SAVOIR

space avionics open interface architecture

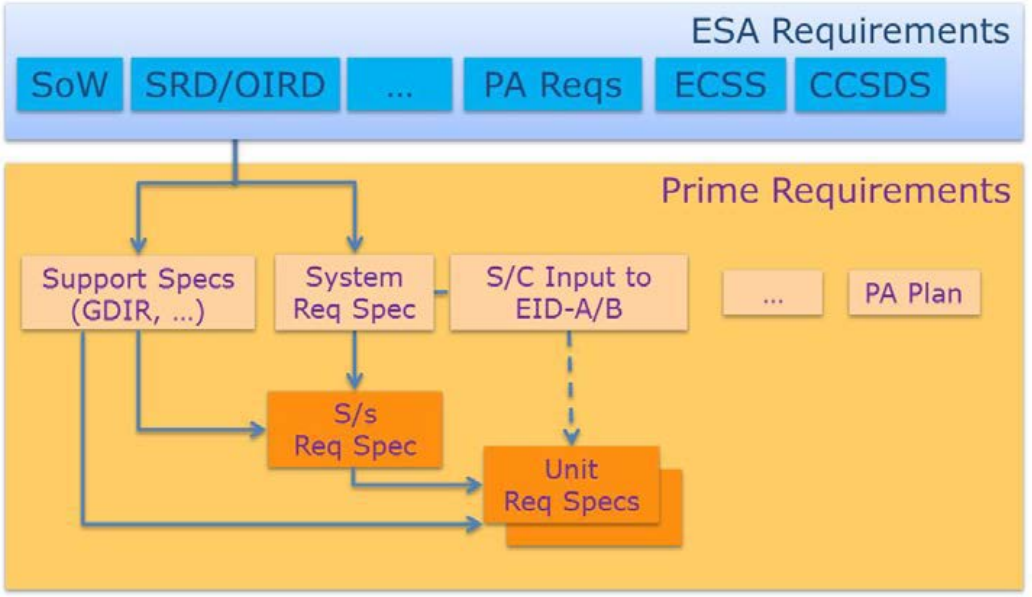
SAVOIR RTU Functional and Operability Requirements status@ADCSS 2016

Agenda

- SAVOIR docs and review process
- The SAVOIR RTU Functional and Operability Requirements:
  - Contents
  - Status
  - Next Steps

Savoir docs – a typical ESA project

- The following figure describes the typical documentation tree of an ESA project:

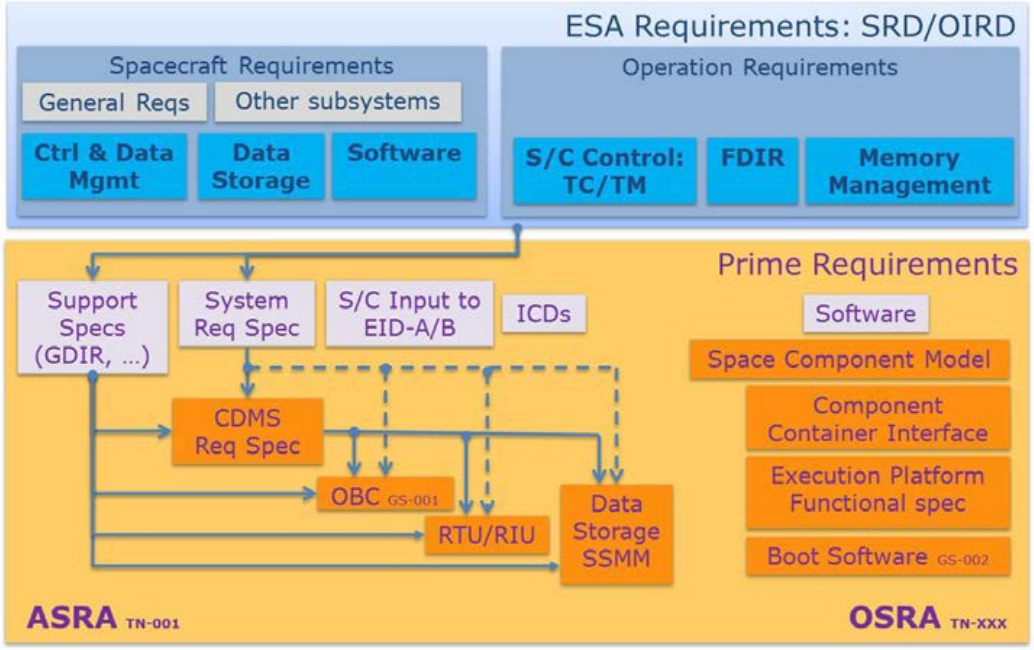


Legenda – SoW =Statement of Work, SRD= System Req doc, SG-ICD= Space to Ground ICD, OIRD= Operation Interface Requirements Document, GDIR = Generic Design & Interfaces Document, EID= Experiment Interface Document

- ESA includes in its Invitation To Tender in particular the Statement Of Work, the project SRD/OIRD, and other documents such that the ECSS and CCSDS applicable standards.
- The project prime produces out of them his own documents, to be used for the procurement of the spacecraft elements, in particular system, sub-systems and units requirements specification.

Savoir docs

- The SAVOIR documents follow the same logic, the following figure shows how the SAVOIR documents are organized starting from the ESA SRD/OIRD, to go down at level of products specification covering control and data management, data storage, software, operability, FDIR, etc.:



- The Savoir docs in form of generic specification (OBC GS-001, Boot SW GS-002, …) intend to support **Primes in re-using product specifications** for their procurement and **Equipment Suppliers to develop compliant products and evolutions**.

SAVOIR documents: status of TNs and Specs

Technical Notes: context			
[ASRA]	SAVOIR Functional Reference Architecture	SAVOIR-TN-001	Available from https://essr.esa.int/ European Space Software Repository
[OSRA]	SAVOIR On-Board Software Reference Architecture	SAVOIR-TN-xxx	(under conversion from a R&D document into a Savoir document)
[PLIF]	SAVOIR general recommendations for Platform Payload interface	TEC-SW/12-538/JLT	(not yet available)
[SCMON]	SAVOIR General Recommendations for Spacecraft Monitoring and Control,	TEC-SW/12-539/JLT	(not yet available)
Generic Specification: product spec			
[OBC]	SAVOIR generic OBC Specification	SAVOIR-GS-001	Available from https://essr.esa.int/ European Space Software Repository
[BootSW]	SAVOIR Flight Computer Initialisation Sequence Generic Specification	SAVOIR-GS-002	Available from https://essr.esa.int/ European Space Software Repository
[RTUop]	SAVOIR generic RTU functional and operability specification	TEC-EDD/2013.11/GM	SAG review completed
	Data Storage SSMM Requirements Spec	-	Draft produced by TRP – under review From Savoir-Masais WG v1

