



# OPTICAL COMMUNICATION TERMINALS IN SPACE 2022

Nils Höpcke

2022-09-14

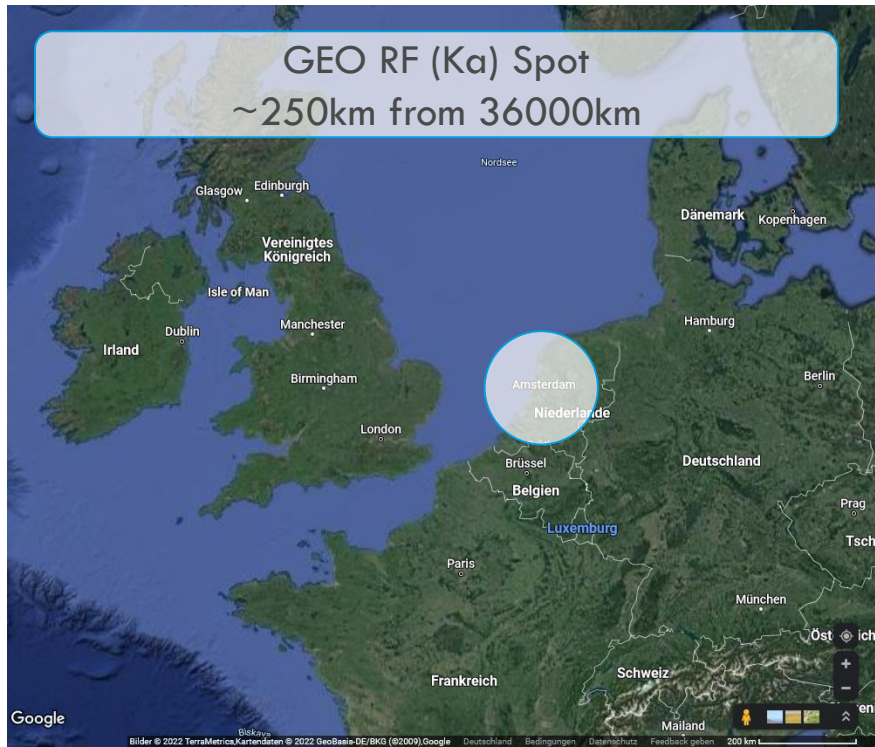
- » Introduction
  - » Advantages of Optical Inter-satellite Laser Communication
  - » Challenges of Optical Inter-satellite Laser Communication
  - » Laser Communication Application
  - » Laser Communication Missions
- » SCOT - Scalable Optical Terminal
  - » Scalable and Modular Approach
  - » SCOT80 - Key Facts
  - » SCOT80 - Design Details
- » LCT135 and SmartLCT70
  - » LCT135
  - » SmartLCT70
- » Smallsat and DTE
  - » TOSIRIS
  - » CubeL
- » Summary



A large, abstract graphic composed of numerous small grey dots of varying sizes, arranged in a pattern that resembles a satellite constellation or a network. The dots are more densely packed in the center and become sparser towards the edges.

