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THE ESA'S OPTICAL GROUND STATION FOR THE EDRS-A LCT IN-ORBIT TEST CAMPAIGN: UPGRADES AND TEST RESULTS

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I. INTRODUCTION

Since the successful demonstration of the Semiconductor-laser Inter-satellite Link EXperiment (SILEX) in 2001 between ARTEMIS and SPOT-4 satellites, the European Space Agency (ESA) and several European National Space Agencies have consolidated the effort in developing the so-called “second generation” of optical communications terminals with reduced mass, size and power consumption, and increased data transmission rate, [1].

The European Data Relay System (EDRS), also referred to as the SpaceDataHighway [2], will become the first commercial European data relay system providing a wide range of operational services (both optical and Ka-band based). The EDRS optical inter-satellite links (O-ISLs) are based on optical Laser Communications Terminals (LCT), which are developed and qualified by Tesat-Spacecom GmbH & Co. KG under DLR (German Aerospace Center) national funding.

The first node (EDRS-A) is a hosted payload embarked on the Eutelsat-9B satellite, which was successfully launched on 29th January 2016. The in-orbit commissioning phase of the EDRS-A payload (including the EDRS-A LCT) is proceeding according to schedule.

This paper will present the test results of the space/ground laser link campaign between the EDRS-A LCT and the ESA’s Optical Ground Station (OGS) carried out between March and April 2016.

A. The European Data Relay System (EDRS / SpaceDataHighway)

The EDRS / SpaceDataHighway is a public-private-partnership program between ESA and Airbus Defence and Space (Germany). The EDRS space segment infrastructure presently consists of two geostationary nodes (EDRS-A and EDRS-C), which will provide data relay and data forward services between user and geostationary nodes, based on both laser-optical and RF Ka-band Intersatellite Link terminals, [3], [4], and [5]. The overall EDRS / SpaceDataHighway system architecture is shown in Fig. 1 and a summary of the EDRS / SpaceDataHighway optical and Ka-band services is given in Fig. 2.

The first node (EDRS-A) is embarked on the Eutelsat-9B satellite (Fig. 3), based on the Eurostar 3000 telecom satellite product family by Airbus Defence and Space. The second node (EDRS-C) is designed as a dedicated satellite, based on the SGEO (Small GEO) telecom satellite product family by OHB.

Both nodes are equipped with high speed RF Ka-Band feeder links between the geostationary nodes and the ground stations. The ground segment includes additional stations and centers to schedule the users service requests, command the satellites and operate / reconfigure the payloads, and receive / consolidate / store / disseminate the user data. The data will be received either at dedicated EDRS Ground Stations or, upon the user’s request, at User Ground Stations to achieve direct delivery of the data to the user premises. The EDRS ground coverage area, within which the Ground Stations have to be located, is Europe.

The first customers of the EDRS / SpaceDataHighway service will be the Sentinel 1 & 2 satellites of the Copernicus Programme (previously known as GMES or Global Monitoring for Environment and Security).

B. The EDRS-A Laser Communications Terminal (LCT)

The LCT embarked on the EDRS-A node (i.e., the Eutelsat-9B satellite) corresponds to the TESAT LCT “second generation”, [6]. Up to date, a total of 5 LCTs based on this “second generation” design have been delivered by TESAT, integrated into the satellite and successfully launched into orbit: Alphasat LCT (launch on 25th July 2013), Sentinel 1A LCT (launch on 3rd April 2014), Sentinel 2A (launch on 22nd June 2015), EDRS-A LCT (launch 29th January 2016) and Sentinel 1B LCT (launch on 25th April 2016). These LCTs have cumulated more than 1.000 optical links in orbit. Additional 2 LCTs of this “second generation” design are about to be delivered to the satellite prime for spacecraft integration or are under spacecraft acceptance testing: EDRS-C LCT and Sentinel 2B LCT. A further 4 LCTs of this “second generation” design are under procurement for Sentinels 1C/1D and Sentinels 2C/2D.

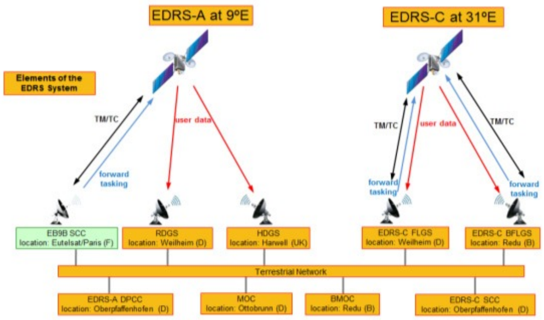
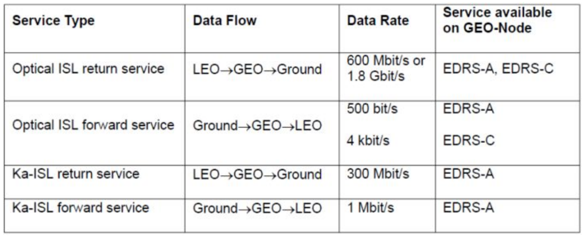


Fig. 1. The EDRS / SpaceDataHighway system architecture including the various elements of the space and ground segments.



