

Optical and Quantum Communication ScyLight, HydRON and SAGA

Dr. Harald Hauschildt & the
Teams of ScyLight,
HydRON and SAGA

ARTES in a nutshell



Voice of our ecosystem



- **NEW DIGITAL ECONOMY**

5G/6G, AI & IoT, Edge & Cloud, Optical & Quantum

- **GREEN** solutions & act for decarbonisation

- **SPEED**

make Europe first mover, sync with private players

- **NON-SPACE PARTNERS** to stimulate innovation

- **PRAGMATIC** in building European ecosystem

- **LEADERSHIP** in European connectivity

- **USER DRIVEN**

for new applications, solutions, business & downstream value to end users + go-to-market strategies



'Innovate & Go-To-Market'



Who we are: ARTES DNA



European Data Relay System - EDRS



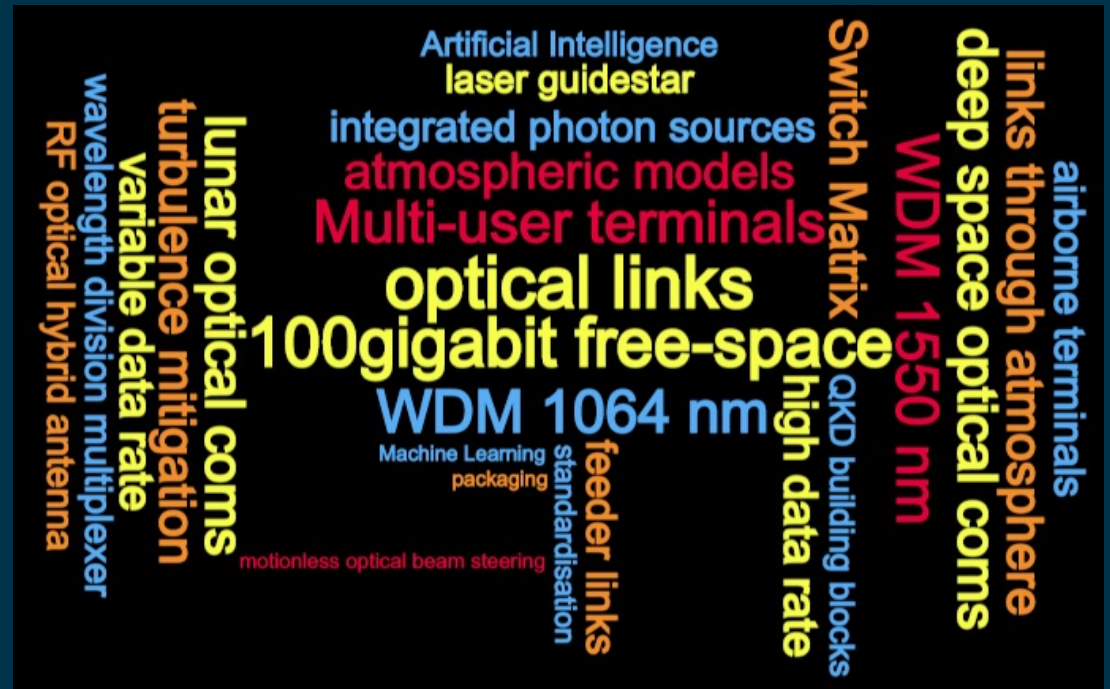
- 2 GEO nodes
- Data from LEO via optical, relay to Earth via RF
- 50 000 + successful data links, limited by Copernicus Sat and not technology



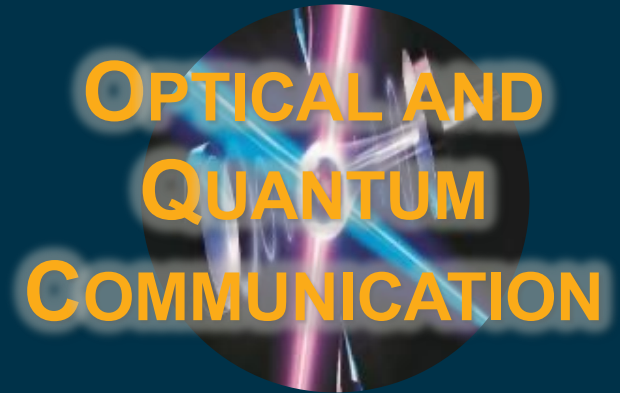
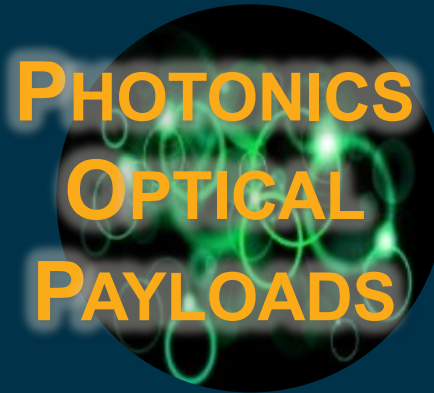
scyLight

- ESA-initiated
- Industry-initiated
- ESA initiated demo missions

*Industrial Excellence and
Market Lead in Optical
Communication Technology
by 2025*



Optical Domains and Roadmap



TECHNOLOGY

- Next Gen Laser Terminals
- Optical Feeder Up Links / Adaptive Optics
- Inter-Sat / Optical Payloads for Optical Coms
- Mass/Optimised Production Processes
- Quantum Coms Technologies

APPLICATION & SERVICES

- QKD & Cryptography Technology
- **HydRON** – Internet above the cloud(s)
- **SAGA** – EuroQCI Space Segment

SYSTEM

- Physics of the Atmosphere
- ESA Demonstration Missions
- **HydRON** – Internet beyond the cloud(s)
- **SAGA** – EuroQCI Space Segment

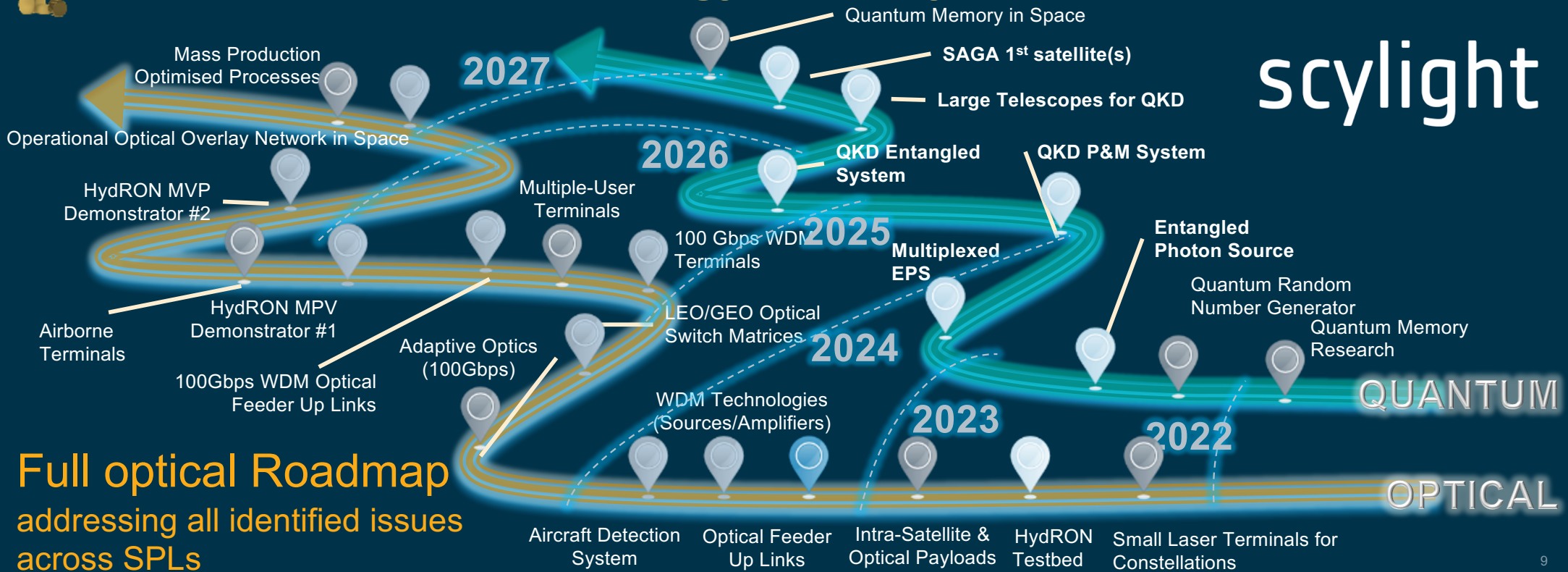


Optical and Quantum Communication - ScyLight



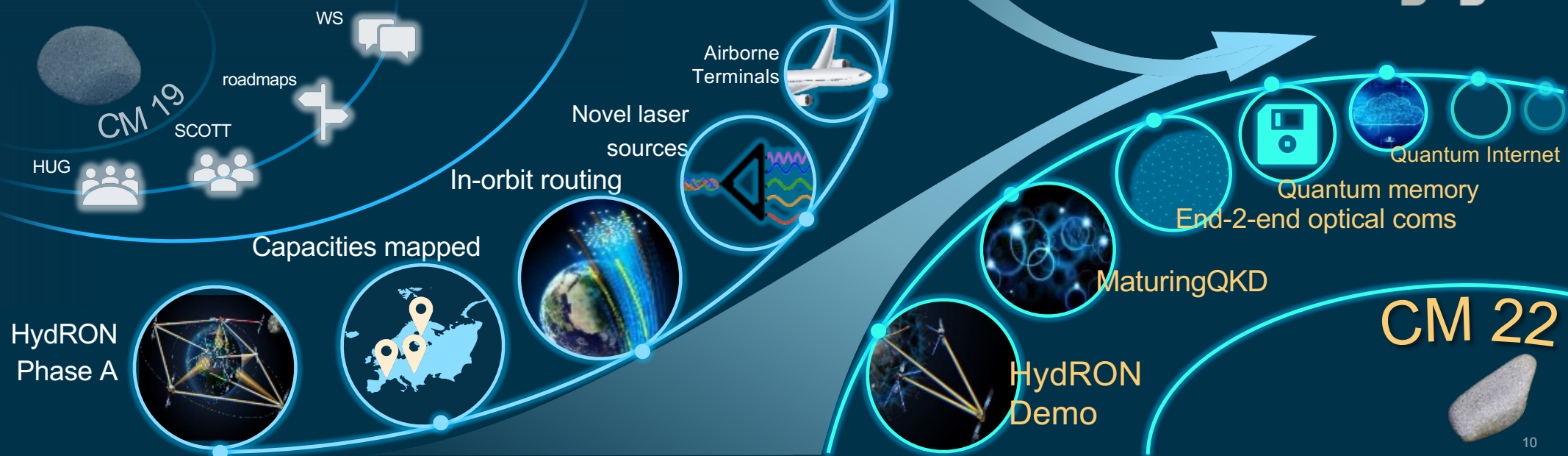
Addressing **gap** between optical solutions and the commercial market in both **technology maturity** and **user adoption**.

