# 7 OBC FUNCTIONS AND PERFORMANCES

## 7.1 Packet Telecommand Handling

### *7.1.1 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 is possible to send data to any TC decoder chain from ground without knowing the spacecraft configuration.

### *7.1.2 TC Functional Requirements*

*Requirement Number* : SAVOIR.OBC.TC.20
**Input selection mechanism**
Each TC Decoder shall be able to select between its TC receiver inputs in a mode with all inputs having equal priority.
*Requirement Rationale* : This is the simplest mode of choosing a receiver input.

*Requirement Number* : SAVOIR.OBC.TC.22
**Deleted**

*Requirement Number* : SAVOIR.OBC.TC.25
**Deleted**

*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 Clause 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 Clause 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 Clause 6

*Requirement Number* : SAVOIR.OBC.TC.60
**TC segment distribution**
The decoded TC segments shall be distributed according to their MAP ID.

Note: The allocation of the MAP IDs is recommended to be as follows:

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

MAP IDs 2,4,6,34 are not part of the SAVOIR baseline but their suggested use are for OBCs that exceed the SAVOIR standard.

*Requirement Rationale* : A standard mapping for the CPDU and currently active PM provides commonality across all missions. Having MAP 1 for the currently active PM ensures that the command always arrives even after a PM reconfiguration. This is important especially for deep space missions where the OPC can have reconfigured since the last TM status was sent ground.

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

### *7.1.3 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 as defined in clause 8.8 of ECSS-E-ST-50-14C
*Requirement Rationale* : The standard interface for digital inputs

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*Requirement Number* : SAVOIR.OBC.TC.100.1
**TC Decoder input configuration**
Each TC Decoder shall receive serial telecommand data on three inputs, of which one is dedicated to the EGSE.
*OptionInfo* : Option TC X-strap=No
*Requirement Rationale* : Simple configuration where only one communication band is required and there is no cross strapping between decoders.

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*Requirement Number* : SAVOIR.OBC.TC.100.2
**TC Decoder input configuration**
Each TC Decoder shall receive serial telecommand data on five inputs, of which one is dedicated to the EGSE.
*OptionInfo* : Option TC X-strap=Yes
*Requirement Rationale* : Typical telecom project with two communication bands and cross strapping between decoders.

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*Requirement Number* : SAVOIR.OBC.TC.120
**TC Security Function**
Each TC Decoder shall be able to

- send incoming TC segments to the Security Function for authentication or decryption and
- receive the authenticated / decrypted TC segments from the Security Function for routing

*OptionInfo* : Option TCSEC=Yes

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*Requirement Number* : SAVOIR.OBC.TC.125
**External TC Security Unit**
Each TC Decoder shall have one external interface of type SDI able to

- send incoming TC segments to the Security Function for authentication or decryption and
- receive the authenticated / decrypted TC segments from the Security Function for routing

*OptionInfo* : Option EXTTCSEC=Yes
*Requirement Rationale* : Used when there is no internal security function or when a higher level of security is required. SDI electrical characteristics are defined in clause 8.8 of ECSS-E-ST-50-14C )

### *7.1.4 TC Decoder Interfaces*

*Requirement Number* : SAVOIR.OBC.TC.130
**TC to PM Link**
Each TC Decoder shall have one communication path to the active PM for transmission of TC Segments
*Requirement Rationale* : The basic ground-to-space communication link

*Requirement Number* : SAVOIR.OBC.TC.140
**TC to Essential TC Link**
Each TC Decoder shall have one communication path to one Essential TC function for transmission of TC Segments
*Requirement Rationale* : Used for reconfiguration directly from ground

*Requirement Number* : SAVOIR.OBC.TC.150
**TC to SGM Link**
Each TC Decoder shall have one communication path to one SGM for transmission of TC Segments
*OptionInfo* : Option GNDSGM=Yes
*Requirement Rationale* : Makes it possible to store data in the spacecraft without the use of application software.

*Requirement Number* : SAVOIR.OBC.TC.160
**TC to RM Link**
Each TC Decoder shall have one communication path to one RM for transmission of TC Segments
*OptionInfo* : Option TCRM=Yes
*Requirement Rationale* : Makes it possible to program the RM directly from ground.

*Requirement Number* : SAVOIR.OBC.TC.170
**TC to AU Link**
Each TC Decoder shall have one communication path to one Security Function.
*OptionInfo* : Option TCSEC=Yes
*Requirement Rationale* : Allows authentication and/or decryption of incoming TC.

*Requirement Number* : SAVOIR.OBC.TC.180
**FAR Telemetry Output**
Each TC Decoder shall provide its FAR (Frame Analysis Report) for inclusion in Essential TM.
*OptionInfo* : Option HPTM=Yes

*Requirement Number* : SAVOIR.OBC.TC.190
**TC to TM link**
Each TC Decoder shall have one communication path to the Active Platform TM Encoder for transmission of CLCW.
*Requirement Rationale* : The outgoing CLCW contains information on both TC Decoders

### *7.1.5 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 of 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 is able to access TC Decoder status

### *7.1.6 TC Decoder Error Handling*

*Requirement Number* : SAVOIR.OBC.TC.230
**Detection of Telemetry reading errors**
The OBC shall allow the ASW to be notified of 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 about errors in TC Segment distribution to PM.

### *7.1.7 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* : Typical value for <TC_DATARATE>: 64kbit/s

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*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.

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### *7.1.8 TC Parameters*

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*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 is not used according to ECSS-E-ST-50-04C. VC 1 and 2 has a (binary) Hamming distance greater than 1.

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*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.

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## 7.2 Security

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*Requirement Number* : SAVOIR.OBC.SEC.10
**No of Security Functions**
The OBC shall provide two security functions operating in hot redundancy.
*OptionInfo* : Option SEC=Yes
*Requirement Rationale* : Security needs to be in hot redundancy to be able to secure the hot operating TC without reconfiguration.

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*Requirement Number* : SAVOIR.OBC.SEC.12
**Security Protocol**
The Security Function shall apply security services according to the CCSDS Space Data Link Security Protocol (CCSDS 355.0-B-1 Blue Book).
*OptionInfo* : Option SEC=Yes

*Requirement Number* : SAVOIR.OBC.SEC.15
**Security Function Operating Modes**
The Security Function shall operate in two different modes: Secure and Clear mode.
*OptionInfo* : Option TCSEC=Yes

*Requirement Number* : SAVOIR.OBC.SEC.20
**Security Function Mode Selection**
It shall be possible to select the TC Security Function Operating Mode by ground command independently of TM Security Function Operating mode.
*OptionInfo* : Option TCSEC=Yes

*Requirement Number* : SAVOIR.OBC.SEC.30
**Secure Mode**
When in Secure Mode, each Security function shall apply Security Services to the user data according to the Security Association .*OptionInfo* : Option TCSEC=Yes

*Requirement Number* : SAVOIR.OBC.SEC.35
**Clear Mode**
When in Clear Mode, each Security function shall propagate the user data unaltered. The only exception being the TC addressed to control the TC Security Function itself for which the Security Services are applied.
*OptionInfo* : Option TCSEC=Yes

*Requirement Number* : SAVOIR.OBC.SEC.40
**Security Function Algorithms**
The Security Function shall use encryption algorithms as defined in CCSDS 352.0-B-1.
*OptionInfo* : Option TCSEC=Yes
Note (not normative): The preferred baseline implementation modes for ESA missions are specified in CCSDS 355.0-B-1 Annex E.:

- TM: Authenticated Encryption, using AES in the Galois/Counter Mode (GCM) with key length of 128 bits, input initialization vector length of 96 bits and the output MAC is 128 bits long.
- TC: authentication, using the AES algorithm in the Cipher-based Message Authentication Code (CMAC) mode, with key length of 128 bits, the anti-replay sequence number is 32 bits and the output MAC is 128 bits in total length.

*Requirement Number* : SAVOIR.OBC.SEC.50
**Deleted**

*Requirement Number* : SAVOIR.OBC.SEC.60
**Deleted**

*Requirement Number* : SAVOIR.OBC.SEC.70
**Deleted**

*Requirement Number* : SAVOIR.OBC.SEC.80
**Security Function Memory Protection**
Memory Areas which contain confidential information (e.g. keys) shall be protected against access by other than the related crypto elements.
*OptionInfo* : Option TCSEC=Yes

*Requirement Number* : SAVOIR.OBC.SEC.90
**Deleted**

*Requirement Number* : SAVOIR.OBC.SEC.100
**Deleted**

*Requirement Number* : SAVOIR.OBC.SEC.110
**Deleted**

*Requirement Number* : SAVOIR.OBC.SEC.120
**Deleted**

*Requirement Number* : SAVOIR.OBC.SEC.130
**Deleted**

*Requirement Number* : SAVOIR.OBC.SEC.140
**Deleted**

*Requirement Number* : SAVOIR.OBC.SEC.150
**Deleted**

### *7.2.1 Security Interfaces*

*Requirement Number* : SAVOIR.OBC.SEC.160
**TC Communication Path**
Each Security Function shall have a communication path to one TC Decoder.
*OptionInfo* : Option TCSEC=Yes
*Requirement Rationale* : One TC Decoder is always using the same security function for authentication / decryption.

*Requirement Number* : SAVOIR.OBC.SEC.170
**TM Communication Path**
Each Security Function shall have a communication path to one Platform TM Encoder.
*OptionInfo* : Option TMSEC=Yes
*Requirement Rationale* : One TM Encoder is always using the same security function.

### 7.2.2 Security API

*Requirement Number* : SAVOIR.OBC.SEC.180
**AU status telemetry**
The OBC shall allow the ASW to read the following information:
* enable/disable status of the TC Authentication
* Key ID in use
* Last TC authenticated
* Anti-Replay state status
* Last AU control command executed
* Authentication error reports
*OptionInfo* : Option TCSEC=Yes

### 7.2.3 Security Performance

*Requirement Number* : SAVOIR.OBC.SEC.190
**Security TM Performance**
The security function shall not limit the TM downlink performance.
*OptionInfo* : Option TMSEC=Yes
*Requirement Rationale* : It is possible to enable and disable the encryption function without altering the downlink performance or settings.

*Requirement Number* : SAVOIR.OBC.SEC.200
**Security TC Performance**
The security function shall not limit the TC uplink performance.
*OptionInfo* : Option TCSEC=Yes
*Requirement Rationale* : It is possible to enable and disable the encryption without altering the uplink performance.

## 7.3 Essential TC

### 7.3.1 Essential TC Configuration

*Requirement Number* : SAVOIR.OBC.ETC.10
**No of Essential TCs**
The OBC shall provide two Essential TC functions operating in hot redundancy.

### *7.3.2 Essential TC Function*

*Requirement Number* : SAVOIR.OBC.ETC.20
**Essential TC control**
Each Essential TC function shall accept commands from either the TC Decoder, at least one RM or from the Active PM.

Note: The Active PM needs to be connected to one of the Essential TC functions. This makes it possible to change to the other Essential TC function in case of a failure - there does not need to be a link active to each Essential TC from the Active PM.

*Requirement Number* : SAVOIR.OBC.ETC.30
**Deleted**

*Requirement Number* : SAVOIR.OBC.ETC.40
**Essential TC command source priority 1**
In case of simultaneous access to the Essential TC by multiple sources (TC Decoder, RM or PM), a Source Selection Mechanism implementation shall ensure that:
* Commands from an RM are never discarded nor aborted (highest priority)
* Commands from ground are never discarded, can be aborted by incoming RM commands
* Commands from Active PM may be discarded
*Requirement Rationale* : The RM has the most recent information and is therefore not be interruptible.

*Requirement Number* : SAVOIR.OBC.ETC.45
**Essential TC command source priority 2**
The OBC shall grant Ground the exclusive control of the Essential TC function by excluding both RM and PM from the Source Selection Mechanism. Exclusive control is entered either by Ground command or in case of failure.
Requirement Rationale: ground operator has the capability to solely control the S/C in contingency phases.

*Requirement Number* : SAVOIR.OBC.ETC.50
**Deleted**

*Requirement Number* : SAVOIR.OBC.ETC.60
**Essential TC command processing**
Each Essential TC function shall process the commands according to ECSS-E-70-41A Annex D2.

*Requirement Number* : SAVOIR.OBC.ETC.70
**PM lockout**
It shall be possible to inhibit the PM from commanding selected CPDU Pulse Commands.
*Requirement Rationale* : This makes it possible to protect critical CPDU commands from malfunctioning software. Inhibiting the RM from CPDU Pulse Commands is handled by correctly programming the reconfiguration sequences.

### *7.3.3 Essential TC Interfaces*

*Requirement Number* : SAVOIR.OBC.ETC.80
**Essential TC TC Input**
Each Essential TC Function shall have an input communication path from one TC Decoder
*Requirement Rationale* : Used for CPDU commands sent from ground

*Requirement Number* : SAVOIR.OBC.ETC.90
**Essential TC RM Input**
Each Essential TC Function shall have an input communication path from one RM
*Requirement Rationale* : Used for autonomous low-level reconfiguration (e.g. PM switchover)

*Requirement Number* : SAVOIR.OBC.ETC.100
**Essential TC PM Input**
Each Essential TC Function shall have an input communication path from the Active PM
*Requirement Rationale* : Used for autonomous commanding handled by the ASW

*Requirement Number* : SAVOIR.OBC.ETC.110
**CPDU Pulse Output Interface**
The external CPDU Pulse Commands electrical interface shall be of type HV-HPC
Note: HV-HPC signals are defined in ECSS-E-ST-50-14C

*Requirement Number* : SAVOIR.OBC.ETC.120
**CPDU Pulse Command source**
Each Essential TC Function shall distribute <CPDU_Pulse#>CPDU Pulse Commands using the CPDU function.
*Requirement Rationale* : Range of <CPDU_Pulse#> is 32 to 128 for the missions considered by SAVOIR.

*Requirement Number* : SAVOIR.OBC.ETC.130
**Reconfiguration Control**
Each Essential TC function shall have a communication path to each reconfiguration module.
*Requirement Rationale* : Used to enable/disable the RMs individually. Makes it possible to turn off a malfunctioning RM from ground or the functional RM.

### 7.3.4 Essential TC API

*Requirement Number* : SAVOIR.OBC.ETC.140
**PM CPDU packets**
The OBC shall allow the ASW to issue CPDU Pulse Commands from the specified Essential TC Function.

*Requirement Number* : SAVOIR.OBC.ETC.150
**Essential TC telemetry**
The OBC shall allow the ASW to read the following minimum telemetry data from the Essential TC Function:
- CPDU STATUS REPORT

### 7.3.5 Essential TC Error Handling

*Requirement Number* : SAVOIR.OBC.ETC.160
**Detection of Essential TC Function communication errors**
The OBC shall allow the ASW to be notified of errors during communication with the Essential TC Function.

