ThalesAlenia Space
A Thales / Finmeccanica Company

SpaceWire Working Group #18

System Requirements
&
use of Interrupts on SpaceWire link

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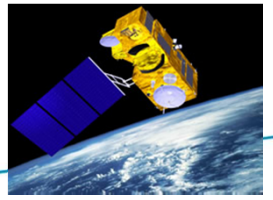
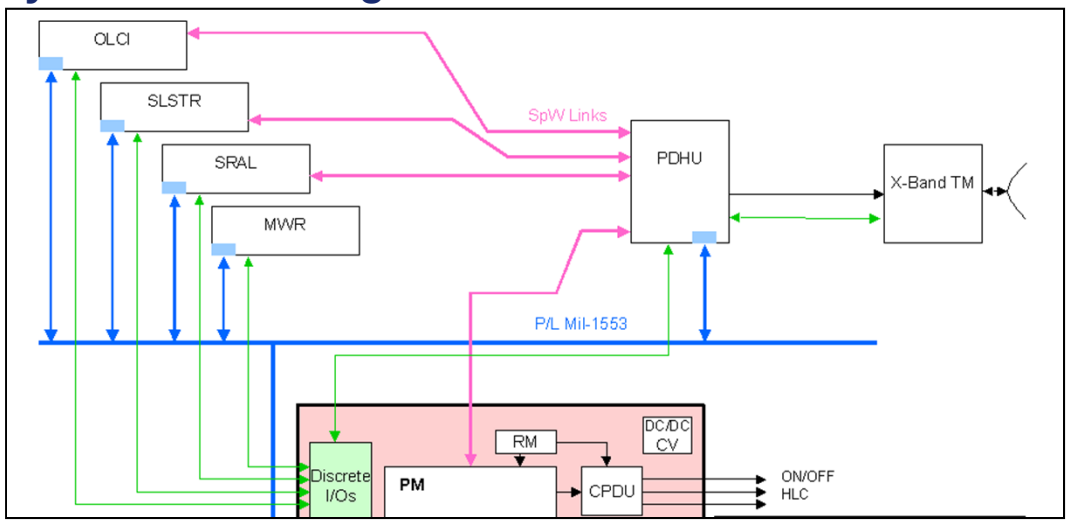
Introduction

- **Thales Alenia Space implements SpaceWire**
  - In more than 12 satellites
  - In coming telecom satellites
  - In most missions for observation
- **With today 3 mission classes for observation**
  - LEO observation like GMES sentinel-1 and 3
  - Inter-planetary exploration like EXOMARS
  - GEO observation like Meteosat 3rd generation
- **Mastering achieved for 100Mb/s point-to-point links in missions**
- **Interest for interruptions over SpW is identified**
- **Process to be improved for**
  - Electrical architecture (protection, harness characterisation and sectioning)
  - Data-Handling architecture (synchronism, link margin and buffering with routers)
  - Allowing 200Mb/s full-duplex network with both mission data distribution and configuration command-control sharing same links
- **High interest for simulation capabilities to cope with extension of SpaceWire usage**



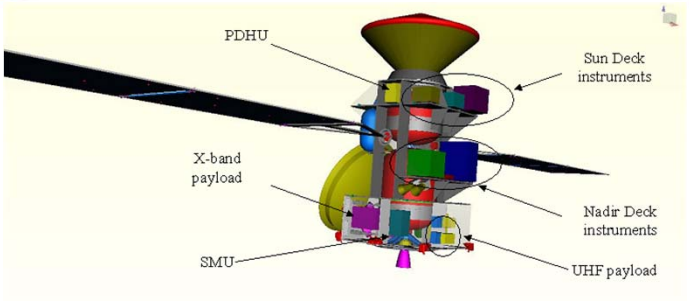
Sentinel-3 Satellite

- **Each SpW link is dedicated to point-to-point communication**
- **Redundancy for a robust payload data management**
- **Without interaction on the other links → no routing 100Mbps data-rate each ~ 300Mbps TMI**

