SSC20-WP1-29 - COMPACT LASER COMMUNICATION TERMINAL FOR SMALL SATELLITES

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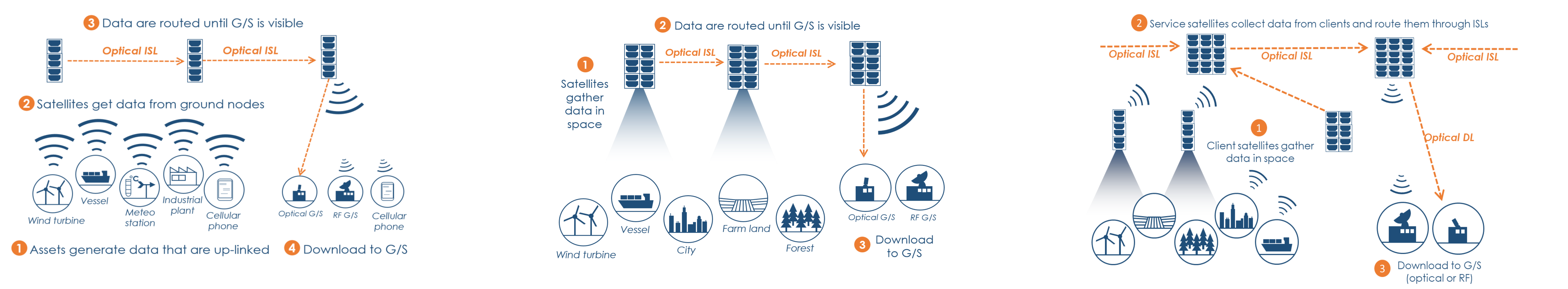
The Need for Optical Communications

The New Space Economy is booming, as more than **7000 small satellites** will be launched in the next decade. Dominant applications such as **telecommunication** & **Earth imaging** will generate data volumes that are simply not manageable with classic RF telecom payloads. Optical communication is a crucial technology of the future commercial space assets, granting stand-alone satellites and constellations the ability to route in space and transmit to ground unprecedented amounts of data, with limited spacecraft's complexity and cost.



IoT – M2M:
- High-efficiency laser intersatellite link (ISL)
- Augmented ISL range
- Minimum data latency
- Simple and low-cost platform design (thanks to telecom system efficiency)

Earth Observation:
- Increased data volumes to ground stations
- Full exploitation of imaging payloads
- Minimum data latency

Data relay networks:
- Relay service to relieve client satellites from telecom duties
- Increased data volume to ground stations
- Minimum data latency
- Client platform and mission simplification

LaserCube System

LaserCube is a **2-way laser communication** terminal providing a **step-change in communication capabilities** of small satellites, increasing their bitrate of more than **10 times** compared to state-of-the-art RF solutions.
The top-level architecture of the terminal is shown in Fig. 1.
The main building blocks are the **Stabilization and Pointing Instrument for Nanosatellites** (SPIN), the Miniature Optical Subsystem (MOS), the Miniature Telecom Subsystem (MTS) and the **Payload Control Subsystem** (PCS). SPIN and MOS form the LaserCube Opto-Mechanical Unit (OMU), while MTS and PCS form the LaserCube Electronic Unit (ELU). Each unit is design to fit in one CubeSat Unit, for a total envelope of 2U and mass below 2 kg.