*Requirement Number* : SAVOIR.OBC.ETC.170
**Handling of Essential TC Function communication errors**
The OBC shall allow the ASW to restart the communication with the specified Essential TC Function.

*Requirement Number* : SAVOIR.OBC.ETC.180
**Handling of Essential TC Function execution errors**
The OBC shall allow the ASW to check for the following errors:
- Attempted Illegal PM command
- Command abortion during execution of CPDU Packets

### 7.3.6 Essential TC Parameters

*Requirement Number* : SAVOIR.OBC.ETC.190
**Value of Essential TC configuration parameters**
The Essential TC parameters shall be:
- CPDU application ID <CPDU_APID>
*Requirement Rationale* : Standard value for <CPU_APID>: 0. Based on heritage.

## 7.4 Platform TM Encoder

### *7.4.1 Platform TM Encoder Configuration*

*Requirement Number* : SAVOIR.OBC.TM.10
**No of Platform TM Encoders**
The OBC shall provide two Platform TM Encoders operating in cold redundancy.
Note : The TM Encoder operating/enabled is called active TM Encoder

### *7.4.2 Platform TM Encoder Function*

*Requirement Number* : SAVOIR.OBC.TM.20
**Initial TM configuration**
All parameters necessary to encode TM frames at OBC power-on (bit rate, coding, frame length, SCID, VCs used, Security Association, etc...) shall be automatically configured at power-on without ASW involvement.
*Requirement Rationale* : The spacecraft shall always be able to transmit TM regardless of the state of the processing functions

*Requirement Number* : SAVOIR.OBC.TM.30
**Platform TM Encoder in-flight programming**
It shall be possible to change parameters of the active Platform TM Encoder.
*Requirement Rationale* : Different mission phases may require different telemetry settings

*Requirement Number* : SAVOIR.OBC.TM.40
**Selecting Active Platform TM Encoder**
It shall be possible to select the Active Platform TM Encoder in at least one of the following ways:
* via CPDU Command
* via ASW
*Requirement Rationale* : Both concepts are used by current hardware.

*Requirement Number* : SAVOIR.OBC.TM.50
**Platform TM Encoder processing**
The active Platform TM Encoder shall support a telemetry transfer frame protocol in accordance with ECSS-E-ST-50-03C Clause 5.

*Requirement Number* : SAVOIR.OBC.TM.60
**Platform TM Encoder processing**
The active Platform TM Encoder shall support synchronization and channel coding in accordance with ECSS-E-ST-50-01C Clause 4.

*Requirement Number* : SAVOIR.OBC.TM.70
**No of Virtual Channels**
The Active Platform TM Encoder shall support up to 8 Virtual Channels

*Requirement Rationale* : Maximum number of channels according to ECSS-E-ST-50-03C

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*Requirement Number* : SAVOIR.OBC.TM.80
**Platform TM Encoder VC multiplexing**
The Active Platform TM Encoder shall support a VC multiplexing scheme that allows a minimum guaranteed bandwidth for each VC.
*Requirement Rationale* : Ensures that a single channel cannot steal all available bandwidth . Other options (e.g. priority mode) are possible but not required.

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*Requirement Number* : SAVOIR.OBC.TM.90
**Virtual Channel allocation**
The following Virtual Channel allocation should be implemented:

VC0: Real Time TM from the Active PM
VC1: Essential TM
VC2: TM from the Platform Data Storage (Platform Data)
VC3: TM from the Platform Data Storage
VC4: Reserved (Can be used for Payload downlink)
VC5: Reserved (Can be used for Payload downlink)
VC6: Reserved (Can be used for extra PM TM link)
VC7: Idle Frames only

Note: This is only a recommendation to unify the settings of different OBCs. In case the spacecraft have dual downlinks these links can have the same Spacecraft ID or different Spacecraft ID. If the Spacecraft ID is the same there cannot be the same VC on the two links unless the VCs carry the same information. , e.g. Idle Frames only. If the Spacecraft ID is different there is no limitation in VC allocation between the two downlinks.

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*Requirement Number* : SAVOIR.OBC.TM.100
**Idle Packet generation**
Idle packets shall be automatically inserted in accordance with ECSS-E-ST-50-03C Clause 5.4.3.2.

Note: This can be done via a timeout mechanism that inserts idle packets when a frame has not been sent within a certain time period. Some VCs e.g. Real-Time TM and Essential TM may not require automatic Idle Packet insertion due to the continuous nature of the data.
*Requirement Rationale* : Ensures that frames are released within a given time. This is typically needed when the data source of a Virtual Channel generates data in bursts with long idle intervals.

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*Requirement Number* : SAVOIR.OBC.TM.110
**TM Time Strobe generation**
The active Platform TM Encoder shall send a synchronization strobe to the OBT to trigger

the sampling of the OBC OBT (ECSS-E-70-41A Clause C.4 Spacecraft time correlation procedures)

Note: For missions with GNSS receivers this function is not needed as long as the GNSS receivers are operational.
*Requirement Rationale* : The OBT value is latched in the 'telemetry datation' register on occurrence of a datation pulse (TM Time Strobe) commanded by Ground , the content of register is then sent in the on-board time packet for on-board time / ground time synchronization : the relation between On-Board time and UTC on ground must be known.

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*Requirement Number* : SAVOIR.OBC.TM.120
**TM data waveforms**
The TM Encoder shall support NRZ-L, NRZ-M and SP-L waveforms.
*Requirement Rationale* : Based on heritage and previous designs. Other output types are possible but not required.

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*Requirement Number* : SAVOIR.OBC.TM.130
**TM data stream coding**
The TM encoder shall provide the possibility to combine different coding schemes as specified in ECSS-E-ST-50-01C and CCSDS 131.0-B-2 limited to the option for Low-Density Parity-Check (LDPC) Codes (section 7).
For other options, ECSS-E-ST-50-01C prevails.

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*Requirement Number* : SAVOIR.OBC.TM.140
**Deleted**

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*Requirement Number* : SAVOIR.OBC.TM.150
**Deleted**

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*Requirement Number* : SAVOIR.OBC.TM.160
**TM data stream Synchronization**
The OBC shall support Frame Synchronization according to ECSS-E-ST-50-01C §8

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*Requirement Number* : SAVOIR.OBC.TM.170
**TM data scrambling**
The OBC shall support pseudo-randomisation of data according to ECSS-E-ST-50-01C §9.

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*Requirement Number* : SAVOIR.OBC.TM.180
**TC Decoder selection for CLCW retrieval**
It shall be possible to configure the Platform TM Encoder to retrieve the CLCW alternately from the two TC Decoders.
*Requirement Rationale* : Information on both TC decoders is mandatory for full spacecraft operation.

*Requirement Number* : SAVOIR.OBC.TM.185
**Deleted**

*Requirement Number* : SAVOIR.OBC.TM.190
**TM Security Function**
The Active TM Encoder shall be able to

- Use the Security Function to encrypt TM frames before they are downlinked to ground

*OptionInfo* : Option TMSEC=Yes
*Requirement Rationale* : Allows encryption of TM data stream

### *7.4.3 Platform TM Encoder Interfaces*

*Requirement Number* : SAVOIR.OBC.TM.200
**Platform TM Encoder CLCW input**
The Active Platform TM Encoder shall have one communication path from each TC function.
*Requirement Rationale* : Required for CLCW data inclusion in the downlink

*Requirement Number* : SAVOIR.OBC.TM.210
**Platform TM Encoder Essential TM Input**
The Active Platform TM Encoder shall have one communication path from the Active Essential TM.
*OptionInfo* : Option HPTM=Yes
*Requirement Rationale* : For downlink of TM packets

*Requirement Number* : SAVOIR.OBC.TM.220
**Platform TM Encoder PM input**
The Active Platform TM Encoder shall have one communication path from the Active PM.
*Requirement Rationale* : For downlink of TM packets and configuration of the Active TM Encoder

*Requirement Number* : SAVOIR.OBC.TM.230
**Platform TM Encoder PFDS inputs**
The Active Platform TM Encoder shall have a communication path with the Platform Data Storage
*Requirement Rationale* : For downlink of TM packets

*Requirement Number* : SAVOIR.OBC.TM.240

**Platform TM Encoder Security Interface**
The Active Platform TM Encoder shall have a communication path with the Security Function
*OptionInfo* : Option TMSEC=Yes
*Requirement Rationale* : For encryption of TM

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*Requirement Number* : SAVOIR.OBC.TM.250
**Space Packet size**
The Active Platform TM Encoder shall support Space Packets with a maximum size according to ECSS-E-70-41A Clause 5.4 .
*Requirement Rationale* : The maximum supported packet size must be stated and may differ between payload and platform data.

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*Requirement Number* : SAVOIR.OBC.TM.260
**TM Time Strobe output interface**
The Active Platform TM Encoder shall provide an output synchronization event to the Master OBT function
*Requirement Rationale* : For the TM Time Strobe synchronization event. Allows synchronization according to PUS.

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*Requirement Number* : SAVOIR.OBC.TM.270
**Platform TM Encoder status in Essential TM**
It shall be possible to include the Platform TM Encoder selection status in the Essential TM
*OptionInfo* : Option HPTM=Yes

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### *7.4.4 Platform TM Encoder External Output*

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*Requirement Number* : SAVOIR.OBC.TM.280
**Platform TM Encoder output cross-strapping 1**
The OBC shall have output interfaces to drive <TM_OUTPUTS> transmitters using one link to each transmitter.
*Requirement Rationale* : Typical values for <TM_OUTPUTS>:
2 - Used when there is only one communication band
4 - Typical telecom project

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*Requirement Number* : SAVOIR.OBC.TM.290
**EGSE output**
The Active Platform TM Encoder shall provide an interface to send telemetry data to an EGSE.

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*Requirement Number* : SAVOIR.OBC.TM.300

**Platform TM Encoder output cross-strapping 2**
The same physical outputs shall be used regardless of which TM is active. This does not apply to the EGSE outputs.

Note: This infers that a selection mechanism is required before the output buffers to select the correct TM data stream.

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*Requirement Number* : SAVOIR.OBC.TM.310
**Deleted**

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*Requirement Number* : SAVOIR.OBC.TM.320
**Platform TM Encoder output interface**
The Platform TM Encoder output interfaces shall be

* NRZ-L encoded I, Q channels and Clock (If IQ-modulation is used)
* NRZ-L encoded Data and clock (If any other modulation is used)

*Requirement Rationale* : Data + Clock Interface is the simplest solution but I, Q output is required for some QPSK cases. I/Q from the OBC is needed when convolutional coding is performed in the OBC or if there is no convolutional coding at all on the downlink. The transmitter does not normally know which bits are I or Q.

---

*Requirement Number* : SAVOIR.OBC.TM.330
**Platform TM Encoder EGSE output interface**
The Platform TM Encoder EGSE output interface shall be
* I, Q and Clock (If IQ-modulation is used)
* Data and clock (If any other modulation is used)

---

*Requirement Number* : SAVOIR.OBC.TM.340
**TM Time Strobe output**
The Active Platform TM Encoder shall have one output interface for the TM Time Strobe pulse.
*OptionInfo* : Option ACCUR_TIME=Yes
*Requirement Rationale* : Used in missions without GNSS receivers, requiring very accurate On-Board Time knowledge and where the OBT sampling is performed by a payload unit that, for instance, includes an atomic clock.

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*Requirement Number* : SAVOIR.OBC.TM.350
**Deleted**

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*Requirement Number* : SAVOIR.OBC.TM.360
**TM Output Interfaces**
The Platform TM Encoder Outputs, Platform TM Encoder EGSE Output, TM Time Strobe Output and Time Strobe test point shall be of type SDI.

*Requirement Rationale* : The SDI interface is in most cases more than sufficient for the data rates required from a Platform TM Encoder. SDI electrical characteristics are defined in clause 8.8 of ECSS-E-ST-50-14C

---

*Requirement Number* : SAVOIR.OBC.TM.365
**External TM Security Unit**
The Active Platform TM Encoder shall support the connection of an external security function operating at the frame level.

Note 1: This can be implemented by adding a large secondary header that provides space for the security function to add security specific information such as key id.

Note 2: In typical systems with the external TM Security unit is connected between the Platform Telemetry Encoder and the transmitter, the encrypted / signed data stream does not return to the telemetry function.
*OptionInfo* : Option EXTTMSEC=Yes
*Requirement Rationale* : Used when the internal security function is not good enough.

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### *7.4.5 Platform TM Encoder API*

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*Requirement Number* : SAVOIR.OBC.TM.370
**Real-time TM input**
The OBC shall allow the ASW to send Real-time TM to the PM Virtual Channel(s) of the Active Platform TM Encoder.

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*Requirement Number* : SAVOIR.OBC.TM.380
**Selecting Active Platform TM Encoder via ASW**
The OBC shall allow the ASW to select the Active Platform TM Encoder.

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*Requirement Number* : SAVOIR.OBC.TM.390
**TM ASW Encoder status**
The OBC shall allow the ASW to read the Platform TM Encoder selection status.

---

*Requirement Number* : SAVOIR.OBC.TM.400
**Downlink configuration change**
The OBC shall allow the ASW to change at least the following downlink configurations:

Symbol rate: *(If different choices are available)*

Reed-Solomon coding: *(On or Off)*
Turbo coding: *(Rate or Off)*
Pseudo-randomiser: *(On or Off)*
Modulating waveform: (NRZ-L, NRZ-M, SP-L)
Convolutional coding: *(On or Off)*
Convolutional coding rate: *(1/2, 2/3, 3/4, 5/6, 7/8)*

Modulation: *(If different choices are available)*
Time Strobe Assertion: Every X frame
VC Multiplexing Method: *(if different choices are available)*
Note: Typical parameters for a project are the following: [ The settings are not required, just recommended unless the project has specific needs.]

Configuration:
Symbol rate: Mission Specific
Reed-Solomon coding: On (255,223)
Turbo coding: Off
Pseudo-randomiser: On
Modulating waveform: NRZ-L
Convolutional coding: Off (Done in transponder)
Convolutional coding rate: 1/2
Frame Length: 1115
FECW: Off
OPCF: On

Modulation: None *(None, SP-L, I/Q or PSK)*
Time Strobe Assertion: Mission Dependant
VC Multiplexing Method: BAT or other methods

*Requirement Rationale* : Different mission phases may require different telemetry settings

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*Requirement Number* : SAVOIR.OBC.TM.410
**VC ASW multiplexing programming**
The OBC shall allow the ASW to modify the VC Multiplexing scheme.

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*Requirement Number* : SAVOIR.OBC.TM.420
**Support for Spacecraft Time Packet generation**
The OBC shall allow the ASW to be notified at the occurrence of the TM Time Strobe event.

