# Photonics in ESA programmes

## Achievements and future outlook

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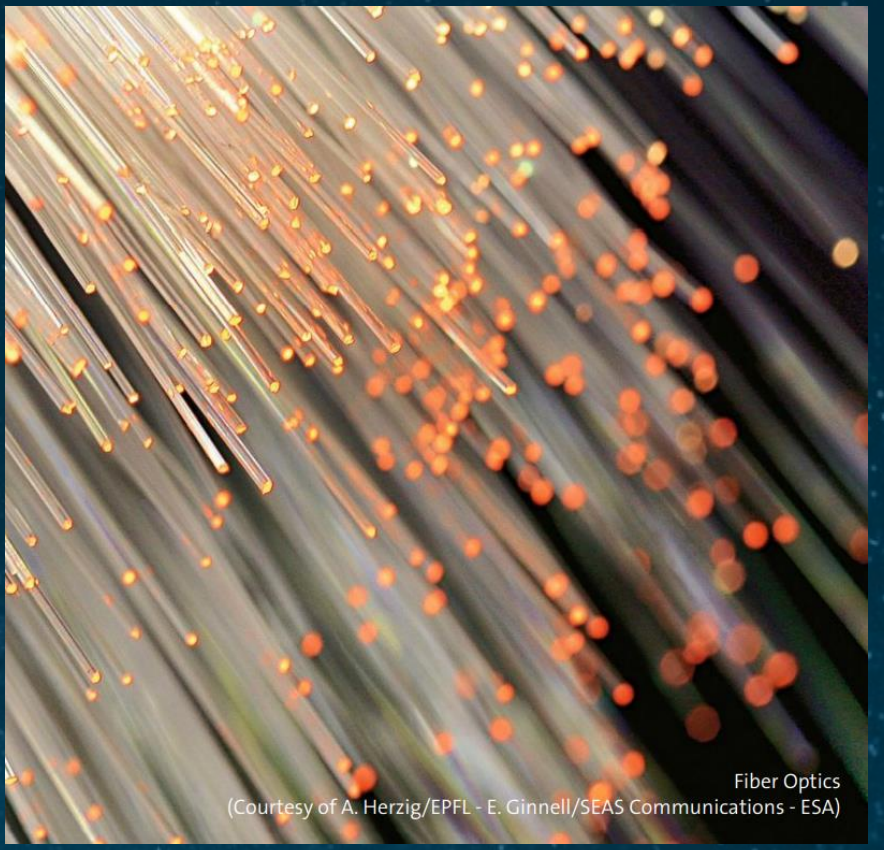


Fiber Optics
(Courtesy of A. Herzig/EPFL - E. Ginnell/SEAS Communications - ESA)

