Ka-band LEO-LEO ISL for Small Satellites

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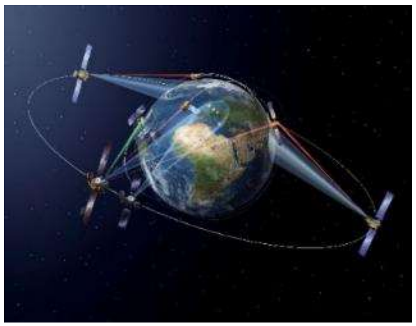
Antwerp Space (as part of OHB group)

RF Strategy

- Since 2010 Antwerp Space is part of the OHB group (although in space business since the 1960's), and is focussing on becoming an **European leader in the field of RF and satellite communications**.
- Antwerp Space is subcontractor in multiple ESA missions, with components as well as complete COM subsystems.
- Beside this classical markets, Antwerp Space is expanding , based on its high reliable RF technology, into cubesat communications and photonic technology (for communication and RADAR).

Antwerp Space success story in Belgium

RF Flight Segment Projects

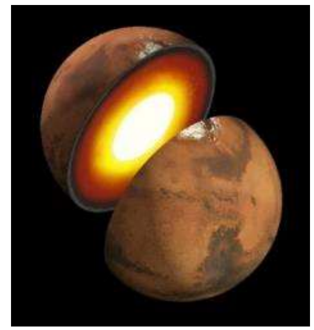


ARGO

A highly innovative modem to be used first on the International Space Station (2018)

ExoMars

Communication subsystem on board the carrier module flying to Mars (2020)



LaRa

The first instrument made in Belgium to ever land on the surface of Mars (2020)

JUICE

Communication subsystem on ESA's next Large Science mission to Jupiter and its moons (2022)

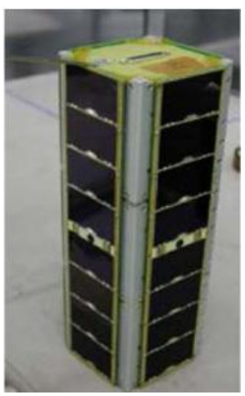
Introduction

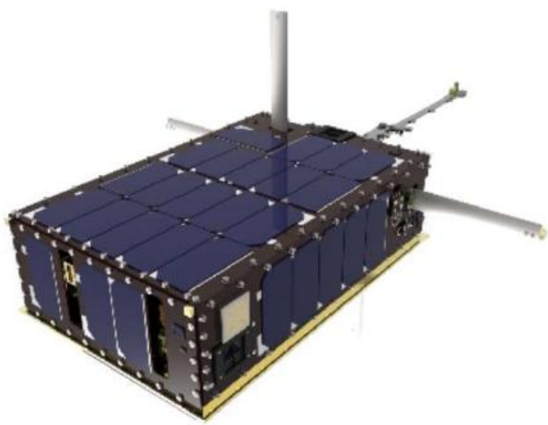
- What is the need for a Ka-band LEO-LEO ISL for small satellites?
  - Small satellite constellations in LEO are exploding
  - Inter-Satellite Links (ISL) enable to improve the downlinking of data
  - LEO – LEO ISL is a cheap way to get data in quasi real time
  - The use of Ka-band offers many advantages
    - In terms of bandwidth available
    - In terms of antenna gain
    - In terms of size, mass and cost of the components

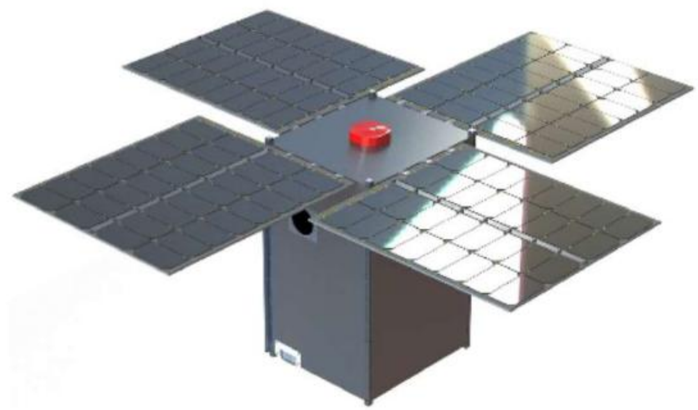
Challenges of the Small Satellite Market

- Need for miniaturization
  - **Low power**, low mass, low volume, low cost, …
  - … but high performance, guaranteed lifetime of > 7 years, etc.

