ESA Optical Communications and the ScyLight Roadmap

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Presentation Outline

- Optical Communications at ESA
- Quantum Communications at ESA
- Introduction to ScyLight (secure and laser communication technology)
- ScyLight technology Roadmap
- Introduction to HydRON (High thRoughput Optical Network)

Optical Communication

Optical communication is a disruptive technology that enables satellite communications:

- without bandwidth limitations
- without licensing requirements
- without interference or jamming
- without link detection by third parties
- without eavesdropping (QKD)
- with small size, weight and power (SWaP) requirements on board the satellite

Optical Communications at ESA

A bit of history:

1975: ESA started investigating optical communication technologies.

1983: Start of SILEX (Semiconductor Inter-satellite Laser communication Experiment) development.

1996: ESA's optical ground station (OGS) in Tenerife, Spain inaugurated

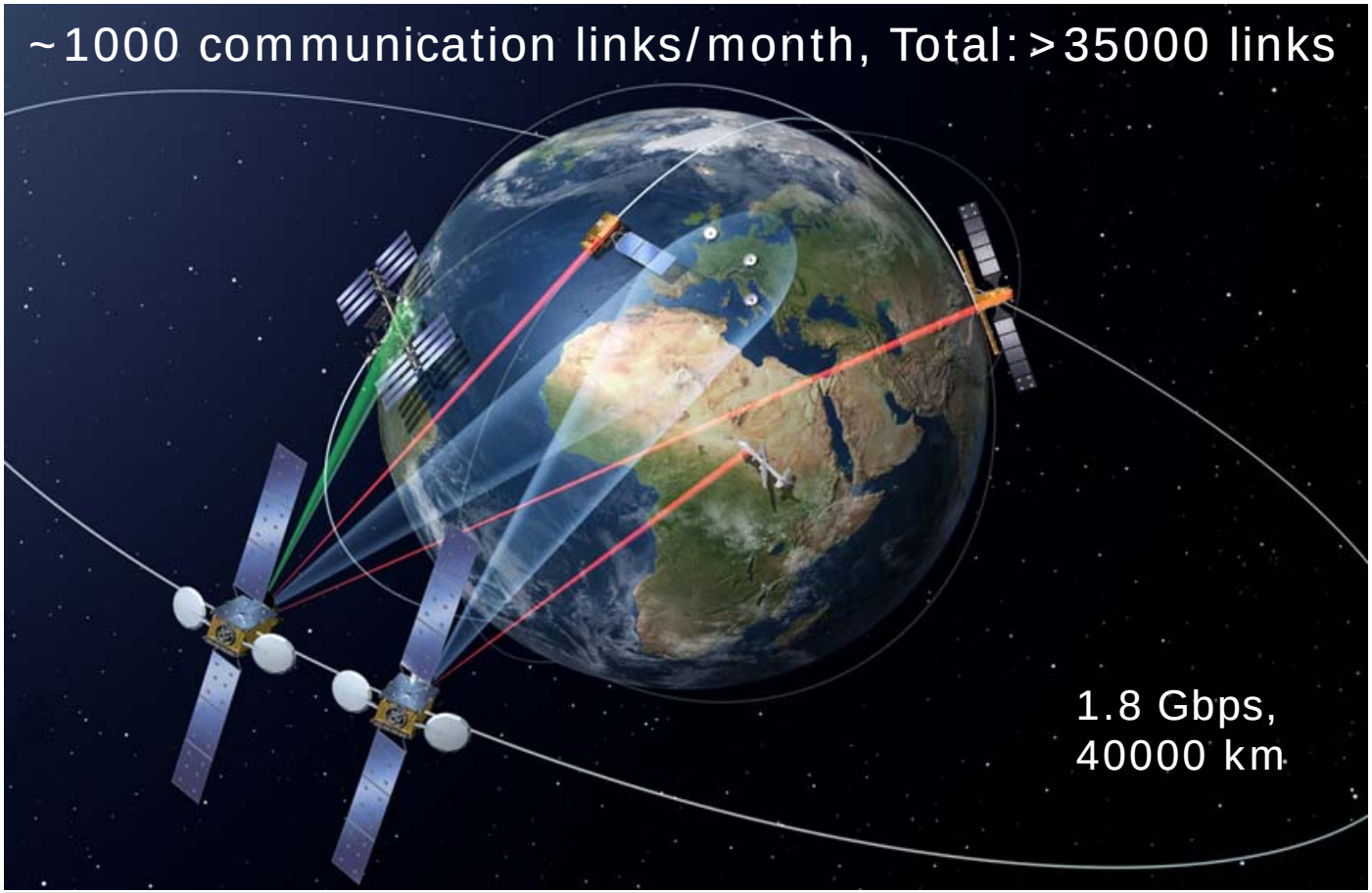
2001: First SILEX optical data-relay link LEO-GEO demonstrated (50 Mbps).

