SAVOIR

space avionics open interface architecture

OBC and RTU Generic Specifications Status

Avionics System Reference Architecture (ASRA), ESA contract

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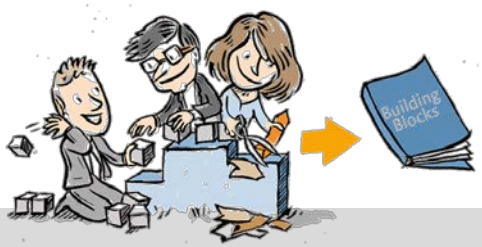
ESA-ESTEC TEC-EDD

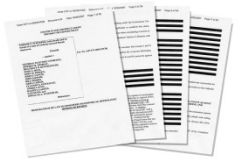


SAVOIR mission

- Improve the way we deliver Space Systems (risk & schedule, and therefore cost, and industry competitiveness) by

An *agreed* Reference Architecture

Functional Specifications (OBC, RTU, …)



Pre-developed / to be developed Building Blocks

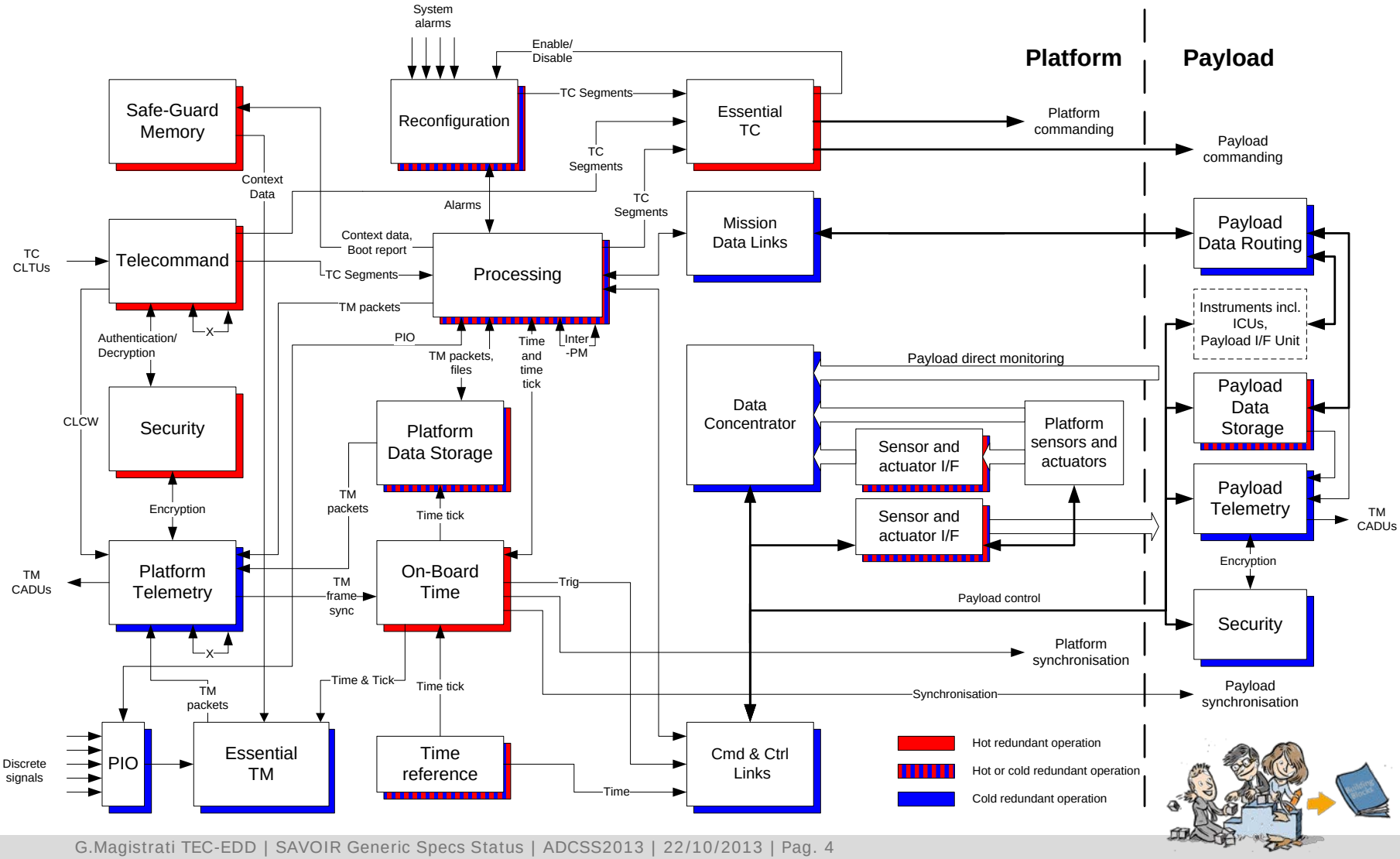
Standardized Interfaces

- If, in ITTs, Customers use *agreed* mission specification and System Integrators use *agreed* product specification, then Suppliers should be in a position to have product lines, and System Integrators should have easier integration phases

