IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Advances in Space-based Communication Systems and Services, Part 2 (3)

Author: Dr. Marcus Knopp
German Aerospace Center (DLR), Germany, marcus.knopp@dlr.de

Dr. Dirk Giggenbach
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany, Dirk.giggenbach@dlr.de
Mr. Andreas Immerz
German Aerospace Center (DLR), Germany, andreas.immerz@dlr.de
Dr. Alexander Koehler
German Aerospace Center (DLR), Germany, alexander.koehler@dlr.de

THE SMALL OPTICAL GROUND STATIONS FOCAL-OPTICS ASSEMBLY (SOFA)

Abstract

Due to an ever-increasing demand for bandwidth and capacity, the microwave spectrum has become a highly limited resource in satellite communications. Therefore, free-space optical communication is being deployed in operational space systems like the European Data Relay Satellite system. Besides, laser-based space-to-ground connections will complement radio downlinks in upcoming Earth observation and science missions allowing for data rates in the 10 to 100 Gigabits per second range. To make the latter a success, a large number of Earth-based receiving stations, so-called Optical Ground Stations (OGS), will be needed, as the mitigation of cloud coverage requires the implementation of a site diversity scheme. On this backdrop, we have developed a fully-integrated, low-cost instrument as a supplement to standard telescope optics, transforming astronomic observatories as well as commercial off-the-shelf (COTS) portable telescopes into optical ground stations – the Small OGS Focal-optics Assembly (SOFA). In the SOFA, pointing, acquisition and tracking functionality is implemented by low-resolution machine vision allowing for arcsecond-level accuracy in combination with COTS telescope mounts. Free-space detection of the laser downlink signal is realized with both a large area Positive Intrinsic Negative (PIN) diode for power assessment and a small area Avalanche Photodiode (APD) for data reception. All sensors make use of the telescope optics' primary beam path obviating the need for elaborate co-alignment systems, hence, mitigating the associated boresight offsets. The SOFA concept is based on a modular design allowing for expansion with further components like laser beacons or different detector variants. Here, we present the opto-mechanic SOFA arrangement and its prototypic implementation by additive manufacturing at an amateur-grade astronomic telescope. Moreover, we demonstrate its functioning for the reception of optical downlinks from low Earth orbiting (LEO) spacecraft providing power vectors and tracking accuracies from laser downlink campaigns with the Flying Laptop satellite and the PIXL-1 mission, both carrying laser communication terminals of the DLR Institute of Communications and Navigation.