# Photonics in ESA missions

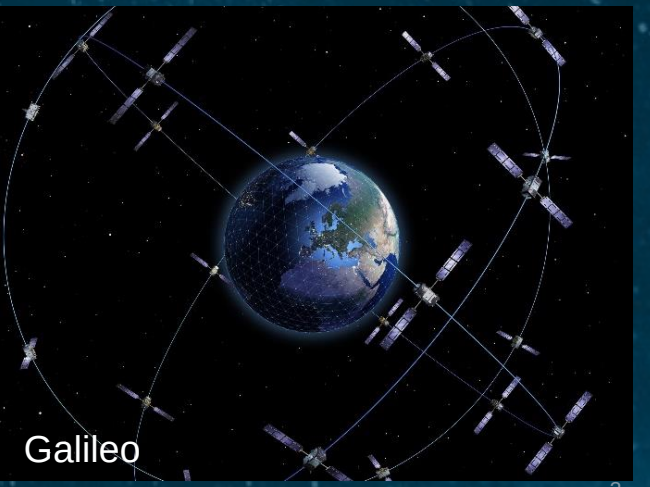
## Earth Observation


## Telecommunications – Optical & Quantum Communications



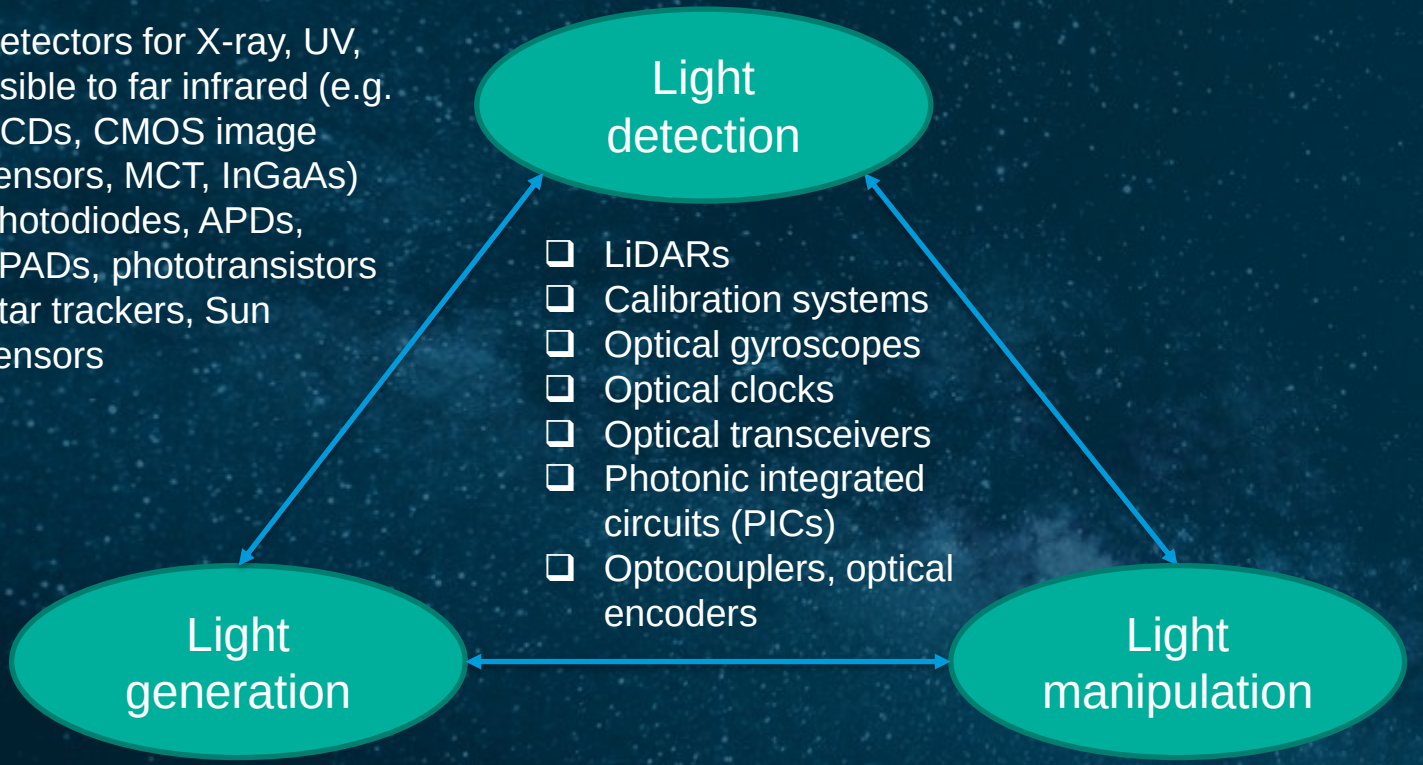
## Science & Exploration


## Navigation



# Photonics – Space technology development challenges

## Photonic components and subsystems




- Detectors for X-ray, UV, visible to far infrared (e.g. CCDs, CMOS image sensors, MCT, InGaAs)
- Photodiodes, APDs, SPADs, phototransistors
- Star trackers, Sun sensors

- LiDARs
- Calibration systems
- Optical gyroscopes
- Optical clocks
- Optical transceivers
- Photonic integrated circuits (PICs)
- Optocouplers, optical encoders

- LEDs
- Lasers
- Single and entangled photon sources
- Lamps

- Optical fibres and connector assemblies, couplers, splitters, harnesses
- Modulators, multiplexers

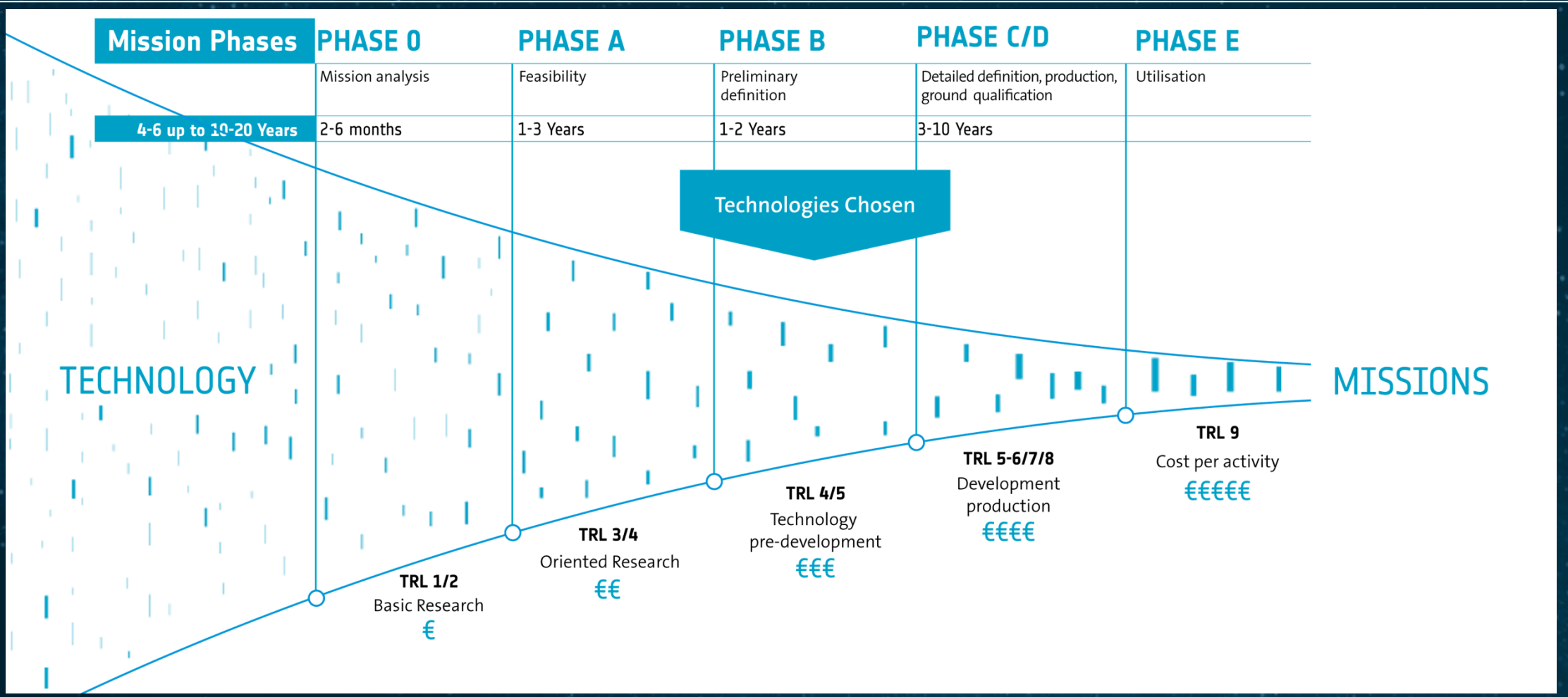
## TECHNICAL Challenges

- Photonic components and subsystems
  - Performance (wavelength, speed, power)
  - Materials
  - Technologies
  - Assembly & Packaging
- Space Environment
  - Radiation
  - Vacuum
  - Thermal
  - Lifetime
  - Long storage times prior to launch
  - Launch (vibration, shock)

