OHB System AG
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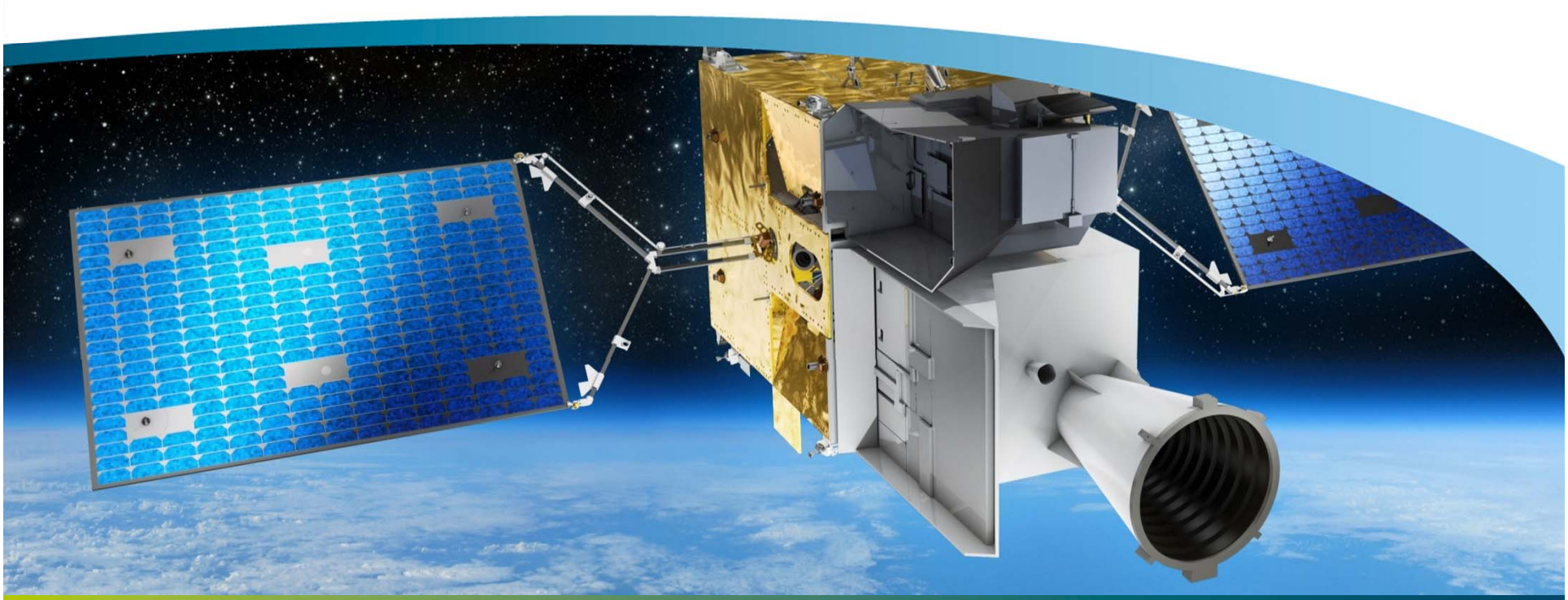
18.10.2018, ADCSS