Service Type	Data Flow	Data Rate	Service available on GEO-Node
Optical ISL return service	LEO→GEO→Ground	600 Mbit/s or 1.8 Gbit/s	EDRS-A, EDRS-C
Optical ISL forward service	Ground→GEO→LEO	500 bit/s 4 kbit/s	EDRS-A EDRS-C
Ka-ISL return service	LEO→GEO→Ground	300 Mbit/s	EDRS-A
Ka-ISL forward service	Ground→GEO→LEO	1 Mbit/s	EDRS-A

Fig. 2. Summary of the EDRS / SpaceDataHighway optical and Ka-band services.

The key parameters of the “second generation” LCT from TESAT and a photograph of the EDRS-A LCT prior to satellite integration are shown in Fig. 4 and Fig. 5 respectively. The EDRS-A LCT can transmit at user data rates up to 1.8Gbit/s over distances of up to 45000km between the LEO user spacecraft and the GEO EDRS node. The user data rate required by the Sentinel 1 & 2 satellites is only 600Mbit/s. The increased range, compared to the “first generation” LCT, is due to the increased telescope aperture diameter, the increased transmitted optical power, and the decreased user data rate.

The EDRS-A LCT is based on the generic “second generation” LCT design. In order to embark the LCT on the Eutelsat-9B satellite, some specific LCT adaptations were required for the electrical, data bus and thermal interfaces between the LCT and the spacecraft, [7]. In addition, some modifications were necessary on the Eutelsat-9B satellite in order to meet the LCT requirements (e.g., LCT accommodation on the Earth deck, attitude knowledge, pointing stability), [7].

C. The Beaconless Spatial Acquisition process

Before establishing a communication link, the LCTs have to search each other through a so-called Pointing, Acquisition, and Tracking (PAT) sequence, outlined in Fig. 6, [8].

TESAT LCTs implement a so-called beaconless spatial acquisition method, which does not require the use of a separate highly divergent beacon laser nor a pixel sensor (e.g., CCD sensor). In a beaconless spatial acquisition process, each LCT scans sequentially its uncertainty cone with its highly collimated communications laser beam and aligns its optical axis perpendicularly to the received optical wavefront, based on the optical signal detected by its quadrant photodiode. This Master/Slave sequence is described in detail in [9]. An overview is summarized in Fig. 7.

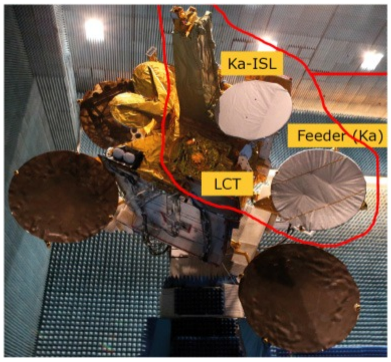
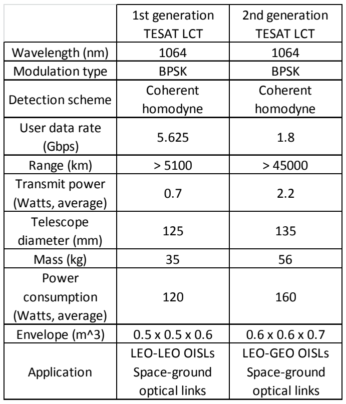


Fig. 3. The Eutelsat-9B satellite carrying its EDRS-A payload highlighted by the red line, including the Ka-ISL and the Ka-band feeder antennae, and the LCT on the satellite’s Earth deck (Courtesy Airbus Defence and Space).



	1st generation TESAT LCT	2nd generation TESAT LCT
Wavelength (nm)	1064	1064
Modulation type	BPSK	BPSK
Detection scheme	Coherent homodyne	Coherent homodyne
User data rate (Gbps)	5.625	1.8
Range (km)	> 5100	> 45000
Transmit power (Watts, average)	0.7	2.2
Telescope diameter (mm)	125	135
Mass (kg)	35	56
Power consumption (Watts, average)	120	160
Envelope (m^3)	0.5 x 0.5 x 0.6	0.6 x 0.6 x 0.7
Application	LEO-LEO OISLs Space-ground optical links	LEO-GEO OISLs Space-ground optical links

Fig. 4. Performance comparison between “first generation” and the “second generation” LCTs from TESAT. The EDRS-A LCT belongs to the “second generation” LCT.