Mission domains considered

- Science and Earth Observation missions with up to 12 years duration to:
  - LEO
  - GEO
  - Lagrange points
  - Interplanetary space
- Telecom missions with up to 15 years lifetime
- The excluded missions are:
  - Manned missions
  - Launchers
- There is however nothing that prevents the Savoir concept and “products” from being used in these missions if the special needs can be somehow fulfilled.

Reference Functional Architecture



Objectives of the ASRA contract

- The aim of ASRA (Avionics System Reference Architecture, ESA contract) is to define an avionics reference architecture meeting the needs of the various mission domains. Commonality between the solutions recommended for each domain will be maximised whenever possible.
- First work package scope was to agree on a common functional architecture and outline the main functions per functional block. **Functional Reference Architecture** (presented at ADCSS2011)
- Four subsequent work packages for generating:
    1. Ground to Space interfacing, general recommendations
    2. **Generic OBC specification (presented at ADCSS2012)**
    3. **Generic RTU specification**
    4. Platform/Payload interfacing, general recommendations
- Documents 2. and 3. reviewed by ESA and SAG industries
- Update of Functional architecture, OBC Spec and RTU operability

ASRA documents - schedule

- May 2012: OBC and RTU Generic Spec delivery by SAG industries together with ASRA Functional Specification
- June –September 2012: ESA review (projects involved !!!)
- Oct 2012-January 2013 : ESA-SAG industries meetings on provided comments
- June 2013 - SAG mtg: The following decisions has been taken:
  - SAG industries to update the (1)) **Functional Reference Architecture** and the (2))**OBC Generic Specification**
  - ESA to write a doc specifying the (3)) **operability requirements** for a RTU
- Sept 2013 – SAG Meeting: A dedicated contract [follow on of ASRA contract] will cover the SAG industries costs for the updating of the documents (1) and 2)), SAG industries to comment/integrate the (3)) **RTU Operability requirements**
- End of the Year 2013 - 1Q2014 Updated issues of the three documents
- Nov 2013 ESA internal meeting to discuss the possibility to publish the three specs as ECSS docs

Produced Documents

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DOCUMENT

SAVOIR Functional Reference Architecture

SAVOIR
space avionics open interface architecture

Prepared by	ASRA project team
Reference	TEC-SW/11-477/JLT
Issue	3
Revision	0
Date of Issue	11/05/2012
Status	
Document Type	
Distribution	

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DOCUMENT

SAVOIR RTU – Operability Requirements

SAVOIR
space avionics open interface architecture

Prepared by	G.Magistrati
Reference	TEC-EDD/2013.11/GM
Issue	1
Revision	0
Date of Issue	07/08/2013
Status	Draft
Document Type	TN
Distribution	

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DOCUMENT

SAVOIR generic OBC specification

SAVOIR
space avionics open interface architecture

Prepared by	ASRA project team
Reference	TEC-SW/12-536/JLT
Issue	4
Revision	0
Date of Issue	11/05/2012
Status	
Document Type	
Distribution	

