Operability and Modularity concepts of new generation RTU & SDIU

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REF 0005-0006898494

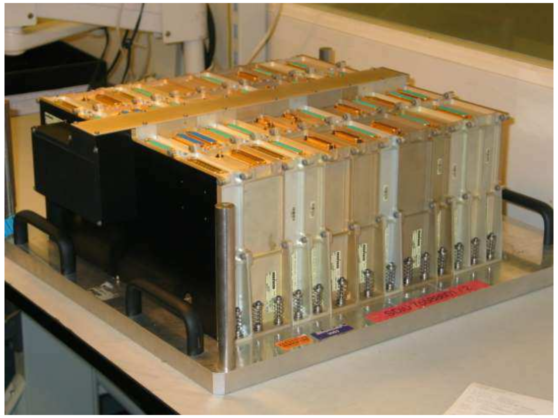
Agenda

- Context : General concepts , input for new generation of RTU /SDIU
- Design drivers : competitiveness & modularity
- Benefits of the DPC micro controller
- first return from experience on ongoing development

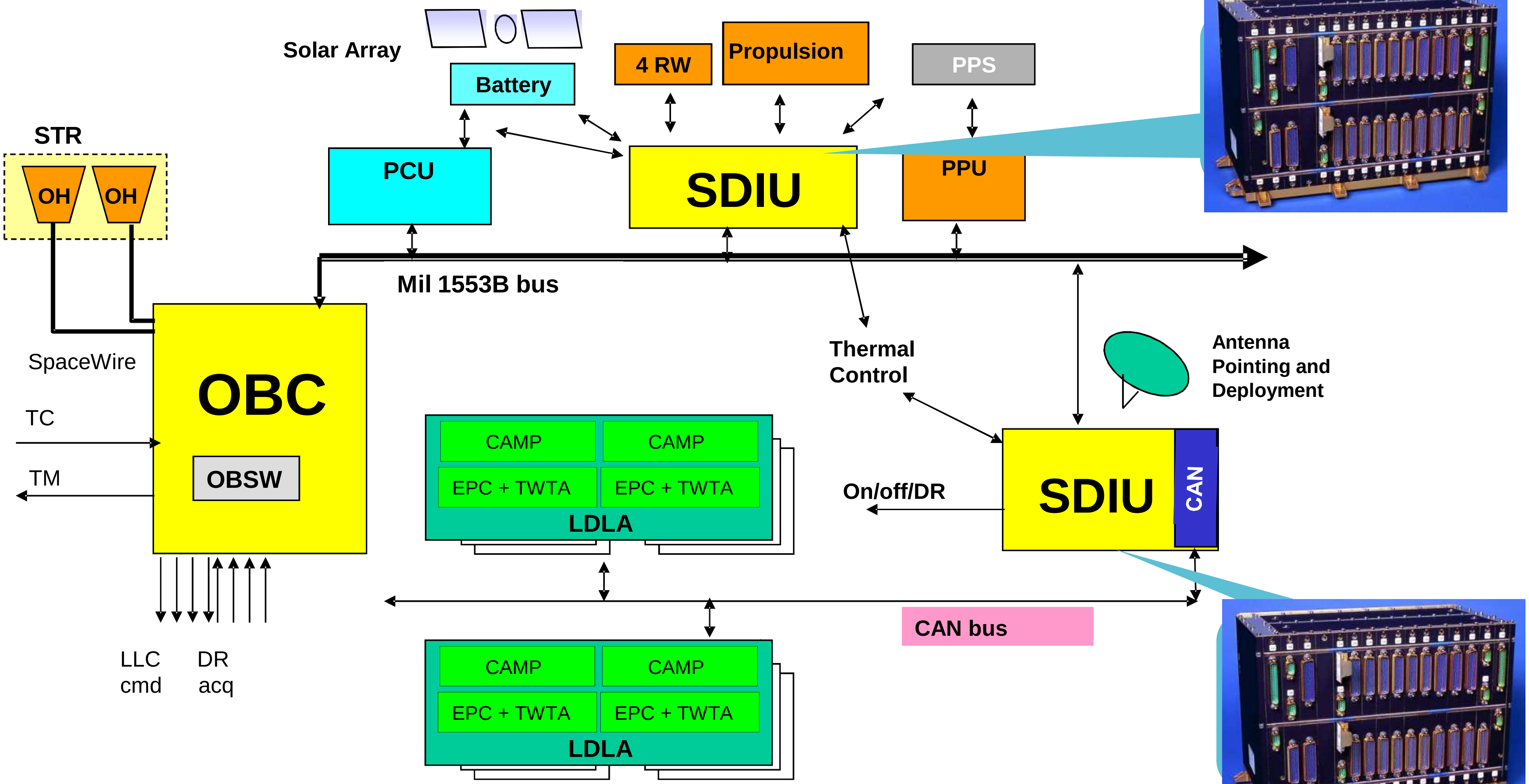
General Concepts, input for new generation of RTU /SDIU