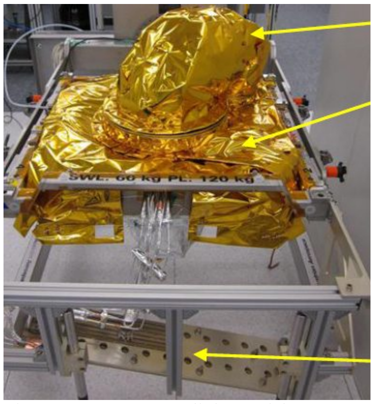


Fig. 5. EDRS-A LCT Flight Model (Courtesy TESAT-Spacecom), with the Coarse Pointing Assembly in parking position (top arrow), MLI installed (middle arrow), and the thermal interface plate (bottom arrow).

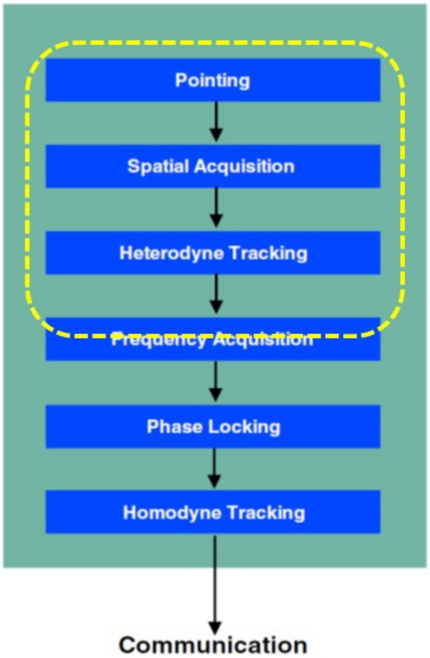


Fig. 6. The overall Pointing, Acquisition, and Tracking (PAT) sequence implemented by the LCTs (Courtesy TESAT-Spacecom). The steps verified during the tests with the OGS are highlighted by the yellow dashed line.

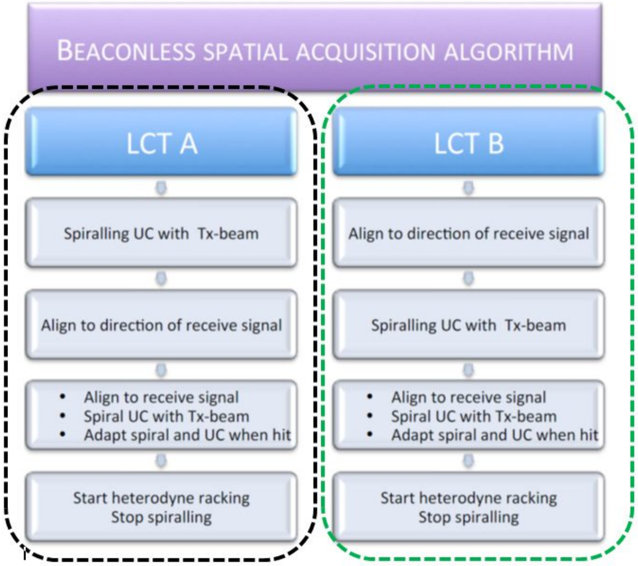


Fig. 7. The Beaconless Spatial Acquisition process (Courtesy TESAT-Spacecom). The steps verified during the tests with the OGS are highlighted by the black dashed line (LCT A = Master = EDRS-A LCT) and by the green dashed line (LCT B = Slave = OGS). These steps detail the Pointing, Spatial Acquisition and Heterodyne tracking steps listed in Fig. 6.

II. THE ESA'S OPTICAL GROUND STATION

Prior to the validation of the end-to-end data relay system (which includes the LEO-GEO O-ISL, the RF feeder link between the EDRS-A payload and the ground segment, and the interfaces and operations with the Copernicus ground segment), an in-orbit test campaign using an Optical Ground Station (OGS) was specified in order to validate the pointing performances of the EDRS-A LCT.

The objective of this test between EDRS-A LCT and the OGS is to tune the LCT setting parameters (e.g., acquisition scanning parameters, alignment matrix between the satellite coordinate reference system and the LCT coordinate reference system, etc.) and to preliminary verify the PAT (Pointing Acquisition and Tracking) performances (e.g., uncertainty cone, link acquisition timing, etc.). No communications tests are required between the EDRS-A LCT and the OGS.

The ESA's OGS in Tenerife (Spain) was selected for the execution of these tests.