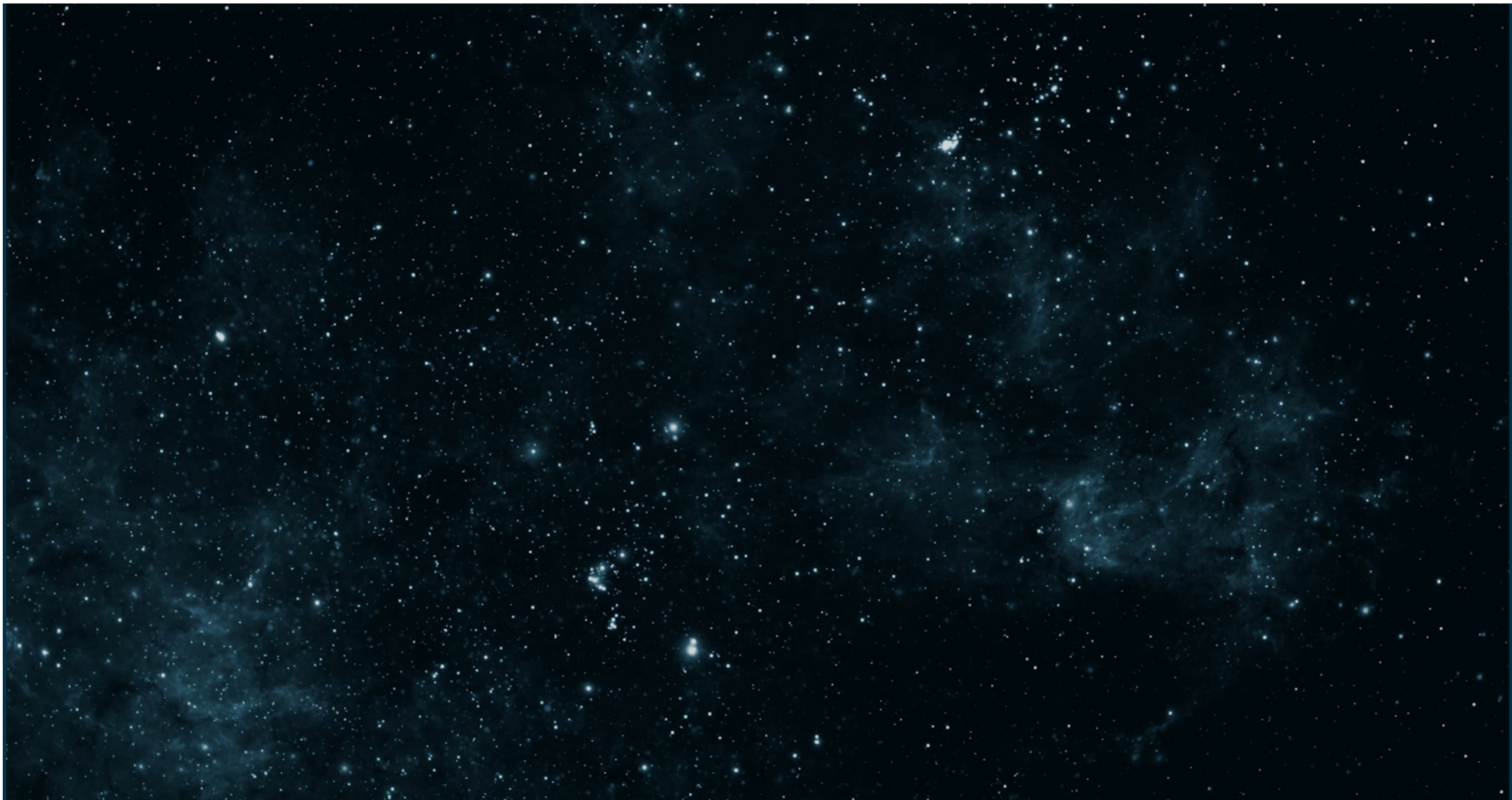
scylight





Addressing **gap** between optical solutions and the commercial market in both **technology maturity** and **user adoption**.





→ THE EUROPEAN SPACE AGENCY

Optical is **THE** strategic topic for Europe and Canada

If we are talking about...

- ...interconnecting space & ground networks
- ...interconnecting space assets in different orbits up to deep space and moon
- ...secure communications
- ...Quantum internet

...we are in fact talking about optical communication technology –

we are talking about HydRON.



HydRON – what we want to achieve



today

Building the optical backbone in space @ terabit capacity in the next five years – European* led



2026+



Seamless inter-operability of Networks

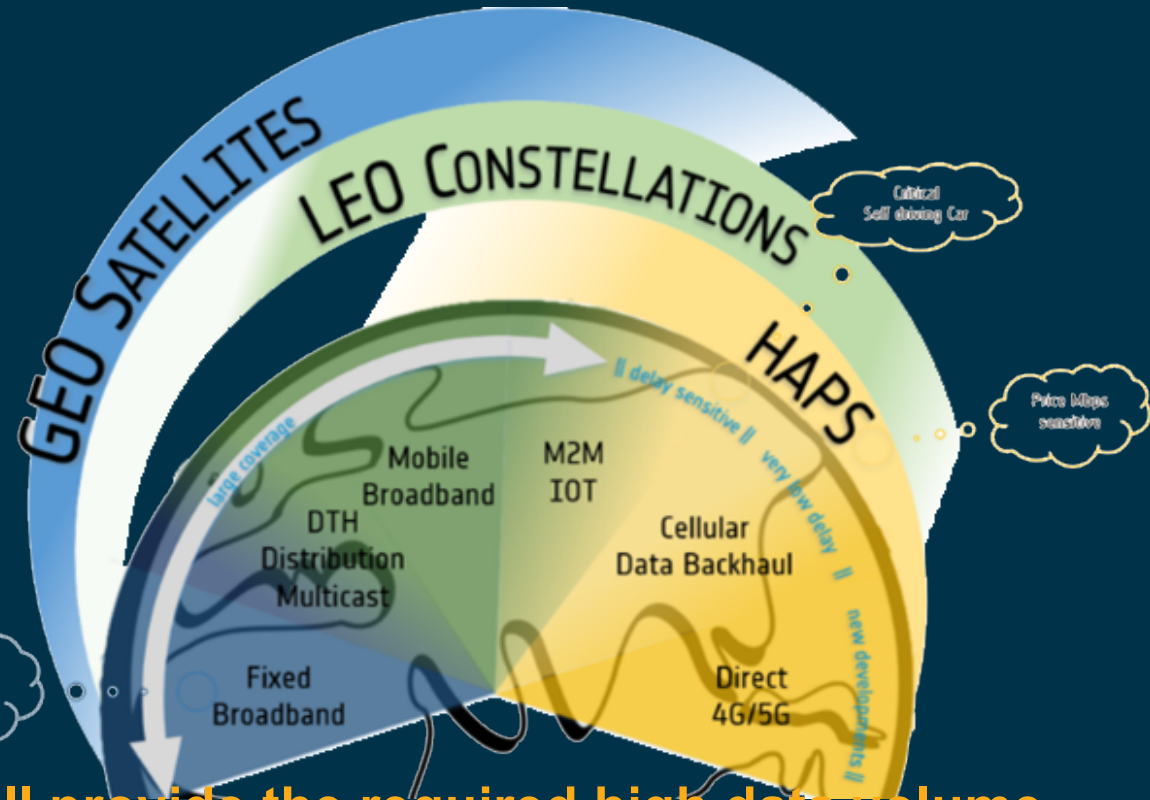
HydRON targets to complement current communication capabilities, as today satellites are..

- the “last mile”,
- difficult to patch in on-demand,
- not configurable by the network,
- have no routing capabilities.

Space architectures today
≠

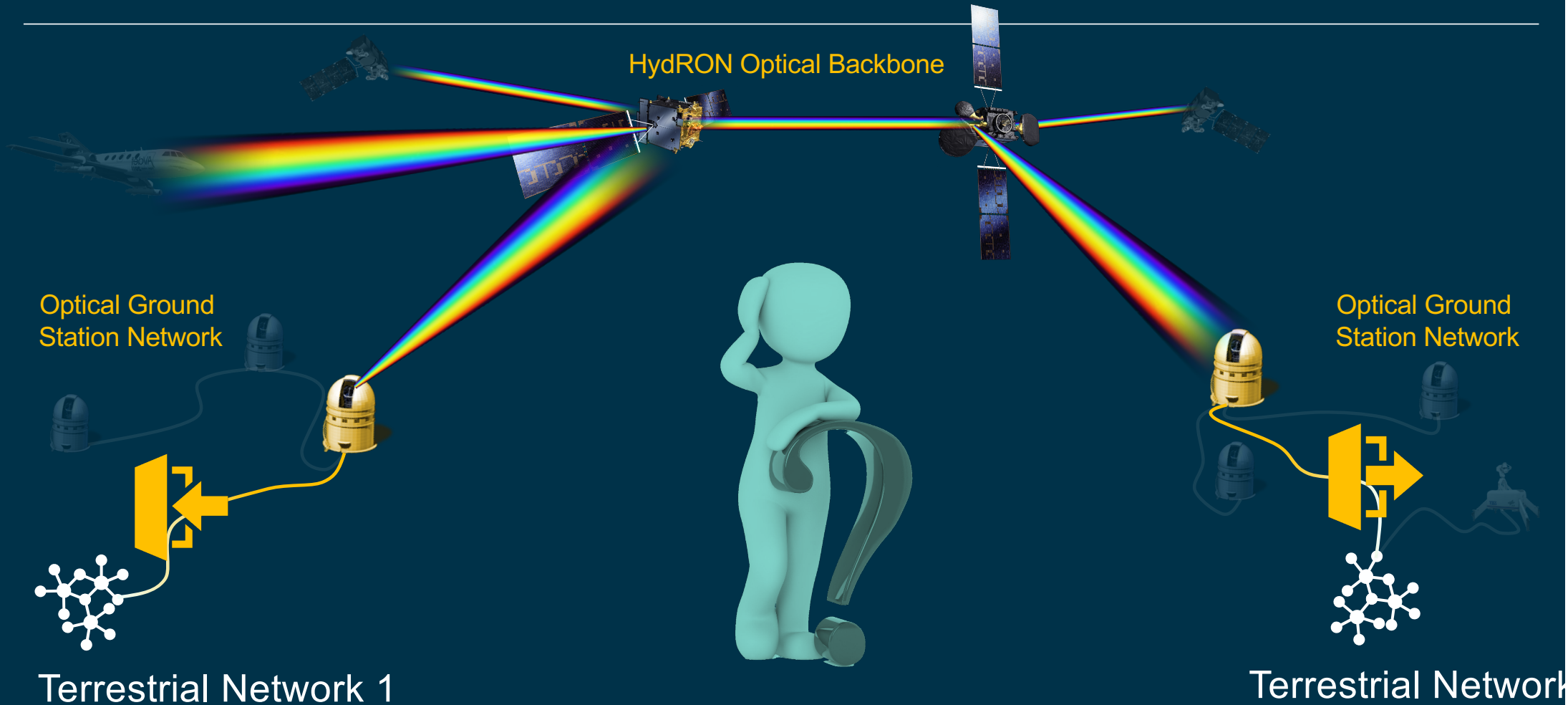
no real network capabilities.