Typical functions of RTU/SDIU are :

- Provide interface for all satellite units which do not have capability to interface directly with system data bus :
  - Distribute operational commands and data.
  - Acquire operational status and data.
- Provide interface with OBC through System Data Bus.
  - Interface Units are Remote Terminals (On Board Computer performs Bus Controller function).
- Provide redundancy, managed by central computer.
- Provide Electrical Power Distribution and Thermal Control.
  - Distribute power through fuses or current limiters.



Telecom GEO Avionics Architecture



Spacebus 4000 SDIU Return from Experience (1)

Modularity

- Platform variability is low.
  Therefore, extensive modularity for PFDIU is not a must : indeed few variations were observed over all models produced for SB4000 product line.
- The main need of PFDIU modularity is mainly induced by battery configuration.
- Modularity is essential for Payload : wide range of payloads sizing.
- PLDIU I/O budget (discrete commands and TM, thermistors and heaters, power lines) is roughly homothetic to the payload sizing (i.e. number of TWTAs).
  Therefore designing one module type per each I/O type, is not optimal.
- Implementing nominal and redundant section on the same module is efficient for cost optimization, but is not well accepted by some customers.

Spacebus 4000 SDIU Return from Experience (2)

Operability

- **Interface standardization : same coupler on each module simplifies On Board Software :**
  - **Same Low Level communication layer for each function.**
  - **Independent communication with each module type, which allows good OBSW modularity.**

- **Interface performed by CPU-less ASICs offers low local autonomy :**
  - **Communication and operation protocols (timings…) shall be fully managed by OBSW, which shall have a "bit level" knowledge of each module hardware.**
  - **OBSW development cannot be engaged before HW is fully designed.**
  - **This induces overhead over OBC CPU load and system data bus bandwidth.**
  - **A high volume of configuration parameters (several thousand…) shall be managed by OBSW, and eventually tuned for each mission.**

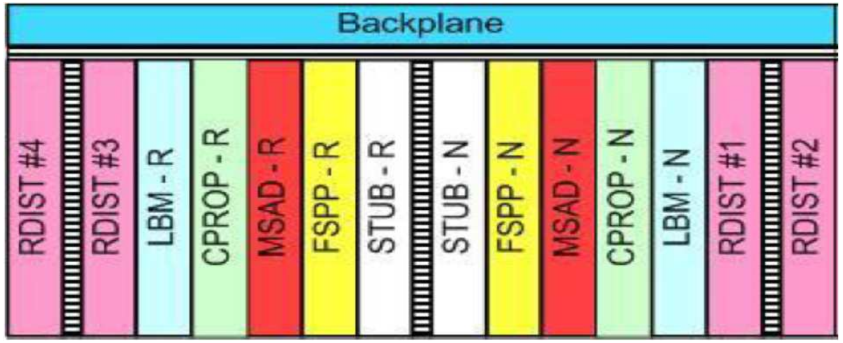
Drivers for new product : SDIU Mk2 & RTU step 2