A. Introduction to the ESA's Optical Ground Station

The OGS is an ESA's observatory equipped with the infrastructure required for the in-orbit check-out of optical terminals (e.g., Laser Communication Terminals). The OGS is also used for astronomical observations and space debris surveillance, [10], [11].

The OGS is located at the Observatorio del Teide, Izaña, Tenerife (Spain), at an altitude well above the first inversion layer (clouds). The site provides astronomical seeing conditions of sub-arcsec quality over long time periods and a high atmospheric transmission. Because of its proximity to the Equator the elevation angle to GEO satellites is maximized.

The OGS consists of an observatory building with a Dome, Shutter and the associated infrastructure, a Telescope including its control system and special test equipment required for optical payload testing. The Telescope used in the OGS is a Zeiss 1-meter Ritchey-Chrétien/Coudé telescope supported by an English mount, as shown in Fig. 8 and Fig. 9.

The telescope can alternatively be used in three different optical configurations: Ritchey-Chrétien system in Cassegrain focus, Cassegrain system with focal reducer and Coudé system. To support the in-orbit test of the EDRS-A LCT, the specific optical configuration used is the Ritchey-Chrétien system in Cassegrain focus, because it minimizes the optical loss of the overall optical chain and because no communications tests are required, hence, a compact optical Receiver (i.e., RX Focal Plane instrumentation) can be directly mounted at the Cassegrain focus, which moves together with the telescope.

Fig. 8. Dome, Shutter and Telescope of the ESA's Optical Ground Station (OGS).

Fig. 9. The telescopes of the ESA's Optical Ground Station (OGS) used for the in-orbit test of the EDRS-A LCT. The Transmitter Telescope (guider telescope on the center of the image) is mechanically attached to the Receiver Telescope (large aperture to the right), a 1-meter Ritchey-Chrétien/Coudé telescope supported by an English mount.

B. ESA's OGS modifications for the EDRS-A LCT in-orbit test

The OGS has been upgraded with some specific adaptations for the in-orbit test of the EDRS-A LCT. The overall configuration of the OGS to execute the EDRS-A LCT in-orbit test is depicted in Fig. 10.

As the objective of the in-orbit test is to validate the Link Acquisition performances (i.e., no Communications tests are planned), the OGS Transmitter and the OGS Receiver do not contain communications equipment.

Spatially separated apertures are used for transmission and reception in order to maximize the optical isolation between transmitted and received optical beams, as shown in Fig. 9.

The specific adaptations of the OGS required for the EDRS-A LCT in-orbit test are:

- OGS Transmitter: it generates an LCT representative signal, which is required by the EDRS-A LCT to successfully perform the Spatial Acquisition test and reach Heterodyne Tracking. It includes:
    - Seed Laser: it is a diode pumped monolithic Nd:YAG laser from Coherent with an output optical power >150 mW and highly linearly polarized (Fig. 11). The laser crystal is thermally stabilized to achieve the required wavelength around 1064nm.
    - Modulator Box (ModBox): it includes an ASK (Amplitude Shift Keying) electro-optic modulator supplied by Photline Technologies (Fig. 12). The ASK modulator is modulated with a sinusoidal pilot tone provided by a Function Generator. The ASK modulator is biased at quadrature by means of the automatic bias control electronics (included in the ModBox). The power extinction ratio of the amplitude modulated optical signal is >15dB.
    - Pilot Signal Function Generator: it generates the sinusoidal pilot tone which drives the ASK modulator. This pilot tone is required during the Spatial Acquisition with the EDRS-A LCT.
    - Optical Power Amplifier (OPA): the amplitude modulated optical signal is amplified by the OPA procured from Nufern. The maximum output power is 50W, which is a Class IV Laser Product. Laser Safety precautions and countermeasures were implemented at the OGS during the tests. The 50W OPA was used during the tests in March 2016. Due to a failure, it was replaced by a 10W OPA during the tests in April 2016 (Fig. 13). The output signal is fiber delivered to the Transmitter Optics mounted on the Transmitter Telescope.
- Transmitter Telescope and the Transmitter Optics: the optical signal of the OGS is transmitted towards the EDRS-A LCT by means of the guider telescope, which has a maximum aperture of 200mm diameter and 3m focal length. The Transmitter Telescope is mechanically attached to the 1-meter aperture Receiver Telescope. The alignment of Transmitter and Receiver optical paths is calibrated by means of a retroreflector bar. The effective aperture size used for transmission depends on the tracking error, pointing error and the required transmitter gain. The Transmitter Optics (TX Optics) adapts the transmitted optical beam delivered by the OGS Transmitter to the Transmitter Telescope. The finally selected transmitted beam diameter is 50mm. The TX Optics also converts the highly linearly polarized signal from the OPA to the required transmitted optical signal polarization.

