DLR’s Transportable Optical Ground Station

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Abstract: This paper will give an overview about the Transportable Optical Ground Station (TOGS) of DLR’s Institute of Communications and Navigation. Furthermore, a short description of its project involvement will be given.
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1. Introduction

Optical free-space communications offer a potential solution for the steadily increasing demand for higher data rates in mobile communication systems. Data rates of few to several Gbit/s have been demonstrated in aircraft-downlink applications [1,2], while the feasibility of downlinks from LEO satellites with high rates has been shown as well [3,4]. Furthermore, optical communication systems offer high power efficiencies and low probabilities of interception and eavesdropping. Challenges include the facts that optical links are easily blocked by clouds and that the high directivity requires very accurate and fast pointing systems.

Optical Ground Stations (OGS) are important components in mobile optical communication systems. As OGSs for satellite downlink applications may be placed and operated at fixed locations around the globe, especially applications that require the transmission of Imagery to a specific location need transportable Optical Ground Stations that can be placed at changing locations. Transportable Ground Stations also allow reacting on annual cloud cover variability and can be used for site-testing and –characterization.

DLR’s Transportable Optical Ground Station (TOGS) fulfills this requirement. It has been designed for optical LEO downlinks as well as for long-distance aircraft downlinks. This paper gives an overview about the capabilities and design of TOGS.

2. Description of TOGS

2.1. Transport Van and TOGS platform

Fig. 1 shows the transport van as well as the TOGS platform itself. Although TOGS is self-sustainable and includes all necessary equipment for the completion of aircraft- and satellite-downlinks, the van includes an acclimatized operation room for convenient control of experiments. The operation room as well as TOGS in transport configuration is visible in Fig. 2.

TOGS can be decoupled from the van by simply applying its stands to the platform and separating the platform from the van. It can be operated either inside the van (as shown in Fig. 1) or the van can simply back out underneath the platform to allow stand-alone operation.

The TOGS platform has been constructed with carbon fiber, resulting in a very stiff and comparably light-weight design (~500 kg). The telescope can be automatically folded and unfolded with a pneumatic system.

Fig. 1. Transportable Optical Ground Station (TOGS) with transport van (left); TOGS platform (right)

The operation room features a Keyboard-Video-Mouse switch matrix which allows simultaneous control of all TOGS systems as well as e.g. the data processer for received data. The quality of the received signal can be monitored on-line with an integrated oscilloscope. An uninterrupted power supply unit (UPS) is available to bridge short power outages and to allow folding and storage of the telescope to prevent damages due to environmental influences during longer outages.

Fig. 2. Operation Room within the transport van (left); TOGS in transport configuration within the van (right)

2.2. Telescope, Mount and Optical System

The heart of TOGS, the 60 cm telescope, is a custom development with aluminum mirrors. The construction process, which has been optimized throughout the project, allows surface qualities comparable to glass mirrors, while being lighter and more robust. The Ritchey-Chretien design allows for a short structure of the telescope.

Hollow shaft torque engines have been selected as motors for the telescope mounting. In conjunction with the nrad encoders on the drive axes, sub-µrad positioning accuracies can be achieved. Furthermore, the design allows high slew rates of more than 10°/s, which is largely sufficient for any applications TOGS is intended to be used in.

The optical system of TOGS is designed for operational downlinks and thus has been kept simple and does not foresee a permanent installation of measurement devices. A movable lens is used for focus adjustments. A tracking camera based on an InGaAs-FPA is used to track the telescope according to the incident angle of the incoming light and to keep the light on the receiver front-end. In case the conduction of specific experiments and thus the installation of custom measurement devices are required, the receiver frontend can be exchanged accordingly. A more detailed description of TOGS as well as of the software concept is available in [5].

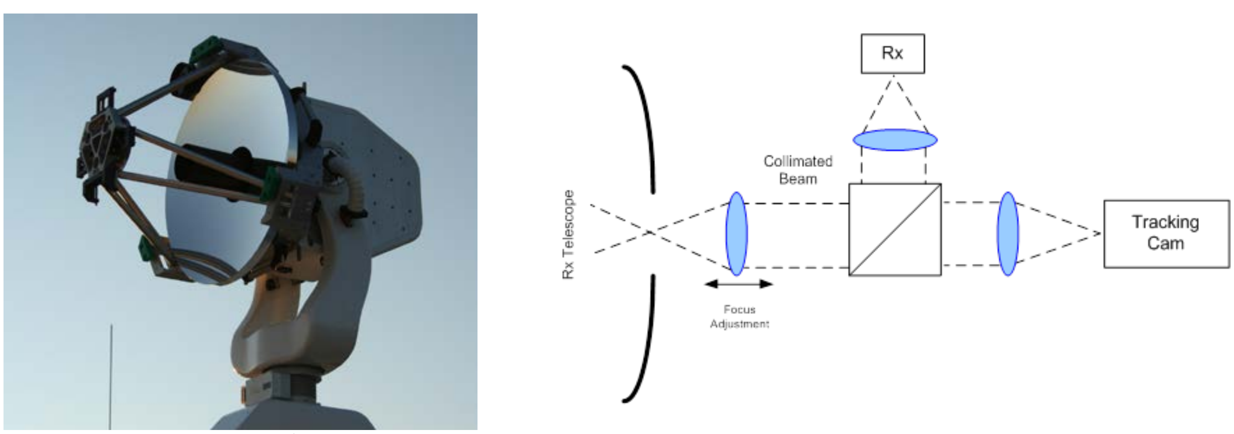

Fig. 3. 60cm-TOGS-telescope (left); Optical system behind the telescope (right)

2.3. Beacon-system and referencing sensors

The beacon system of TOGS consists of two 5W laser sources in the 1550 nm range powered by C-Band-EDFAs. Two collimators, enabling spatial diversity, are co-aligned to the telescope. Eye-safety was a crucial requirement in the design of the beacon system.

Furthermore, a couple of sensors exist for automatic position- and attitude-determination. A dual-antenna GPS is used for the determination of position and heading angle of the station. A highly accurate pitch/roll sensor is available as well. For the purpose of checking the alignment as well as for optimization purposes, a GPS rover equipped with a DGPS receiver and retro-reflector exists. It can be placed in a distance of up to few kilometers and transmits its position to TOGS via an RF data link. By pointing to the rover, the pointing error can be determined and included in the pointing model of TOGS. For higher accuracy, a star calibration of the system can be carried out.

3. Current Project Involvement and Outlook

The first operational experiments were conducted in August 2013 in the framework of the DLR internal project VABENE [6]. The TOGS has been used to receive data from DLR's Dornier 228-212, which was equipped with the Free-space Experimental Laser Terminal II. The system was used to transmit high-resolution imagery to TOGS. The idea behind VABENE is to distribute real-time imagery to coordination centers in disaster relief applications.

Fig. 4. Free-space Experimental Laser Terminal II (FELT II, left); Dornier 228-212 Short Take Off and Landing Aircraft with FELT II mounted underneath (right)

It is foreseen to use TOGS in a broad spectrum of applications, as e.g. in further aircraft downlink experiments. A main focus will be the conduction of optical satellite downlinks in the OSIRIS-project [7]. OSIRIS aims at the development of experimental optical communication systems optimized for small satellites. The first payloads are expected for launch in Mid-2014.

4. Acknowledgement

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