Interconnection seen as a futuristic

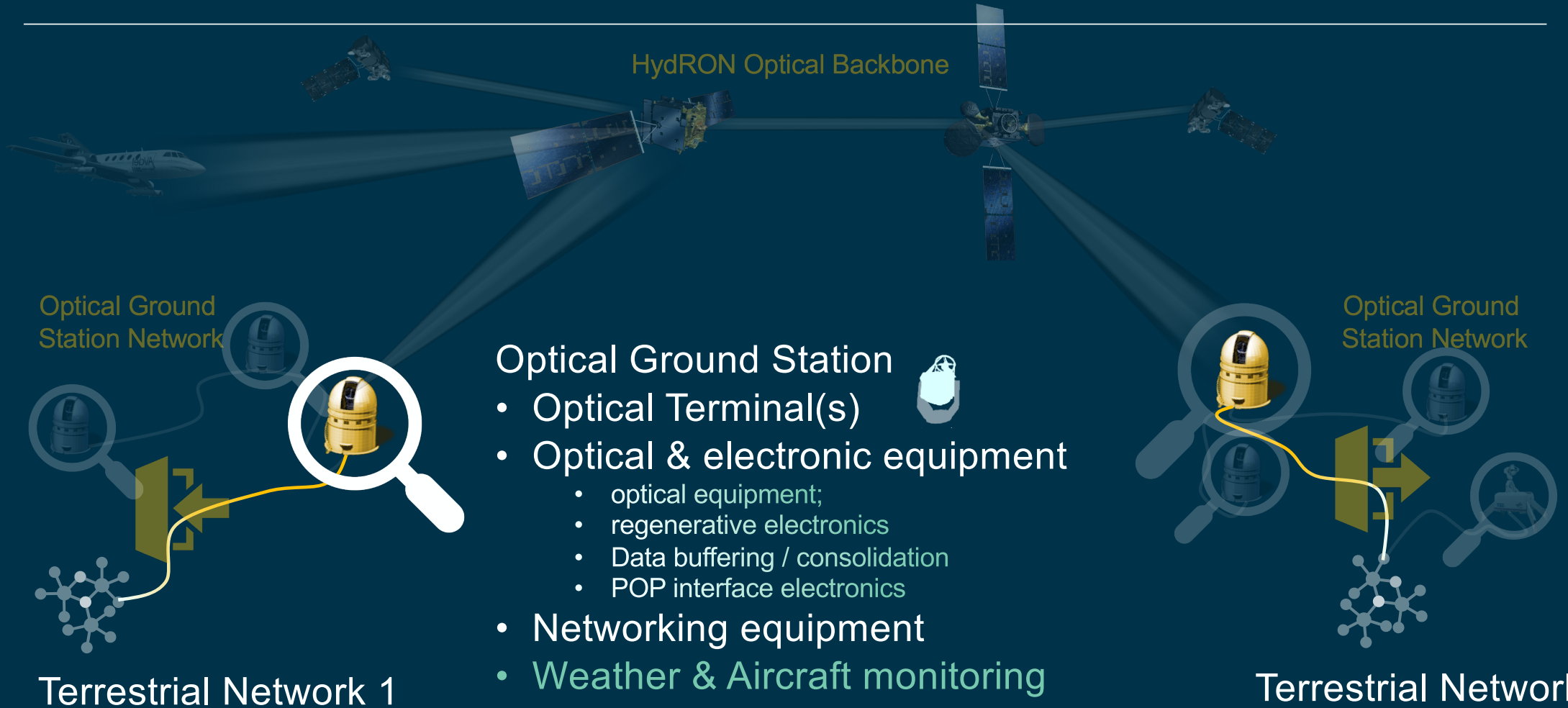


Only Optical Communications will provide the required high data volume and high volume switching capabilities!

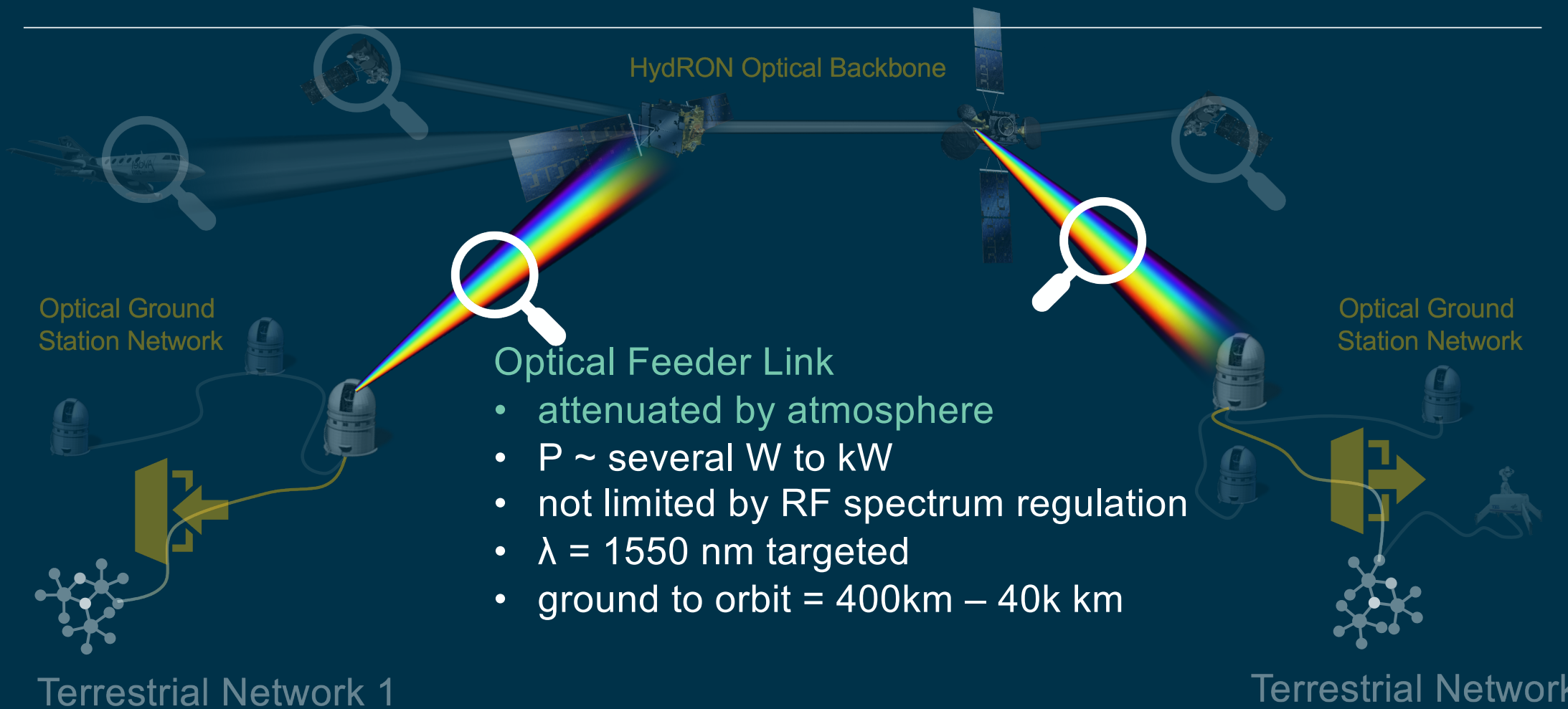
Optical connections – optical satcom 101



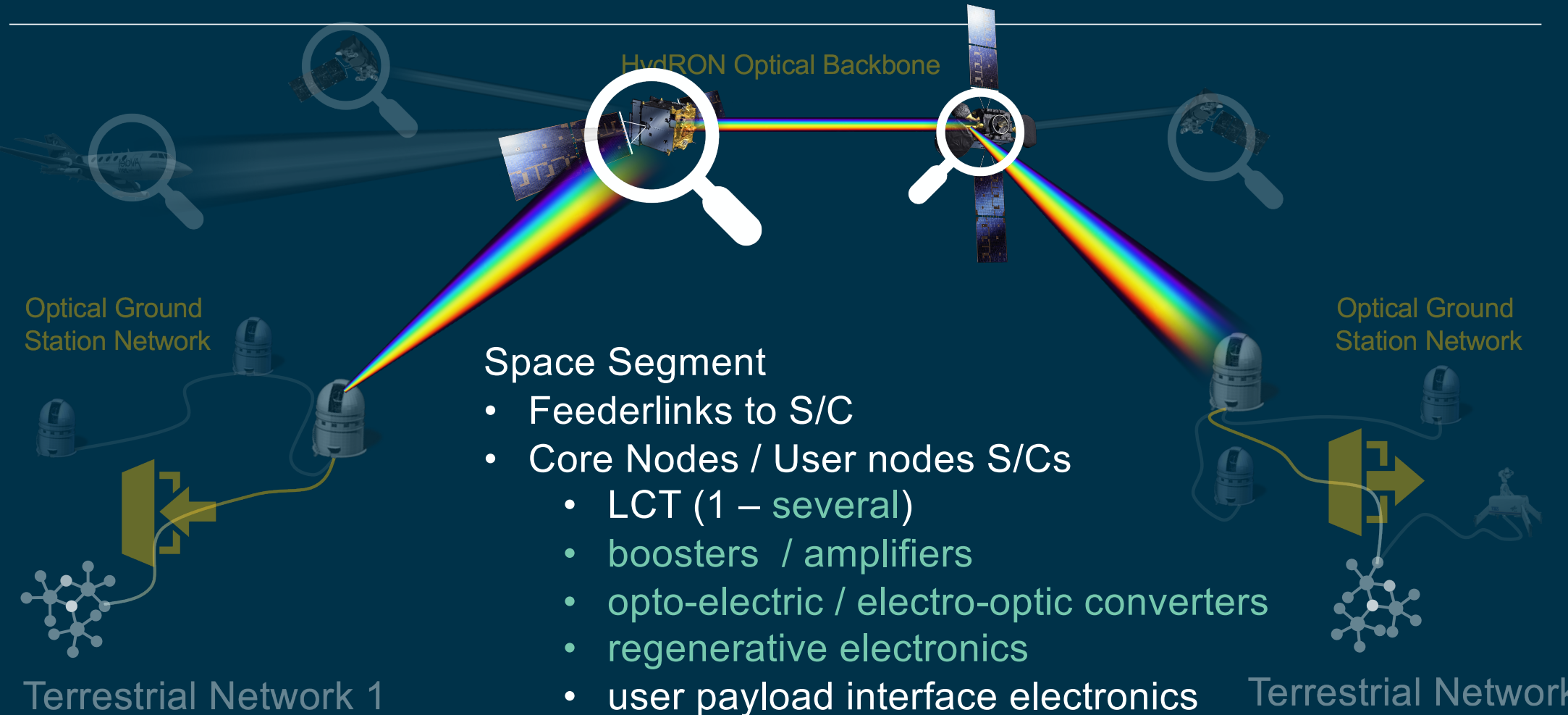
Optical connections – optical satcom 101