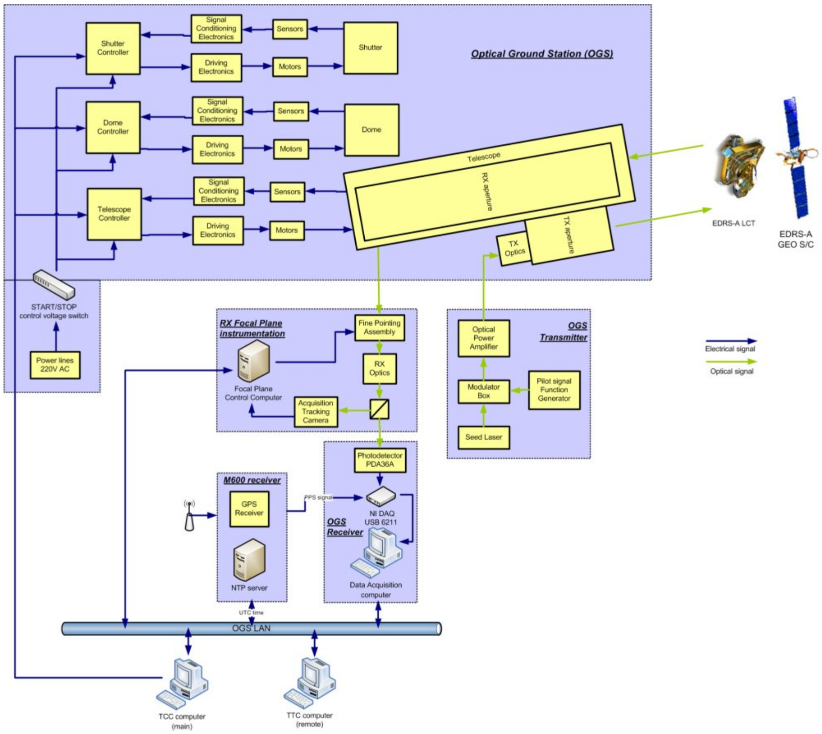


Fig. 10. The OGS configuration for the EDRS-A LCT in-orbit test campaign. The OGS transmitter and the OGS Receiver sub-systems have been designed specifically for the tests with the EDRS-A LCT.

Fig. 11. The Mephisto diode pumped monolithic Nd:YAG Seed Laser from Coherent.

Fig. 12. The ModBox from Photline Technologies.

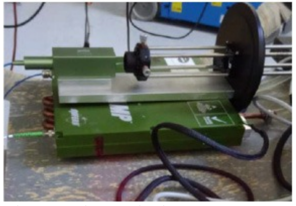


Fig. 13. The Optical Power Amplifier from Nufern, fiber coupled to the Transmitter Optics.

- OGS Receiver: the OGS Receiver converts the received optical beam from the EDRS-A LCT to an electrical signal which is amplified, filtered, digitized and stored on a computer. It includes:
  - Photodetector: it is a silicon amplified detector from Thorlabs (PDA36A), directly mounted on the focal plane of the Receiver Telescope. The field of view of the Photodetector is much larger than the remaining misalignment between the Transmitter and the Receiver optical paths after calibration. The gain of the transimpedance amplifier is optimized in terms of sensitivity and electrical bandwidth, resulting in a Photodetector sensitivity ~10nW.
  - Data Acquisition Card: the DAQ USB 6211 card from National Instruments digitizes the electrical signal from the Photodetector together with the time information available from the GPS Receiver.
  - Data Acquisition Computer: it stores the time-tagged samples of the received optical beam of the EDRS-A LCT for further analysis and processing.

TLE (Two Lines Element) data defining the orbital location of the Eutelsat-9B satellite is used by the Telescope Controller for the telescope pointing (open loop). As soon as the OGS Receiver detects the EDRS-A LCT signal on the Acquisition Tracking Camera (ATC), then the tracking system using the ATC is activated (closed loop). The tracking algorithm reads out the position of the focused beam on the ATC and commands the telescope pointing accordingly in order to center the spot on the ATC. The field of view of the Photodetector is sufficiently large to compensate for image motion due to atmospheric turbulence or telescope jitter.