## PROGRAMMATIC Challenges

- Funding
- Availability / Timing
- Continuity
- Reliance on COTS

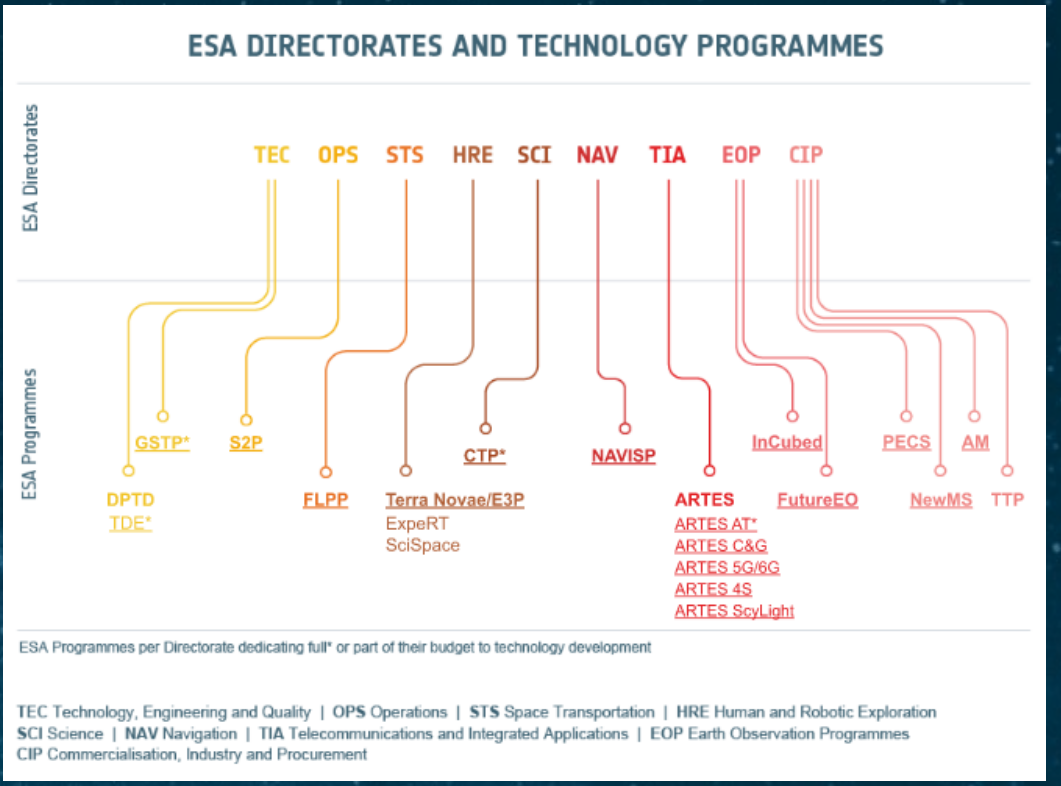
# Photonics – Space technology development challenges




**Enabling missions by making sure the right technology, at the right maturity level is available at the right time**

# ESA funding programmes

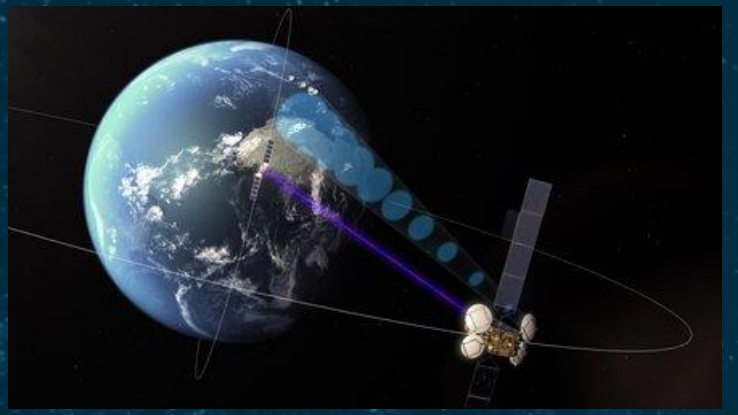
- Main programmes covering photonics:
  - Technology Development Element (TDE)
  - General Support Technology Programme (GSTP)
  - ARTES Secure and Laser communication technology Program (Scylight)
  - Open Space Innovation Platform (OSIP)
  - List of other relevant funding programs available on this link
- The scope of these programs varies by application domain and by Technology Readiness Level.
- **Activities published in esa-star**

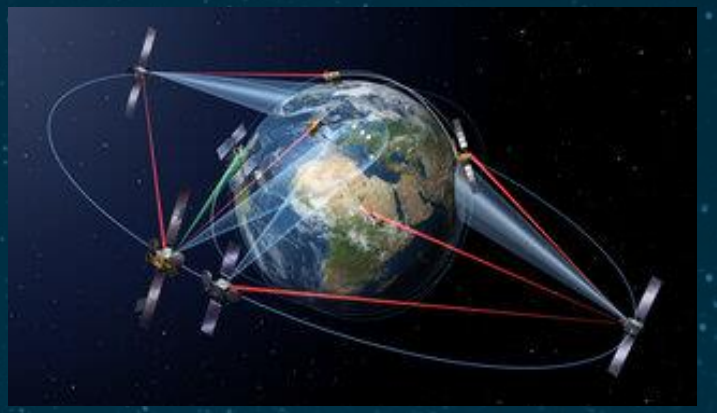



From ESA Technology Master Plan 2022

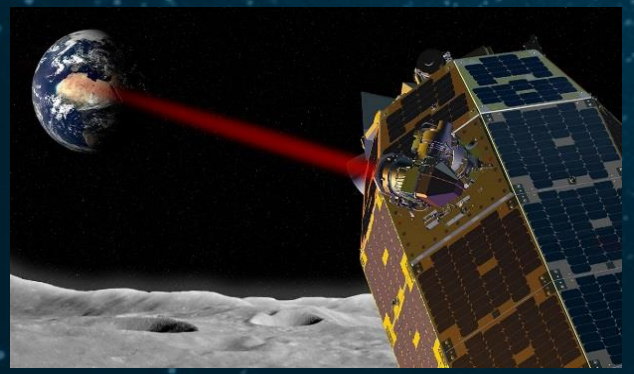
# Achievements and highlights – Optical communication systems

