eSpace EPFL Space Center

Dedicated On-Board Computer for Active Debris Removal Mission

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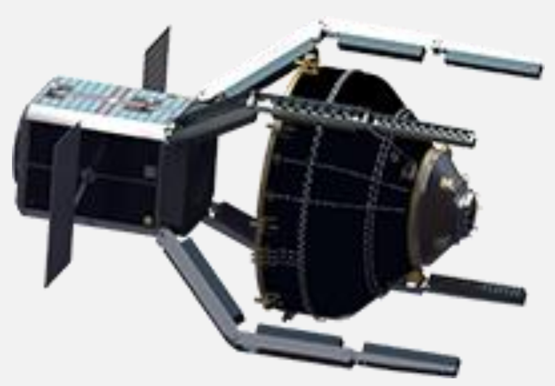
ClearSpace-1 Mission

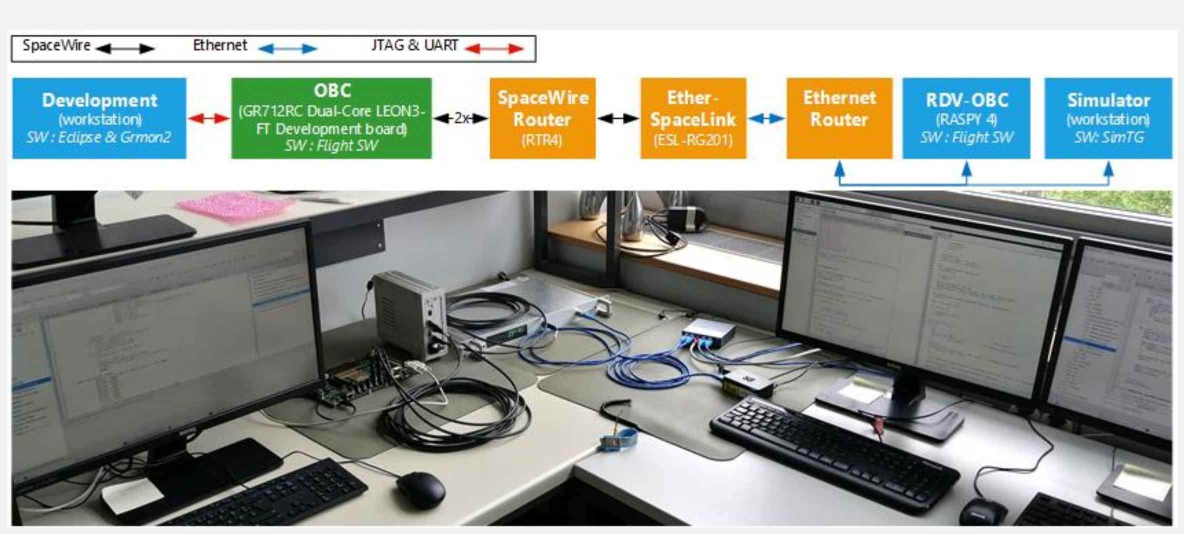
- CS-1 is an Active Debris Removal (ADR) mission led by the start-up ClearSpace and the EPFL Space Center, previously known as CSO. [1]
- The goal is to rendezvous with VESPUP (VEga Secondary Payload Adapter Upper Part) and deorbit it
- The development focuses on two main aspects :
  - A capture mechanism able to retract and deploy multiple times, moreover it should perform a soft capture of the target.
  - A Payload On-Board Computer (POBC) to host the different relative navigation and image processing algorithms. It should merge the data from various sensors needed for the approach and rendezvous phases.