Driver n° 1 = competitiveness : decrease both non-recurring and recurring costs

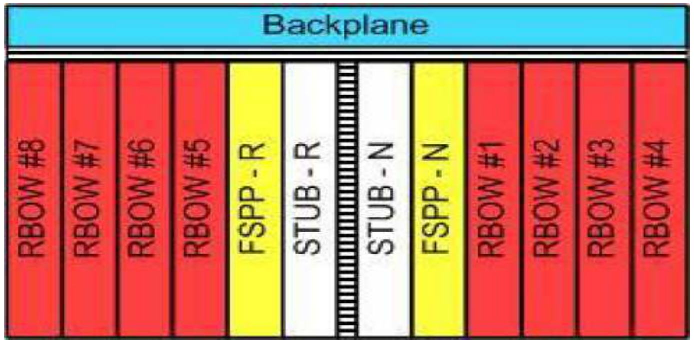
- Offer modularity only if useful, in line with spacecraft product line needs.
- Rationalization of the cost of EEE parts : decrease the number of ASICs and hybrids types
- Offer high level interface to On Board Software : less registers and timings to manage, less configuration parameters to handle.
- Capability to better adapt PLDIU configurations to Payload sizes, optimizing I/O margins.
- Offer industry standard CAN bus interface for new Telecom Payload units.
- Customer satisfaction : perform physical segregation between nominal and redundant parts.

Modularity : SDIU Mark2 concept

- **Objective = minimize the quantity of different module types to take profit of the production volume and optimize resources to interface payload**
- **7 module types (instead of 14 in the previous design) are defined to cover Platform and Payload needs :**



PFDIU

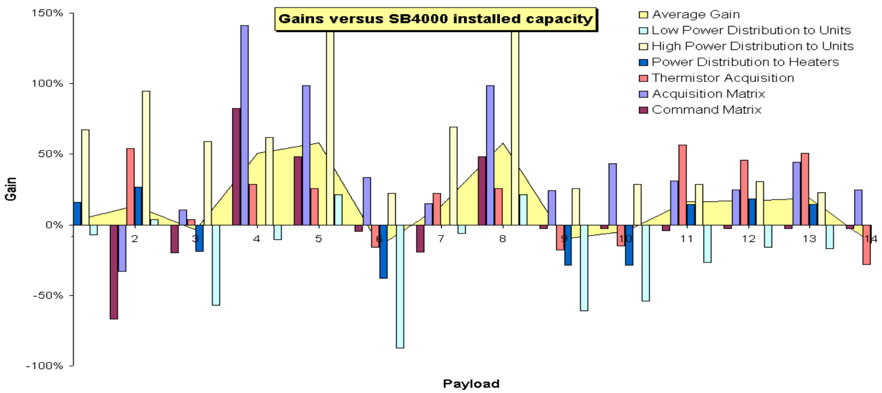


PLDIU

Optimization of payload I/O margins

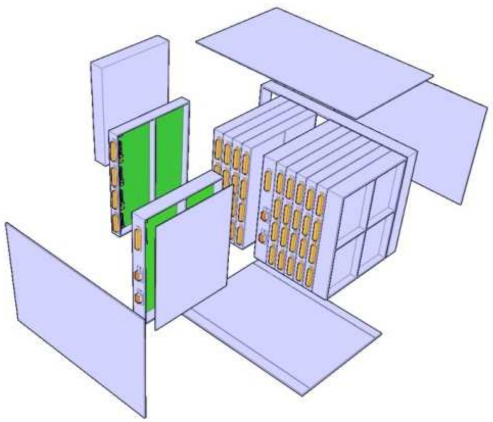
- **On a telecom spacecraft, allocation of I/O shall be proportional :**
  - To the number of TWTA : power lines, thermistors and heaters lines, switches commands and status
  - To the number of antennas : motors commanding, deployment pyro lines.

