CDS WIRELESS

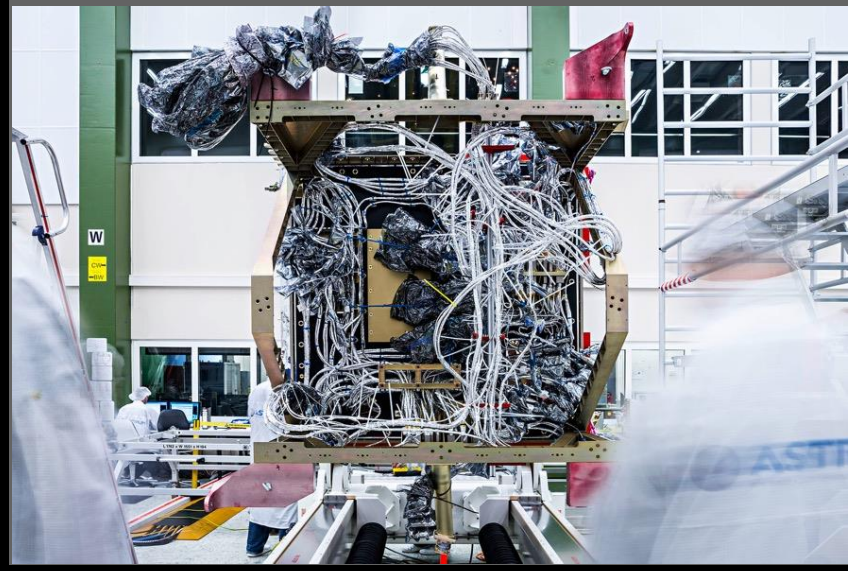
Wireless for Intra-Satellite Communications

Control Data Systems SRL

Wired Harness

- Dry mass contribution of 10%.
- Complex AIT (Assembly Integration and Test)
- Signal leakage requires isolation for EMC
- Physical dimensions restrictions
- High cost of late design changes
- Difficult reconfiguration
- Possible failures of wires and connectors

Satellite data handling systems are traditionally **wired** as point-to-point or bus connections such as RS422, SpaceWire, Mil-1553b, CAN etc).



