Future and Challenges on Optical Communication Terminal Developments

ESA's view

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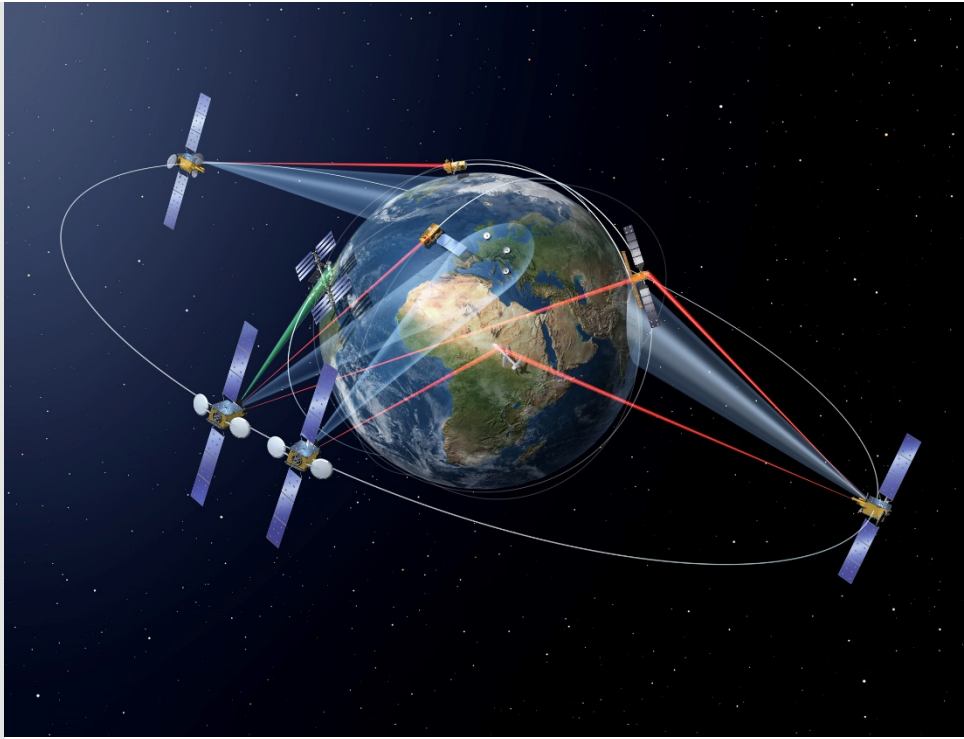
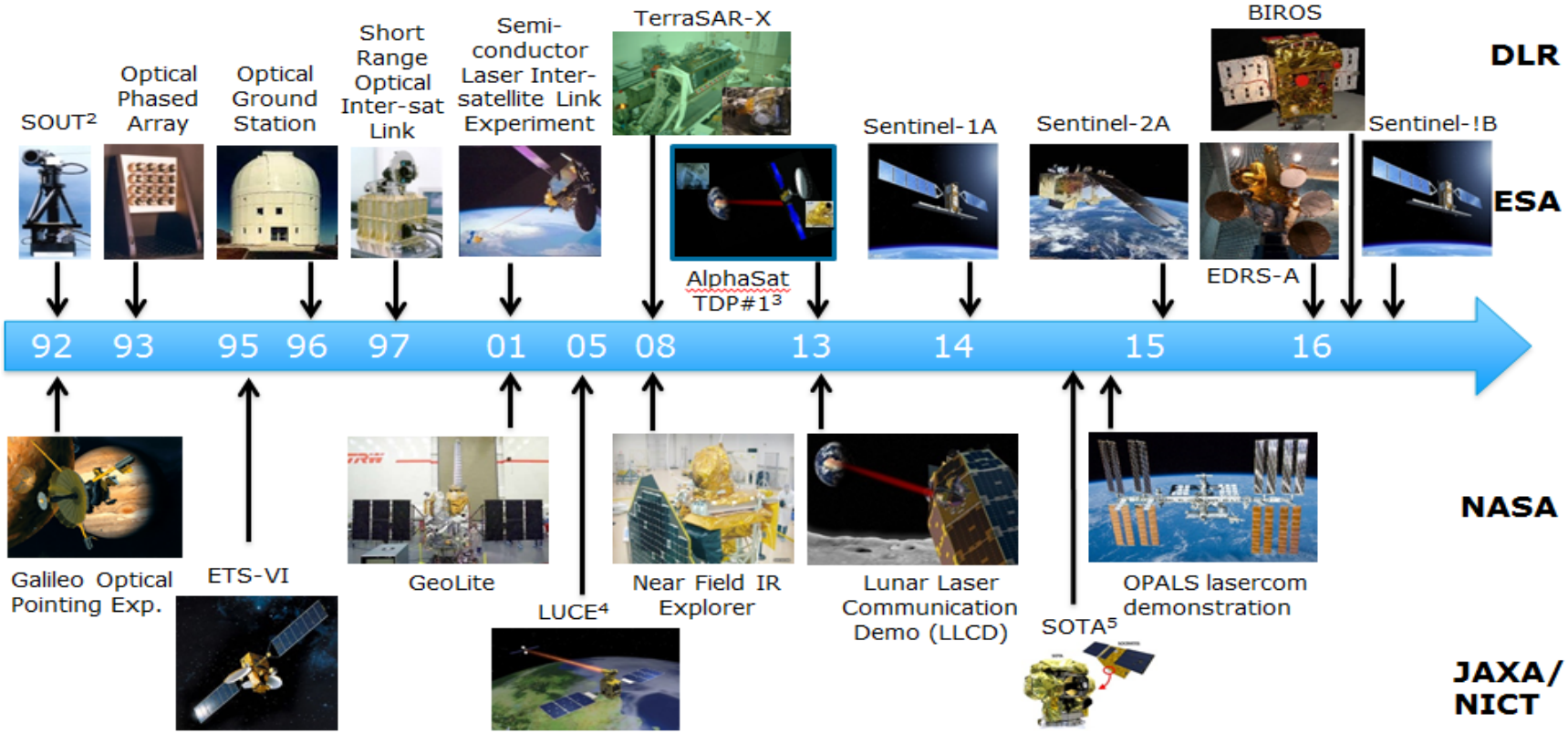
Optical Communication Terminal Facts

