Reduction of the Harness
The One Interface Illusion
- reloaded -

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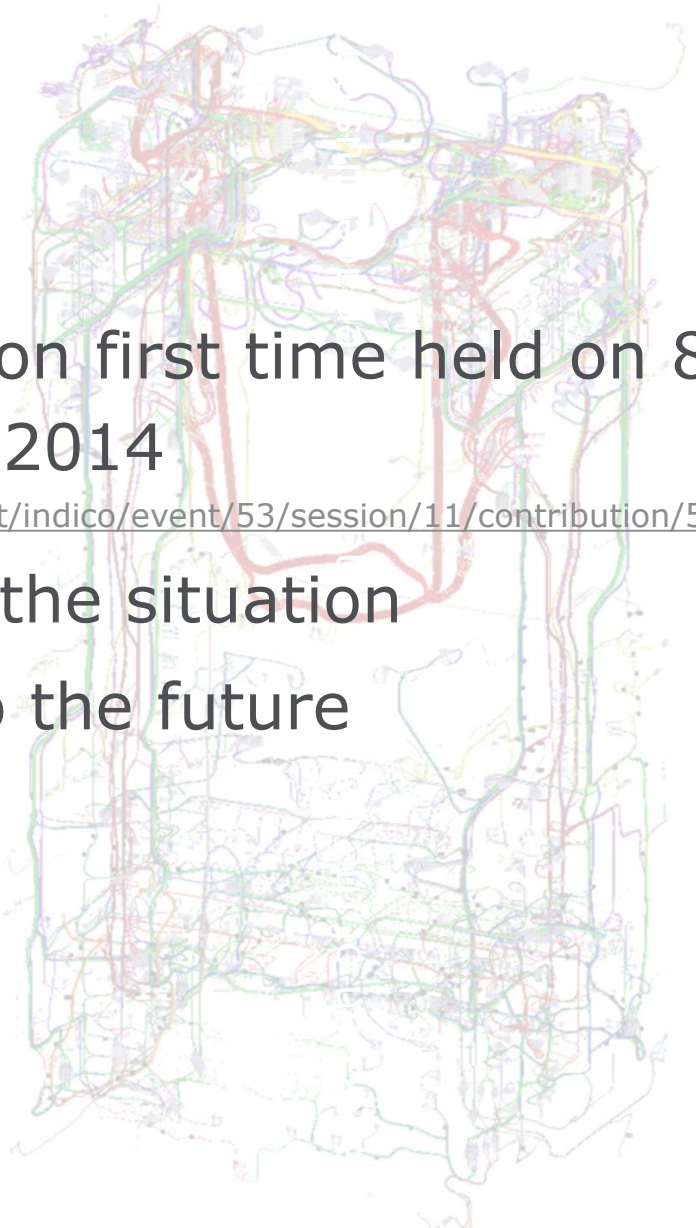
Why "reloaded"

- Presentation first time held on 8th ADCSS workshop 2014
  https://indico.esa.int/indico/event/53/session/11/contribution/57/material/2/0.pdf
- Re-cap of the situation
- Outlook to the future



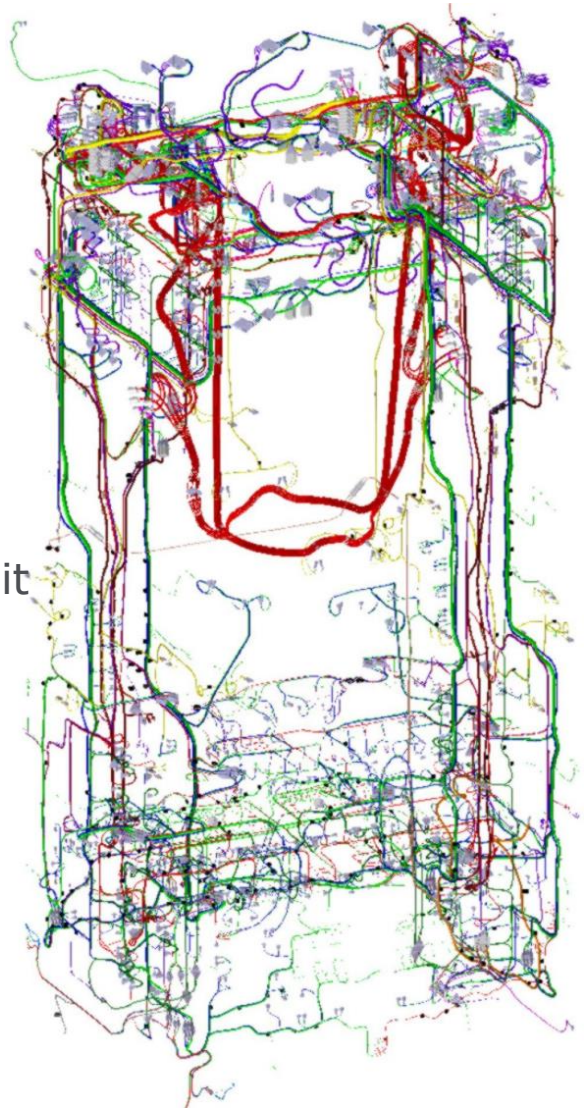
Picture: Space Passive Component Days 2013 Session 4 - Malagoli – Courtesy of ADS