- Need for an appropriate procurement policy
  - The use of COTS components is encouraged (cost, power, lead-time, etc.)
  - A certain reliability is nonetheless required
  - No established standard…

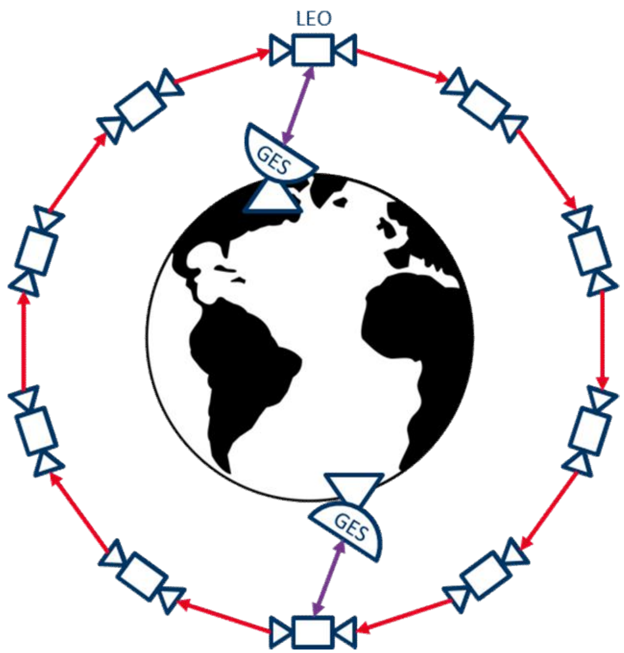






The reference scenario corresponds to a typical M2M / IoT constellation

Configuration	Walker
Altitude	520 km
Inclination	52°
Number of planes	9
Number of satellites/plane	10
Total number of satellites	90
Coverage min. elevation	10°
Inter-satellite distance	4300 km

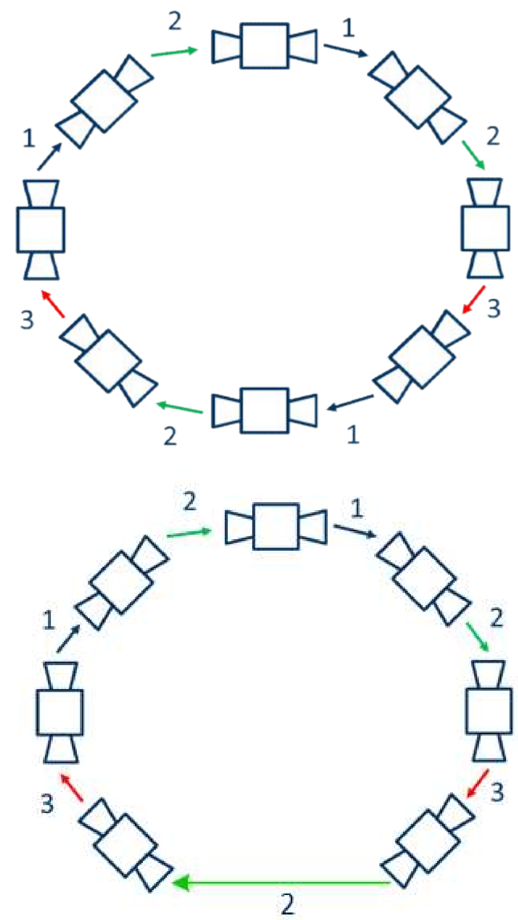


System Design Aspects

- Use of 3 frequency channels with a separation of 30 MHz in order to avoid interference and to provide the needed Tx/Rx isolation