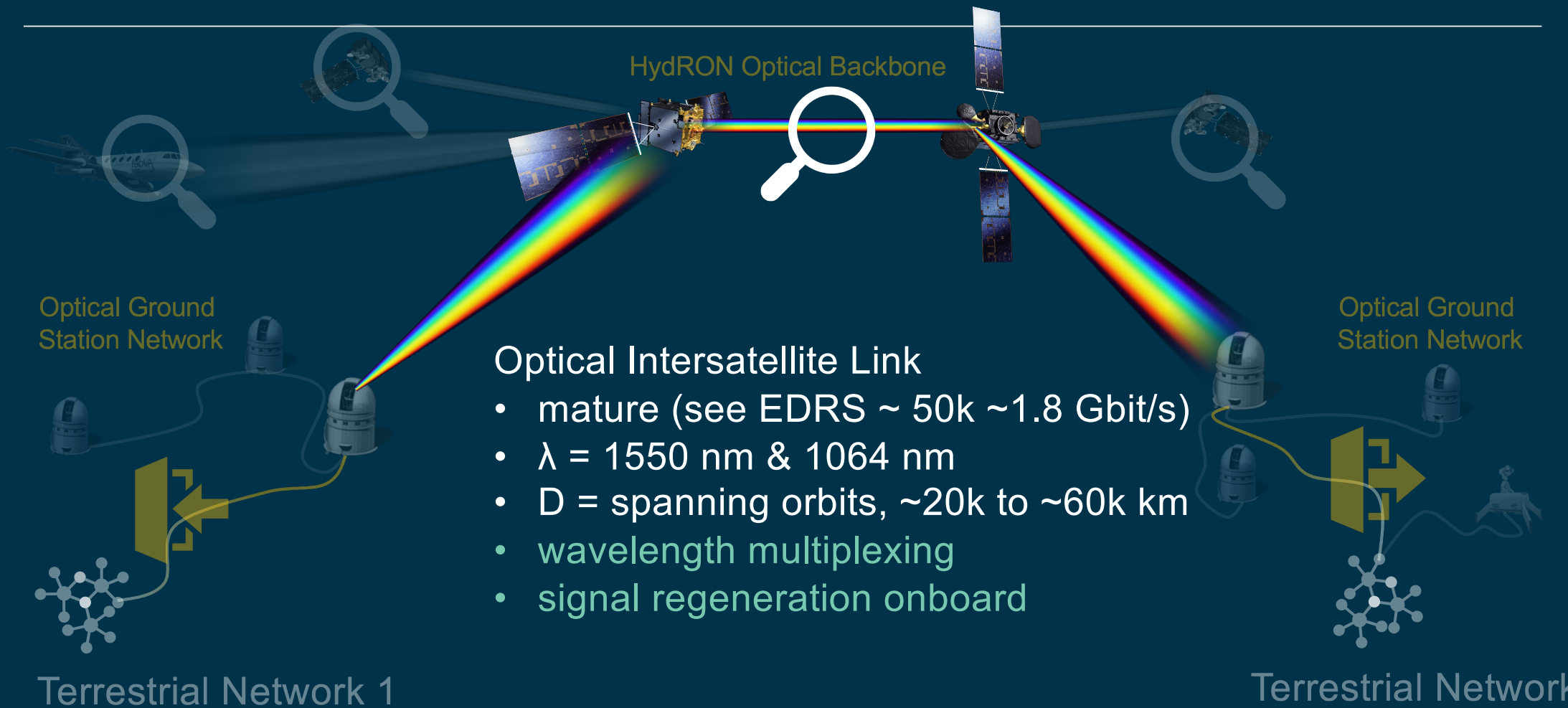
Optical connections – optical satcom 101



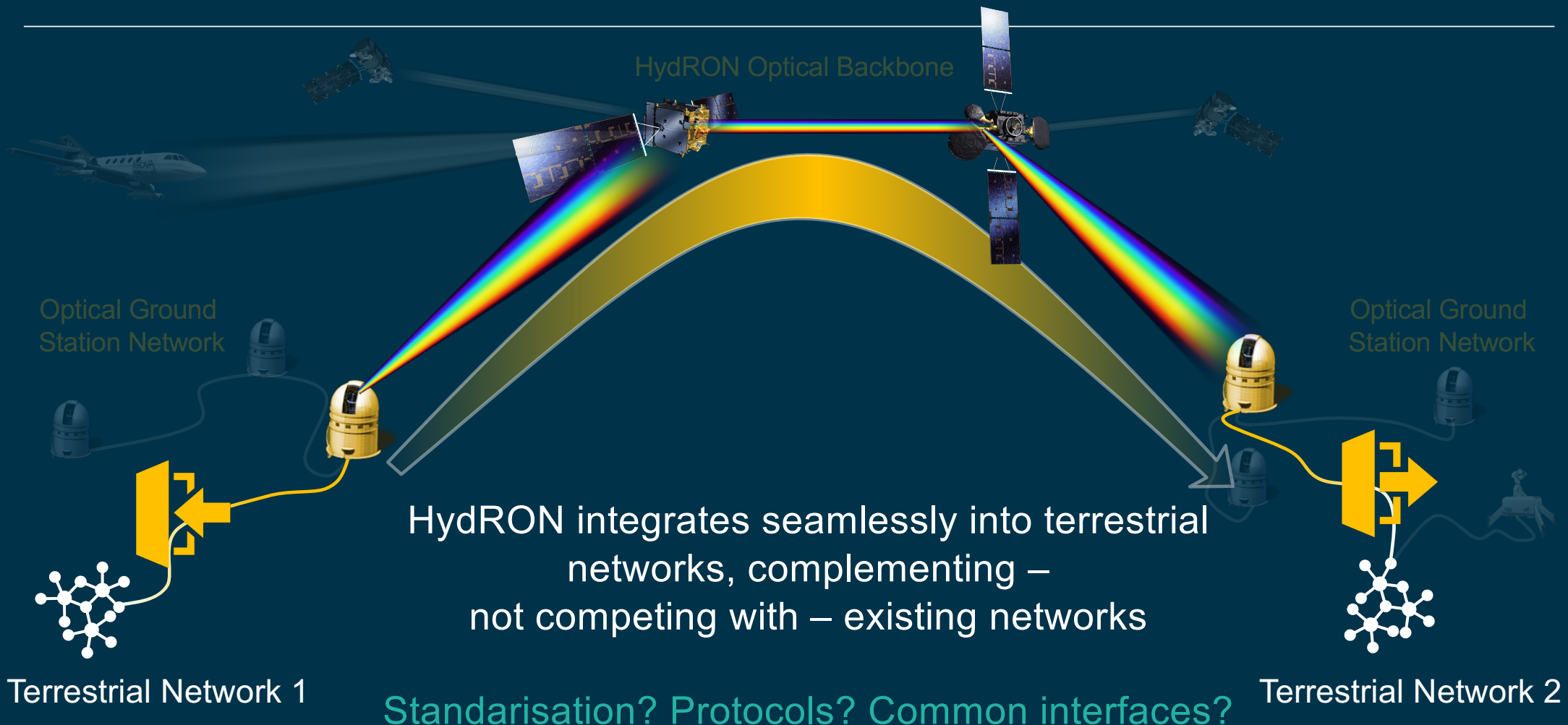
Optical connections – optical satcom 101



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Optical connections – optical satcom 101

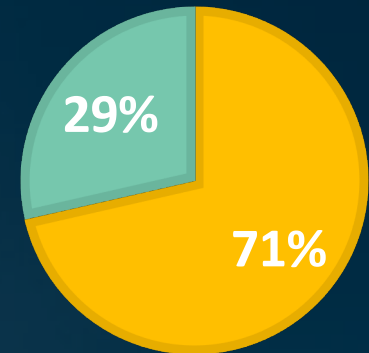


HydRON – State of Play

Stakeholder / User Workshop

71% of users would potentially use HydRON Demo Service, tech demo not enough!

■ Demo/service user ■ Demo user



2026+



Highlighted user needs

- Data repatriation (global coverage)
- Data rates from 10G through to 1Tbit/s
- >99.5% service availability or/and continuous operation

First users identified

- ESA EOP Missions – Sentinel Next Gen (>2028)
- ESA OPS ESTRACK

• On-demand inter-continental data transport

• Services like terrestrial networks (e.g.



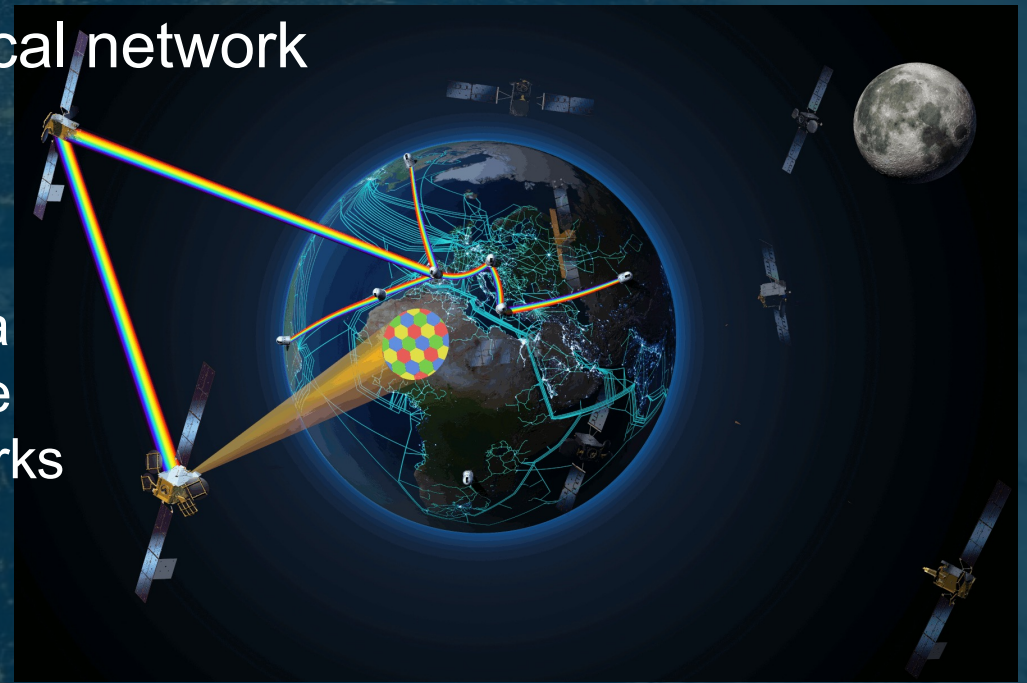
HydRON Mission Vision



HydRON envisions to provide *high-capacity data transport* and *flexible network services* to space and ground assets

HydRON, a high-throughput space optical network

- Tbit/s DTE and Space-Space links
- High speed optical / electrical switching
- Collection and distribution of end user data
- Terabit Optical Transport Network in Space
- Seamless integration into terrestrial networks
- HydRON **minimum viable product** is being assessed



HydRON Key Characteristics



Aiming for seamless inter-operability of terrestrial and space networks

This requires

- High data rates Tbits – only achievable by optical communication
- Routing to connect all assets and to mitigate atmospheric interference
- Expandable system approach to prepare for services and be open for lunar / deep space network.