Why change – It was always like this

- Harness reduction is a recurrent topic, but
- Evolution on the topic seems to be difficult

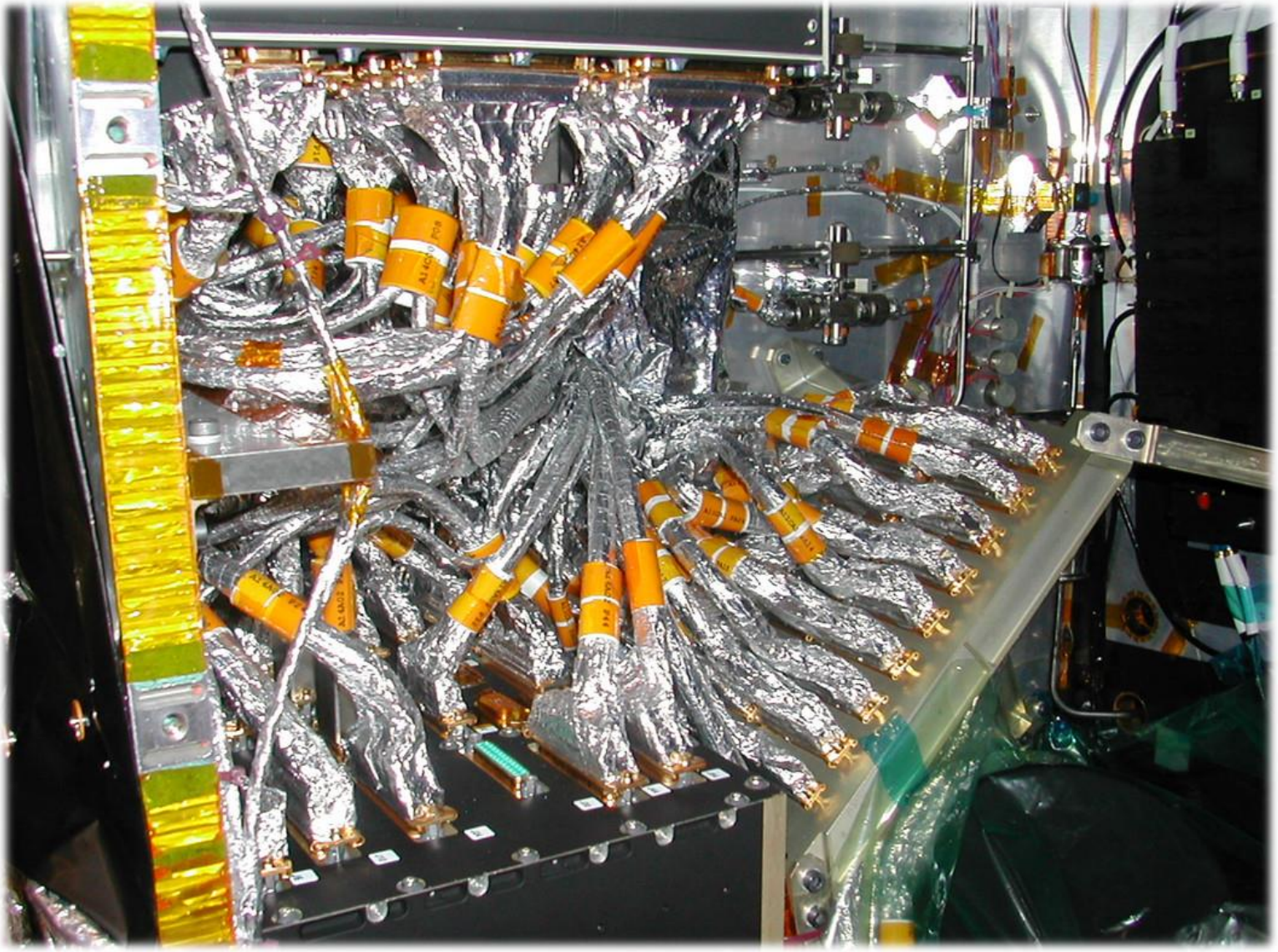
"I'm involved in missions for 20 years and did not see a significant change on this over the years"

- Nevertheless it seems to make sense to think about it
- A huge satellite has (SPCD 2013 – Malagoli)
  - 50.000 connections
  - 1.000 connectors
  - 20.000 meters of wires
  - harness mass exceeding 100kg



Picture: Courtesy of ADS - SPCD 2013

Why change – Because it is like this



Picture: Courtesy of ESA - MarsExpress

What can be done

- Harness based
  - Cable length/ volume/ mass
  - Amount and dimensions of connectors