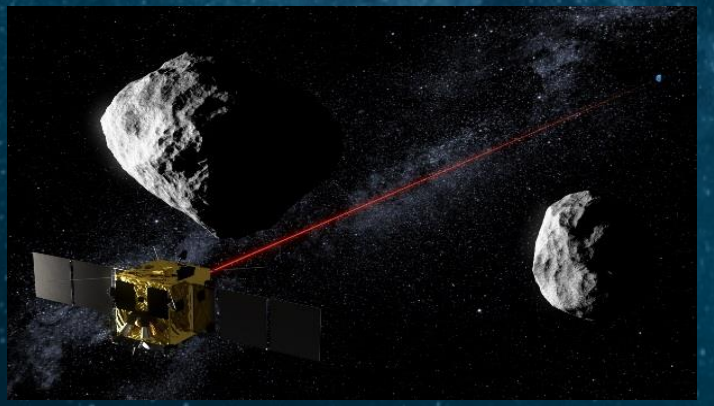
**From near Earth:** SILEX (the first optical data relay system) via EDRS to EDRS Global





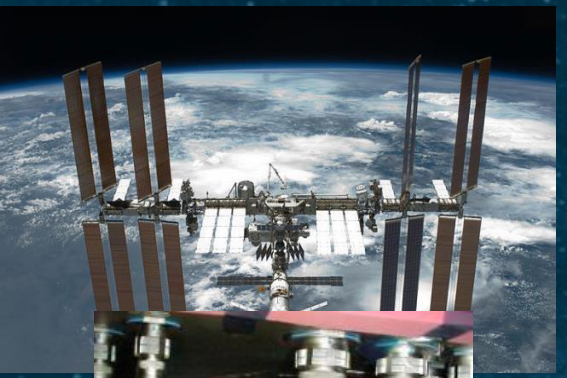
**To deep-space:** LADEE (lunar optical communication) via AIM to Space Weather mission L5





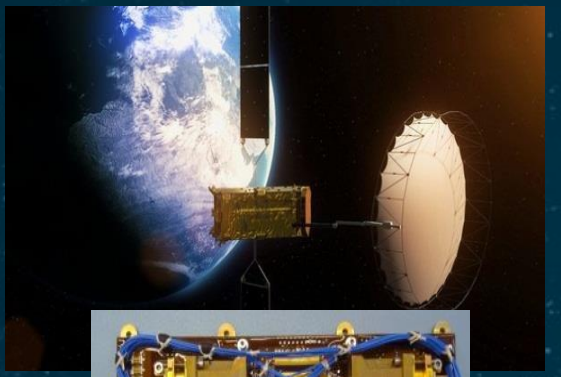
# Achievements and highlights – Fibre optics

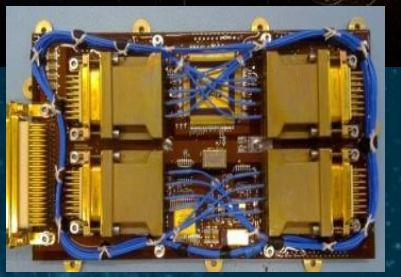
### 1998: ISS – Optical Comms



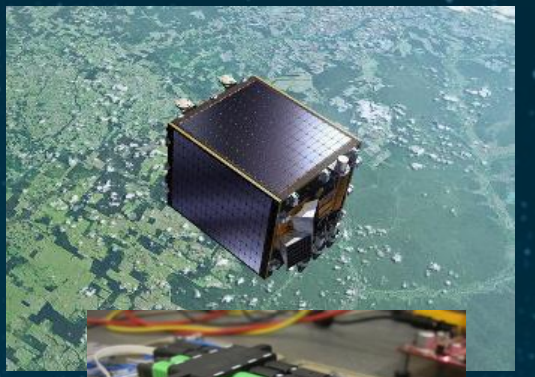
### 2009: SMOS – Optical Data and Clock Distribution