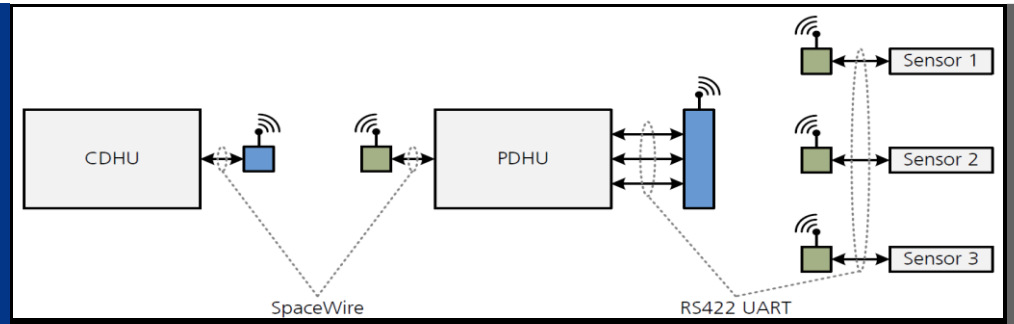
Wireless Harness

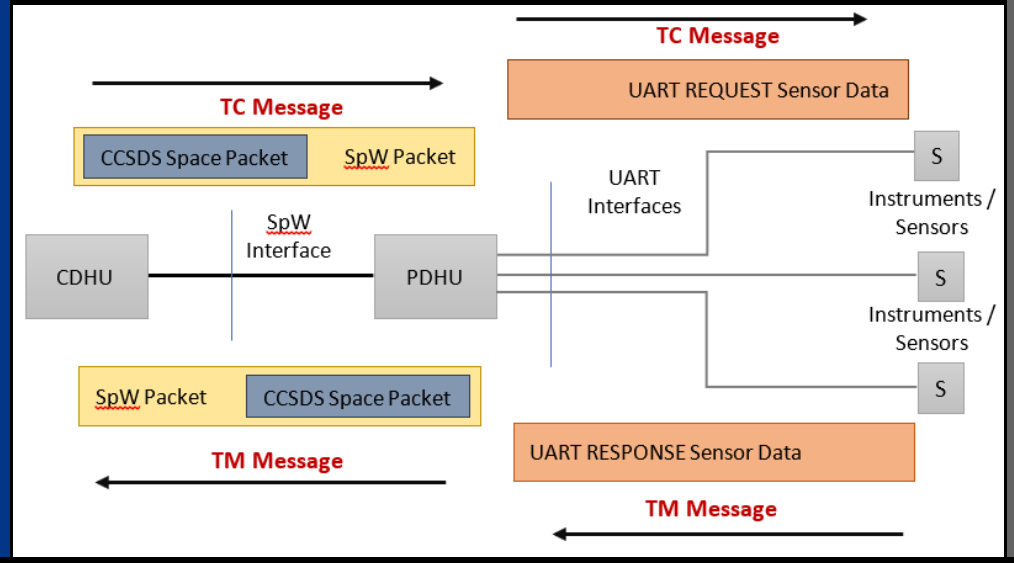
- Advantages
  - Up to 10% reduction of S/C mass Lower launch cost
  - Reduction in AIT complexity
  - Lower assembly costs
  - Increased reliability
  - Implicit redundancy
  - Lower cost for late design changes
  - Reconfiguration on the fly

- Challenges
  - Power supply needs
  - Limited channel bandwidth
  - Reliability of Service
  - No line of sight
  - Interference
  - Limited In band emissions
  - Out of band emissions
  - Multipath fading
  - Reflections

Requirements

- provided by GMV
- updated by DLR





- Low number of nodes – sensors and actuators
- High volume of data from sensors
- Strict timings for actuators control (100s of msec)
- Resistant to interference from other equipment
- Must not interfere with other equipment
- Minimal node weight (10s of grams)
- Low power consumption (10s of mW)

Previous work

Wireless Compliance Institute (WCI)

- develops the specifications and compliance procedures for ISA100 Wireless
- driven by major industrial players (GE, Honeywell, Yokogawa)
- Widely applied in Oil&Gas

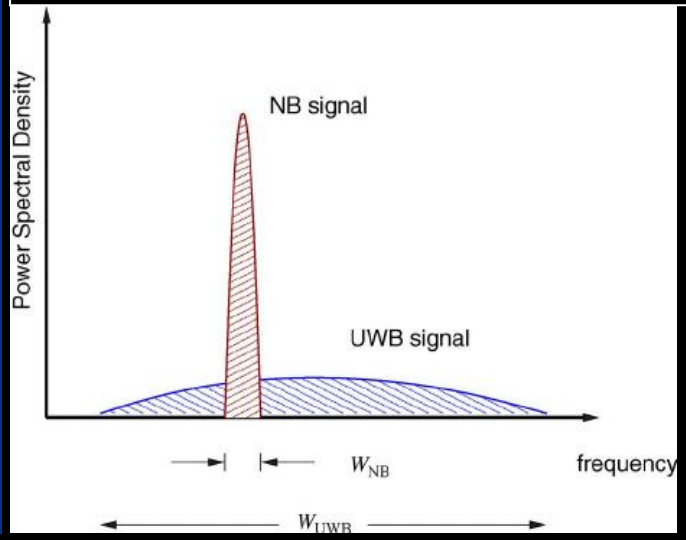
Consultative Committee for Space Data Systems (CCSDS)

- develops recommendations for communications and data systems
- 11 member agencies (ESA, NASA, DLR, JAXA, etc.)
- Recommends ISA100 Wireless as a communication protocol

- ESA study from 2013 investigates 802.15.4 UWB as a physical layer for intra-S/C communications
- NASA study from 2012 recommends ISA100 as an upper layer wireless protocol

