The SAVOIR Functional Reference Architecture

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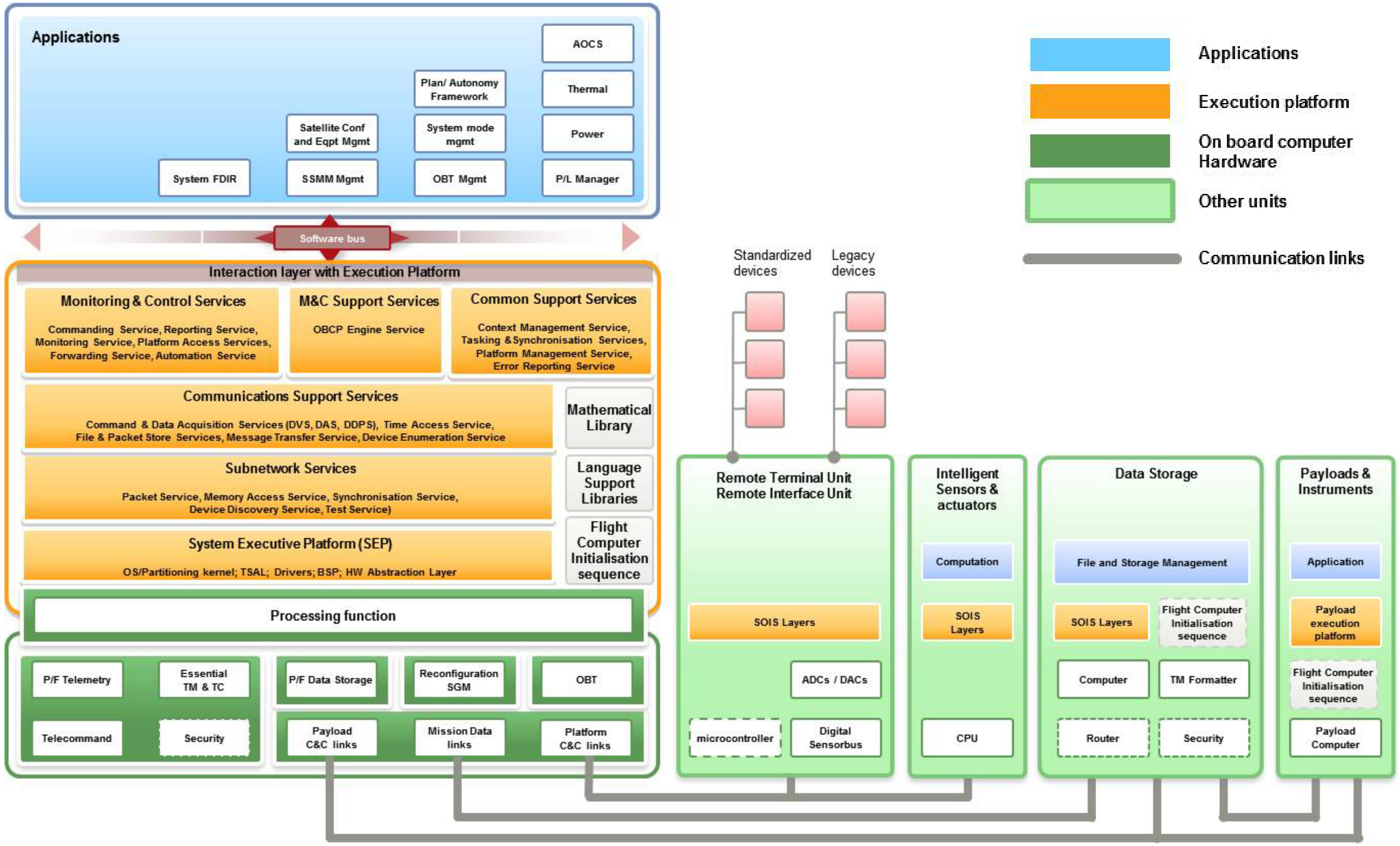
Overview of presentation

- Overview of SAVOIR Functional Reference Architecture (FRA)
- Functions in SAVOIR Functional Reference Architecture
- Mapping of SAVOIR FRA on hardware blocks
- Data handling systems in CubeSats
- Mapping of SAVOIR functions on CubeSat architectures
- Benefits of standardisation
- Concepts, ideas, proposals