### 2013: AlphaSAT – TDP 8



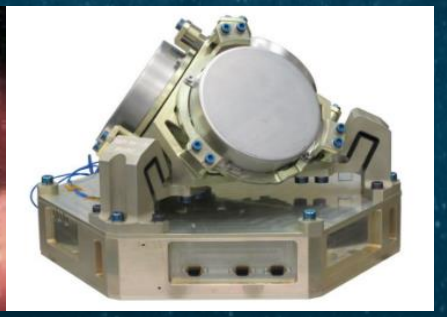


### 2013: PROBA V- HERMOD

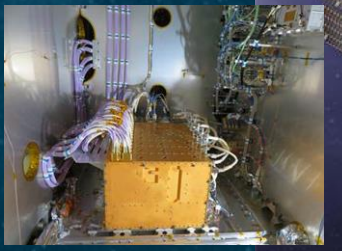


### 2004: Demeter – Opto-pyrotechnic demonstrator

### 2009: Planck – Fiber optic gyro (4 axis)

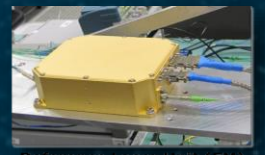


### Oct. 2021: SES-17 VHTS Payload

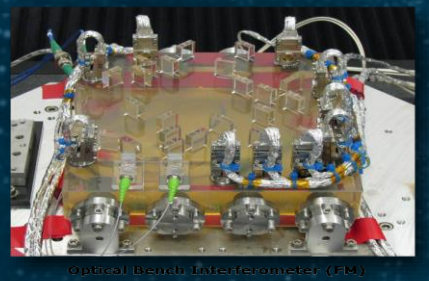


# Achievements and highlights – Laser metrology systems

## Metrology laser system developments for LISA pathfinder, LISA and NGGM (GOCE follow on)

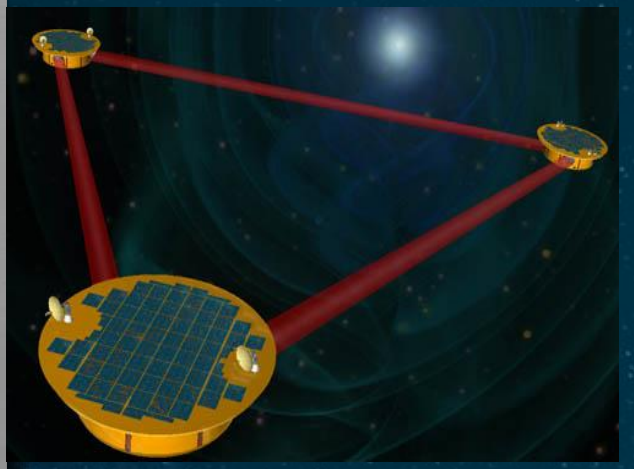