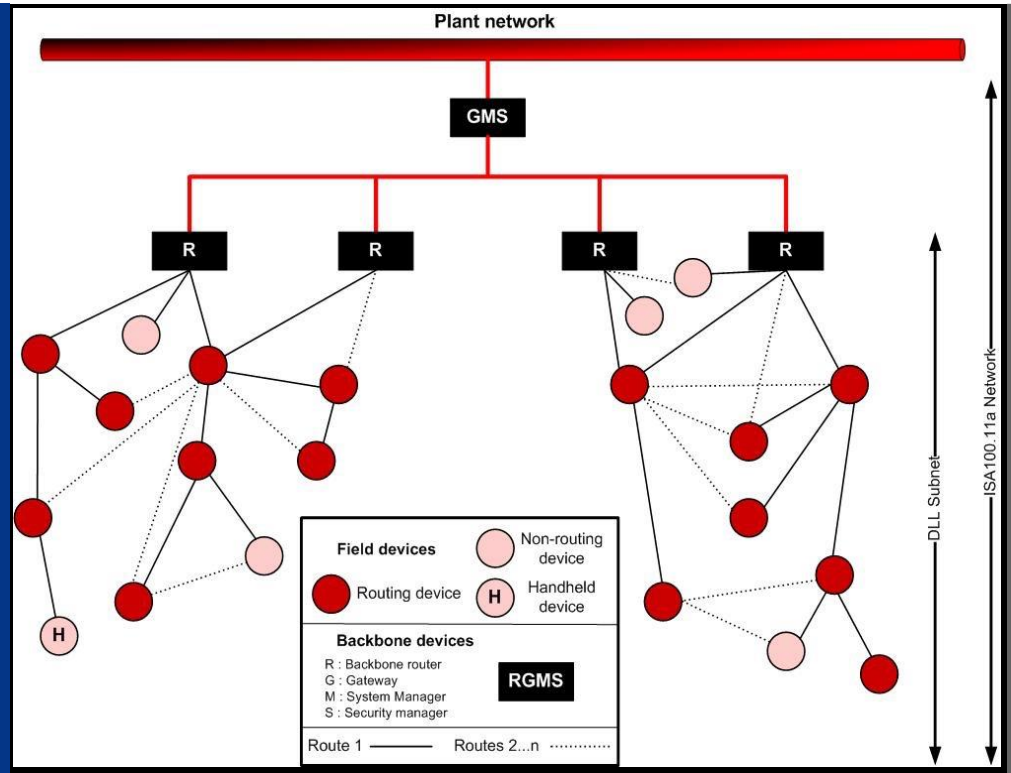
802.15.4 UWB-IR Ultra Wide Band

Channel Number	Center Frequency (MHz)	Bandwidth (MHz)
1	3494.4	499.2
2	3993.6	499.2
3	4492.8	499.2
4	3993.6	1331.2
5	6489.6	499.2
6	6489.6	1331.2



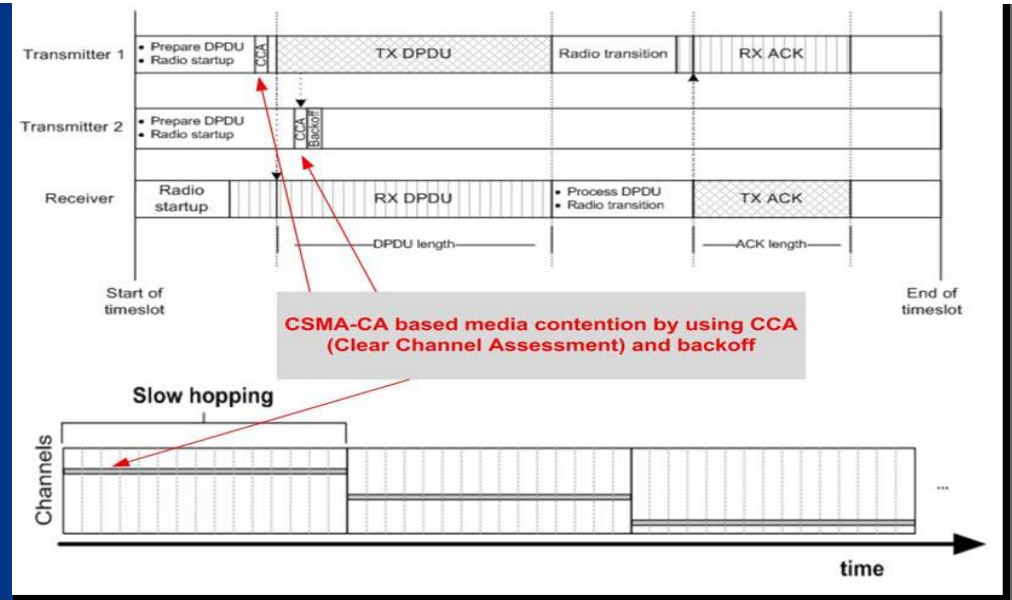
- Short impulse transmission technique
- A span of six RF bands from 3.5GHz to 6.5GHz
- Support for data rates of 110kbps, 850kbps and 6.8Mbps
- Short on-air time due to the high data rates
- Low power consumption and extended battery lifetime
- 2ns impulse results in 500 MHz channel bandwidth
- Ability to deal with severe multipath environments
- Ideal for highly reflective RF environments