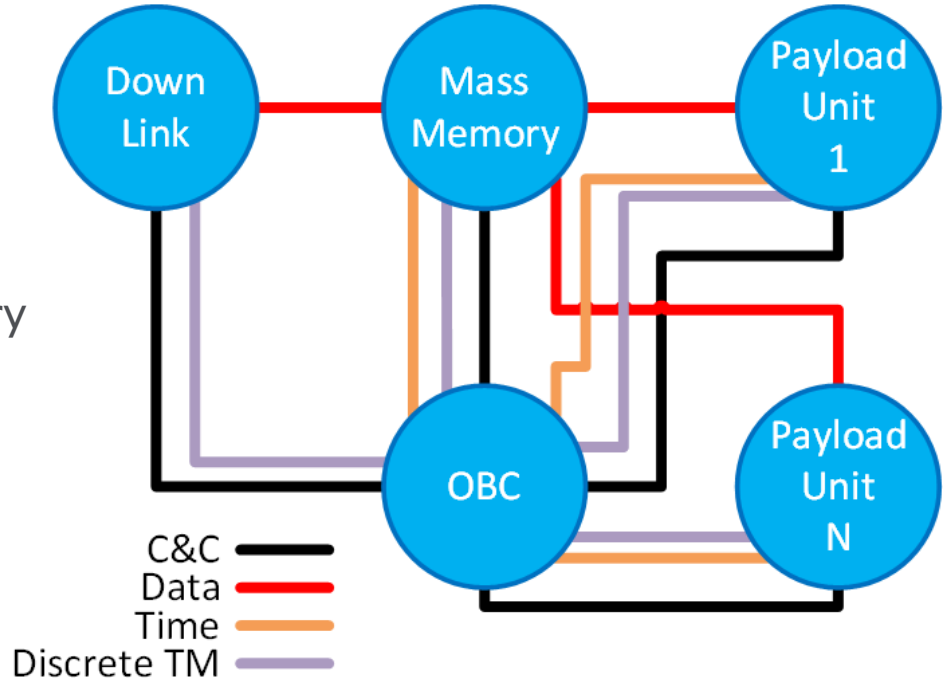
- Architecture based
  - Assessment of current solutions
  - Reducing the number of interfaces
  - Combining functions

⇒ **Make better use of available cables and cable bandwidth**
(R. Janssen, TEC-EDM)

Picture: Courtesy of ESA – Seosat RTU

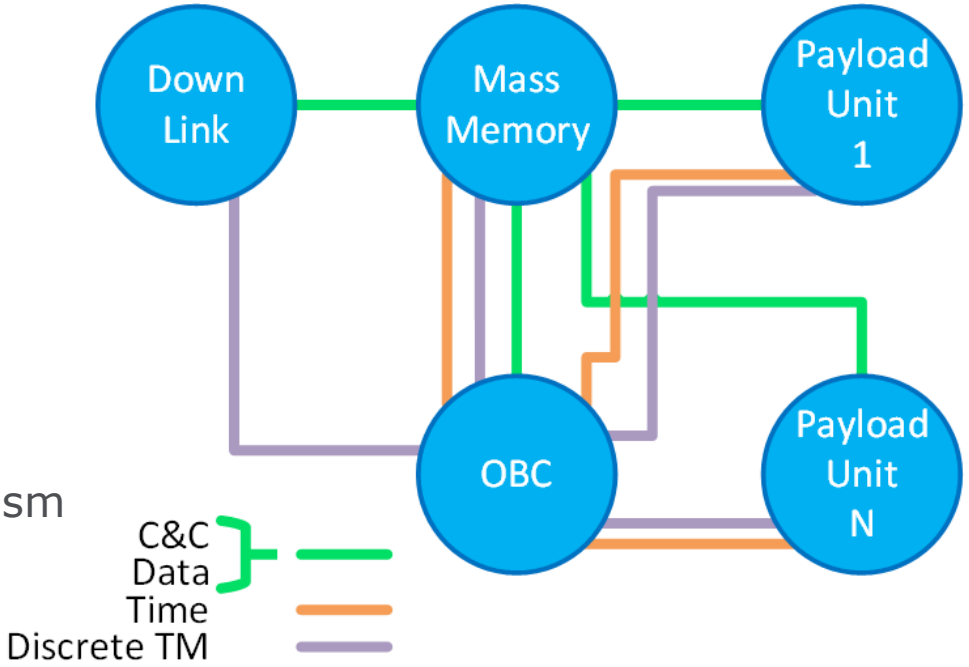
Payload Interfaces – Architecture based

- Science Data
  - SpaceFibre, WizardLink, SpaceWire
- Command & Control
  - SpaceWire, CAN, MIL-1553, UART
- Discrete Signals (ECSS-E-ST-50-14C based)
  - Digital
    - Switch operation
    - Status detection
  - Analog
    - Power telemetry
    - Temperature telemetry
- Timing
  - 1 Pulse per Second synchronization
- Survival
  - Heaters
  - Temperature sensors



Payload C&C and data interfaces

- Science Data
  - High to medium speed
  - Point-to-Point
- C&C
  - Low to medium speed
  - Bus or point-to-point
  - QoS, schedules, determinism