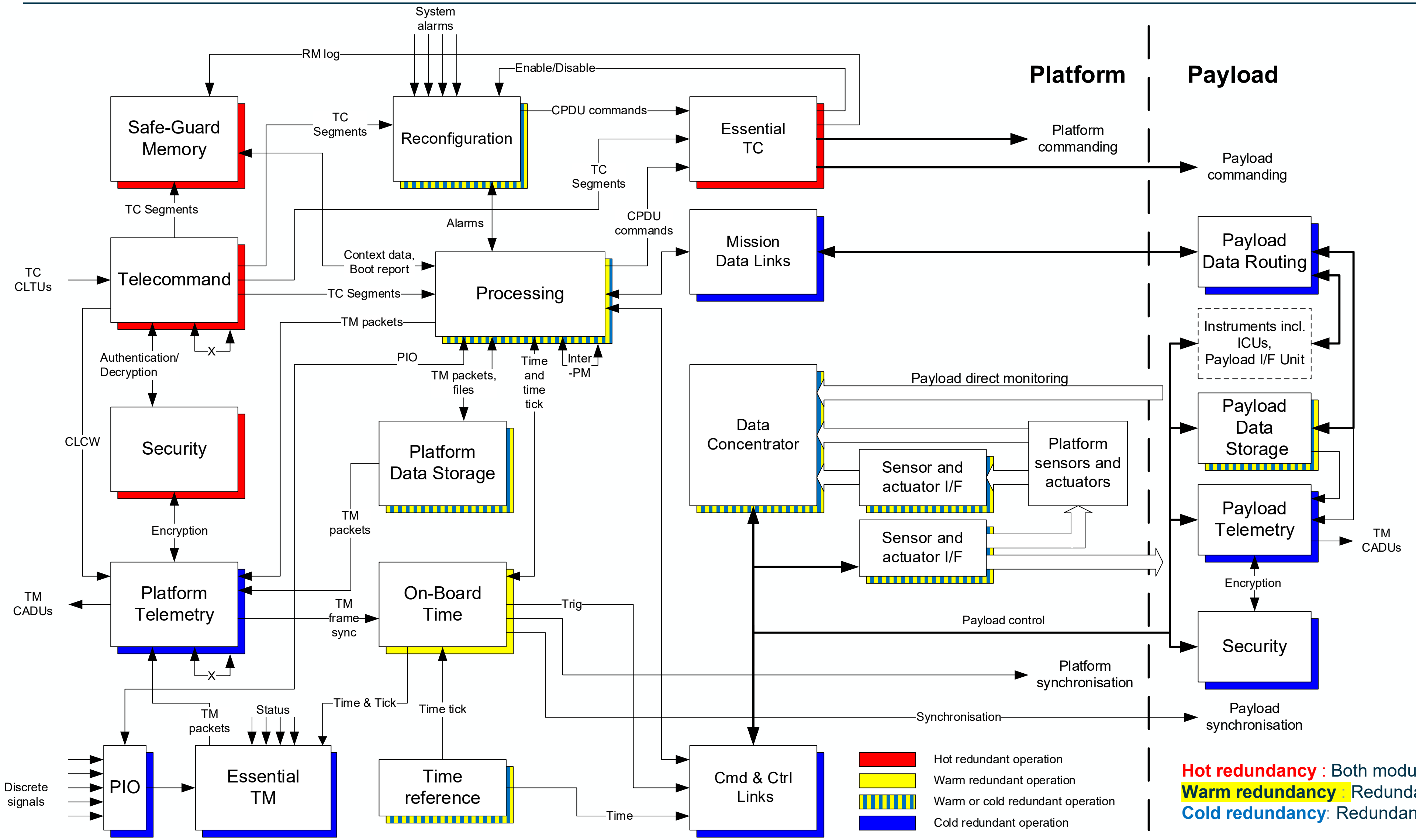
SAVOIR
space avionics open interface architecture

SAVOIR Functional Reference Architecture (FRA)

- Architecture is generic and configurable enough to meet performance and architecture needs of most European missions.
- Focuses on platform units. Payloads and instruments are considered “external functions”.
- Decentralised I/O architecture (use of RTUs)
- SW architecture (Execution Platform, and Applications) are covered by the SAVOIR OSRA documentation



SAVOIR Functional Reference Architecture (FRA)