2008: First optical LEO-LEO inter-satellite link demonstrated by DLR (5.6 Gbps).

2014: Europe's second generation data-relay link LEO-GEO demonstrated (1.8 Gbps).

2017: European Data Relay System (EDRS) deployed, **the first commercially operated space-based optical communication system**.

Optical Communications at ESA – EDRS



EDRS is composed of two satellites in GEO:

- EDRS-A (09ºE, 29.01.2016)
- EDRS-C (31ºE, 06.08.2019)

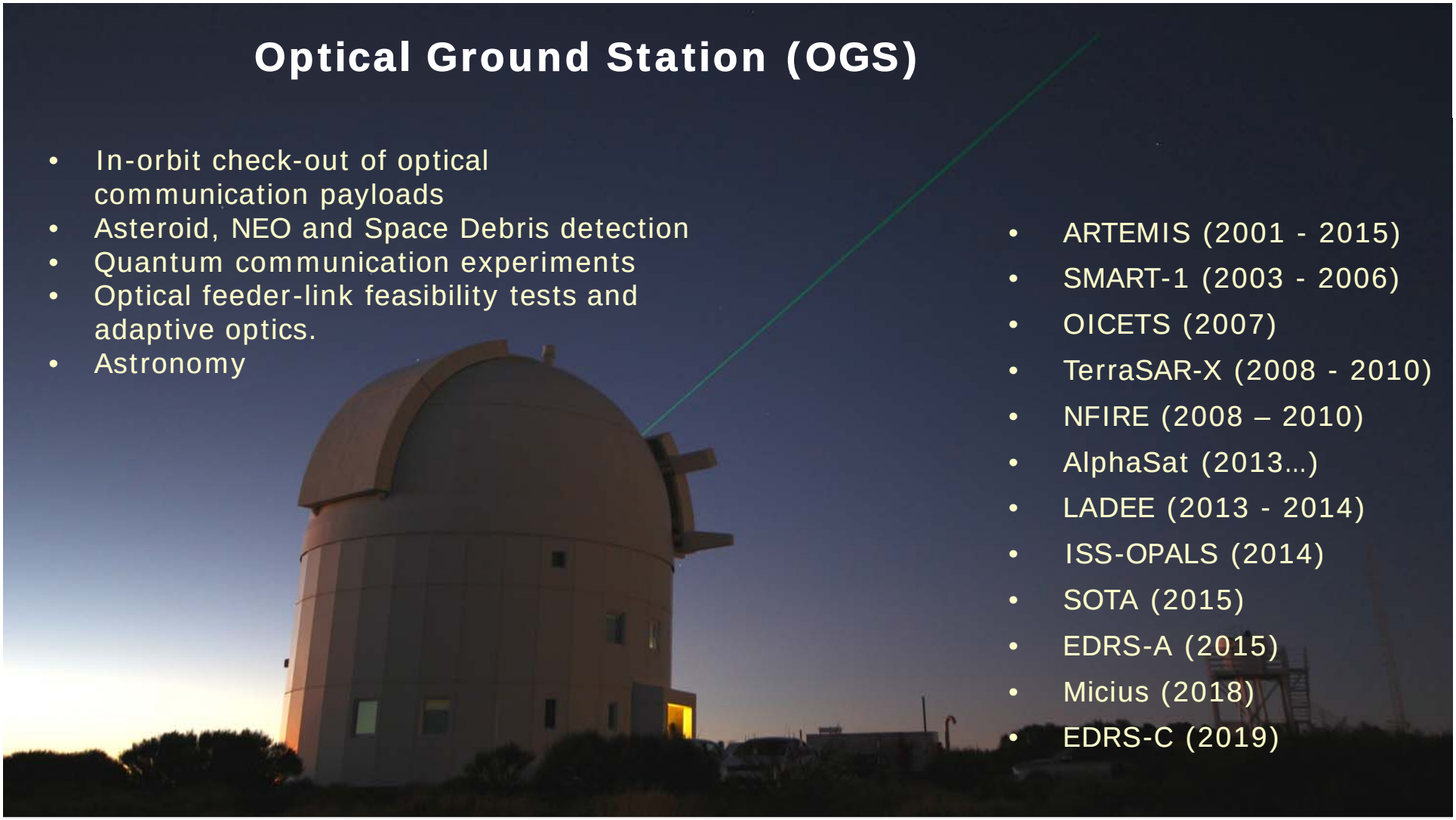
It provides data relay services for four satellite in LEO:

- Sentinel 1a (LEO, 03.04.2014)
- Sentinel 2a (LEO, 22.06.2015)
- Sentinel 1b (LEO, 22.04.2016)
- Sentinel 2b (LEO, 07.03.2017)

LEO satellites that will be added in the coming years:

- Sentinel 1c
- Sentinel 1d
- Sentinel 2c
- Sentinel 2d
- Pleiades

Optical Ground Station (OGS)



- In-orbit check-out of optical communication payloads
- Asteroid, NEO and Space Debris detection
- Quantum communication experiments
- Optical feeder-link feasibility tests and adaptive optics.
- Astronomy

- ARTEMIS (2001 - 2015)
- SMART-1 (2003 - 2006)
- OICETS (2007)
- TerraSAR-X (2008 - 2010)
- NFIRE (2008 – 2010)
- AlphaSat (2013…)
- LADEE (2013 - 2014)
- ISS-OPALS (2014)
- SOTA (2015)
- EDRS-A (2015)
- Micius (2018)
- EDRS-C (2019)

Quantum Communications at ESA

A bit of history:

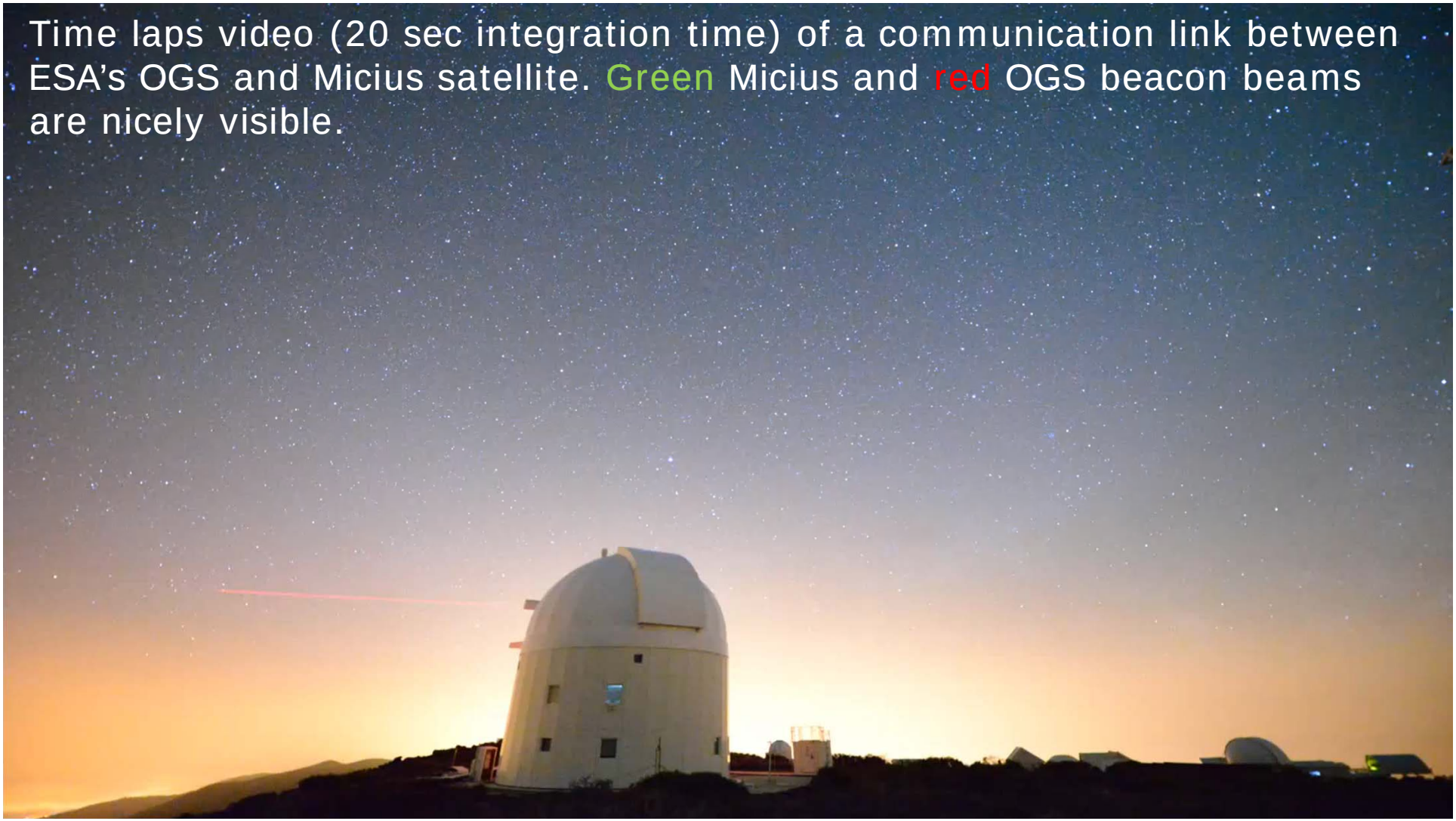
2001: ESA established first quantum communication cooperation agreement with Institute for Quantum Optics and Quantum Information (IQOQI) of Prof. Anton Zeilinger in Vienna.