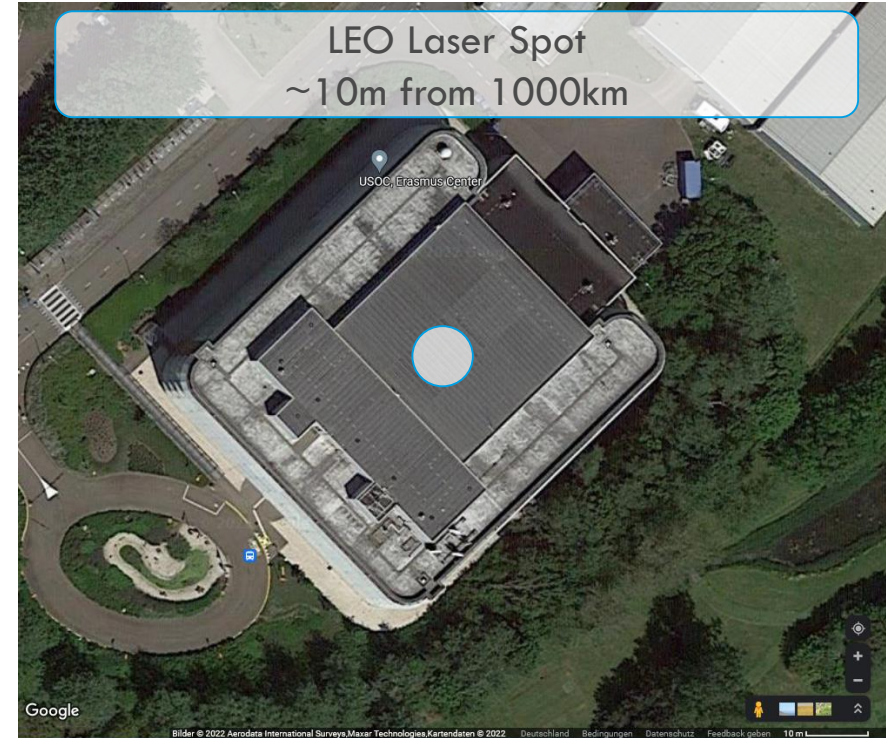
## INTRODUCTION

# ADVANTAGES OF OPTICAL INTER-SATELLITE LASER COMMUNICATION



## » Reasons for Laser Communication

- » Power efficient
- » Secure communication
- » Resilient against jamming
- » High data rate support
- » No frequency regulations
- » Low data latency using GEO relay or LEO constellation



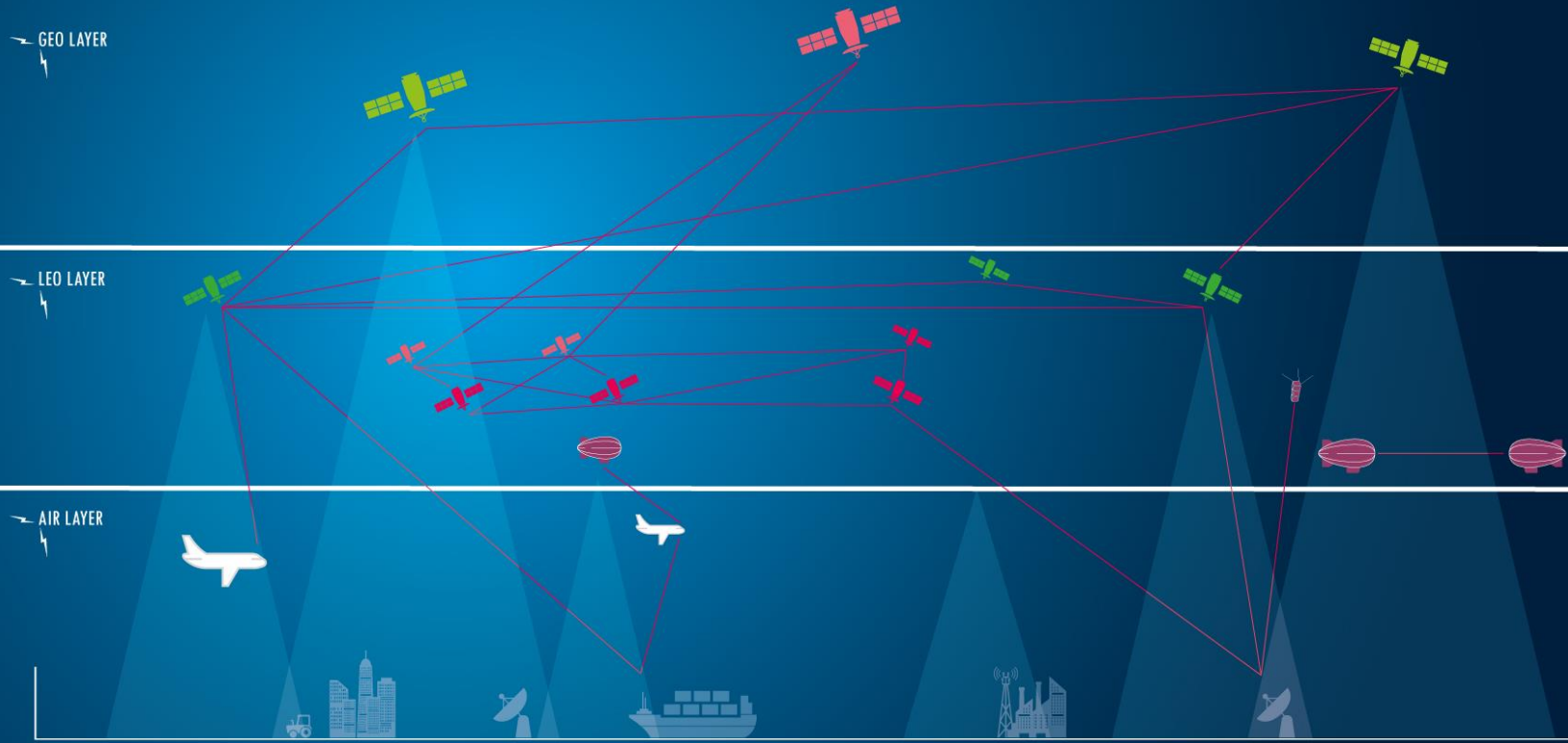
- » Challenges of Laser Communication
  - » Low beam divergence requires excellent beam pointing  $\sim \mu\text{rad}$
  - » Dedicated Pointing Acquisition and Tracking (PAT) Algorithms
  - » Space environment
  - » Higher optical power than in terrestrial application



