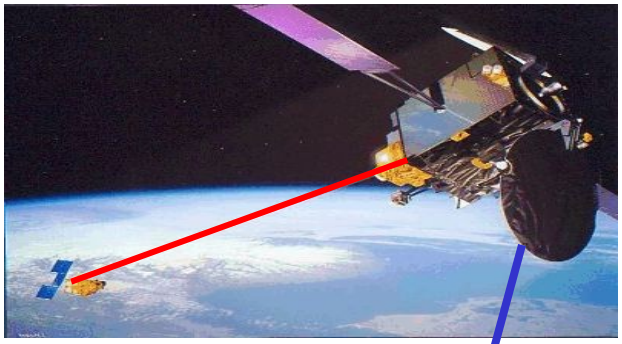
OPTICAL SPACE COMMUNICATIONS

Josep Perdigues & Zoran Sodnik
E-mail:
Josep.Maria.Perdigues.Armengol@esa.int,
Zoran.Sodnik@esa.int

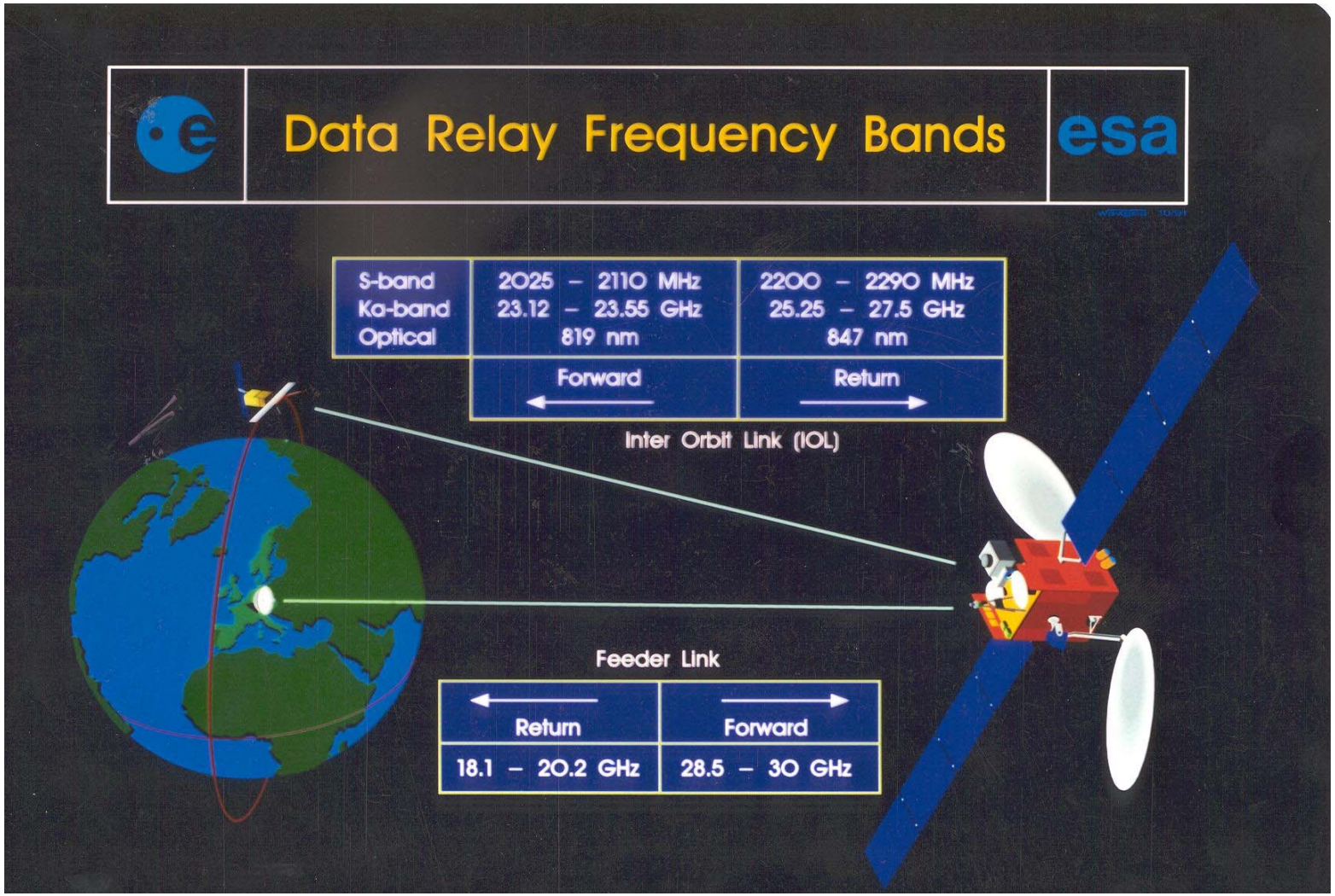
European Space Agency (*ESA – ESTEC)*
www.esa.int