2004: Multiple inter-island experiments performed using faint-pulse and entangled photon sources for quantum key distribution and quantum teleportation.

2016: Chinese quantum communication satellite (Micius) launched.

2018: ESA's OGS participates in optical quantum downlink experiments with Micius

2019: Two ESA quantum key distribution missions started (QUARTZ and QKDSat). In cooperation with the European Commission the SAGA program was launched to establish a cyber-secure communication infrastructure in Europe.


Time laps video (20 sec integration time) of a communication link between ESA's OGS and Micius satellite. Green Micius and red OGS beacon beams are nicely visible.

Optical and Quantum Communications

The challenge:

- Radio frequency communications from space started with the first satellite (Sputnik launched in October 1957), while first optical communication links from space were only tested in the early 1990s.
- Optical communication is still considered an unproven technology, which satellite operators are reluctant to implement.
- Cloud coverage of an Optical Ground Station (OGS) in direct to Earth links is an important additional risk factor.

The consequence:

- In ESA optical communication technology developments took 26 years (1975 – 2001) until the first system (SILEX) was launched.
- For space based Quantum communication technology developments it took 15 years (2001 – 2016) until the first system was launched by the Chinese Space Agency.

Optical Communication ScyLight

ESA therefore implemented scylight (secure and laser communication technology), a dedicated telecommunications funding scheme to support European and Canadian industry in the development of Optical Communications, Photonics and Quantum technologies, Systems and Demonstration Missions.

Optical Communications ScyLight has a budget of **~173 Mio €**.

21 Participating States:

Austria, Belgium, Czech Republic, Denmark, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, United Kingdom, Canada

Optical Communication ScyLight - Roadmap

The following technologies are implemented:

- Space / air-borne Optical Communication Terminals
- Reliable transmission through atmosphere
- Feeder Links and Optical Ground Stations (OGS)
- Quantum Key Distribution (QKD)
- On board Photonics
- Demonstration missions