- Relative velocity  $\sim 40,000 \text{ Km/h}$
- Laser spot after  $1000\text{Km} \sim 10\text{m}$
- Pointing accuracy  $\sim \mu\text{rads}$

# OPTICAL NETWORK PRODUCTS PROVIDED BY TESAT SINCE 2007

## - Multi Orbit Connectivity



GROUND LAYER

LCT135  
1.8 Gbps @ 80,000 km

SmartLCT70  
1.8 Gbps @ 45,000 km

SCOT135  
100 Gbps @ 45,000 km

SCOT80  
2.5 Gbps @ 7,000 km

CubeLCT DTE/ISL  
100 Mbps @ 1,500 km

CubeLCT4Air  
100 Mbps @ 1,500 km

COHERENT, 1,064 nm TECHNOLOGY

1,550 nm TECHNOLOGY

SMALLSAT &amp; AIR

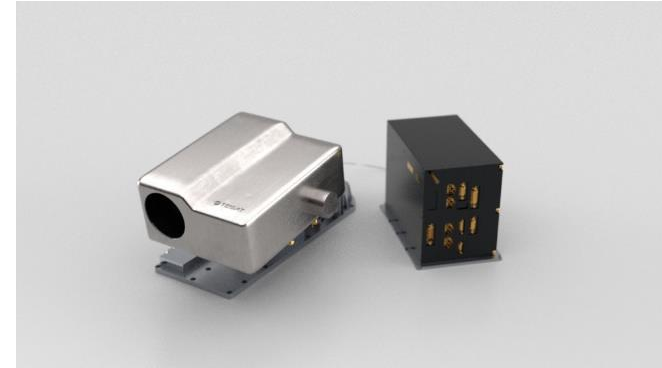
# LASER COMMUNICATION IN ORBIT MISSIONS- MORE THAN 500,000 OPERATIONAL HOURS



**250** LCTs  
Under Contract



## SCOT - SCALABLE OPTICAL TERMINALS



# SCALABLE AND MODULAR APPROACH FOR CUSTOMIZED SOLUTIONS

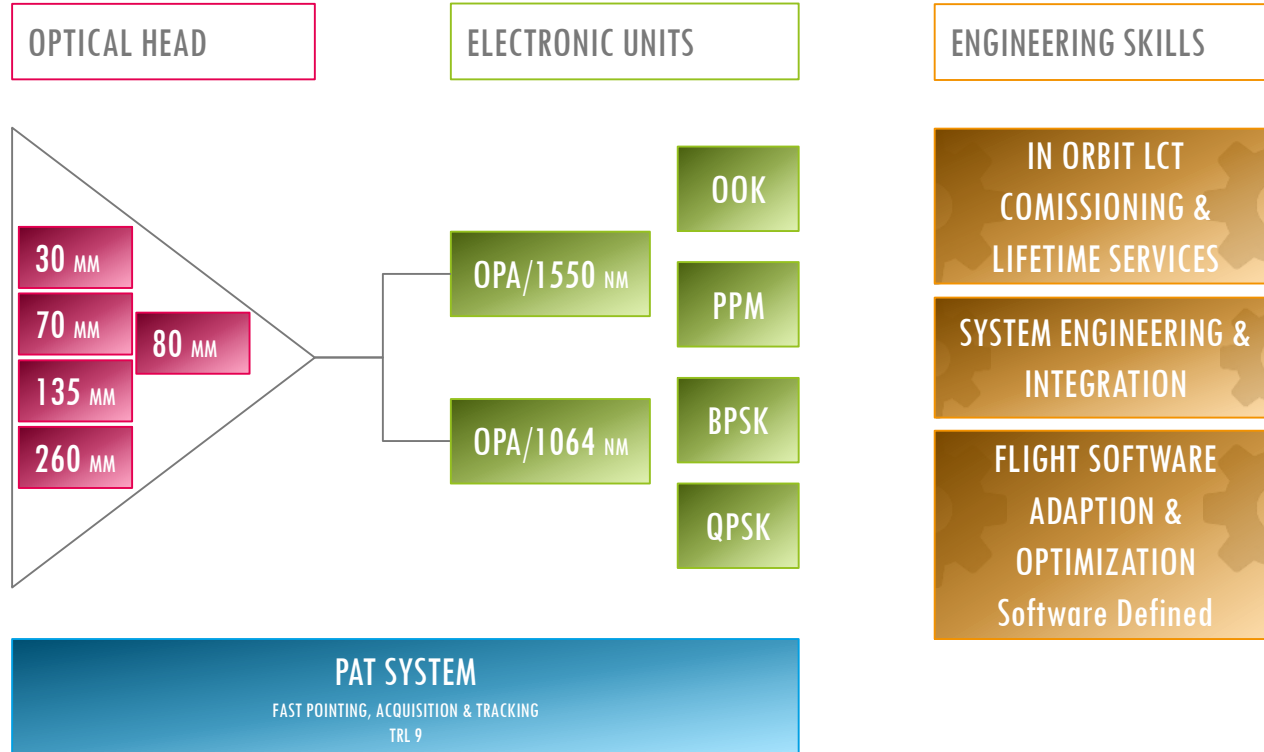