⇒ Approach: combine in a single solution
- Data rate driven by science data requirements
- QoS/ scheduling/ determinism driven by C&C

⇒ Solution:
- SpaceFibre (via copper cable or optical fibre)
- Assessment SpaceFibre wrt SAVOIR UNION requirements:
  https://indico.esa.int/indico/event/182/session/9/contribution/27/material/1/

Payload Time Distribution

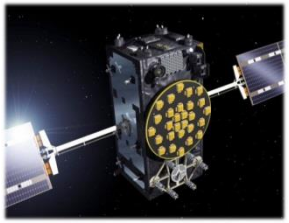
Time Synchronization/ Distribution

- Missions need defined synchronization performance
- 1PPS gives "best" results, but may be better than needed

- Approach:
  - via C&C interface

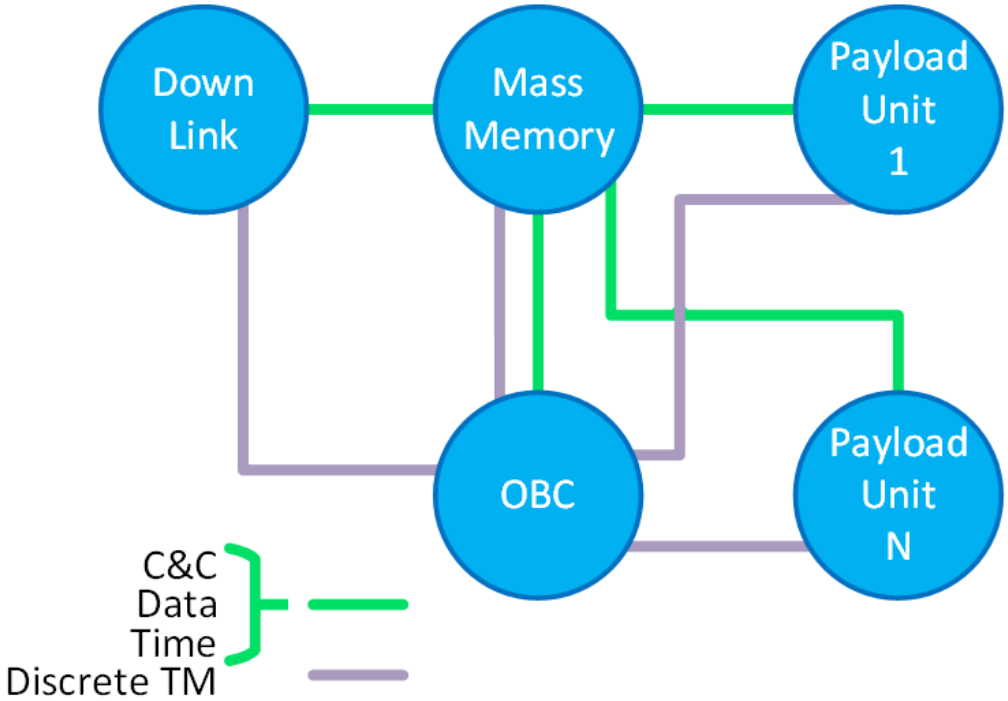
⇒ Solution

- Time codes



Picture: Courtesy of ESA

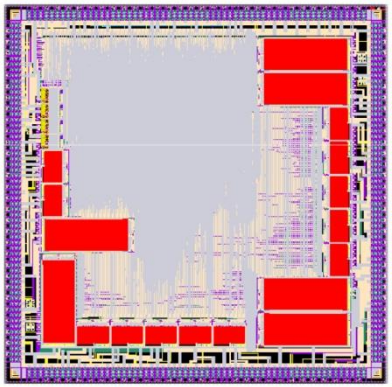
Picture: Courtesy of ESA