SPACE SYSTEMS

Current Spacecraft Data Handling Interfaces and Future Needs at OHB

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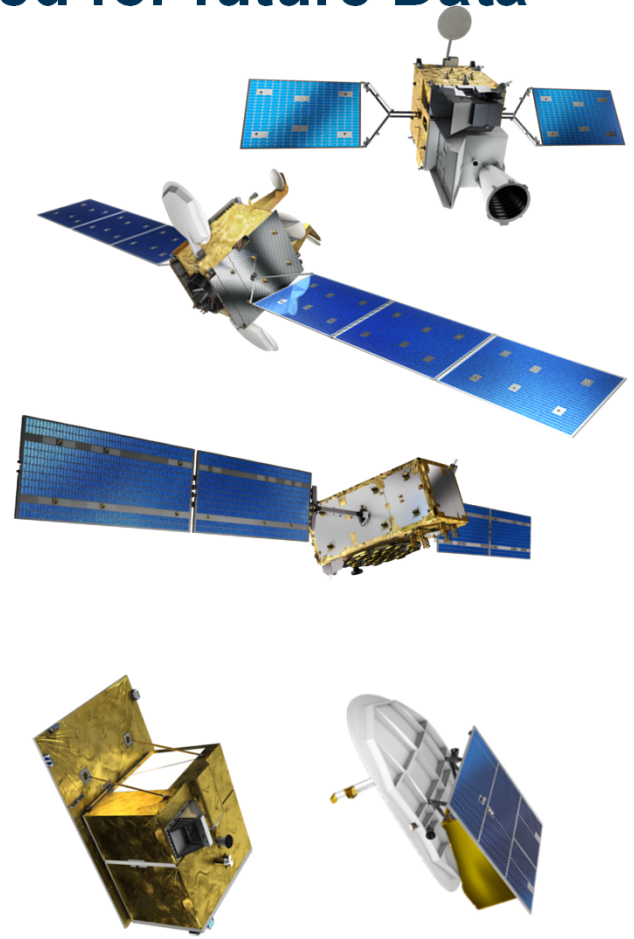
Contents

- OHB demands in context to the product range
- Current Spacecraft Electrical Architecture
- Needs to replace the 1553 bus(?)
- Investigations of CAN bus and SpW /SpFi
- Optimization approaches of the electrical architecture wrt. discrete interfaces
- Conclusion

Major OHB Satellite Platforms considered for future Data Handling needs

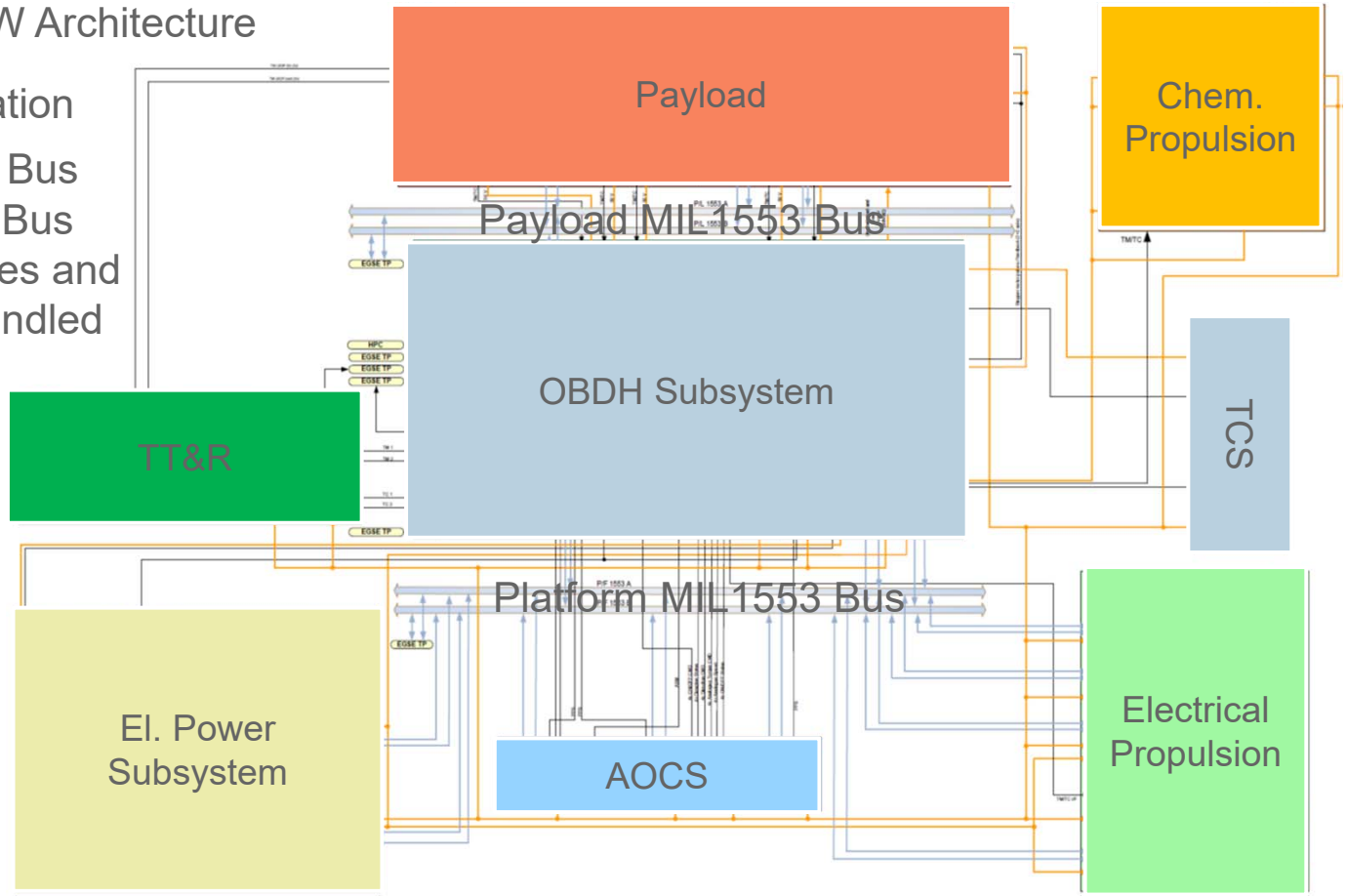
- **SmallGEO:** Telecom, Earth Observation, Meterology
  - Launch mass 2400-3800kg
  - P/L power up to 10 kW
  - Lifetime 8...15 years
- **SmartMEO:** e.g.Galileo Navigation Satellites
  - Launch mass 700-800kg
  - P/L power up to 1.1kW
  - Lifetime 12 years
- **SmartLEO:** Earth Observation, Reconnaissance and Science
  - Launch mass 600-2100kg
  - P/L power up to 1kW
  - Lifetime up to 12 years



