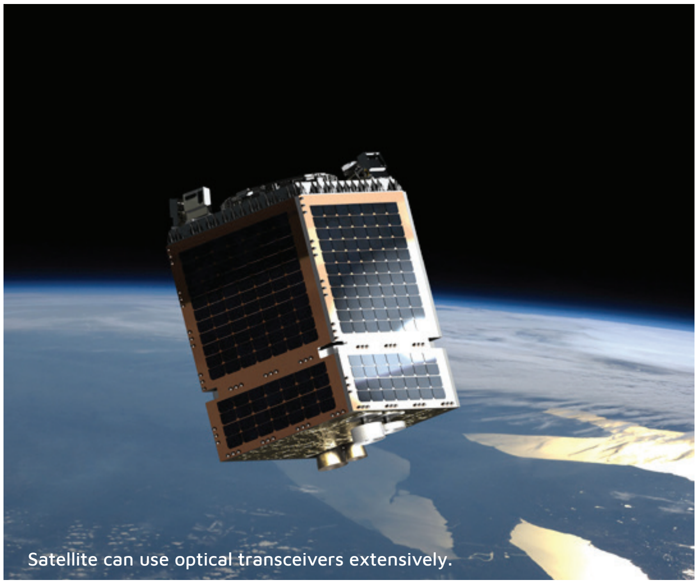
Optical interconnect within space vehicles in low-Earth orbit



Satellite can use optical transceivers extensively.

The push for LEO global coverage

Many competing projects of satellite operators promise to launch thousands of satellites that can bring global internet coverage. For example, SpaceX plans to launch nearly 12 000 internet-beaming satellites, while, OneWeb plans to launch close to 2000, all in the next few years.

Low-Earth orbiting satellites (LEOs) are often deployed in satellite constellations, because the coverage area provided by a single LEO satellite only covers a small area that moves as the satellite travels at the high angular velocity needed to maintain its orbit.

Hence, many LEO satellites are needed to maintain continuous coverage over an area and compete with Earth fibered network. This contrasts with geostationary satellites, where a single satellite, moving at the same angular velocity as the rotation of the Earth's surface, provides permanent coverage over a large area.

Broadband applications benefit from low-latency communications offered by LEO satellite constellations. A LEO satellite constellation can also provide more system capacity by frequency reuse across its coverage.

Optical interconnect solutions reduce payload weight and harnessing complexity.

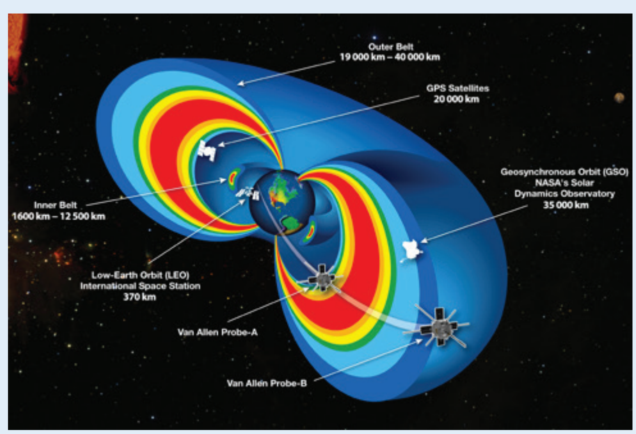
Optical interconnect helps lowering the weight of every satellite which help reducing the launching price and the resulting price per bit for satellite operator.

Optical interconnects help improve the cost-effectiveness of high-throughput LEO constellation satellites and *Space*ABLE and the *Space*CONEX radiation-resistant optical transceivers, with their intrinsic radiation resistance, are the best COTS optical interconnect for LEO space vehicles.

Description of the application

When components, like embedded optical transceivers are deployed in space on a satellite or on a space vehicle, they are exposed to both protons and heavy ions from cosmic rays and solar flares. This is why, unlike most electronic equipment designed for terrestrial use, hardware deployed at LEO (low-Earth orbit: altitudes between 500 and 2000 km), must be radiation resistant.