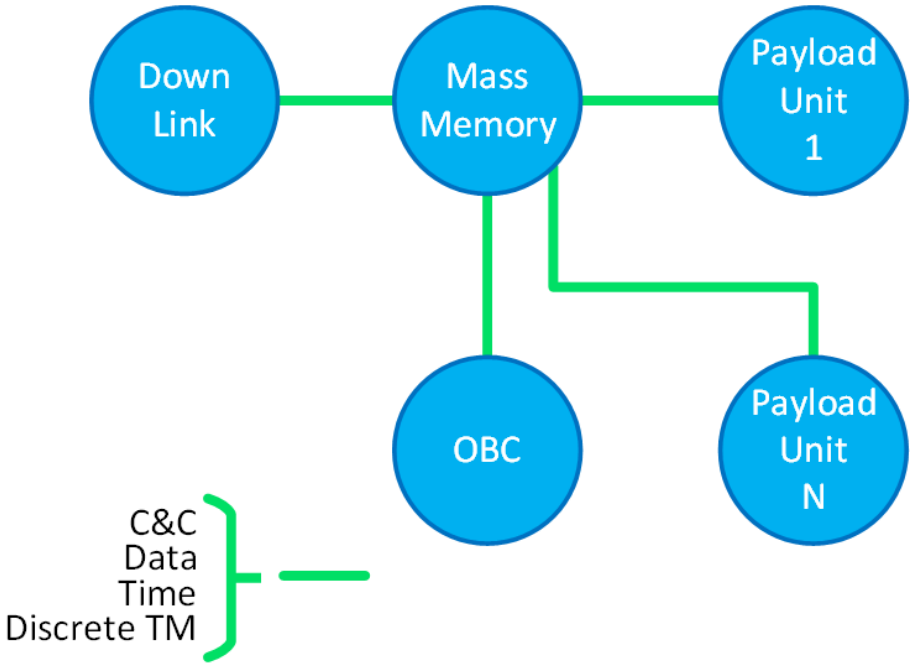
Payload Discrete TM

Discrete TM

- Analog telemetry, status detection
- Approach:
  - Sensor circuitry (ADC) included in payload units
  - Mixed-Signal ASICs & uController
  - Telemetry via C&C



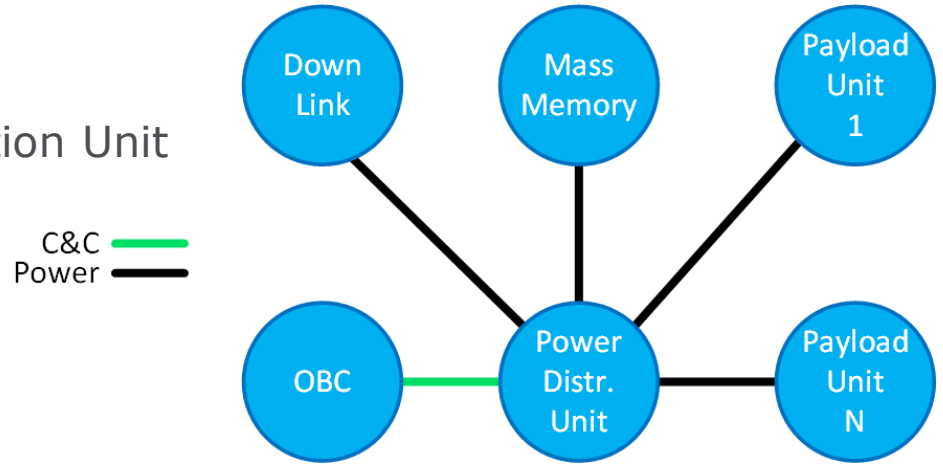
Picture: Courtesy of Tesat
KNUT Mixed-Siganl ASIC

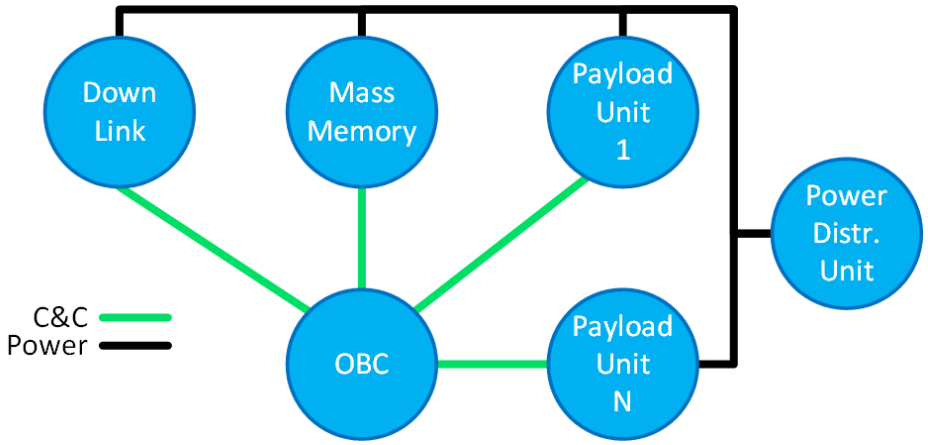


Payload Discrete TC

Discrete TC

- ON/ OFF command
- Approach
  - LCL/ Switch in Power Distribution Unit
    - No standby current
  - WoC – Wake-on-C&C
    - Less power harness
  - TC-OFF in both cases via C&C





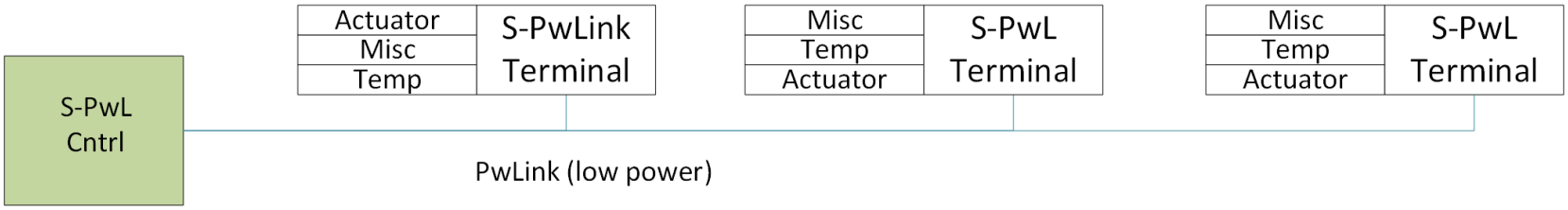
From Payload to System Point of View

Independent payload monitoring and control (PL units unpowered)