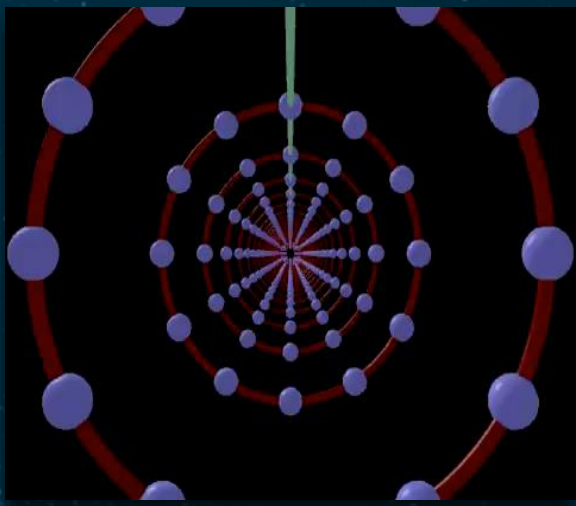


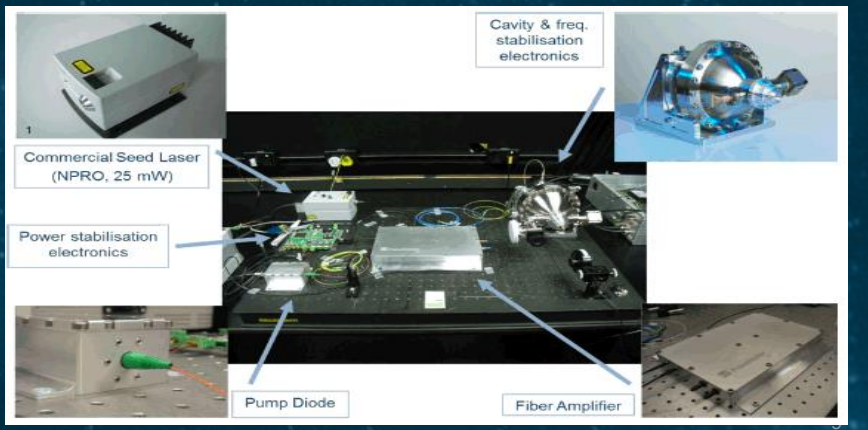






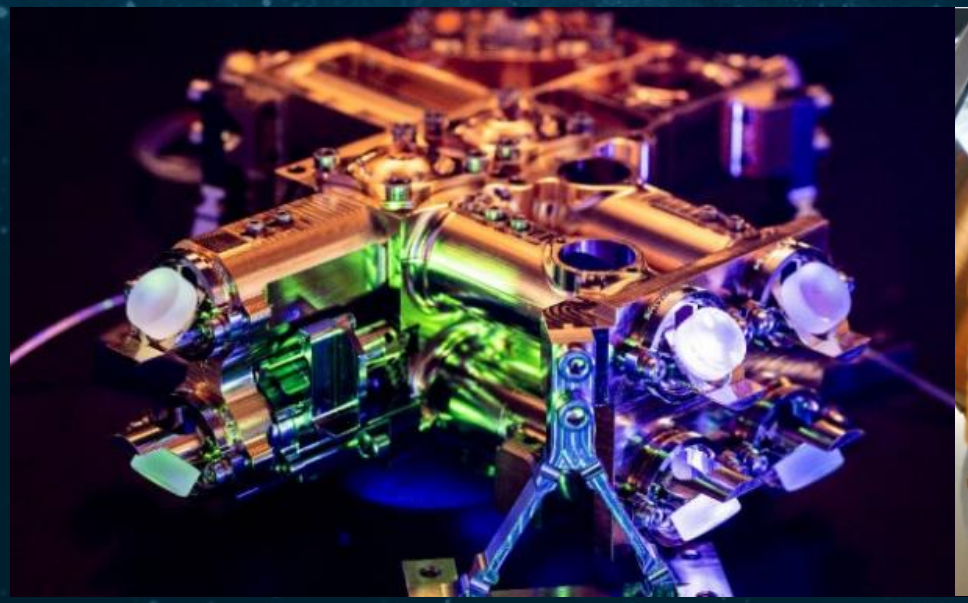




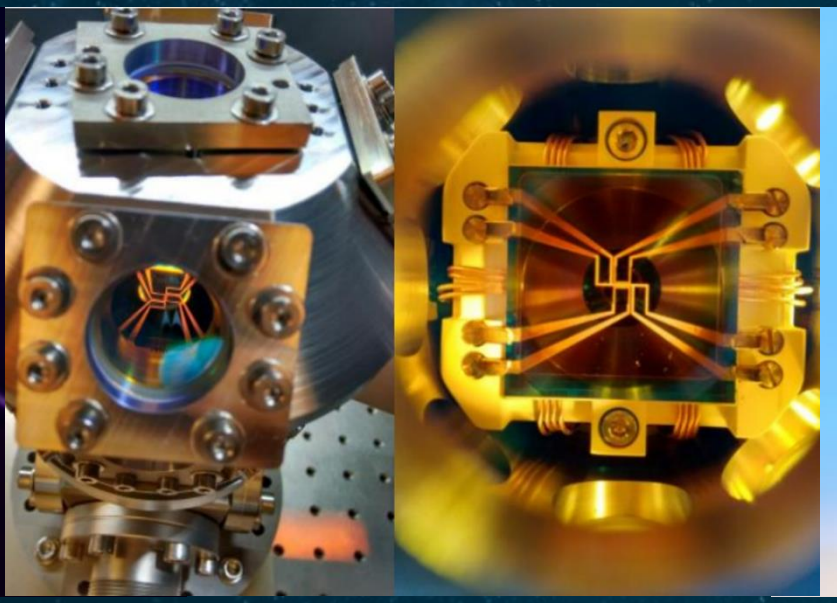


# Achievements and highlights – Quantum

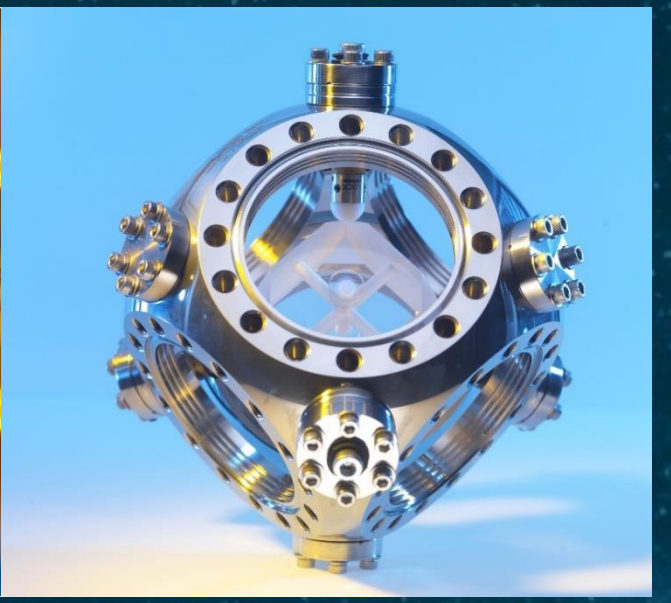
- Quantum Key Distribution (QKD) for secure communication
- Cold Atom Interferometers for precise gravity measurements and fundamental physics
- Optical Clocks using Cold Atoms or Ions



Entangled photon source (ARTES contract with Fraunhofer IOF Jena)



