RUAG

ASTRIUM OHB SYSTEM ThalesAlenia Space

SAVOIR
space avionics open interface architecture

Avionics System Reference Architecture - ASRA – consolidation study

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Objectives of the ASRA study

- The aim of ASRA 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. The work will be focused on data management and communications architectures.

- First work package to agree on a common functional architecture and outline the main functions per functional block. Presented at ADCSS2011.
- Four subsequent work packages for generating:
  - Ground to Space interfacing, general recommendations
  - OBC functions, generic specification
  - RTU functions, generic specification
  - Platform/Payload interfacing, general recommendations
- Documents reviewed by SAG and ASRA study completed

Document style

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DOCUMENT

SAVOIR generic OBC specification

SAVOIR
space avionics open interface architecture

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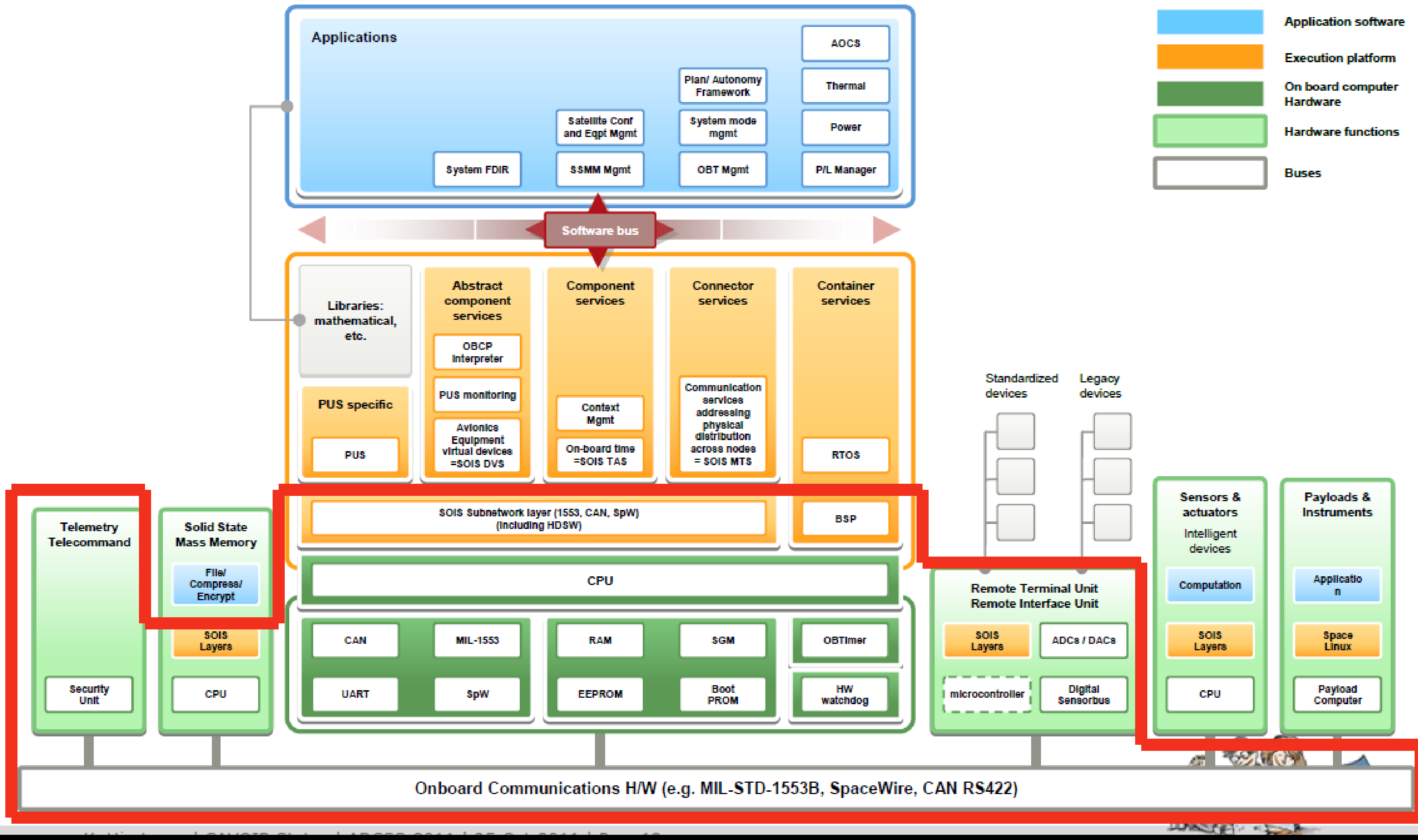
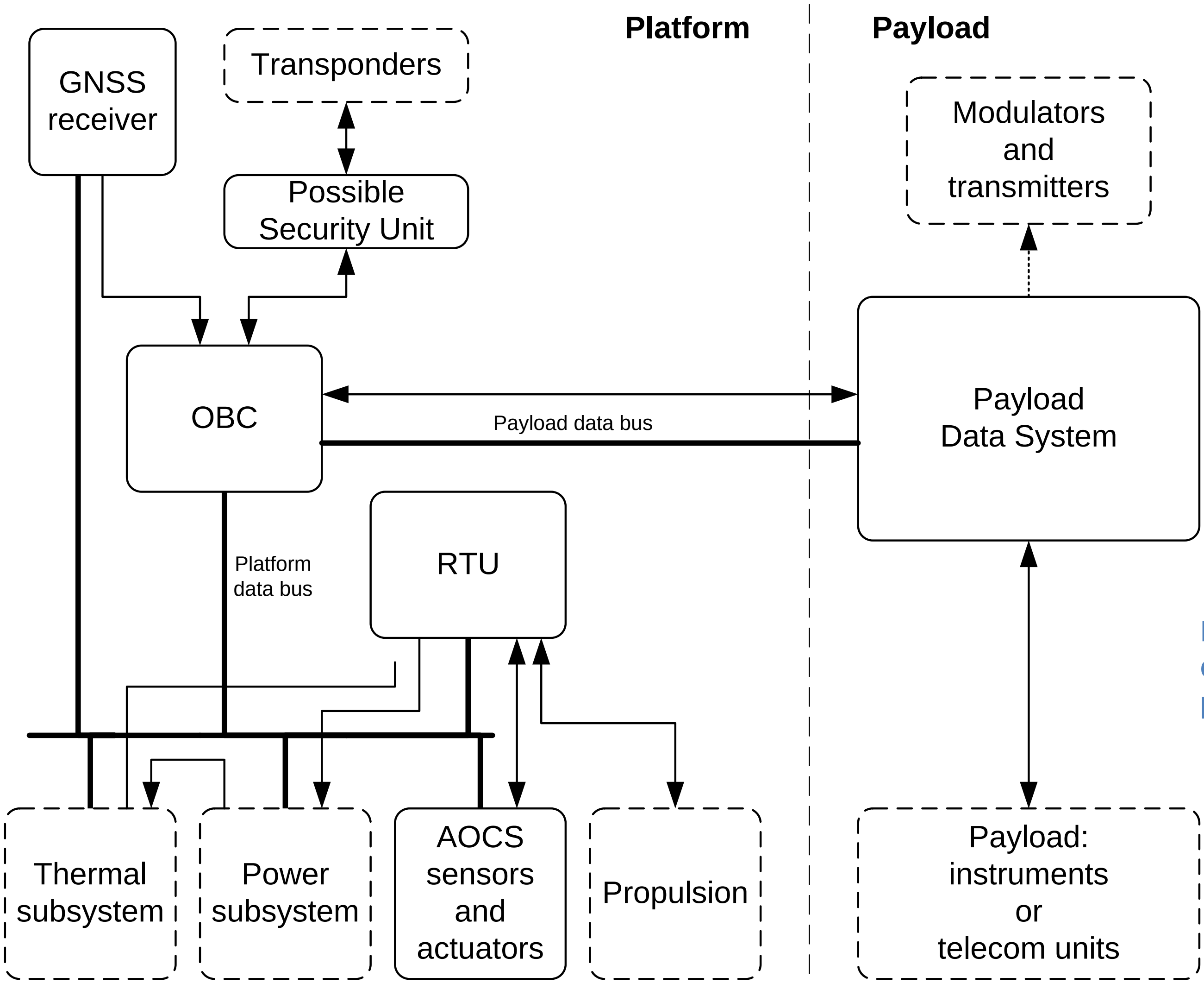
ASRA part of the SAVOIR architecture