ISA100 Wireless



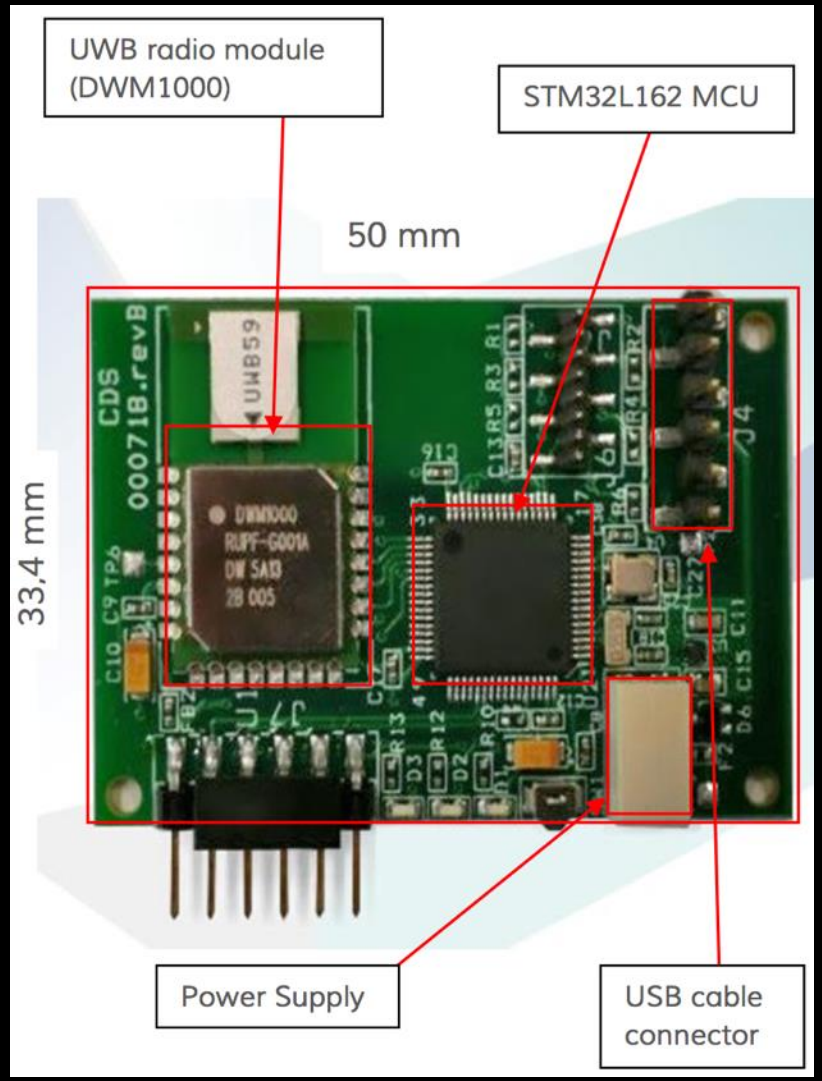
- Determinism
  - TDMA (10ms timeslots)
  - Optional CSMA-CA
- Path Diversity
  - Mesh topology
  - Graph/source routing
  - Duo-cast redundancy
- Low Power
  - Sleep mode for routing devices
- Security
  - Link layer security
  - End to end security
- Flexibility
  - Changeable PHY
  - Variable TS duration