CS-1 design ©ClearSpace SA

Hardware-In-the-Loop Setup

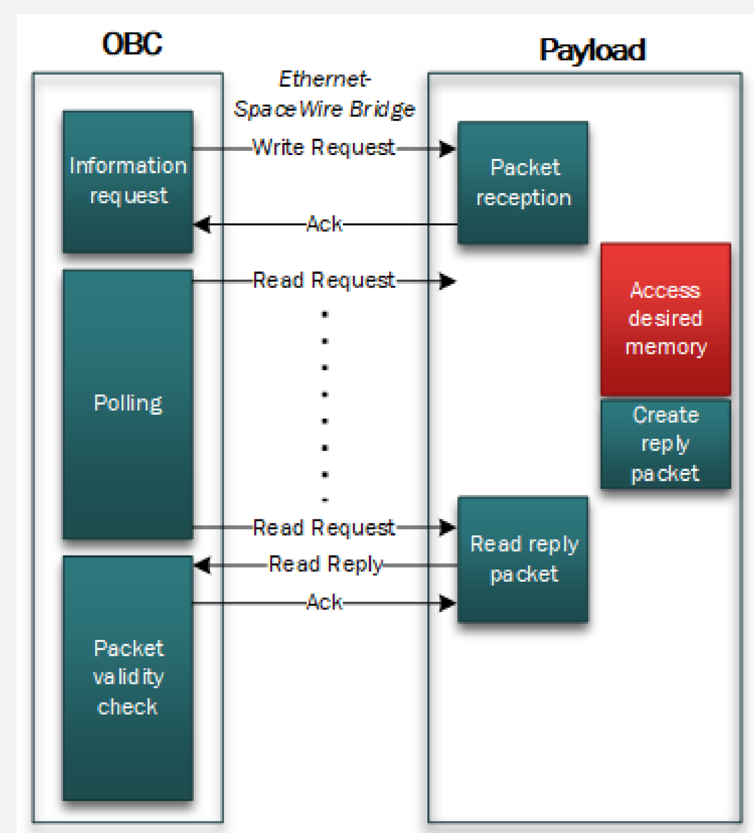
- Main avionic inherits from the FLP2 platform [2] designed by *Airbus DS Friedrichshafen*.
- Processor Board is connected to a SpaceWire Router and Ethernet-SpaceLink Bridge, then to the prototype payload and the simulator workstation.
- The OBC is the GR712RC development board build by *Cobham Gaisler AG*. It is a Dual-Core LEON3FT SPARC V8 processor.
- SpaceWire Router and Bridge are provided by *4Links*.
- POBC is a Raspberry Pi 4 for the first phase of development. It will be upgraded to a more powerful board later.



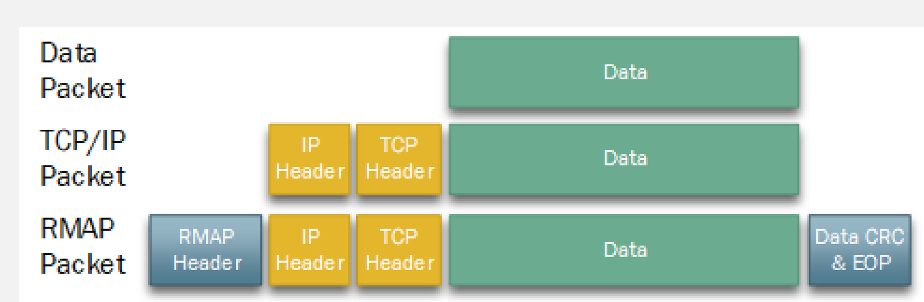
HIL Setup at EPFL Space Center

OBC-Payload Interaction

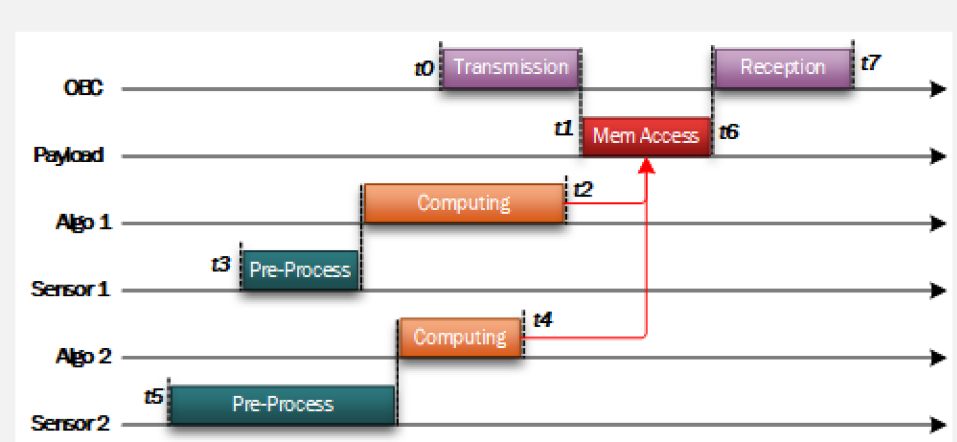
- Interaction
  - Connection through SpaceWire (SpW) & Ethernet
  - Hand-shake protocol with OBC as Master and POBC as Slave