### *7.4.6 Platform TM Encoder Configuration Parameters*

*Requirement Number* : SAVOIR.OBC.TM.430
**TM Transfer Frame length**
If Reed-Solomon is used the Transfer Frame length shall be selectable between the values according to ECSS-E-ST-50-01C Clause C.3

*Requirement Number* : SAVOIR.OBC.TM.440
**TM Transfer Frame length**
If Turbo Coding is used the Transfer Frame length shall be selectable between the values according to ECSS-E-ST-50-01C Clause C.4

*Requirement Number* : SAVOIR.OBC.TM.450
**TM Time Strobe rate**
The TM Time Strobe generation rate shall be selectable to occur at the intervals of Virtual Channel 0 frames according to ECSS-E-70-41A Clause C.4

*Requirement Number* : SAVOIR.OBC.TM.460
**Synch marker**:
The Attached synchronization Marker shall be according to ECSS-E-ST-50-01C Clause 8.3

*Requirement Number* : SAVOIR.OBC.TM.470
**Secondary Header**
The OBC shall support the inclusion of a secondary header according to ECSS-E-ST-50-03C Clause 5.3, with as a minimum the Extended virtual channel frame count (Clause 5.3.4).

*Requirement Number* : SAVOIR.OBC.TM.480
**FECW Field**
The OBC shall support the inclusion of the FECW field according to ECSS-E-ST-50-03C Clause 5.6

*Requirement Number* : SAVOIR.OBC.TM.490
**CLCW Field**
The OBC shall support the inclusion of the CLCW field according to ECSS-E-ST-50-03C Clause 5.5 (Type-1-Report)

*Requirement Number* : SAVOIR.OBC.TM.500
**Deleted**

### *7.4.7 Platform TM Encoder Error Handling*

*Requirement Number* : SAVOIR.OBC.TM.510
**Detection of Platform TM Encoder communication errors**
The OBC shall allow the ASW to be notified at errors during communication with the Platform TM Encoder.

*Requirement Number* : SAVOIR.OBC.TM.520
**Handling of TM communication errors**
The OBC shall allow the ASW to separately restart the communication between a Platform TM Encoder and the PM.

*Requirement Number* : SAVOIR.OBC.TM.530
**Deleted**

### *7.4.8 Telemetry Performance*

*Requirement Number* : SAVOIR.OBC.TM.540
**Deleted**

*Requirement Number* : SAVOIR.OBC.TM.550
**Real-time TM data rate**
The OBC shall support transfer of Real Time TM packets from the PM at transfer rates up to <TM_RTDATARATE>.
*Requirement Rationale* : Typical value for <TM_RTDATARATE>: 10-20 kbps

*Requirement Number* : SAVOIR.OBC.TM.560
**Deleted**

*Requirement Number* : SAVOIR.OBC.TM.570
**PFDS data rate**
The OBC shall support transfer of TM data from the Platform Data Storage at transfer rates up to <TM_PFDSDATARATE> per Virtual Channel.
*Requirement Rationale* : Typical value for <TM_PFDSDATARATE>: 1Mbps

*Requirement Number* : SAVOIR.OBC.TM.571
**PFDS packet rate**
The OBC shall support transfer of TM data from the Platform Data Storage at a rate of up to <TM_PFDSRATE> per Virtual Channel.
*Requirement Rationale* : Typical value for <TM_PFDSRATE>: 5000 packets / s.

*Requirement Number* : SAVOIR.OBC.TM.580
**Output data rate**
The OBC shall support output symbol transfer rates up to <TM_DATARATE> Mbps
*Requirement Rationale* : Typical value for <TM_DATARATE>: 2 Msymbols/s.
1Mbps is enough for Platform data and results in approximately 2,3 Msymbols/s on the output link when R-S coding with interleave depth = 5 and convolutional coding is applied. If the Payload TM is included in the same functional block higher rates may be required.

*Requirement Number* : SAVOIR.OBC.TM.590
**Output data rate stability**
The long, medium and short term stability and accuracy of the output data transfer rate shall be according to ECSS-E-ST-50-05C Rev 2Clause 6.1.4.2.2

*Requirement Number* : SAVOIR.OBC.TM.600
**TM Time Strobe test point delay**
The time delay between the first bit of the Attached Sync Marker and the TM Time Strobe test signal shall be known and stable to an accuracy better than +/- <TM_TIMESTROBEACC>.
*Requirement Rationale* : Typical value for <TM_TIMESTROBEACC>: 50 ns.

## 7.5 Processing (PM) Function

### *7.5.1 PM Configuration*

*Requirement Number* : SAVOIR.OBC.PM.10
**No of Processor Module functions**
The OBC shall provide two PM functions operating in warm or cold redundancy.

*Requirement Number* : SAVOIR.OBC.PM.20
**Active PM Definition**
It shall be possible to operate the PM functions in an Active / Inactive scheme.

Note: The Active PM executes the nominal ASW and has access to avionics interfaces. The Inactive PM runs in a limited functionality mode mainly used for test, reprogramming, or fast switchover purposes.

### *7.5.2 PM Function*

*Requirement Number* : SAVOIR.OBC.PM.30
**Selecting Active PM function**
It shall be possible to configure active and inactive PMs via a CPDU Pulse Command which is also accessible from ground or from the Reconfiguration Unit.
*Requirement Rationale* : In case of a PM malfunction autonomous or ground driven reconfiguration may be necessary

*Requirement Number* : SAVOIR.OBC.PM.40
**Only one Active PM**
No single fault shall result in both PMs becoming Active.

*Requirement Number* : SAVOIR.OBC.PM.50
**Active PM function performance**
The Active PM shall fulfil all performance requirements independently of whether the Inactive PM is powered/operating/working correctly or not.
*Requirement Rationale* : Occurrence of failure(s) in one of the two PM does not produce a degradation of the mission

*Requirement Number* : SAVOIR.OBC.PM.60
**TC Reception**
The Active PM shall be able to receive TC Segments from the TC communication paths.
*Requirement Rationale* : Makes it possible to send commands to ASW from ground.

*Requirement Number* : SAVOIR.OBC.PM.70
**SGM Data**
The Active PM shall be able read data from and write data to both SGM functions,

*Requirement Number* : SAVOIR.OBC.PM.80
**SGM Data Inactive PM**
The Inactive PM shall be able to receive data from both SGM functions.

Note: This may be implemented by the inter-pm path or by the inactive PM reading the SGMs.

*Requirement Number* : SAVOIR.OBC.PM.90
**Inactive PM Reprogramming**
The Active PM shall be able to read from and write to the software storage memory of the Inactive PM via the inter-PM path.
*Requirement Rationale* : Allows reprogramming of the ASW of the inactive PM from ground (refer to SAVOIR.OBC.PM.250 for a definition of software storage memory)

*Requirement Number* : SAVOIR.OBC.PM.100
**OBT Time Ticks**
The Active PM shall receive the time tick used for the software cycle generated by the OBT function.

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*Requirement Number* : SAVOIR.OBC.PM.110
**OBT Time Ticks Inactive PM**
The Inactive PM shall receive the time tick used for the software cycle generated by the OBT function.
*OptionInfo* : Option InactivePMTick=Yes
*Requirement Rationale* : If the software used for the inactive PM needs time ticks to function.

---

*Requirement Number* : SAVOIR.OBC.PM.120
**OBT Time Data**
The Active PM shall be able to read the current OBT Time from the OBT function.

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*Requirement Number* : SAVOIR.OBC.PM.130
**OBT Time Data Inactive PM**
The Inactive PM shall have access to the current OBT Time from the OBT function.

Note: This may be implemented by the inter-pm path or by the inactive PM reading the OBT.
*OptionInfo* : Option InactivePMOBT=Yes
*Requirement Rationale* : Required if the Inactive PM runs back-up software that needs to know the current time.

---

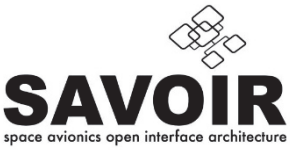
*Requirement Number* : SAVOIR.OBC.PM.140
**Mission Data Link**
Only the Active PM shall be able to send and receive data using the Mission Data Link
*Requirement Rationale* : Allows platform and payload communication

---

*Requirement Number* : SAVOIR.OBC.PM.150
**Command & Control Link**
Only the Active PM shall be able to send commands and receive data using the Command & Control Link
*Requirement Rationale* : Allows platform and payload communication

---

*Requirement Number* : SAVOIR.OBC.PM.160
**Configuration Destinations**
Only the Active PM shall be able to configure at least the following functions:
- Both Platform TM Encoders
- Both Platform Data Storage Functions (If used in warm redundancy)
- Both On-Board Time Functions





- Both Reconfiguration Module Functions (If used in warm redundancy and when they are not Active)
- Both Safe Guard Memory Functions
- Mission Data Links
- Command & Control Links

*Requirement Rationale* : If changes to the RM are done by ASW they are initiated by ground control.

---

*Requirement Number* : SAVOIR.OBC.PM.170
**Active PM CPDU Generation**
Only the Active PM shall be able to send commands via an Essential TC Function
*Requirement Rationale* : Allows PM to reconfigure the spacecraft

---

*Requirement Number* : SAVOIR.OBC.PM.180
**TM Packet Generation**
The Active PM shall be able to send TM data to the Active TM Encoder
*Requirement Rationale* : Allows PM to send TM to ground

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*Requirement Number* : SAVOIR.OBC.PM.190
**PFDS Communication**
The Active PM shall be able to read and write data and packets to both Platform Data Storage functions

---

*Requirement Number* : SAVOIR.OBC.PM.200
**Death Report**
The Active PM shall be able to initialize and generate a Death Report that may include information from the ASW.
*Requirement Rationale* : A Death Report aids anomaly investigations on ground. The ASW may provide useful higher level context.

---

*Requirement Number* : SAVOIR.OBC.PM.210
**Death Report Location**
The Death Report shall be stored in a memory that is independent from the Active PM fault containment group.

Note: This may, but is not required to be, the SGM
*Requirement Rationale* : The Death Report is accessible regardless of the state of the malfunctioning PM. Malfunction of a PM includes unplanned power cycling of the PM

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*Requirement Number* : SAVOIR.OBC.PM.220
**Death Report Access**
The Active PM shall be able to access the Death Report from both the Active and the Inactive PM.

*Requirement Rationale* : The Death Report is accessible regardless of the state of the malfunctioning PM. Malfunction of a PM includes unplanned power cycling of the PM

### *7.5.3 PM Function: Memory*

*Requirement Number* : SAVOIR.OBC.PM.230
**Boot Memory**
Each PM function shall have a non-volatile memory used for storage of the Boot Software.
*Requirement Rationale* : The boot software is run at power-up and its memory is thus non-volatile

*Requirement Number* : SAVOIR.OBC.PM.240
**Boot Memory Write Protection**
Boot memory shall be write protected.
*Requirement Rationale* : The boot is the most basic software and is protected from ASW

*Requirement Number* : SAVOIR.OBC.PM.250
**Software Storage Memory**
Each PM function shall have at least <CPUNVM> MiBytes of non-volatile memory for storing independent software images.

Note: Typical size of a software image today is ~2MiByte. Future expected requirement is ~4MiByte.
Software images may also contain data like system parameters and On-Board Control Procedures (OBCP).

*Requirement Number* : SAVOIR.OBC.PM.260
**Software Storage Memory, Write protection default state**
After PM power on all software storage memory write protections shall be in enabled state, i.e. writing prohibited.
*Requirement Rationale* : The default power-up mode is as safe as possible.

*Requirement Number* : SAVOIR.OBC.PM.270
**Software Storage Memory, reprogramming cycles**
It shall be possible to disable/enable the write protection of the software storage memory and rewrite each byte of the software storage memory <SWstorage_mem_programming_cycle#> during the OBC lifetime.
Note : typical value of <SWstorage_mem_programming_cycle#> is 1000
*Requirement Rationale* : Number based on limitations in typical implementations (e.g. EEPROM), for long life mission the typical value can be reduce down to 200

*Requirement Number* : SAVOIR.OBC.PM.280
**CPU Working Memory**
The PM function shall have at least <CPURAM> MiBytes of Random Access Memory (RAM) for data and software execution.
*Requirement Rationale* : Typical Value for <CPURAM>: At least 8 MiBytes.

*Requirement Number* : SAVOIR.OBC.PM.290
**Memory Protection**
All OBC memories shall be protected from radiation induced errors (SEU, SEFI, SEL).

Note: Some memory types (e.g. PROM) will not need any error correcting protection.
*Requirement Rationale* : Implementation details may differ depending on the chosen memory technologies.

*Requirement Number* : SAVOIR.OBC.PM.295
**Uncorrectable error effects**.
The number of OBC outages due to uncorrectable memory errors shall be less than <ERRORS#> over Mission Service Lifetime.

*Requirement Number* : SAVOIR.OBC.PM.296
**SEU reporting and visibility**.
For volatile memory SEU protection means that:
for each implemented memory type:

- correctable errors shall be counted
- uncorrectable error shall be detected, time tagged and location shall be reported to PM
- SEFI and SEL shall be time tagged and errors/failure location shall be reported to PM

*Requirement Number* : SAVOIR.OBC.PM.297
**Non-volatile Memory Data Retention**.
The PM shall provide non-volatile memory with a data retention time of at least <Data Retention Time 1> from hardware unit manufacturing to launch + <Data Retention Mission time 2>.

Note Source is SAVOIR.MMSRD.GEN.110 (SAVOIR MASAIS System Req Document)

### 7.5.4 PM Interfaces

*Requirement Number* : SAVOIR.OBC.PM.300
**Inter-PM Communication Path**
The Active PM shall have a communication path to the Inactive PM.
*Requirement Rationale* : This path can be used for configuration of the inactive PM via the active PM or to send time/SGM content to the inactive PM.

*Requirement Number* : SAVOIR.OBC.PM.310
**PM OBT Communication Path**
The Active PM shall have a communication path to each OBT.
*Requirement Rationale* : This path is used for transferring time and configuring the OBT.

*Requirement Number* : SAVOIR.OBC.PM.320
**PM OBT Synchronization Path 1**
The Active PM shall have a synchronization path to the Master OBT.
*Requirement Rationale* : This synchronization path is used for distributing time ticks used to initiate Software Cycles.

*Requirement Number* : SAVOIR.OBC.PM.330
**PM OBT Synchronization Path 2**
The Inactive PM shall have a synchronization path to the Master OBT.
*OptionInfo* : Option InactivePMTick=Yes
*Requirement Rationale* : This synchronization path is used for distributing time ticks used to initiate Software Cycles.

*Requirement Number* : SAVOIR.OBC.PM.340
**PM PFDS Communication Path**
The Active PM shall have a communication path to each Platform Data Storage.
*Requirement Rationale* : This path is used for data transfers and configuration of the PFDS.

*Requirement Number* : SAVOIR.OBC.PM.350
**PM TM Communication Path**
The Active PM shall have a communication path to the Active Platform TM Encoder.
*Requirement Rationale* : used for packet downlink and configuration of the Active TM.