Atom interferometry vacuum chamber with atom chip

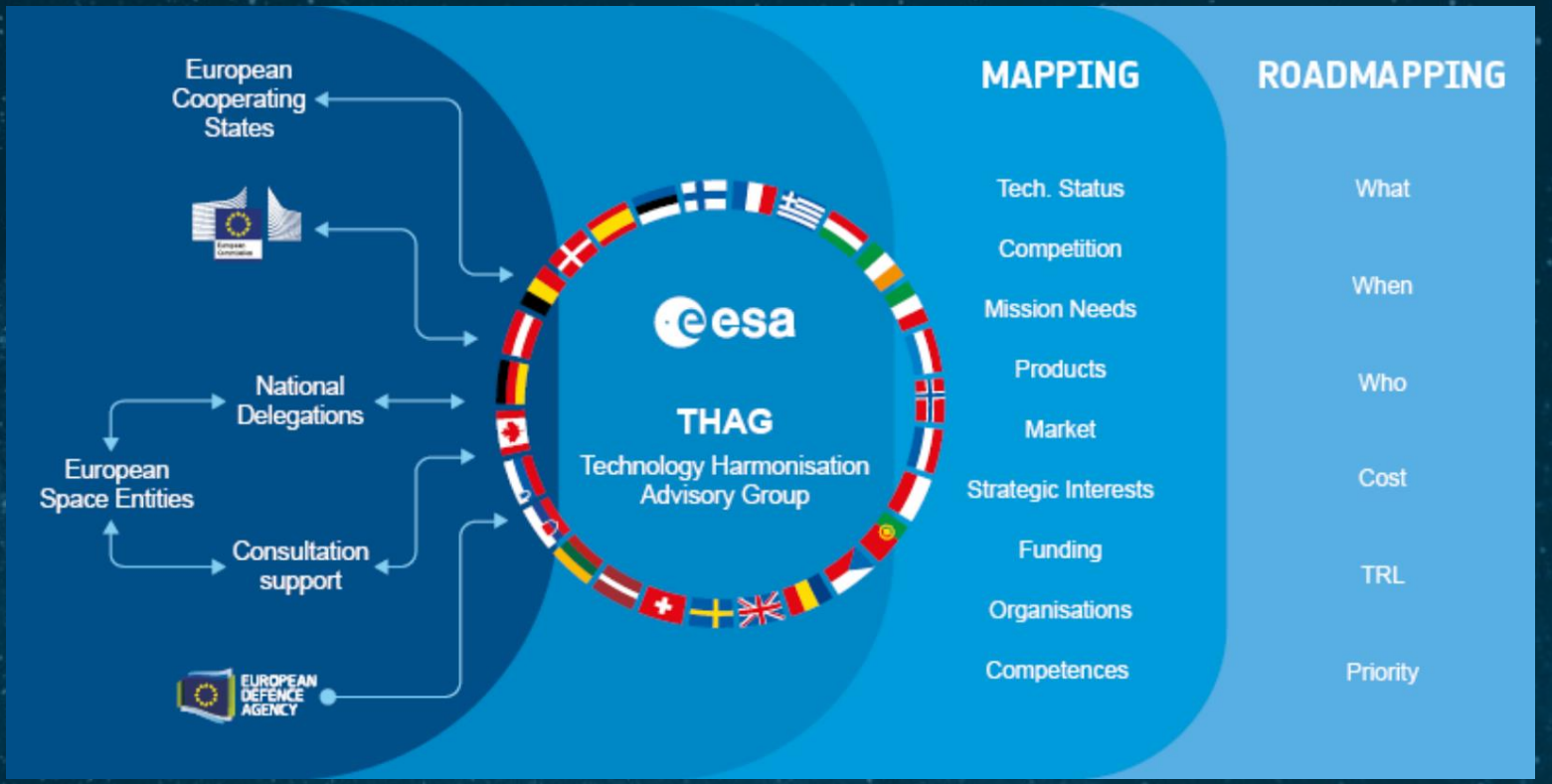


Optical reference cavity inside vacuum chamber

# State of the art and highlights –Technology Harmonisation in Photonics

**5 Harmonisation Dossiers and roadmaps on Photonics topics:**

- **Optical Communications** – recently updated, released in January 2023
- **Lidar Critical Subsystems** – recently updated, released in October 2022
- **Optical Detectors** – recently updated, released in June 2022
- **Photonics** – Update started in January 2023, to be released in January 2024
- **Frequency & Time Generation and Distribution** – Update started in January 2023

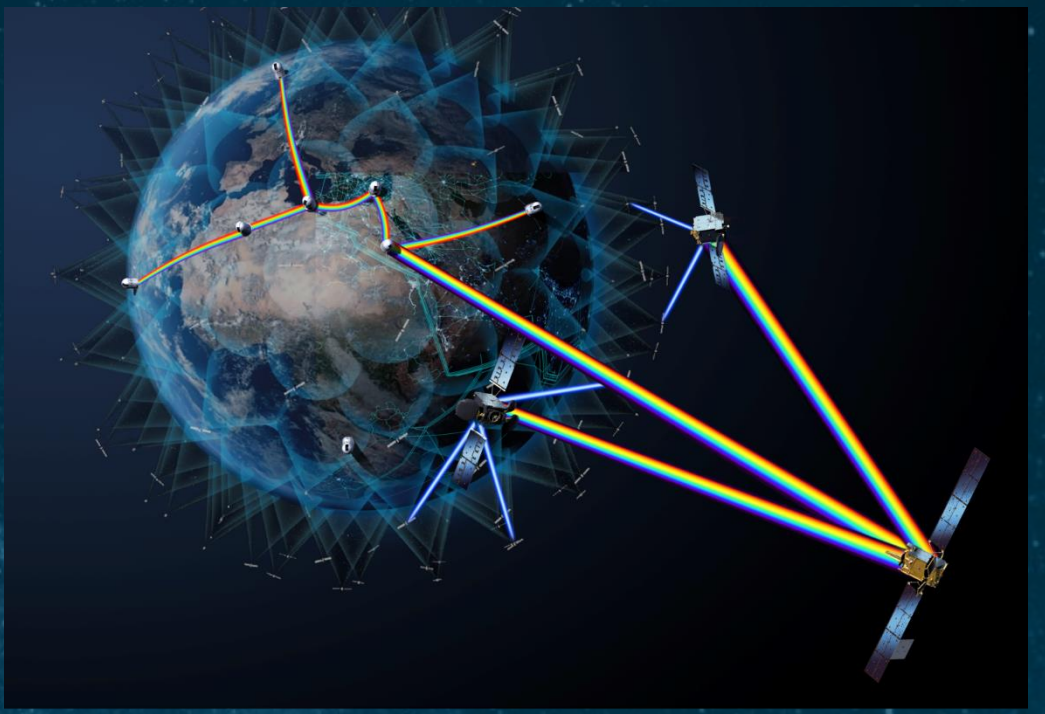



From ESA Technology Master Plan 2022

# Future outlook

With very successful CM22 total subscription of 16.9 B€, large number of new missions and technology development activities in planning:

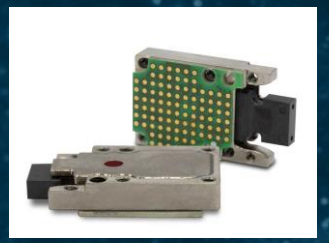
- **Supporting projects** in all areas through major milestones and technical challenges
- **Roadmap implementation** of TDE Workplan and GSTP:
  - **GSTP EEE Component Sovereignty Initiative – Photonics** one out of six strategic focus areas
  - **Quantum Technology Cross Cutting Initiative** – Coordinated with all ESA directorates and external stakeholders → White paper ready, strategy to be implemented in GSTP and TDE
- **ARTES ScyLight** – implementation of **ESA's Hydron project**



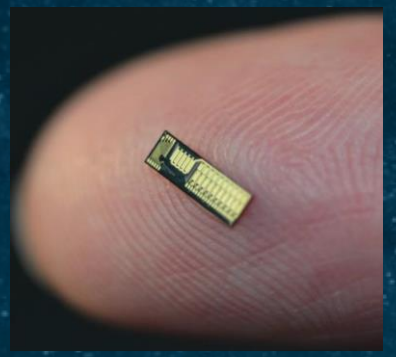
ESA's Hydron project

# GSTP EEE Component Sovereignty Initiative – Photonics Technology Line

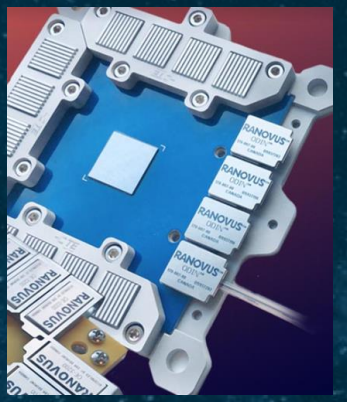
## Driving modular avionics for the next generation digital and RF payloads



