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Author: Dr. Martijn Dresscher
TNO, The Netherlands, martijn.dresscher@tno.nl

Mr. Eric Bertels
ISIS - Innovative Solutions In Space B.V., The Netherlands, E.BERTELS@ISISPACE.NL
Mr. Dorus de Lange
TNO, The Netherlands, dorus.delange@tno.nl
Mr. Jeroen Rotteveel
ISIS - Innovative Solutions In Space B.V., The Netherlands, J.Rotteveel@isispace.nl
Dr. Oana van der Togt
TNO, The Netherlands, oana.vandertogt@tno.nl

DESIGN OF MOON TO EARTH OPTICAL TRUNK DATALINK FOR 400 MBPS

Abstract

There is a clear trend in expansion of activities in, around and beyond the Moon. These activities require communication and navigation capabilities, currently done via radio communications. Radio features high reliability but also requires sizable ground and space communication instruments. Accommodating the increasing data rate demands is furthermore challenging. Optical communications may provide a complementary function, where specifically the implementation of a high data rate trunk link is considered enabling for various applications in science and exploration.

This trunk link design under development at TNO features a terminal in Lunar orbit and ground stations that are in place on the Earth surface. The system is developed to provide 400 Mbps downlink in accordance with the CCSDS high photon efficiency standard. This assures broad usability of developed components that minimizes the space terminal size, weight and power needs.

The space terminal design re-uses existing laser satellite communication components -developed at TNO - where possible to keep the costs low. New and crucial developments are underway for the detector, the modem and the laser transceiver. The resulting system is a 70mm aperture HPE compliant space terminal with an average output power of up to 4 Watt (0.5 – 1 Watt anticipated). The precise allocation of optical power is to be chosen together with a decision on the aperture size of the optical ground station and the definitive data rate for specific scenarios.

As a baseline, a ground terminal with an aperture diameter smaller than 1 meter is considered. This ground station is anticipated to be equipped with cryocooled nanowire detectors (SNSPD) so that sensitivity and data rate are increased. Design of the back-end optics and specifically the routing of light to the cryocooled detectors is an open design challenge. SNSPD arrays are difficult to manufacture and therefore costly, while also their fill factor is not optimal. An alternative implementation under development at TNO considers the use of photonic lantern that can simultaneously allow for fiber-coupled detection, in-fiber spectral filtering before detection and wavefront sensing. The latter would additionally allow to implement adaptive optics so that spatial, e.g. angle of incidence, selectivity of incoming light can be enhanced, in turn promoting higher data rates.

In this work we present the envisioned link architecture and comment on the critical trades and considerations. We will furthermore give an update on the current status of the developments at TNO and present our outlook.