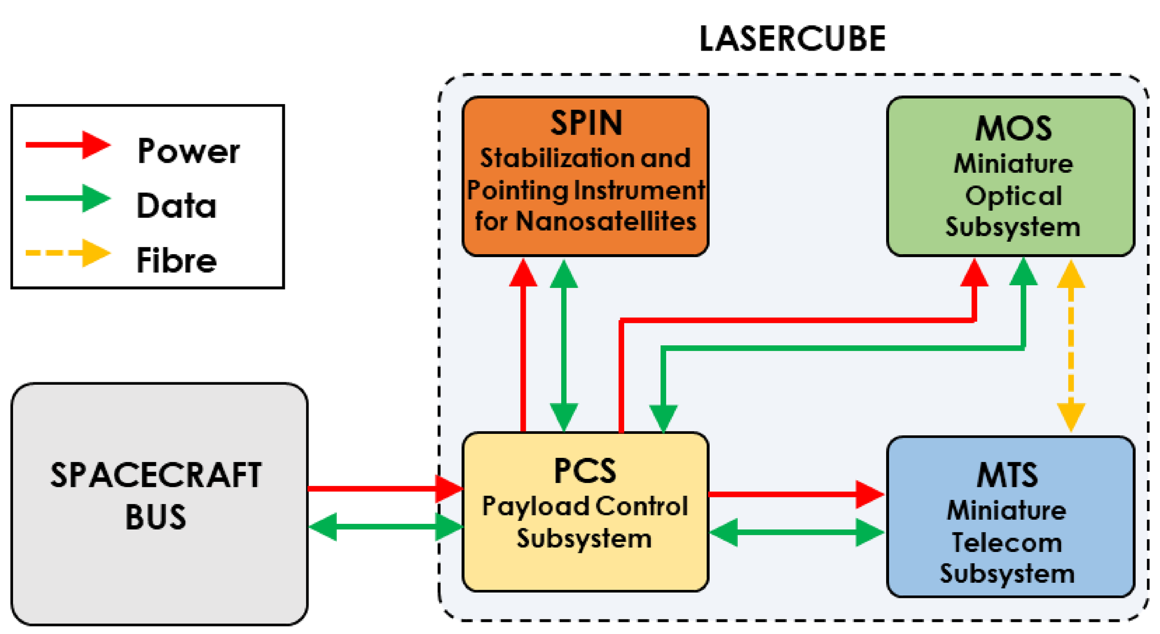


Fig. 1. LaserCube terminal top-level architecture.

OPTO-MECHANICAL UNIT

LaserCube features **an innovative two-stage pointing system**, with a first stage represented by the SPIN subsystem and the second stage consisting of a fast steering mirror inside the MOS. SPIN is a compact pointing mechanism with two rotational degrees-of-Freedom (elevation and azimuth), based on the parallel platform configuration that serves as coarse pointing (accuracy: 60 µrad rms, range: ±10 deg) of the MOS along elevation and azimuth angles, while reducing the disturbances coming from the satellite bus. The **SPIN technology is patented by Stellar Project**. The MOS features a 42 mm lens that is the system optical aperture, through which the telecom signals at 1550 nm are conveyed. A laser beam acting as beacon is also transmitted by the MOS through a dedicated collimator, while beacon signals are collected by the main optical aperture. Telecom and beacon signals are separated by optical elements inside the MOS.

ELECTRONIC UNIT

The ELU is a stack of electronic boards that condition and modulate the laser sources, detect and demodulate the received optical signals, execute the control algorithms of the dual-stage pointing system, monitor the experiment, perform conversion and distribution of electrical power, manage communication with the host satellite.

Table 1. LaserCube main figures

Parameter	Value
Size	2U (200x100x100 mm)
Mass	< 2 kg
Power	≤30 W
Input voltage	16-40 V, unregulated
Data interface	CAN Bus, >250 kbps
Operational Temperature	-25 / +30 °C
Coarse pointing range / accuracy	±10 deg / <60 µrad rms
Fine pointing range / accuracy	±1 mrad / <10 µrad rms
Operational telecom wavelength	1550 nm
Operational beacon wavelength	808 nm
Bitrate	Up to 2 Gbps (DL) up to 100 Mbps (ISL)