Combination of building blocks to tailor the LCT to the mission

## PERFORMANCE RANGE

Data Rate versus Distance

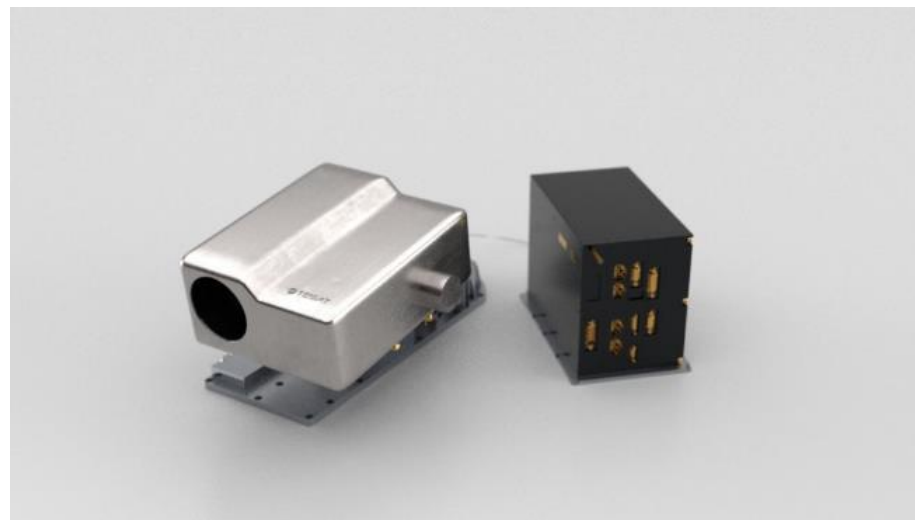
**0.25 Gbps to +100 Gbps**  
over

100 km to 80,000 km



## SCOT80 Scalable Optical Terminal provides broadband connectivity in LEO constellations

	SCOT80
Optical Head Aperture	80 mm
Wavelength	1550 nm
Modulation	OOK
Data Rate	200 Mbps SDA Tranch 0 2.5 Gbps SDA Tranch 1 10 Gbps at 7000 km for commercial broadband missions 100 Gbps (Transceiver Qualification)
Coding	LPC, RS, LDPC (re-programmable in-orbit)
Ranging	1-way, 2-way ranging
Data Interface	Ethernet
TM/TC Interface	Ethernet
Max OAU Power	2W, 4W, 5W
Range	250 km – 10,000 km
Gimbal Range	Azimuth +/-160°, Elevation +/-55°
LOS Velocity	5°/s tracking & slew
Mass	12.5kg incl. harness
SDA Std. Compliant	2.1.2 (T0), 3.0 (T1)