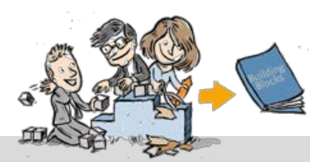
Mission domains considered

- 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
  - Military missions
- There is however nothing that prevents the system from being used in these missions if the special needs can be somehow fulfilled.

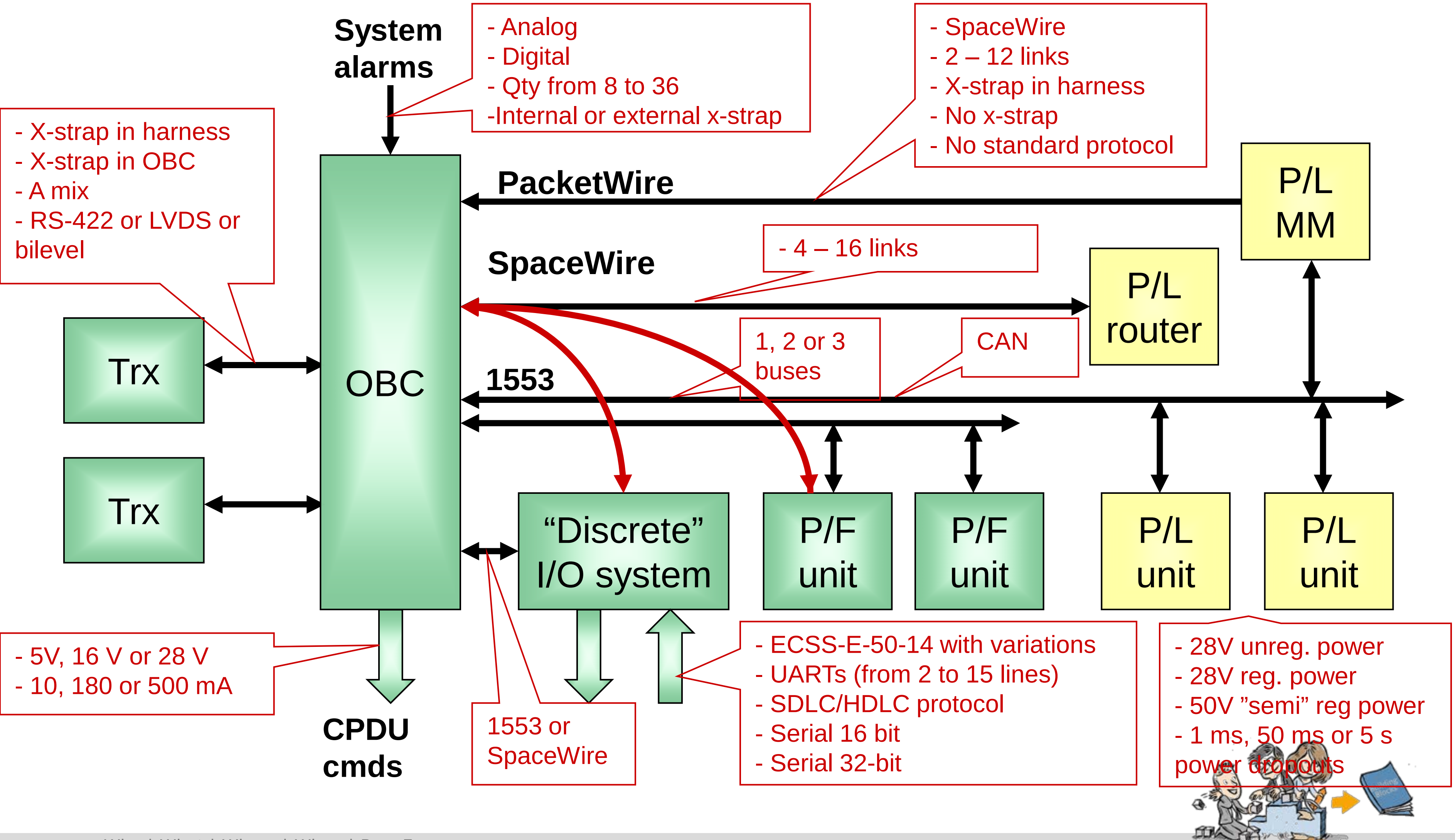
Typical view of the avionics



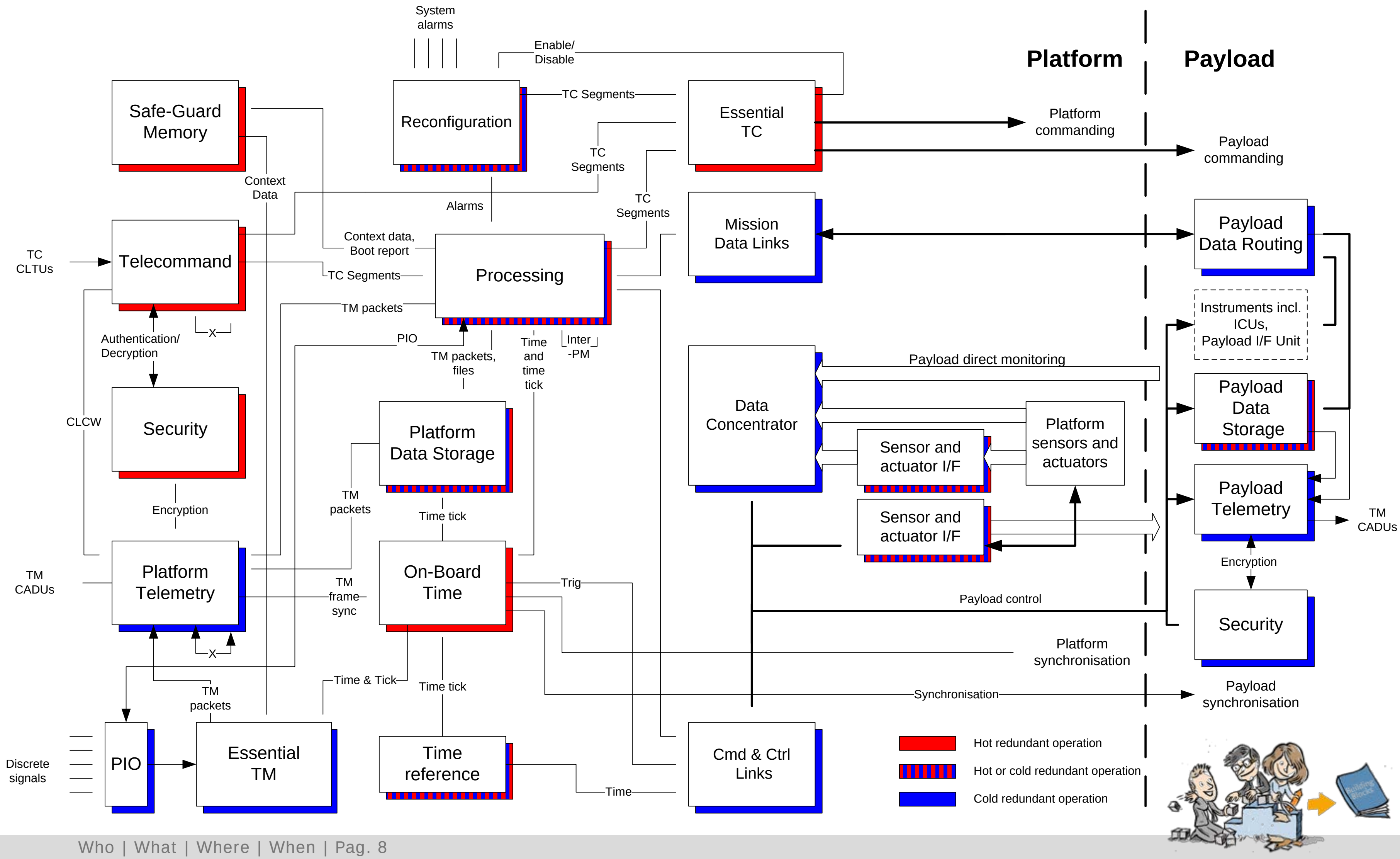
Dashed functions are ouside of ASRA perimeter



