TESAT SPACECOM

PIONEERING WITH PASSION

Laserkommunikation – ein neues Kapitel in der maritimen Überwachung

DLRK – Rostock September 2015

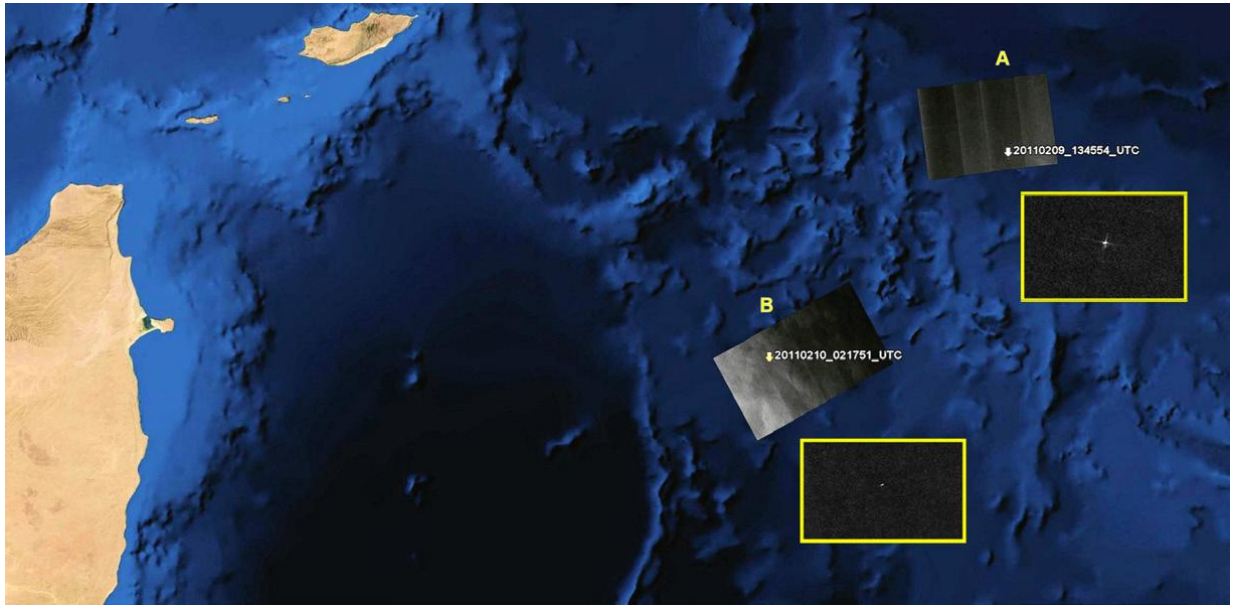
Dipl. Ing. Matthias Motzigemba

Facts about maritime security

- **UN estimates annual cost of piracy in the Indian Ocean $ 5 to 7 billion.**
- According to the International Maritime Bureau > 200 vessels were hijacked in the last 3 years
- Three main naval tasks forces are operating in the area, including EU's Operation **Atalanta**.
- **Satellite-based maritime surveillance** has supported anti-piracy operations since 2008 including the EMSA-led 'Pirasat' satellite-based surveillance exercises.

- **Actuality and precise data quality is a strong demand for improving the success of fast reaction forces.**

Todays maritime surveillance



COSMO-SkyMed images © ASI, 2011 - processed and distributed by e-GEOS

Auszug aus der Hightech Strategie für Deutschland:

Echtzeitdienste für die maritime Sicherheit – (EMSec)

- **Motivation des Bundesministeriums für Bildung und Forschung**
  - Mehr als zwei Drittel des gesamten **Frachtaufkommens** weltweit werden über die Weltmeere transportiert. Zudem soll durch ständig **wachsende** Offshore Windparks **die Energieversorgung** auch ohne fossile Brennstoffe sichergestellt werden.. Neben der Gefährdung durch kriminelle Handlungen, bedrohen auch Havarien und Sturmfluten die maritime Sicherheit.
- **Ziele und Vorgehen**
  - Es ist in erster Linie die Aufgabe von Behörden und Einrichtungen des Bundes und der Länder, den Risiken im maritimen Bereich zu begegnen. Dazu sind **detaillierte Informationen nötig, um die aktuelle (Not-)Situation einschätzen** und reagieren zu können. Im Projekt EMSec sollen Informationen und Lagebilder aus verschiedenen Quellen wie **Satelliten und Flugdiensten** für die behördlichen Endnutzer verständlich und je nach Anforderung flexibel dargestellt und schneller verfügbar gemacht werden.

=> Ganzheitliches Lagebild in hoher Auflösung in nahezu Echtzeit

IDEEN INNOVATION WACHSTUM
Die Hightech-Strategie für Deutschland

Innovation by **Laser Communication** in Space

- Available Microwave **Spectrum – „…the future** is optical“
- **No frequency regulation** - therefore no coordination process with other operators
- **High data** transmission – the „**Fiber in Space**“
- **Near real-time mission** tasking based on **bi-directional** link
- **Minimum latency of data refresh** by use of data relay – **from days to minutes**
- **Robust security** - narrow beam- **stealth** link
- **Protection** against jamming - **saftey from interception- no harmful Interference**

Optical Communication and GEO-Relay Service

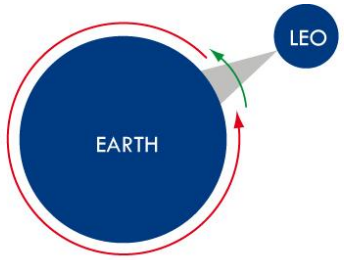
TODAY:
Typical LEO to Ground RF-Downlink

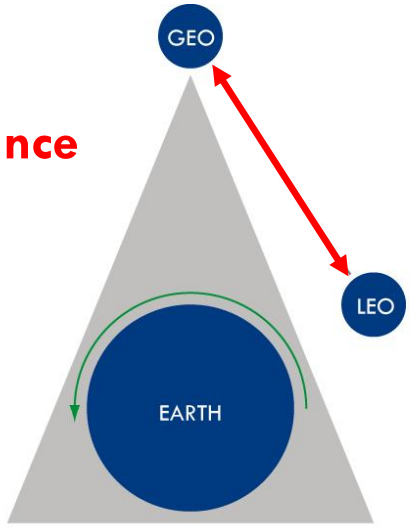
TOMORROW:
Optical Relay Service

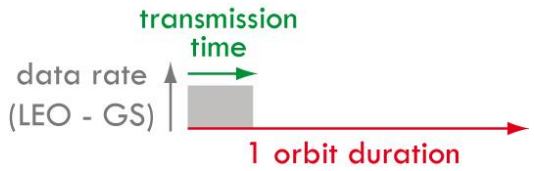
= Sovereignty of data: The ground station can be situated in the own country within line of sight to GEO S/C.

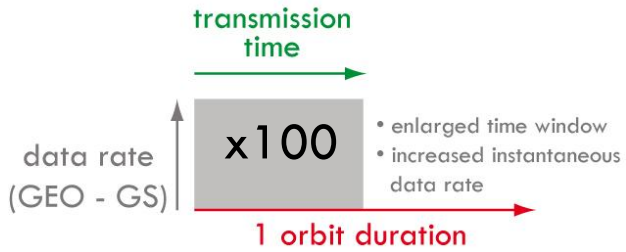
Transition from Mapping to re-active Surveillance

= Dependency: the EO-teleport could be a **foreign service** with use of terrestrial unprotected networks.