*Requirement Number* : SAVOIR.OBC.PM.360
**PM TC Communication Path**
The Active PM shall have a communication path to each TC Decoder.
*Requirement Rationale* : This path is used for TC segment transfer to the Active PM.

*Requirement Number* : SAVOIR.OBC.PM.370
**PM Essential TC Communication Path**
The Active PM shall have a communication path to one Essential TC function.
*Requirement Rationale* : Used for ASW reconfiguration of the spacecraft

---

*Requirement Number* : SAVOIR.OBC.PM.380
**PM Reconfiguration Communication Path**
The Active PM shall have a communication path to each RM.
*Requirement Rationale* : This path is used for reconfiguration of the RM function and to send alarms from the Active PM to the RMs.

---

*Requirement Number* : SAVOIR.OBC.PM.390
**PM SGM Communication Path**
The Active PM shall have a communication path to each SGM.
*Requirement Rationale* : This path is used for storage of context data, boot report etc.

---

*Requirement Number* : SAVOIR.OBC.PM.400
**PM Discrete Parallel IO Communication Path**
The Active PM shall have a communication path to the Active Discrete Parallel IO function.
*OptionInfo* : Option PIO=YES PMPIO=YES
*Requirement Rationale* : Can be used for software execution measurements, fast response to external events or interrupts.

---

*Requirement Number* : SAVOIR.OBC.PM.410
**PM Mission Data Link Communication Path**
The Active PM shall have a communication path to one Mission Data Link Function.
*Requirement Rationale* : This path is used for external communication.

---

*Requirement Number* : SAVOIR.OBC.PM.420
**PM Cmd & Ctrl Data Link Communication Path**
The Active PM shall have a communication path to one Cmd & Ctrl Link Function.
*Requirement Rationale* : This path is used for external ASW communication.

---

*Requirement Number* : SAVOIR.OBC.PM.425
**PM PVT Communication Path**
The Active PM shall have a communication path to the Active Position/ Velocity Sensor and Time Reference functions.
*Requirement Rationale* : This path is used for controlling and monitoring the PVT functions.
*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.PM.430
**PM Test Interface**
Each PM shall supply a test interface to itself. The test interface capabilities are implementation specific.
*Requirement Rationale* : Can be used for testing, debugging or supervision during development and final testing.

*Requirement Number* : SAVOIR.OBC.PM.440
**PM status in Essential TM**
The PM power on/off status of both PMs and the Active/Inactive status shall be available to the Essential TM.
*OptionInfo* : Option HPTM=Yes

*Requirement Number* : SAVOIR.OBC.PM.450
**Deleted**

*Requirement Number* : SAVOIR.OBC.PM.460
**Deleted**

*Requirement Number* : SAVOIR.OBC.PM.470
**Deleted**

*Requirement Number* : SAVOIR.OBC.PM.480
**Software Storage Memory write protection status in Essential TM**
The write protection status of the Software Storage Memory both PMs shall be available to the Essential TM
*OptionInfo* : Option HPTM=Yes

### *7.5.5 PM API*

*Requirement Number* : SAVOIR.OBC.PM.490
**Deleted**

*Requirement Number* : SAVOIR.OBC.PM.500
**PM Active/Inactive status**
The OBC shall allow the ASW to retrieve the PM Active/Inactive status.

*Requirement Number* : SAVOIR.OBC.PM.510
**PM memory access**
The PM shall allow the ASW to access to all PM memory and registers, except writing to the write-protected areas.
*Requirement Rationale* : Gives ground access to as much information as possible to aid post mortem investigations and to perform routine operations such as SW patching.

*Requirement Number* : SAVOIR.OBC.PM.520
**Software Storage Memory Write**
The PM shall allow the ASW to write the PM Software Storage Memory that is enabled for write operation.
*Requirement Rationale* : To ensure that the ground operator can only overwrite a software image that is intended to be changed. PM Software Storage memories are enabled/disabled for write operation by Ground commands.

*Requirement Number* : SAVOIR.OBC.PM.530
**Local Boot Report Reading**
The OBC shall allow the ASW to read the Boot report of the local PM.
Note: Implies that it is also readable by Boot SW

*Requirement Number* : SAVOIR.OBC.PM.540
**Redundant Boot Report Reading**
The OBC shall allow the ASW to read the Boot report of the redundant PM.

*Requirement Number* : SAVOIR.OBC.PM.550
**Software Storage Memory write protection status telemetry**
The OBC shall allow the ASW to read the write protection status of the software storage memory of both PMs.

*Requirement Number* : SAVOIR.OBC.PM.560
**Death Report**
The OBC shall allow the ASW to add information to the Death Report.

Note: This can be implemented as a memory area that the ASW continuously updates.
*Requirement Rationale* : A Death Report aids anomaly investigations on ground. The ASW may provide useful higher level context.

### *7.5.6 PM Performance*

*Requirement Number* : SAVOIR.OBC.PM.570
**CPU and Processing Capability**
The processing capability shall have a performance of at least <PMMIPS> MIPS (Dhrystone 2.1 or Coremark ) and <PMMFLOPS> MFLOPS (Whetstone) with compiler version and options used during the test specified and reported.

*Requirement Rationale* : Current numbers based on currently used processors. Future expected requirements based on next generation processor expectations.

Typical Values for <PMMIPS>: Typically at least ~10-40, future expected requirement is

~100.
<PMMFLOPS>: Typically at least ~2-10, future expected requirement is ~30.

*Requirement Number* : SAVOIR.OBC.PM.575
**Inter-PM Link Capability**
The link connecting the Active and the Inactive PM shall be capable of transferring data at rates up to 100 kbps.
*Requirement Rationale* : This data rate is sufficient to support patching and dumping of Inactive PM memory at typical TC and TM link rates used by missions.

*Requirement Number* : SAVOIR.OBC.PM.577
**PM Boot process duration**
The time from an Active PM power-on or reset to the Application Software being started shall not exceed <PM_NOMINAL_BOOT_TIME> when the Fast Boot Path is not selected and <PM_FAST_BOOT_TIME> when the Fast Boot Path is selected.
*Requirement Rationale* : The boot time is often essential during critical mission phases. See section 7.5.8 for more details on the Boot process.

### *7.5.7 PM and Memory Error Handling*

*Requirement Number* : SAVOIR.OBC.PM.580
**Memory access protection**
The OBC shall allow the ASW to set up memory access protection for all PM memory, and to be notified at violations.
*Requirement Rationale* : To protect code. Memory can be organized in different areas with an individual capability to be protected against access.

*Requirement Number* : SAVOIR.OBC.PM.590
**Detection of unsuccessful Software Storage Memory Area writes**
The OBC shall allow the ASW to be notified at unsuccessful Software Storage Memory Area writes.
*Requirement Rationale* : To include at least erroneous data written but may also cover write attempts when writing is prohibited

### *7.5.8 PM Booting*

*Requirement Number* : SAVOIR.OBC.PM.600
**Booting Start**
When the PM function has been reset or powered on it shall start a Boot process.
*Requirement Rationale* : Defines the starting behaviour of the PM functions

*Requirement Number* : SAVOIR.OBC.PM.610
**Deleted**

*Requirement Number* : SAVOIR.OBC.PM.620
**Deleted**

*Requirement Number* : SAVOIR.OBC.PM.630
**Deleted**

*Requirement Number* : SAVOIR.OBC.PM.640
**Deleted**

*Requirement Number* : SAVOIR.OBC.PM.645
**Deleted**

*Requirement Number* : SAVOIR.OBC.PM.650
**Deleted**

*Requirement Number* : SAVOIR.OBC.PM.660
**Deleted**

*Requirement Number* : SAVOIR.OBC.PM.670
**Deleted**

*Requirement Number* : SAVOIR.OBC.PM.680
**Deleted**

*Requirement Number* : SAVOIR.OBC.PM.690
**Deleted**

*Requirement Number* : SAVOIR.OBC.PM.700
**Deleted**

## 7.6 On Board Time Management

### *7.6.1 OBT Configuration*

*Requirement Number* : SAVOIR.OBC.OBT.10
**No of OBT modules**
The OBC shall provide two OBT modules operating in warm redundancy.

*Requirement Number* : SAVOIR.OBC.OBT.20
**OBT module designation**
The OBTs shall operate in a Master / Slave configuration.

*Requirement Number* : SAVOIR.OBC.OBT.30
**Selecting Master OBT**
It shall be possible to select Master / Slave OBT either via CPDU Pulse Command or directly by the ASW.

*Requirement Number* : SAVOIR.OBC.OBT.40
**OBT Reconfiguration**
The time shall be maintained during OBC reconfiguration.
*Requirement Rationale* : Guarantees consistent date and time tagging even in case of reconfiguration.

### *7.6.2 OBT Functional Requirements*

*Requirement Number* : SAVOIR.OBC.OBT.50
**OBT Module basic function**
The OBT function shall be based on an OBT module containing a time counter that uses the CCSDS Unsegmented Time Code (CUC) format, as is required by ECSS-E-70-41A Clause C.2.
*Requirement Rationale* : If an external payload unit needs time in another format, this will be handled as part of the platform / payload interface.

*Requirement Number* : SAVOIR.OBC.OBT.60
**OBT Time Counter Size**
The time counter shall provide 4 octets of coarse time (seconds) and two or three octets of fine time (subseconds) according to the CUC format in CCSDS 301.0-B-4.

Note: this implies a P-Field of either 0b00101110 or 0b00101111
*Requirement Rationale* : Smaller P-Field options limits usage/precision without any significant advantages.

*Requirement Number* : SAVOIR.OBC.OBT.70
**OBT wrap around**
The OBC OBT wrap around time shall be 2^32 s
*Requirement Rationale* : Four octets of coarse time, even though the counter never reaches 2^32s it is better to wrap around than to stop incrementing the OBT.

*Requirement Number* : SAVOIR.OBC.OBT.80
**OBT operating modes**
The OBC OBT function shall be able to operate in one of two different modes:
- Autonomous Mode
- Synchronized Mode

*Requirement Rationale* : Allows missions with or without GNSS receiver or high-accuracy time reference.

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*Requirement Number* : SAVOIR.OBC.OBT.90
**OBT start value at power-on**
At OBC power-on the Master and Slave OBTs shall start counting from zero.

Note: At power-on the Master and Slave OBTs can start at different points in time
*Requirement Rationale* : Other start values reduce the longest possible mission time.

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#### 7.6.2.1 Autonomous Mode

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*Requirement Number* : SAVOIR.OBC.OBT.100
**Autonomous mode; Master OBT**
In the ***Autonomous*** mode the Master OBT shall be running independently of the signals available on the synchronisation inputs.
*Requirement Rationale* : This mode is used if there is no external time reference available, either by spacecraft design or in case of a temporary GNSS malfunction.

---

*Requirement Number* : SAVOIR.OBC.OBT.110
**Autonomous mode; Slave OBT**
It shall be possible to keep the Slave OBT synchronized either to the absolute time of the Master OBT or at a constant configurable phase difference.
*OptionInfo* : Option SynchModeSlaveOBT=Yes
*Requirement Rationale* : This makes it possible to synchronize the Slave OBT to the subseconds smoothly without entire seconds mattering. If synchronized to absolute time: No time jumps in case of Master OBT failure

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#### 7.6.2.2 Synchronized Mode

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*Requirement Number* : SAVOIR.OBC.OBT.120
**Synchronized mode**
In the ***Synchronized*** mode the Master and Slave OBT functions shall be running synchronously with the time reference function.
*Requirement Rationale* : This mode is used if an external time reference (GNSS receiver / OCXO) is available. Both Master and Slave OBT run in sync with the time reference.

---

### *7.6.3 OBT Interfaces*

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*Requirement Number* : SAVOIR.OBC.OBT.130
**OBT PM Communication Path**
There shall be one communication path between each OBT and the Active PM.
*Requirement Rationale* : Used for configuration and reading of the OBT

*Requirement Number* : SAVOIR.OBC.OBT.140
**OBT PM Synchronization Path**
There shall be one synchronization path between the Master OBT and the Active PM.
*Requirement Rationale* : Used for software cycle timing

*Requirement Number* : SAVOIR.OBC.OBT.150
**OBT PM Synchronization Path**
There shall be one synchronization path between the Master OBT and the Inactive PM.
*OptionInfo* : Option InactivePMTick=Yes
*Requirement Rationale* : Used for software cycle timing if inactive PM software requires it.

*Requirement Number* : SAVOIR.OBC.OBT.155
**OBT Time Reference Synchronization Path 1**
There shall be one synchronization path between the Master OBT and the Active Time Reference function.
*OptionInfo* : Option GNSS=Yes
*Requirement Rationale* : Used to synchronize the OBT to the GNSS time in all modes.

*Requirement Number* : SAVOIR.OBC.OBT.156
**OBT Time Reference Synchronization Path 2**
There should be one synchronization path between the Slave OBT and the Active Time Reference function.
*OptionInfo* : Option GNSS=Yes
*Requirement Rationale* : Used to synchronize the OBT to the GNSS time in Synchronized mode. In a specific implementation the Slave OBT can also be synchronised to the GNSS time from the Inactive Time Reference function and then there is no need for a cross-strap between the Active Time Reference function and the Slave OBT.

*Requirement Number* : SAVOIR.OBC.OBT.160
**OBT Command & Control Link Synchronization Path**
There shall be one synchronization path from the Master OBT to each Command & Control Link.
*Requirement Rationale* : Makes it possible to send high-precision time information via command links.

*Requirement Number* : SAVOIR.OBC.OBT.170
**OBT TM Time Strobe Input**
There shall be one synchronization path between the Master OBT and the Active Platform TM Encoder.
*Requirement Rationale* : Used to sample the OBT to synchronize the OBT with ground as described in ECSS-E-70-41A Annex C.

*Requirement Number* : SAVOIR.OBC.OBT.180
**Deleted**

*Requirement Number* : SAVOIR.OBC.OBT.190
**OBT Essential TM**
It shall be possible to include the current Master OBT time in the Essential TM.
*OptionInfo* : Option HPTM=Yes

*Requirement Number* : SAVOIR.OBC.OBT.200
**OBT status in Essential TM**
It shall be possible to include the OBT Master/Slave status in the Essential TM
*OptionInfo* : Option HPTM=Yes

### *7.6.4 OBT External Interfaces*

*Requirement Number* : SAVOIR.OBC.OBT.210
**OBT external synchronisation input**
Each OBT shall have one redundant external synchronization input.
*OptionInfo* : Option GNSS=No
*Requirement Rationale* : Normally used for connecting nominal and redundant time references like GNSS receivers, where one of the receivers act as the primary time reference (can also be called Active GNSS receiver).

*Requirement Number* : SAVOIR.OBC.OBT.220
**OBT external synchronisation input electrical interface**
The external synchronization inputs shall be of type SDI.
*OptionInfo* : Option GNSS=No

*Requirement Number* : SAVOIR.OBC.OBT.230
**OBT Synchronization Pulse Outputs**
The OBC shall supply <external_synch#> external synchronization signals from the Master OBT.
Note typical value of <external_synch#> is 8 for the missions considered (Science, EO and Telecom)

*Requirement Number* : SAVOIR.OBC.OBT.240
**OBT Synchronization Pulse Outputs Electrical Interface**
The external synchronization outputs shall be of type SDI.