ISA100 Wireless



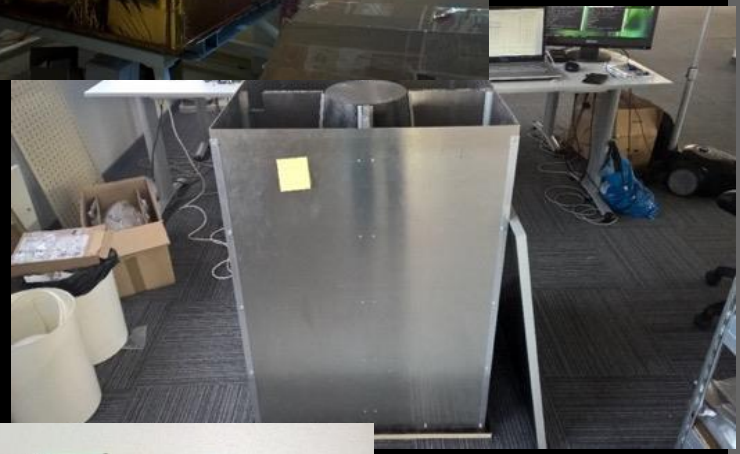
- TDMA
  - Predetermined TS
  - 10ms TS standard
  - 5ms TS in development
  - 0.1 ms synchronization
  - Link ACK in the same TS
  - Latencies in 100's ms
- CSMA-CA
  - Shared TS
  - Less deterministic
  - Lower latencies (ms)
- Combination of access techniques
  - QoS features
  - Optimal channel usage

VN360
UWB modem



- Ultra Wide Band
- Decawave UWB transceiver
- ARM processor (TRL4)
- ISA100 Wireless communication stack
- TDMA based
- CSMA-CA option with shared TS
- 250ms super-frames
- 10ms TS
- 5ms TS in development
- SpaceWire and RS422 interfaces in development

Test and Validation (TRL4)



6 nodes network

- 1 BBR/SM
- 2 sensors
- 1 actuator
- 1 provisioning device
- identical HW

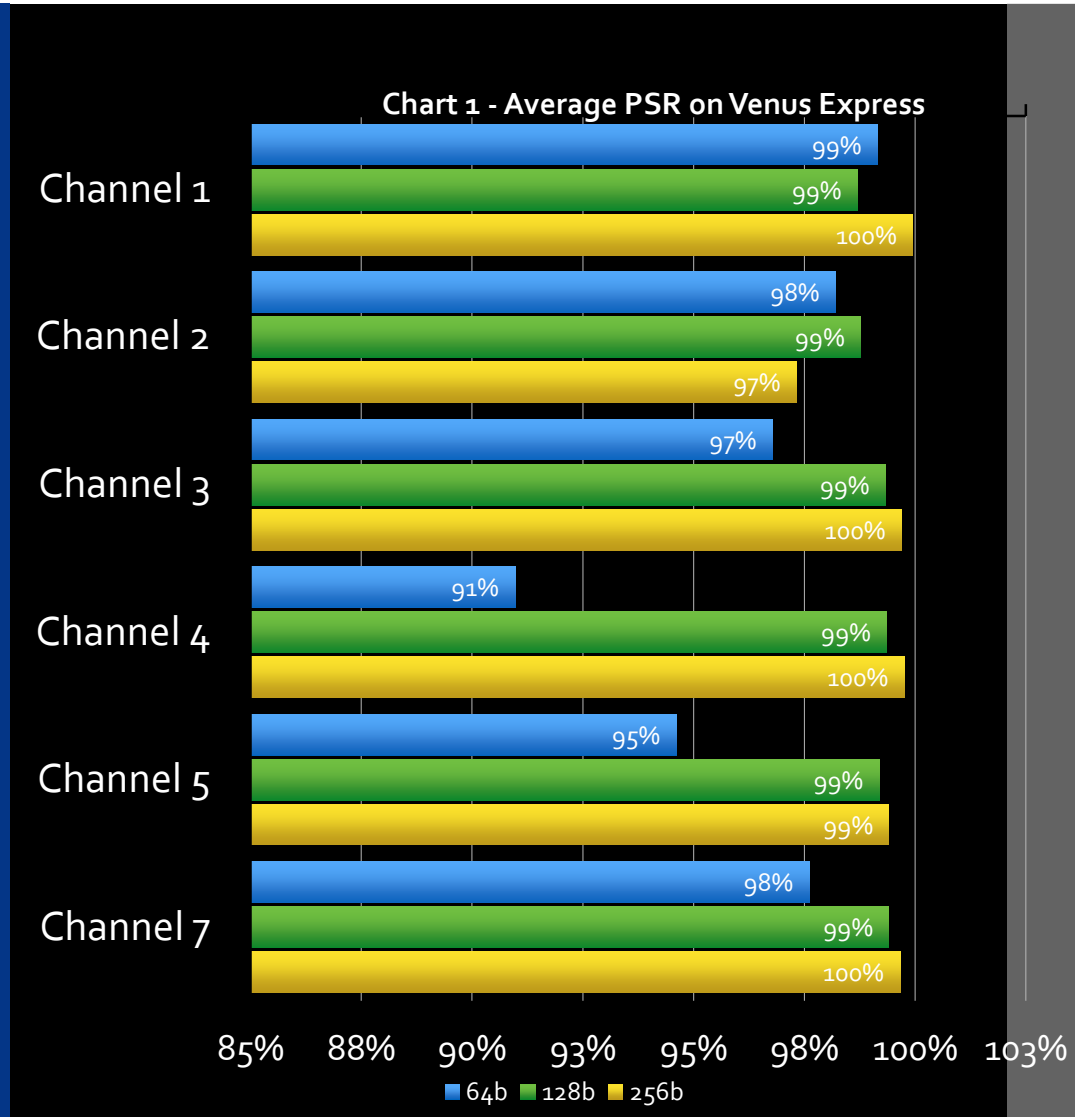
Functional Test performed on 2 satellite mock-ups