European Space Agency
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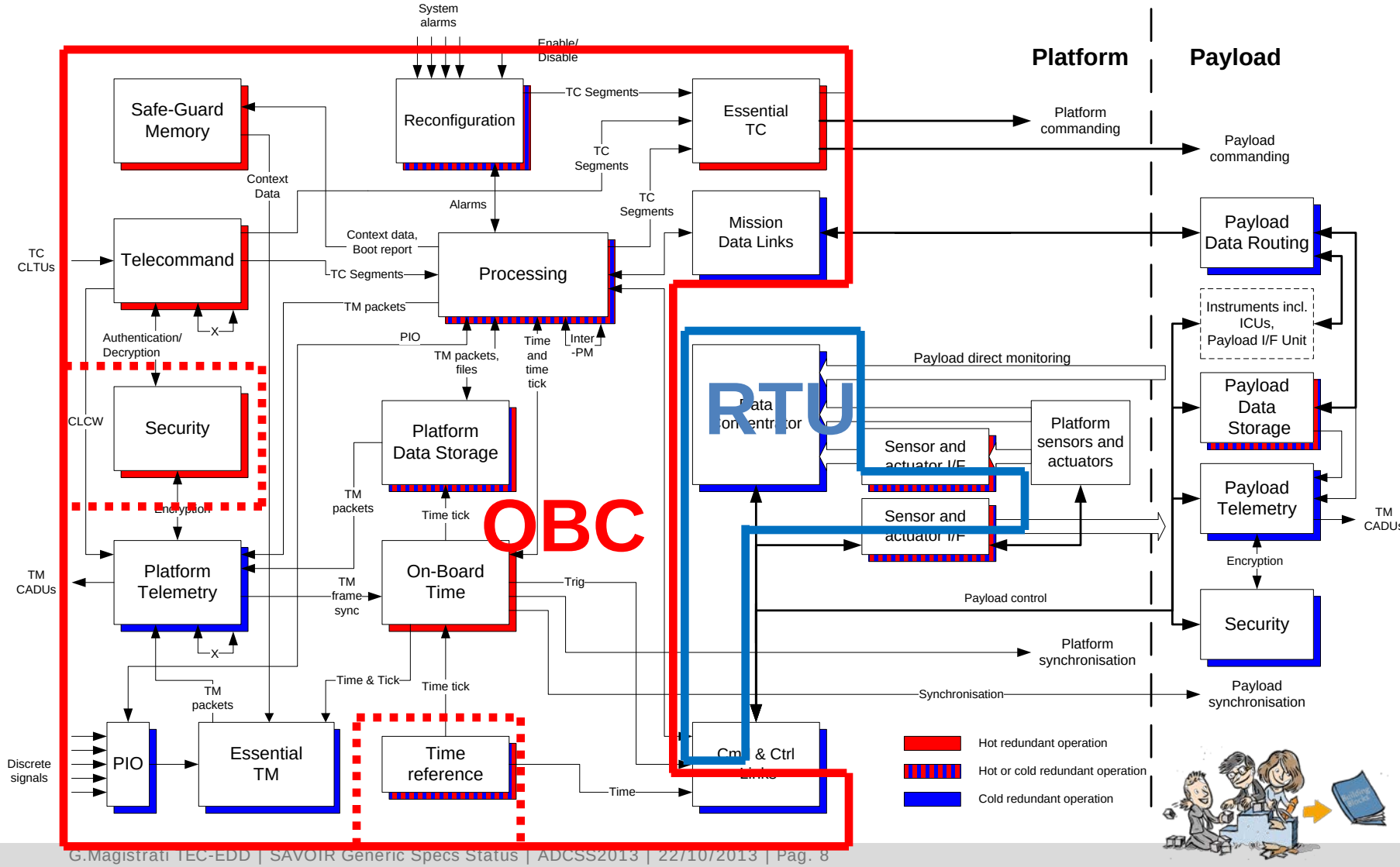
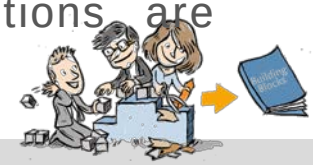
Avionics functions mapped on units



OBC Generic Specification

- OBC Spec TOC:
  - **Functional Requirements**
    - Telecommand reception, authentication, decoding and handling.
    - Telemetry Transfer Frame generation, coding and modulation.
    - Processing capability
    - Timing and Synchronisation management.
    - Platform Data Storage
    - Fault Detection Isolation and Recovery (FDIR): Reconfiguration Module (RM), Essential TC function , and a Safeguard Memory (SGM)
    - Security Function (optional)
    - Essential TM (optional)
  - **Interface Requirements**
  - Section with a list of suggested **CDMS/CDMU** (and a list of non desiderata !!!) **requirements for System Requirement Docs**

Important: Modular Structure [parameters ranges , options are present !]



Interface requirements in the OBC generic specification

- There are interface requirements in the OBC spec:
  - **Requirement Number : SAVOIR.OBC.TC.90**

TC Decoder input electrical characteristics.

The electrical characteristics of the TC Decoder inputs shall be of Serial Digital Interface (SDI) type.

(Note SDI ANSI/TIA/EIA-422 is defined in section 8.8 of ECSS-ST-50-14C)

6.9.1 Mission Data Link Function - PM

- ***Requirement Number : SAVOIR.OBC.MDL.10***

No of Processing SpaceWire link interfaces

- *The OBC shall provide at least four external SpaceWire link interfaces operated two and two in cold redundancy.*
- *Requirement Rationale : Allows connection to a redundant Payload Data Routing*

FDIR requirements in the OBC generic spec

Several requirements address FDIR in term of architecture, redundancy and X-strapping, examples:

- **Requirement Number : SAVOIR.OBC.RM.30**

RM Task

The RM shall handle FDIR level 3 and level 4 failures by monitoring alarms from the processing unit as well as a number of system alarms.