SAVOIR documents: review process and the RTU case

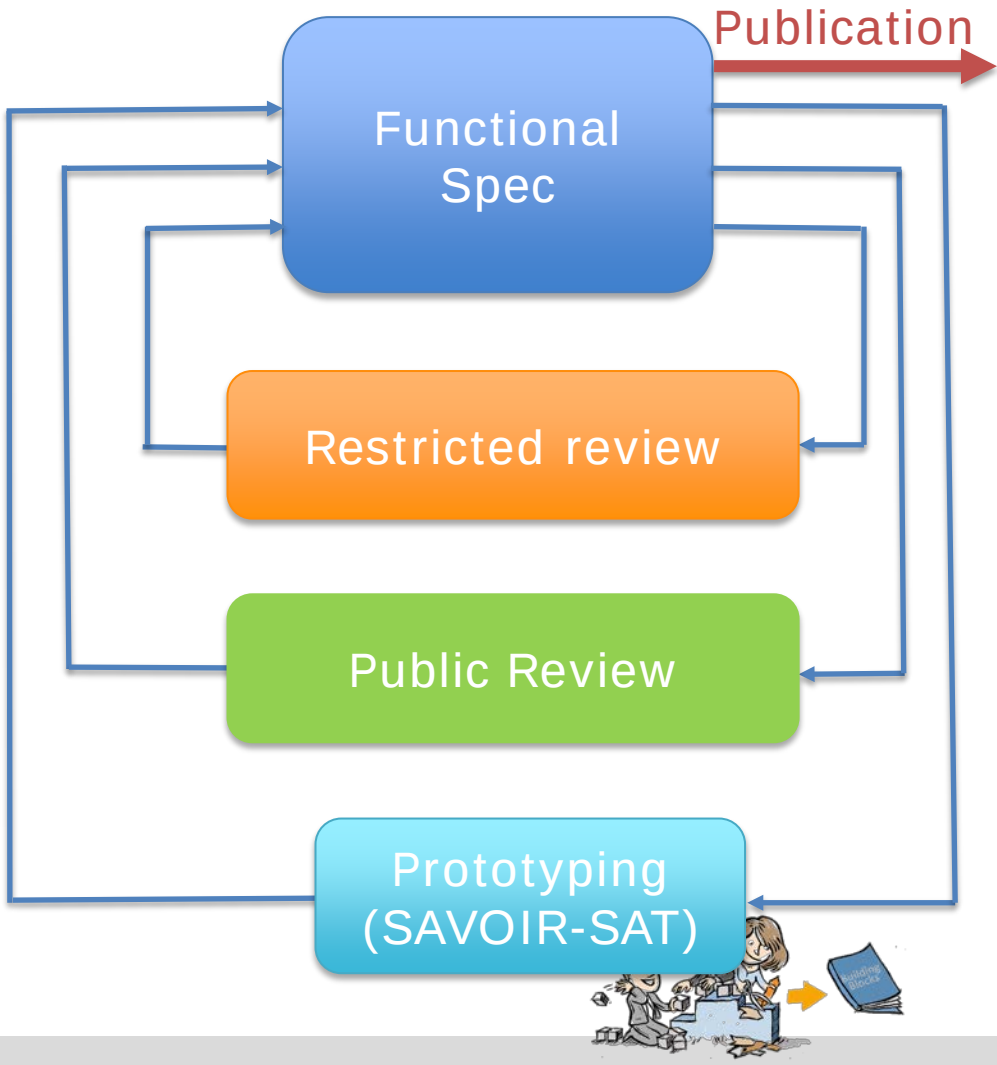
Under SAG agreement, a draft version is produced either by a SAG working group, or as an output of an R&D activity, or proposed by Industry, or as an ESA internal document

It is then submitted for a restricted review (e.g. SAVOIR group/sub-group, ESA projects) and updated as needed. The goal is to check compliance to the SAVOIR architecture and principle, the completeness / consistency, the appropriateness for projects, … 1