Main Market Drivers for optical Data Relay Service

- Demand for High data rate connectivity => **advanced sensors**
- Demand for fast information updates => **short latency time**

Weather Forecast & Now casting

Environment Monitoring & Agriculture

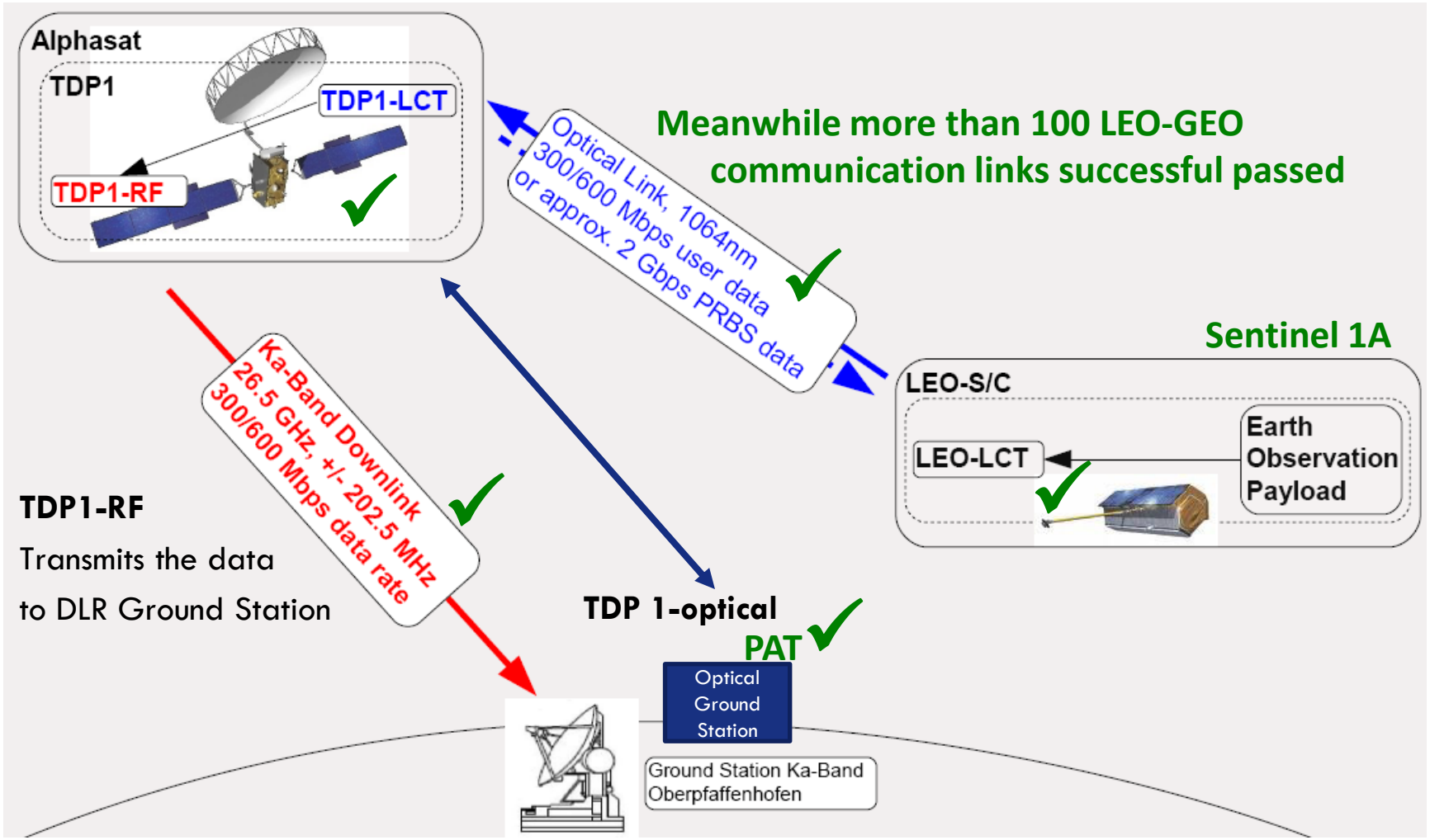
Natural Disasters & Emergency Response

Maritime Domain Awareness

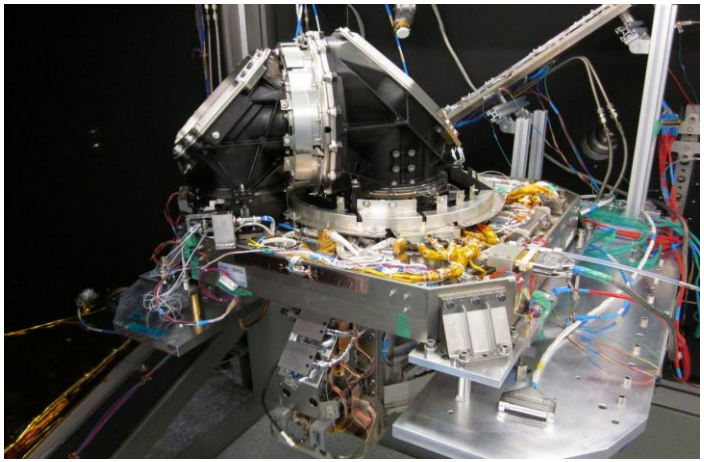
Credit: Airbus DS - CIS

- **Transmission of HD full motion video to support near real time situational awareness missions around the globe**

Optical Data Relay Service - End2End Demonstration



GEO- stationary LCT on Alphasat



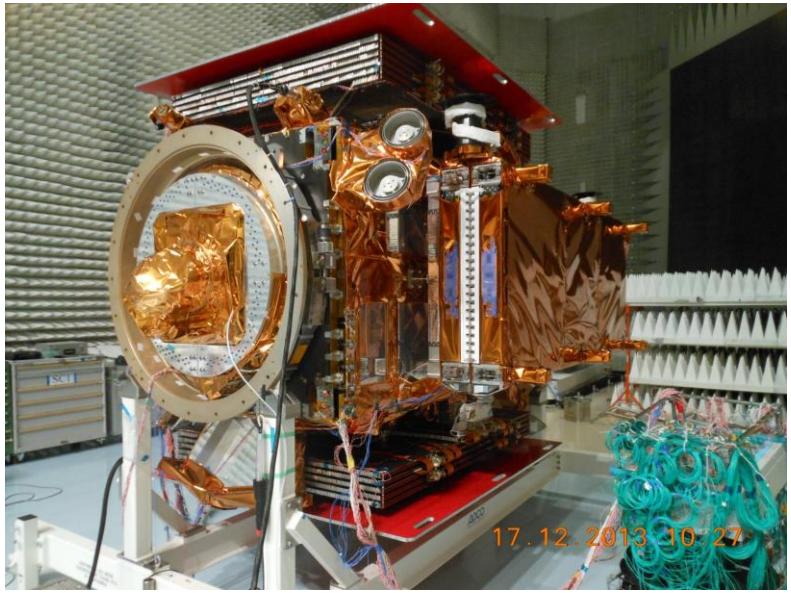
Pictures: TESAT

Picture: Airbus Defence & Space

Picture: Arianespace

Groundstation for optical Links with GEO Alphasat

Followed by LCT on LEO Sentinel 1A – launched in April 2014



LCT – successful integrated and tested on Sentinel 1A (Dez 2013)