### *7.6.5 OBT API*

*Requirement Number* : SAVOIR.OBC.OBT.250
**OBT Current Time Readout**
The ASW shall be able read the current time of both the Master and the Slave OBT.

*Requirement Number* : SAVOIR.OBC.OBT.260
**OBT external synchronisation signals frequency**
The ASW shall be able to set the frequency of the Master OBT synchronization output signals

*Requirement Number* : SAVOIR.OBC.OBT.270
**OBT status**
The OBC shall allow the ASW to read the OBT Master/Slave status.

*Requirement Number* : SAVOIR.OBC.OBT.280
**Selecting Master OBT via ASW**
The OBC shall allow the ASW to select Master/Slave OBT.

*Requirement Number* : SAVOIR.OBC.OBT.290
**OBT operating mode switching**
The OBC shall allow the ASW to switch between Autonomous and Synchronised Mode.

*Requirement Number* : SAVOIR.OBC.OBT.300
**OBT External Synchronization Receiver switching**
The OBC shall allow the ASW to switch between the nominal and redundant external synchronization PPS inputs.
*OptionInfo* : Option GNSS=No
*Requirement Rationale* : In case of GNSS nominal receiver malfunction.

*Requirement Number* : SAVOIR.OBC.OBT.310
**OBT setting in Autonomous mode 1**
The OBC shall allow the ASW to set the OBTs synchronously with the Master OBT second tick.
*Requirement Rationale* : Generally used to get the coarse time (seconds) in sync

*Requirement Number* : SAVOIR.OBC.OBT.320
**OBT setting in Autonomous mode 2**
The OBC shall allow the ASW to set the Master and Slave OBTs at any point in time.
*Requirement Rationale* : This possibility exists as a simple brute-force synchronization solution.

*Requirement Number* : SAVOIR.OBC.OBT.330
**Sampled OBT readout**
The OBC shall allow the ASW to read the value of all OBT modules sampled at the last TM Time Strobe event
*Requirement Rationale* : Allows generation of synchronization messages in accordance with ECSS-E-70-41A Annex C

### *7.6.6 OBT Synchronisation Signals Generation and Distribution*

*Requirement Number* : SAVOIR.OBC.OBT.340
**OBT synchronisation signals distribution 1**
It shall be possible to define <OBTfrequencies#> tbc different frequencies used for the Master OBT synchronization output signals where <OBTfrequencies#> can vary from 1 to 4 tbc.

Note: Typical value of <OBTfrequencies#> is 3. This means that the eight synchronization outputs will be divided into N groups with different frequencies. It is only possible to change the frequency of an entire group.
*Requirement Rationale* : Three different frequencies allows one PPS, one AOCS cycle and one mission specific frequency which is enough for a typical mission.

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*Requirement Number* : SAVOIR.OBC.OBT.350
**OBT synchronisation signals distribution 2**
The frequency of the Master OBT synchronization output signals shall be configurable to 1, and M^N Hz, where M is usually 2 and N usually being an integer value between 1 and 8

Note: The proposed values for N and M are the typical ones for the missions considered by SAVOIR, as an option M=10 with N= 1 to 3 be supported.
*Requirement Rationale* : A compromise between flexibility and current implementation restrictions.

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*Requirement Number* : SAVOIR.OBC.OBT.360
**OBT synchronisation signals distribution 3**
All synchronization output pulses shall be generated synchronously with the 1Hz signal (i.e. all active synchronization pulses have a leading edge when a potential 1Hz signal has its leading edge).
*Requirement Rationale* : Defines a known phase relationship between all synchronization outputs.

---

*Requirement Number* : SAVOIR.OBC.OBT.370
**OBT synchronization signals relation to OBT counter**
It shall be possible to determine the relation between any 1Hz PPS signal leading edge and the OBT subsecond count reaching zero.
*Requirement Rationale* : To be able to define a known phase relationship between the current OBT value and the synchronisation outputs.

### *7.6.7 OBT Error Handling*

*Requirement Number* : SAVOIR.OBC.OBT.380
**Lost Synchronization Input Signal**
The OBT function shall not malfunction or produce incorrect output in case of missing synchronization input signals (e.g. GNSS failure). A malfunction is defined as:
- Losing or repeating time codes
- Operating at a frequency outside of the requirements of autonomous mode
- Losing or duplicating synchronization pulses

*Requirement Rationale* : Ensures that the system behaves predictably in case of input synchronization failure.

*Requirement Number* : SAVOIR.OBC.OBT.390
**Spurious Synchronization Input Signal**
The OBT function shall not malfunction or produce incorrect output if case of additional synchronization input signals (e.g. GNSS failure). A malfunction is defined as:
- Losing or repeating time codes
- Operating at a frequency outside of the requirements of autonomous mode
- Losing or duplicating synchronization pulses

Note: This may require ASW involvement
*Requirement Rationale* : Ensures that the system behaves predictably in case of input synchronization failure.

### *7.6.8 OBT Performance*

*Requirement Number* : SAVOIR.OBC.OBT.400
**OBT Master switchover**
A switch of Master OBT shall take place in less than <OBT_SWITCHTIME>.
*Requirement Rationale* : Typical Value for <OBT_SWITCHTIME>: 10 ms. In case the Master OBT is malfunctioning this is typically detected by the ASW using some kind of time-out mechanism. The ASW then commands an OBT reconfiguration and this reconfiguration is done within a limited time to minimise the outage of the synchronisation pulses generated from the OBT function.

*Requirement Number* : SAVOIR.OBC.OBT.410
**OBT Synchronisation Performance**
The Master and Slave OBT shall be synchronized to within <OBT_SYNCACC> both in synchronised and autonomous mode.
*Requirement Rationale* : Typical value for <OBT_SYNCACC>: 2 µs.

*Requirement Number* : SAVOIR.OBC.OBT.420

**Master OBT oscillator stability**
The Master OBT oscillator shall have the following characteristics:
Absolute Error: <+/-<OBT_OSCABS> (at oscillator procurement - not delivery of FM)
Frequency stability: <+/-<OBT_OSCSTAB> over temperature
Ageing: <+-<OBT_OSCAGM> / month
Ageing: <+-<OBT_OSCAGY>
*Requirement Rationale* : Typical Values:
<OBT_OSCABS>: 10 ppm
<OBT_OSCSTAB>: 25 ppm
<OBT_OSCAGM>: 1 ppm
<OBT_OSCAGY>: 50 ppm / 15 years

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*Requirement Number* : SAVOIR.OBC.OBT.430
**OBT setting in Synchronised mode**
The setting of any OBT shall be done with an accuracy better than <OBT_EXTSYNCACC> relative to the reference signal.
*Requirement Rationale* : Typical value for <OBT_EXTSYNCACC>: 1 µs.

---

*Requirement Number* : SAVOIR.OBC.OBT.440
**OBT coarse time setting in Synchronised mode**
It shall be possible to set the coarse time of any OBT without any glitches on any of the following synchronization functions:
* External synchronization pulses
* Software cycles
* Command & Ctrl link synchronization (e.g. 1553 bus synchronization)
*Requirement Rationale* : Makes it possible to change the time to arbitrary value without glitches. Smooth synchronization for the fine time and the possibility of directly setting the coarse time.

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*Requirement Number* : SAVOIR.OBC.OBT.450
**OBT setting in Autonomous mode**
It shall be possible to directly set the OBT via the ASW with an accuracy of better than <OBT_ASWACC>.
*Requirement Rationale* : Typical value for <OBT_ASWACC>: 1 ms.

---

*Requirement Number* : SAVOIR.OBC.OBT.460
**TM Time Strobe sample accuracy**
The total delay from Master OBT sample, including the sample jitter, to the falling edge of the clock defining the first bit of the sync marker (ASM) in the TM Frame causing the datation event shall be known to an accuracy better than <TmStrobeDelayAcc>
*Requirement Rationale* : Specifies a worst-case OBC inaccuracy of the datation of the OBC.

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*Requirement Number* : SAVOIR.OBC.OBT.470

**Sync signal output jitter 1**
The jitter of a sync output signal when the OBT is synchronised to the external synchronization input having a jitter of less than<OBT_SYNC_INJITTER>, shall be better than <OBT_SYNC_OUTJITTER>.
*Requirement Rationale* : Typical Values for <OBT_SYNC_INJITTER>: ±100ns <OBT_SYNC_OUTJITTER>: ±400ns

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*Requirement Number* : SAVOIR.OBC.OBT.480
**Sync signal output jitter 2**
The jitter of a sync output signal when the OBT is running in autonomous mode, shall be better than <OBT_AUTO_JITTER>.
*Requirement Rationale* : Typical Value for <OBT_AUTO_JITTER>: ±300ns

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## 7.7 Platform Data Storage

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### *7.7.1 Platform Data Storage Configuration*

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*Requirement Number* : SAVOIR.OBC.PFDS.10
**No of PFDS functions**
The OBC shall provide two PFDS functions capable of operating both in hot and cold redundancy.
*Requirement Rationale* : In some applications data must not be lost in case of a PFDS failure

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*Requirement Number* : SAVOIR.OBC.PFDS.20
**Accessing the PFDS from PM**
It shall be possible to access any PFDS from the currently active PM.
*Requirement Rationale* : Data are not lost in case of a PFDS failure. Also, each PM has access to both TM downlinks via the mass memory

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### *7.7.2 Platform Data Storage Function*

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*Requirement Number* : SAVOIR.OBC.PFDS.30
**PFDS size**
Each PFDS shall provide an EOL memory capacity of <PFDS_SIZE>.

Note: Either volatile or non-volatile memory technology may be used, the requirements pose no restrictions on this choice.
*Requirement Rationale* : Typical memory technologies may be SDRAM for present implementations and flash memory for future products. 8 GiBit is sufficient for platform operations.
Typical Value for <PFDS_SIZE>: 8 GiBit.

*Requirement Number* : SAVOIR.OBC.PFDS.40
**PFDS access**
The OBC shall allow access to all areas of both PFDS functions in hot redundancy

Note: Restrictions for concurrent reading/writing may apply.

*Requirement Number* : SAVOIR.OBC.PFDS.50
**PFDS configuration 1**
It shall be possible to configure the PFDS storage area into a set of at least one linear area and <Packet-Store#> Packet Stores
*Requirement Rationale* : Linear areas are used for general data storage and files, packet stores are used for complete TM packets for downlink. Typical value of <Packet-Store#> is eight (8)

*Requirement Number* : SAVOIR.OBC.PFDS.55
**PFDS configuration 2**
It shall be possible to configure individually the size of the PFDS Packet Stores
*Requirement Rationale* : zero size is supported

*Requirement Number* : SAVOIR.OBC.PFDS.60
**Deleted**

*Requirement Number* : SAVOIR.OBC.PFDS.70
**PFDS self-test**
Each PFDS Function shall support an autonomous self-test (non-destructive and/or destructive) that tests any of its memory areas..
*Requirement Rationale* : To verify integrity without load on the PM and the communication link. Self-test can be destructive ( e.g. erase of memory content or (re-)initialization) or non-destructive ( e.g. scrubbing to avoid SEUs accumulation)

*Requirement Number* : SAVOIR.OBC.PFDS.80
**PFDS downlink concurrency**
The PFDS connected to the active Platform TM Encoder shall be able to downlink data in parallel via at least two different Virtual Channels.

*Requirement Number* : SAVOIR.OBC.PFDS.90
**Deleted**

### *7.7.3 Platform Data Storage Interfaces*

*Requirement Number* : SAVOIR.OBC.PFDS.100

**PM Interface**
Each PFDS shall have a communication path to the currently Active PM for transfer of data to and from the PFDS.
*Requirement Rationale* : Since there is no cross-strapping between PFDS and TM the cross-strap is implemented here. The Active PM typically stores the same data in both PFDS.

---

*Requirement Number* : SAVOIR.OBC.PFDS.110
**TM Output**s
Each PFDS shall have one communication path to a Platform TM Encoder for TM packet downlink.

Note: This means that the Active PM can command a downlink of only one PFDS at any given time since only one Platform TM Encoder is active at a time. As the two PFDS typically contain the same data, this is not considered as an operational disadvantage.
*Requirement Rationale* : The path is used for downlink of all virtual channels associated with the PFDS.

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*Requirement Number* : SAVOIR.OBC.PFDS.120
**Deleted**

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*Requirement Number* : SAVOIR.OBC.PFDS.130
**PFDS status in Essential TM**
It shall be possible to include the PFDS on/off status of each PDFS in the Essential TM
*OptionInfo* : Option HPTM=Yes

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### *7.7.4 Platform Data Storage API*

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*Requirement Number* : SAVOIR.OBC.PFDS.140
**PFDS ASW status**
The OBC shall allow the ASW to read the PFDS on/off status.

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*Requirement Number* : SAVOIR.OBC.PFDS.150
**PFDS content loss**
The OBC shall allow the ASW to determine whether the PFDS content is lost due to power outage.
*Requirement Rationale* : The PFDS integrity must be known after an OBC reconfiguration or power-on

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*Requirement Number* : SAVOIR.OBC.PFDS.160
**PFDS ASW bank configuration**
The OBC shall allow the ASW to configure the PFDS storage area

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*Requirement Number* : SAVOIR.OBC.PFDS.170

**PFDS ASW File Support**
The OBC shall allow the ASW random access to the linear memory areas to create, open, read, write, copy and delete files
*Requirement Rationale* : Gives ASW the possibility to create, open, read, write, copy and delete files in the linear memory areas using for instance the services defined in CCSDS 873.0-M-1 “File and Packet Store Services”.

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*Requirement Number* : SAVOIR.OBC.PFDS.180
**PFDS ASW Packet Support**
The OBC shall allow the ASW to write into the packet stores
*Requirement Rationale* : Gives ASW the possibility to store packets in the PFDS.

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*Requirement Number* : SAVOIR.OBC.PFDS.190
**PFDS ASW self-test**
The OBC shall allow the ASW to start and configure an autonomous self-test.
*Requirement Rationale* : To verify memory integrity

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*Requirement Number* : SAVOIR.OBC.PFDS.200
**PFDS ASW downlink 1**
The OBC shall allow the ASW to start a downlink of a PFDS Packet Store to the Platform TM Encoder.
*Requirement Rationale* : To be able to downlink packets to ground that operates with a minimum of ASW involvement.

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*Requirement Number* : SAVOIR.OBC.PFDS.210
**PFDS ASW downlink 2**
The OBC shall allow the ASW to check whether a downlink to a specified Virtual Channel is on-going or completed.