Level 3 is defined as software independent monitoring of the software and processor (OBC internal) .

Level 4 is defined as software independent monitoring of critical/vital system functions (external to the OBC)

- **Requirement Number : SAVOIR.OBC.RM.70**

RM Configuration Interface

Each RM shall have a communication path to the Active PM.

Requirement Rationale : This link is used to configure and read the status of the RM

Design requirements in the OBC generic specification

- There are also design requirements in the OBC spec:
  - **Requirement Number : SAVOIR.OBC.TC.100**

    TC Decoder input configuration

    Each TC Decoder shall receive serial telecommand data on three inputs, of which one is dedicated to the EGSE. There shall not be any internal cross-strapping between the two TC Decoders.
  - ***Requirement Number : SAVOIR.OBC.PM.480***

    Software Storage Memory write protection status in Essential TM

    The write protection status of the Software Storage Memory of both PMs shall be available to the Essential TM

    OptionInfo : Option HPTM=Yes
  - ***Requirement Number : SAVOIR.OBC.PM.485 Data Integrity***

    The existence of transmission error protection mechanisms shall be demonstrated for critical links inside the OBC

    (e.g. inter processor and inter modules, in particular for the TM/TC channels)

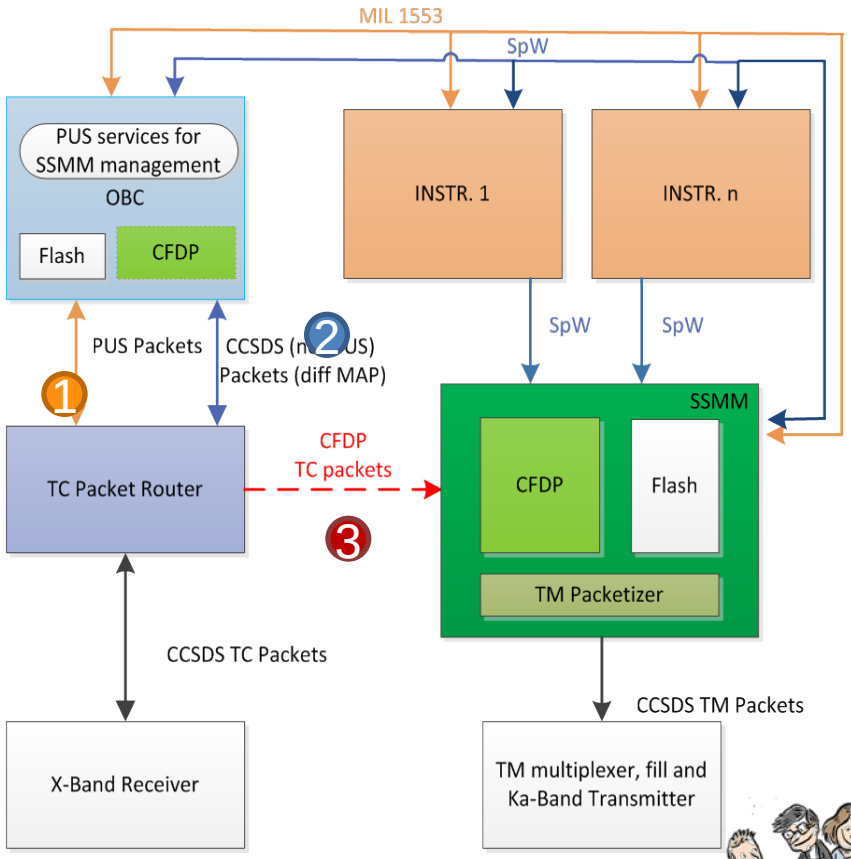
SAVOIR Functional Reference Architecture is evolving !