LCT – launched in Orbit (April 2014)

Laser Com Inter Satellite Link and Ka-Band Downlink for Gigabit Data Relay Service – successful communication Links

SENTINEL-1A OCP

LAT: 80.92° LON: 39.87° ALT: 708km

TERMINAL MODE: **COMMUNICATION**

OPTICAL LINK

DATE/TIME: 2014-10-16 11:07:25

STATUS: **DUPLEX ENGAGED**

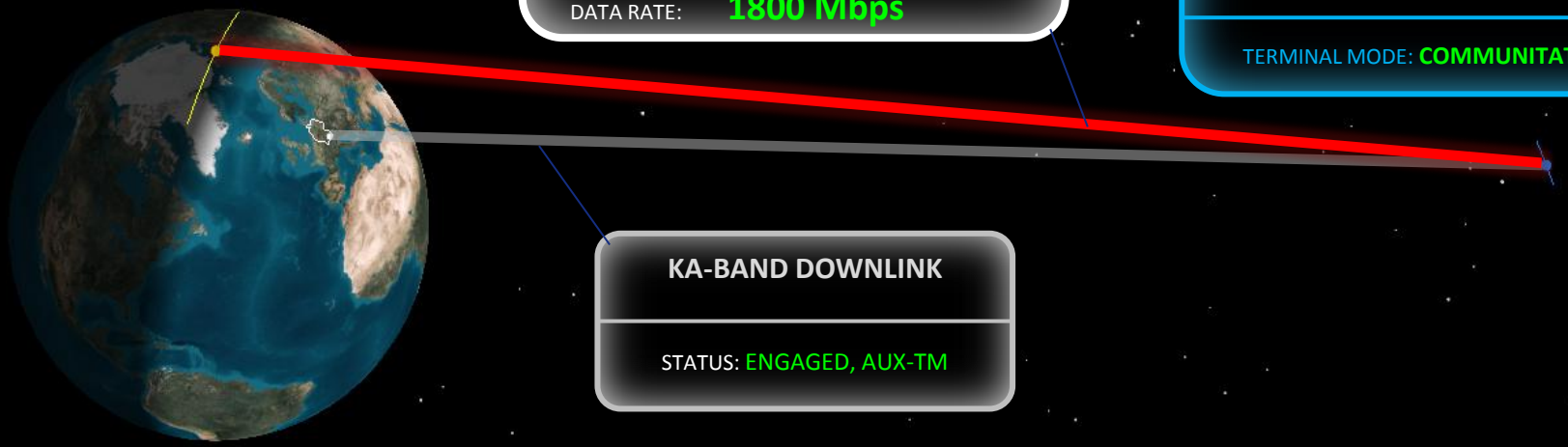
LINK DISTANCE: **41.700 km**

DATA RATE: **1800 Mbps**

ALPHASAT TDP1

LAT: 0.01° LON: 24.89° ALT: 35778km

TERMINAL MODE: **COMMUNITATION**



KA-BAND DOWNLINK

STATUS: ENGAGED, AUX-TM

LASER COMMUNICATION TERMINALS

WE LIGHT UP SPACE

TESAT SPACECOM

PIONEERING WITH PASSION

DLR

esa

First Sentinel Laser Link via Gigabit Data Relay (Nov. 2014)

Magalie Vassiere: "**You can visualise the link of today as an optical fibre in the sky that can connect the**
ESA director TIA **Sentinels back home to Europe, from wherever they are on their orbit around Earth.**

The occasion was marked by an event held at ESA's Space Operations Centre in Darmstadt, Germany. Attendees included Wolfgang Scheremet, Director General of Industrial Policy, German Federal Ministry for Economic Affairs and Energy; Gerd Gruppe, Member of the DLR Executive Board responsible for Space Administration; Daniel Quintart, from the European Commission DG Enterprise and Industry; Magalie Vassiere, ESA Director of Telecommunications and Integrated Applications; Guido Levrini, ESA Copernicus space segment program manager; Peter Schlote, Tesat Spacecom Managing Director.

Radar Images – now just in time

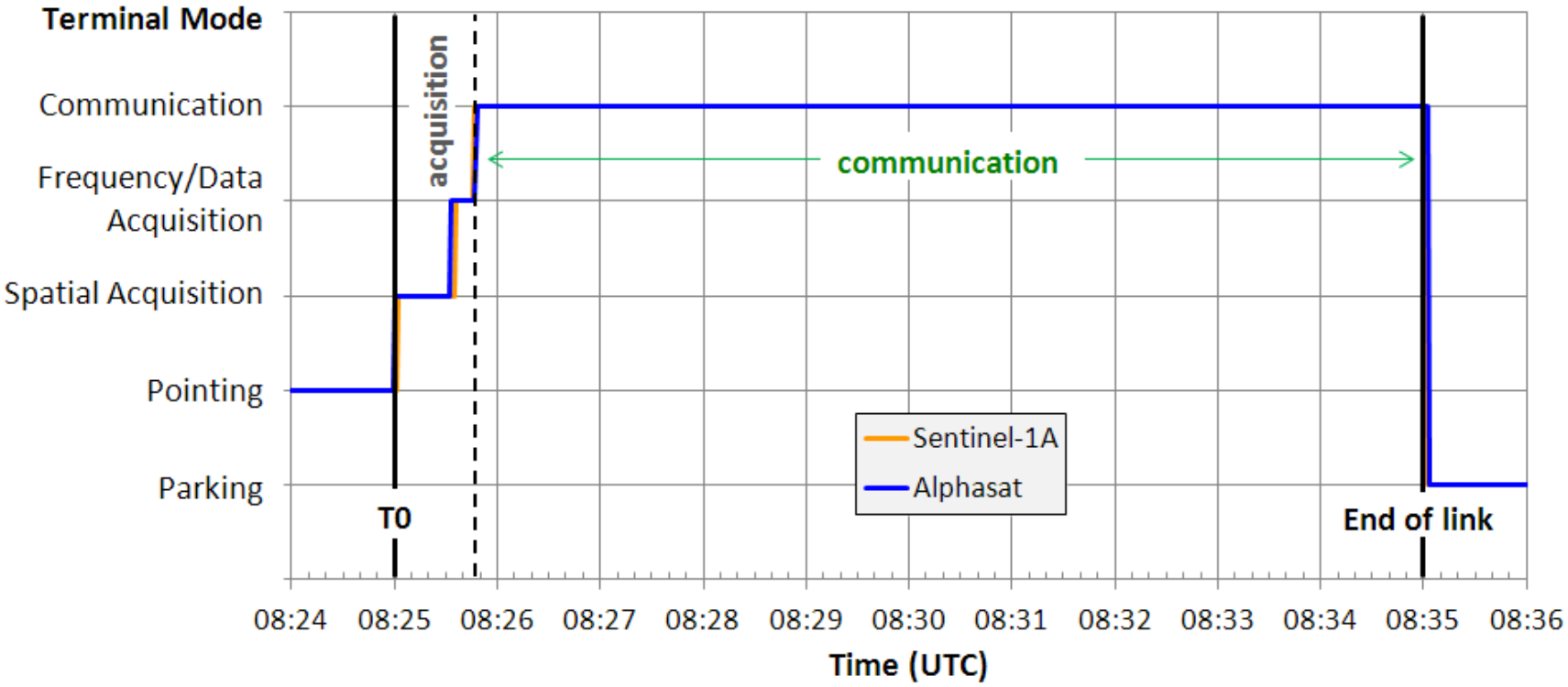
(source ESA, Internet)

This image was captured by **Sentinel-1A** on 28 November 2014 and **directly transmitted** almost 40 000 km **across space by laser** to the Alphasat telecommunications satellite in geostationary orbit, which then downlinked the data to Earth.