- Can be reconfigured for mitigating the failure of one small satellite
  - Re-positioning of the satellites using differential drag
  - Distance increased from 4300 to 4700 km
  - De-pointing of 2°, within the antenna beamwidth of 5°

- Data-rate:
  - > 1.5 Mbps in nominal mode
  - > 500 kbps in failure mode



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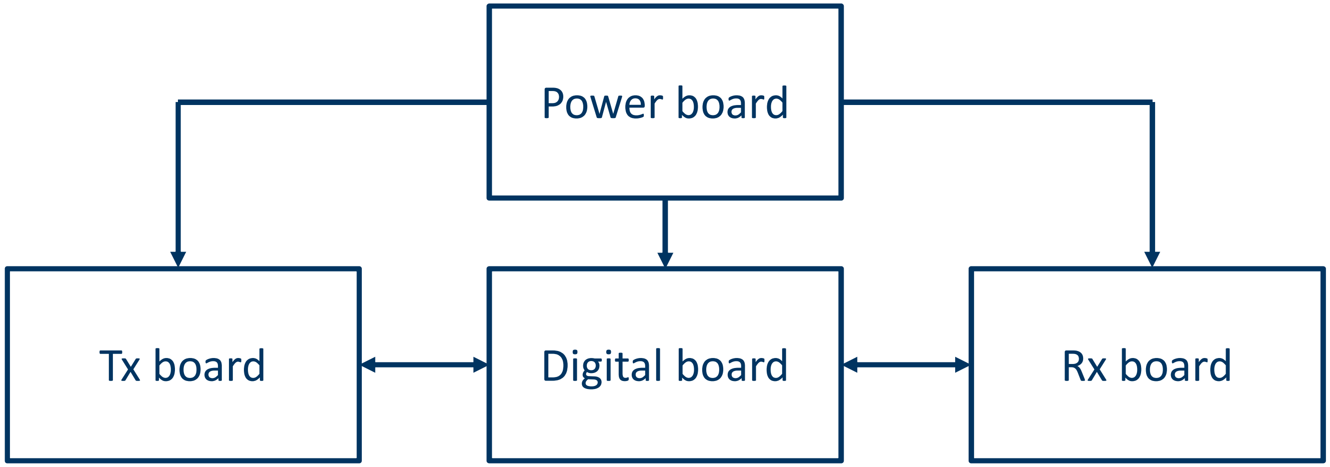
Ka-band ISL Architecture



- The Rx board consists of a LNA, a down-conversion to L-band and an ADC
- The Tx board consists of a DAC, an up-conversion from L-band to Ka-band and an SSPA
- The digital board consists of a COTS FPGA performing the demodulation and modulation (DVB-S2 MODCOD: QPSK with rate 1/3) and a space-qualified MCU