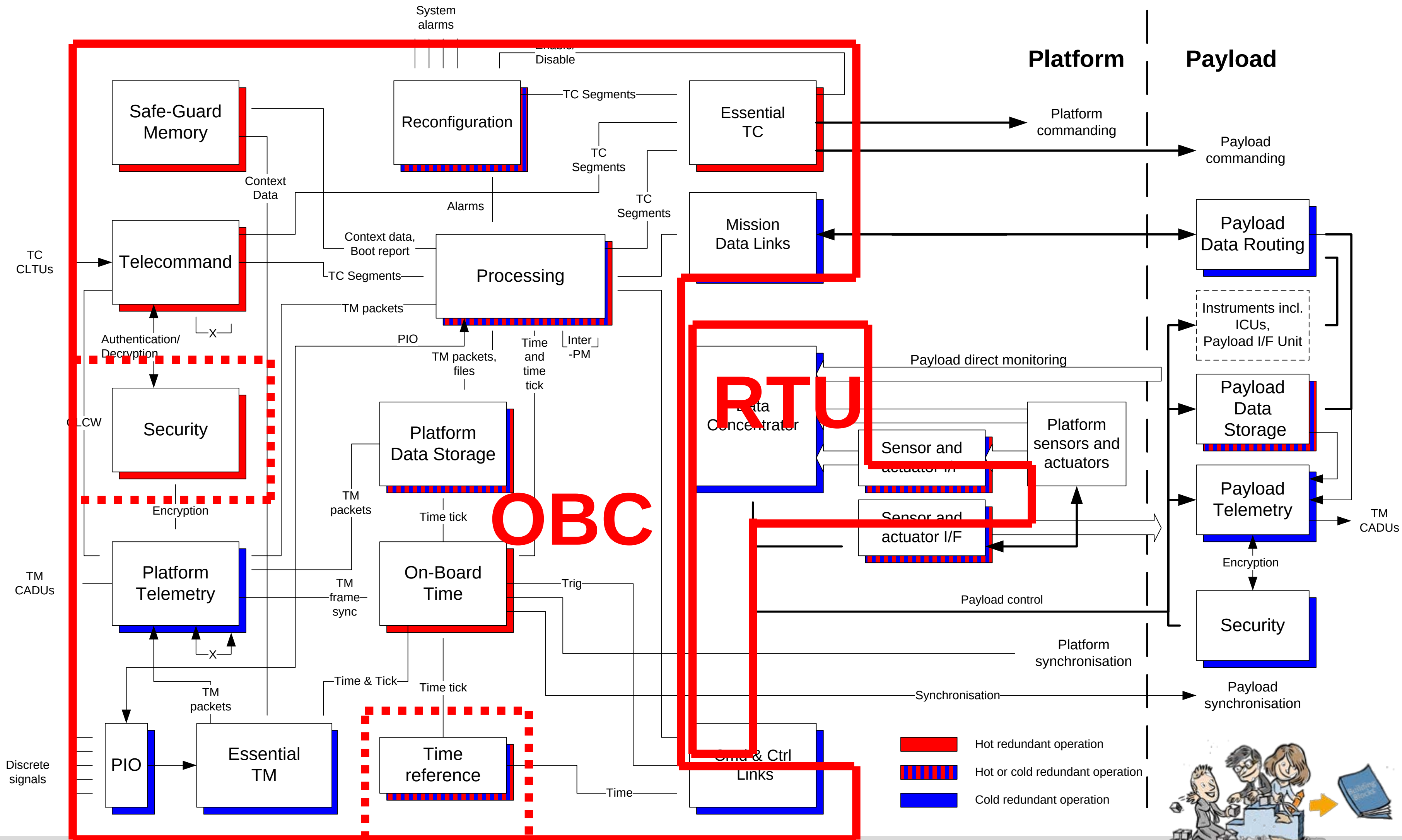
Basic problem, variability



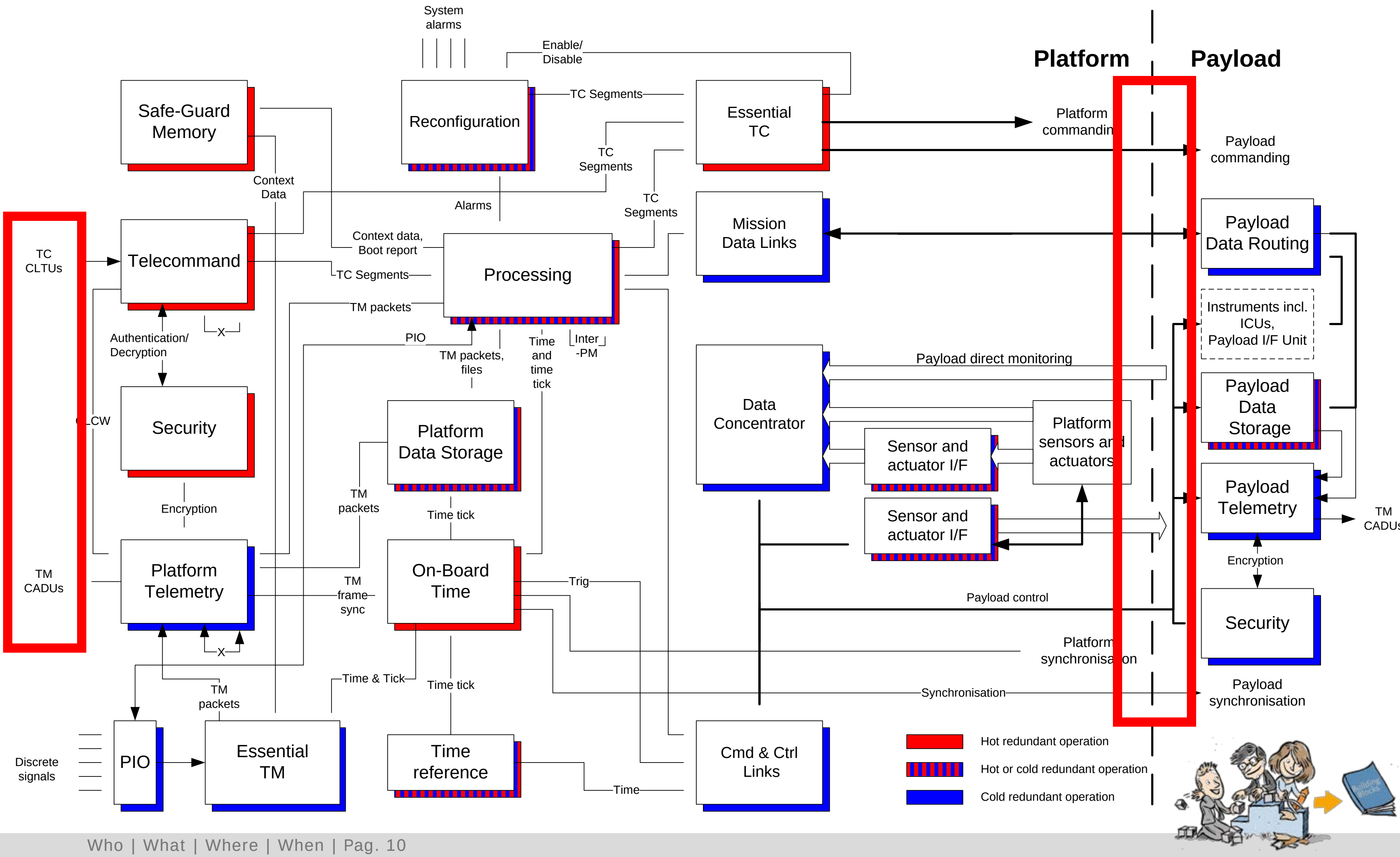
Avionics functions



Avionics functions mapped on units



Avionics main interfaces



General recommendations for Ground to Space interfacing

- Focus on reviewing existing documentation such as ECSS standards and the documentation prepared in the frame of the CNES ISIS initiative
- Matching those relevant for the functions of the SAVOIR architecture and extending them to the SAVOIR broader perimeter
(ISIS is LEO only)
- Review of various file transfer protocols
    - No recommendation made, ESA decision to use CFDP
- Generating inputs to ESA system level requirements, SRD and OIRD
- Generating inputs to update of ECSS-E-ST-70-11C

Ground to Space interfacing document

- Content of the document (TEC-SW/12-539/JLT)
  - Chapters 1, 2 & 3: introduction & objectives
  - Chapter 4: inputs to system-level requirements (SRD)
    - Mission phases & operations
    - Mission requirements
    - Operability requirements
    - Autonomy and FDIR: including satellite modes