All of this happened in a matter of moments

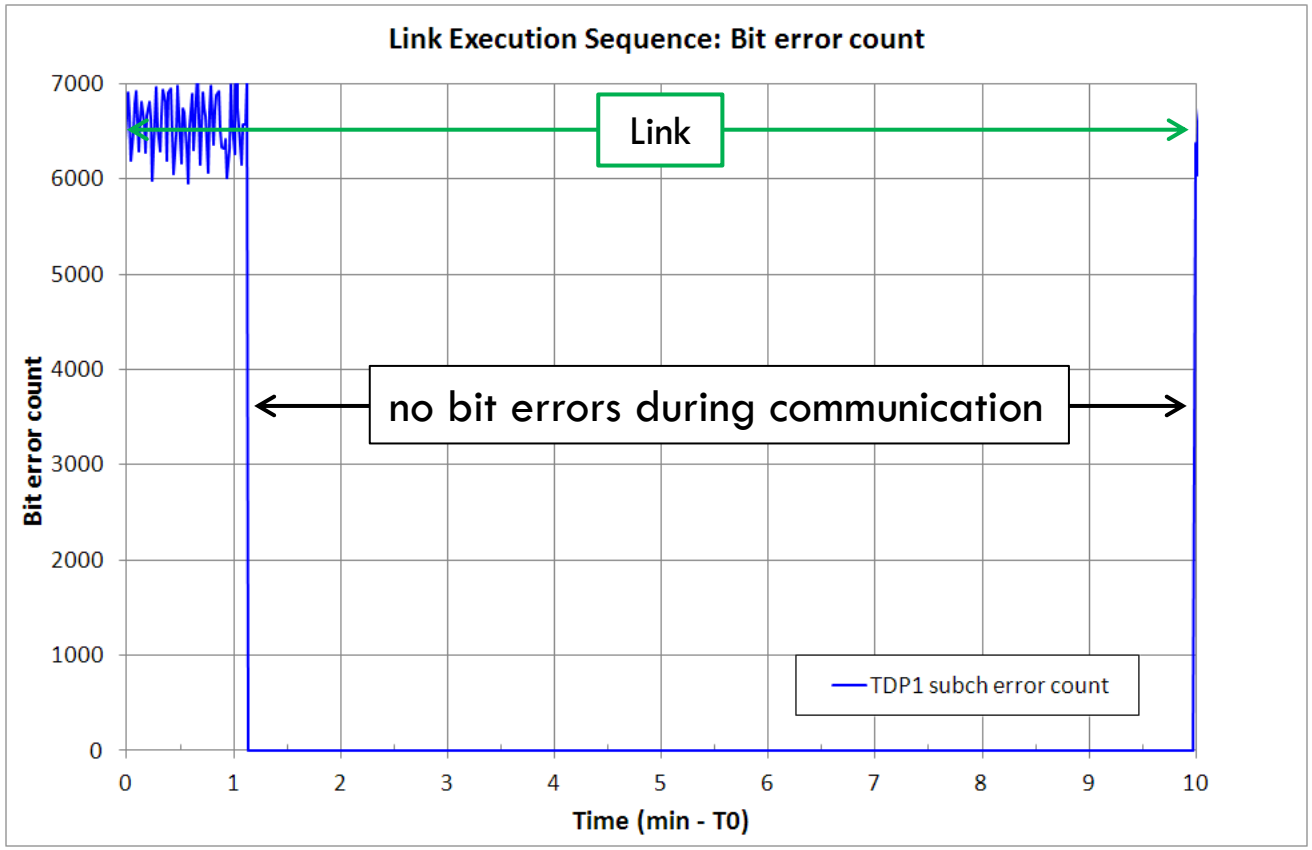
- part of a live demonstration at ESA's space operation centre ESOC.

Fast acquisition and perfect communication for SAR data transmission



Live Link with highest quality

- Bit-Error free communication



Robust System Design – stress tests…

- Stable link acquisition and communication **performance verified** under various hard conditions:

  - Link durations between 3 Minutes and 20 Minutes
  - Link distances between 37.000 km and 44.500 km
  - Relative velocities up to 7.300 m/s
  - Sun angles down to 9° vs line of sight (tests down to 0° planned in 2015)
  - Grazing altitude down to 100 km (tests down to 20 km planned in 2015)
  - Artificially induced orbit uncertainties > 1000 µrad
  - S/C microvibration environment
    - by different reaction wheel speeds within nominal range
    - Tests at solar array angles with worst case coupling to LCT

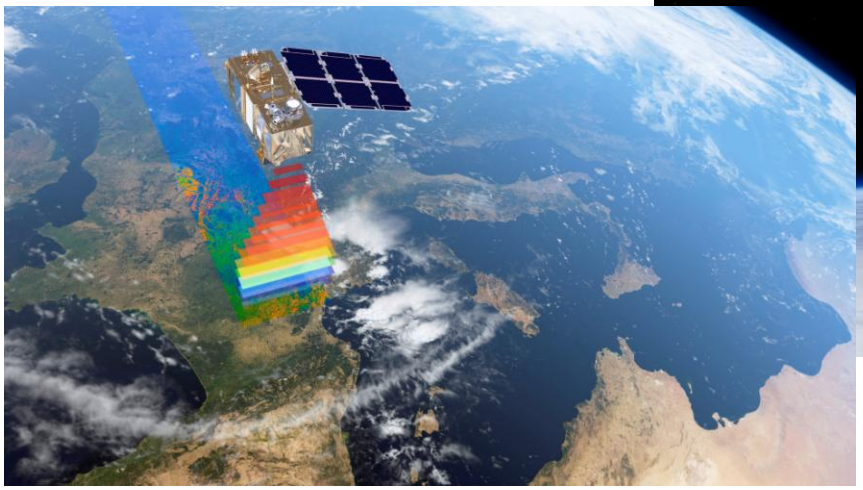
- **LCT shows budget for longer distances or smaller LEO LCT design.**

Example of ongoing Tests with Alphasat TDP1

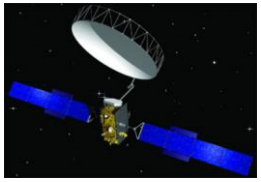
Test No.	Titel	TDP1	with S1A	with S2A	with TAOGS
001	Parameter and algorithm optimization		x	x	x
002	Link budget verification		x	x	
003	Com Performance vs. optical TX power		x	x	x
004	TX-beam opening angle		x	x	x
005/006	Open/Closed loop jitter measurement		x	x	
007/008	Influence of sun on spatial acquisition / comm			x	
009/010	Influence of low grazing altitude on spatial acquisition / comm		x		
011	CAS/FAS noise determination		x	x	
012/013/014	Thermal tests with LCT off / LHP startup / performance	x			
015/016	Influence of thrusters on spatial acquisition / comm			x	
017	Generation of atmospheric model for 1064nm		x	x	x
018	Optical uplinks from selected locations				x