SILEX: First Laser Inter-Satellite CommunicationsLink

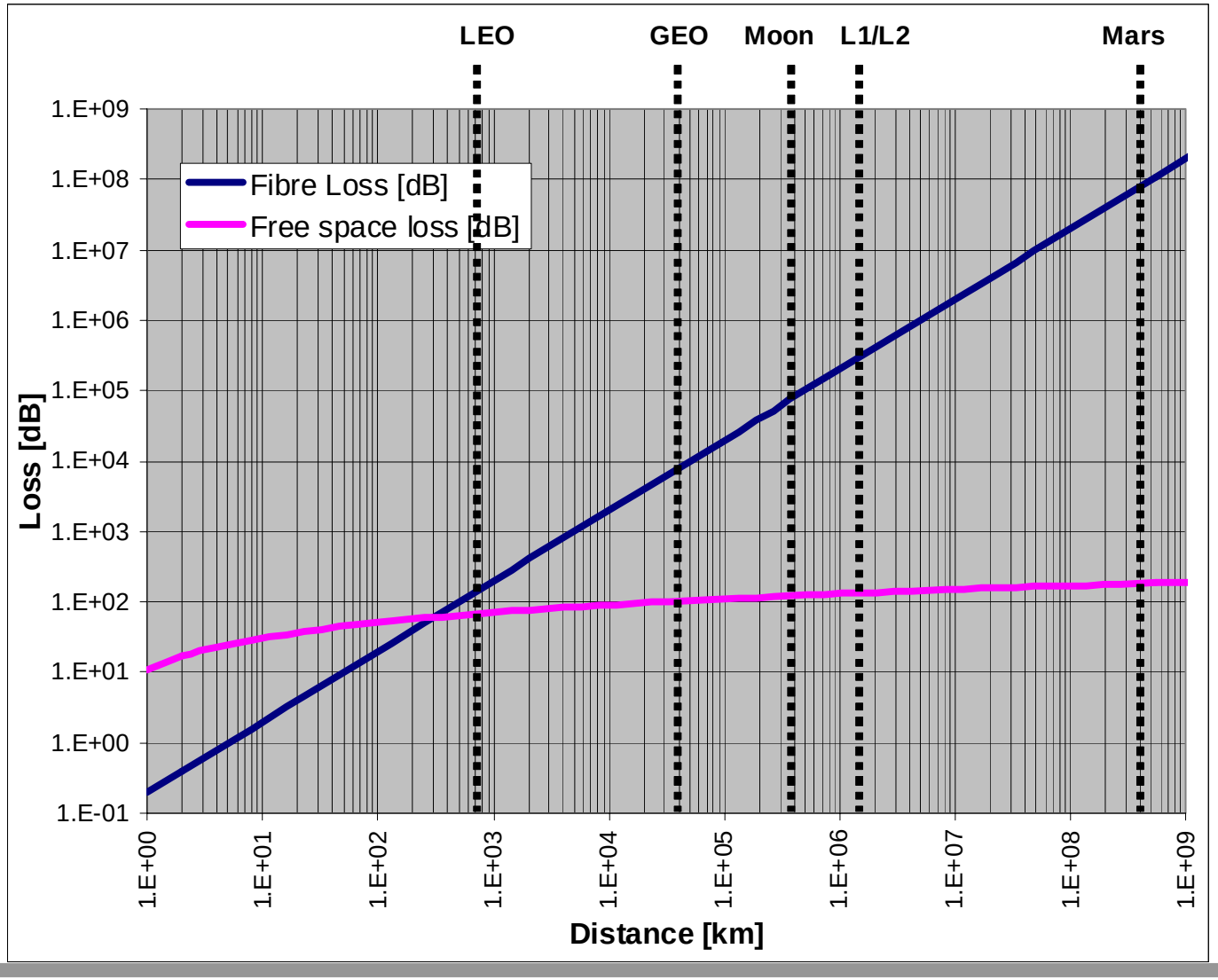


30 November 2001 17:45 Lanzarote, Canary Islands, in the Atlantic ocean west of Africa, the first image trans-mitted via optical intersatellite link from SPOT4 to ARTEMIS and then to SPOTIMAGE in Toulouse, France via ARTEMIS' Ka-band feeder link