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### *7.7.5 Platform Data Storage Performance*

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*Requirement Number* : SAVOIR.OBC.PFDS.220
**PFDS PM data rate**
The OBC shall support transfer of data from the currently active PM to any PFDS at transfer rates up to <OBC_PFDSSPEED>
*Requirement Rationale* : Typical value for <OBC_PFDSSPEED> is 10-20Mbps.

---

*Requirement Number* : SAVOIR.OBC.PFDS.230
**PFDS PM transfer rate**
The OBC shall support transfer of data between the currently active PM and any PFDS at rates up to <OBC_PFDSRATE> transfers per second, with transfer sizes up to at least 65542 bytes.
*Requirement Rationale* : Makes it possible to transfer one max-length space packet in one transfer

Typical value for <OBC_PFDSRATE> is 256 since 256 transfers allows ASW to generate ~25-30 packet with a software cycle of 8-10Hz.

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*Requirement Number* : SAVOIR.OBC.PFDS.240
**PFDS downlink data rate**
The OBC shall support transfer of data to the currently active Platform TM Encoder from one PFDS at a transfer rate of at least <TM_PFDSDATARATE>, using packet sizes >16 bytes.

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*Requirement Number* : SAVOIR.OBC.PFDS.250
**PFDS downlink packet rate**
The OBC shall support transfer data to the currently active Platform TM Encoder from one PFDS at rates up to <TM_PFDSRATE> packets per second, with a limitation that one transfer may not exceed 65542 bytes.

Note: The total data rate must still be below the maximum downlink rate
*Requirement Rationale* : Allows downlink of many small packets

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*Requirement Number* : SAVOIR.OBC.PFDS.260
**PFDS error rate**
The probability of reading incorrect data from the PFDS shall be less than 2% over 1 year.
*Requirement Rationale* : 2% in 1 year covers both permanent and transient errors. This reliability may require a memory scrubber.

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### *7.7.6 Platform Data Storage Error Handling*

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*Requirement Number* : SAVOIR.OBC.PFDS.270
**Handling of PFDS communication errors**
The OBC shall allow the ASW to separately restart the communication with the specified PFDS.
*Requirement Rationale* : The two paths to each PFDS are treated separately

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*Requirement Number* : SAVOIR.OBC.PFDS.280
**Handling of PFDS reading errors**
The OBC shall allow the ASW to read the status of errors occurring during PFDS reading.

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*Requirement Number* : SAVOIR.OBC.PFDS.290
**Handling of PFDS writing errors**
The OBC shall allow the ASW to read the status of errors occurring during PFDS writing.

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*Requirement Number* : SAVOIR.OBC.PFDS.300
**Handling of PFDS self-test errors**
The OBC shall allow the ASW to read the status of the self-test.

## 7.8 Command & Control Link

### *7.8.1 Command & Control Link Configuration*

*Requirement Number* : SAVOIR.OBC.COC.10
**No of Command & Control Link Functions**
The OBC shall provide two Command & Control Link Functions operated in cold redundancy

### *7.8.2 Command & Control Link Interfaces*

*Requirement Number* : SAVOIR.OBC.COC.20
**Cmd & Ctrl Platform Data Link**
The Cmd & Ctrl link function shall have one external redundant data link used for transmitting and receiving messages on the Cmd & Ctrl link platform bus.

Note: For the Platform C&C link the possible solutions are MIL-STD-1553B, SpaceWire and CAN. A SpaceWire routing function is suggested to be located in the RTU.
*Requirement Rationale* : Makes it possible for the Cmd & Ctrl function to access platform units.

*Requirement Number* : SAVOIR.OBC.COC.30
**Cmd & Ctrl Payload Data Link**
The Cmd & Ctrl link function shall have one external redundant data link used for transmitting and receiving messages on the Cmd & Ctrl link payload bus.

Note: For the Payload C&C link the possible choices today are the MIL-STD-1553 , the CAN bus, and SpaceWire with a deterministic protocol. A SpaceWire routing function is suggested to be located in the payload architecture of Figure 1 (Payload Data Routing or Payload Data Storage) .
*Requirement Rationale* : Makes it possible for the Cmd & Ctrl function to access payload units

*Requirement Number* : SAVOIR.OBC.COC.40
**Trigger Input**
The Cmd & Ctrl link function shall have one synchronization path to the OBT Function used for receiving synchronization pulses
*Requirement Rationale* : The trig pulses are used to send messages synchronized with the OBT

*Requirement Number* : SAVOIR.OBC.COC.50

**PM Communication Path**
There shall be one communication path between the Cmd & Ctrl link and the Active PM used for transmitting and receiving messages and data to and from the external command and control links.
*Requirement Rationale* : Makes it possible for the processing function to access payload and platform units.

### *7.8.3 Command & Control Link API*

*Requirement Number* : SAVOIR.OBC.COC.60
**C&C Link reinitialisation**
The OBC shall allow ASW to reinitialise a Cmd & Ctrl Link.

*Requirement Number* : SAVOIR.OBC.COC.70
**C&C Link services**
The OBC shall allow the ASW to transfer sequences of Cmd & Ctrl link messages.

*Requirement Number* : SAVOIR.OBC.COC.80
**C&C Link message Interrupt**
The OBC shall be able to notify the ASW when a Cmd & Ctrl link transfer is completed

*Requirement Number* : SAVOIR.OBC.COC.90
**C&C Link message sequence check**
The OBC shall allow ASW to check the progress of an ongoing or completed Cmd & Ctrl link transfer.

*Requirement Number* : SAVOIR.OBC.COC.100
**SOIS Services**
The OBC shall supply the following services to the ASW as defined in the CCSDS 85x.0-M-1 applicable documents listed on section 2.1:

- Packet Service
- Memory Access Service
- Time Synchronisation Service
- Test Service

Note: See also SAVOIR-FAIRE (TEC-SWE(09-289/AJ Issue 1)
*OptionInfo* : Option SOIS=Yes
*Requirement Rationale* : This might be used in future missions but is not foreseen for current missions.

### 7.8.4 1553 Specific Bus Controller Functional Requirements

*Requirement Number* : SAVOIR.OBC.COC.110
**Bus Controller low level function**
A Bus Controller shall be compliant to ECSS-E-ST-50-13C clause 6.

*Requirement Number* : SAVOIR.OBC.COC.120
**Bus Controller Intermessage gap**
Intermessage gap sizes are allowed to be variable but shall be deterministic.

*Requirement Number* : SAVOIR.OBC.COC.130
**Time Message format**
The OBC shall allow the ASW to send Time Messages with any valid P-field value.

Note: The value of the P-field determines the number of bytes used in the Time Message.

*Requirement Number* : SAVOIR.OBC.COC.140
**Communication Frame synchronisation**
The OBC shall at least allow the 1553 Communication Frames to be synchronized to the 1Hz synchronization event from the Master OBT function.

Note: Other frequencies are allowed but not required.
*Requirement Rationale* : Synchronization with a higher pulse frequency imposes unnecessary restrictions on how the frame length can be altered during OBT synchronization.

### 7.8.5 1553 Specific Bus Controller Performance

*Requirement Number* : SAVOIR.OBC.COC.150
**Data bus communication rate**
The OBC shall be able to support a useful traffic including any mixture of transmit and receive commands on each active MIL-STD-1553B bus of at least <COC_1553DATARATE>.
*Requirement Rationale* : Typical value for <COC_1553DATARATE>: 700 kbps when using maximum size messages.

*Requirement Number* : SAVOIR.OBC.COC.160
**Time Synchronisation accuracy**
The OBC shall provide the Time Synchronisation Message with an accuracy of better than <COC_1553ACCURACY> relative to the input synchronization event.
*Requirement Rationale* : Minimum value for <COC_1553ACCURACY> is recommended to be 50 us according to ECSS-E-ST-50-13C.

*Requirement Number* : SAVOIR.OBC.COC.170
**Communication Frame accuracy**
The OBC shall start a Communication Frame within <COC_1553ACCURACY> relative to the nominal start time of the frame

### *7.8.6 1553 Specific Bus Controller Error Handling*

*Requirement Number* : SAVOIR.OBC.COC.180
**Bus transmission errors (Interrupt)**
The OBC shall allow the ASW to be notified in case of errors occurring during a Communication Frame.

*Requirement Number* : SAVOIR.OBC.COC.190
**Bus transmission errors (Polling)**
The OBC shall allow the ASW to check if errors have occurred during a Communication Frame and to find out the type of error that occurred.

*Requirement Number* : SAVOIR.OBC.COC.200
**Bus transmission errors**
If an error occurred the OBC shall allow the ASW to check which message that failed.

### *7.8.7 SpaceWire Specific Bus Controller Requirements*

Requirements for a SpaceWire-based Command & Control Link function will be written when suitable SpaceWire standard extensions are available.

The anticipated number of links required for the OBC is either
* two and two in cold redundancy (allows connection to a redundant platform data network)
* zero, if the same physical SpaceWire links that are used for the (payload) mission data links are utilized for the platform data network. This solution requires that it is possible to combine the payload and platform network - the payload typically requires high data rates and large packets whereas the platform requires determinism.

### *7.8.8 CAN Specific Bus Controller Requirements*

*Requirement Number* : SAVOIR.OBC.COC.250
**Data bus communication rate**
The OBC shall be able to support a useful traffic considering back-to-back worst-case scenario at 1Mbps signalling rate, without significant impairment of processor functions.
*Requirement Rationale* :

Typical value of useful traffic is 440 kbps when using maximum size messages.

*Requirement Number* : SAVOIR.OBC.COC.260
**Time Synchronisation accuracy**
The OBC shall provide the Time Synchronisation Message as described in ECSS-E-ST-50-15C with an accuracy of better than <COC_CAN_ACCURACY> relative to the input synchronization event.
*Requirement Rationale* : The ECSS-E-ST-50-15C time distribution protocol provides a mechanism to transfer and read back the time with no specific requirements on accuracy. The optional high-resolution time distribution protocol allows for the best possible time synchronization via the CAN Network. It is possible to use both protocols on the same CAN Network. The actual accuracy of the time distribution is implementation dependent. Accuracy <COC_CAN_ACCURACY> in the microsecond range can be achieved using the high-resolution time distribution with a bit rate of 1 Mbps. The standard time distribution protocol recommended <COC_CAN_ACCURACY> is better than 50 microseconds with a bit rate of 1 Mbps.

### *7.8.9 CAN Specific Bus Controller Error Handling Requirements*

*Requirement Number* : SAVOIR.OBC.COC.280
**Bus transmission errors (Interrupt)**
The OBC shall allow the ASW to be notified in case of errors occurring during a Communication Frame.

*Requirement Number* : SAVOIR.OBC.COC.290
**Bus transmission errors (Polling)**
The OBC shall allow the ASW to check if errors have occurred during a Communication Frame and to find out the type of error that occurred.

*Requirement Number* : SAVOIR.OBC.COC.300
**Bus transmission errors**
If an error occurred the OBC shall allow the ASW to check which message failed.

## 7.9 Mission Data Links

### *7.9.1 Mission Data Link Function - PM*

*Requirement Number* : SAVOIR.OBC.MDL.10
**No of Processing Mission Data link interfaces**
The OBC shall provide at least four external Mission Data link interfaces operated two operational and two cold redundant.

Note: For the Mission Data link the preferred choice today is SpaceWire, possibly with a foreseen evolution towards deterministic protocol. A SpaceWire routing function is in this located in the spacecraft payload.
*Requirement Rationale* : Allows connection to a redundant Payload Data Routing

---

*Requirement Number* : SAVOIR.OBC.MDL.20
**Mission Data links' concurrent operation**
The OBC shall allow ASW to send and receive data on the operating Mission Data links concurrently.

---

*Requirement Number* : SAVOIR.OBC.MDL.30
**Mission Data link SOIS Services**
The OBC shall supply the following services to the ASW as defined in CCSDS 85x.0-M-1 applicable documents listed on section 2.1:

- Packet Service
- Memory Access Service
- Time Synchronisation Service
- Test Service

Note: See also SAVOIR-FAIRE (TEC-SWE(09-289/AJ Issue 1)
*OptionInfo* : Option SOIS=Yes
*Requirement Rationale* : This might be used in future missions but is not foreseen for current missions.

---

*Requirement Number* : SAVOIR.OBC.MDL.40
**Link transmission errors**
The OBC shall allow the ASW to be notified in case of errors occurring during transmission or reception of Mission Data link transfers.

### *7.9.2 Mission Data Link Interfaces*

*Requirement Number* : SAVOIR.OBC.MDL.50
**PM Communication Path**
There shall be a communication path from one Mission Data Link to the Active PM function.
*Requirement Rationale* : The Active PM needs to be able to access one set of the Mission Data Links for external communication

### *7.9.3 Generic SpaceWire Requirements*

*Requirement Number* : SAVOIR.OBC.MDL.60
**SpaceWire links Protocol**
The external SpaceWire links shall follow the protocol defined in ECSS-E-ST-50-12C clauses 7, 8 and 9.

*Requirement Number* : SAVOIR.OBC.MDL.70
**Handling of external IF errors**
The OBC shall allow ASW to read the status of errors occurring during transfers on the external links.

### *7.9.4 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 up to <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>: 5000 packets per second

---

*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>: 5000 packets per second

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## 7.10 Safe Guard Memory

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### *7.10.1 SGM Configuration*

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*Requirement Number* : SAVOIR.OBC.SGM.10
**No of SGMs**
The OBC shall provide two SGMs operating in hot redundancy.

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*Requirement Number* : SAVOIR.OBC.SGM.20
**Concurrent Access to the SGM**
The OBC shall allow access to both SGMs simultaneously, each SGM by its dedicated access.
*Requirement Rationale* : Allows the PM to operate in a Parallel mode where both SGM memories holds the current context

---

*Requirement Number* : SAVOIR.OBC.SGM.30
**Accessing the SGM**
Only the active PM shall have write access to the SGM
*Requirement Rationale* : Ensures that a faulty inactive PM cannot alter the context of the currently active PM.

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### *7.10.2 SGM Functional requirements*

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*Requirement Number* : SAVOIR.OBC.SGM.40
**SGM areas**
Each SGM shall have at least the following two areas:

- Area 1: Non-Volatile Area (>=<SGM_NONVOLSIZE>)
- Area 2: Volatile area (>=<SGM_VOLSIZE>)
*Requirement Rationale* : Area 1 and 2 are used by the PM for storing context data.
Typical parameter values:
<SGM_NONVOLSIZE>: 127 Kibyte.
<SGM_VOLSIZE>: 256 Kibyte.

---

*Requirement Number* : SAVOIR.OBC.SGM.50
**SGM areas**
Each SGM shall have the following two additional areas:
- Area 3: Non-Volatile Area (>=<SGM_NONVOLSIZE>)
- Area 4: Volatile area (>=<SGM_VOLSIZE>)
*OptionInfo* : Option DBLSGM=YES
*Requirement Rationale* : Area 3 and 4 can be used by the PM for storing context data. By using the areas 1,3 and 2,4 alternately there will be a slightly older context available if the present context is lost (for instance due to a reconfiguration during SGM write).