- “Unlimited” bandwidth.
- License and interference free operation.
- Strong dependence on weather and atmospheric turbulence.
- First optical communication terminal in orbit since 1995 (on ETS-VI, JAXA).
- Feasibility demonstrated in 2001 (by SILEX, ESA).
- JAXA, NASA, ESA, Roscosmos, (China?) have launched optical communication terminals.
- The first commercial optical communication system in space is EDRS, the European Data Relay System.



GlobeNet proposal for EDRS extension

Timeline of International Developments



¹ Miniaturised Optical Monolithic Terminal
² Small Optical User Terminal
³ Technology Demonstration Payload #1
⁴ Laser Utilising Communication Equipment
⁵Small Optical Transponder Antenna

Space-based optical communication terminals

The European Data Relay System (EDRS) has – de facto - established a standard, that is challenged by NASA and – so far - not followed by other space agencies.

Technical challenges are:

- Improved wall-plug efficiency of lasers and amplifiers.
- Bandwidth (data rates >10 Gbps) beyond RF capabilities.
- Varying SWaP, but mutually compatible designs, to cope with different satellite sizes (maybe down to CubeSats).
- Support both currently used wavelength regimes (1064 nm and 1550 nm).
- Modulation and coding standardization for international inter-operability.
- Optically transparent designs (e.g. for feeder-links).
- Support dense wavelength division multiplexing (DWDM).
- Seamless switch-over between optical terminals in space or on ground.

Ground-based optical communication terminals

ESA, DLR, NICT and NASA (JPL, MIT-LL) are currently operating dedicated optical ground stations (OGS) for laser communication terminal testing in space.

Technical challenges are:

- Downlink bandwidth (data rates >10 Gbps) beyond RF capabilities.
- Reliable uplink bandwidth (through atmospheric turbulence).
- Wavelength, modulation and coding standardization for inter-operability.
- Global terrestrial network of OGS for frequent access and weather mitigation.
- Terrestrial high bandwidth fiber connection.
- Atmospheric turbulence compensation (adaptive optics - AO)
- Laser safety and aircraft monitoring.
- Large aperture optical antennas (4 – 12 meter that can operate close to the sun) for deep-space communication links.

Ground-based optical feeder-link terminals

ESA has done a breadboard pre-cursor activity and is starting TRP and ARTES (C&G and ScyLight) activities on feeder-link technology.

Technical challenges are:

- Feasibility demonstration (is reliable wave-front pre-distortion possible?).
- Wave-front pre-distortion technology (AO with deformable mirrors, or phase-controlled multiple Tx beam combining – phased array).
- Laser guide star generation (Rayleigh or Sodium, for wave-front measurement beyond the isoplanatic angle and in day- and nighttime conditions).
- Local network of OGS' (e.g. 15 for terabit feeder links) with >300 km separation for weather and worst-case turbulence mitigation.
- Terrestrial ultra-high bandwidth fiber connection.
- Seamless switch-over to other feeder-link terminals.
- Laser safety and aircraft monitoring.

Thank you for your attention!