Objectives & HydRON Mission concept

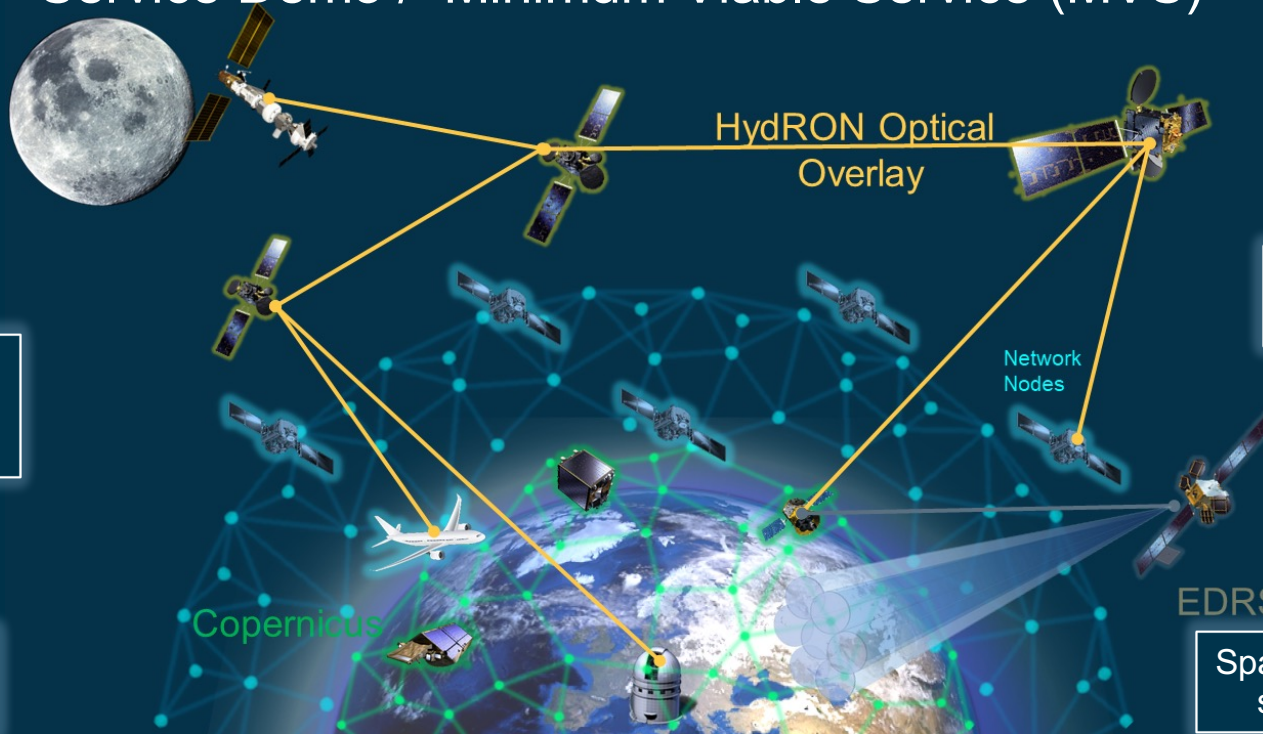
Objectives

- 1 tech verification & end-to-end system demo
- 2 Operational Concepts validation in support of Service Demo
- 3 Service Demo / Minimum Viable Service (MVS)

Internet beyond the Clouds concept

Multi-Orbit
GEO/LEO/MEO/HAPS
3-D interconnection

Data switching &
routing capabilities



Optical Network
overlay in Space

Ultra-High Speed
Terabit/second

EDRS
Space & Ground Networks
seamlessly integrated



HydRON Project Phases

HydRON-DS will demonstrate **key optical technologies** & validate main **concepts & functionalities**

Phases

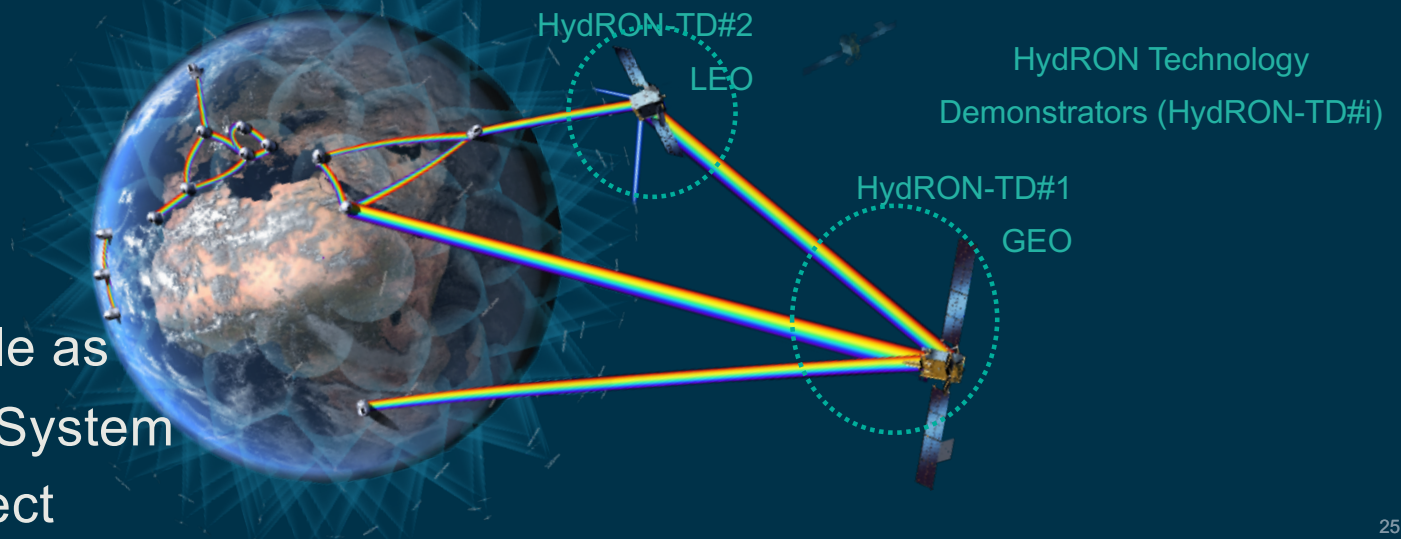
Definition

Development

Demonstration

- System Level/End-2-End concept of HydRON-DS & Demonstrators
- Flight/Demo opportunities to build-up industrial capabilities & create competitive advantage
- prove maturity to end users and to lower market barriers

ESA's role as
HydRON's System
Architect



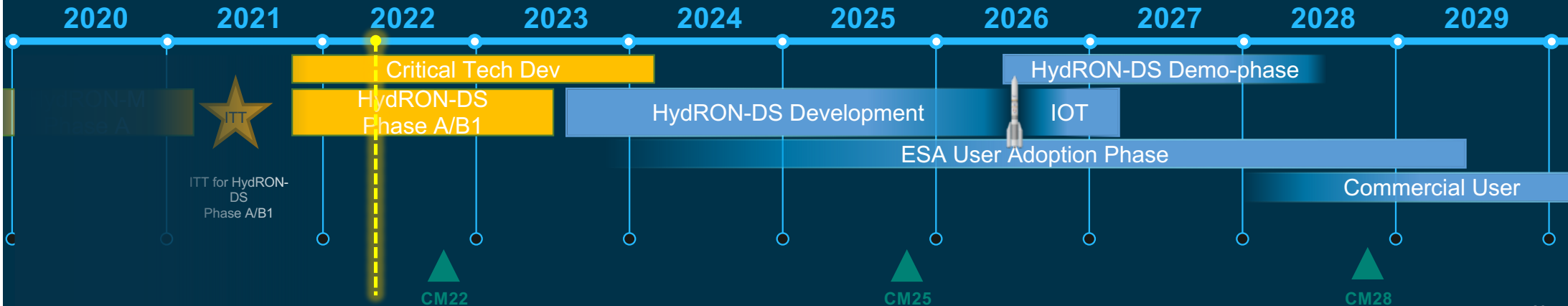
HydRON Phase A/B1 and Critical Technologies



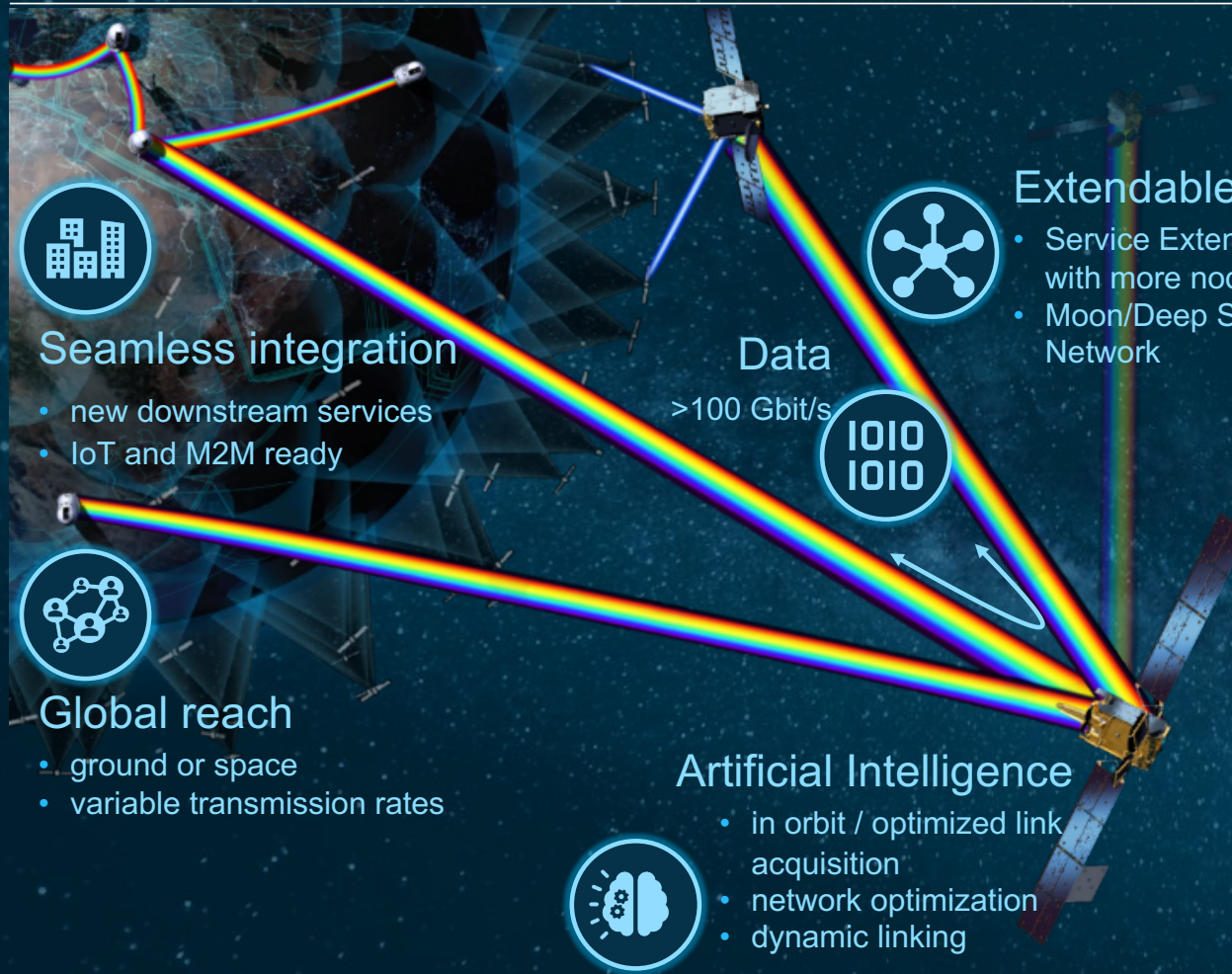
HydRON-DS Phase A/B1 Studies successfully kicked-off