    - Information security level
  - Chapter 5: inputs to operational requirements (OIRD) and update of ECSS-E-ST-70-11C
    - On-board data management requirements
    - Presentation of services absent in ECSS-E-ST-70-41A
  - Appendices with:
    - discussion on file transfer services
    - list of parameters and options
    - traceability matrix toward ISIS heritage
- Supplementary traceability toward ECSS-E-ST-70-11C from CNES

OBC functions

- TC decoding and distribution
- Platform TM formatting and coding
- Security (optional)
- Essential TC
- Essential TM (optional)
- Platform data storage, e.g. TM, MTL, OBCP, ...
- On-Board Time counting and distribution
- Application software execution platform (=processing)
- Command and control links to platform and payload equipment
- Mission data link to the payload
- Discrete data collection supporting Essential TM and processing
- FDIR function
    - Safeguard memory
    - Reconfiguration function

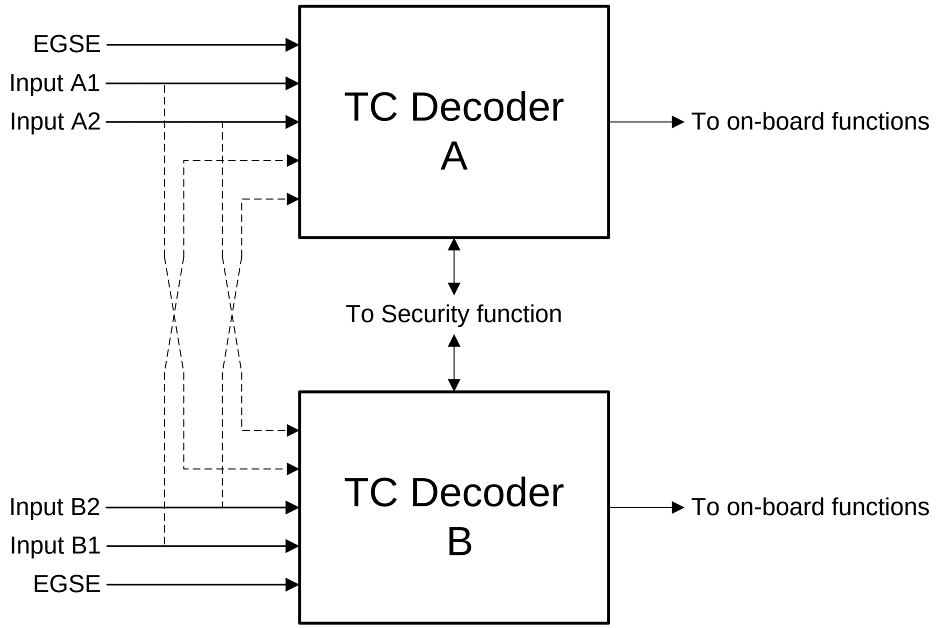
- Payload Data Storage and Payload TM not included in the specification