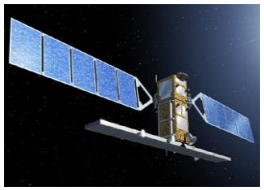
Successful launch of LCT on Sentinel 2A

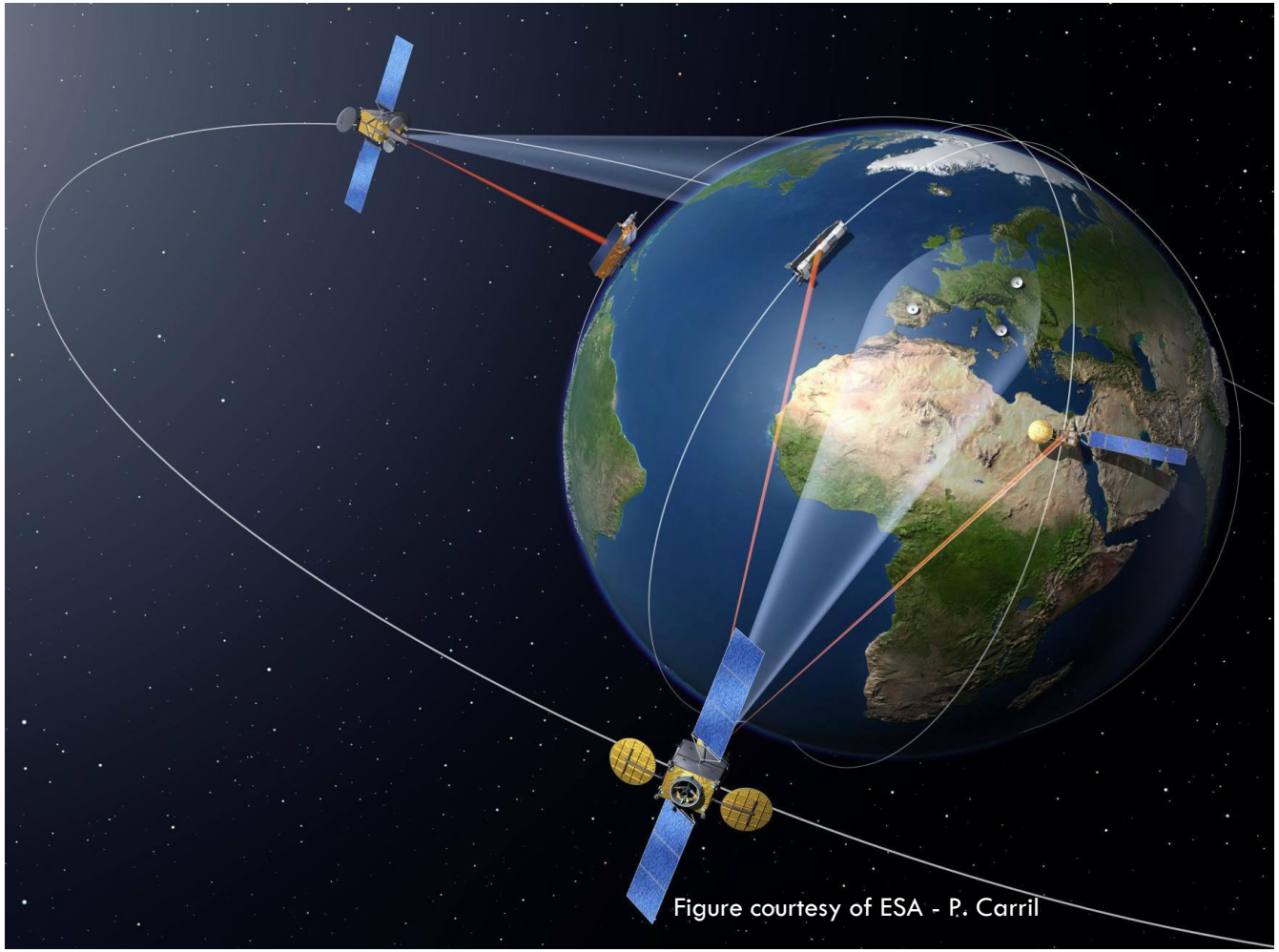
- In orbit since 23.06.2015
- Start of Inter Satellite Links to GEO by Oct .2015



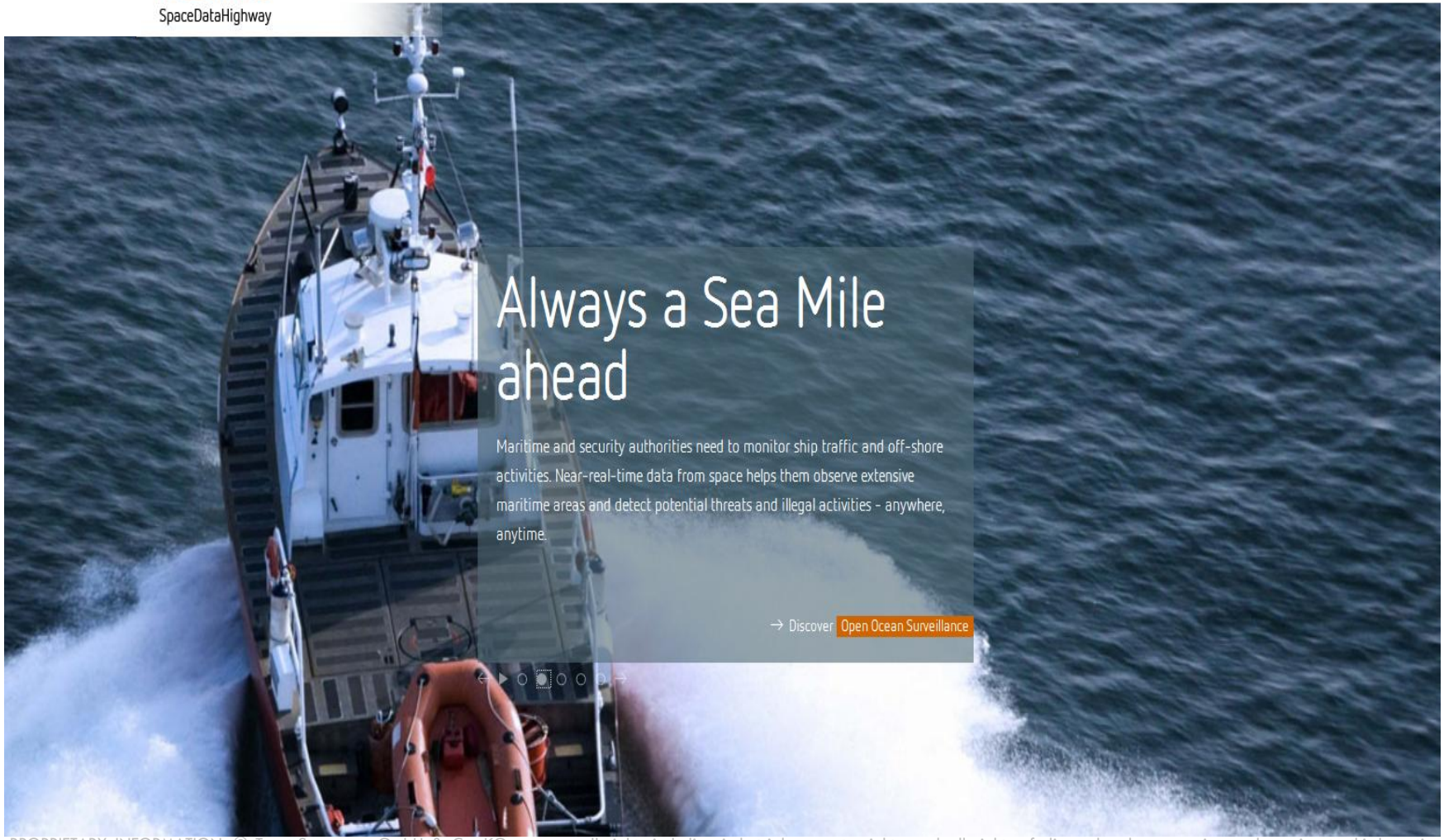
Commercial Service offered in EDRS – European Data Relay System