- The SAVOIR Functional Reference Architecture and the OBC and RTU generic spec are in continuous evolution
- At the ADCSS2012 day on Mass Memories for Payload applications and file based operations the CCSDS File Delivery Protocol (CFDP, www.ccsds.org) has been presented and discussed as solution for future Mass Memories.
- CFDP provides the capability to transfer ‘files’ and the associated ‘Meta data’ to and from a spacecraft mass memory [note: the content of the files may be anything: timeline update, ASW image or a SAR image]
- Transmission of massive amount of data on K-band with high data rate and need of retransmission capability can found in CFDP a solution covered by an international standard
- CFDP is baseline in Euclid and in Juice

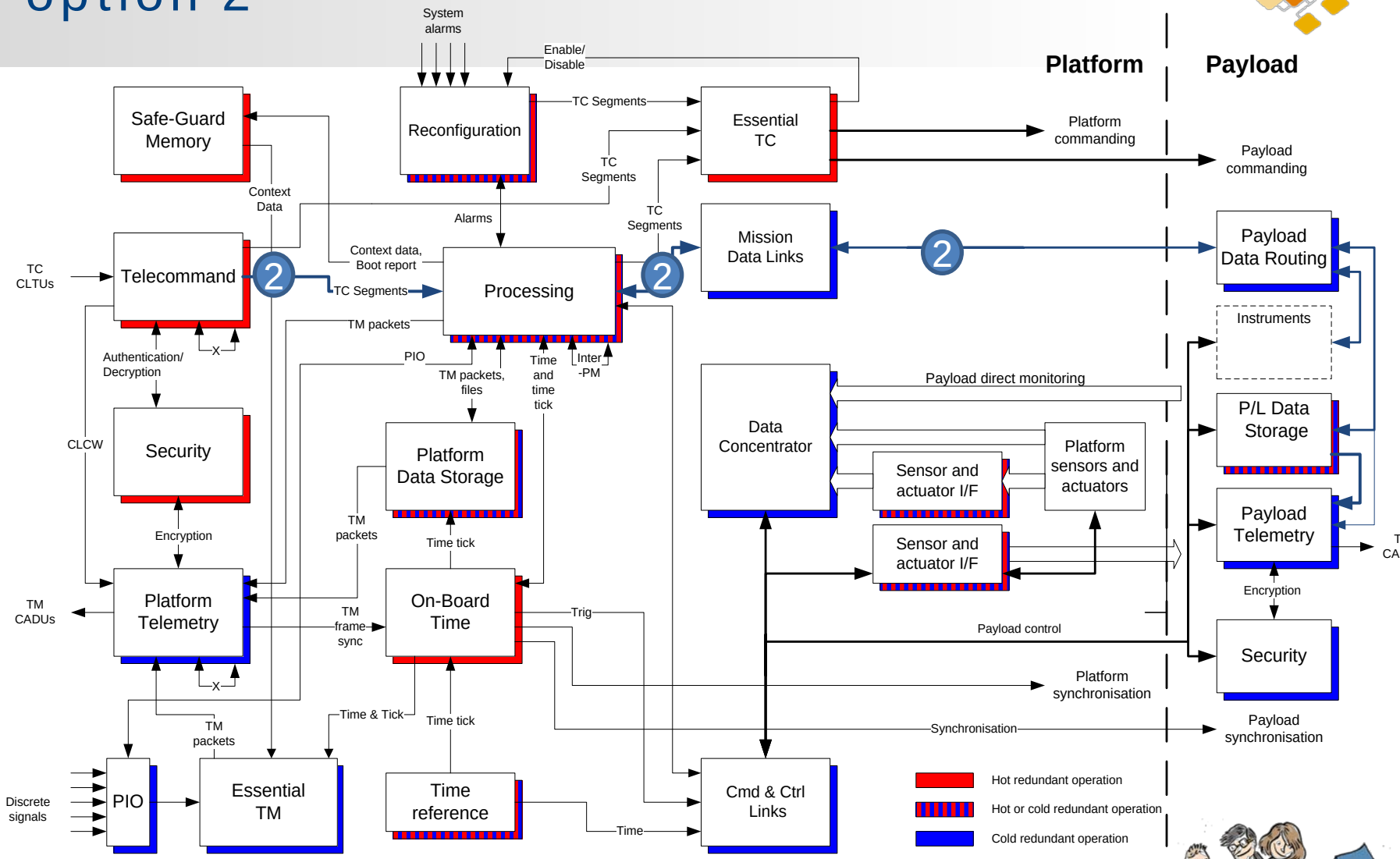
ADCSS2012 day-3 – SSMM, OBC and CFDP

Various possible options for a CFPD implementation on board have been presented:

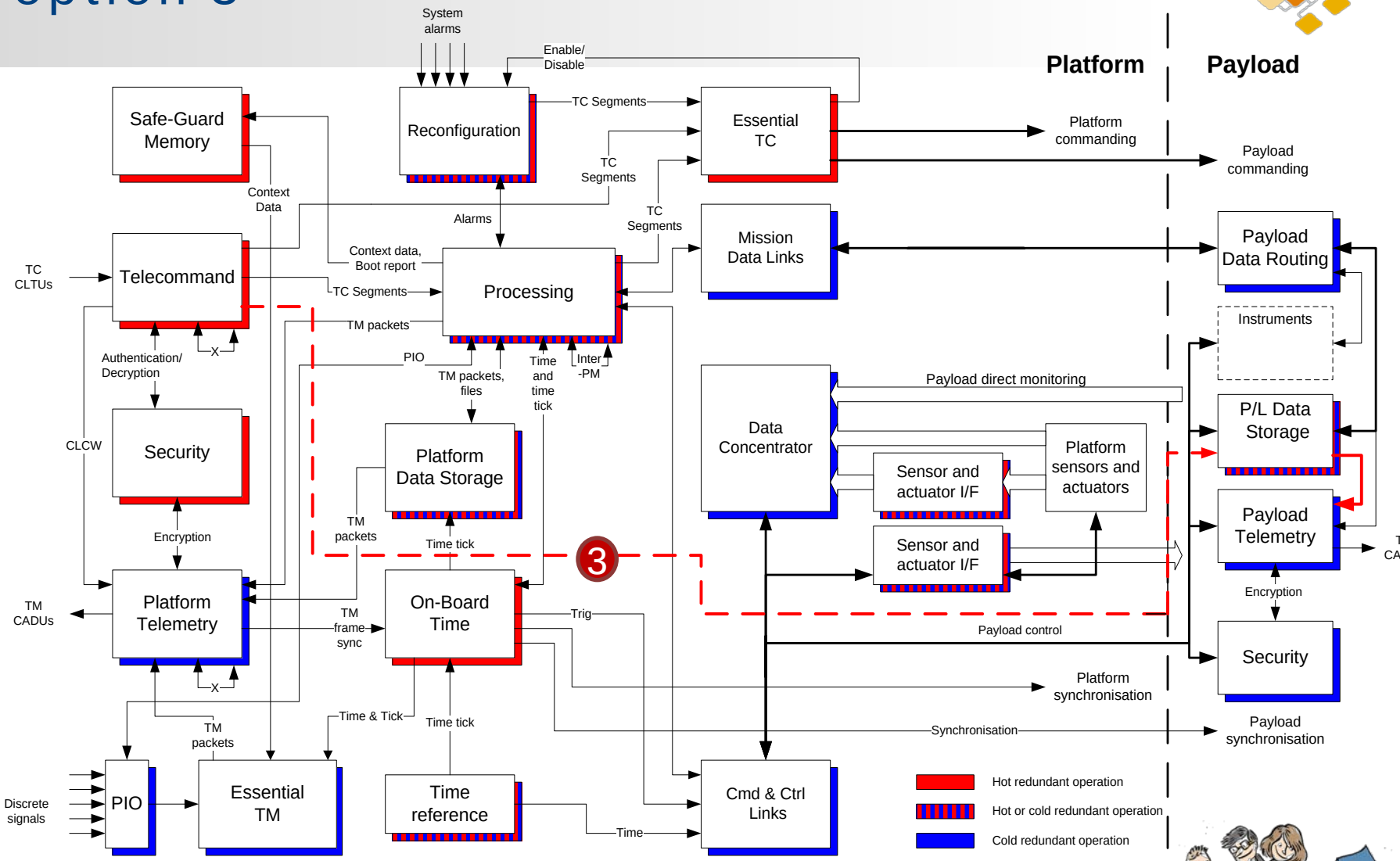
- CFDP entity is located in the SSMM (for P/L data) but could also be located in the OBC MM (ASW image,…)
- Direct link from the SSMM to the Transponder (X, Ka band)
- CFDP Metadata (CCSDS packet) for CFDP transactions to/from SSMM are routed directly to SSMM (3) or passed via the OBC (2), see next slides
- In some on-going project (Bepi Colombo) implementation of large data transfer are using PUS packet (1)



CFDP Metadata sent through the OBC option 2



CFDP Metadata sent directly to the SSMM option 3



Specs derived from the SAVOIR OBC Spec

- Critical SW and RUAG are involved in the activity "**Reference Architecture for High Reliability – Availability Systems" TRP activity** (TEC-EDD).
- A document titled "On-board Computers - Generic Requirements Document" has been produced. The SAVOIR OBC specification has been tailored to fulfill the project requirements.
- Additional requirements have been added:
  - Functional requirements
  - Performance requirements: Response time, Throughput, Start-up Time
  - Dependability requirements: Lifetime, Reliability, Availability, Maintainability,
  - Design requirements: Redundancy, Resource utilisation
- Also a Dependability Plan has been developed that provides the description of the processes, activities and procedures to be executed in order to provide assurance of the dependability characteristics of on-board computers.