OBC specification

- Content of the document (TEC-SW/12-536/JLT)
    - Chapters 1 - 5: introduction, objectives and overview
    - Chapter 6: functional and performance requirements. One chapter per function and for each function:
        - Configuration (quantity and redundancy)
        - Function
        - Application Program Interface
        - Error handling
        - Performance
        - Parameters to control the function
    - Chapter 7: interface requirements
    - Chapter 8: list of parameters and options
    - Chapter 9: inputs to SRD
    - Annex: what we do not want to see in the SRD

TC decoding

- Hot redundant
- Four inputs from transponders
  - X-strap in harness
- Operates at up to 64 kbps
- No major evolution foreseen
- Define settings (VC ID 1 and 2, etc.)
- Freeze MAP allocation
  - MAP ID 0: To Essential TC function
  - MAP ID 1: To Processing function
  - MAP ID 2: Optionally to Inactive Processing function
  - MAP ID 3: Optionally to the Safe-Guard Memory function
  - MAP ID 5: Optionally to the Reconfiguration function



TC Decoder specification text (1)

1.1.1 TC Configuration

Requirement Number : SAVOIR.OBC.TC.10
No of TC Decoders
The OBC shall provide two TC decoders operating in hot redundancy.
Requirement Rationale : It shall be possible to send data to any TC decoder chain from ground without knowing the spacecraft configuration.

1.1.2 TC Functional Requirements

Requirement Number : SAVOIR.OBC.TC.20
Input selection mechanism
Each TC Decoder shall be able to choose between its TC receiver inputs in a round robin mode with all inputs having equal priority.
Requirement Rationale : The simplest mode of choosing a receiver input shall also be the standard reason. Priority modes are also possible but not required.

Requirement Number : SAVOIR.OBC.TC.30
TC Decoder function
Each TC Decoder shall be compliant to the Synchronization and Channel Coding specified in ECSS-E-ST-50-04C §8

Requirement Number : SAVOIR.OBC.TC.40
TC Decoder function
Each TC Decoder shall be compliant to the Segmentation Sublayer specified in ECSS-E-ST-50-04C §5

Requirement Number : SAVOIR.OBC.TC.50
TC Decoder function
Each TC Decoder shall be compliant to the Transfer Sublayer specified in ECSS-E-ST-50-04C §6

TC Decoder specification text (2)

Requirement Number : SAVOIR.OBC.TC.60
TC segment distribution
The decoded TC segments shall be distributed according to their MAP ID. The allocation of the MAP IDs should be as follows:

0 Essential TC (CPDU)
1 Currently Active PM
2 Reserved (Inactive PM)
3 Reserved (Option: Nominal SGM or Local SGM)
4 Reserved (Option: Redundant SGM)
5 Reserved (Option: Nominal RM or Local RM)
6 Reserved (Option: Redundant RM or Lock Essential TC Function for TC only)
7..32 Not Used
33 Active PM
34 Reserved (Inactive PM)
35..62 Not Used
63 Reserved (Option: Authentication Unit Control)

Note: MAP Id 2,4,6,34 are not part of the ASRA baseline or options. The MAP Id's suggested usage are for OBCs that exceed the ASRA standard.
Requirement Rationale : MAP 1 is currently active PM. This is a good allocation because it is not known which PM that will be active when a command is sent. Deep space probes may reconfigure before the command is received.

Requirement Number : SAVOIR.OBC.TC.70
CLCW Telemetry Output
The CLCW according to ECSS-E-ST-50-04C §6.3 shall be provided for inclusion in the TM downlink.
Requirement Rationale : As required by TM/TC standards

TC Decoder specification text (3)

1.1.1 *TC Decoder External Inputs*

Requirement Number : SAVOIR.OBC.TC.80
Serial TC input signals
Each serial TC input shall consist of the following signals:

- TC Data on NRZ form
- TC Clock
- TC Data Valid (typically the demodulator squelch signal)
- RF Available (not for EGSE input)

Requirement Rationale : RF Available is required for CLCW generation

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Requirement Number : SAVOIR.OBC.TC.90
TC Decoder input electrical characteristics
The electrical characteristics of the TC Decoder inputs shall be of SDI type.
Requirement Rationale : The standard interface for digital inputs.

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.
OptionInfo : Option TC X-strap=No
Requirement Rationale : Simple configuration where only one communication band is required

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Requirement Number : SAVOIR.OBC.TC.110
TC Decoder input configuration
Each TC Decoder shall receive serial telecommand data on five inputs, of which one is dedicated to the EGSE. The transponder inputs shall be internally cross-strapped between the two TC decoders.
OptionInfo : Option TC X-strap=Yes
Requirement Rationale : Typical telecom project

TC Decoder specification text (4)

1.1.1 TC Decoder API

Requirement Number : SAVOIR.OBC.TC.200
Initiation of TC segments reception
The OBC shall allow the ASW to receive TC Packets distributed to the PM from both TC Decoders.

Requirement Number : SAVOIR.OBC.TC.210
Handling of received TC segments
The OBC shall allow the ASW to be notified at the reception of a TC packet distributed to the PM.

Requirement Number : SAVOIR.OBC.TC.220
TC Decoder Telemetry
The OBC shall allow the ASW to read the following telemetry data from each TC decoder:

- FRAME ANALYSIS REPORT

Requirement Rationale : The ASW shall be able to access TC Decoder status

TC Decoder specification text (5)

1.1.1 TC Decoder Error Handling

Requirement Number : SAVOIR.OBC.TC.230
Detection of Telemetry reading errors
The OBC shall allow the ASW to be notified at errors during reading of TC function telemetry data.

Requirement Number : SAVOIR.OBC.TC.240
Notification of TC reception errors
The OBC shall allow the ASW to be notified at reception errors during TC packet distribution to the PM.

1.1.2 TC Performance

Requirement Number : SAVOIR.OBC.TC.250
TC Input data rate
Each TC Decoder shall accept data on any input with a transmission rate of up to <TC_DATARATE>.