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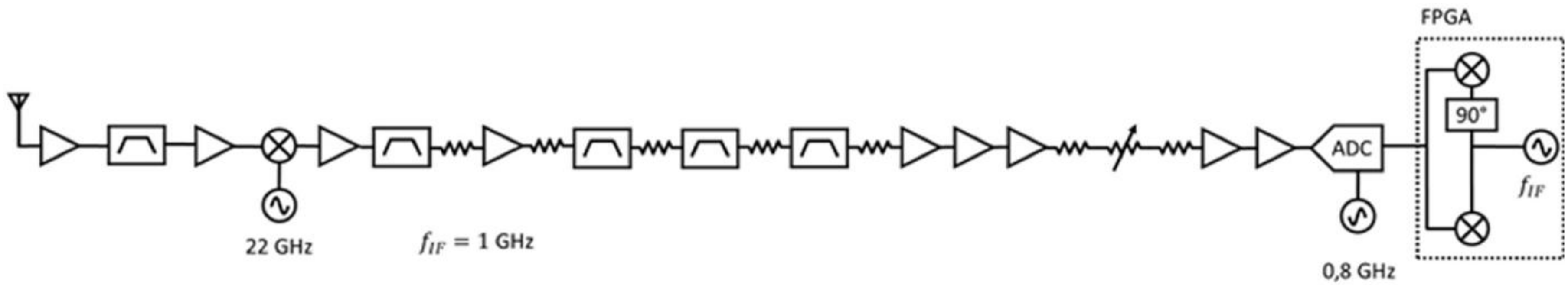
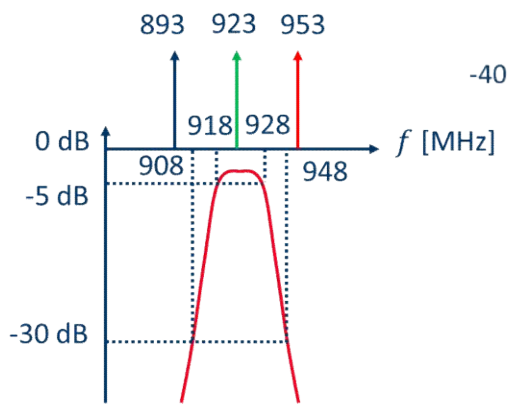
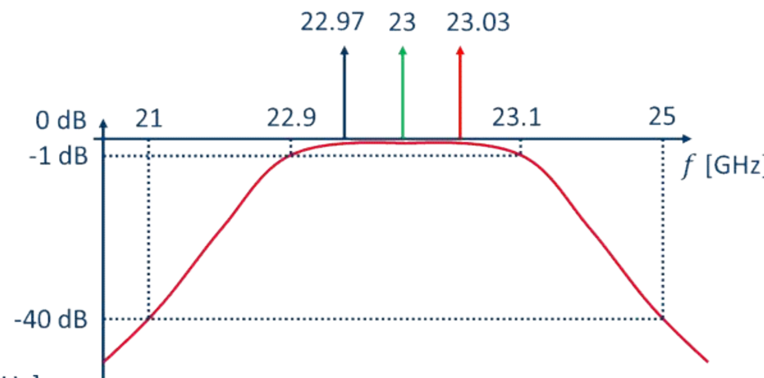
Receiver Block Diagram

