**LFR Validation test report for R3 flight software**

**Solar Orbiter Mission**

**RPW INVESTIGATION**

**MEB (Main Electronic Box) Instrument**

**LFR (Low Frequency Receiver) Sub-Instrument**

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# Introduction

## Purpose and scope

This document provides acceptance test report for **R3++ LFR FSW**. Scope is V3++ requirements validation tests results and non-regression tests results on V3, V2 and V1. **Non regression tests consisted in replaying all scenario related to V1, V2 and V3.** Also, since January 2015 calibration activities are ongoing and many calibration test cases (CTC) and associated results have been used to validate part of requirements of V2 and V3 as specified in [AD03].

# Documents

## Applicable Documents

|  |  |  |  |
| --- | --- | --- | --- |
|  | Reference | Ver. | Title |
| AD01 | RPW-MEB-LFR-SDP-00040-1-1\_LFR\_Software\_Development\_Plan | 2.0 | Software Validation and Verification Plan (included in referenced Software Development Plan) |
| AD02 | RPW-SYS-SSS-00013-LES | 4.3 | RPW Instrument - Software System Specification |
| AD03 | RPW-MEB-LFR-PLN-00035-LPP-0-0\_SValP | 1.1 | SOFTWARE VALIDATION PLAN (SVALP) - Version 1.1 - Solar Orbiter Mission - RPW INVESTIGATION - MEB (Main Electronic Box) Instrument - LFR (Low Frequency Receiver) Sub-Instrument |
| AD04 | RPW-MEB-LFR-SRS-00020 | 2.1 | Software Requirements Specification (SRS) |
| AD05 | RPW-MEB-LFR-SVS-00066-LPP | 1.6 | Software Validation Specification (SVS) |
| AD06 | RPW FDIR | V2.2 | RPW-SYS-MEB-###-FMC-000207-LES\_Issue2\_Rev2\_FDIR\_Analysis |
| AD07 | RPW-SYS-MEB-LFR-ICD-00097 | Issue 4  Rev 3 | RPW LFR Software ICD |

## Reference Documents

### Normative References

This document is based on the documents listed in the following table:

|  |  |  |  |
| --- | --- | --- | --- |
|  | Reference | Ver. | Title |
| RD01 | ECSS-Q-ST-80 | C | Space product assurance Software product assurance |
| RD02 | ECSS-E-ST-40 | C | Space engineering - Software |
| RD03 | RPW-MEB-LFR-CPS-00191-LPP | 1.3 | LFR Calibration Plan Specification |
| RD04 | RPW-MEB-LFR-RPT-00168-LPP | 1.4 | LFR Calibration Report |
| RD05 | RPW-MEB-LFR-RPT-00095-LPP | 2.4 | LFR FSW Verification Report |
| RD06 | RPW-MEB-LFR-NTT-00213 | 1.0 | LFR acquisition time accuracy |
| RD07 | RPW-MEB-LFR-NTT-00123 | 1.5 | LFR Flight Software User Manual |

### Informative References

|  |  |  |
| --- | --- | --- |
| ID | Document Title | Reference |
| IR-01 | BAGHERA DOC 2.2 - Gestion de la Documentation Technique - Manuel d'utilisation | EC\_OPE\_BDO\_DOC\_031 |
| IR-02 | Failure modes, effects (and criticality) analysis (FMEA/FMECA) | RNC-ECSS-Q-ST-30-02 |
| IR-03 | Risk management | RNC-ECSS-M-ST-80 |
| IR-04 | Guide pour les Projets Scientifiques CNES | DTS/AQ/QP 98-083 |
| IR-05 | Space product assurance - Software product assurance | ECSS-Q-ST-80C, 6/03/2009 |
| IR-06 | Space engineering – Software | ECSS-E-ST-40C, 6/03/2009 |
| IR-07 | Démarche de développement objet pour les logiciels– Document Chapeau | RNC-CNES-E-HB-40-508 |
| IR-08 | Démarche de développement objet pour les logiciels – Annexe A – Principes de mise en œuvre des concepts Orienté Objet | RNC-CNES-E-HB-40-508-A |
| IR-09 | Démarche de développement objet pour les logiciels – Annexe B – Documentation | RNC-CNES-E-HB-40-508-B |
| IR-10 | LPP Redmine server for LFR flight software bug tracking :  https://hephaistos.lpp.polytechnique.fr/redmine/projects/lfr-fsw/issues |  |
| IR-11 | LPP Rhodecode server for mercurial repository of test cases scripts and result logs:  https://hephaistos.lpp.polytechnique.fr/rhodecode/HG\_REPOSITORIES/LPP/INSTRUMENTATION/SOLO\_LFR/VALIDATION\_R3plusplus |  |