Inter-Satellite Laser Comms



Inter-Satellite Laser Comms



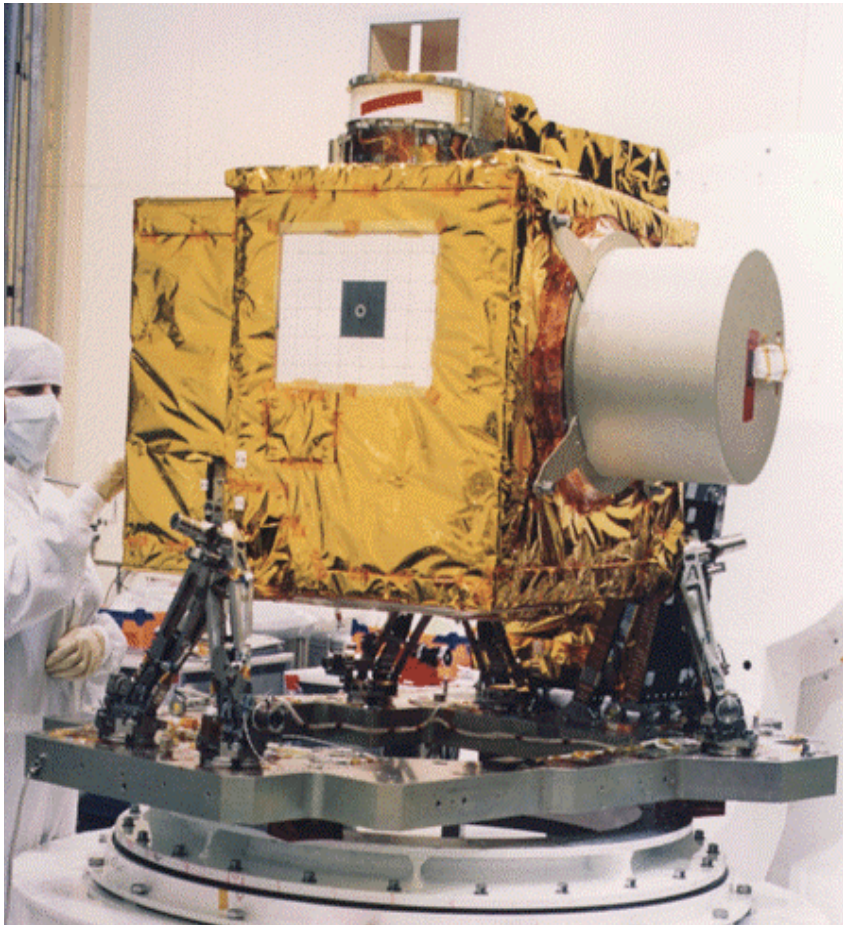
Why laser communications in space?

1. **High antenna directivity.**
2. **No frequency regulatory constraints.**
3. **Large available bandwidth due to operation in optical bands.**
4. **Narrow beamwidth of the laser beam offers tight spatial confinement, ideal against interception, eavesdropping and jamming**

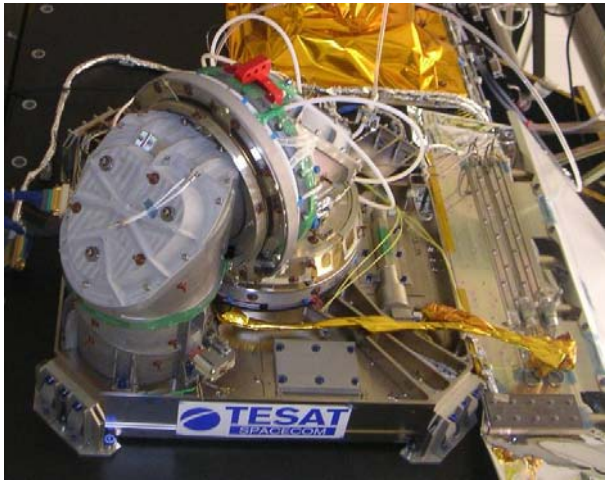
But it requires very high pointing and tracking accuracy (~1/2000 degrees = footprint of 350 meters from GEO orbit)

