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TOWARDS THE UTILIZATION OF OPTICAL GROUND-TO-SPACE LINKS FOR LOW EARTH ORBITING SPACECRAFT

Abstract

Microwave spectrum has become a highly limited resource in satellite communications owing to an ever increasing demand for bandwidth and capacity. Therefore, a shift to the exploitation of optical carrier frequencies is currently underway. Focusing on high-rate transmissions of payload-data from remote sensing satellites, operational systems, like the well-known European Data Relay Satellite system, are based on optical inter-satellite links. Besides, direct-to-earth free-space optical communication from low-earth orbiting spacecraft holds high potential for upcoming space missions through considerably lower complexity. In that regard, we study the viability of the ground-to-space beacon laser signal of optical ground stations to be additionally modulated with telecommand tokens. Such an optical return channel could be variously put into use, e.g. to trigger automatic-repeat-requests of payload-data downlinks, for jamming-free control of the spacecraft or for high-rate software uploads to its on-board processor. Also, ranging measurements could be performed at high accuracy by optical means. A particular challenge is posed by the unequal fading behavior of the optical channel regarding the down- and uplinks, which cover asymmetric optical pathways through the atmosphere. We define the end-to-end architecture of the communication chain including both, the uplink station and the space-based receiver. Special attention is given to compatibility with established space data and system standards. Moreover, we examine the effects on the scheduling of satellite control, resulting from a constrained availability of the optical uplink due to cloud blockages. Our analysis aims at the employment of available space protocols for bidirectional asymmetric optical communications with low earth orbiting spacecraft. Further on, we consider modifications of the current standards to account for the optical fading channel. Certain applications, like immediate automatic-repeat-requests for the downlink or optical ranging, will require novel, optimized protocols.