→ Large platforms, high reliability, power demands of DH architecture low compared payload provisions

OHB Current Satellite Electrical Architecture

- Classical Satellite Architecture in line with the SAVOIR generic HW Architecture
- For internal communication
  - Platform-MIL1553 Bus
  - Payload-MIL1553 Bus
  - Discrete Telemetries and Telecommands handled by the SMU / dedicated RTUs
- So far no limitations on bus capacity due to decentral processing (e.g. in AOCS)



Replacement of the 1553 Bus?

- MIL1553 bus offers a very robust physical layer (galvanic isolation, failure propagation protection), redundancy, a simple protocol and HW-implemented error detection.
- In view of the increasing processing power of the OBDH, options may come in view to centralize several processing tasks e.g. star tracking from AOCS which requires transmission of video data not achievable through 1553 bus. Also extended monitoring (HRDM) partly becomes difficult.
- More than 30 RTs require multiple busses
- In case of MIL1553 replacement, the change to another bus technology is preferable to avoid extra harness and routing efforts imposed by point-to-point connections for low data rate interfaces.
- Can CAN replace the MIL1553 bus at least for low data rate connections? Similar max. data rate and more complex protocol don't offer an answer to larger bandwidth needs.
    - very robust physical layer
    - lower cost, lower power, >100 nodes possible
    - Nor redundant but solutions for redundant layout already sketched / available
    - Components available (space-qualified transceivers, IP cores, test equipment)

OHB insights from hands-on work with the CAN Bus

- CAN investigated for a first step MIL1553 replacement for a payload bus
  - ~60 nodes
  - simple equipment commanding (mostly limited to mode changes) without strict time dependencies
  - low speed housekeeping data with 1s update rate
  - communication to several uRTUs enabling a decentral collection of TM data
  - bus length approx. 35m

- OHB tailored ECSS-E-ST-50-15, CIA CANOpen and ISO 11898 standard to an inhouse spec tailored to payload TMTC demands.