C. Assessment of the EDRS-A LCT / OGS Link Budget

The Downlink and Uplink budgets for the optical link between EDRS-A LCT and the OGS have been evaluated and the following conclusions are derived:

- Downlink budget (i.e., EDRS-A LCT towards OGS) => Acquisition link margin > 21dB
  - With the 1-meter telescope receiver aperture the collected optical power at OGS is estimated ~1µW.
  - Fluctuations of the received optical power at OGS are expected < 1dB thanks to the aperture averaging effect of the 1-meter telescope receiver aperture.
  - The Photodetector sensitivity of the OGS Receiver is ~10nW.
- Uplink budget (i.e., OGS towards EDRS-A LCT) => Acquisition link margin > 2dB
  - The maximum (average) optical power transmitted by the OGS Transmitter is 50W.

- Considering typical astronomical seeing conditions at OGS, the Fried parameter is estimated between 100-250mm at zenith at 1064nm wavelength. For the Uplink budget the worst case Fried parameter of 100mm at zenith at1064 nm wavelength is considered.
- The Uplink budget takes into account 7dB fading. This is a worst case assumption because fades are not a principal problem during Spatial Acquisition. Therefore this 7dB can be considered as an additional margin.

As previously mentioned, the tests in April 2016 were performed with a 10W OPA (instead of the originally planned 50W OPA). This 7dB reduction of the transmitted optical power by the OGS can be tolerated thanks to the assumed 7dB fading, as confirmed by the test results.

The elevation angles required at the OGS location to point towards Alphasat LCT and EDRS-A LCT are 34° and 46.7° respectively. The Downlink and Uplink budget margins for the optical link between Alphasat LCT and the OGS are reduced by ~1dB due to the lower elevation angle.

III. THE OPTICAL GROUND STATION TEST RESULTS

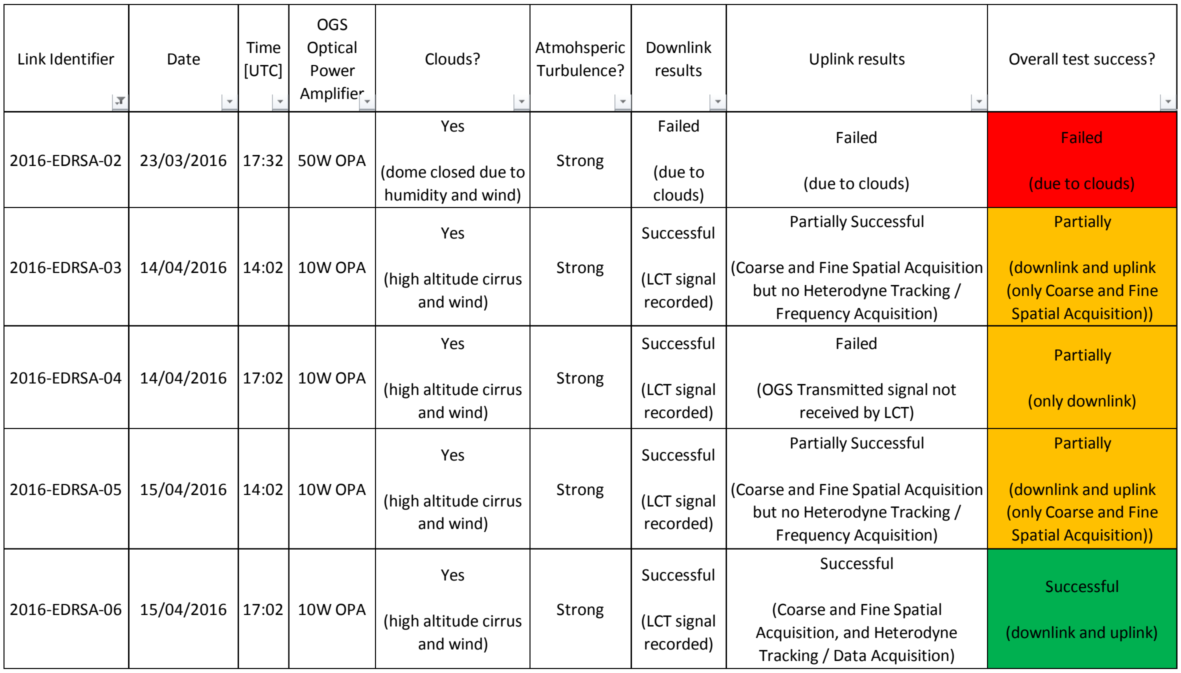
A. Tests results with Alphasat LCT

Prior to the EDRS-A LCT in-orbit test campaign, the ESA's OGS conducted a series of rehearsal tests with the Alphasat LCT (whose link commissioning phase together with Sentinel 1A was successfully completed by DLR, TESAT-Spacecom and ESA in 2014), in order to verify and validate the previously described OGS modifications. These commissioning tests were successfully executed in February 2016 (1 link), March 2016 (7 links) and April 2016 (6 links).