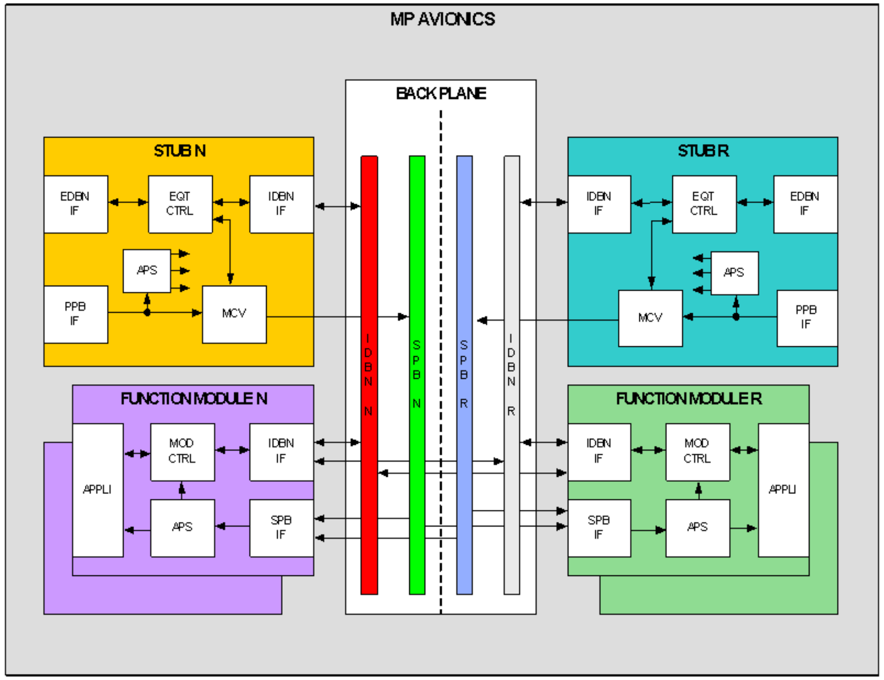
- **Therefore it is more efficient to design I/O module type gathering a subset of those interfaces.**
  - With relevant distribution.
- **PLDIU will embed the relevant number of modules.**
  - Proportional to mission requirements



RTU Step 2 : Modularity concept

- **Architecture concept inherited from SDIU mk2, adapted to the needs of LEO/MEO programs**
  - Re-use SDIU Mk2 building blocks : DPC & hybrids, OBSW drivers.
  - Standardization of internal data bus, based on re-use of SDIU CAN standard.
  - Same mechanical concept.





Generic RTU / SDIU architecture

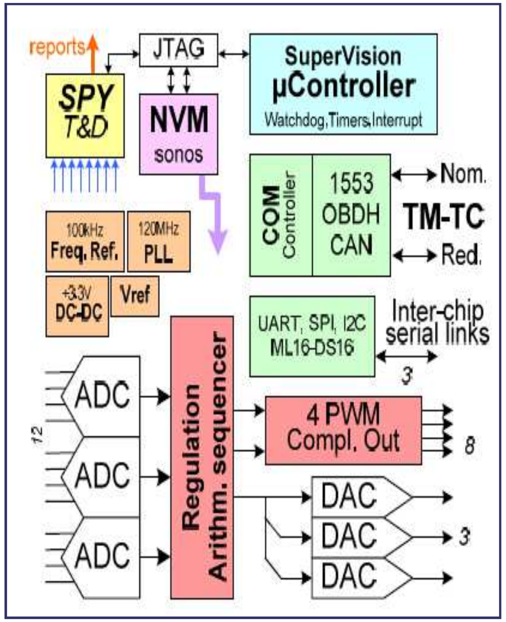
Building Block : Extensive use of standard micro-controller

Change of paradigm : “Think Numeric”

- Replace most ASICs and Hybrid circuits by one type of mixed ASIC, embedding local Micro-Controller : DPC Digital Programmable Controller.

Deployment of DPC on all modules

- Replace most ASICs and Hybrid circuits by one type of mixed ASIC.
- Only one ASIC type (= DPC) inside whole SDIU MK2 instead of 5 previously.