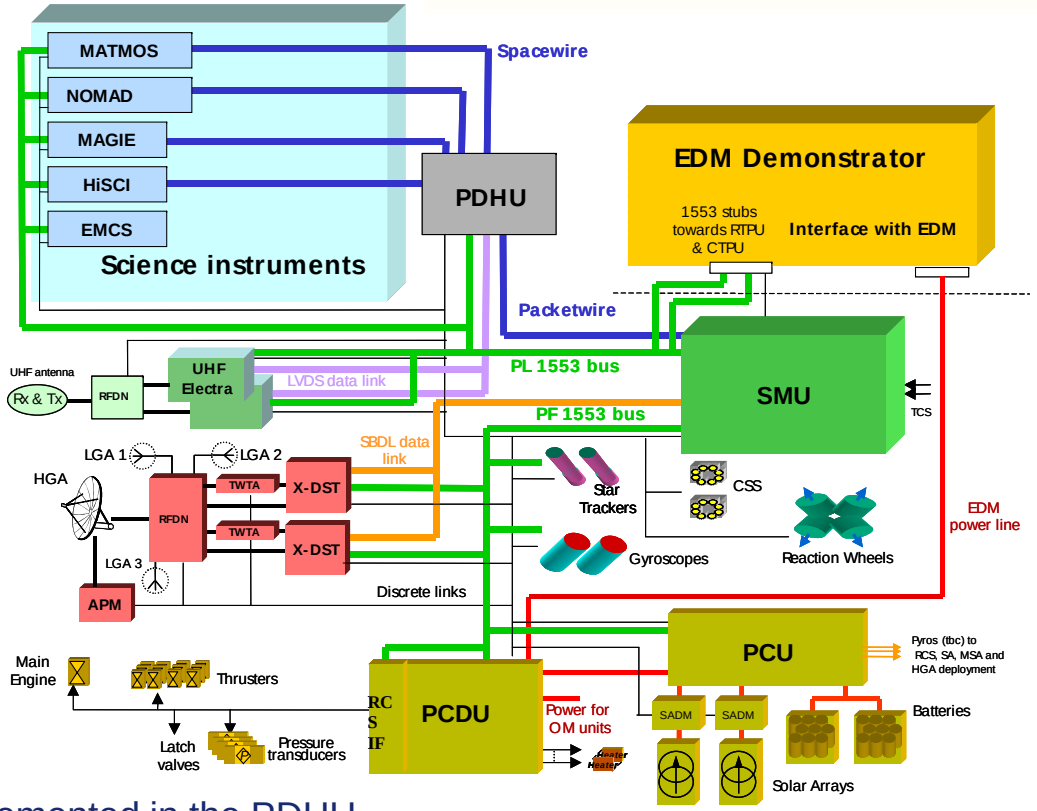


- **PDHU is able to handle 4 SpW sources**
- **Test has been performed between EM with 5V Emitter, 3.3V Receiver at 100Mbps and a bracket on the LVDS cable:**
  - Functional behaviour: OK
  - Compliance to LVDS standards: OK
- **Use of 3.3V components only is recommended**
- **1553 command-control bus kept to minimize risks**
- **Cross-strapping included in PDHU, for reducing harness mass and instrument's complexity**