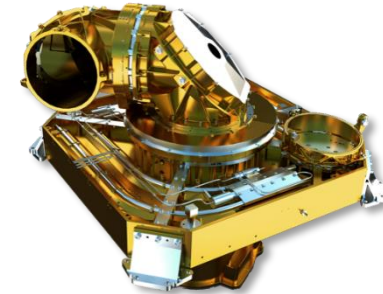
- » Technology Key Fact
  - » EU
    - » EDFA
    - » Re-programmable FPGA for optical channel FEC
    - » Re-programmable FPGA for Pointing Acquisition and Tracking Algorithms
  - » OH
    - » 4-mirror athermal off-axis telescope
    - » Voice coil Fine Steering Mechanism (FSM)
    - » InGaAs Tracking and Acquisition Sensor (ATS)
    - » Integrated Transceiver Modules
    - » Wavelength switch (WSX) based on waveguide mechanism
- » New Space Parts Approach
  - » Parts Agency with 60 EEE Experts
    - » Industrial grade parts
    - » Not worse quality as Class A parts, but often better
    - » Comply to industry standards
    - » Quality is individually verified (e.g. by manufacturer reliability data, lot testing, ...)
  - » Lead free process (soldering/cleaning/coating)

A large, abstract graphic composed of a dense field of small grey dots of varying sizes, arranged in a pattern that resembles a stylized map of Europe or a similar geographical shape. The dots are more concentrated in the center and become sparser towards the edges.

## LCT135 AND SMARTLCT70

# DATA RELAY TRL9 – GEO LCT 135

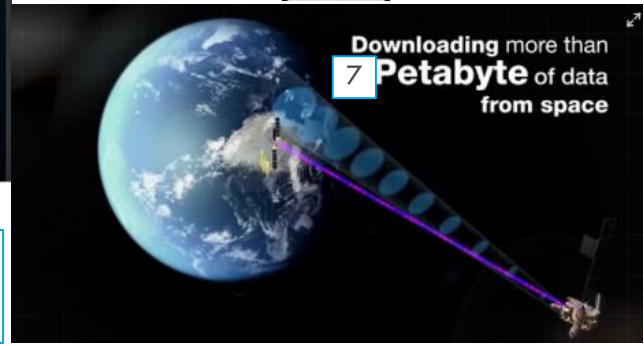
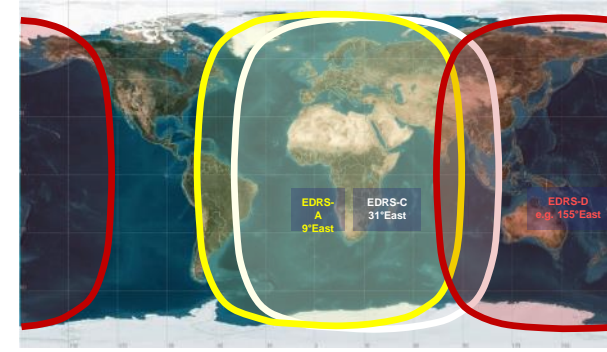
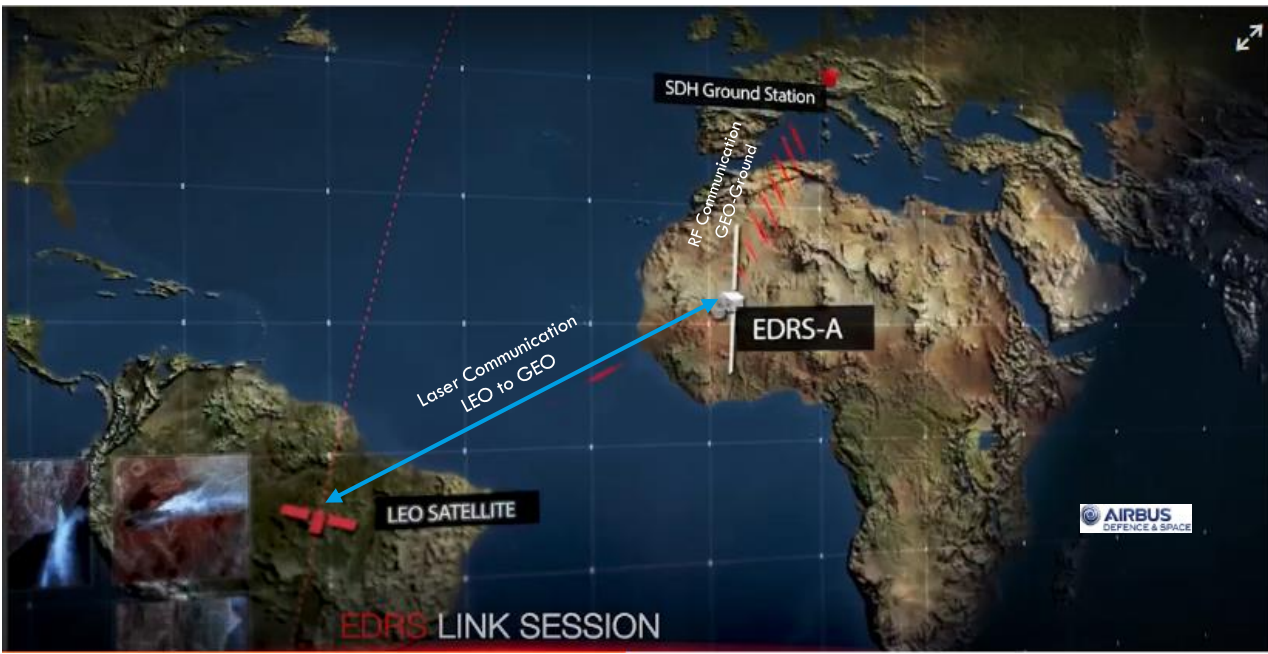
- » Tesat LCT in Space with Coherent, **Space Qualified**  
1064 nm Laser Source, using **Homodyne BPSK** Modulation
- » Results in the **Most Efficient** Design for Long Range,  
High Data Rate Transmissions with Resiliency to Sunlight  
and Jamming
- » Perfect Media for **Quantum Key Distribution**
- » **16 Flight Models** Delivered or in Production
- » Design will **Support GEO - GEO Backbone up to 80,000 km  
at 1.8 Gbps**