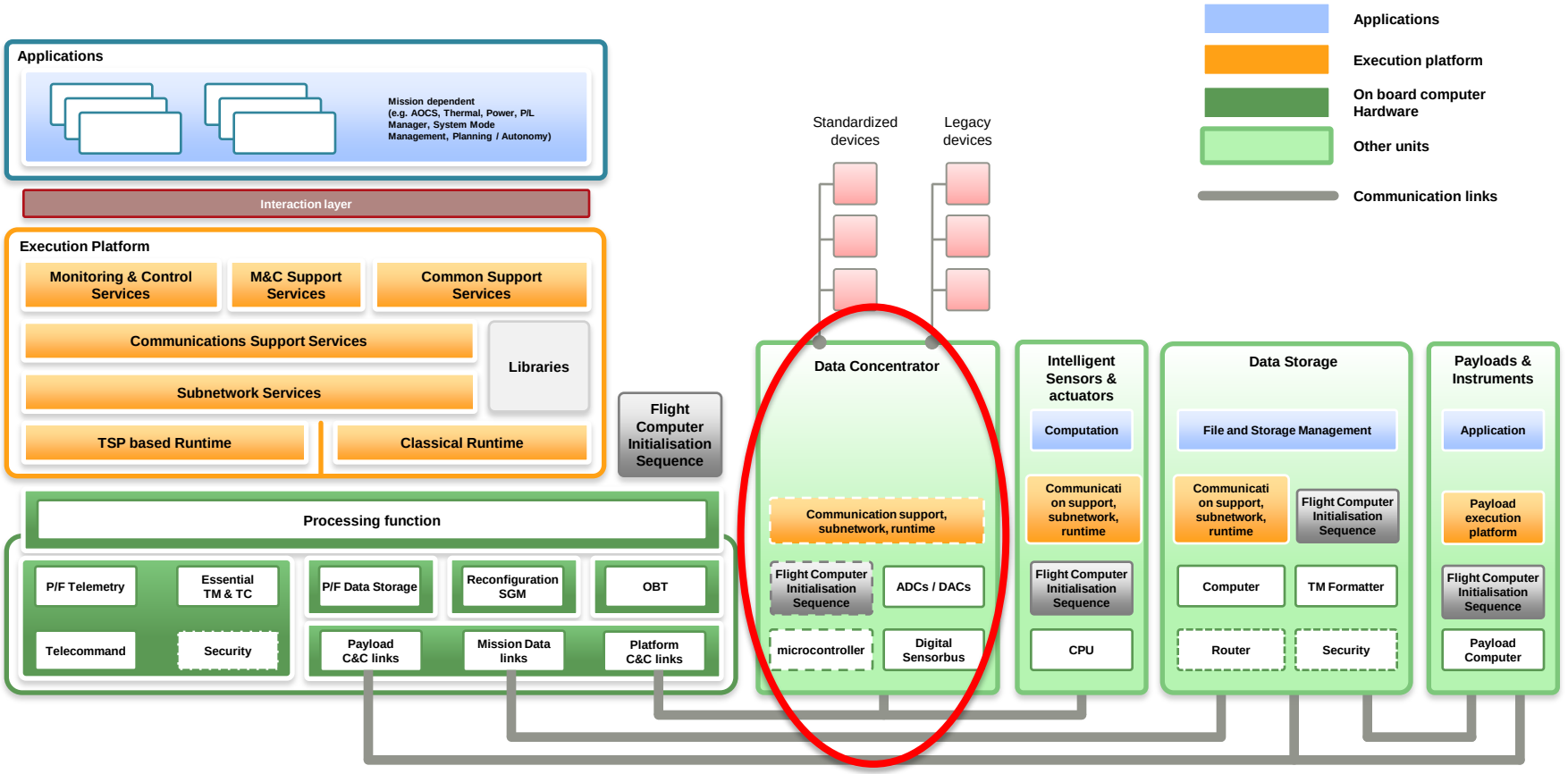
The document is then submitted for a public review and updated. The review is organized with support of Eurospace to identify the SAVOIR focal points in industry 2

The specifications are in parallel verified by prototyping, to demonstrate their maturity, consistency with the reference architecture (as far as possible on a case by case basis). 3

The last version issued out of the review is then passed to the SAVOIR Advisory Group for final endorsement, and then it is published. 4