SAVOIR FRA – Platform Functions

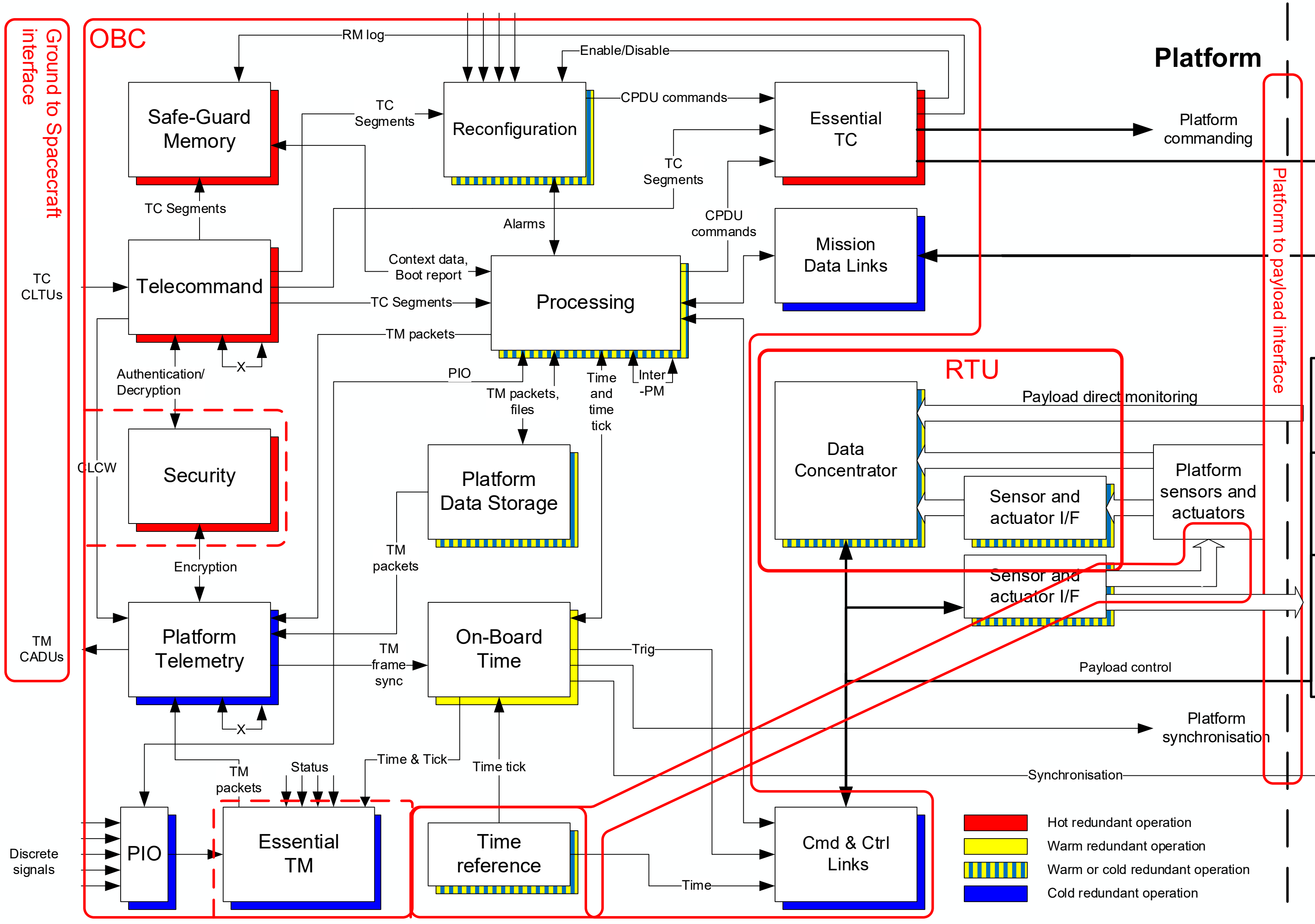
- Processing Module (PM)
- Telecommand (TC)
- Telemetry (TM)
- Essential TC
- Essential TM
- Security (optional)
- Reconfiguration (RM)
- P/F Data Storage (PFDS)
- On-Board Time (OBT)
- Time Reference (GNSS)
- Data Concentrator
- Sensors & Actuators
- Sensors & Actuators I/Fs
- Mission Data Links
- Cmd & Ctrl Links

Payload functions (informative):

- Payload Data Routing
- Instruments (Payloads), ICUs, P/L I/Fs
- P/L Data Storage (Optional)
- Payload TM (Optional)
- Payload Security (Optional)

Hot redundancy : Both modules powered-on and active
Warm redundancy : Redundant module can be powered-on, but on stand-by/ inactive
Cold redundancy: Redundant module powered-off.