- Venus Express (at ESTEC)
- Sentinel 3 (at CDS)

EMC Tests performed in anechoic chamber

Functional Test Results

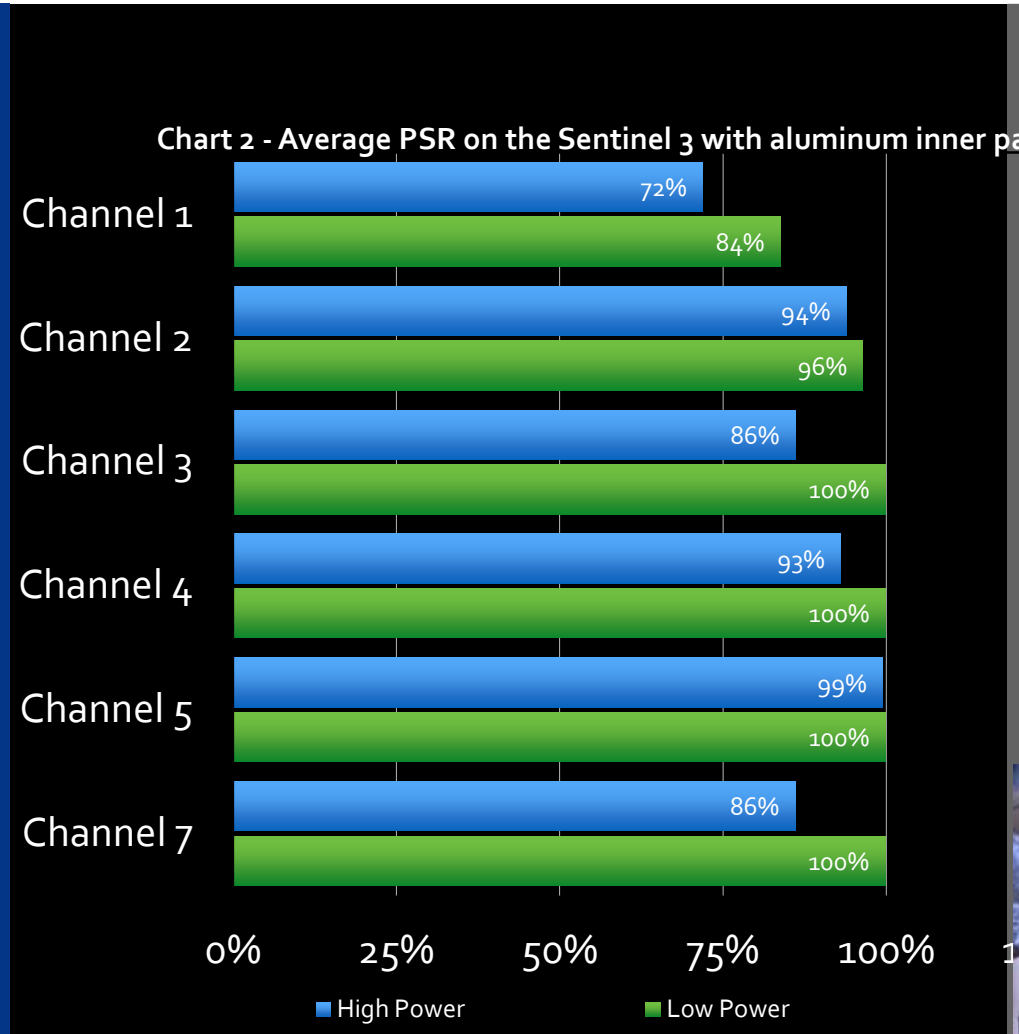
(Venus Express mock-up)