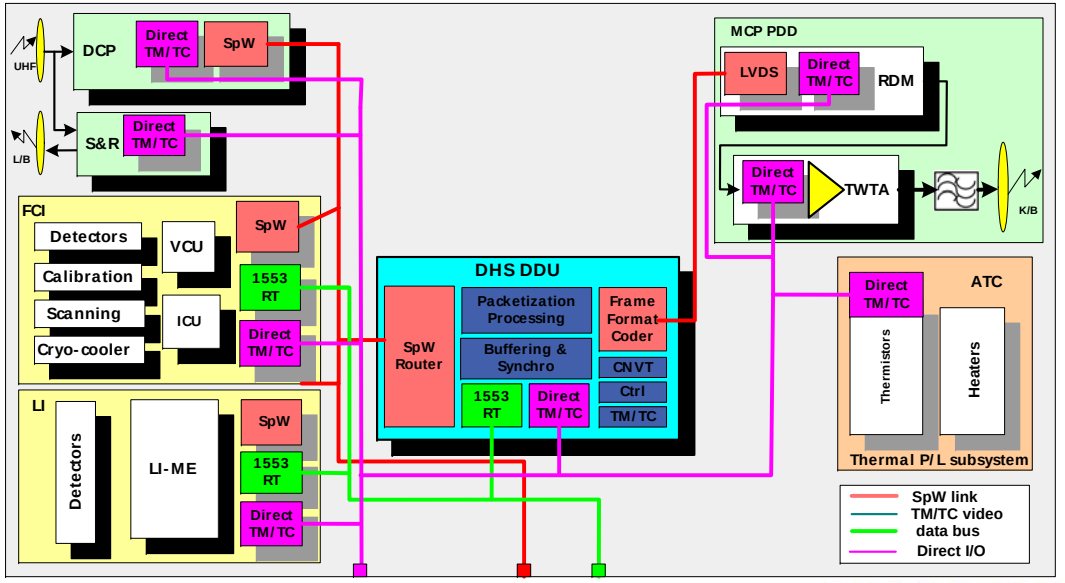
EXOMARS Orbiter



- **SpaceWire network to acquire and multiplex data from instruments**
  - Low mass and consumtion
  - For both mission data-handling and Command/control through a unified payload network
- **Data flows 25Kbps to 90Mbps**
- **global science data volume**
  - < 15Gb per day
  - stored in PDHU Mass Memory
- **payload network**
  - built around the PDHU
  - 6 functional nodes:
    - 4 instruments,
    - the UHF transceiver
    - the SMU
  - cold redundant pair of SpW links
  - full cross-strapping redundancy implemented in the PDHU



- **For payload data network**
  - constant ground station visibility (GEO) continuous mission data transfer in real time **without storage** without any risk of bottleneck
  - 295Mbps and 557Mbps continuous downlink for imager and sounder S/C
  - Full cross-strapping between each source - platform
  - Full-duplex used for instrument fast configuration (8MBytes data cmd)
  - Based on 200Mb/s link **-> Derating has been decided to reduce risks**
  - PUS packets exchanged on the network; 1 node incl. routing function



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Interruptions on SpaceWire network 1/3

- **TAS feedback on use of Interrupts on a SpaceWire link**
  - SpW is a “free space”: collision and bottlenecks can occur
  - IT can be used to drive the communication on the network if deterministic behaviour is expected:
    - To avoid polling for special controlling of some units
    - The SpW network master can send IT to devices to enable them to send data or stop them
    - The devices can send IT to the master to request a channel allocation
    - This is part of the pre-requisites/safety issues mitigation to merge C&C bus with Payload data bus: during nominal high data rate use of SpaceWire network for Payload data transfer, an IT could “lock” a given channel for sending Command&Control messages without collision while avoiding to freeze the complete network (this is less violent than TDMA on the complete network while insuring timely delivery of Command&Control messages) ->1-10Hz cycles

Interruptions on SpaceWire network 2/3

- **TAS feedback on use of Interrupts on a SpaceWire link**
  - For FDIR purposes:
    - Currently SpW network is monitored through other interfaces (1553)
    - As SpW topology evolved, FDIR over SpW will become more and more mandatory
    - FDIR IT could be used for:
      - Notification of a failure/event on a component,
      - Periodic (1Hz) Health status / Heart beats
    - Some instruments require currently additional I/F for monitoring & control
      - 1553 for configuration -> deported to SpW (ex. MTG with 8Mo scan tables for instr.)
      - Discrete interface for EQSOL & SOR: could be a SpW IT to reduce number of interfaces and mass, possible if SpW FDIR is secure enough!!

