmits an optical beam to the expected position of the other transceiver, and if the beam is received at the inlet opening in a particular field of view (fov), each transceiver detects the transmitted beam. Generally, when the transceiver is aligned to point to the expected position of the remote transceiver, the transmitted beam misses the remote transceiver due to an overall pointing error. The latter generally includes the causes of all errors, including transceiver platform (spacecraft) attitude errors, transceiver pointing errors to the platform, and errors in locating remote transceivers.

In general, the angular width of the transmit beam covers only a small part of the range of uncertainty in which the remote transceiver is likely to be located. A remote transceiver can detect beams transmitted by other transceivers only if the following two conditions are met: (1) the remote transceiver "hits" with the transmitted beam. H. It is within the angle footprint of the transmitted beam. (2) The angle of incidence of the received beam is within the field of view (FoV) of the remote transceiver.

A total of four different methods were presented and their performance was compared. This shows that all analytical predictions are in very good agreement with the results of the Monte Carlo simulation. We also investigated the effect of scan beam jitter on the probability of not finding a link, based on a derived analytical model that predicts error rates for specific track widths, detection radius, and jitter magnitude.

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