- Sensor acquisition
- HRM/ Rf-switch operation
- Heater control

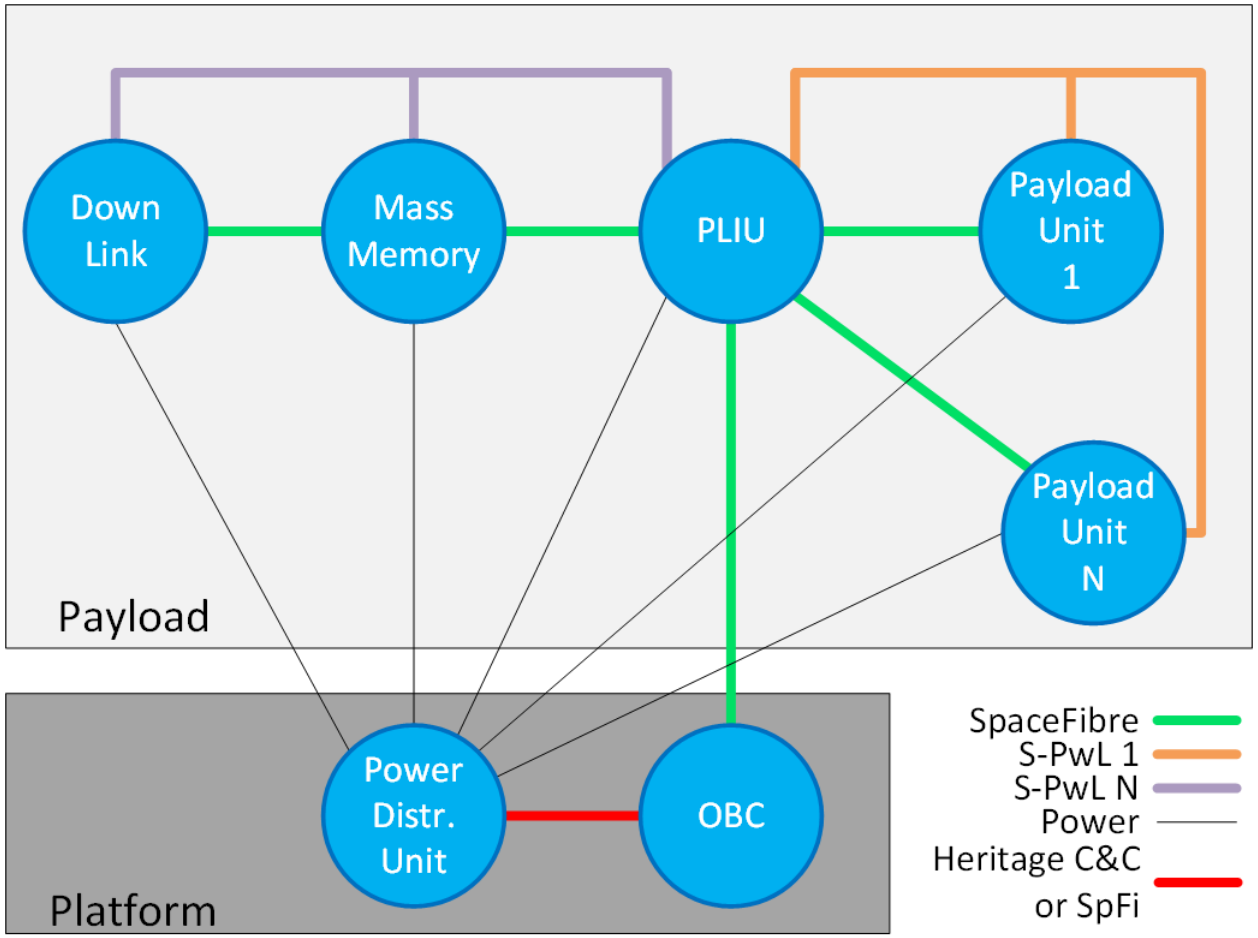
Approach: Secondary Power Line Communication

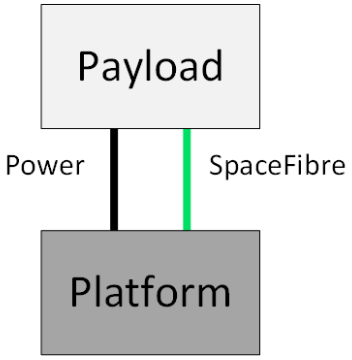
- Space-PowerLink - thumbs up to Wahida Gasti ☺
  https://indico.esa.int/indico/event/182/session/1/contribution/10/material/0/
- In RTU or ….