<https://artes.esa.int/news/esa-awards-two-contracts-lasercommunication-projects-related-hydron>



Evolution towards end-to-end optical systems



Seamless integration

- new downstream services
- IoT and M2M ready



Global reach

- ground or space
- variable transmission rates



Artificial Intelligence

- in orbit / optimized link acquisition
- network optimization
- dynamic linking



Extendable

- Service Extension with more nodes
- Moon/Deep Space Network

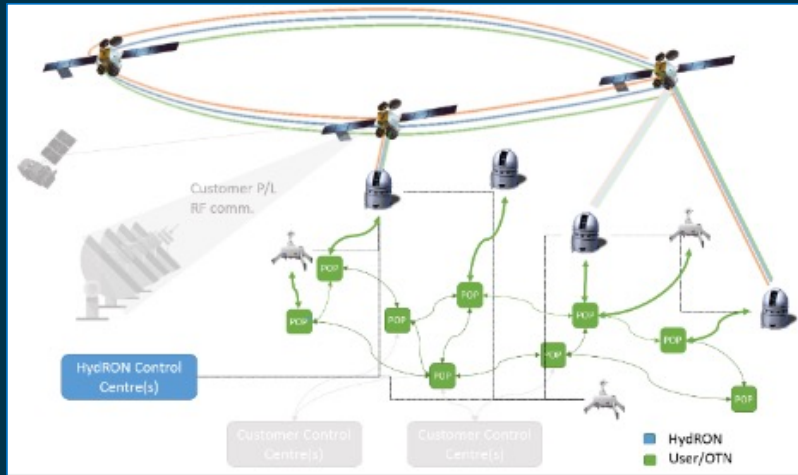


What's in the Package

- First internet nodes in space (GEO & LEO)
- Key technology Development + IOD from **different vendors**
 - WDM LCTs: 100 - 500 Gbps
 - Optical amplifiers
 - Switches
 - Terrestrial/space network integration
 - Artificial Intelligence Technologies
- End-2-End **concept** validation
- **Commercial** positioning of European industry
- PPP opportunity & for international cooperation

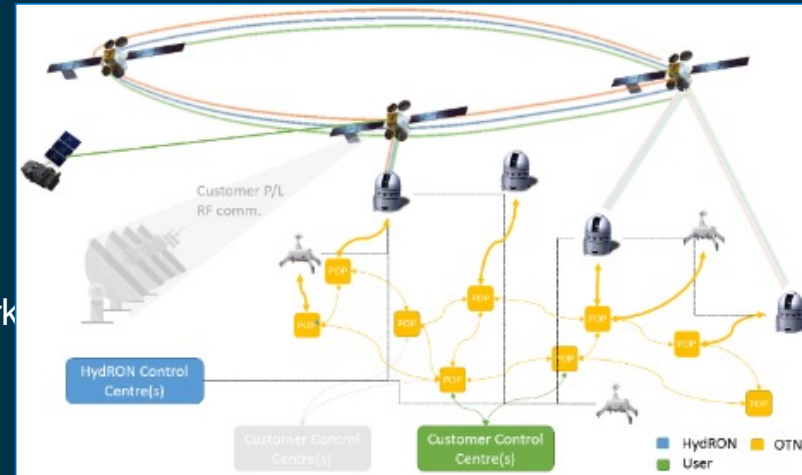


HydRON User Categories



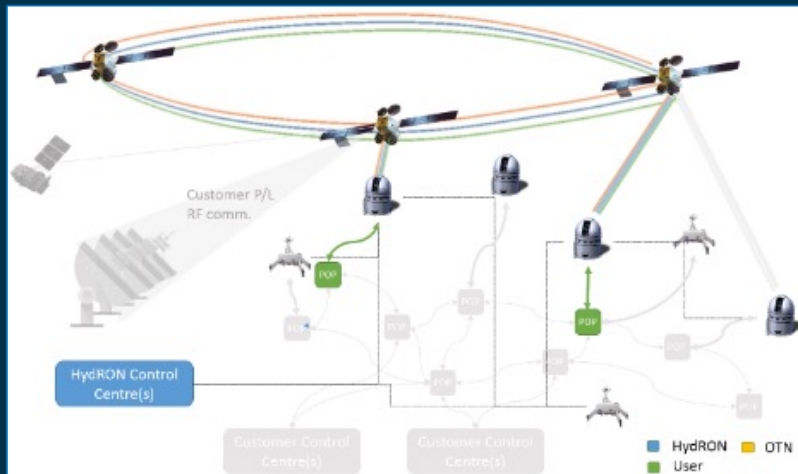
Terrestrial Network Operators

expanding their terrestrial network to route traffic



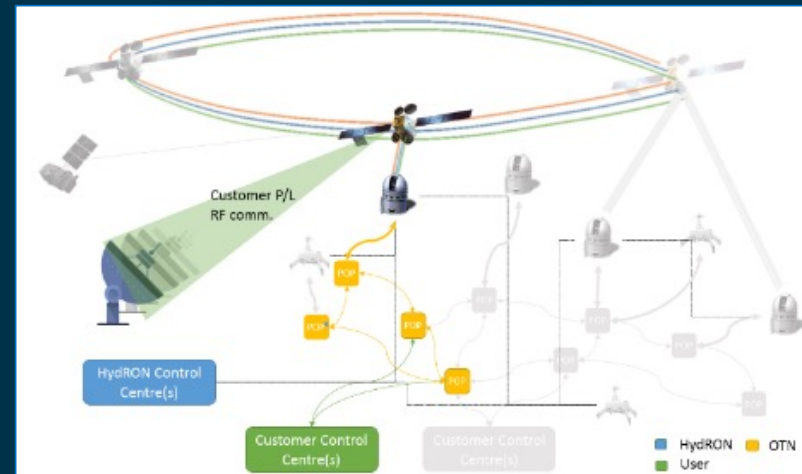
Satellite / Airborne Users

connecting own satellites / UAV / aircraft to the network



Private Network Users

securing connections avoiding terrestrial infrastructures



Telecom Satellite Operators

connecting their fleet to the Network



Critical Technology Developments



CTDs initiated in support of technical trade-offs for the definition of the HydRON-DS & leverage key HydRON technologies TRL levels almost completely issued.

Closed and awarded CTDs ITTs

- ✓ HydRON Simulator Testbed (awarded)
- ✓ Optical technologies for next generation high throughput optical inter-satellite links (awarded)
- ✓ WDM High-Power Optical Amplifier at 1550nm (awarded)
- ✓ reliable GEO Optical Feeder Link demonstration (awarded)
- ✓ Atmospheric monitoring to assess the availability of optical links through the atmosphere (awarded)
- ✓ Assessment of analogue optical links through the atmosphere (awarded)
- ✓ Digital technologies for future high throughput optical satellite systems (negotiation)
- ✓ WDM Laser Sources at 1064nm (evaluation)
- ✓ 100 Gbps free-space experiment using fibre optical transceivers (awarded)



Critical Technology Developments



Open and planned ITTs

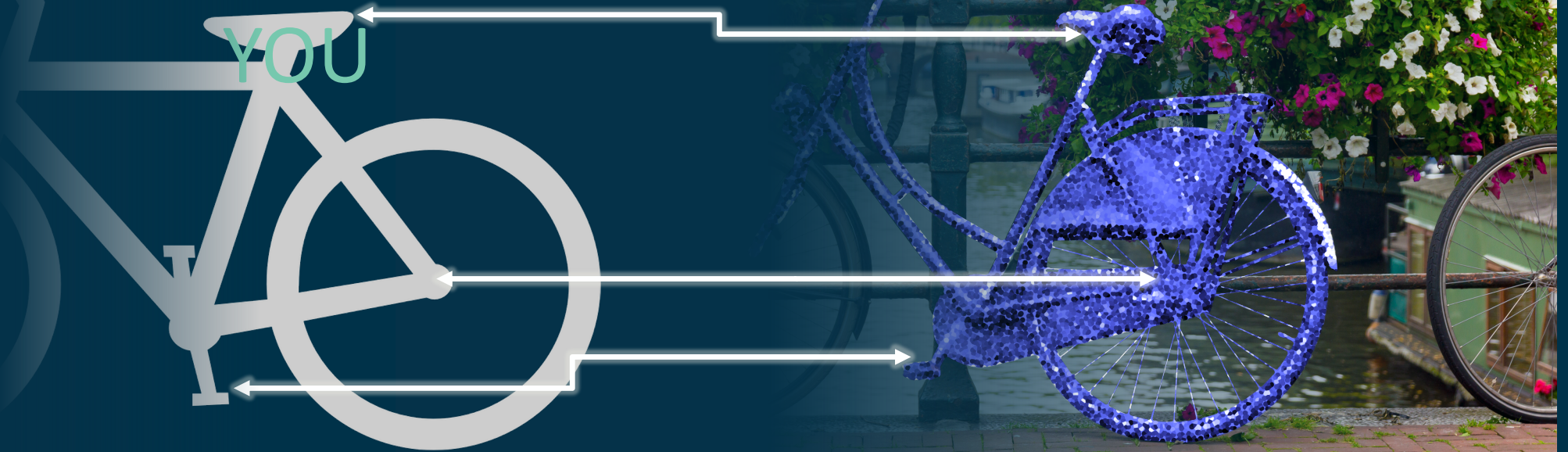
- Machine learning in optical communication systems ITT open (closing April)
- LEO/GEO Optical Switch Matrices 25x25
- Low-noise optical pre-amplifier at 1064nm
- WDM High-Power Optical Amplifier at 1064nm Q3 2022
- Aircraft detection system for Optical Ground Stations



Reinventing the wheel? No thank you...



