Laser Communication with Alphasat - FD Challenges and Flight Results

Benjamin Schlepp(1), Ralph Kahle(2), Juri Saleppico(3), Sven Kuhlmann(4), Uwe Sterr(5) and Christoph Rochow(6)

(1)(2)(3)(4) *German Aerospace Center (DLR), German Space Operations Center (GSOC), D-82234 Wessling (Germany), phone: +49 8153 282124, Benjamin.Schlepp@dlr.de*

(5) *ST²C Satellite Telecommunication Consulting, Krummenackerstr. 8, D-73733 Esslingen (Germany), phone: +49 711 35131580, Uwe.Sterr@st2c.de*

(6) *Tesat-Spacecom GmbH & Co. KG, Gerberstrasse 49, D-71522 Backnang, phone: +49 71919300, Christoph.Rochow@tesat.de*

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ABSTRACT

Inmarsat's geostationary satellite Alphasat, launched on July 25 2013, is the largest European telecommunications satellite ever built with a weight of 6.6 tons. For technology demonstration it is carrying different payloads, hereunder the laser communication terminal (LCT) built by Tesat-Spacecom. Its purpose is to establish bi-directional data links with data rates of up to 1.8 Gbit/s. Links can be either within space, so called inter-satellite links (ISL) to counter terminals in low Earth orbit (LEO), or from the geostationary satellite to terminals mounted on ground stations, space-to-ground links (SGL).

As a precursor to the European Data Relay System EDRS that will perform data relay services in particular for ESA's Sentinel Earth observation fleet, it is obvious that Sentinel-1A and Sentinel-2A, to be launched in 2014 & 2015 respectively, are currently foreseen partners for ISL with Alphasat, too. For SGL mainly the optical ground station positioned on Tenerife is envisaged, to demonstrate that the pointing is precise enough to hit a target more than 36,000 km away.

GSOC flight dynamics (FD) is responsible for the computation of long-term visibility windows between Alphasat's LCT and its various counter terminals using the available orbit and attitude information of the spacecraft / ground station. Many different characteristics and constraints of each LCT have to be considered as well, e.g. LCT mountings and mounting offsets, azimuth & elevation limits and forbidden areas, sun blinding angles, etc. Based on the computed visibility periods and other constraints the mission planning system schedules customer link requests.

Subsequently, regarding updated attitude and orbit information, FD computes the required command parameters for each terminal and link. These comprise refined azimuth and elevation angles for a coarse LCT pointing previous to link start. Furthermore, the Chebyshev coefficients describing the relevant orbit arc of the partner LCT for the link duration are included within the command. The configurable LCT scan-cone of Alphasat, defining the area in which the counter terminal is searched for, is very restricted to avoid long link acquisition times. This means that the pointing accuracy prior to link establishment must be better than 2 mrad during LCT commissioning.

The first 3 links were successfully performed on 2013/11/08. After a successful link the dumped telemetry data of the spacecraft allows an analysis of the link performance accuracy resulting in an update of the LCT alignment matrix which is considered within later experiments. An example plot depicting the differences between the on-board predicted and measured azimuth and elevation angles for the link at 13:00 UTC is provided in the Figure below.

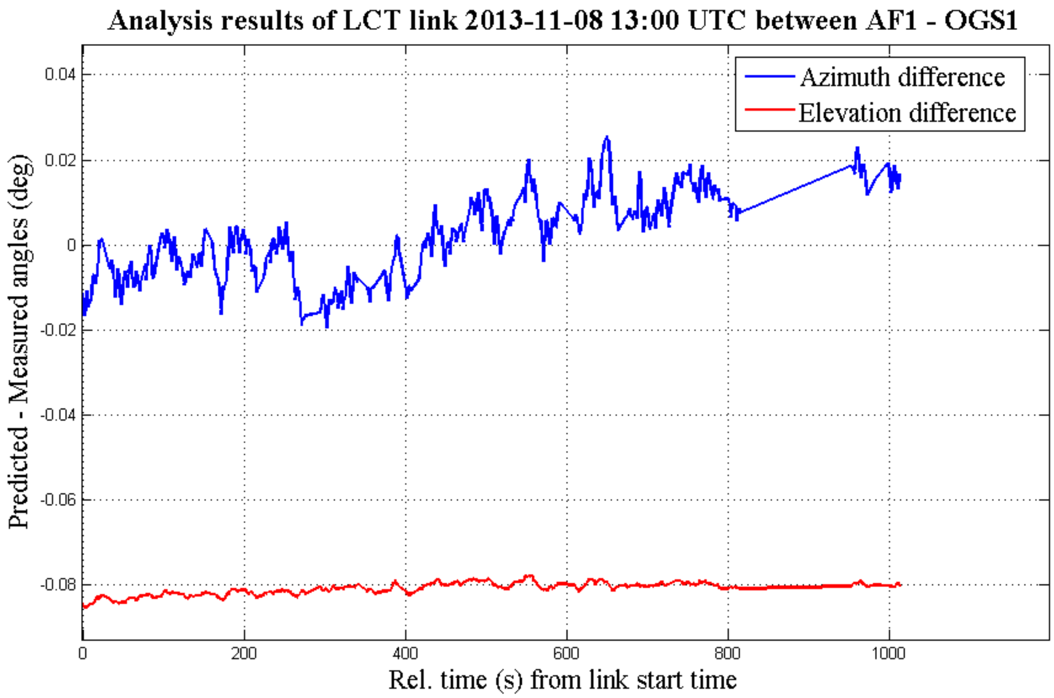

Figure 1: Analysis results of the link on 2013/11/08 13:00 UTC between Alphasat and the Tenerife ground station showing the differences between the on-board predicted and measured azimuth and elevation angles in degree.

It can be seen that the differences are rather constant which suggests the opportunity to reduce the offsets by a correction of the LCT alignment matrix.

This paper provides an overview about the work flow from visibility computations over link scheduling until command generation. Furthermore, it gives a deeper insight into the requirements on and implementation of the visibility calculation and coarse pointing computation considering the objects' positions, attitudes, LCTs' mountings, characteristics and constraints. Additionally, the link performance analysis and the resulting alignment matrix calculation in general is further discussed. Some achievements based on the flight data after successful links are presented, too.