RUAG Single Board Computer Core (SBCC): a product derived from OBC spec

- KO on 04/07/2012, SRR concluded 21/12/2012, PDR concluded on 05/03/2013, DDR September 2013 , activity closure April 2014 (Phase 1)
- 3-phased activity:
  - *Phase 1* : **Single Board Computer analysis and design**
    - Currently running, expected completion Apr-2014
    - 18 months duration, Target TRL = 4
    - SBC analysis, design and implementation
    - SBC integration with NGMP
    - Development of prototype SW drivers
  - *Phase 2* **: FPGA Validation activity**
  - *Phase 3* : **Single Board Core EQM**

Generic RTU specification > RTU Operability Requirements

- The first draft version of the RTU Spec contained an architectural description of a generic RTU and a long list of requirements specifying all the possible I/Fs to be managed by a generic RTU, in partial overlapping with:
  - Mission Specific GIRD/GERDs
  - ECSS-E-ST-50-14C Spacecraft Discrete Interfaces
- ESA- SAG discussions concluded that the first task related to the RTU to be solved is the definition of an Operability/Commandability concept.
- Different concepts of RTU/RIU operability/commandability from the OBC have been implemented so far:
  - From a simple RTU (full slave unit of the OBC)
  - To a more complex RTU architecture that using a PPS signal and timing information can provide time datation of HK data, autonomous handling of sequences of HK acquisition and motors & valves actuations.
- ESA has started to compile requirements related to the operability concept of a RTU

RTU operability requirements

Requirement Number : SAVOIR.RTU.FU.10 *RTU Function 1*

The RTU shall perform the following functions:

- *Reception and decoding of commands from the OBC on the Command and Control bus*
- *Generation of data messages to the OBC on the Command and Control bus*

Requirement Rationale : The RTU shall be a slave unit controlled by OBC/SMU.

Requirement Number : SAVOIR.RTU.FU.20 *RTU Function 2*

Besides the functions defined by SAVOIR.RTU.FU.10 the RTU shall perform additional functions as :

- *Conditioning and analogue-to-digital conversion of discrete analogue (voltages, currents, thermistor/thermocouples values, …)*
- *Acquisition of status signals (relay status and bi-level digital signals)*
- *…*

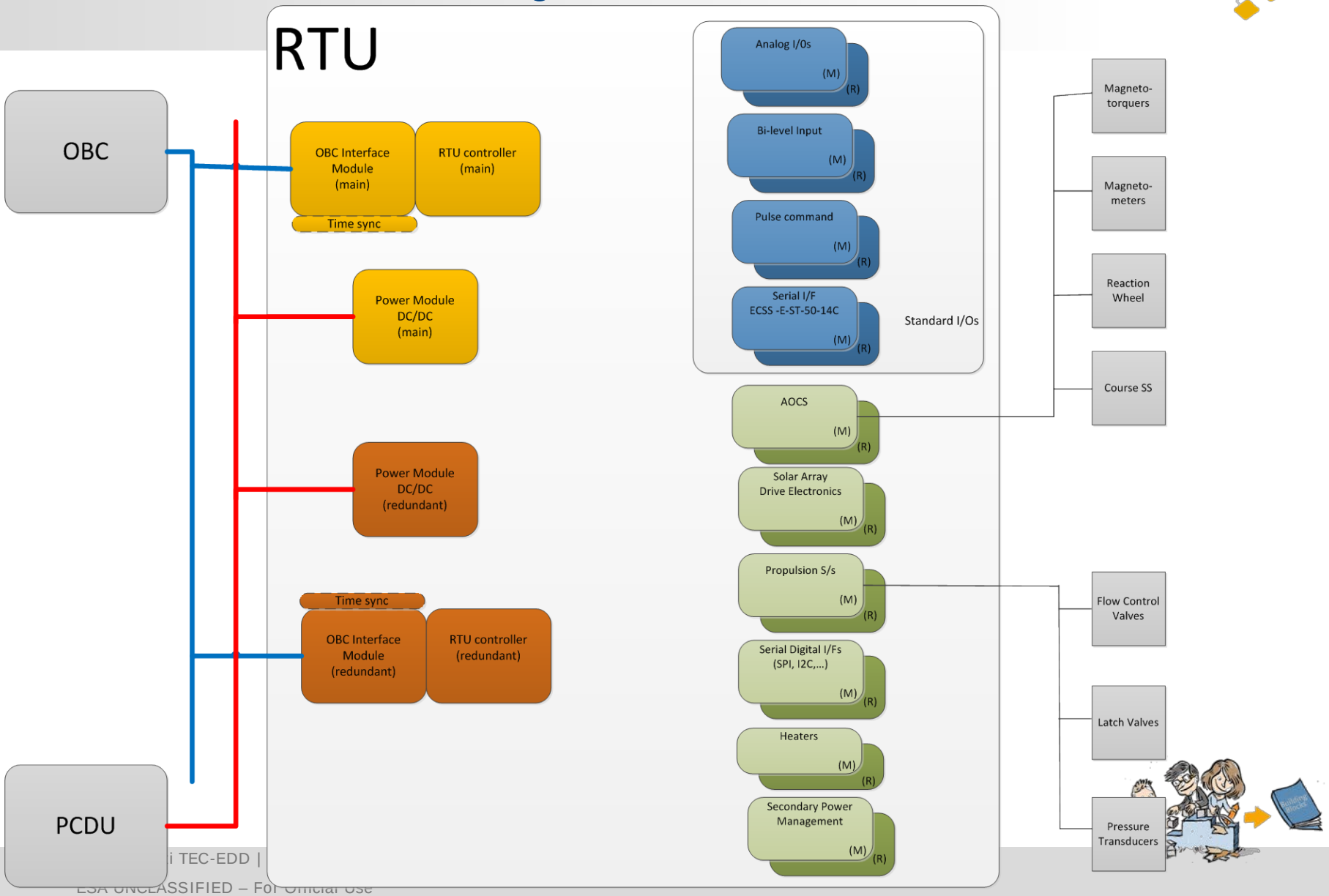
Requirement Number : SAVOIR.RTU.FU.30 *RTU Function 3*

