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Author: Mr. Andrea Vettor
Italy

Dr. Francesco Sansone
Italy
Prof. Alessandro Francesconi
University of Padova - DII/CISAS, Italy

EXPERIMENTAL SIMULATION OF OPTICAL LINK ACQUISITION BETWEEN A SMALL SATELLITE AND A GROUND STATION

Abstract

Free Space Optical Communication (FSOC) is a fast-developing technology that could represent a key factor in the improvement of space-to-ground connectivity. Thanks to the extremely narrow beamwidth obtainable in the optical wavelength range, FSOC allows to transmit data rates up to two orders of magnitude higher than RF at the same mass and transmitted power. Narrow beamwidths also eliminate the need for bandwidth regulation and are intrinsically immune to interception and jamming. Moreover, optical wavelengths are suitable for the application of quantum communication protocols for enhanced security. The large-scale implementation of space-to-ground optical communication would meet the remarkable increase in data rate demand from space to ground envisaged in the next few years, addressing applications that require the reliable transmission of large volumes of data to the ground at affordable costs. These include secure data relay services (potentially leveraging quantum technologies, e.g. Quantum Key Distribution), and applications based on collection and analysis of earth observation data. On the other hand, FSOC imposes very strict requirements on beam Pointing Acquisition and Tracking (PAT) capabilities, both on the space and ground segments. Few in orbit demonstrations have been carried out showing the feasibility of this technology on relatively large satellites; its application to small satellites is even more challenging due to their limited resources and capabilities. In this paper we describe the PATHOS (Pointing Acquisition and Tracking Hemispherical Optical System) experiment, which is conceived to simulate the PAT behaviour of an optical ground station during the operations of data downlink from a small satellite, based on the reciprocal pointing and tracking of the terminals by means of orbital predictions and laser beacons. Its main objective is to support the design of an optical ground segment for space-to-ground optical telecommunication and the development of optimal acquisition strategies. In this setup the ground segment is simulated by a gimbaled optical assembly with a dedicated beacon detection and actuation system, while the flight segment is represented by the Engineering Model of LaserCube, a lasercom terminal for small satellites at a late stage of development, whose in-orbit validation is expected in Q1 2021. This will allow to test the complete PAT operations on both sides of the optical communication system. Experimental results are compared with numerical simulations.