SAVOIR FRA – Mapping on HW blocks



Mapping of SAVOIR functions within typical hardware building blocks:

- On-Board Computer (**OBC**)
  (Security and ETM optional)
- Remote Terminal Unit (**RTU**)
  Limits impact of avionics variability wrt the OBC I/O interfaces, by concentrating the many avionics interfaces toward a single communication bus with the OBC
- Time Reference **(GNSS)**
  Provides PPS, but is also a Position & Velocity sensor
- Ground-to-Spacecraft Interfaces
  (S-band, X-band, Ka-band transponders)
- Platform to payload interfaces
  High data rate links, and lower data rate Cmd & Ctrl links

Hot redundancy : Both modules powered-on and active
Warm redundancy : Redundant module can be powered-on, but on stand-by/ inactive
Cold redundancy: Redundant module powered-off.

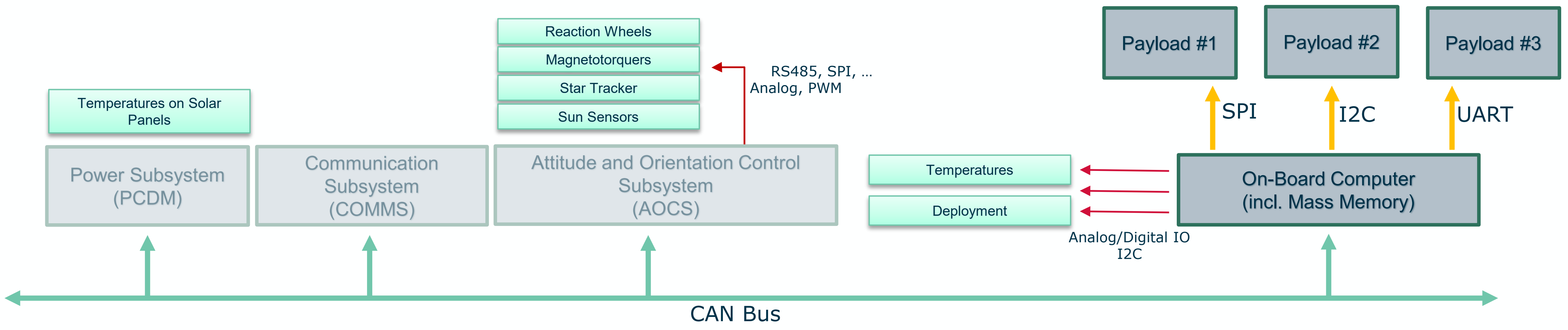
Data Handling System in CubeSats (1/2)

In CubeSats, the Data Handling Subsystem looks similar to this ("good practice" example):

- On-Board Computer (OBC): single PC104 board
- Platform and Payload Mass Memory: included in OBC board (Flash chip, eMMC, MRAM, SD Card,…)
- Remote Terminal Unit (RTU) is rather dispersed (temperature/voltage sensors , separation sensors, actuators)
- Buses and Interfaces: CAN Bus is most commonly used, also I^2C
- Payloads with various interfaces to OBC (SPI, I^2C, UART, RS-422,…)

Following figure illustrates "good practice" example for a CubeSat DHS architecture.

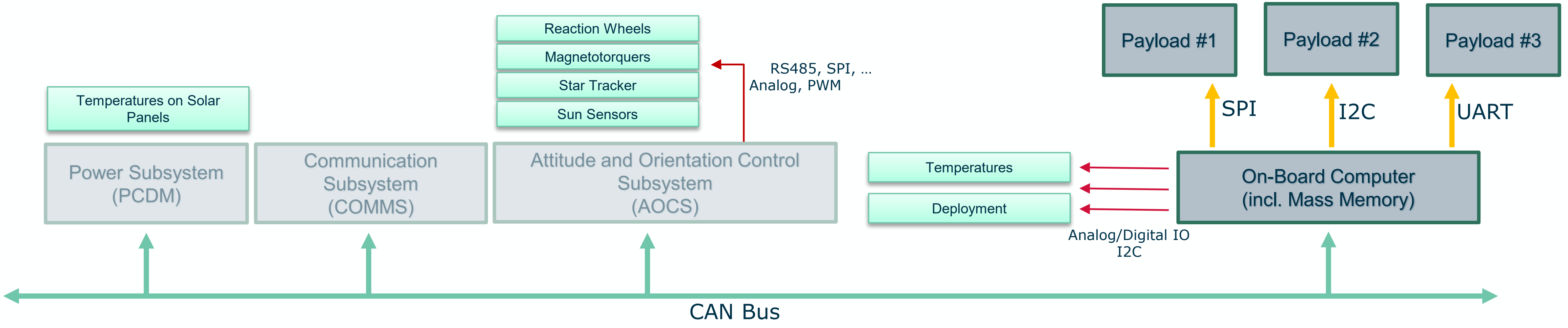
- (most) SAVOIR functions can be implemented with this architecture, based on CAN and CSP (CubeSat Space Protocol)