Inter-Satellite Laser Comms

1st Generation (1985-2001)



2nd Generation (1989-2008)



- **Mass / 3**
- **Power consumption ~**
- **(LEO-GEO) data rate x 50**

Intra-Satellite Laser Comms

Satellite operators looking forward to versatile solutions that can adapt to the evolving telecom traffic and connectivity needs

Optical technologies offer to satellite telecom payloads

- Intrinsic broadband operation
- Transparency to RF frequency bands
- Compactness, lightweight
- Flexibility on equipment accommodation
- No EMC/EMI issues, galvanic isolation, RF isolation
- Low fibre cable loss
- Integration capability with microwave technology
- WDM multiplexing

Where laser communications inside a satellite?

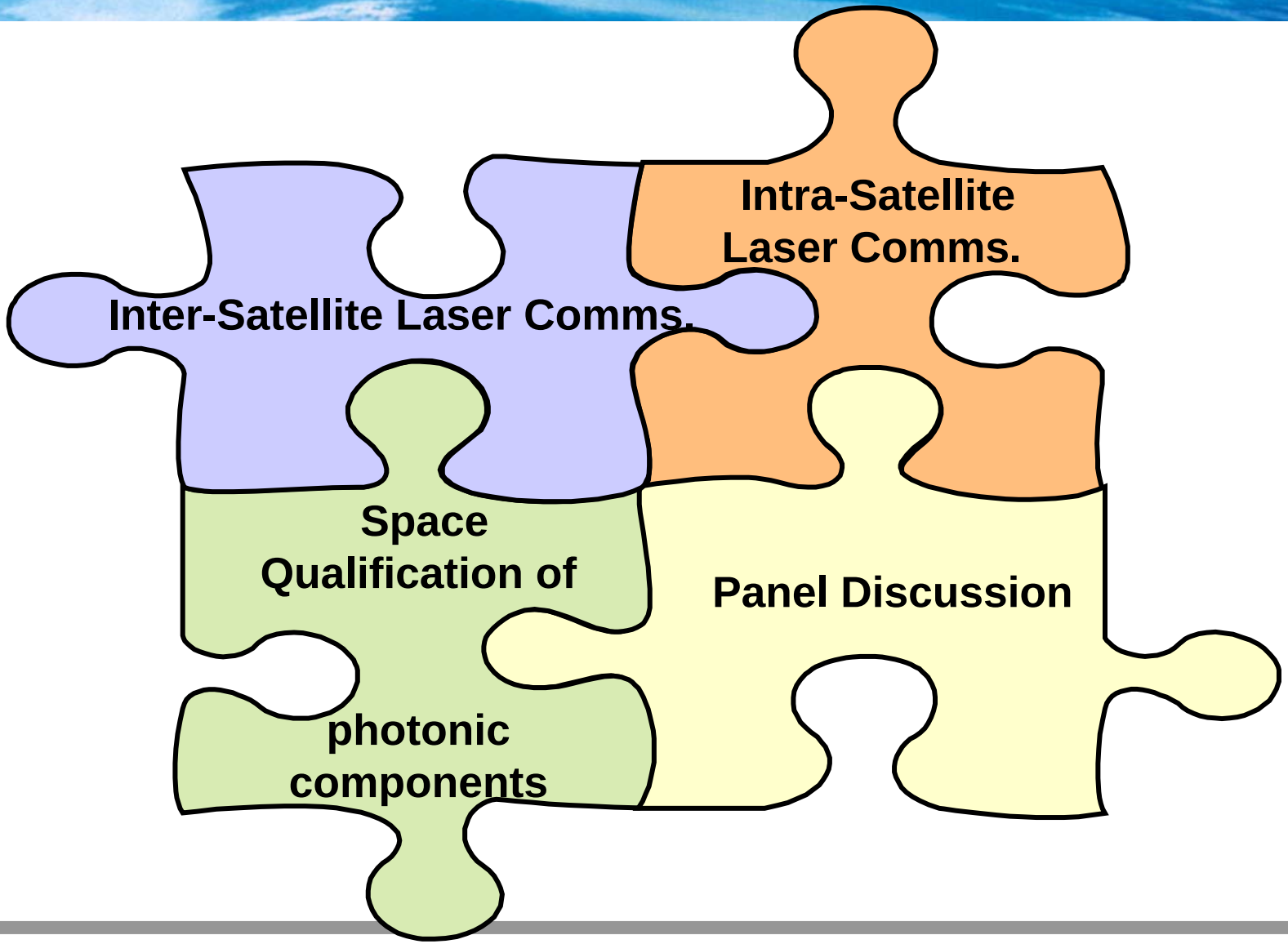
1. **Digital payloads:**
   - ✓ **Equipment to equipment interconnects**
   - ✓ **Inter-board interconnects**
   - ✓ **Inter-chip interconnects (or intra-board interconnects)**
   - ✓ **Intra-chip interconnects**
   - ✓ **ADC to DSP and DSP to DAC interconnects**
   - ✓ **Electro-photonic fast sampling**
   - ✓ **Ultra-fast switching (~nanosecond switching time) of packets/bursts**