- Detailed investigations showed that the bus can be operated safely only up to 250kbits/s due to harness delays (~200ns), node delays (~1ms) and clock drifts (+/-300ppm) between transmitters and receivers.

→ Due to the found limitations the CAN bus was considered as not eligible for replacing the 1553 bus in general for OHB satellites but may be considered for low data rate devices in specific environments.

SpW /SpFi

- Point-to-point interconnections, require specific router circuits to form a network, significantly less robust physical layer than CAN or MIL1553 bus.
- Simple protocol solutions e.g. RMAP to communicate with devices not containing a processor
- Time-deterministic operation possible but not standardized
- SpW efficient to be used for TMTC in case the equipments provide a high data rate interface anyway instead of introducing an additional separate interface for TM/TC (e.g. PLATO instrument holding 24+2 cameras)

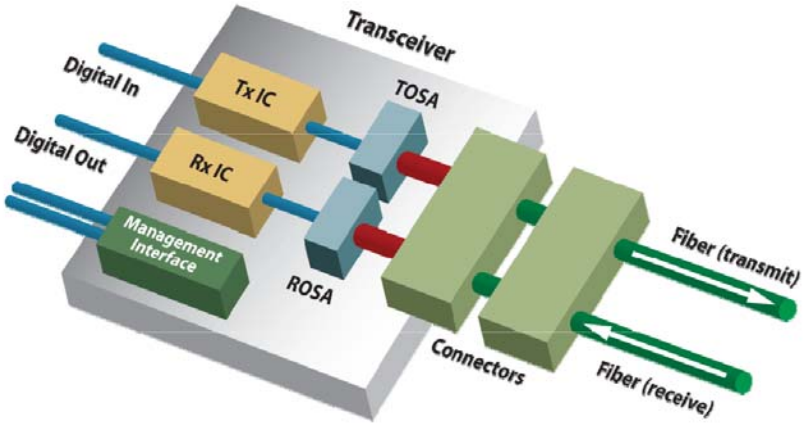
→ EMC-sensitive physical layer and implementation cost / weight (router, cross-strapped heavy harness for each point-to-point connection) and the need for fast processing electronics (FPGAs) even in equipments providing low data volumes makes the bus attractive only for high speed data exchange.

→ SpFi even more demanding in interface costs. Especially if using optical links for SpFi no “qualified” transceivers are available. The reliable interconnection (electrical and optical) to such devices is difficult

Investigation of Optical Transceivers for Space Applications (OPTISA)

ESA-funded project to identify eligible optical transceiver devices for high speed intra-satellite data transfer.

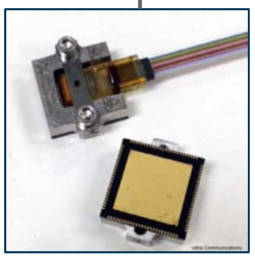
- Market analysis and assessment of available products
- Selection of devices for closer investigation
- Test setup definition & creation for suitable units
- Environmental testing against space effects of a subset of candidates
- project ongoing and to be finished by Dec. 2018



Key Functional Selection Criteria for Evaluation

- 850 nm VCSEL laser & PIN Diode
- Multichannel (up to 4x TX and 4x RX)
- 10 Gbit/s per Channel
- Compatible to ESA SpaceFibre Standard

Examples:


Ultracomm


Reflex Photonics

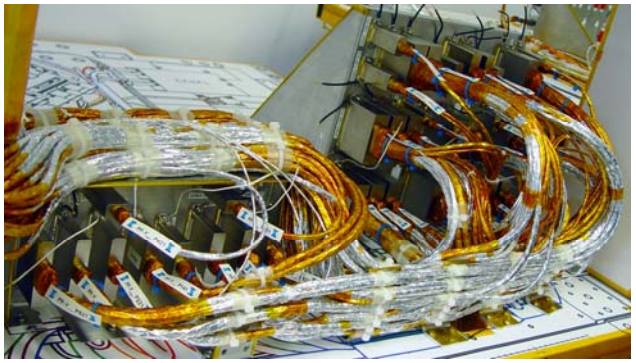

Glenair

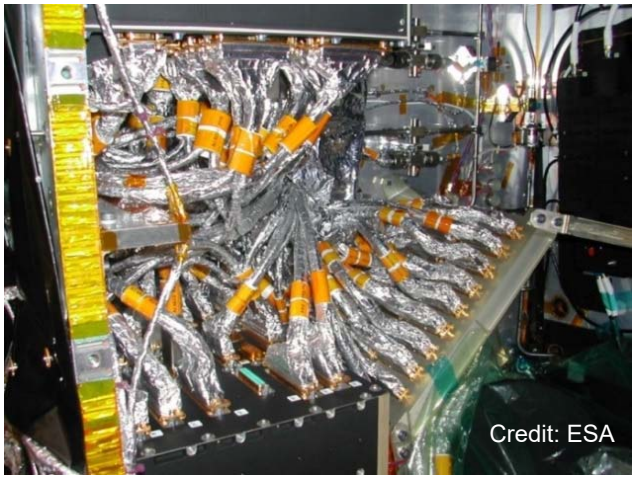
TSN / TTETH

- No experience at OHB with Ethernet derivatives (TSN, TTEthernet) at OHB. The main advantage of those communication links compared to SpW/SpFi is seen in the more robust physical layer (galvanic separation via transformers) and the widespread test equipment being available almost for free.

Discrete Signal Handling in Centralized Architecture

- Typically spacecraft monitoring requires the acquisition of approx. 1000 discrete TMs (Thermistors, analogue voltages, bi-level status etc), control of 10…50 heater lines and the generation of several High-level Commands being connected to the SMU or a separate RTU.
- SMU / RTU specifically designed to system interface needs.
- Harness Mass
  - For the OHB SGEO platform the harness mass (just cables w/o connectors, overshield and fixations) is 66kg.
  - Approx. 42,5kg (65%) of that mass is dedicated to discrete signals, heater group supply.
- Harness Density
  - SMU interconnections 3000…10.000 pins with a contact density of 5pins/cm², most of them dedicated to discrete signals need to be interconnected.
- Integration and Test
  - Highly populated harness areas need specific cable support solutions
  - System level testing only after full harness integration