Use of new Services for the benefit of the society

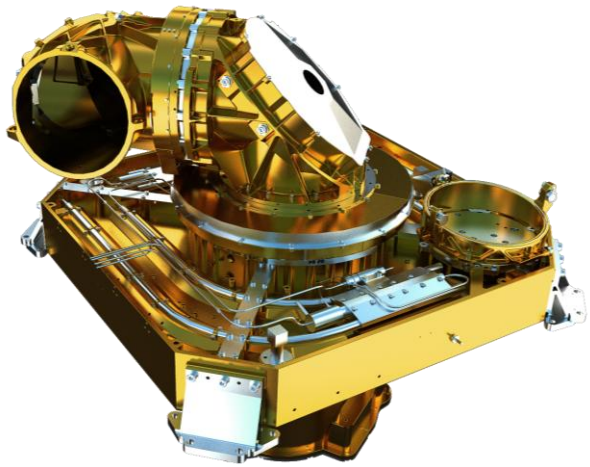


Commercial product Laser Communication Terminal LCT

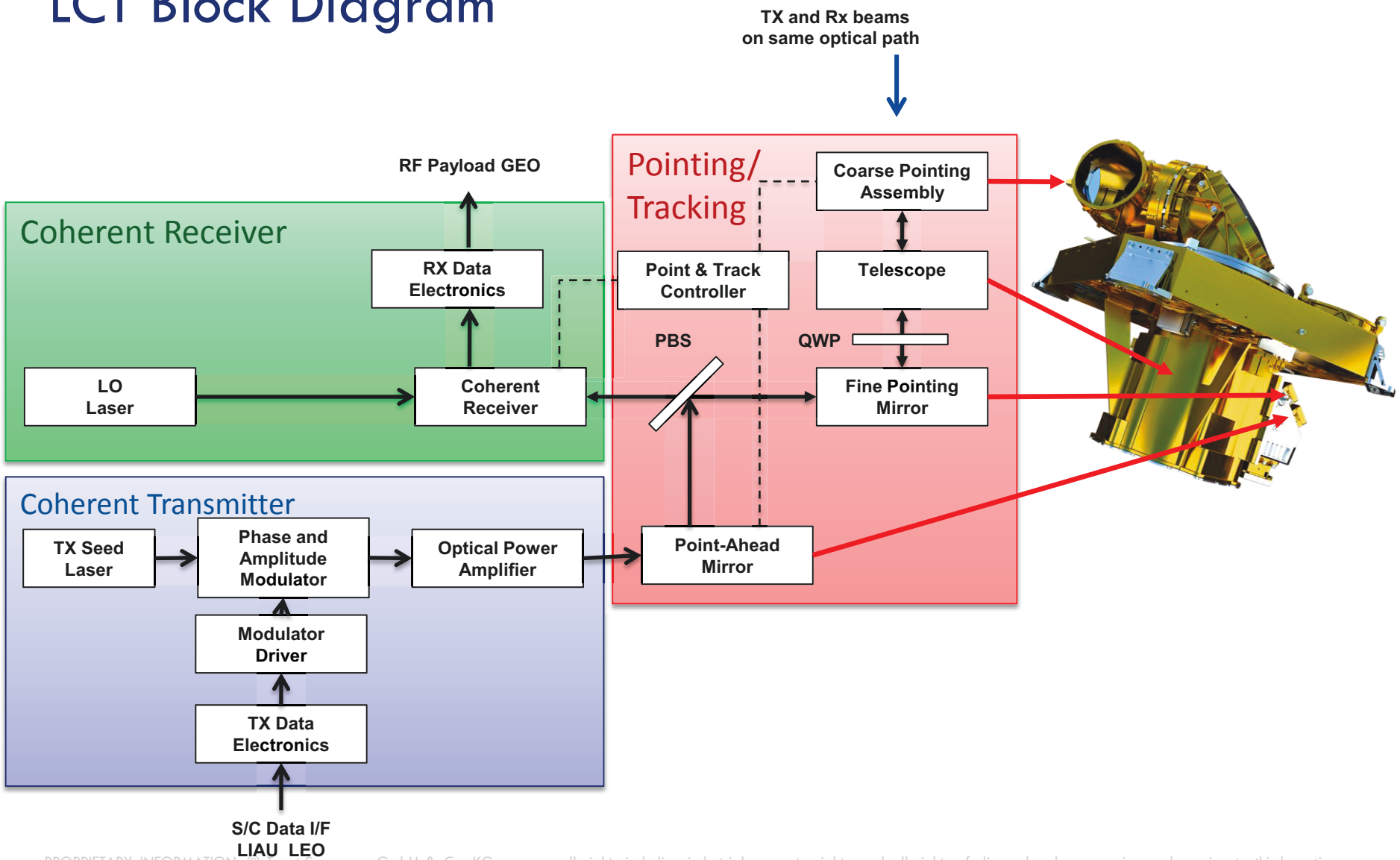
Tesat LCT is in Space with a coherent, **space qualified** 1064 nm Laser Source, using homodyne BPSK-Modulation.
This results in most efficient modulation scheme for **high data rate** transmission **RX efficiency** and an **immunity against sunlight and jamming.**

- actual: **14 Flight Models** are delivered or under production.

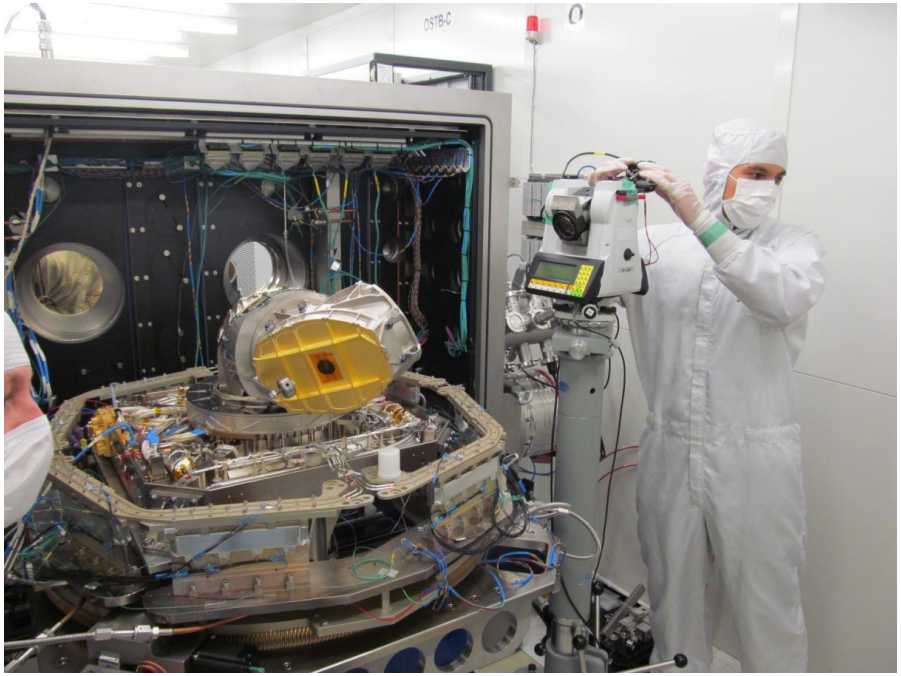
Long Range Version	**LEO – GEO**
Range	**45,000 km**
Data Rate	**1,8 Gbps**
Transmit Power	**2,2 W**
Telescope Diam.	**135 mm**
Mass	**~ 53 kg**
Power consumption	**~ 160 W max.**
Volume	**~ 0.6 x 0.6 x 0.7 m**