Long Range Version    LEO2GEO and    GEO2GEO

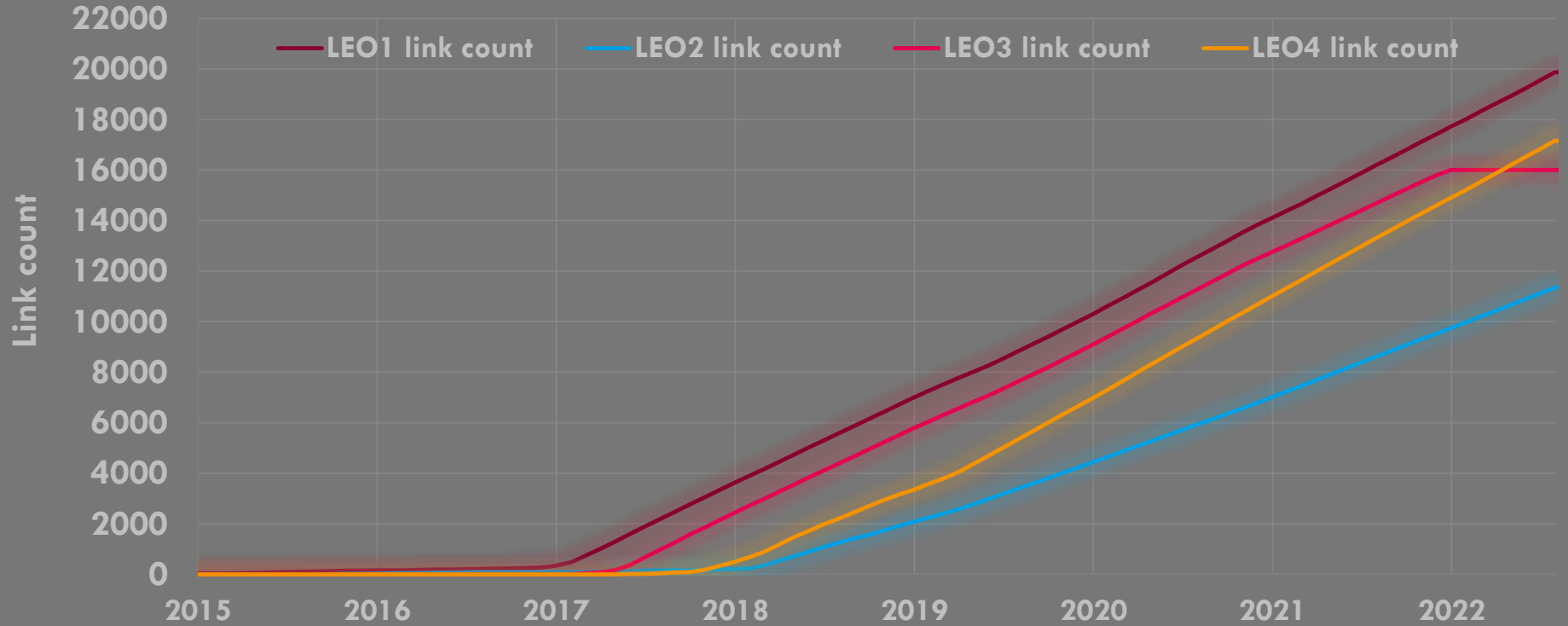
Range	45,000 km / 80,000 km
Data Rate	1.8 Gbps
Transmit Power	2.2 W
Telescope Diam.	135 mm
Mass	ca. 53 kg
Power Consumption	ca. 150 W max.
Volume	ca. 0.6 x 0.6 x 0.7 m