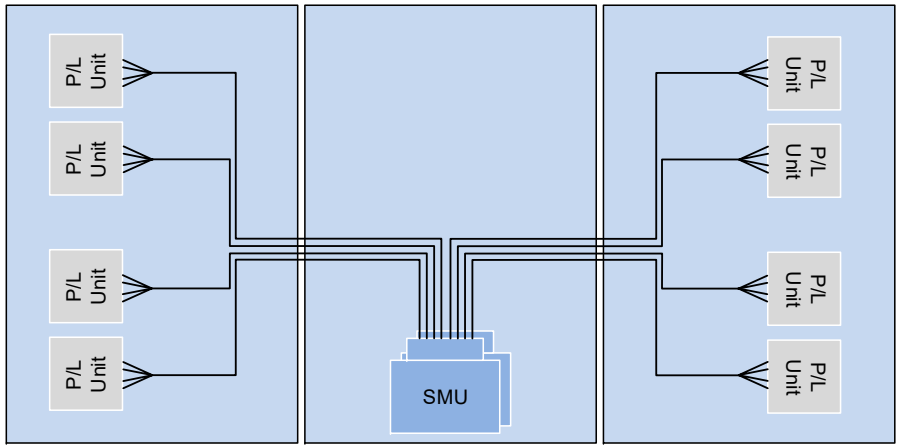




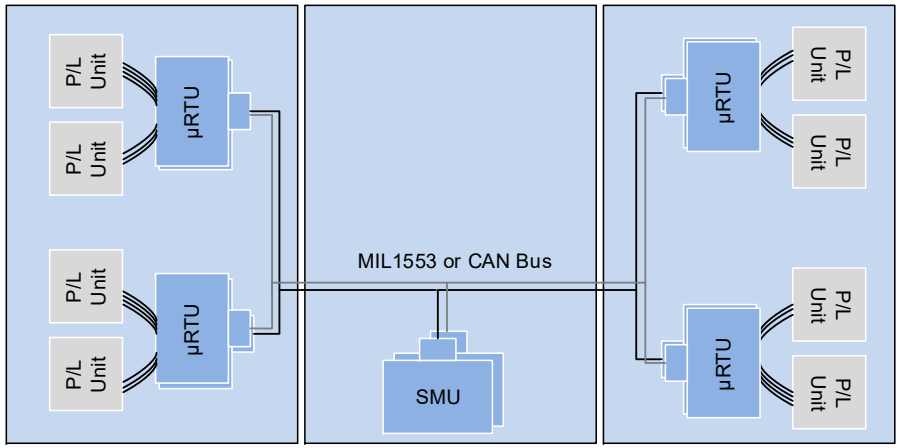
Changing from a Centralized Architecture to Distributed uRTUs

- Offloading the SMU from the platform / payload-specific interfaces limited to data bus based communication.
- uRTUs will handle:
  - Discrete TM Acquisition Function
  - Discrete TC Generation Function
  - Heater Driving Function
  - Specific I/O Functions e.g. Motor Drives or Reaction Wheel / Gyro Interfaces
- Harness reductions but increase of data bus traffic.
- uRTUs will be assembled to cover the specific needs of the local environment for TM/TC.
- OHB has produced SMU and uRTU specs in line with the SAVOIR architecture adapted to the SGEO platform-specific needs.