SAVOIR documents: generic RTU functional and operability specification

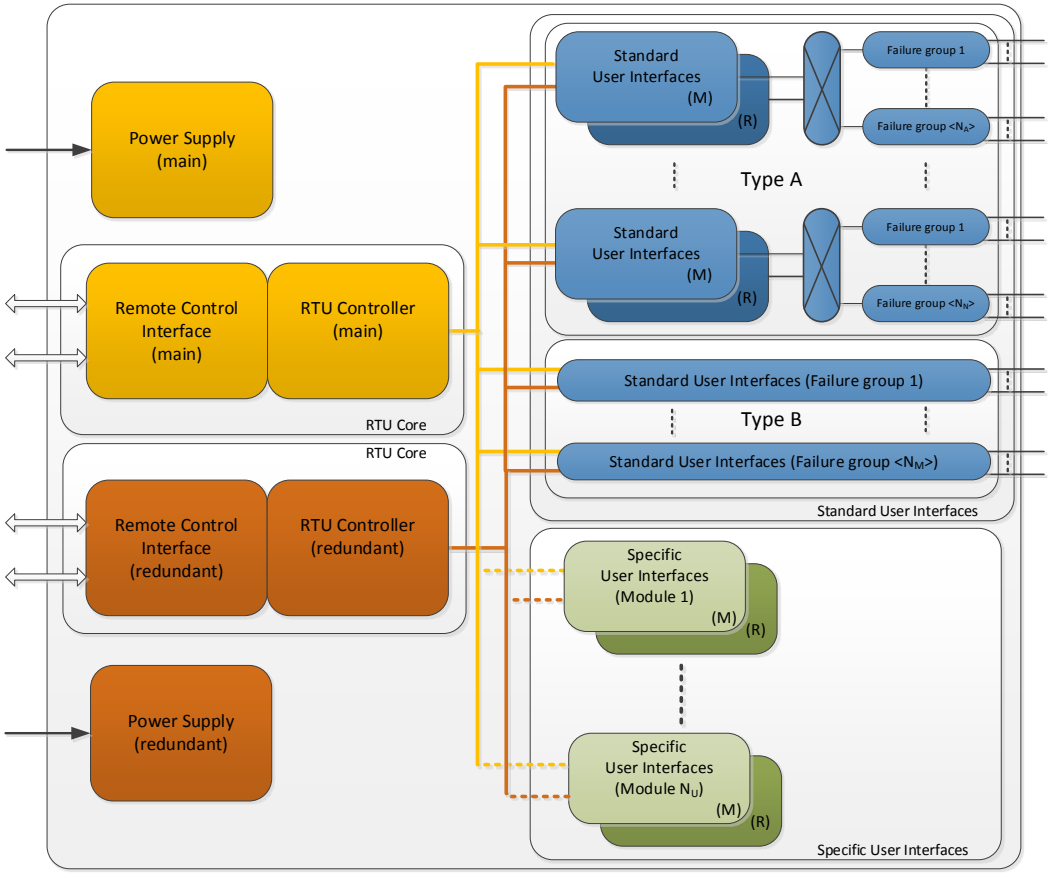


What is a RTU?

- The Remote Terminal Unit (RTU) is an Avionics element that provides functions such as the collection of housekeeping data, the generation of pulse commands, the interfacing to sensors & actuators, and in general to devices which do not have a direct link to the OBC via the spacecraft Command & Control bus.
- The RTU acts as a slave unit to the main S/C computer and controlled by a dedicated Remote Control Interface. More than one RTU can be present within the avionics system
- The most relevant specification characteristics of a RTU include the type of communication interface with the OBC, the number of channels for digital and analogue I/Os and the number and type of additional functions.
- The typical interfaces with the OBC are the MIL-STD-1553B (e.g. Solar Orbiter, EarthCARE), RS422 (e.g. Proba-x), SpaceWire (e.g. BepiColombo) and CAN