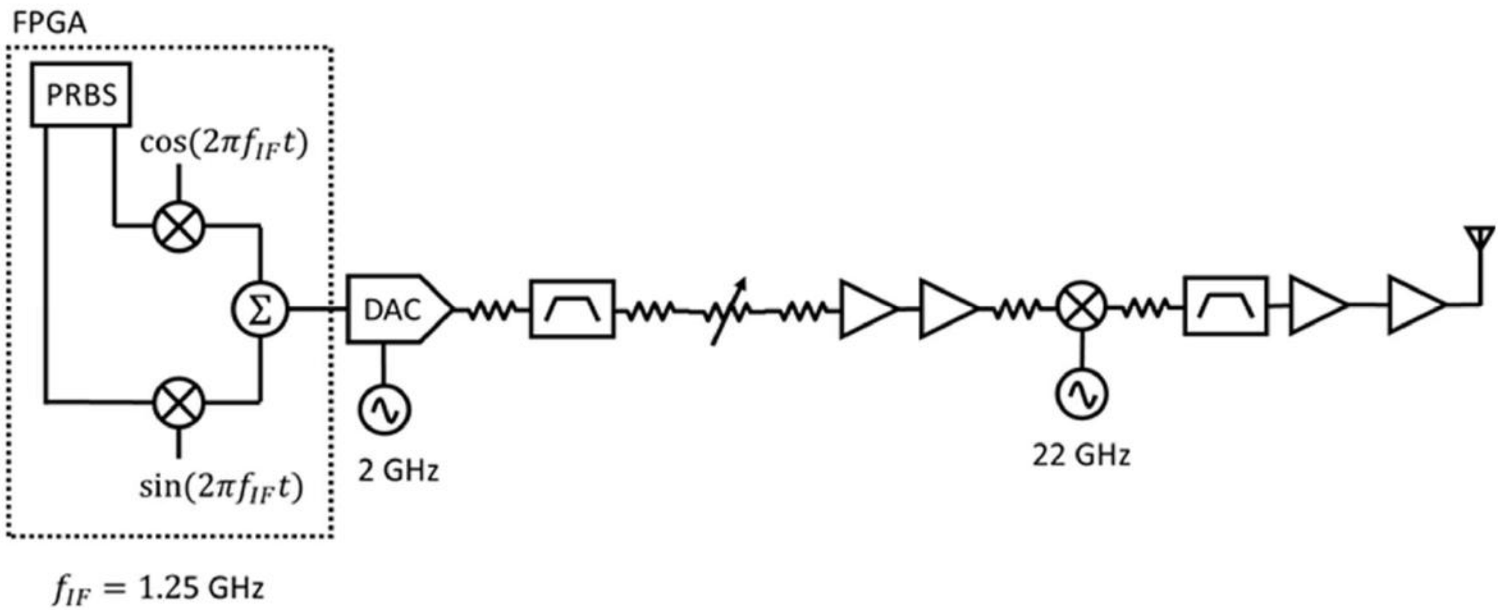


- The receiver includes
  - LNA
  - RF filter
  - Mixer
  - IF filter (SAW filter)
  - IF amplifier