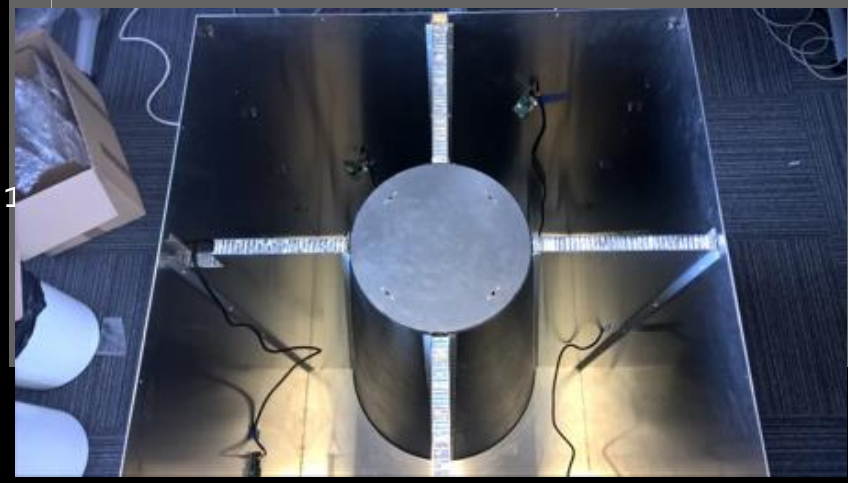
- No retries used
- 3 preambles tested: 64b, 128b and 256b
- 256b preamble performed best
- No significant difference between channels

Functional Test Results

(Sentinel 3 mock-up)

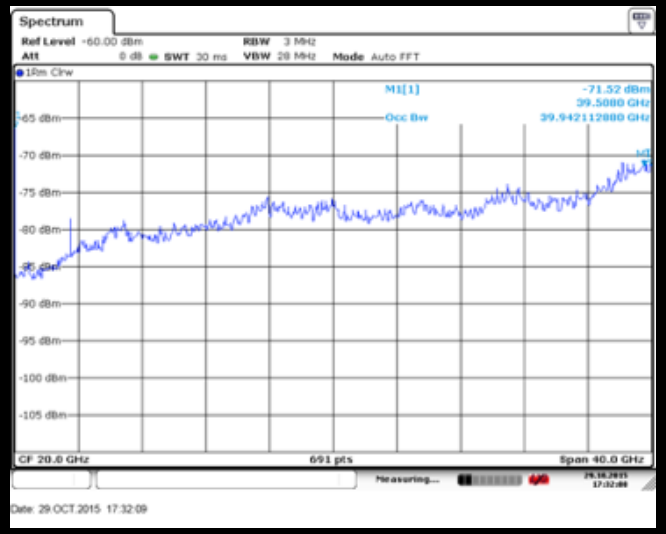


- No retries used
- 3 preambles: 64b, 128b and 256b
- 256b preamble performed best
- Carbon fiber vs aluminum inner panels tested
- Carbon fiber had better results (100%)
- High power vs low power test
- Low power had better results



