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TRANSMISSION OF GROUND-TO-SPACE NARROW BEAM FOR SMALL SATELLITE OPTICAL COMMUNICATION THROUGH GPS-BASED PRECISE ORBITAL DETERMINATION

Abstract

The increasing demand for high throughput satellite-to-ground data transmission has recently boosted the development of innovative satellite communication technologies, among which optical communications is likely the most promising one. Due to the extremely narrow beams used in optical communications, an optical transmitter typically requires a precise pointing reference, which usually consists in a beacon beam transmitted by the receiver. In a LEO-to-ground scenario, the relatively small aperture available onboard small satellites requires that narrow beacon beams from the ground station must be uplinked in order to keep the transmitted power within reasonable values. This translates into very challenging orbital prediction requirements, since ground station beacon pointing is based on the a-priori knowledge of the spacecraft position (at least during the link acquisition phase). Moreover, extremely precise optical alignment is required to guarantee that the transmitted beam is pointing in the correct direction. Orbital predictions are typically based on publicly available TLE data, which nevertheless guarantee a position prediction accuracy which might not be adequate for the purpose of very narrow (¡0.5 mrad) beam pointing. In this context, the use of orbital prediction algorithms based on GPS data could enable more precise pointing of the beacon beam towards the satellite. In this paper, the application of orbital prediction based on Kalman-filtering of GPS data acquired onboard the transmitting spacecraft few hours before a pass over the ground station is presented. Expected performance in terms of orbital determination accuracy and pointing error are presented and compared with performance allowed by TLE data. The application of the described approach in support of the design of the uplink beacon transmission section of the Matera Laser Ranging Observatory telescope for the demonstration of optical downlink from small LEO satellites is also presented.