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SPACE COMMUNICATIONS PROTOCOLS FOR FUTURE OPTICAL SATELLITE-DOWNLINKS

Abstract

As telemetry downlink data rates from EO-satellites increase and available RF transmission spectrum narrows, optical data downlinks based on modulated laser sources become a beneficial alternative. While solving the bottleneck of data rate by providing licensing-free transmission at up to multi-Gigabit per second data rates, the required onboard terminal hardware is at the same time small and uses low transmit power. However, the transmission channel is very different to what we are used to from RF downlinks as new physical effects have to be regarded.

To enable also with optical downlinks the level of global cooperation prevailing in RF downlink operations, it is necessary to elaborate and standardize optimized transmission formats in terms of synchronization, channel coding, packet-layer coding, and ARQ.

While the physical layer is given by the chosen optical communications technology (IM/DD, PPM, coherent), the higher protocol layers can be optimized to the specific channel. Further to be taken into account is the availability of a return channel and the capability of scheduled on-board storage for data fragments that could not be transmitted reliably during one OGS-contact.

New challenges have to be tackled in comparison to existing RF downlinks:

• Atmospheric attenuation of laser signals increases at low elevations, causing a higher overall link dynamic

• Link-blockage by clouds has to be regarded: long-term (complete blockage of an Optical Ground Station by cloud cover during an over-flight); short-term (transitional blocking by small clouds during one downlink)

• Scintillation of Rx-power: in contrast to RF-links, optical downlinks feature very small scale amplitude scintillation patterns (cm to dm size). This leads to fast fades and surges (ms-range) of the received optical power of typical up to +/-10dB in the downlink and more in the uplink

• With the extremely narrow optical beam, residual pointing errors from the space terminal can cause an additional source of fading

• Depending on the modulation format and the applied receiver technology, further impacts onto the signal stability have to be regarded

This paper shall describe the impact of the optical transmission channel onto a reliable data transmission format with respect to higher protocol layers. Based on in-situ measurements of several optical LEO

downlink signals and by applying channel models, requirements are defined for the adaptation of existing and the implementation of new transmission formats and protocols.