ScyLight technology developments

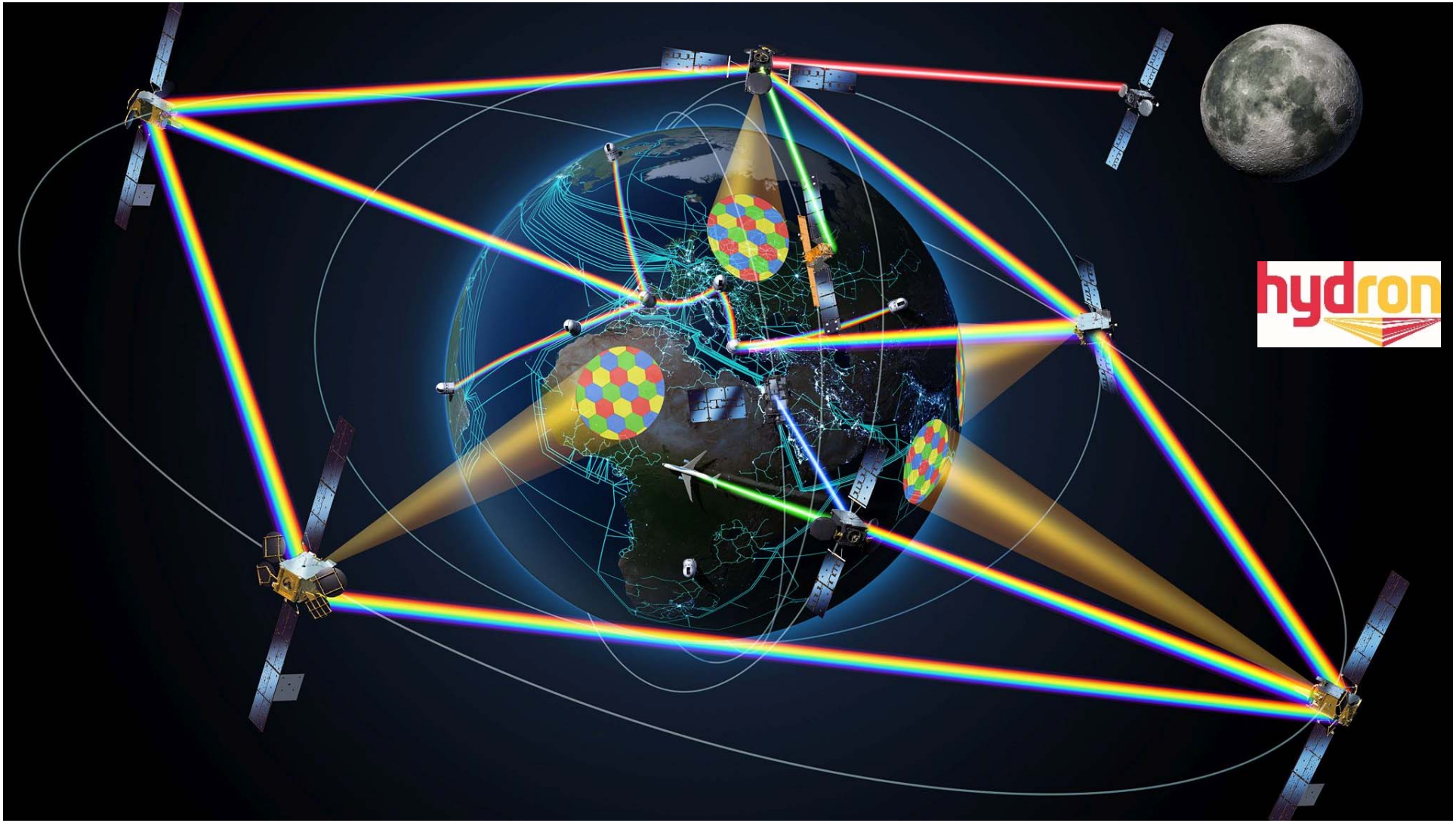
- Develop optical communication technologies for ultra-high data rates.
  - ✓ Reliable transmission through atmosphere (e.g. adaptive optics…)
  - ✓ Feeder-link technologies (e.g. pre-distortion, WDM, laser guide star…)
  - ✓ Modulation and coding systems
  - ✓ Ranging, time & frequency transfer
  - ✓ International standardization for interoperability (e.g. HPE, O3K…)
  - ✓ Terrestrial network connectivity and routing concepts
  - ✓ Laser safety
- Optimize cost, size, weight and power (C-SWaP).
- Develop photonics based payloads and demonstrate C-SWaP improvement.
- Develop space based cyber-secure QKD technologies:
  - ✓ Quantum sources
  - ✓ Quantum memories
- Provide demonstration missions (e.g. Alphasat, HydRON, SAGA, ISS…).