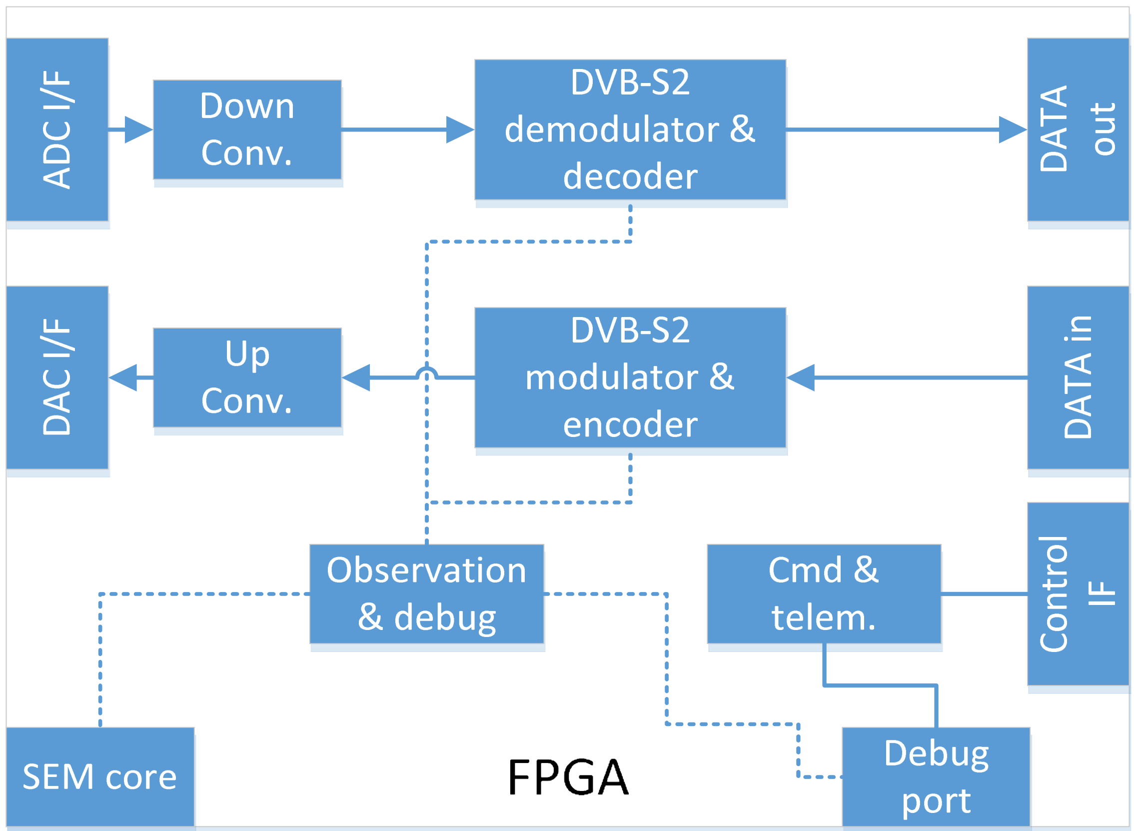


Transmitter Block Diagram



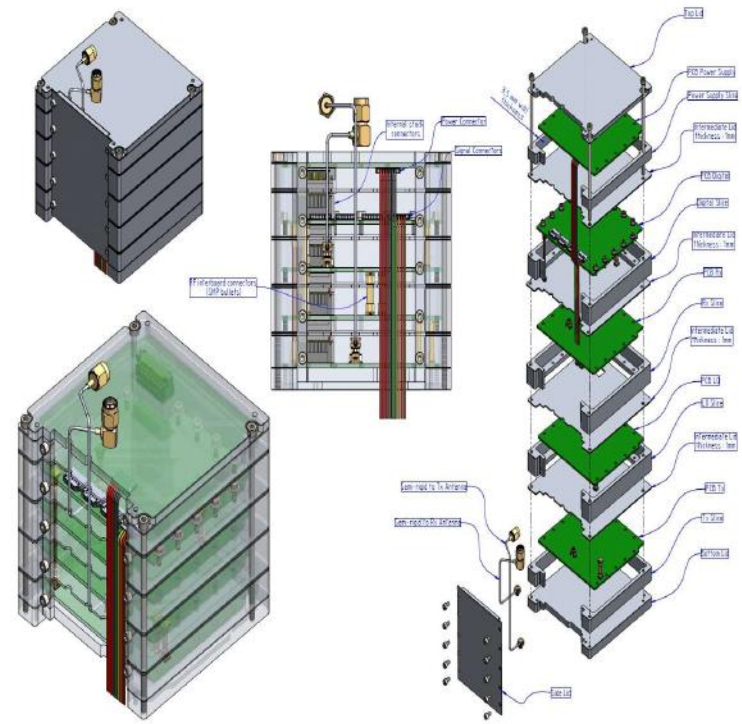
- The Transmitter includes
  - IF anti-aliasing filter
  - IF amplifier
  - Mixer
  - RF filter
  - SSPA, with an output power of 1.6 W at Ka-band

FPGA Architecture



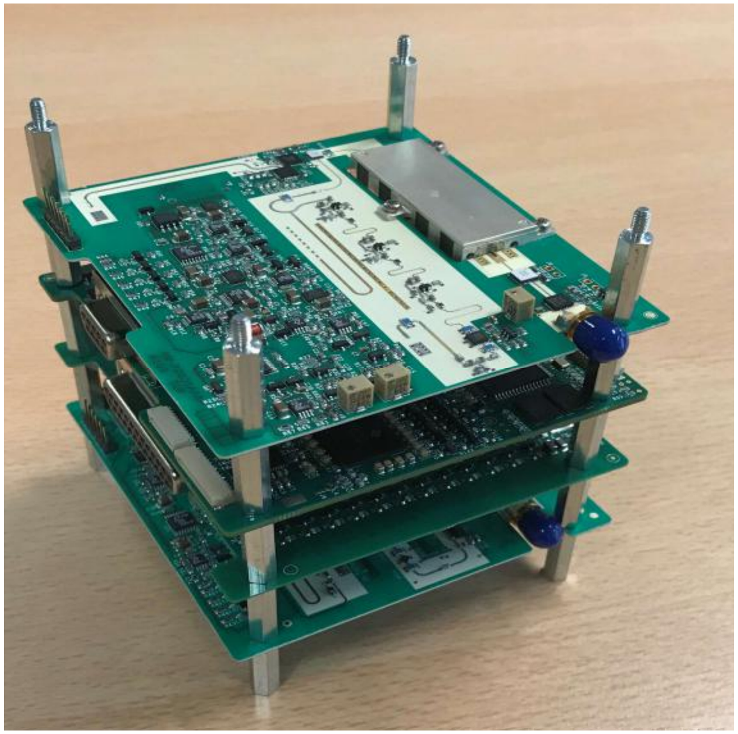
Ka-band ISL Implementation

- The four boards have a standard PC104 format and are stacked
- Everything fits in 1U
- Interfaces
  - Mechanical: ISIS 6U chassis
  - Data & power interface: 2 x RS485
  - Antenna connection: 2 x SMA (interface with Ka-band patch antennas)