Powering On/Off of the functions listed in SAVOIR.RTU.FU.20 shall be performed under control of the OBC (with exception of …

RTU functions

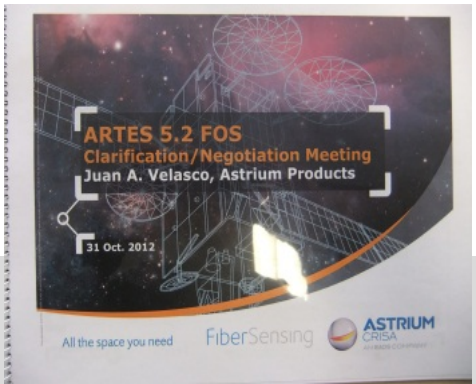
- Remote control I/F
- RTU controller
- Data Concentrator:
  Collects data from sensors with standard interfaces
  - Analog
  - Digital bilevel
  - Serial communication like UART and CAN
    Possible future I/F here could be I^2C or SPI
- Discrete pulse command interface
- AOCS sensor/actuator interface
- Propulsion interface
- Secondary power distribution to sensors/actuators
- Heaters power distribution
- SpaceWire router
  (in case there is a platform C&C network that needs routing)
- Sync signal distribution (extension of OBC capability)

RTU functional diagram



Modular RTU

- The Modular RTU (or RTU2015) is a Building Block developed in the frame of the SAVOIR initiative
- GSTP Activity Contractor: EADS Astrium Crisa
- KO on 26/04/2012, CDR in September 2013
- Development of a multi-purpose modular Remote Terminal Unit for Space applications. EQM
  - The main objective: Modular, flexible and easily adaptable RTU for Telecom-Science-Earth Observation Platforms.
- Flight Opportunity and Evolution:
  - Two RTUs for Proba-3
  - Draft electrical and mechanical interface spec has been sent to ACRA-Curtiss-Wright that will be involved in the D&D of a wireless module (GSTP-STRIN)
  - ARTES 5.2 FOS will develop a Temp Mon System based on Fiber Bragg Gratings for thermal Mapping on Telecom satellites: the module will use the Mod RTU form factor



Conclusions and Future

- Produced Docs:
  - Issue 1- draft of Reference Functional Architecture
  - Issue 1- draft of OBC Generic Spec
  - Preliminary version of RTU operability requirements doc
- On-going & future activities:
  - SAVOIR Reference Functional Architecture, OBC Generic Spec OBC will be updated by SAG industries
  - Finalization of RTU Operability requirements doc
  - ESA is evaluating the possibility to publish the ASRA documents as ECSS docs (ESA internal meeting)
  - Future dissemination process controlled by ESA:
    - ESA SRDs / OIRDs inspired by the ASRA work (done already for Euclid, in progress for Juice).
    - Products to be derived from Savoir concept and Specs

Contact

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Questions ?