Interruptions on SpaceWire network 3/3

- **How to do?**
  - Use of time-code and allocation of special values of the control bits to identify IT (ex. 63 for heart beat of router 1, 62 for heart beat of router 2, ex…)? -> Update of time-code behaviour to enable this mechanism
  - Use of current time-codes to enable TDMA on spacewire network (device#1 to communicate on time-code N modulo M, device#2 on N+1 modulo M, etc…)
  - New control codes (code ESC+00XXXXXXX or ESC+11XXXXXXX)?
- **Interrupts required frequency**
  - Depends on application, as identified:
    - Periodic events: heart beats ~1Hz, synchronisation of PF&PL units? 1Hz-10Hz?
    - FDIR asynchronous events: SpW events, unit events (EQSOL/SOR)…
    - All events are supposed to be broadcasted over the network
- **Interrupts reliability vs timeliness**
  - As per identified applications, reliability is more interesting than timeliness: high security with “reasonable” timeliness: few ms is OK, 100ms too much for FDIR
- **Acknowledgment of interrupts**
  - Low interest (increased complexity), other actions are supposed to be taken on IT -> ON/OFF, RMAP command for register update, etc…

Concerns identified 1/3: Harness

- **Harness mass**
  - Over-sized for low data-rate and unidirectional link
    - Induce mass penalty
    - Implement internal cross-strap in order to reduce harness mass
  - Full-duplex mostly not used

  ➔ need of a lighter half-duplex harness
- **Harness length**
  - AIT requires >10m cables: repeaters are expensive: cost issue for AIT
- **Harness sectioning and characterization**
  - Point-to-point link at 100Mb/s correct even with one sectioning
  - How to be sure correct link performance without characterization I.e. to tune data-rate without putting into question qualification
    - for higher data-rate and/or for more sectioning

  ➔ Abacus of link performance vs data-rates and sections could help

Concerns identified 2/3: EMC & common modes

- **Radiated emissions**
  - Induced potential spurious in Satellite RF reception bandwidths (**UHF**, L, S bands)
  - Issues on shielding: what constraints to take into account for harness over-shielding and routing? -> Inputs for the SpaceWire community are welcome
  - Depends on network topology, data rates, grounding network quality, signals rise & fall times
- **ATMEL 10X ASIC:**
  - EMC common mode voltage susceptibility level seems not to be guaranteed by the manufacturer -> system impact on the SpW communication?
  - Alternative solution: adding of repeaters (discrete I/O interfaces) on the link to improve common mode susceptibility, impact of skew/jitter?
- **EMC common mode voltage emission level is worrying (S3 is marginal with requirements @100Mbps)**
- **Detector concern : data acquisition vs noise immunity**
  - cannot prevent data transfer during optical signal acquisition
  - There is perturbation risk on detector signal quality
  - synchronized acquisition through a parallel bus is implemented
  - Then Data transferred by SpW in dedicated electronics

Concerns identified 3/3: network design

- **Concern about actual maximum data-rate (200Mb/s)**
  - Of-the-shelf components supporting 200Mb/s as SpW-10X
  - Careful implementation required in PCB design and connection vs skew/jitter
  - What is the suitable maximum limit for a network 120, 160, 200 Mb/s ?
  - Conflicting positions from the space SpW community
    → **characterisation through end to end bread boarding including harness ?**

- **Network & routing**
  - Full duplex capability is mostly not used
    - neither for time code nor command-control
    - Except for some smart instrument configuration
  - replaced by data multiplexing through memory, with advantage to be deterministic
    - when low need of bi-directional communication (no command-control)
  - Next steps required to implement routing to take advantage of full-duplex
    - Difficult to master a network implementation
      - for deterministic aspect
      - For FDIR vs failure propagation between redundancies
  - Highest (≥200Mb/s) data-rate required to minimize latency, buffers and recovery