The Alphasat LCT optical power received at the OGS confirmed the assumptions of the link budget reviewed in section II.C. From the time-tagged samples of the Alphasat LCT optical beam received at the OGS, the Uncertainty Cone (UC) of the Alphasat LCT, i.e., the initial pointing error, was estimated to be <250µrad, confirming the excellent pointing accuracy of the Alphasat LCT. These test results also confirmed the readiness of the ESA's OGS to proceed with the EDRS-A LCT in-orbit test campaign.

B. Tests results with EDRS-A LCT

Fig. 14 gives a summary of the Link Acquisition tests between the EDRS-A LCT and the ESA's OGS. It was expected that the EDRS-A LCT could reach at maximum the operational mode Frequency Acquisition. Due to atmospheric disturbances the EDRS-A LCT may only reach Heterodyne Tracking. Hence, the objective was to validate the overall Pointing, Acquisition, and Tracking (PAT) sequence implemented by the LCTs up to Frequency Acquisition (as highlighted in Fig. 6). As part of it, the Spatial Acquisition process described in Fig. 7 will be fully validated (the EDRS-A LCT acts as Master (=LCT A) and the OGS acts as Slave (=LCT B)).



Link Identifier	Date	Time [UTC]	OGS Optical Power Amplifier	Clouds?	Atmohsperic Turbulence?	Downlink results	Uplink results	Overall test success?
2016-EDRSA-02	23/03/2016	17:32	50W OPA	Yes (dome closed due to humidity and wind)	Strong	Failed (due to clouds)	Failed (due to clouds)	Failed (due to clouds)
2016-EDRSA-03	14/04/2016	14:02	10W OPA	Yes (high altitude cirrus and wind)	Strong	Successful (LCT signal recorded)	Partially Successful (Coarse and Fine Spatial Acquisition but no Heterodyne Tracking / Frequency Acquisition)	Partially (downlink and uplink (only Coarse and Fine Spatial Acquisition))
2016-EDRSA-04	14/04/2016	17:02	10W OPA	Yes (high altitude cirrus and wind)	Strong	Successful (LCT signal recorded)	Failed (OGS Transmitted signal not received by LCT)	Partially (only downlink)
2016-EDRSA-05	15/04/2016	14:02	10W OPA	Yes (high altitude cirrus and wind)	Strong	Successful (LCT signal recorded)	Partially Successful (Coarse and Fine Spatial Acquisition but no Heterodyne Tracking / Frequency Acquisition)	Partially (downlink and uplink (only Coarse and Fine Spatial Acquisition))
2016-EDRSA-06	15/04/2016	17:02	10W OPA	Yes (high altitude cirrus and wind)	Strong	Successful (LCT signal recorded)	Successful (Coarse and Fine Spatial Acquisition, and Heterodyne Tracking / Data Acquisition)	Successful (downlink and uplink)

Fig. 14. Summary of the Links Acquisition tests between the EDRS-A LCT and the ESA's OGS in March 2016 (1 link) and April 2016 (4 links).

Fig. 15. The ESA's OGS set up during the EDRS-A LCT in-orbit test campaign in April 2016.

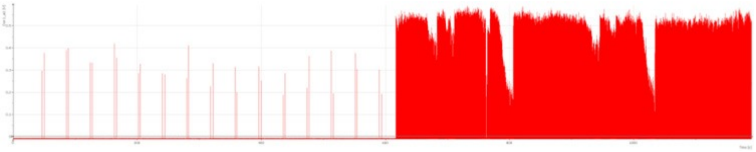


Fig. 16. On the left hand side, the EDRS-A LCT optical beam received at the OGS during the large spiraling of the EDRS-A LCT (Coarse Spatial Acquisition). On the right hand side, the EDRS-A LCT optical beam received at the OGS during the fine spiraling of the EDRS-A LCT (Fine Spatial Acquisition). Measured data from Link #2016-EDRSA-06.

Fig. 17. Example of adverse weather conditions at the OGS during the EDRS-A LCT in-orbit test campaign in March 2016 and April 2016. Links were disturbed by high altitude cirrus clouds and strong atmospheric turbulence.

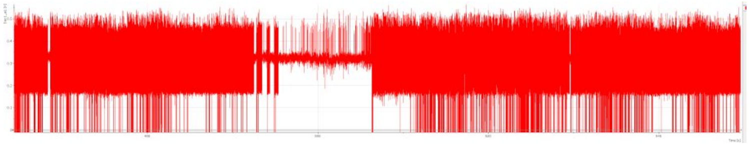


Fig. 18. The EDRS-A LCT optical beam received at the OGS during the fine spiraling of the EDRS-A LCT (Fine Spatial Acquisition), where several intervals of heterodyne tracking and even one attempt of Frequency Acquisition can be identified. Heterodyne tracking suffered from interruptions caused by the low link margin in the Uplink due to the adverse weather conditions at the OGS. Measured data from Link #2016-EDRSA-06.