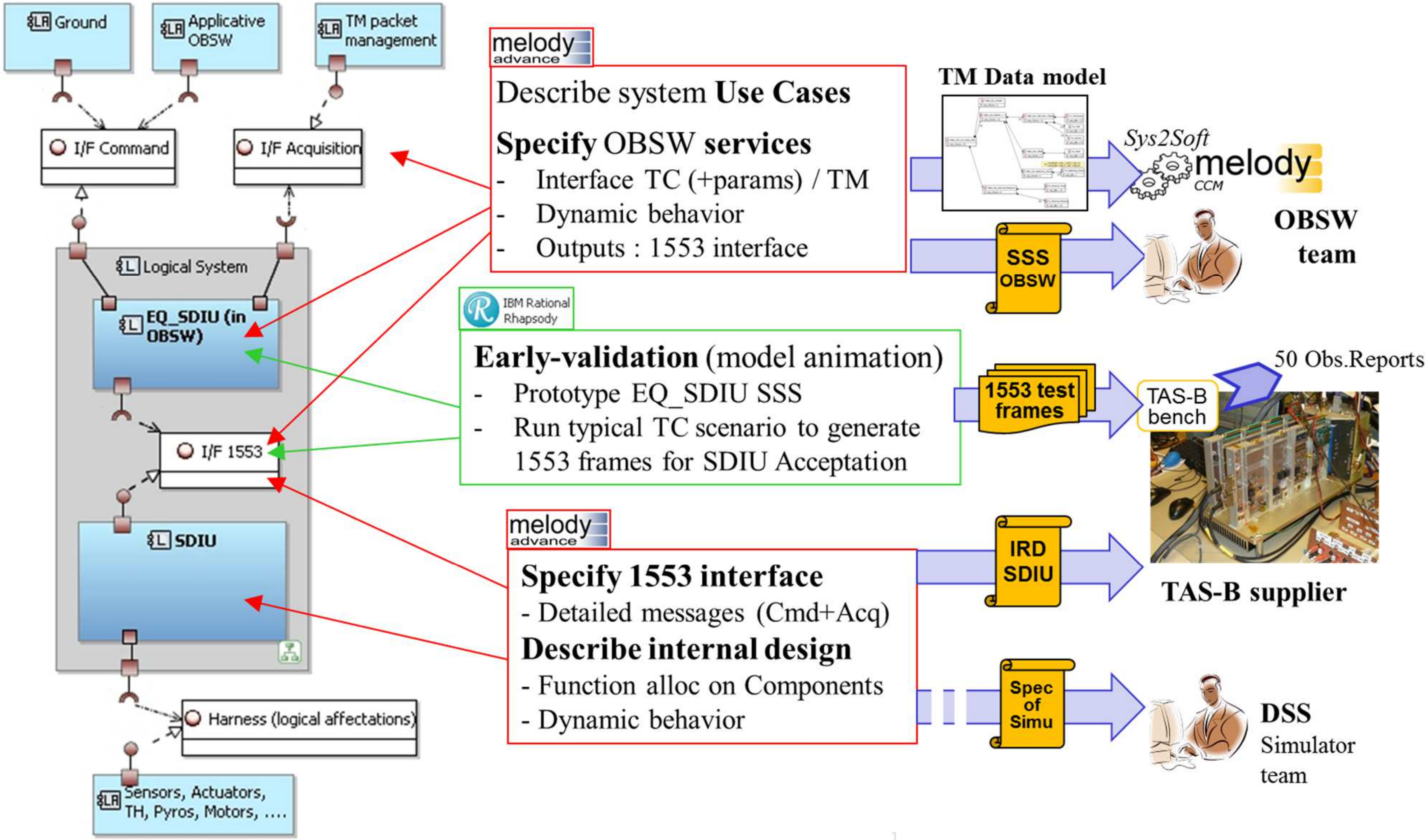


Building Block : Extensive use of standard micro-controller

Flexibility for Concurrent Avionics development :

- **Collaborative work between prime and supplier to define interface with OBSW.**
  - This process is supported by MBSE approach.
- **Co-Engineering : OBSW specification / development and SDIU specification/development, in parallel.**
  - Use of micro-controller based design, offers relevant flexibility, which could not be possible with pure HW development approach.
- **ISVV - Independent Software Validation : Avionics team is able to define very early detailed test scenarios, used by unit supplier for testing.**
  - Several errors detected and corrected during firmware development, before unit integration to Avionics Test bench.

Concurrent Development Process



Conclusion

Extensive use of DPC : first Return of Experience

Advantages of Deployment of DPC on RTU & SDIU modules

Gain of Flexibility :

- For example, with the same board/hardware, some outputs can be used to provide pulse commands to a Latch Valve, or permanent commands to Thruster Valve.

Reduction of Spacecraft Data Base Volume and easier management :

- Calibration data of high accuracy acquisitions chains (battery cells voltages) are no more managed by OBSW, but directly aboard the module (managed by a DPC) in charge of those acquisitions.
- If the concerned board needs to be replaced by a new one (in case of failure) before the launch, there is not any impact on Spacecraft Data Base nor OBSW.

Standardization of Engineering and OBSW process & tools.

Thank you for your attention !