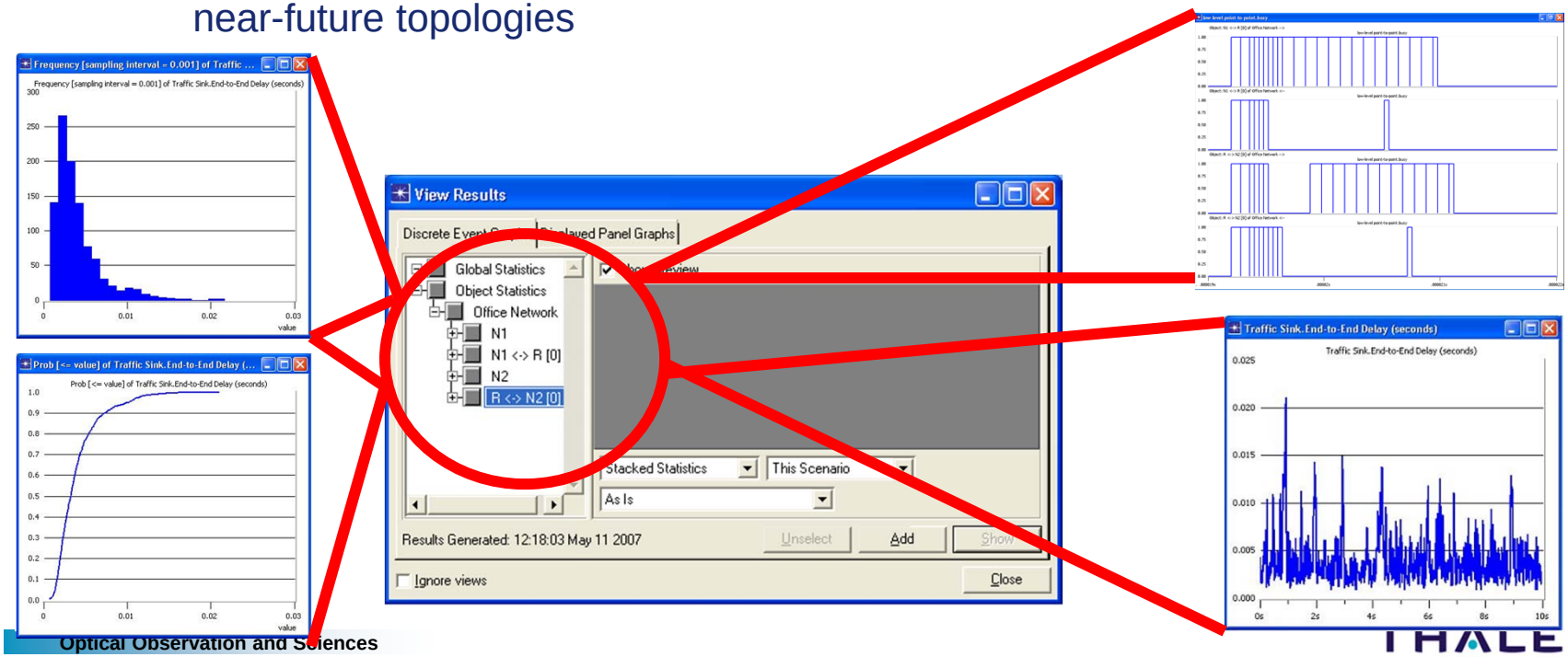
Conclusion 1/2

- **Implementing SpW with point-to-point links (without routers) allows to**
  - reduce interface complexity up to 100Mb/s
  - to separate interface management and development between contractors
  - easily build EGSE and check functional behaviour.
- **Need for some improvements**
  - Optimisation for unidirectional “low” data-rate ➔ **need for lighter harness**
  - Design effort shall also be spent to define cross-strapping
    - ➔ **Need of electrical an data-handling architecture rules**
  - Require a way to synchronize communication ➔ **Need of deterministic protocol**
  - Characterization of the actual SpW performance needed
    - For section (bracket, feed-through) ➔ **harness characterisation needed**
    - Highest link data rate, 200Mbps ? ➔ **max speed assessment needed**
    - Common mode emissivity & susceptibility, EMC ➔ **avoid late qualification of networks**
- **Mastering of network/routing for**
  - payload command/control merging with mission data distribution, bringing interface and harness optimization
  - avionics AOCS performance and extended operability
    - management of high throughput sensors – currently implemented
    - involvement of instrument’s in the AOCS control loop – currently studied

  ➔ **Need for determinism, robust FDIR and suitable process vs industrial organisation**

Conclusion 2/2

- **Need of a SpaceWire simulator to simulate the new FDIR issues, evolution of standards and new components**
  - High interest is expressed for the deterministic protocol
  - High interest is expressed for the multi-cast possibilities
- **Thales Alenia Space continues to develop the MOST simulator**
  - Simulation of current standard, current components to test, analyse & optimize near-future topologies



THANK YOU !