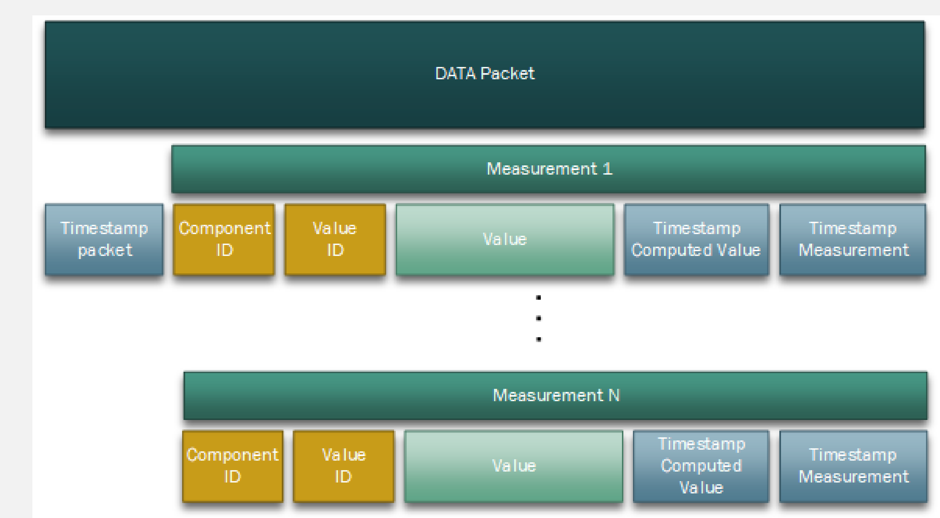
- Packets
  - Transformation from SpW to Ethernet
  - TCP/IP protocol for Ethernet & RMAP for SpW
  - Encapsulation by OBC
  - Routing management by Eth-SpW Bridge



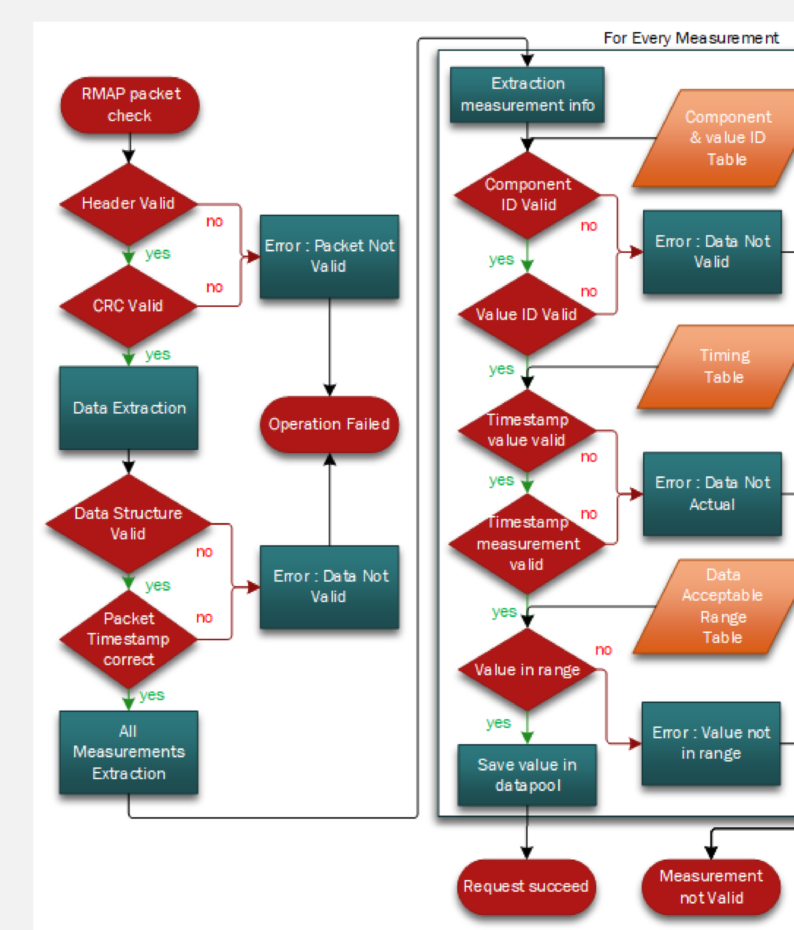
- Reaction Time
  - Determination of various timing from pre-processing to transmission protocol
  - For navigation purpose, all measurements should have a timestamp.
  - Some timing might be not deterministic