Where laser communications inside a satellite?

2. **Analog payloads:**
   - ✓ **Reference/LO/microwave signal generation and distribution**
   - ✓ **(Single or multi) frequency conversion**
   - ✓ **Circuit switching (~milisecond switching time) of RF signal**
   - ✓ **Optical BFNs for transmitter and receiver multi-beam antennas**
   - ✓ **Opto-microwave transparent repeater**

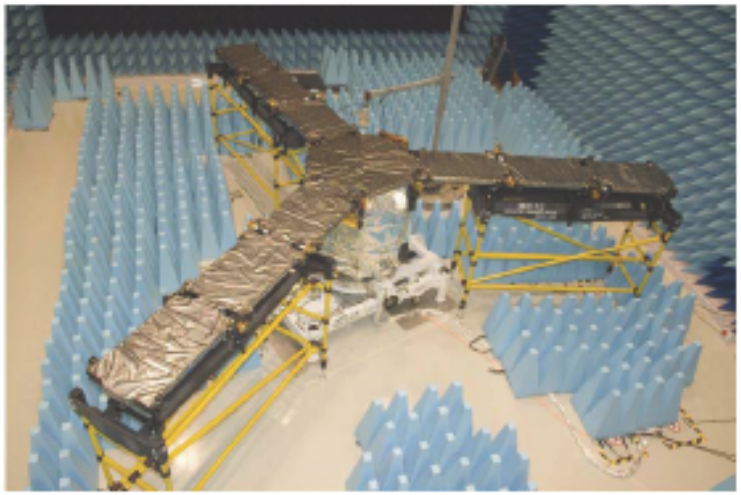
Future-proof repeater (15-20 year lifetime) at affordable MVP, complexity, risk and costs

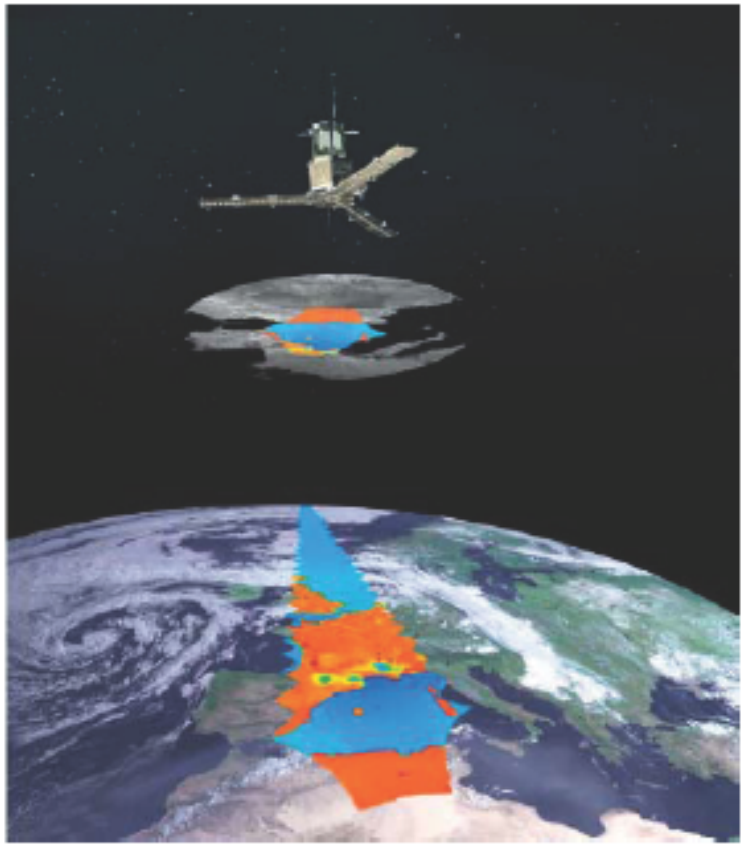
Optical Space Communications



Earth Observation

SMOS (Soil Moisture and Ocean Salinity) is the first Satellite Payload to rely critically on fiber optics (to be launched this year)