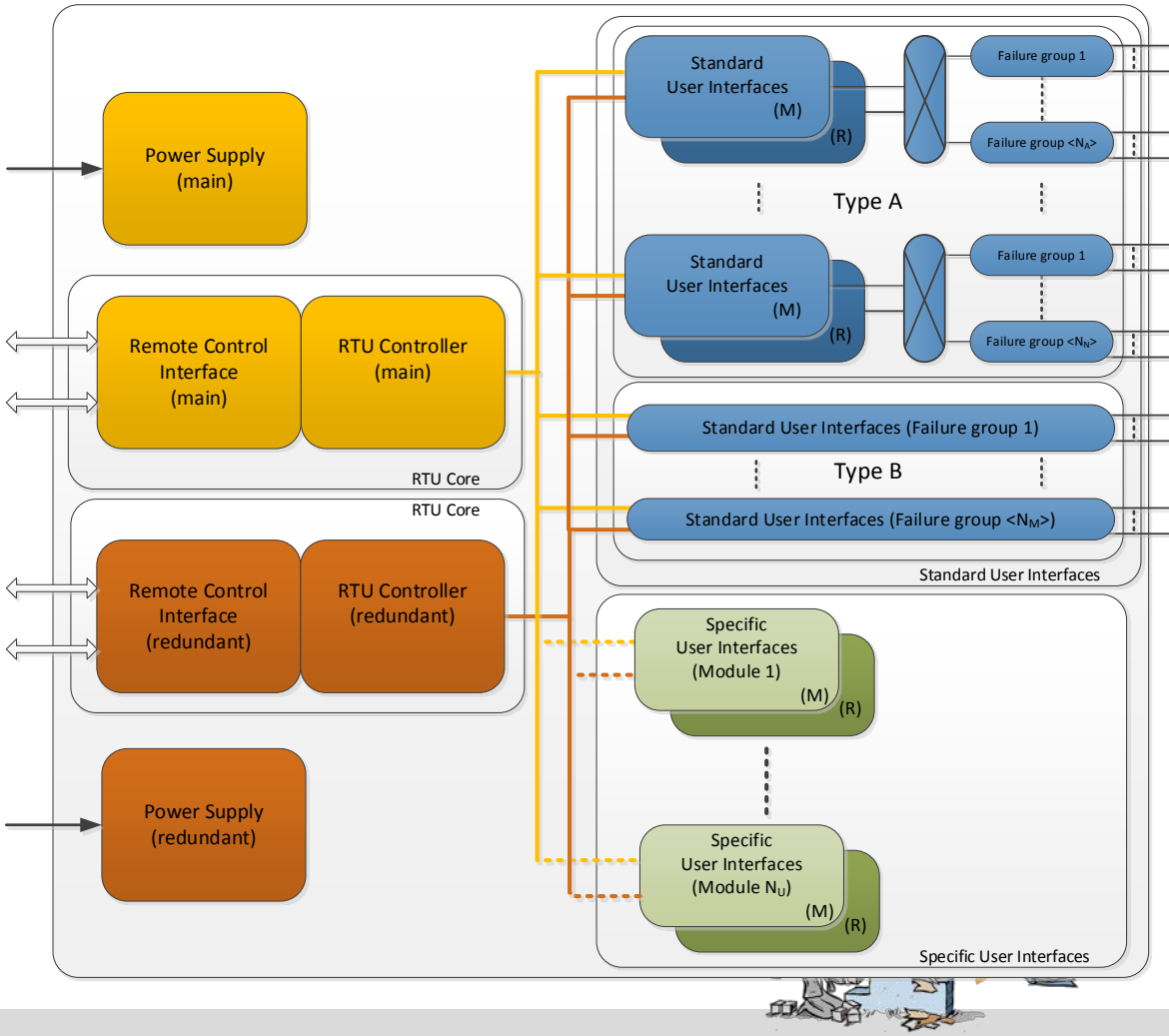
What is a RTU?

- The RTU main functional modules are the *Remote Control Interface*, the *RTU Controller*, the *Power Supply* or DC/DC module and a number of *Standard or Specific User Interface Modules*.
- More than one power feed are normally used independently from the implementation of redundancies: Propulsion or Heater Power Distribution modules can be directly supplied by separate power feeds.
- The User Interface modules can include analog input/output module, digital input/output module, communication interfaces, interfaces to AOCS actuators and sensors etc.



What is a RTU?

- The provision of the RTU functions is usually **fully redundant**, however, in applications where a huge amount of interface lines are required, for thermistors, the concept of **failure group** is introduced: the temperature acquisition channels are grouped such that no single failure shall cause simultaneous loss in more than one group.
- In the Figure two typical redundancy schemes are shown.
  - Type A: A number of failure groups are individually connected to a redundant interface module
  - Type B: In this configuration, each failure group has its own interface towards the RTU Controller



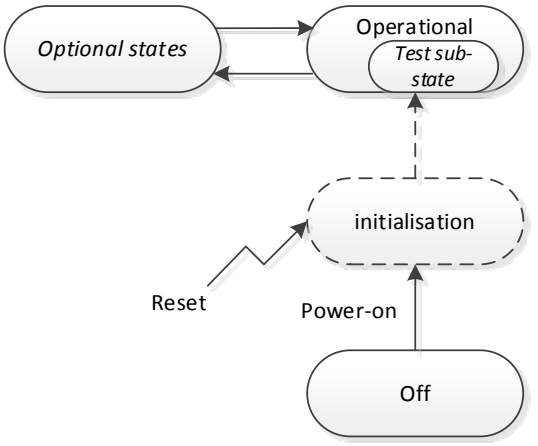
SAVOIR RTU spec: Operating states

Requirement Number : SAVOIR.RTU.STATE.1

Operating States

The RTU shall implement at least the following operating states (see also Figure 2):

- Off State
- Initialisation State
- Operational State
- Test sub-state (a sub-state of Operational State)
- Optional States (optional)



Requirement Rationale :

The mandatory operating states of the RTU (Off, Initialisation, Operational and Test) shall be kept similar across missions and suppliers in order maximise the reusability of the RTU design and the RTU operational concept. However, in case of mission specific needs, additional states could be added. The Initialization state is a temporary state with a limited duration (it can be considered a transition phase).