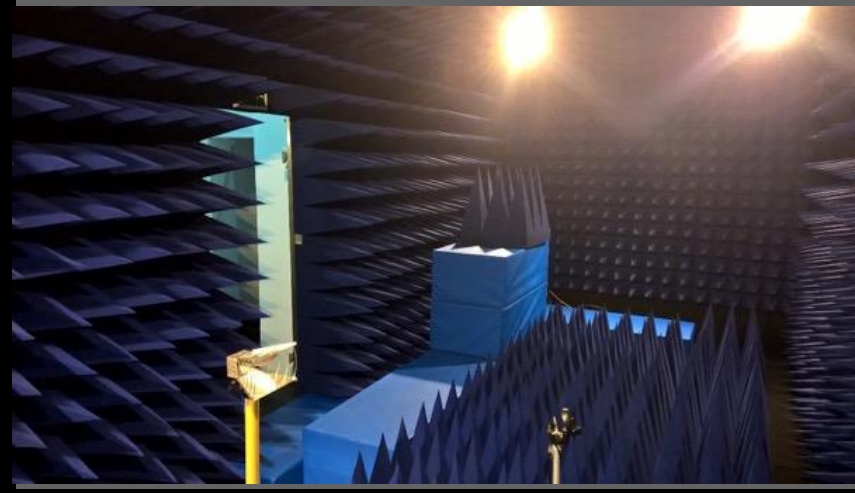
EMC Tests

Channel	Measured power (dBm)	Measured power (dBµV)	E-field (dBµV/m)	Limit (dBµV/m)
1	-67.77	39.23	79.36	120
2	-73.86	33.14	79.00	120
3	-79.37	27.63	79.23	120
4	-73.65	33.35	79.21	120
5	-71.71	35.29	109.82	120
7	-66.16	40.84	115.37	120



Type of EMC tests performed

- In band emissions
- Out of band emissions
- Susceptibility



Test Conclusions

- Node placement inside the mock-up cavity does not influence the overall performance of the UWB transmissions
- UWB transmissions are affected by the material composition of the mock-up: carbon fiber walls perform better that aluminum plated walls
- Round openings between cavities yield better results than square openings
- Low power transmission provides better results than high power transmissions in the highly reflective intra spacecraft environment
- All UWB channels can be used with similar results
- The overall results show that the UWB technology is suitable for replacing the intra-satellite sensor wired communication

- ISA100 UWB Kit includes:
  - 4 x VN360 UWB nodes
  - 1 x VN360 gateway
  - 5 x FTDI USB cable
  - SW Test Application
  - User manual

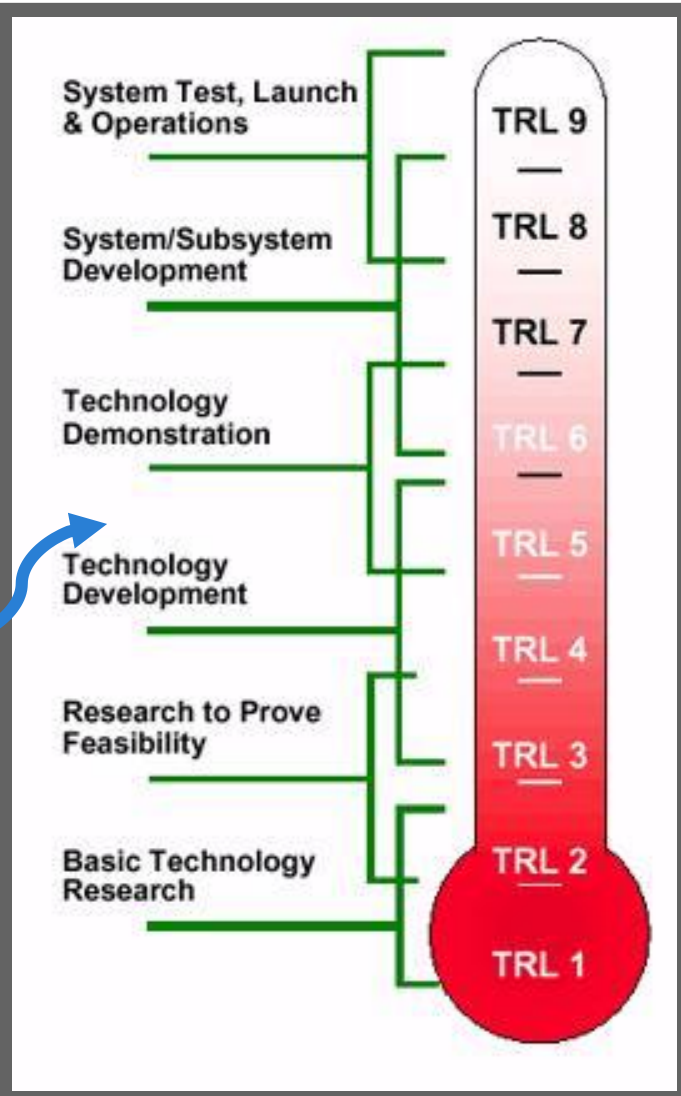
Roadmap

2019-2020 IOD

2018-2019 Radiation tests (TRL6)

2017-2018 Environmental tests (TRL5)

2014-2016 Laboratory prototype (TRL4)



Questions

Thank you