The tests conducted in the March 2016 campaign were not successful due to adverse weather conditions at the OGS (high altitude cirrus clouds and strong atmospheric turbulence) and due to failure of the 50W OPA. After replacement by a 10W OPA, a new test campaign was successfully executed in April 2016, in spite of similar adverse weather conditions as in the March 2016 campaign, as it can be observed in Fig. 17.

The validation of the PAT (Pointing Acquisition and Tracking) performances (i.e., link acquisition timing) is presented in Fig. 16 and Fig. 17, corresponding to the measured data during the Link #2016-EDRSA-06.

Fig. 16 (left hand side) displays the received optical beam (i.e., recorded by the OGS Receiver) during the large spiraling of the EDRS-A LCT (so-called Coarse Spatial Acquisition). At each individual received pulse, the OGS tracking algorithm aligns the OGS telescope pointing accordingly. Fig. 16 (right hand side) shows the received optical beam during the fine spiraling of the EDRS-A LCT (so-called Fine Spatial Acquisition). The low frequency fades on the received optical power are due to the OGS pointing optimization process.

After successful completion of the Spatial Acquisition process, the EDRS-A LCT reached Heterodyne Tracking and also started the operational mode Frequency Acquisition, as shown in Fig. 18. Completion of the Frequency Acquisition was not feasible due to strong atmospheric turbulence conditions disturbing the optical phase locked loop of the EDRS-A LCT.

The adverse weather conditions during the execution of the link tests caused fading, resulting in a low link margin for the Uplink with the 10W OPA. As a consequence, the OGS transmitted beam was frequently interrupted, and therefore, sometimes not detected by the EDRS-A LCT. In that case, the EDRS-A LCT re-started automatically the Fine Spatial Acquisition process, which can be observed by the optical power fluctuations visible in Fig 18. The periods, during which the EDRS-A LCT received optical beam at the OGS was stable, demonstrates that the OGS transmitted beam was sufficiently stable at the EDRS-A LCT to allow transition into the operational mode Heterodyne Tracking.

The temporal shape of the individual pulses from the EDRS-A LCT received at the OGS during the Coarse Spatial Acquisition is Gaussian, in line with the expected far field pattern of the EDRS-A LCT beam. The estimated beam divergence angle ($1/e^2$ value) matches the theoretical beam divergence angle with an error <35%.

The EDRS-A LCT optical power received at the OGS correlates very accurately with the link budget predictions. During heterodyne tracking, the EDRS-A LCT optical power received at the OGS ranges between $1\mu W$ and $2\mu W$.

The Uncertainty Cone (UC) of the EDRS-A LCT, i.e., the initial pointing error, has been assessed based on the time-tagged samples of the optical beam from EDRS-A LCT received at the OGS. The following UC values are derived:

- Link #2016-EDRSA-03, 14/04/2016, 14:02UTC => UC = 835-875µrad
- Link #2016-EDRSA-04, 14/04/2016, 17:02UTC => UC = 725-750µrad
- Link #2016-EDRSA-05, 15/04/2016, 14:02UTC => UC = 835-890µrad
- Link #2016-EDRSA-06, 15/04/2016, 17:02UTC => UC = 715-740µrad

The measured UC of the EDRS-A LCT (<900µrad) is well within the field of view of the EDRS-A LCT acquisition sensor. This supports the EDRS-A LCT setting parameters used during the in-orbit test with the OGS (i.e., acquisition scanning parameters, alignment matrix between the satellite coordinate reference system and the LCT coordinate reference system)

IV. CONCLUSIONS

The EDRS-A LCT is part of the EDRS-A hosted payload embarked on the Eutelsat-9B satellite, which was launched on 29th January 2016. As part of the in-orbit commissioning phase of the EDRS-A payload, the EDRS-A LCT in-orbit test campaign with the ESA's Optical Ground Station (OGS) was successfully performed between March and April 2016.

The measured optical power and the estimated far field pattern characteristics of the EDRS-A LCT are within expectations, ratifying the EDRS-A LCT / OGS Link budget predictions. The measured Uncertainty Cone (UC) (<900µrad) proves the excellent initial pointing error of the EDRS-A LCT. The initial alignment matrix between the satellite coordinate reference system and the LCT coordinate reference system is, therefore, maintained for the next commissioning tests. Finally, the overall PAT (Pointing Acquisition and Tracking) sequence and timing from Pointing to Heterodyne Tracking (and including start of Frequency Acquisition) was successfully validated.

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