---

*Requirement Number* : SAVOIR.OBC.SGM.60
**SGM areas 2**
Each SGM shall support an optional direct TC SGM storage area by PUS service 2 commands or PUS service 6 commands:
- Area 5: Non-Volatile Area (>=1 Kibyte)
*OptionInfo* : Option GNDSGM=YES

---

*Requirement Number* : SAVOIR.OBC.SGM.90
**SGM Ground Storage Area**
SGM Area 5 is a ground storage area that shall only be writable by direct telecommand from ground.
*OptionInfo* : Option GNDSGM=YES

---

*Requirement Number* : SAVOIR.OBC.SGM.70
**SGM write protection**
SGM areas 1 to 4 shall be write protectable, individually or in groups.

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*Requirement Number* : SAVOIR.OBC.SGM.80
**SGM Non-volatile content loss**
The SGM Non-volatile areas shall not lose its contents in case of primary bus loss.

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### *7.10.3 SGM Function Interfaces*

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*Requirement Number* : SAVOIR.OBC.SGM.100
**SGM PM Interface**
Each SGM shall have a communication path to the currently active PM.

*Requirement Rationale* : Can be used for Boot Report Memory (BRM), Death Report Memory, Context Data. Also used to get data from the SGM

---

*Requirement Number* : SAVOIR.OBC.SGM.110
**SGM Essential TM Output**
Each SGM shall have a communication path to the currently active Essential TM.
*OptionInfo* : Option HPTM=YES
*Requirement Rationale* : An optional link to include part of the context data or other important information in the essential TM.

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*Requirement Number* : SAVOIR.OBC.SGM.120
**SGM TC Input**
Each SGM shall have a communication path to one TC Decoder
*OptionInfo* : Option GNDSGM=YES
*Requirement Rationale* : Used for writing TC directly into the SGM from ground

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### *7.10.4 SGM API*

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*Requirement Number* : SAVOIR.OBC.SGM.130
**SGM read access**
The OBC shall allow the ASW to read all areas of the SGM.

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*Requirement Number* : SAVOIR.OBC.SGM.140
**SGM write access**
The OBC shall allow the ASW to write all areas of the SGM except the optional ground storage area

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*Requirement Number* : SAVOIR.OBC.SGM.150
**ASW Concurrent Access to the SGM**
The OBC shall allow the ASW to access both SGMs simultaneously, each SGM by its dedicated access.
*Requirement Rationale* : Allows the PM to operate in a Parallel mode where both SGM memories holds the current context

---

*Requirement Number* : SAVOIR.OBC.SGM.160
**SGM Volatile content loss**
The OBC shall allow the ASW to determine whether SGM Volatile Memory content is lost due to power outage.

Note: This can be implemented as checksum verification

*Requirement Rationale* : Used to ensure that the SGM content is valid.

### *7.10.5 SGM Performance Requirements*

*Requirement Number* : SAVOIR.OBC.SGM.170
**Deleted**

*Requirement Number* : SAVOIR.OBC.SGM.180
**SGM Non-Volatile reprogramming cycles**
Any write limitations on the number of reprogramming cycles for the non-volatile areas of the SGM shall be documented.

*Requirement Number* : SAVOIR.OBC.SGM.190
**SGM memory performance**
The Volatile areas of the SGM shall support a minimum read data rate of <SGM_READDATARATE> (Read from SGM to Processing function)
*Requirement Rationale* : Good performance is required because it impacts the duration of the processor switch-over.
Typical parameter value:
<SGM_READDATARATE>: 5 Mbit per second

*Requirement Number* : SAVOIR.OBC.SGM.200
**SGM memory performance**
The Volatile areas of the SGM shall support a minimum write data rate of <SGM_WRITEDATARATE>(Write from processing function to SGM)
*Requirement Rationale* : Typical parameter value:
<SGM_WRITEDATARATE>: 5 Mbit per second

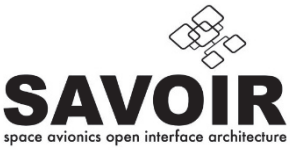
### *7.10.6 SGM Error Handling*

*Requirement Number* : SAVOIR.OBC.SGM.210
**Detection of SGM communication errors**
The OBC shall allow the ASW to be notified at errors during communication with the SGM.

*Requirement Number* : SAVOIR.OBC.SGM.220
**Handling of SGM communication errors**
The OBC shall allow the ASW to separately restart the communication with the specified SGM.

*Requirement Number* : SAVOIR.OBC.SGM.230
**Handling of SGM errors**
The OBC shall allow the ASW to read the status of the SGM with, as a minimum, the following information provided:

- SGM error status





- Status of any error correction mechanisms

## 7.11 Essential TM

### *7.11.1 Essential TM Configuration*

*Requirement Number* : SAVOIR.OBC.ETM.10
**No of Essential TMs**
The OBC shall provide two Essential TM functions operated in cold redundancy.
*OptionInfo* : Option HPTM=YES

### *7.11.2 Essential TM Function*

*Requirement Number* : SAVOIR.OBC.ETM.20
**Essential TM Implementation**
The Essential TM functionality shall be independent from the processing function and acquire fundamental/vital parameters selected in the design phase to allow ground control to assess the status of essential spacecraft items.
*OptionInfo* : Option HPTM=YES
*Requirement Rationale* : Essential TM is always be available regardless of the state of the PMs.

*Requirement Number* : SAVOIR.OBC.ETM.30
**Initial Essential TM configuration**
All parameters necessary to configure the essential TM function (data to be transferred etc..) shall be automatically configured at power-on without ASW involvement.
*OptionInfo* : Option HPTM=YES
*Requirement Rationale* : Essential TM is always be available at power-on

*Requirement Number* : SAVOIR.OBC.ETM.40
**Essential TM Collection**
The Active Essential TM function shall be able to collect and packetize OBC status data and data generated by application software according to an application specific predefined table.
*OptionInfo* : Option HPTM=YES
*Requirement Rationale* : A predefined table is a good compromise between complexity and flexibility

*Requirement Number* : SAVOIR.OBC.ETM.50
**Essential TM Generation Interval**
The Active Essential TM shall be able to generate TM packets with at least one of the following two interval types:

- TM Packets are generated with a programmable frequency
- TM Packets are generated with a programmable ratio of the downlink speed

*OptionInfo* : Option HPTM=YES
*Requirement Rationale* : These two modes each have their advantage: One guarantees Essential TM with a fixed frequency, the other ensures that the function will be synchronized with the downlink speed

### *7.11.3 Essential TM Interfaces*

*Requirement Number* : SAVOIR.OBC.ETM.60
**Discrete Parallel IO Communication Path**
The Active Essential TM Function shall have a communication path to the Active Discrete Parallel IO Function.
*OptionInfo* : Option PIO=YES HPTM=YES
*Requirement Rationale* : Used for inclusion of Discrete Parallel IO in Essential TM (e.g. external relay status)

*Requirement Number* : SAVOIR.OBC.ETM.70
**Essential TM Output Link**
The Active Essential TM Function shall have a communication path to the Active Platform TM Encoder for transmission of essential TM packets.
*OptionInfo* : Option HPTM=YES
*Requirement Rationale* : Output link for transmission of the data

*Requirement Number* : SAVOIR.OBC.ETM.80
**Essential TM Time synchronization Input**
The Active Essential TM may have an input synchronization event from the OBT.
*OptionInfo* : Option HPTM=YES
*Requirement Rationale* : Used to generate essential TM with a fixed frequency

*Requirement Number* : SAVOIR.OBC.ETM.90
**Essential TM Frame synchronization Input**
The Active Essential TM may have an input synchronization event from the active Platform TM Encoder.
*OptionInfo* : Option HPTM=YES
*Requirement Rationale* : Used to generate essential TM with a fixed TM ratio

*Requirement Number* : SAVOIR.OBC.ETM.100
**Essential TM Internal Inputs 1**
The Active Essential TM shall have a number of input communication paths from other functional blocks in the OBC. These inputs are specified in the respective functional blocks.
*OptionInfo* : Option HPTM=YES

*Requirement Rationale* : For inclusion of some internal statuses, FAR report, context data et cetera. The Essential TM function can be located inside or outside the OBC box, the term "internal" refers to the case the Essential TM is located inside the OBC box.

*Requirement Number* : SAVOIR.OBC.ETM.110
**Essential TM Internal Inputs 2**
All internal communication paths for data gathering shall be available from both the nominal and redundant functions where applicable.
*OptionInfo* : Option HPTM=YES
*Requirement Rationale* : Gives the Essential TM the possibility to include information on the whole OBC, not just the nominal or redundant side.

## 7.12 Discrete Parallel IO

### *7.12.1 Discrete Parallel IO Configuration*

*Requirement Number* : SAVOIR.OBC.PIO.10
**No of Discrete Parallel IOs**
The OBC shall provide two Discrete Parallel IO functions operated in cold redundancy.
*OptionInfo* : Option PIO=YES

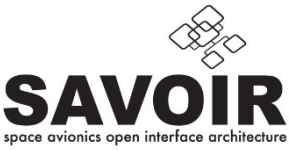
### *7.12.2 Discrete Parallel IO Function*

*Requirement Number* : SAVOIR.OBC.PIO.20
**Parallel Input to Essential TM**
The Active Discrete Parallel IO function shall be able to send the status of the Essential TM external inputs to the Active Essential TM Function.
*OptionInfo* : Option PIO=YES HPTM=YES
*Requirement Rationale* : Used for inclusion of for instance the end result of external CPDU commands in the essential TM data packets)

### *7.12.3 Discrete Parallel IO Interfaces*

*Requirement Number* : SAVOIR.OBC.PIO.30
**External Inputs for Essential TM**
The Active Discrete Parallel IO function shall have at least <PIO_ESSTMINPUTS> discrete external inputs of type BSM or BDM.

Note: These inputs are used for the Essential TM Function
*OptionInfo* : Option PIO=YES HPTM=YES





*Requirement Rationale* : For inclusion of mission specific essential TM status.
Typical Value for <PIO_ESSTMINPUTS>: 16.
The typical value comes from the assumption that the number of items to be monitored is half the number of the external CPDU commands. The essential TM inputs will most likely be used to monitor relays or discrete status signals.

---

*Requirement Number* : SAVOIR.OBC.PIO.40
**Essential TM Communication Path**
The Active Discrete Parallel IO function shall have a communication path to the Active Essential TM Function.
*OptionInfo* : Option PIO=YES HPTM=YES
*Requirement Rationale* : Used for inclusion of Discrete Parallel IO in HPTM (e.g. status of external CPDU commandable functions)

---

*Requirement Number* : SAVOIR.OBC.PIO.50
**External Inputs for Active PM**
The Active Discrete Parallel IO function shall have at least <PIO_PMINPUTS> external inputs of type SDI.

Note: These inputs are used for the Active PM Function
*OptionInfo* : Option PIO=YES PMPIO=YES
*Requirement Rationale* : Typical value for <PIO_PMINPUTS>: 2.

---

*Requirement Number* : SAVOIR.OBC.PIO.60
**Active PM Communication Path**
The Active Discrete Parallel IO function shall have a communication path to the Active PM
*OptionInfo* : Option PIO=YES PMPIO=YES

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### *7.12.4 Discrete Parallel IO API*

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*Requirement Number* : SAVOIR.OBC.PIO.70
**PM Input Reading 1**
The OBC shall allow the ASW to read the status of the Active PM external inputs.
*OptionInfo* : Option PIO=YES PMPIO=YES

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*Requirement Number* : SAVOIR.OBC.PIO.80
**PM Input Reading 2**
The OBC shall allow the ASW to read the status of the Essential TM external inputs.
*OptionInfo* : Option PIO=YES PMPIO=YES

## 7.13 Reconfiguration Module

### *7.13.1 RM Configuration*

*Requirement Number* : SAVOIR.OBC.RM.10
**No of Reconfiguration Modules**
The OBC shall provide two hot or cold operating Reconfiguration Module functions.

### *7.13.2 RM Functional Requirements*

*Requirement Number* : SAVOIR.OBC.RM.20
**RM enable/disable**
It shall be possible to individually enable and disable each RM via a CPDU Pulse Command accessible from ground. *Requirement Rationale* : Ensure that RMs can be activated and controlled regardless of ASW state.

*Requirement Number* : SAVOIR.OBC.RM.30
**RM task 1**
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.

Note: FDIR levels are defined in [RefArc], where Level 3 is defined as software independent monitoring of the software and processor (OBC internal) and Level 4 is defined as software independent monitoring of critical/vital system functions (external to the OBC)

*Requirement Number* : SAVOIR.OBC.RM.40
**RM task 2**
The RM shall be able to reset, power off and power on the currently active PM, to switch to the redundant PM and to generate CPDU commands to external equipment upon occurrence of alarm events.
*Requirement Rationale* : This provides the safest way of switching from a malfunctioning PM.

*Requirement Number* : SAVOIR.OBC.RM.50
**Initial RM configuration**
All parameters necessary to configure the RM function (reconfiguration patterns, alarm settings etc..) shall be automatically configured at power-on without ASW involvement.
*Requirement Rationale* : The RMs are always be available at power-on regardless of the PM state.

### *7.13.3 Reconfiguration Interfaces*

*Requirement Number* : SAVOIR.OBC.RM.60
**RM Enable / Disable Inputs**
Each Essential TC shall have one communication path to each RM function.
*Requirement Rationale* : Used to turn on/off the reconfiguration modules.

*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

*Requirement Number* : SAVOIR.OBC.RM.80
**RM TC Segment Output**
Each RM shall have a communication path to one Essential TC function.
*Requirement Rationale* : This link sends reconfiguration TC commands to the essential TC function for execution

*Requirement Number* : SAVOIR.OBC.RM.90
**RM status in Essential TM**
The RM enable/disable status shall be available to Essential TM
*OptionInfo* : Option HPTM=Yes

*Requirement Number* : SAVOIR.OBC.RM.100
**Reconfiguration Log in Essential TM**
It should be possible to include a log of the last reconfiguration of each RM in the currently active Essential TM.
*OptionInfo* : Option HPTM=YES

#### 7.13.3.1 Alarm Inputs

*Requirement Number* : SAVOIR.OBC.RM.110
**RM inputs**
Each RM shall provide the following alarm inputs:
- Level 4 alarms (External alarms)
- Level 3 alarms (Internal alarms)

*Requirement Number* : SAVOIR.OBC.RM.120
**No of Level 4 alarm inputs**
Each RM shall provide at least <EXT_ALARMS> Level 4 alarm inputs, the electrical interface for these alarm inputs being either BSM or BDM.

*Requirement Rationale* : The number of external alarms vary significantly between programmes. In several cases a single alarm is sufficient but for almost all missions it is sufficient with 8 alarm inputs.