From Payload to System Point of View

… in Payload Interface Unit (PLIU)

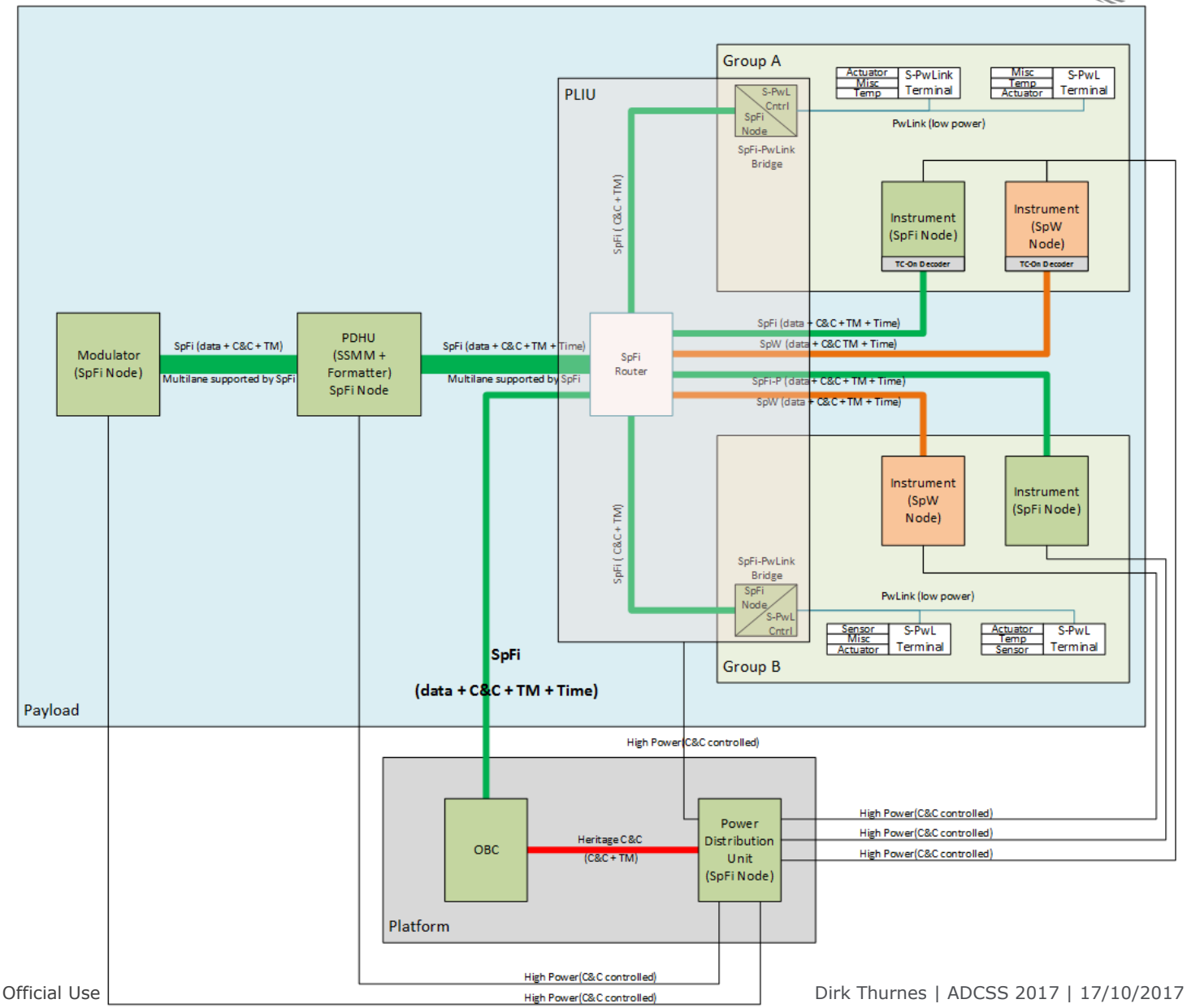




Advantage:

- Only two electrical interface types between PL & PF

Architecture based - Putting it all together



Harness based approach

- Harness can drive unit dimension due to
  - connector size
  - number of connectors
- Harness can significantly contribute to payload mass due to
  - number of connectors and cables
  - EMC shielding of cables

Approach:

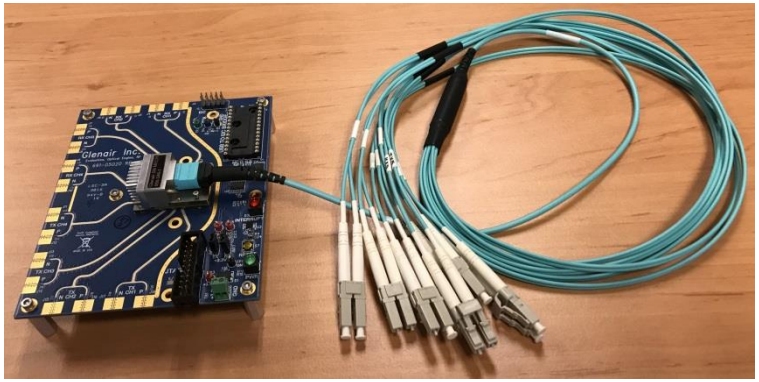
- Combine as many interfaces in one connector
  - Reduces the number of connectors
- Use optical links
  - Reduces connector size and weight
  - removes EMC shielding needs