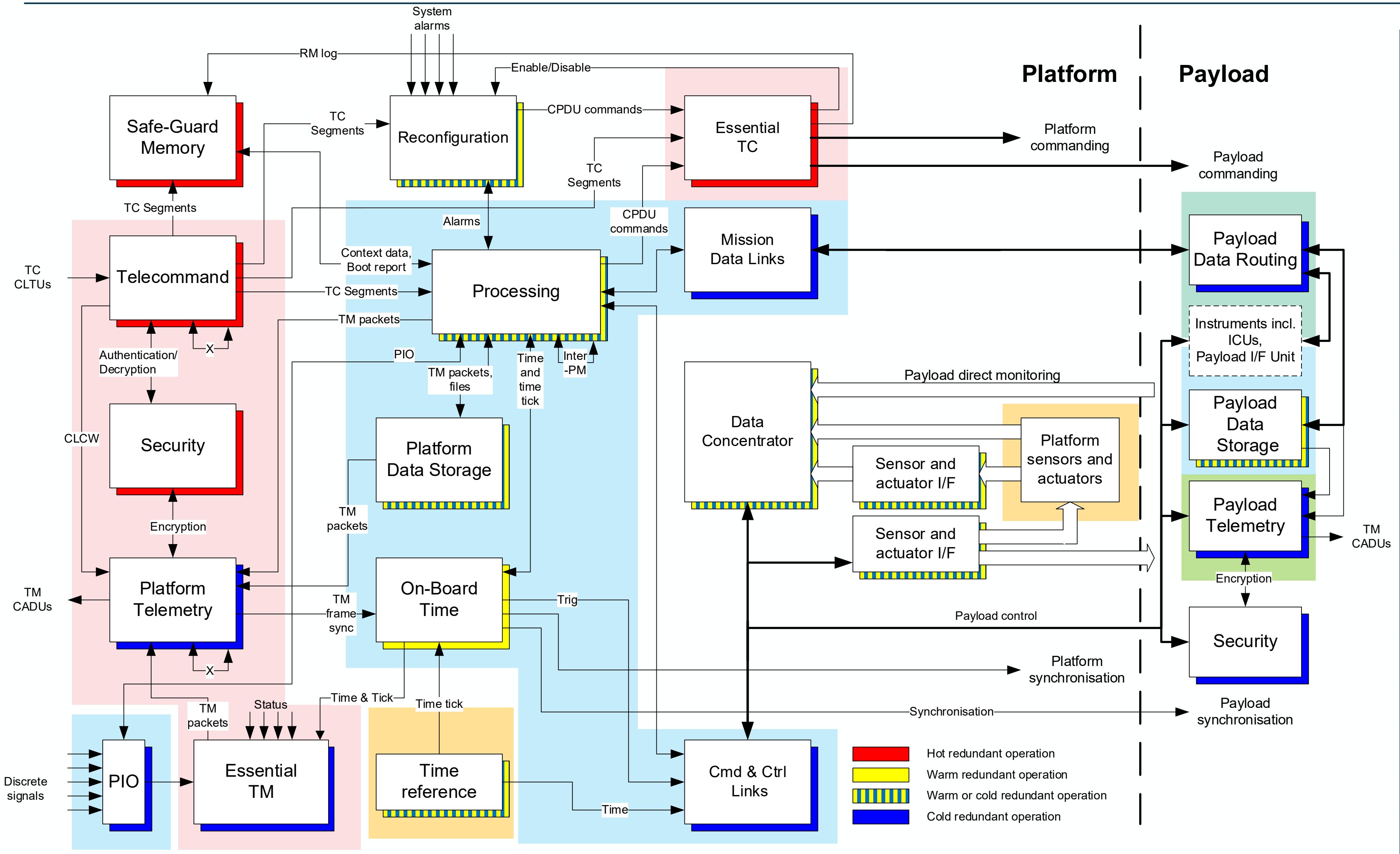
Data Handling System in Cubesats (2/2)

Few points to give context of SAVOIR in CubeSat world:

- Redundancies, and therefore cross-strapping, are not common on CubeSats.
- CAN Bus across all platform subsystems allows inter-communication (everyone can talk to everyone).
- Common protocol (CSP – CubeSat Space Protocol) allows access to all sub-systems as it would be on one network.
- Implementation of DH functions on CubeSat might fall into different subsystems.