Courtesy of Smith Interconnects



Courtesy of Effect Photonics




Courtesy of Ranovus

Active Components

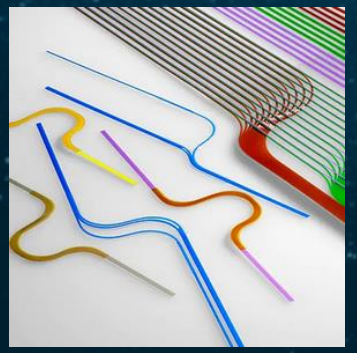
**Co-packaged Optics**

- Advanced European Solution for co-packaged optics suitable for interfacing to next generation digital processor payloads; Covering intra and inter spacecraft applications.
- Radiation hard PICs – NRZ, PAM4 and Coherent
- Radiation hard drivers and DSPs
- Advanced multi-chip packaging concepts

**Microwave Photonics**

- Develop efficient microwave photonic transmitters and receivers up to V band.
- Low power consumption transmitters and modulators
- High saturation power efficient detectors

Courtesy of Radiall



Courtesy of TE Connectivity

Courtesy of Leoni

Passive Components

**Fiber Optic Harness Components**

- Optical fiber harness technologies for distribution of optical signals on board satellites covering, high density, modular avionics also including high power applications.
- Connectors
- Fibre cables
- Flexible Fibre Circuits

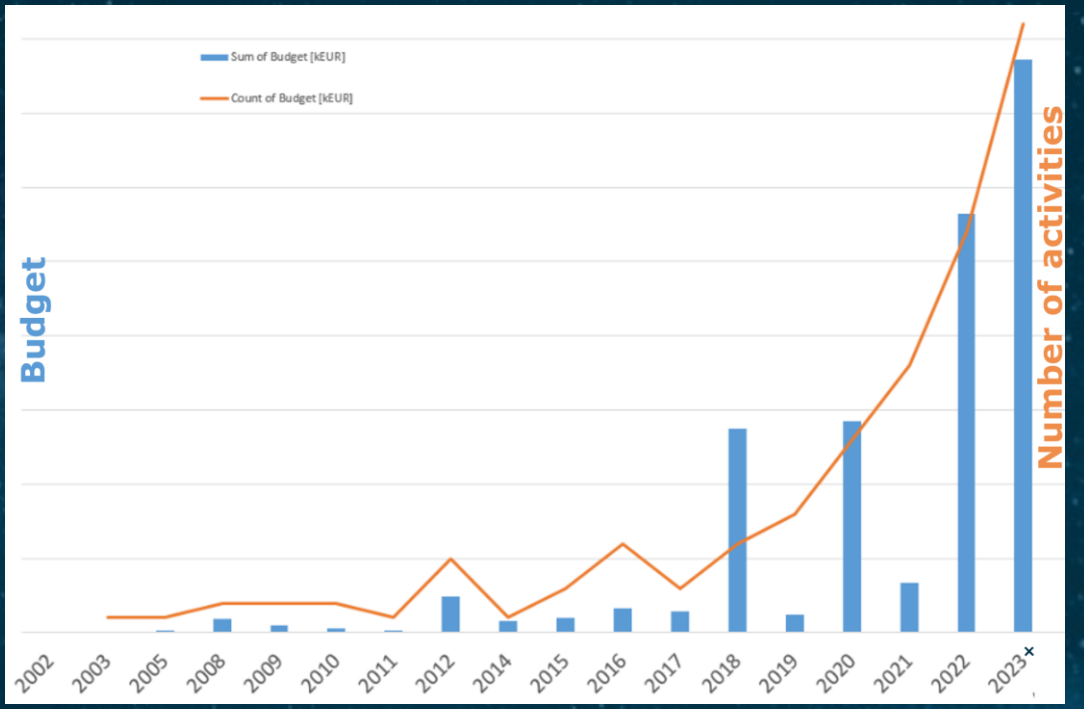
# ESA Quantum Technology Cross Cutting Initiative

The QT-CCI is coordinating the content of ESA Quantum Technology Activities

- Established as an ESA priority in 2021 as part of the ESA Agenda 2025
  - > 50 ESA colleagues involved from 10 directorates
  - Close collaboration with **Industry & academic colleagues** in ESA Member States
  - New activities are selected and executed in the regular ESA programmes

**Technical topics:**

Atomic Frequency Standards
Atom Interferometers
Decoherence Experiments
Post Quantum Cryptography
Quantum Communication
Quantum Computing
Quantum Memories
Quantum Enhanced Sensing Techniques
Quantum Random Number Generators




Evolution of budget and number of activities for quantum at ESA

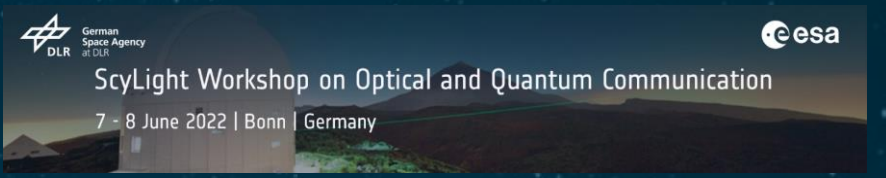
QT-CCI point of contact: eric.wille@esa.int

# Summary and conclusions

- Photonics is set to play an increasingly important role in future space missions.
- Many technology development activities are already supported by ESA in the area of Photonics.
- A range of exciting new activities are coming up in ESA's programmes, such as:
  - GSTP EEE Component Sovereignty Initiative – Photonics
  - Quantum Cross Cutting Initiative
  - ARTES ScyLight programme

# Are you ready to discover more?

- ESA's Commercialisation Gateway
- ESA Open for Business
- **Conferences and trainings**
  - 6th Annual ScyLight Conference, May 2023
  - Infrared Detection for Space Applications Workshop, June 2023
  - 6th Quantum Technology Conference, September 2023
  - International School on Space Optics (ISSO), October 2023
  - International Conference on Space Optics (ICSO), October 2024





***Thank you!!***

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