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Author: Dr. Dirk Giggenbach
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany, Dirk.giggenbach@dlr.de

TRANSMITTER BIAS VERIFICATION FOR OPTICAL SATELLITE DOWNLINKS WITH OPEN-LOOP BODY POINTING

Abstract

Optical communication is becoming the solution for extremely high-rate communications with space-assets located in Deep-Space, near-Earth and low Earth orbits (LEOs). For data downlinks from LEO, several Gigabits per second are being achieved experimentally and soon operationally. According communication terminals rely on tracking of an optical ground-beacon with a dedicated agile opto-mechanical pointing system (Coarse Pointing Assembly, CPA). This allows the satellite-transmitter to very precisely and dynamically adjust the signal orientation during the overflight over an optical ground station (OGS), keeping the laser beam aligned to the ground by this CPA. A much less complex approach, however, avoids the elaborate ground-beacon tracking by the satellite terminal, and provides the ground-orientation only based on its attitude knowledge from star-sensor data – the so called “open-loop pointing”. This can be combined with a body-pointing of the satellite during OGS-overflight, thereby avoiding both the CPA and the Beacon-tracking. According attitude data must be delivered rather fast and body-pointing must be achieved with high precision, since the pointing dynamic in typical LEO downlinks can reach more than 1-per-second in zenith. The precision to be achieved must fit to the signal’s divergence and thus shall be in the order of 100 rad. Interconnected control loops between predefined pointing trajectories, the star sensor data, and the laser’s direction versus the satellite body guarantee the according OGS illumination. Viability of this approach has already been shown in different missions. Depending on the mounting concept and the rigidness of the satellite structure, the initial error offset of the laser beam can have values much higher than the signal divergence. Thus, before such links can be employed on a reliable and operational basis, the orientation-bias of the laser transmitter direction versus a reference axis of the star sensor must be identified and ground-pointing must be calibrated accordingly. Estimation of this bias can become a long-term and high-effort exercise. Here, we detail the concept of open-loop body-pointing by small satellites to ground receiver stations, we describe the signal propagation through the atmospheric channel and its reception on ground, and demonstrate an automated device (“Satellite-Flash-Finder”) to calibrate the satellite’s laser terminal and the ground station towards each other.