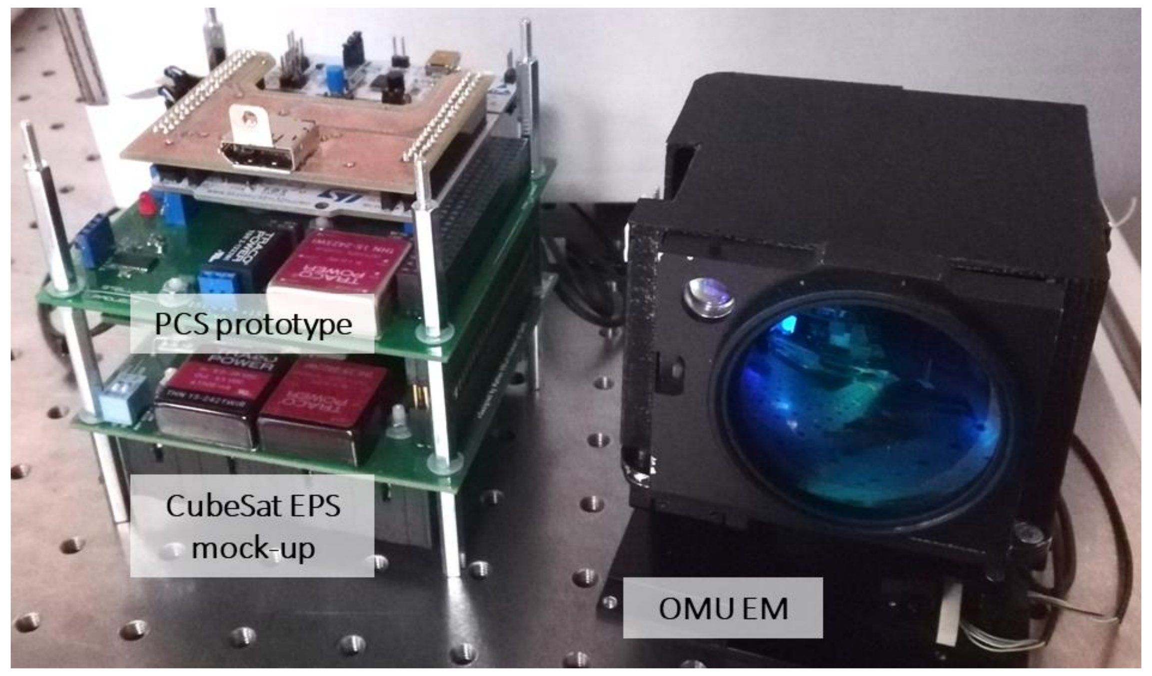


Fig. 2. LaserCube Engineering Model (MTS not sown).

System Verification

System verification in terms of pointing accuracy (Fig. 3) and telecom performance (Fig. 4) has been carried out in laboratory environment that is representative of a real intersatellite link scenario in terms of ISL distance (signal attenuation) and dynamic disturbances coming from the satellite, exploiting the LaserCube Engineering Model shown in Fig. 2.

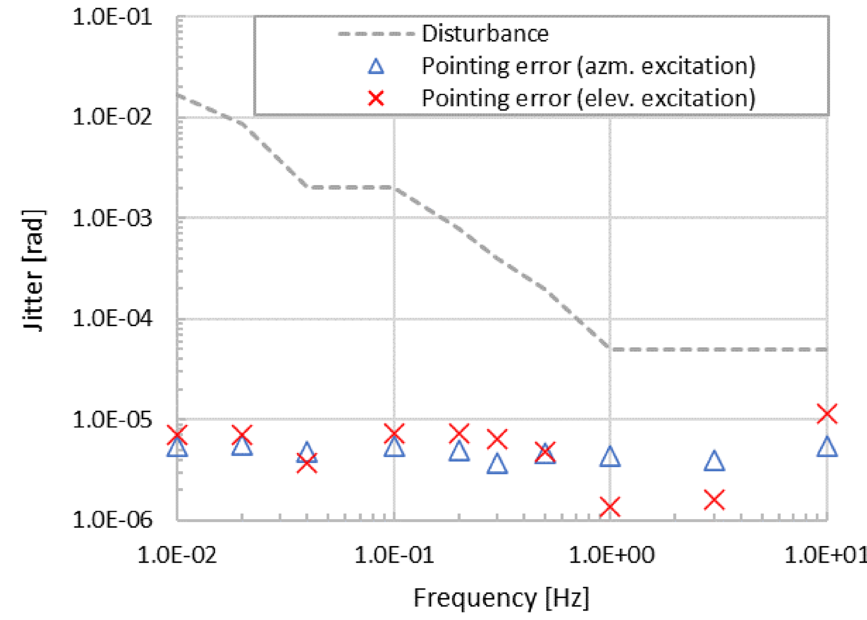


Fig. 3. Left: pointing accuracy with dynamic disturbance profile applied on elevation and azimuth axis. Right: disturbance rejection.