Ka-band ISL Performance

- Final specs:
  - Volume: 1U
  - Data & power interface: RS485
  - Mechanical interface: ISIS CubeSat standard
- 100% duty-cycling (continuous operation)
  - Power: 30W
  - Data rate: 1.5 Mbps
- Implementation loss: 2 dB
- Lifetime in orbit: 3 years



Commercial derivation

- From the above development two other transceiver are being currently developed

  - ALPHA transceiver
    - LEO to GROUND
    - Uplink frequencies: 27-30 GHz
    - Downlink frequencies: 17-20 GHz
    - RF Power 2 WATT
    - Data Rates 1-4 Mbps (higher can be customized)
    - 1U equipment for a 6U (or bigger) cubesat

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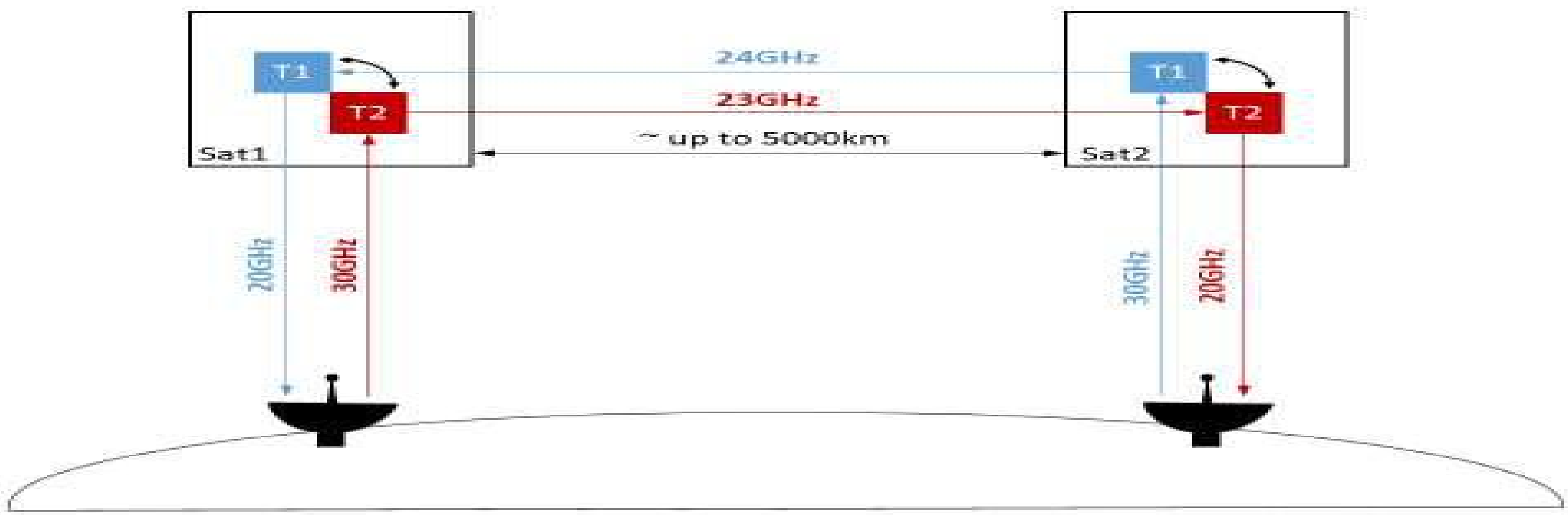
Commercial derivation

- Hybrid version
  - 2 modified ALPHA transceivers
  - LEO to LEO ISL (23/24 GHz)and LEO to GROUND tranceiver (20/30 GHz)
  - 2x1U equipment for a 12U (or bigger) cubesat



Conclusion

- A Ka-band ISL prototype has been developed and is being fully tested
- It meets the expectations in terms of
  - Functionality
  - Volume (1U)
  - Mass
  - Cost
  - Performance

- The average power consumption can be reduced by adapting the duty cycle

Commercial derivation development ongoing thanks also to the ARTES Advanced Technology program of ESA

Thank you !

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