SAVOIR RTU spec : Telemetry Acquisition & Observability

Concept of Telemetry Acquisition list

The RTU telemetry acquisition concept is based on cyclic acquisition of predefined sequences of RTU input channels by means of one or more **telemetry acquisition lists**. The sequence and frequency of the telemetry acquisition is controllable by means of commands via the RTU Remote Control Interface.

The start of the acquisition of a group of channels defined in a telemetry acquisition list is triggered by a corresponding **“Start TM Acquisition”** event. This event can be a command or a discrete pulse and is typically provided to the RTU at a rate of 1 Hz. As a minimum, generation of a “Start TM Acquisition” event by means of a command is always possible.

A **1 Hz update rate** is generally sufficient for housekeeping telemetries such as temperatures, voltages and status bits. However, it might be necessary to increase the sampling rate of selected parameters during operation and some parameters might need to have a constantly higher acquisition rate.

SAVOIR RTU spec : Commanding and Actuation

- Generally, there are **three different categories of commands** identified for the RTU.
  - Commands for internal control and management of the RTU configuration.
  - Commands for immediate control and actuation of Standard or Specific User Interfaces
  - Commands for scheduling the actuation of Standard or Specific User Interfaces in relation to a dedicated reference event.

- The **commands related to internal control and management of the RTU** can always be executed and does generally not affect any other ongoing telemetry acquisition or actuation processes (unless the command specifically concerns such function).
- The **commands for immediate execution** are typically Standard User Interface pulse commands, used for controlling the on/off switching of units.
- Actuation of **AOCS actuators** such as thrusters, magnetorquers etc. are however, usually done in relation to a well-defined reference event, typically corresponding to the AOCS cycle. In these cases the actuation commands and the associated relevant parameters (delay, pulse length etc.) are pre-loaded into the RTU. The execution of the command is then triggered by a dedicated event (“Start TC Actuation”).

SAVOIR RTU spec : other requirements

- **Redundancy**

A set of generic requirements for redundancy and failure isolation are included. There are specific requirements defined for each RTU Standard User Interface and RTU Specific User Interface modules.

Redundancy is usually implemented by means of full duplication of functional modules in combination with suitable usage of the principle of failure groups for similar interface channels. The failure group concept could be the preferred redundancy solution for interfaces that are implemented in a high multiplicity (e.g. pulse command interfaces or analogue acquisition interfaces).

- **Self Test**

Requirements for Power-On Self test & Commanded-Self test have been proposed and extensively discussed with SAG. Power-On-Self Test and Commanded-Self Test does not imply the use of intelligence inside a RTU (but the use of uC will allow extended self-test capability …)

- **Interfaces**

Set of requirements but essentially reference to ECSS-E documents are included (the SAVOIR RTU spec is not a replica of a GDIR !)

SAVOIR RTU spec

- **History:**

CHANGE LOG

Reason for change	Issue	Revision	Date
First release after major update	2	Draft 1	17/07/2015
Update including functional requirements	2	Draft 2	October 2015
Update after comments from SAG	2	Draft 3	September 2016
Update after mtgs with SAG	2	Draft4	04/10/2016

- **what you do not find…**
  - Environmental requirements (EMC, Mechanical, Thermal, radiation)
  - Design Requirements (Power, Volume, Mass …)
  - Verification methods
- **Definition of a common protocol to access the RTU? Or protocols considering the three most used interfaces : MIL-STD-1553B, SpW and CAN ?**
  - Discussion with primes and some equipment suppliers on going
  - For MIL-STD-1553B seems too late
  - For SpW and CAN it could be worth and the possibility to develop (or adapt) two protocols based on the same access principle could be investigated starting from the draft SpW-D and a common AD between ADS and TAS on NEOSAT

Conclusions

- **Public review to be started soon (1Q2017 ?)**
- **The same infrastructure used for SAVOIR-GS-001 and SAVOIR-GS-002 will be used**
- **Your contribution as reviewer is expected !**