Solution:

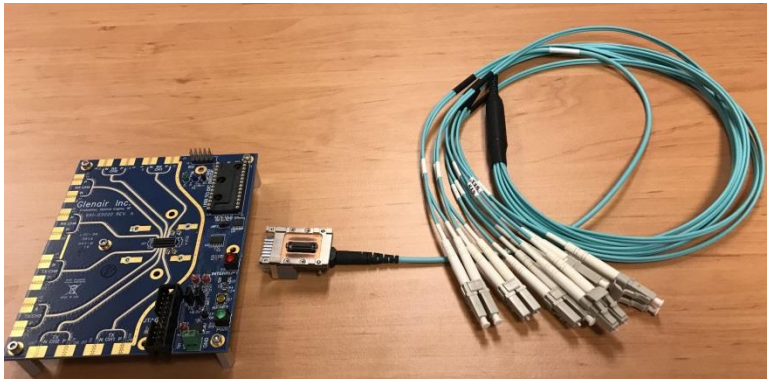
- SpaceFibre (optical physical layer part of the standard)

Optical Harness – an example

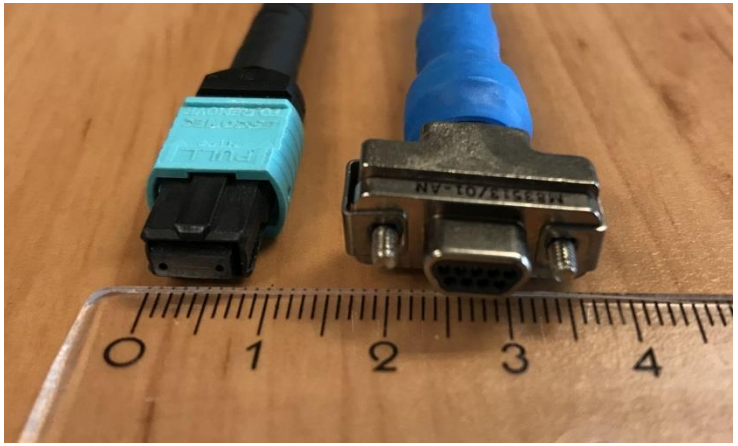
12 Fibre transceiver & Harness



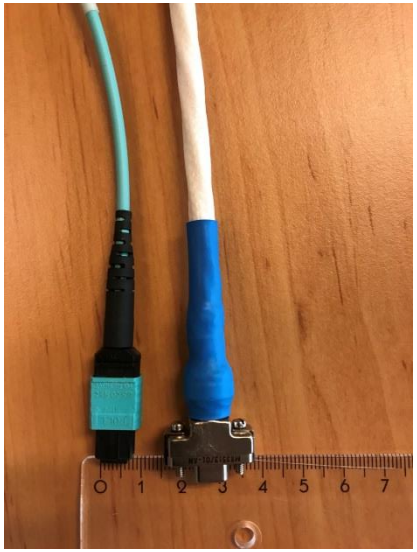
Easy to mount transceiver & detachable pigtail



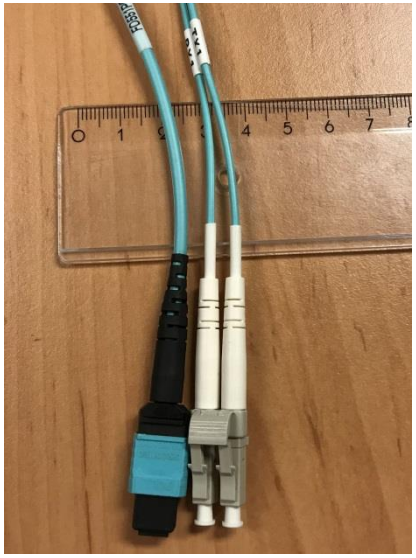
Optical connector with 6 SpFi links @ 10Gbps each smaller than single SpW connector at 200Mbps



12 Fibre vs single SpW cable



Single vs 12 fibre cable – scales nicely



Summary of the proposed approaches

Architecture based

- Combine C&C and Science data bus
- Time synchronization via suitable C&C interface protocols
- Discrete Signals to be replaced by functions integrated in PF and PL
  - TC ON/OFF =>LCL/ switch in PSU, Wake-on-Command
  - PL digitized analog signal telemetry via C&C bus
- Connect sensors/ actuators for PF managed PL control via Space-PowerLink (secondary power line communication)

=> Possible with SpaceFibre ECSS-E-ST-50-11C via copper cable or optical fibre

Harness based

- Optical harness to shrink dimensions and mass of connectors and cables

⇒ Possible with SpaceFibre ECSS-E-ST-50-11C via optical fibre

Comments welcome to get the discussion started

☺

Thank you very much

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On-board Payload Data Processing Section

TEC-EDP

ESA/ESTEC