---

*Requirement Number* : SAVOIR.OBC.RM.130
**No of Level 3 alarm inputs**
Each RM shall provide a number of Level 3 alarms to detect PM errors.
*Requirement Rationale* : The number of internal alarms needed to detect PM errors varies depending on~~n~~ different implementations and thus the quantity is not specified.

---

*Requirement Number* : SAVOIR.OBC.RM.140
**PM ASW Malfunction Detection**
Each RM shall support at least one alarm input for PM ASW Malfunction Detection.

Note: Typically implemented as a Watchdog that is toggled by the ASW at a regular time interval.
*Requirement Rationale* : Makes it possible to switch PM if the Active PM has malfunctioned.

---

*Requirement Number* : SAVOIR.OBC.RM.150
**Level 4 Alarm input cross-strapping**
A Level 4 alarm input shall be routed to both RMs.

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### *7.13.4 RM API*

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*Requirement Number* : SAVOIR.OBC.RM.160
**RM programming readout**
The OBC shall allow the ASW to read the configuration parameters and status irrespective of whether the RM is enabled or disabled.

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*Requirement Number* : SAVOIR.OBC.RM.170
**RM status readout**
The OBC shall allow the ASW to read at least the following status in an RM that is enabled or disabled:

- Log of performed reconfigurations

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### *7.13.5 Alarm Processing*

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*Requirement Number* : SAVOIR.OBC.RM.180
**Start of alarm monitoring**
The RM shall wait a configurable time <RM_Tmask> after power-on
or RM induced PM reboots or switch-over, before it starts monitoring alarm inputs..

*Requirement Rationale* : Ensures that false reconfigurations are not executed because the system is still booting. <RM_Tmask> duration is mainly dependent upon the time needed by PM to perform a reboot. This booting time does not change during the mission life time therefore updating <RM_Tmask> in flight is not requested. <RM_Tmask> does not exceed 90 seconds

---

*Requirement Number* : SAVOIR.OBC.RM.190
**Alarm masking**
It shall be possible to mask alarms from generating alarm events.

Note: This can be done via ASW or ground command
*Requirement Rationale* : Alarm generations may be erroneous and there must thus be mechanisms that can disable the effects of false alarms.

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*Requirement Number* : SAVOIR.OBC.RM.195
**Alarm Filtering**
It shall be possible to specify for each alarm a filtering delay such that an alarm is generated only if the input signal is permanently present during the filtering delay
*Requirement Rationale* : Alarm filtering is considered necessary for proper masking of spurious spikes or glitches.

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### *7.13.6 Alarm Pattern Detection*

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*Requirement Number* : SAVOIR.OBC.RM.200
**Alarm Pattern Matching**
The RM shall use the current alarm information to decide on a reconfiguration sequence to be executed.

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### *7.13.7 Reconfiguration Sequence Generation*

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*Requirement Number* : SAVOIR.OBC.RM.210
**Generation of CPDU packet**
When an alarm event has been detected the RM shall generate CPDU commands forming a reconfiguration sequence that is uniquely identified for the alarm event.

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*Requirement Number* : SAVOIR.OBC.RM.230
**Reconfiguration log**
Each RM should store log(s) of at least the <MIN_RM_LOG_SIZE> latest reconfiguration.
*Requirement Rationale* : Typical value of <MIN_RM_LOG_SIZE> is 3-6. Used for analysis by the ground operator. Multiple logs are desired in case there are several subsequent reconfigurations in between each ground contact.

### 7.13.8 RM In-Flight Modifiable Parameters

*Requirement Number* : SAVOIR.OBC.RM.240
**RM parameter write access**
The OBC shall allow the ASW or the ground operator to modify parameters using an arm-and-fire mechanism.
*Requirement Rationale* : If changes are done by ASW they are initiated by ground control. The RM parameters could be either simple mask registers but also complete reconfiguration sequences if needed by mission requirements.

### 7.13.9 RM Error Handling

*Requirement Number* : SAVOIR.OBC.RM.250
**Detection of RM communication errors**
The OBC shall allow the ASW to be notified of errors during communication with the RM.

## 7.14 Position/ Velocity Sensor and Time Reference (PVT) Common Requirements

### 7.14.1 PVT Configuration

*Requirement Number* : SAVOIR.OBC.PVT.10
**Number of PVT functions**
The OBC shall provide two PVT functions operating in cold redundancy.
*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.PVT.20
**Selecting PVT function**
The OBC shall allow the ASW to select the Active PVT.
*OptionInfo* : Option GNSS=Yes

### 7.14.2 PVT Function

*Requirement Number* : SAVOIR.OBC.PVT.30
**Number of GNSS frequency bands**
The OBC shall support single or dual frequency.
*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.PVT.40
**GNSS frequencies**
The OBC shall support the following frequencies:
- GPS L1
- GPS L5
- Galileo E1
- Galileo E5

*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.PVT.50
**GNSS measurements, single frequency**
The OBC shall support tracking of at least 24 satellites in single-frequency mode.
*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.PVT.60
**GNSS measurements, dual frequency**
The OBC shall support tracking of at least 18 satellites in dual-frequency mode.
*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.PVT.70
**GNSS space vehicles**
The OBC shall consider all space vehicles (SVs) of the supported GNSS constellation(s) with an unobstructed line-of-sight from at least one antenna's field-of-view.
*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.PVT.80
**GNSS space vehicles threshold**
The OBC shall support setting a threshold for the number of GNSS SVs of a certain constellation to be acquired and tracked before SVs of another constellation may be acquired.
*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.PVT.90
**PVT operation control**
The OBC shall allow the ASW to control the following operational parameters:
- Acquisition and tracking parameters
- Satellite selection

*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.PVT.100
**GNSS unhealthy signals**
The OBC shall disregard any signal marked as unhealthy in the navigation message, for the calculation of position, velocity and time.
*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.PVT.110
**PVT baseline clocking scheme**
The Position/ Velocity Sensor and Time Reference shall be able to operate without any externally supplied LOs or clocks.
*OptionInfo* : Option GNSS=Yes

### *7.14.3 PVT Interfaces*

*Requirement Number* : SAVOIR.OBC.PVT.120
**PM Communication Path**
There shall be one communication path between the Active Position/ Velocity Sensor and Time Reference functions and the Active PM.
*Requirement Rationale* : Used for transmitting and receiving messages.
*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.PVT.130
**GNSS signal inputs**
The Position/ Velocity Sensor and Time Reference functions shall have two inputs for GNSS signals from two different antennas or Low Noise Amplifiers (LNAs).
*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.PVT.140
**GNSS signal inputs**
The Position/ Velocity Sensor and Time Reference functions shall have two outputs for powering external LNAs.
*OptionInfo* : Option GNSS=Yes

### *7.14.4 PVT API*

*Requirement Number* : SAVOIR.OBC.PVT.150
**Diagnostics**
The OBC shall allow the ASW to perform all operations listed in section 7.14.6.
*OptionInfo* : Option GNSS=Yes

### *7.14.5 PVT Performance*

*Requirement Number* : SAVOIR.OBC.PVT.160
**Signal acquisition 1**
The Position/ Velocity Sensor and Time Reference functions shall be able to acquire signals at an effective C/No (at the correlators) of 30 dBHz, without any external aiding.

*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.PVT.170
**Signal acquisition 2**
The Position/ Velocity Sensor and Time Reference functions shall be able to perform guided acquisitions of signals at an effective C/No (at the correlators) of 25 dBHz.
*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.PVT.180
**Signal acquisition 2**
The Position/ Velocity Sensor and Time Reference functions shall be able to track all considered GNSS signals at an effective C/No (at the correlators) of down to at least 27 dBHz.
*OptionInfo* : Option GNSS=Yes

### *7.14.6 PVT Diagnostics*

*Requirement Number* : SAVOIR.OBC.PVT.190
**PVT Diagnostics 1**
The OBC Position/ Velocity Sensor and Time Reference functions shall support forced SV selection, which overrides autonomous SV selection and ignores health flags.
*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.PVT.200
**PVT Diagnostics 2**
The OBC Position/ Velocity Sensor and Time Reference functions shall support patching and dumping of all memories and registers.
*OptionInfo* : Option GNSS=Yes

### *7.14.7 PVT Error Handling*

*Requirement Number* : SAVOIR.OBC.PVT.210
**Detection of PVT communication errors**
The OBC shall allow the ASW to be notified of errors during communication with the PVT functions.

## 7.15 Position and Velocity Sensor Specific

*Requirement Number* : SAVOIR.OBC.PVS.10
**GNSS measurements**
The Position and Velocity Sensor function shall provide pseudo range, carrier phase and Doppler measurements.
*OptionInfo* : Option GNSS=Yes
*Requirement Rationale* : This is needed for precise orbit determination (POD)

*Requirement Number* : SAVOIR.OBC.PVS.20
**PVS API**
The OBC shall allow the ASW to read the Position and Velocity Sensor outputs as listed in SAVOIR.OBC.PVS.10.
*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.PVS.30
**Pseudorange performance**
The Position and Velocity Sensor function receiver error of the pseudorange measurements, for the single frequency case, shall be provided with the following characteristics (without carrier smoothing):

- Receiver inter channel bias < 10 cm
- Receiver pseudo range error at C/No = 45 dBHz:
  - L1: 0.5m
  - E1: 0.5m
  - L5: 0.12m
  - E5: 0.12m

*OptionInfo* : Option GNSS=Yes
*Requirement Rationale* : This will allow a GNSS software package to provide at least the following accuracy, using only GPS or only Galileo and assuming a dual-frequency operation:

- Radial: 3m
- Position (3D): 3.75m
- Velocity (3D): 5mm/s
- Time: 30ns

The values are taken from the specification of a combined OBC/GNSS receiver made in the ESA contract 4000112458. Actual receivers will have better performance, typically by a factor of 2 or more

*Requirement Number* : SAVOIR.OBC.PVS.40
**Carrier phase performance**
The Position and Velocity Sensor function receiver error of the carrier phase

measurements, for the single frequency case and with a C/No = 45 dBHz, shall be less than (1sigma-Rx carrier Phase Error):

- L1/E1: 0.6mm
- L2/L5/E5: 1mm

*OptionInfo* : Option GNSS=Yes

## 7.16 Time Reference Specific

*Requirement Number* : SAVOIR.OBC.TR.10

**OBT Synchronisation Path 1**

There shall be one synchronisation path between the Active Time Reference function and the Master OBT.

*OptionInfo* : Option GNSS=Yes

*Requirement Rationale* : Used to synchronise the OBT to the GNSS time in all OBT modes.

*Requirement Number* : SAVOIR.OBC.TR.20

**OBT Synchronisation Path 2**

There should be one synchronisation path between the Active Time Reference function and the Slave OBT.

*OptionInfo* : Option GNSS=Yes

*Requirement Rationale* : Used to keep also the Slave OBT synchronised to the GNSS time in Synchronized mode. In a specific implementation the Slave OBT can also be synchronised to the GNSS time from the Inactive Time Reference function and then there is no need for a cross-strap between the Active Time Reference function and the Slave OBT.

*Requirement Number* : SAVOIR.OBC.TR.30

**Time Reference API**

The OBC shall allow the ASW to read the GNSS time.

*OptionInfo* : Option GNSS=Yes

*Requirement Number* : SAVOIR.OBC.TR.40

**Time Reference performance**

The Time Reference function shall provide at least the following accuracy, using only GPS or only Galileo:

- Time: 30ns

Note: Dual-frequency is assumed.

*OptionInfo* : Option GNSS=Yes

## ~~7.14~~7.17 Overall performance

*Requirement Number* : SAVOIR.OBC.OP.10

**Overall data interface performance**
The OBC shall operate nominally when subjected to data interface traffic corresponding to the sum of data rates specified for each interface.

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*Requirement Number* : SAVOIR.OBC.OP.20
**OBC power-on performance**
The power-on sequence of the OBC shall be predictable.

# 8 INTERFACE REQUIREMENTS

## 8.1 Electrical Interfaces

### *8.1.1 General*

*Requirement Number* : SAVOIR.OBC.IF.10
The OBC shall continue to function nominally if one input or output is left non connected.
Note: This requirement is not applicable to the power bus.

### *8.1.2 SDI Interface Type Definition*

*Requirement Number* : SAVOIR.OBC.IF.SDI.10
**SDI Input Electrical Interface**
The SDI Input shall be implemented according to clause 8.8 in ECSS-E-ST-50-14C

*Requirement Number* : SAVOIR.OBC.IF.SDI.20
**SDI Output Electrical Interface**
The SDI Output shall be implemented according to clause 8.8 in ECSS-E-ST-50-14C with the following exception:
* The differential output impedance (8.8 a.4) shall be between 100 and 140 ohms.

### *8.1.3 SpaceWire Interfaces*

*Requirement Number* : SAVOIR.OBC.IF.SPW.10
**SpaceWire links Electrical IF**
The external SpaceWire links shall have the electrical characteristics according to ECSS-E-ST-50-12C clause 5 and 6 with the following addition:

- A node must in case of failure not produce a voltage on output or input signals outside the range 0V to +3,6V relative to its signal ground.
- A node must tolerate an input signal in the range -0,3V to +3,9V relative to its signal ground without being damaged.

*Requirement Rationale* : Overvoltage tolerances are not specified in ECSS-E-ST-50-12C. The limits are designed for a typical 3.3V system.

### *8.1.4 MIL-STD-1553B Interface*

*Requirement Number* : SAVOIR.OBC.IF.1553.10
**1553 Electrical Interface**
The 1553 Bus shall be compliant to ECSS-E-ST-50-13C clause 5.

### 8.1.5 BDM Interface Type Definition

*Requirement Number* : SAVOIR.OBC.IF.BDM.10
**BDM Electrical Interface**
The BDM Interface shall be implemented according to clause 6.1 in ECSS-E-ST-50-14C

### 8.1.6 BSM Interface Type Definition

*Requirement Number* : SAVOIR.OBC.IF.BSM.10
**BSM Electrical Interface**
The BSM Interface shall be implemented according to clause 6.2 in ECSS-E-ST-50-14C

### 8.1.7 HV-HPC Interface Type Definition

*Requirement Number* : SAVOIR.OBC.IF.HPC.10
**HV-HPC Pulse Command electrical characteristics**
The HV-HPC electrical characteristics shall be according to ECSS-E-ST-50-14C clause 7.1.

### 8.1.8 CAN Bus Interface

*Requirement Number* : SAVOIR.OBC.IF.CAN.10
**CAN Electrical Interface**
The CAN Bus shall be compliant to ECSS-E-ST-50-15C clause 5.

Note: ECSS foresees two alternative implementations based on ISO 11898-2:2003 and (for legacy systems) on modified RS-485 transceivers. So the physical layer specifications comply with either ISO 11898-2:2003 as specified in clause 5.3.2 or EIA RS485 as specified in clause 5.3.5 of ECSS.