Centralized Architecture

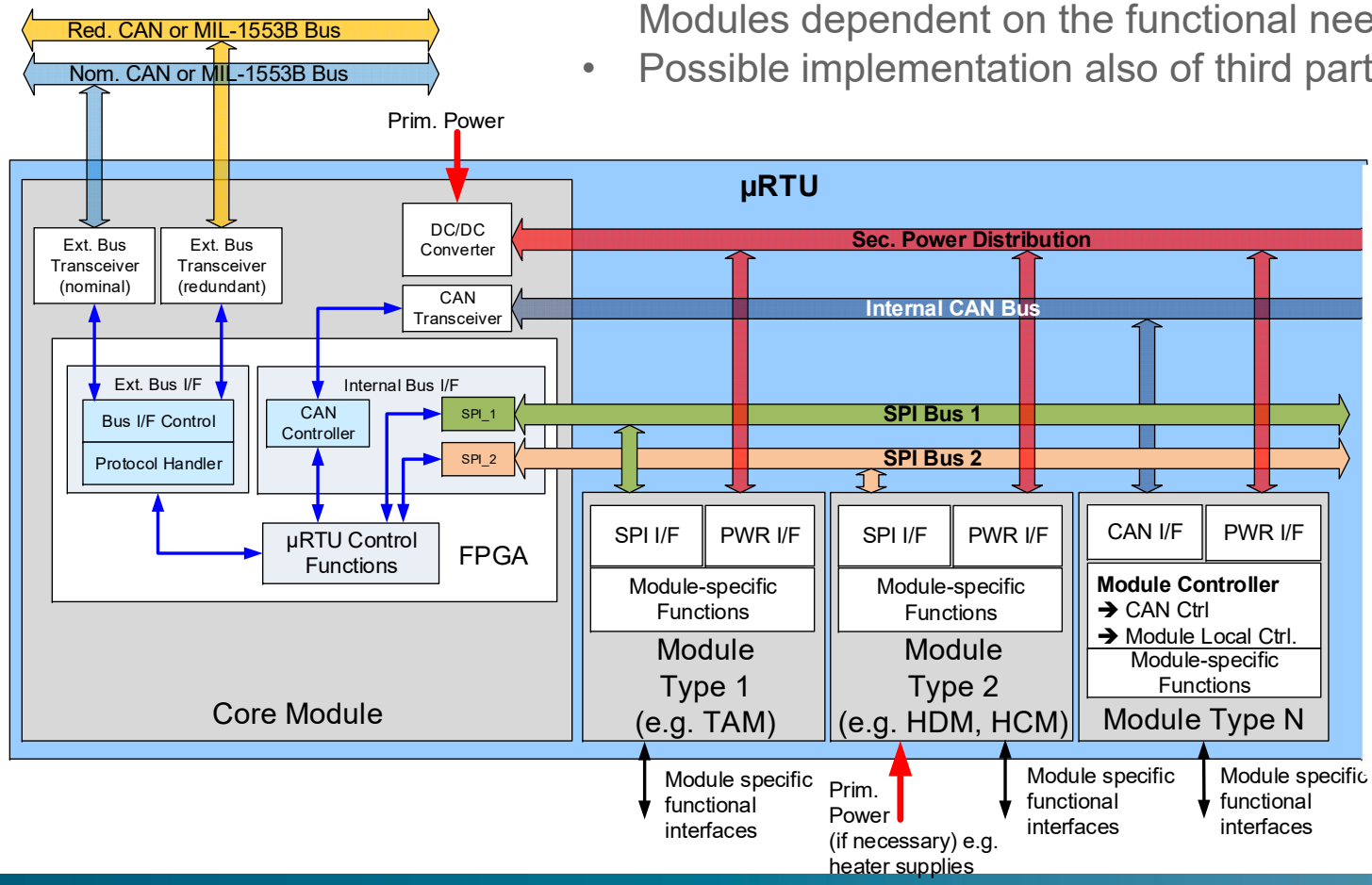


Distributed uRTUs



Concept Definition - uRTU Architecture

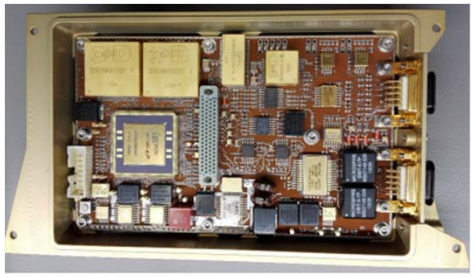
- Each uRTU consists of a Core Module and a set of I/O Modules dependent on the functional needs.
- Possible implementation also of third party modules



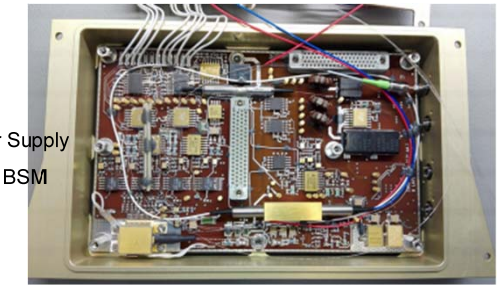
Hybrid Sensor Bus

- Research project to use fibre-optical networks for temperature sensings through Fibre-Bragg-Gratings
- funded by DLR and ESA/ARTES and closed mid 2017
- Approach put in question due to
  - Complex HW and algorithms make the solution financially unattractive.
  - Handling problems of FBGs during integration.
  - sensor accuracies remained below the expectations (+/-5°C).

HCM



AFE



Summary

- Replacement of MIL1553 bus is not a dominant topic at OHB. The current focus is more towards maximizing the benefits of a distributed architecture for discrete TM/TC handling through RTUs to reduce weight, complexity and integration efforts.
- CAN bus was investigated as an alternative for low data rate connections and could find its place in the payload domain in case a high number of nodes needs to be addressed. CAN FD could improve the performance but was not investigated yet.
- Usage of SpW/SpFi for TM/TC should be made in case the interfaces already exist e.g. for science data provision. Lack of robustness of physical layer wrt. EMC issues. Ethernet derivatives appear more robust due to galvanic isolation being implemented.
- The distributed RTU concept also offers in the mid term the opportunity to be interfaced via the preferred high speed interface (SpW/SpFi/ETH) and could serve as interface hubs also to low data volume clients e.g. by offering RS422 or CAN interfaces.