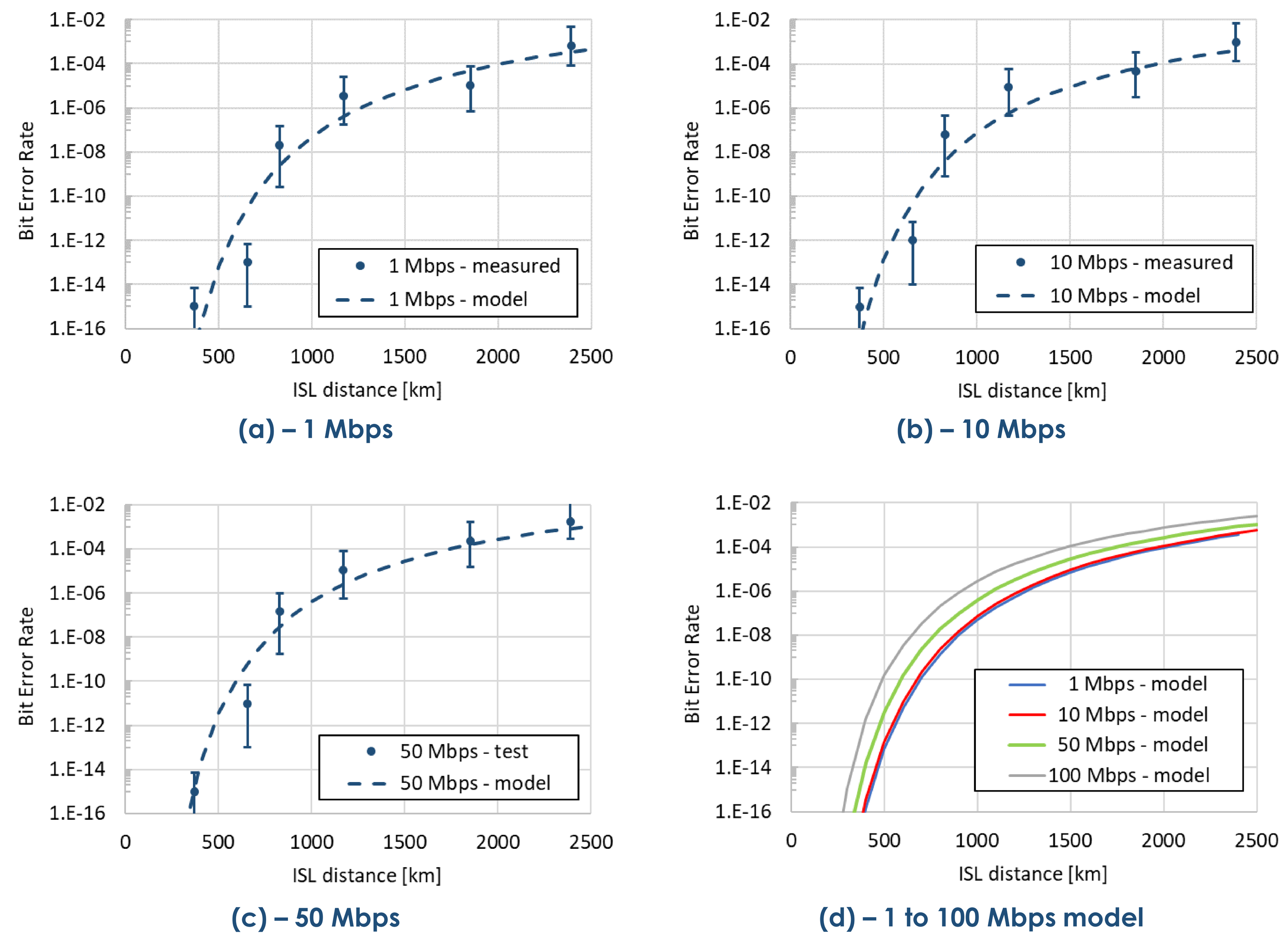
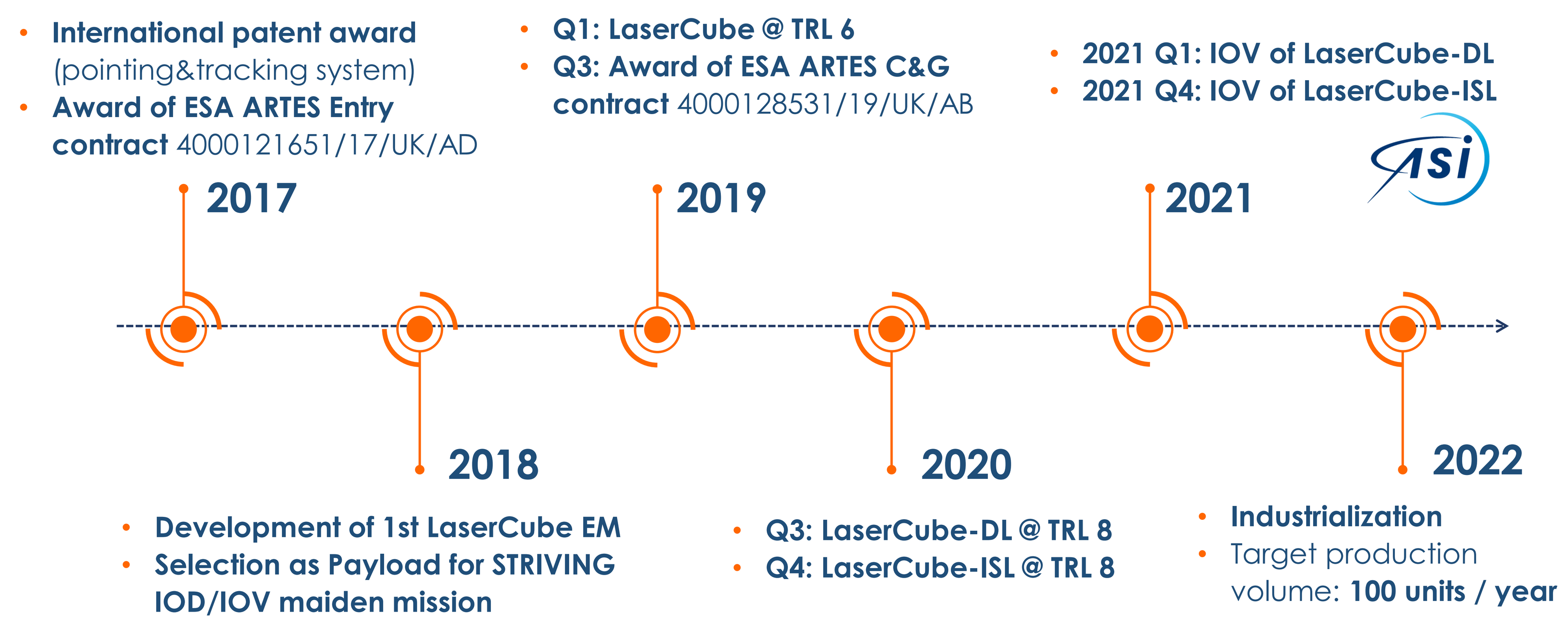


Fig. 4. BER vs intersatellite link distance for different bitrates; (a) to (c): test results. (d): model for bitrates up to 100 Mbps.

Status and roadmap

Stellar Project is developing LaserCube in the framework of the ESA ARTES Competitiveness & Growth programme, with financial support of ASI.

- **LaserCube Engineering Model integration and testing up to TRL 6** has been completed successfully in Q1 2019
- **LaserCube – Downlink IOV by Q1 2021**
- **LaserCube – Inter Satellite Link IOV by Q4 2021**



Updated @July 2020