LCT Block Diagram



Assembly, Integration and Test



LCT in clean room and optical test bed with Thermo Vaccum Chamber

LCT – ready for shipment

Award fromJPL/NASA for excellent performance of Reference Laser Units in 1064nm.

JPL
Jet Propulsion Laboratory
California Institute of Technology

NASA

Certificate of Recognition

Presented to the

Tesat Spacecom Laser Products Team

GRACE FOLLOW-ON

For outstanding partnering throughout the Reference Laser Unit (RLU) program life cycle for the Laser Ranging Interferometer on the GRACE Follow-On Mission, and in appreciation for the early delivery and excellent performance of the RLUs.

Awarded on this day, the 22nd day of June, 2015.

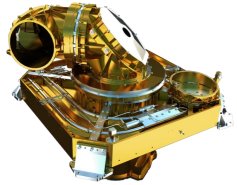
Alex Abramovici
Alex Abramovici

William Klipstein

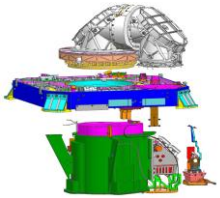
LCT Product Portfolio

Based on heritage building blocks, we are able to offer tailored and adapted variances for different LCT applications, like:

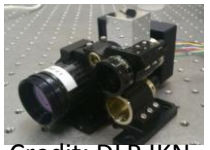
1. ISL/IOL LEO to GEO (45.000 km, 1.8 Gbps)
2. Backbone GEO to GEO (75.000 km, 1,8 Gbps)



3. LEO light (CPA less, TX only, TLA70, 30kg, 45.000 km)
4. LEO smart (modular, CPTL, 22kg, 45.000 km)

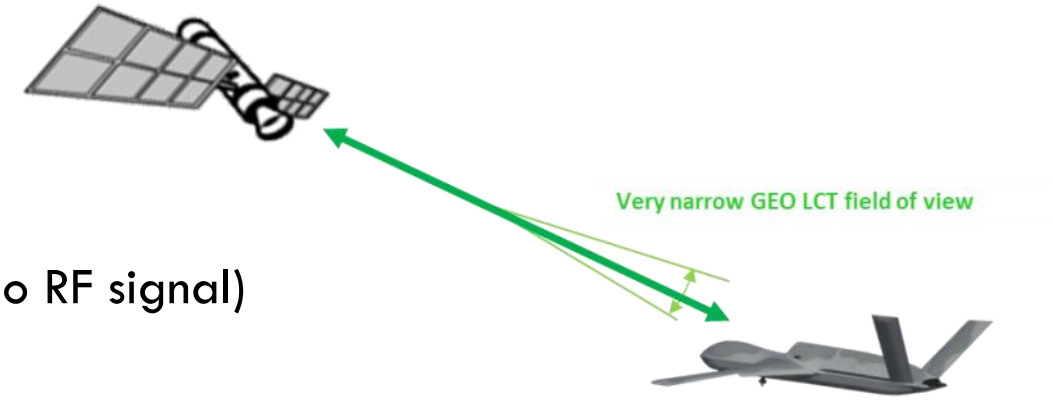


5. LEO DTE (IKN design, 5kg, downlink, up to10 Gbps)
6. ConLCT (Navigation, ISL Constellation, low SWAP)



Credit: DLR IKN

Next Application – UAV BLOS Laser Link Robustness



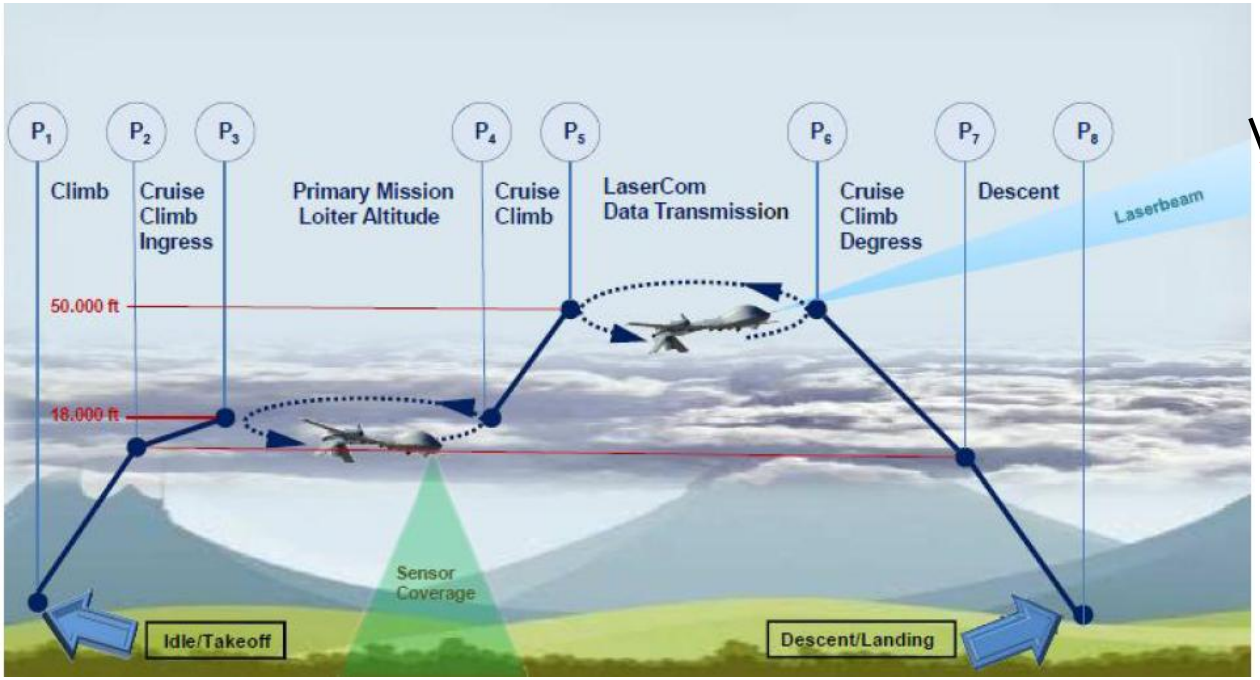
- **Stealth link:**
  protection against passive
  electronic emissions RADAR (no RF signal)

- **Free use of spectrum:**
  optical link not regulated

- **Jamming-proof:**
  Laser link cannot be broken by rogue kW ground laser due to coded acquisition signal and coherent detection (phase lock)

