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Open issues for Space Laser Communication.

A number of open issues are worth consideration for the success of Space to ground optical communication. In this short summary, the points discussed below are mainly concerning Deep Space Optical Communication, however, they can be extended, in some cases, to GEO/LEO free space optical (FSO) scenarios.

Turbulence Modeling/Verification

Link design and FSO performances are greatly dependent on the modeling and understanding of the effects of the optical turbulence that a propagating signal beam is experiencing. For a Ground-to-Space optical link, this is even more critical for uplink beam propagation.

It is known that the uplink beam experiences a more severe fading with respect to the downlink, furthermore the beam spreading and beam wandering affect both the quality of the beam (signal fading) and its strength (atmospheric Strehl loss).

At the moment atmospheric models are available, supported by analytical description and/or computer simulation (e.g. waveoptics) to study uplink beam propagation. However, 1) analytical description of the uplink problem is generally applicable to limited number of cases and turbulence profiles, 2) modeling results cannot be compared/validated against experimental data, due to the limited availability of experimental uplink data.

Ground Infrastructures.

Due to the growing interest in space FSO applications a number of commercial companies are interested in deployment of ground infrastructures to support LEO/GEO operations. For deep space optical communication missions, however, ground infrastructure (e.g. optical ground stations) are not present. While NASA is considering to deploy large ground apertures for deep space missions, including adapting existing ground RF antennas in a hybrid fashion, for the present time, the only solution is to temporarily use and adapt an astronomical telescope.

Ground High Power Laser

A deep space terminal must rely on an uplink beacon signal as a pointing reference for the narrow downlink beam with small pointing error. For a deep space mission, in absence of a beacon-less scheme, high power laser(s) of Kilo-Watt class average powers are necessary to deliver the signal irradiance to 1) enable the flight terminal acquisition/tracking/pointing system and 2) to close the communication link. For relatively high uplink data rate, the uplink laser(s) must have high modulation bandwidth in conjunction with high output average power. However, at the moment, limitations in the laser performance restrict the data rate to a few kb/s for the uplink. Moreover, due to technology limits, the development of high power lasers in the range of 1550 nm (which is less affected by the atmospheric channel) is unavailable. A comprehensive laser safety system is also necessary to ensure safe propagation of the high power beams through FAA navigable airspace.

Flight Acquisition System/Camera

At the flight terminal, at low photon flux regime, high sensitive detector arrays are necessary for acquisition/tracking/pointing in order to extend the communication range and to reduce the necessary uplink power from ground stations. Photon counting arrays (PCA) with low dark count, and short blocking time can be optimal for these links. At the moment, the availability of space qualified PCA's is limited, therefore effort must be considered in this technology area in order to provide a number of qualified devices in the near infrared spectrum of interest (e.g. 1020-1550 nm).