# LONG RANGE MISSIONS UP TO 80,000 KM WITH GEO LCT135...



...each month 1,000 optical LEO to GEO links  
total amount today 68,000 links performed

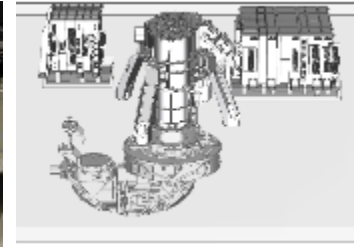
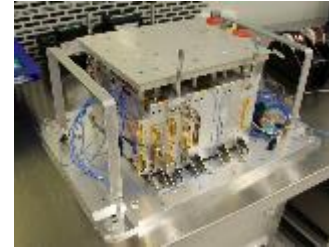
## EDRS cumulated link count





## DATA RELAY - LEO SMART 70 - THE USER TERMINAL FOR COPERNICUS

- » From 135 mm to **70 mm Aperture, 1,8 Gbps@45.000km**
  - » Reduction of SWAP and Price compared to the GEO LCT135
  - » Modular Approach with separate Communication Unit, Optical Unit and Coarse Pointer Assembly (CPA, if needed)
- 
- » Homodyne BPSK modulation at 1064 nm
  - » Resiliency to jamming and sun outages
- 
- » First flight on Airbus “Pleiades Neo“ Program. **Delivery in 2021**
- 
- » ULTRA Precision Timing and Ranging **COMPASSO**
    - » DLR-Galileo Competence Center DLR-IQT/IKN, MENLO, TESAT
    - » Accomodation on ArGUS / Bartolomeo
    - » Future use in GNSS



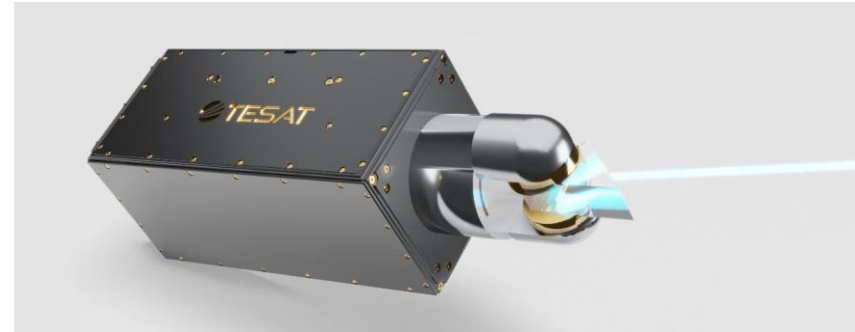
A large, abstract graphic composed of numerous small grey dots of varying sizes and densities, arranged in a pattern that resembles a satellite constellation or a network. The dots are more concentrated in the center and become sparser towards the edges.