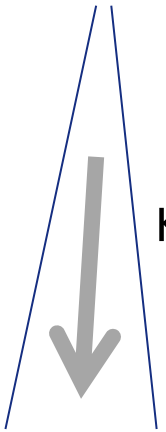
- **High data rate:**
  up to 1.8 Gbps connection for high class sensor technology

UAS – BLOS Concept of Operations



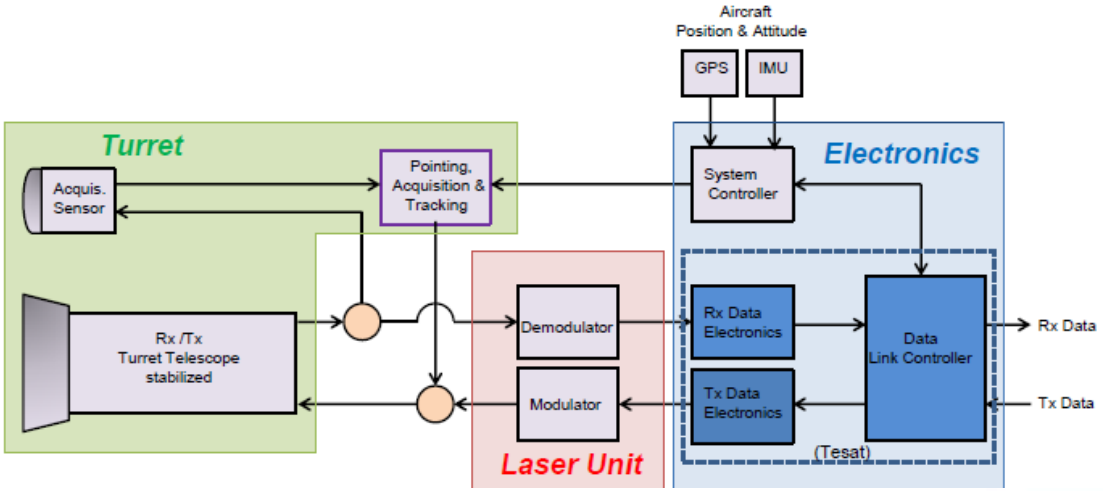
„For laser com, stay above the weather“

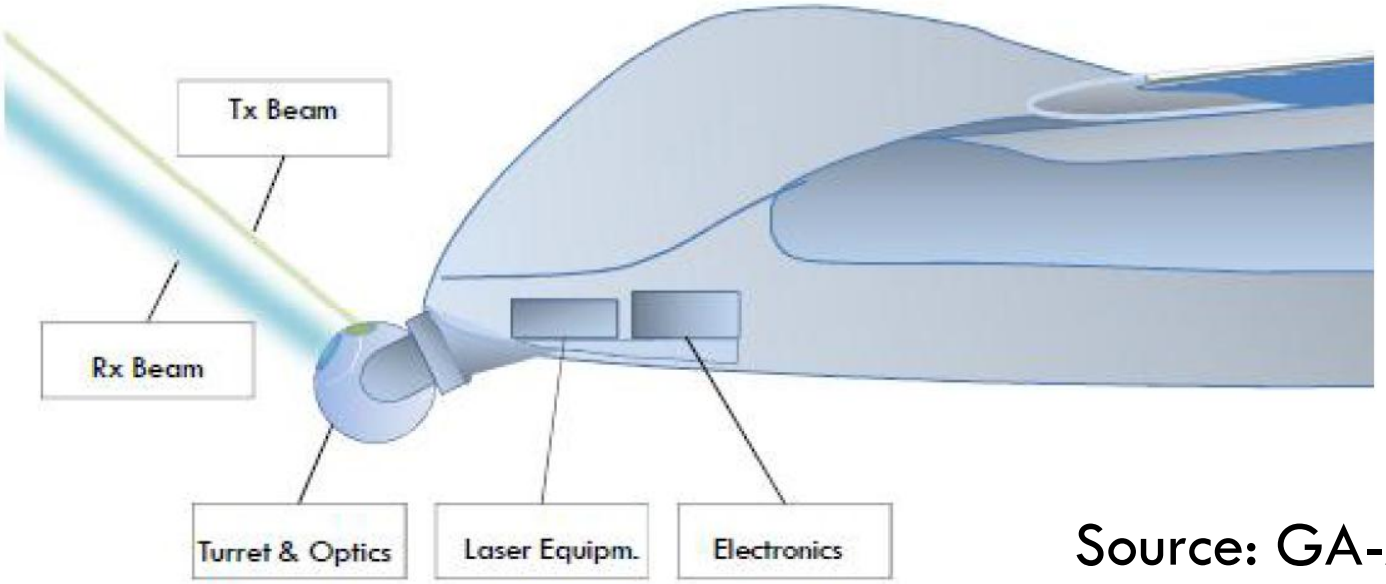
Laser



Ka-band

UAV Airborne terminal: Teaming concept



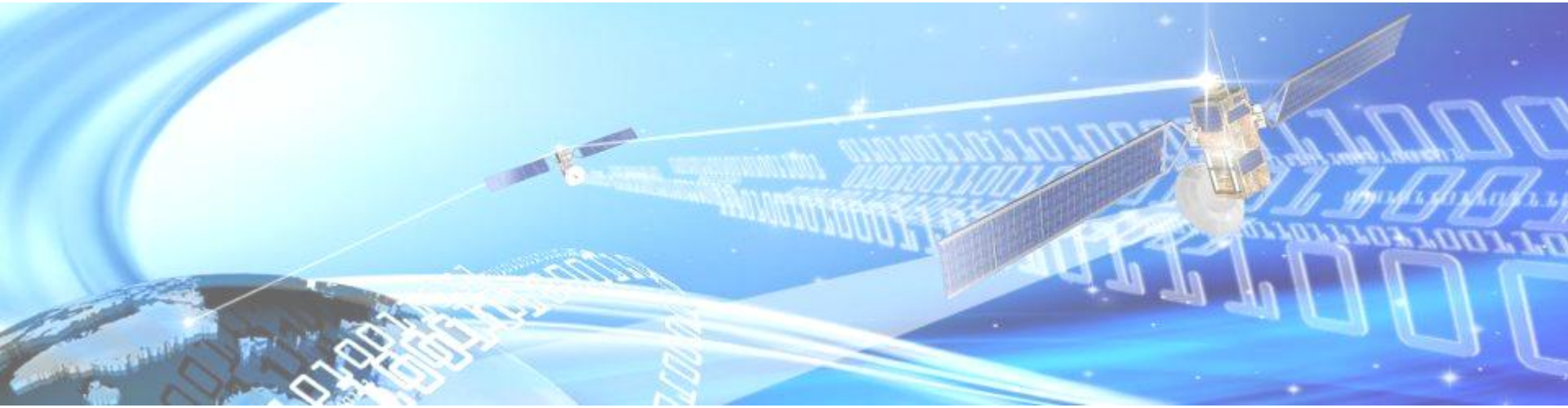


Source: GA-ASI

PR

Summary

- A new chapter begins for earth observation missions- from mapping to **reactive surveillance -** under data souvereingty aspects.
- The laser communication is the solution to protect your invest against intentional or unintentional **harmful interferences(IHI) .**
- This innovative technology **enhance future applications** in space and airborne, **for new sensors** and improved concepts of operations with **high data rate** and **low latency** time.
- TESAT has established a **commercial production** line with actual 14 LCTs under contract, of which 7 LCTs will be in orbit until 2015.



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