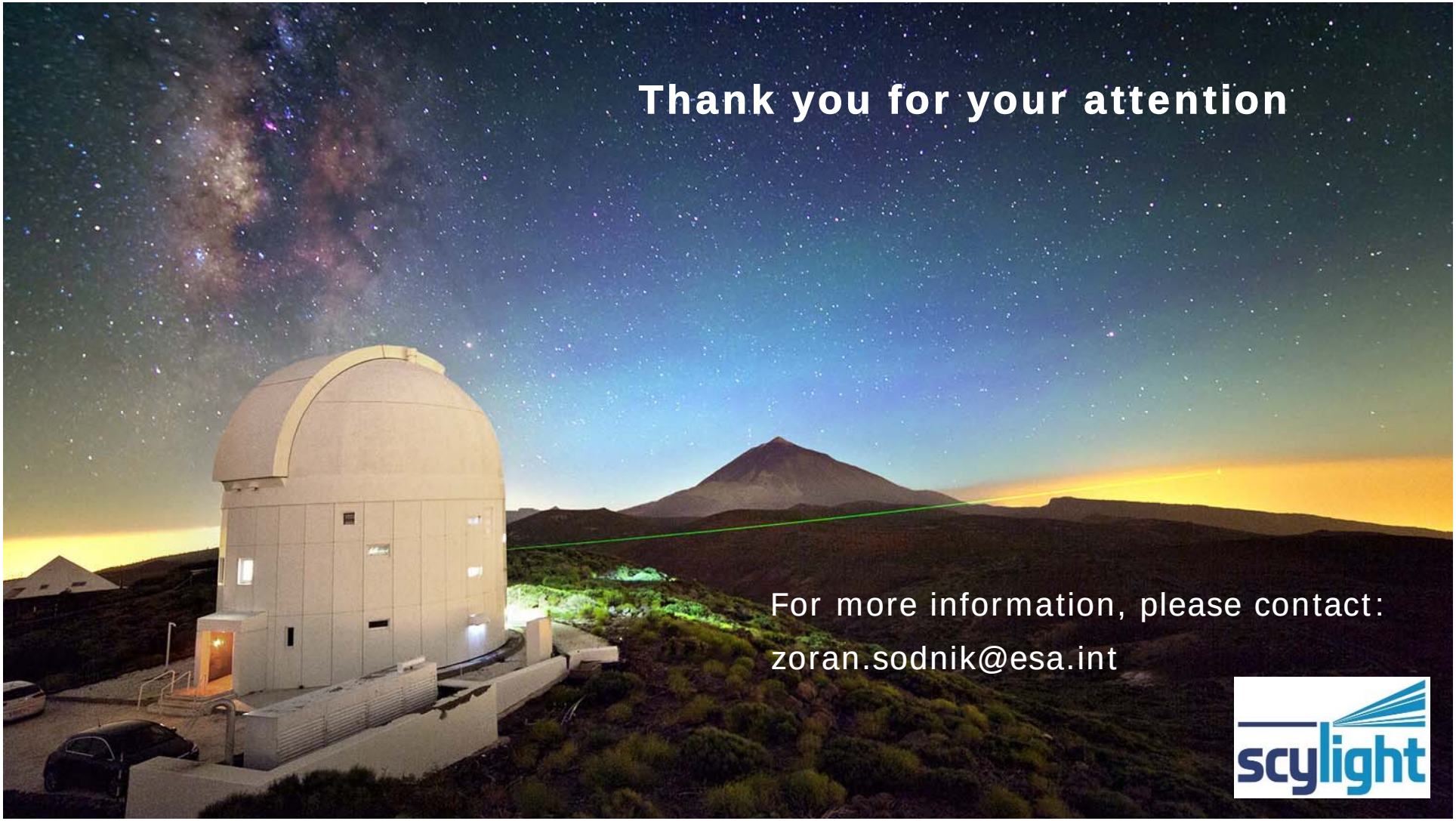
hydron high throughput optical network

Vision

Develop the world first (all) Optical Transport Network at Terabit Capacity in space.

Extend terrestrial Fiber Networks seamlessly by a **“Fiber in the Sky”.**


hydron


Thank you for your attention
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scylight