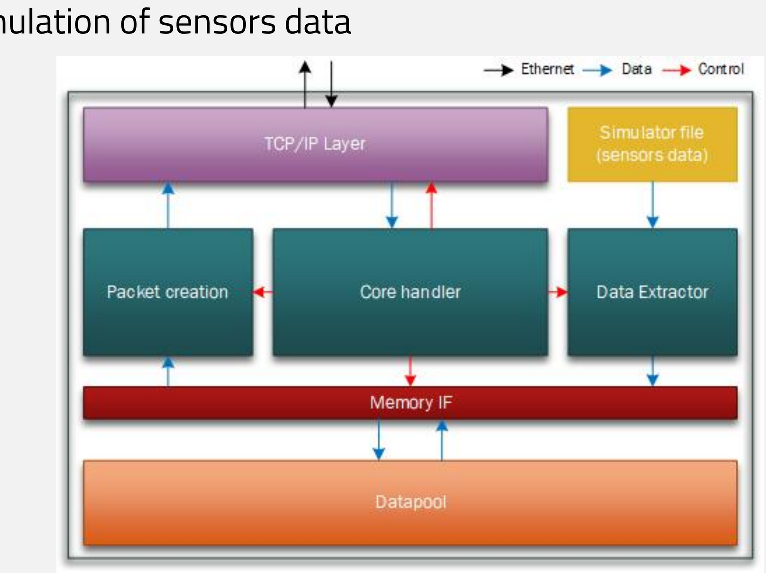
- Time Synchronization
  - Multiple timing information in each packets
  - Differentiation between measurement and process value



- Handling & Verification
  - Packet validation then structure validation
  - Comparison of each measurements with expected values (Range Table)
  - Table computed prior to mission with simulation



- Task Simulation
  - POBC prototype architecture
  - Simulation of sensors data



Challenges & Future Development

- High Priority Command
  - HPC to overcome timing issue
  - Increase in complexity & verification
  - Small data packet transfer for speed
  - POBC algorithm dependent
- OBC Polling & Redundant information
  - Determination of polling frequency
  - Constant information request thread in OBC
  - Transmission of redundant information
  - Time & resources consumption for verification procedure
- Integrity Check
  - Check of packets & measurements timestamps
  - Validity duration for measurements
  - Determination of data validity with respect to previously computed values
  - Expected data depend on mission phase
- Critical Situation Detection
  - Detection of critical situation by POBC
  - Critical status flag in regular packet
  - Increase of polling frequency
- Failure Detection, Isolation and Recovery
  - Dedicated FDIR for POBC
  - Level of autonomy of POBC vs OBC
  - FDIR information transmission through SpW
- Future Development
  - Verify protocol & timing
  - Ground control loop for POBC
  - Upgrade of POBC hardware
  - Increase complexity of payload software

Conclusion

- Prototype of communication management between OBC & POBC
- Characterization of time delay in the protocol
- Testing of timing synchronization
- Establishment of validation procedure for packets
- Elaboration of POBC prototype software
- More information in paper *SSC20-P2-17*

References

[1] M. Richard, L. Kronig, F. Belloni, ..., and H. Shea, "Uncooperative rendezvous and docking for MicroSats," In 6th International Conference on Recent Advances in Space Technologies, RAST, 2013
[2] Eickhoff, Jens (Ed.), "The FLP Microsatellite Platform - Flight Operations Manual," Springer, 2016.