Requirement Rationale : Faster bit rates may be supported by the system but this is the ASRA baseline. Typical value for <TC_DATARATE>: 64kbit/s

Requirement Number : SAVOIR.OBC.TC.260
TC Input CLTU rate
Each TC Decoder shall handle at least <TC_RATE> CLTUs per second.
Requirement Rationale : Typical value for <TC_RATE>: 20 CLTUs per second.

TC Decoder specification text (6)

1.1.1 TC Parameters

Requirement Number : SAVOIR.OBC.TC.270
Value of TC configuration parameters 1
The TC parameters shall be:
- Spacecraft ID: <SCID>
- Virtual channel ID, Decoder A 1
- Virtual channel ID, Decoder B 2

Requirement Rationale : VCID 0 shall not be used. VC 1 and 2 has a (binary) Hamming distance greater than 1.

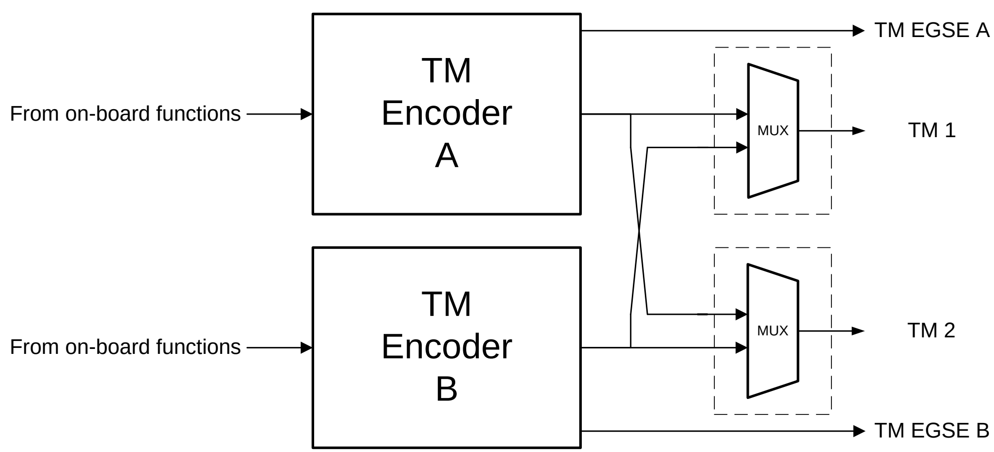
Requirement Number : SAVOIR.OBC.TC.280
Value of TC configuration parameters 2
The TC parameters should be:
- FARM positive window, PW <FARM_POS_WIN>
- FARM negative window, NW <FARM_NEG_WIN>

Requirement Rationale : Typical values for these parameters are 100, as used in several programmes.

Platform TM encoding

- Cold redundant
- One output per transponder
  - X-strap in OBC
- Operates up to 10 Mbps
- No major evolution foreseen

- Recommended VC allocation:
  - VC0: Real-time TM
  - VC1: Essential TM
  - VC2 & 3: Platform Data Storage TM
  - VC4 & 5: Reserved (Payload TM)
  - VC6: Reserved (Extra ASW TM)
  - VC7: Idle frames



Command and Control link function

- Connected to:
  - Platform sensors/actuators with a direct interface to the data link
  - Platform Input/Output concentrators (RTUs)
  - Platform subsystems units (e.g. PCDU)
  - Payload units which generate house keeping telemetry and/or set the configuration of the payload. Examples are :
    - Payload dedicated Input/Output concentrator (Payload RTU)
    - Payload devices such as Channel Amplifiers in a telecom payload
  - Payload units for distribution of PUS packets to be further processed for payload command & control
- Platform control link candidates:
  - MIL-STD-1553B data bus, the most used solution today.
  - A deterministic version of the SpaceWire network (named SpaceWire-D), which is still at R&D stage. A routing function, if needed, is located in the RTU.
- Payload control link candidates:
  - 1553 and SpaceWire
  - CAN bus, flown on SMART-1 and is considered for some future applications such as :
    - Planetary rover vehicles and landers
    - Telecommunication payloads

Mission Data link function

- Interconnects the platform processing and space-ground communication resources with on-board entities, e.g.:
  - Distribution of ancillary AOCS data by the OBC to a payload unit
  - Distribution of platform telemetry packets generated inside the OBC to be delivered to Ground using payload downlink capabilities
  - Collection of payload data for storage in OBC mass memory
- Possible candidates
  - MIL-STD-1553B data bus, the most common solution today
  - CAN bus (see comment in the previous section)
  - SpaceWire (point-to-point)
  - SpaceWire network (through a router in the payload) in case a significant number of units is to be interconnected.

- Mission Data link and Payload Command Control link may be physically the same link !

Typical OBC requirements with parameters

6.9.4 Generic SpaceWire Performance

Requirement Number : SAVOIR.OBC.MDL.80
Link transmission rate
Each link interface shall be able of running at a transmission rate of at least <SPW_OUTDATARATE>.

Note: <SPW_OUTDATARATE> is the raw transfer rate, ~20% overhead and ~5% loss due to return FCTs
Requirement Rationale : Typical Value for <SPW_OUTDATARATE>: 100 Mbps

A high SpaceWire bitrate is necessary regardless of the actual data transfer rate. A slower rate may limit performance in a SpaceWire network.

Requirement Number : SAVOIR.OBC.MDL.90
Link reception rate
Each link interface shall support a reception rate of at least <SPW_INDATARATE>.

Note: <SPW_INDATARATE> is the raw transfer rate, ~20% overhead and ~5% loss due to return FCTs
Requirement Rationale : Typical Value for <SPW_INDATARATE>: 100 Mbps

A high SpaceWire bitrate is necessary regardless of the actual data transfer rate. A slower rate may limit performance in a SpaceWire network.

Requirement Number : SAVOIR.OBC.MDL.100
Link packet transmission rate
The link interface shall support transfer of SpaceWire packets from the OBC at rates up to <SPW_OUTRATE>.
Requirement Rationale : Typical Value for <SPW_OUTRATE>: 50000 packets per second