The charged particles are concentrated by the Earth magnetic field into two principal zones called the Val Allen belts. The inner belt ranges from 1000 to 10 000 km in altitude and overlap the LEO zone where most satellites discussed by this application will be located.

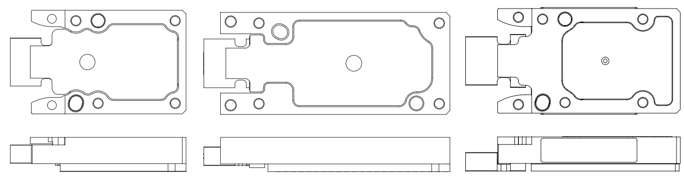


Van Allen belts representation.

*Space*ABLE radiation-resistant optical transceivers

Leveraging its expertise in embedded optical communication modules for defense and aerospace, Reflex Photonics is offering radiation-resistant optical transceivers aimed at the space market with the introduction of the *Space*ABLE™ and *Space*CONEX™ "radiation resistant" line of products.

We are taking environmental threats seriously when it comes to qualifying our radiation resistant modules and this is why we have placed so much effort on testing for heavy ions, protons and gamma rays. Reflex Photonics' radiation resistant or "Space-grade" transceivers are engineered to withstand radiation doses >100 krad (Si). Furthermore, all our devices are tested following ECSS process and lot acceptance testing, and component pre-screening can be done for every batch of transceivers sold for this application.



Real size for *Space*ABLE SL 40G (full duplex) and 120G (left), *Space*ABLE SL 120 (full duplex) (center) and *Space*ABLE28 100G (full duplex) (right).

Space qualification tests summary

- **Proton testing**: Total Non-Ionizing Dose (TNID)
- **Heavy ion testing**: Single Event Effect & Latch-up (SEE and SEL)
- **Gamma Ray using Cobalt-60**: Total Ionizing Dose (TID)
- **Random vibration**: NASA GEVS, GSFC-STD-7000A
- **TVAC**: Vacuum < 5E-5 hPa
- **Outgassing**: ECSS-Q-ST-70-02C

*Space*ABLE™ also passed standard *Light*ABLE™ qualifications

- **Vibration** tests per MIL-STD-883, Method 2007.3
- **Mechanical shock** tests per MIL-STD-883, Method 2002.4
- **Thermal shock** tests per MIL-STD-883, Method 1011.9
- **Damp heat** tests per MIL-STD-202, Method 103B
- **Cold storage** tests per MIL-STD-810, Method 502.5
- **Thermal cycling** tests per MIL-STD-883, Method 1010.8

Space qualification program technological partners

TEXAS A&M UNIVERSITY

UBC

UNIVERSITY OF SASKATCHEWAN

C2MI

TRAD Tests & radiations

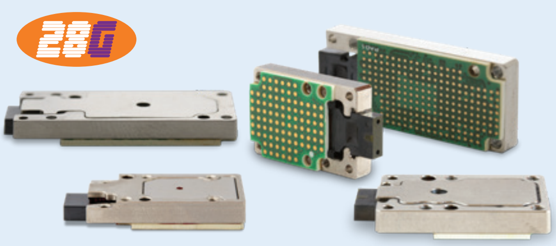
university of groningen

TRIUMF

NTS

Benefits of using *Space*ABLE optical solutions

- Meet highest level SWaP requirement.
- Smallest transceiver on the market, low weight
- SEE: heavy-ion tested.
- TID: Gamma rays tested.
- TNID: high energy protons tested.
- ECSS/ESCC/NASA standards
- Lot acceptance tests
- 12-lane parallel optical transceiver
- Up to 28 Gbps/lane
- Operation temperature from –40 °C up to 100 °C



*Space*ABLE SL 40G (full duplex) and 120G, *Space*ABLE SL 120 (full duplex), and *Space*ABLE28 100G (full duplex).