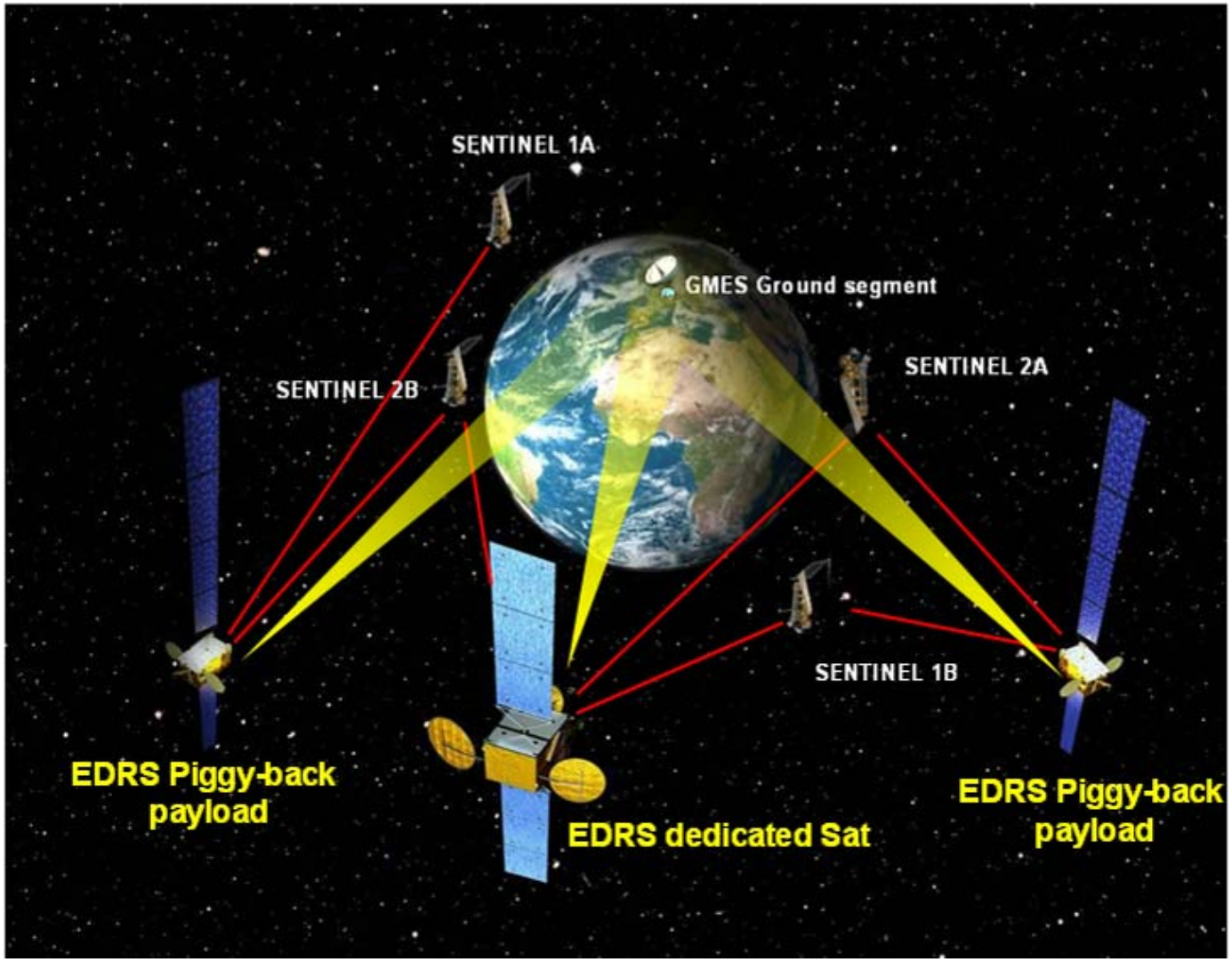




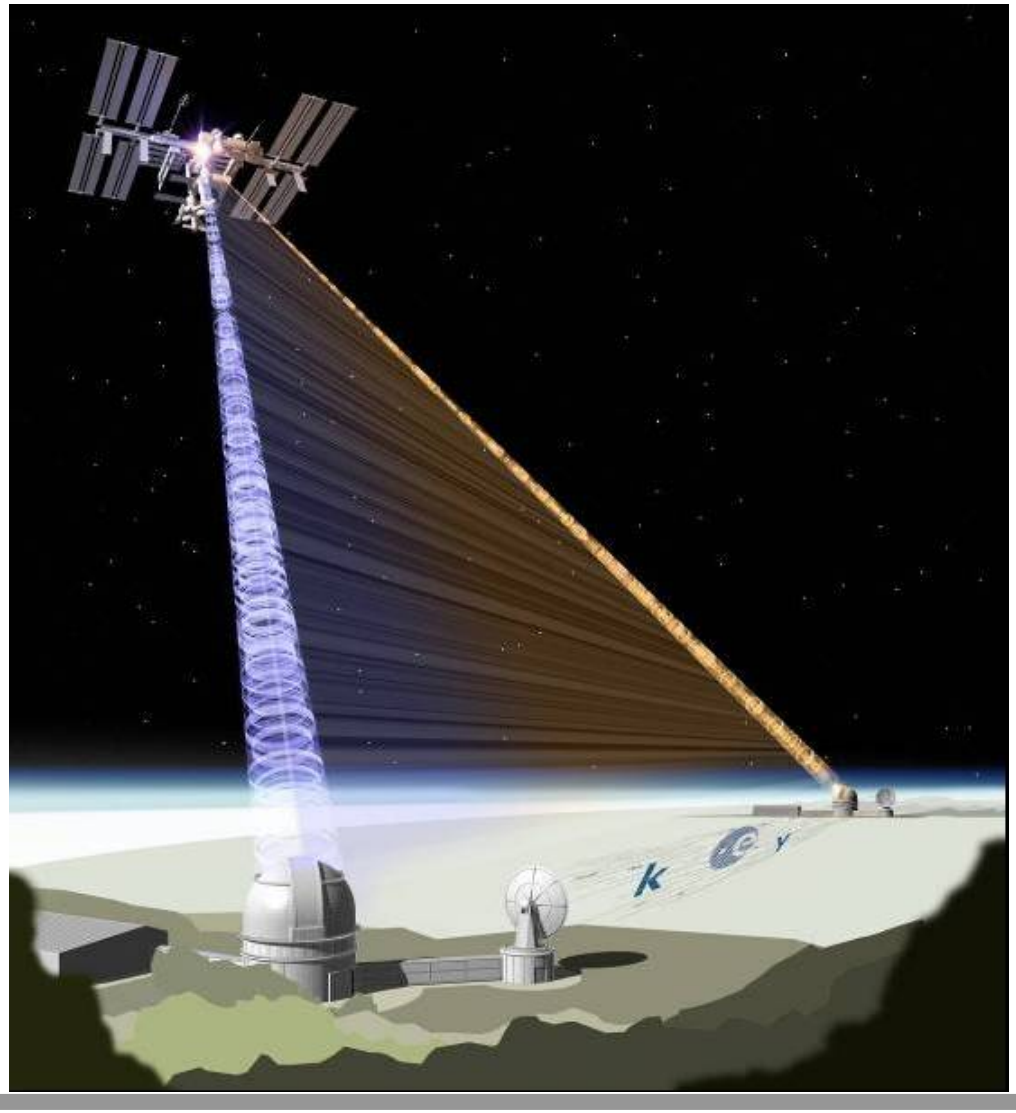
144 links at 110 Mbps (72 to and 72 from antenna elements)

- very low EM emission levels (from Tx/Rx)
- galvanic isolation
- mechanically flexible and lightweight
- better phase stability when bended

European Data Relay System



Fundamental Science: Space-QUEST



Open Questions

- **What will the 3rd Generation Laser Communication Terminals look like? Which wavelength? Which modulation scheme? Which detection scheme? Which data rate?**
- **Are we ready (willing to) establish international cooperation to support interoperability of laser communication systems? Network of ground stations?**
- **Which development approach: customized photonic components or modified/adapted COTS components?**
- **Are component suppliers willing to provide continuous support during qualification process (including design modifications, fabrication processes, packaging, etc.)?**
- **ITAR regulation issues?**
- **Standard approach for qualification of photonic components for space? Public database of photonic preferred parts list?**