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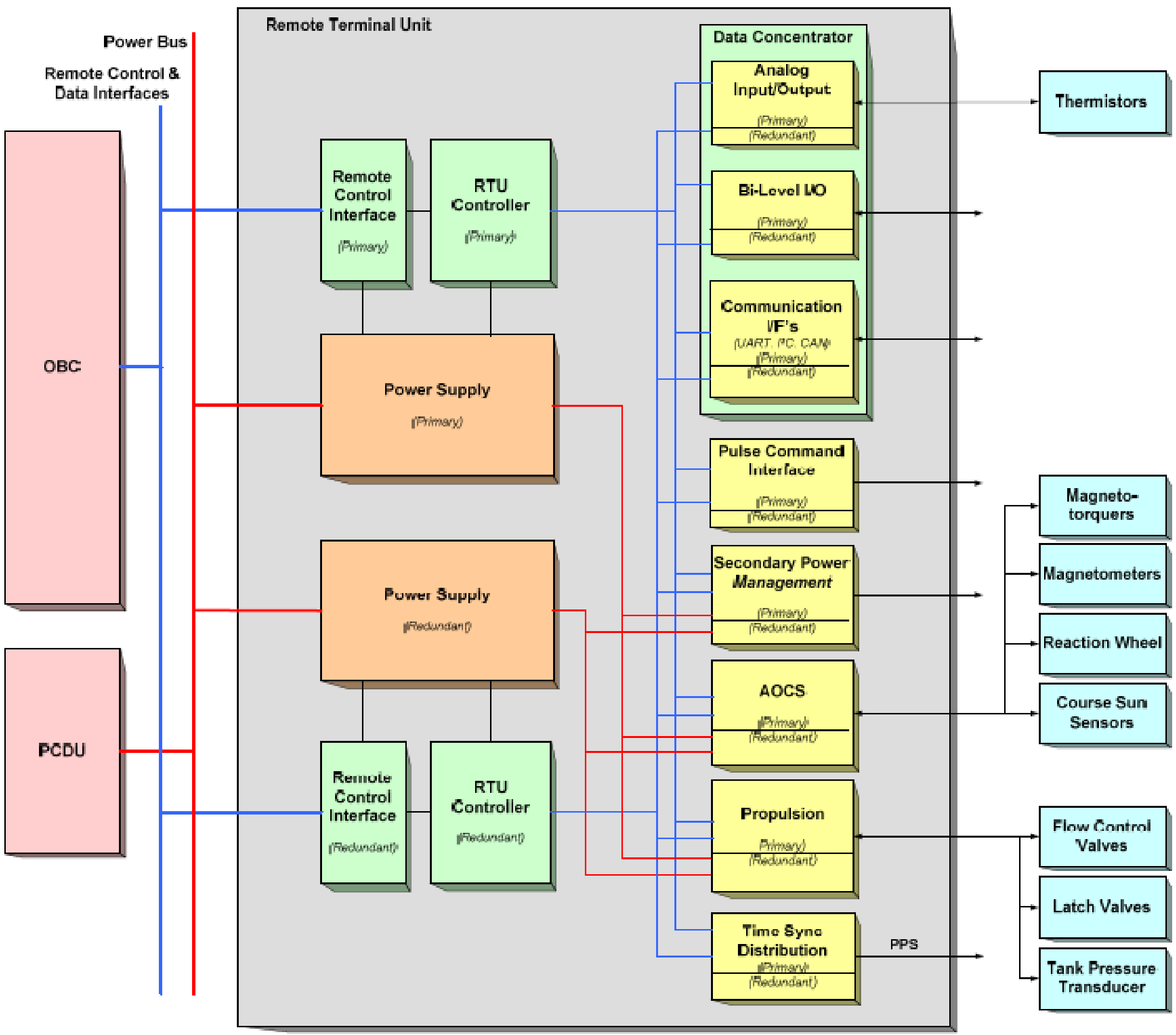
Requirement Number : SAVOIR.OBC.MDL.110
Link packet reception rate
The link interface shall support reception of SpaceWire packets to the OBC at rates up to <SPW_INRATE>.
Requirement Rationale : Typical Value for <SPW_INRATE>: 50000 packets per second

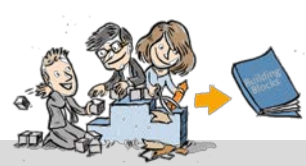
RTU functions

- Remote control I/F (1553 or SpaceWire)
- 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
- SpaceWire router
  (in case there is a platform C&C network that needs routing)
- Sync signal distribution (extension of OBC capability)

- The mix of interfaces is highly dependent on the mission

RTU functional diagram





RTU specification

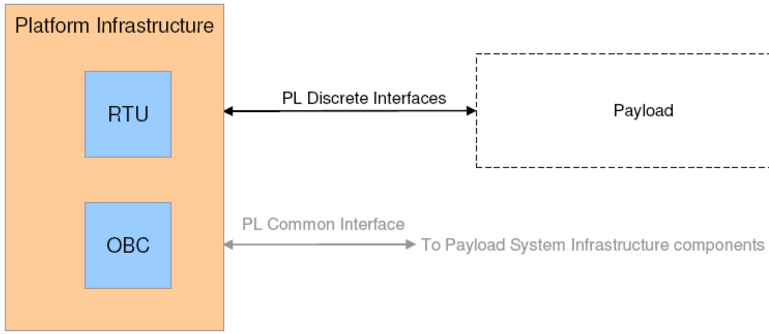
- Content of the document (TEC-SW/12-537/JLT)
  - Chapters 1 - 3: introduction, objectives and overview
  - Chapter 4: functional and performance requirements.
    - General and FDIR requirements
    - One chapter per function with mainly types and details of interfaces per function
  - Chapter 5: interface requirements
  - Chapter 6: list of parameters and options

- The RTU specification structure is slightly different from the OBC due to lower complexity per function, thus several general aspects are gathered in a single section

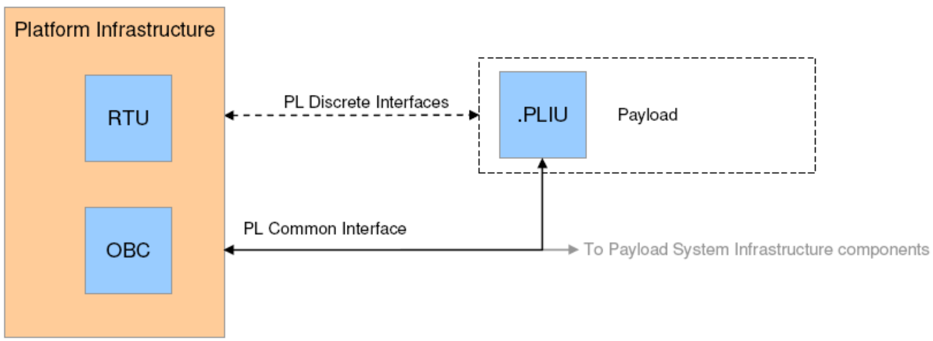
General recommendations for Platform to Payload interfacing

- Common terms are defined
- The interface is seen from two different views:
  - Functional view
    - Time management
    - Active thermal control
    - Payload mission (scheduled) operations
    - Payload contingency operations
    - Payload mission data management
    - Payload being part of platform control loops
    - Downlink of platform data
    - Security services
  - Implementation view (next slide)