WE WANT
TO WORK WITH
YOU



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Way forward with HydRON



- Unique industry opportunities (photonics, networks, ...)
- ESA initiated project to allow multiple implementations & maximize industry participation.
- HydRON is about national industry – new pre-developments can be customized to meet your needs.



Participation in HydRON is essential to:

- ✓ Join as many industrial stakeholders in early stages
- ✓ trigger time critical developments
- ✓ allow early selection on flight opportunities & join forces with interested parties.

ESA can offer targeted support to your company in close coordination with your ESA delegation.





SAGA

Security And cryptoGrAphic mission

Quantum Communication at
regional level



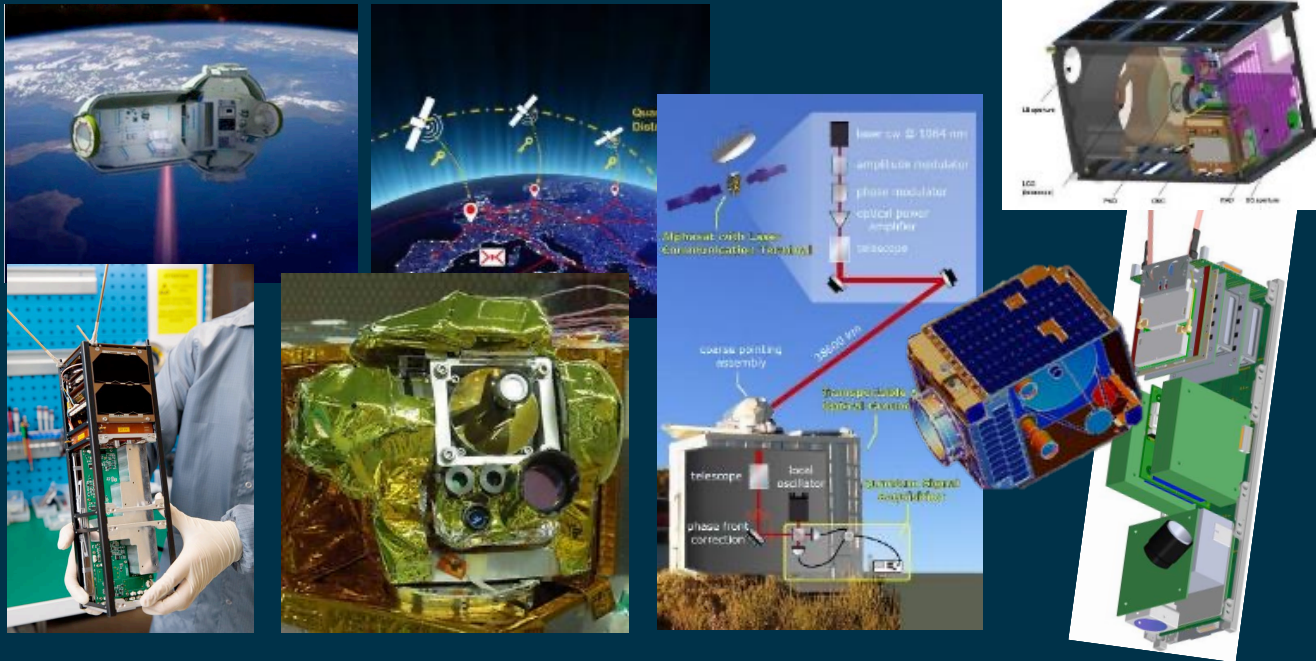
QKD Global Snapshot (1/2)



Research and Development Activities

- >10 space based national QKD activities
- >10 terrestrial fibre based test beds

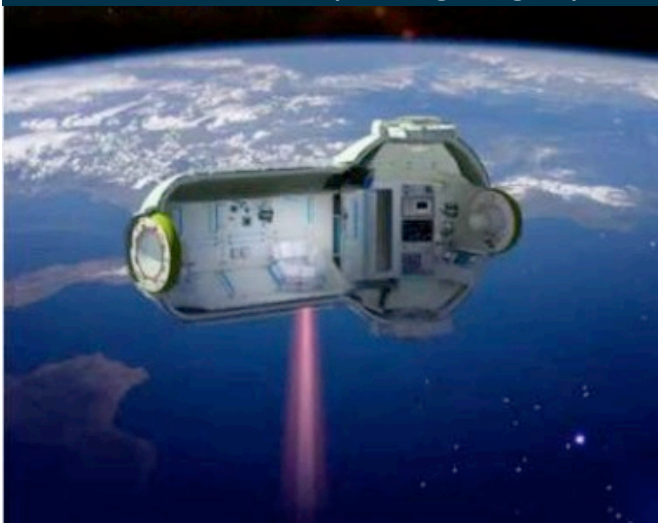
2x commercial QKD activities at ESA (QUARTZ and QKDSat)



QKD Global Snapshot (2/2)

China moving to operational systems

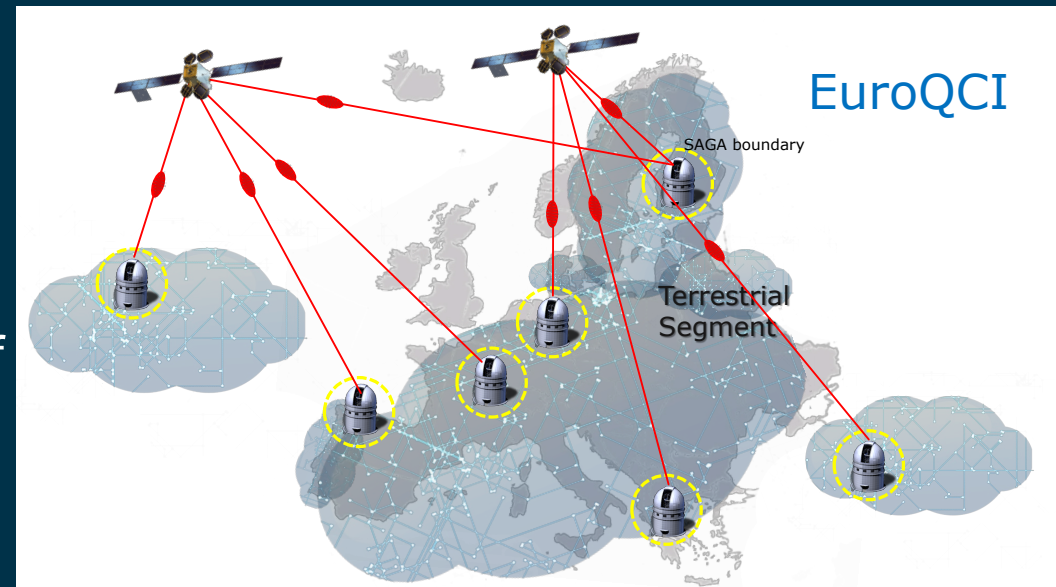
- 2000 km QKD fibre backbone between Shanghai and Beijing, extended to 4600 km by use of free space QKD links.
- 2nd generation QKD satellites after successful Micius QKD satellite operation and QKD links from the Chinese Space Station (Tiangong 2)



SAGA and the EuroQCI

ESA's Security And cryptoGrAphic Mission is built in coordination with EC.

- EuroQCI is targeting a fully operational system based on user requirements for governmental users in the EU.
- SAGA was created to be a component of the EuroQCI Initiative. The ESA SAGA project will design, develop and validate the EuroQCI space segment.
- SAGA and EuroQCI will provide cryptographic keys to protect communication systems of European institutions and critical infrastructures.



SAGA Contributing Missions

Industry Initiated activities Smallsat(s)

- third party owned to provide commercial / institutional QKD services for e.g. IOD / IOV
- QKD photon sources & single downlink
- QKD system testing daylight
- 2+ optical terminals for multiple downlinks

- SAGA-CON are **completely segregated**, self-standing projects

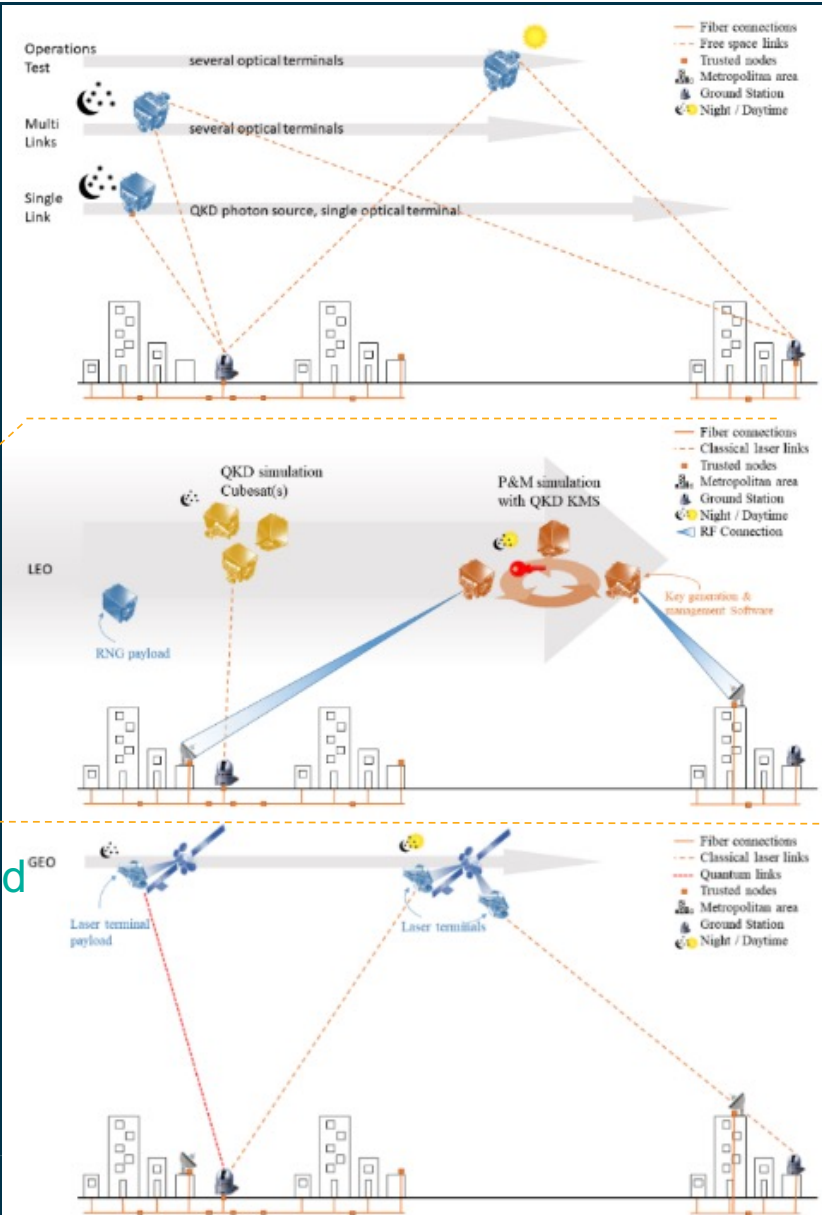
- Can be used to develop national industrial expertise in view of EuroQCI.