## SMALLSAT AND DTE

# LEO LCT FOR 10G Down LINK MISSIONS – TOSIRIS

## Tesat Direct-to-Earth (DTE) Data Transmission LCT:

- » Downlink Data Rate: 10 Gbps
- » Dimensions: 28 x 20 x 15 cm<sup>3</sup>
- » Mass: 9 kg
- » Power Communication: 80 W
- » Design Lifetime in Orbit: 5 Years
- » Standard Compliance: CCSDS



## Features:

- » OSIRIS (IKN) Prototype Based on TRL8 Technologies **In Orbit** on the BIROS Satellite since 2017
- » TOSIRIS will Include Coarse Pointing Mechanism, Mass Memory Supporting the 10 Gbps Downlink Rate, with a Low Data Rate SC IF and Terminal Controller Inside
- » 1 Mbps Optical Uplink Channel from Ground to SC for TM/TC and Handshake
- » **First commercial Mission on Titania**

- » CubeLCT is an optical Transmitter for optical data downlinks from LEO
- » Technology Cooperation with **DLR-IKN, Tesat as the industrial partner for Cube manufacturing**
- » Cubel: **400g / 8W @ 100 Mbps**
- » CubeL+ : Evolution to **1Gbps** and bi-directional inter satellite links in 2023

© GOMSPACE

## » TRL9

### In-orbit verification in PIXL-1 Mission



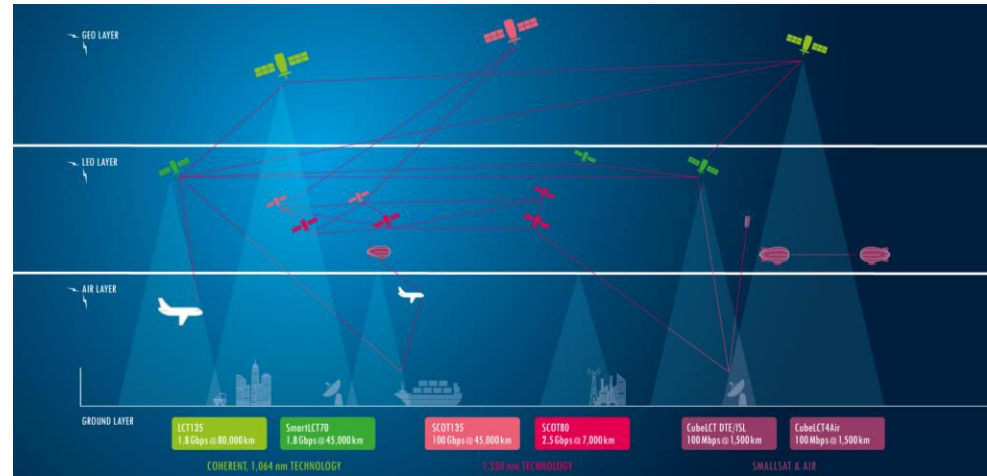
A large, abstract graphic composed of numerous small dots of varying shades of gray, arranged to form a shape that resembles a stylized satellite or a complex network structure. The dots are more densely packed in the center and become sparser towards the edges.

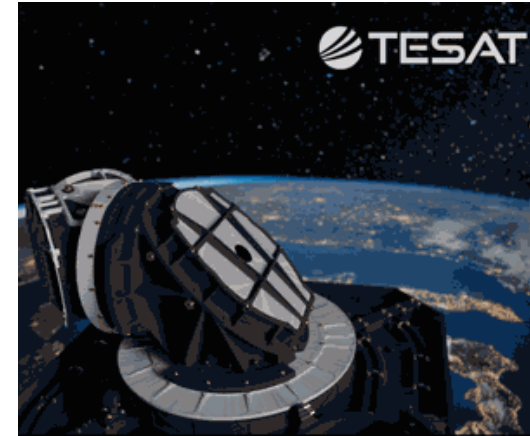
## SUMMARY

# SUMMARY

## Laser Communication at TESAT

- » Laser communication for ISL and SGL
  - » Heritage space applications like LEO/ GEO data relay and scientific applications
  - » New / next space applications in a modular product approach scalable from 0.05Gbps + 100Gbps
  - » More application to come ! PNT, QKD, Science
- 
- » Solution for different applications
    - » Long Range, GEO Relay
    - » LEO node for GEO Relay
    - » DTE
    - » LEO Constellations
    - » Ultra Precision Timing and Ranging, GNSS
    - » QKD





**Nils Höpcke**

**+49 7191 930-2778**

**+49 170 2231017**

**[Nils.Hoepcke@tesat.de](mailto:Nils.Hoepcke@tesat.de)**

**Tesat-Spacecom GmbH & Co. KG**

**Gerberstraße 49**

**71522 Backnang**

**[www.tesat.de](http://www.tesat.de)**

11/09/2023