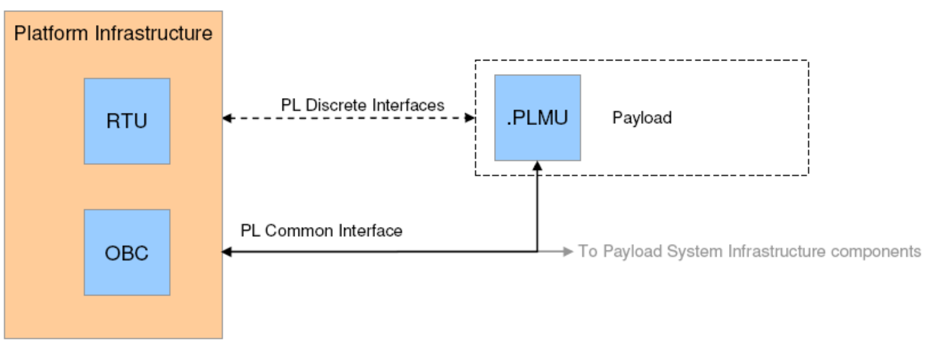
Platform to Payload interfacing implementation view



Direct interface



Interface via a
Payload Interface Unit



Interface via a
Payload Management Unit

Deriving the requirements

- The functional view is mapped on each implementation view to establish the requirements (TEC-SW/12-538/JLT) for
  - Synchronisation interface
  - Data interface
    - Monitoring and control
    - Time distribution
    - Payload packets
  - Discrete monitoring and control (ECSS-E-ST-50-14C)
  - Protocols for the data interfaces
    - 1553 (ECSS -13C with detailed Table A1)
    - CAN (awaiting ECSS standardization)
    - SpaceWire (ECSS -12C, -51C, -52C and -53C
  - Power, thermal etc. interfaces are not considered

Platform – Payload interface redundancy

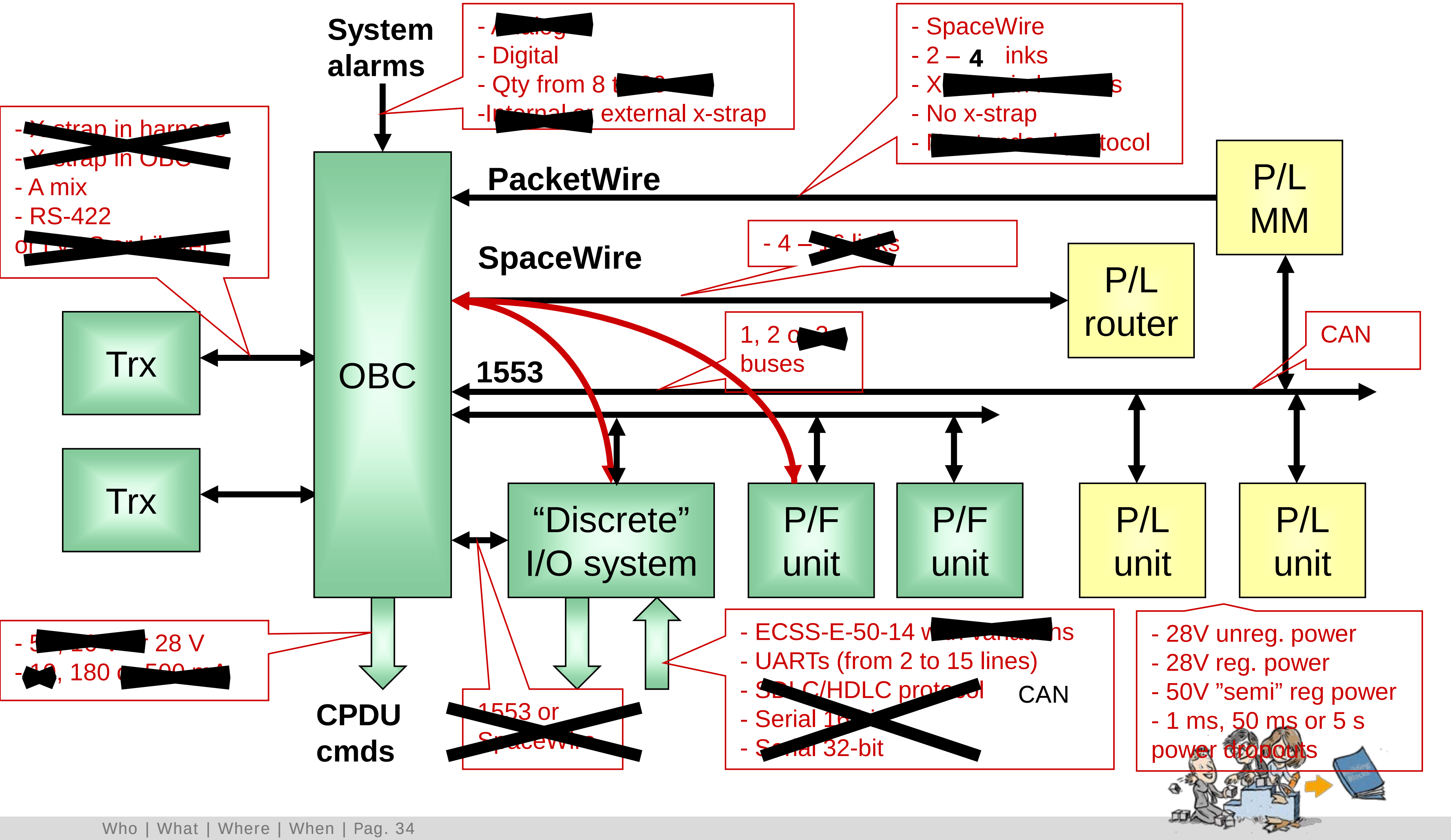
- Payload C&C link:
  - 1553, CAN — P/F provides nom and red bus
    P/L units interface both
  - SpaceWire — P/F provides four links
    P/L units interface one, two or four links
- Mission data link — As for SpaceWire C&C link
- Synchronization signals — P/F provides nom and red for each pulse
  P/L units interface one or both
- Discrete pulse commands — P/F provides nom and red for each pulse
  P/L units interface one or both
- Discrete monitoring — P/F provides nom and red for each signal
  P/L units interface one or both

- Full cross-strap capability from the platform
  Full freedom for payload redundancy except for the buses

Some key decisions made for the SAVOIR communication links

- OBC – Transponder: TC: Cross-strap in the harness
  TM: Cross-strap inside the OBC
- Platform C&C link: 1553 now, SpaceWire in the future with the router inside the RTU
- Payload C&C link: 1553, CAN or SpaceWire now
- RTU secondary links: UART or CAN
- Mission data link: SpaceWire
  (with 1553 or CAN as low data rate options)

Solving the basic variability problem ?



What happens next?

- ASRA documents to be put on a review among some ESA projects
- Future dissemination process controlled by ESA

- Expected further activities:
  - Initiation of ECSS-E-ST-70-11C update process
  - OBC and RTU specs used by primes when preparing future ITTs
  - ESA SRDs and OIRDs inspired by the ASRA work
  - ASRA documents used for harmonization discussions between ESA and NASA for instrument interfacing

Contact

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