Cubesat(s)

- IOV of a high-performance true Quantum Random Number Generators (QRNG)
- Onboard key generation and management system

Geostationary hosted payload

- Single GEO downlink for entangled photons
- A double classical GEO downlink



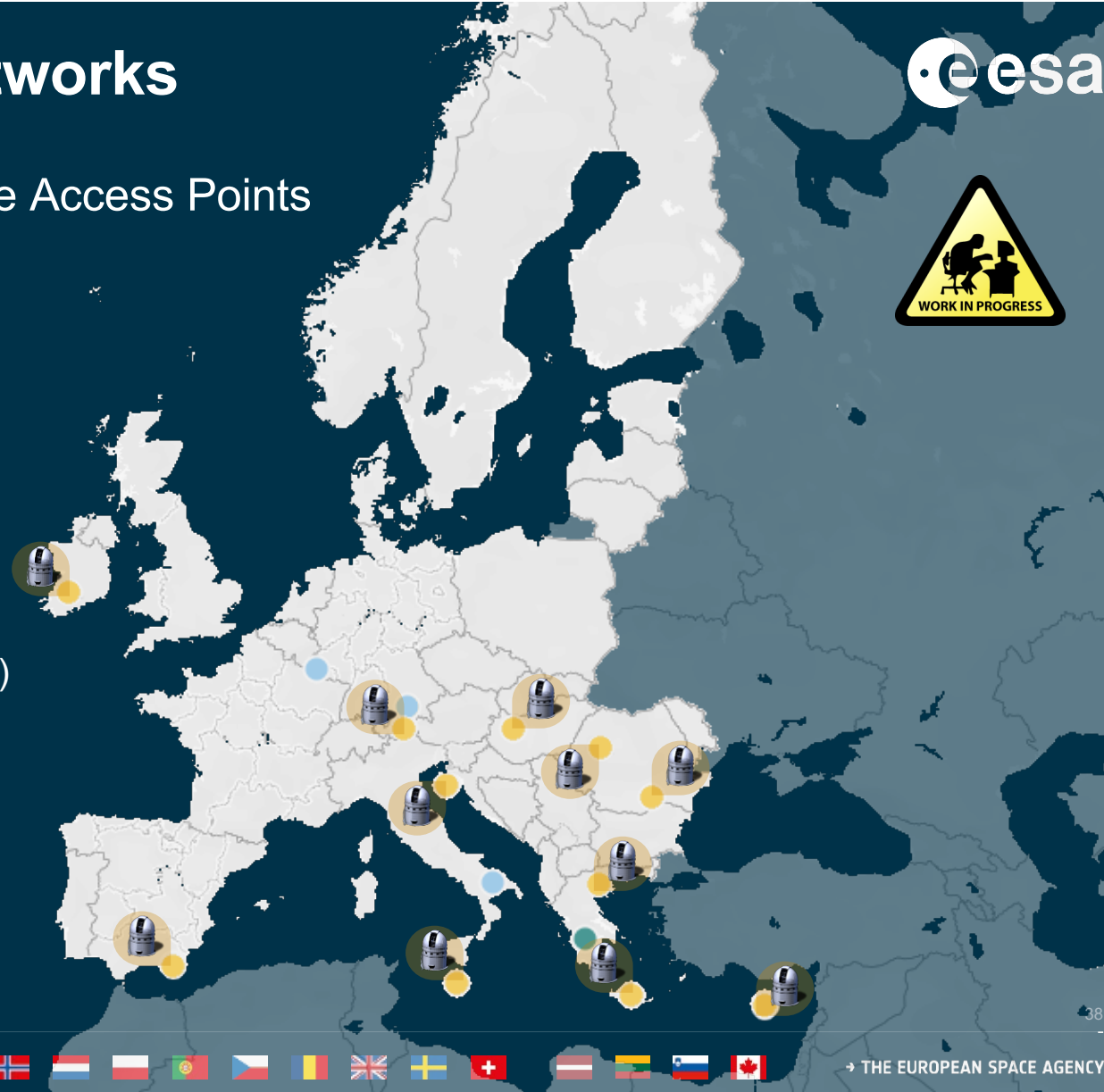
National Space Access Networks

Status of deployment of National Space Access Points
as of December 2021



Intentions for OGS declared:

- GR: Crete and Thessaloniki
(*upgrades of existing facilities*)
- MT: Gozo Island
(*new site development*)
- HU: Debrecen or Budapest (TBC)
- RO: Bucharest and/or Cluj Napoca (TBC)
- CR: location (TBC)
- AT: possibility being evaluated (TBC)
- CY: location (TBC ?)
- IE: location (TBC)
- ES: Calar Alto
(*upgrade of existing facility*)



National Space Access Network

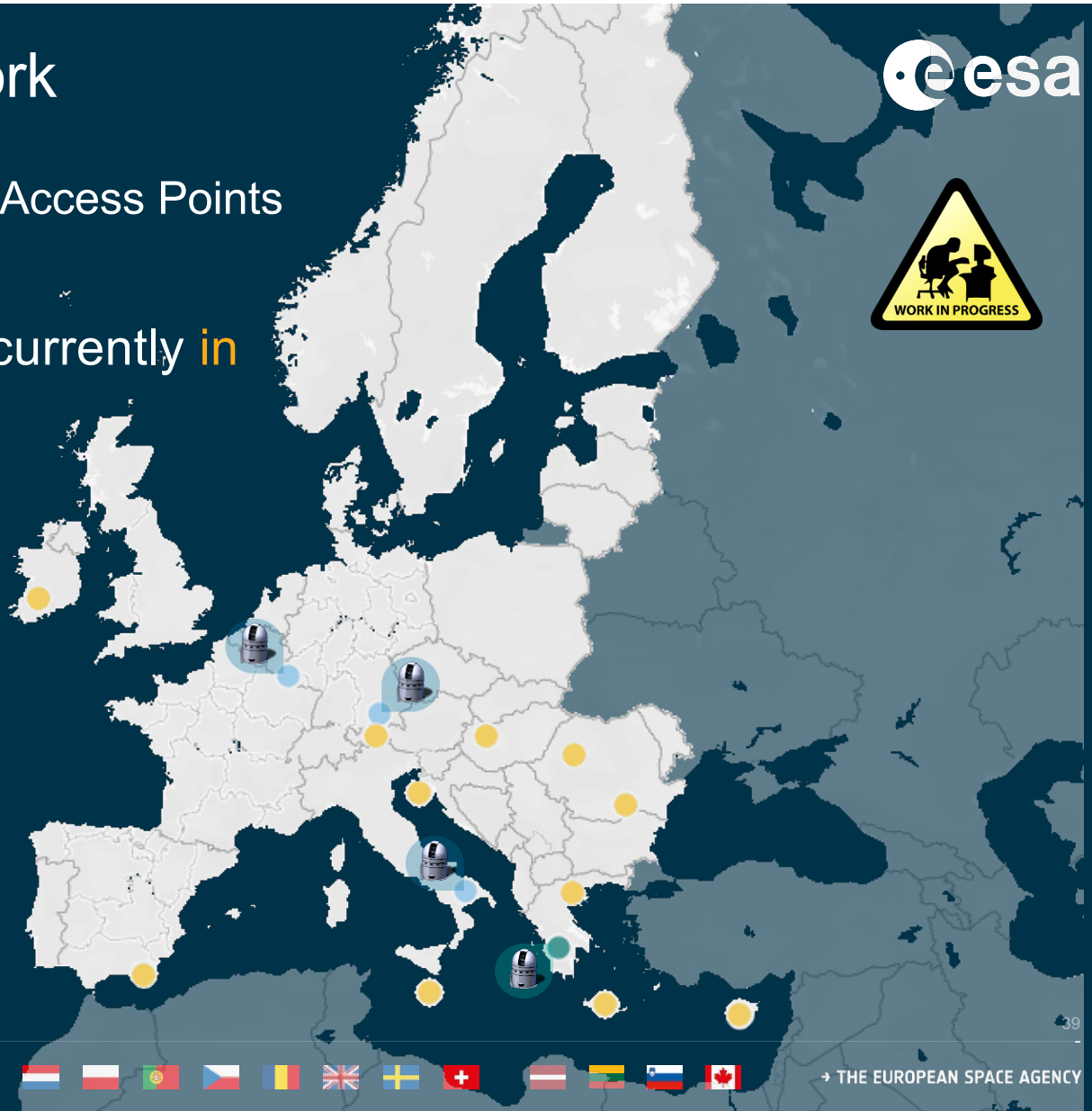


Status of deployment of National Space Access Points
as of December 2021



Concrete development **proposed** & currently **in progress**:

- GR: **Kalavrita/Helmos Observatory**
- DE: **Southern Bavaria**
(DLR intention & lead)
- IT: **Matera**
(upgrade laser ranging facility)
- LU: **Luxembourg**
(various locations under evaluation)





- **Turnkey Optical Ground Stations**

Telescope, mount dome, station base, electronics, management and system AIT, transport, deployment and commissioning included (assumed on secure site)

Costs	Ø 0.8m	1.2 M€
	Ø 1.5m	2.3 M€
	Ø 2.5m	6.9 M€

- **QKD and Optical COMs package**

Adaptive Optics; single mode optical fibre coupling; QKD module (key generation and initial storage capacity)

Costs	0.5 M€ - 1.2 M€
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All cost figures exclude security protection measures.

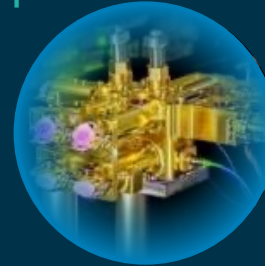


Quantum Technologies – Under ScyLight or 4S



Urban optical ground stations

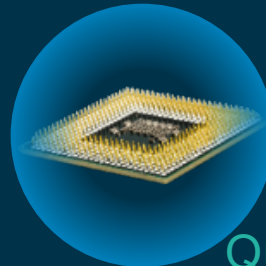
High Performance Entangled photon source



Optical Space Terminal



QKD key management systems



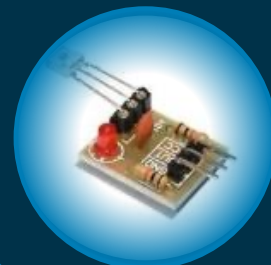
Quantum Random number Generator



Large optical terminals (for GEO or MEO)



Quantum transmitter



Detectors



Processing Software

Quantum Memory



Next Steps

Doing Business? <https://doing-business.sso.esa.int/>



DOING BUSINESS WITH ESA esa

Doing Business with ESA

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