Mapping of SAVOIR functions to Cubesats



CubeSat	SAVOIR
OBC/Processing Module	○ Processing ○ Platform Data Storage ○ Payload Data Storage ○ On-board Time ○ Mission Data Links ○ Cmd & Ctrl Links ○ (Optional) Payload processing ○ Parallel I/O
COMMS	○ Telecommand ○ Platform Telemetry ○ Essential TC/Essential TM (by direct CAN connection to modules) ○ Security (optional, for TC authentication/decryption)
Power Conditioning and Distribution Module (PCDM)	○ Power control & distribution ○ Reconfiguration (limited. Can power cycle modules via CAN bus) ○ Parallel I/O (if MCU present)
AOCS Incl. GPS module	○ Time reference ○ Position and velocity sensor ○ AOCS sensors and actuators
Payload TM (optional)	Payload Telemetry
-	Payload Security
(Distributed function)	Data Concentrator (RTU)
-	Sensor & actuator I/F
(Partial, in COMMS and PCDM)	Reconfiguration
-	Safe Guard Memory

Benefits of standardization

1. Streamline the design and development of avionics modules, units and systems
2. Reduce integration and assembly times (shorter “time to flight”)
3. Facilitate and possibly even accelerate the verification of these elements
4. Reduce costs and effort for design and verification cycles, also by design reuse
5. Improve quality, via adoption and use of engineering and QA standards
6. Increase competition and competitiveness
7. Facilitate cooperation and interoperability

Concepts, ideas, proposals

- Reliability requirements of future CubeSat (NanoSat) / MicroSat missions may increase.
  - CubeSats will be used for Moon and Mars missions, as companions to other satellites (e.g. HERA), etc

- Consider adopting methods for increasing reliability to meet (future) mission requirements, as (if/when) needed:
  - FDIR concepts (Fault Detection, Isolation and Recovery)
  - Fault tolerance measures

    Mitigation of radiation induced SEE: SEUs (memories, FPGAs), SEFI (SDRAM), SEL (CMOS devices)
    - Memories: EDAC/ECC (SEC/DED, R-S, CRC), scrubbing
    - FPGA logic: TMR
    - Software: Watchdogs, lock-stepping, duplicate-and-compare
    - Hardware: current monitoring, latchup-up protection;
  - Use of redundancy
    - Duplication of modules, links

Concepts, ideas, proposals

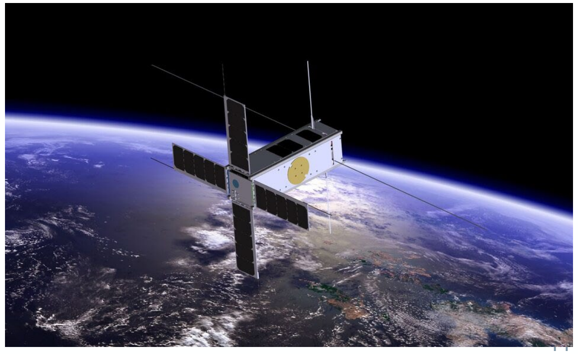
- Consider use of ESA COTS guidelines (public release of doc – coming soon!)

- Benefit from adopting concepts from SAVOIR and other standardisation initiatives

  Consider adoption of (or at least, consult) guidelines and requirements from SAVOIR specifications, ECSS and CCSDS standards, for both engineering (HW, SW) and quality assurance. Indicatively:

  - ECSS-E-ST-10-03C Rev.1 – Testing
  - ECSS-M-ST-80C – Risk management
  - ECSS-E-ST-10-06C – Technical requirements specification
  - ECSS-Q-HB-60-02A – Techniques for radiation effects mitigation in ASICs and FPGAs handbook
  - ECSS-Q-ST-60-13C Rev.1 – Commercial electrical, electronic and electromechanical (EEE) components

- Standardisation of communication protocols
  - Preference for CAN bus + Cubesat Space Protocol (CSP)



Thank you for your attention!

Feedback:

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