# Terms, definitions and abbreviated terms

|  |  |
| --- | --- |
| Acronym | Definition |
| FSW | Flight Software |
| HK | House Keeping |
| LFR | Low Frequency Receiver |
| MEB | Main Electronic Box |
| N/A | Not Applicable |
| RPW | Radio and Plasma Wave analyzer |
| SpW | SpaceWire |
| SRS | Software Requirement(s) Specification |
| VHDL | VHSIC Hardware Description Language |
| CTC | Calibration Test Case |
| PFM | Proto Flight Model |
| RW | Reaction wheel |
| PAS | Proton-Alpha Sensor (SWA-PAS) |

# Configuration

The configuration has been checked before tests execution:

## Software

**On LFR EM1:**

* Vhdl : 1.1.91
* FSW : **3.2.0.24**
* Timegen 0.0.0.1

Test Environment:

* SocExplorer 0.7.3 (on fedora23)
* TortoiseHg 2.11.1
* redmine (projects lfr\_fsw [IR-10], and the project “INSTRU » LPPMON » LPPMON\_Plugins\_PAUL on pc-instru)
* Jira
* Python 2.7
* Python 3 with jupyter notebooks\*
* Rhodecode server for mercurial repository (IR-11)

***Note:*** As specified in [AD03], all test cases material (e.g. tests scripts, logs, backtraces, result files) are versioned on a mercurial repository ([IR-11]). Each test case material is stored in a separate folder identified with the test case number (SVS-XXX).

\* For R3++ specific purposes, a dedicated Python framework has been deployed (lfrcompliance/test\_engineR3++). It consists of :

- A Jupyter notebook that is used to describe a scenario to be played with notebook cell that contain specific variables and test steps characteristics. The execution of the cell generates an input file.

- A test engine that can run specific scenarii (written in Python) with specific generated input file (see above) and generates output file containing test results and parameters.

- Several jupyter notebooks to analyze automatically the results of tests played. Those notebooks use output files from the test engine and criteria defines to acknowledge the PASS/FAIL state of a given test.

## Hardware

Board = EM1

Brick = Star-DUNDEE.

System clock simulator = Mini-LFR with specific VHDL

Signal generators : LPP Discospace module and stand-alone Analog discovery devices (Digilent)

# Indicators

For non-regression tests, no exhaustive long stress tests have be done.

So several tests are tagged “**P**artially **T**ested” even if they are OK.

## Indicators

For R3++, 13 strictly V3++ requirements are identified "Test".

The distribution of those strictly V3 TEST CASES results is:

|  |  |
| --- | --- |
| OK | 13 |
| POK | 0 |
| NOK | 0 |
| PT | 0 |
| NT | 0 |

For R3, 10 strictly V3 requirements are identified "Test".

The distribution of those strictly V3 TEST CASES results is:

|  |  |
| --- | --- |
| OK | 9 |
| POK | 1 |
| NOK | 0 |
| PT | 0 |
| NT | 0 |

Concerning V2 requirements (§6.3), all test cases have been replayed. The distribution of V2 test cases results is:

|  |  |
| --- | --- |
| OK | 55 |
| POK | 4 |
| NOK | 0 |
| PT | 9 |
| NT | 2 |

Concerning V1 requirements (§6.4), almost test cases have been replayed. The distribution of V1 test cases results is:

|  |  |
| --- | --- |
| OK | 23 |
| POK | 0 |
| NOK | 0 |
| PT | 9 |
| NT | 0 |

## Summary

Technical facts have been raised during this test run:

|  |  |  |
| --- | --- | --- |
| **Reference** | **Title** | **Classification** |
| [IR-10] Bug #553 | SSS-CP-EQS-326: since FSW >=3.0.0.20 LFR is partially but relevantly compliant. RFD 227 issued. | Minor |
| [IR-10] Bug #554 | SSS-CP-EQS-340: Acquisition synchronization is higher than 500 µs as required but this system level requirement is not possible for LFR. Discussions are in progress at system level. | Minor |
| [IR-10] Bug #245 | SSS-CP-EQS-350: Snapshot centering precision higher than 1ms as required but jitter is stable and compatible with TDS snapshot range cover. Improvements are ongoing. RFW 230 issued. | Minor |
| [IR-10] #627 | To improve snapshots centering, TC\_LFR\_ENTER\_MODE with argument 0 for due date is performed on the next sharp second (current coarse time +1). RFD 226 issued. | Minor |

# Validation results on EM1 (fsw 3.2.0.24)

## Specific V3++ tests

Coverage is made through SVS scenario and tests.

For parameters configuration SY\_LFR\_N\_ASM\_P is set to 4 seconds instead of the default value (3600s).

SY\_LFR\_N\_SWF\_P is 300s in nominal or 22s.

| **Requirement Id** | **Object Short Text** | **RPW Software System Specification** | **ID** | **Covered by** | **Verdict** |
| --- | --- | --- | --- | --- | --- |
| SSS-CP-EQS-750 | LFR Filtering of S/C reaction wheel emission frequencies | Upon reception of the TC\_LFR\_UPDATE\_INFO packet, the LFR flight software shall be able to discard in the science data processing the 16 S/C reaction wheel emission frequencies, according to:   * the reaction wheel frequencies CP\_RPW\_SC\_RW[1-4]\_F[1-4] * the available/unavailable state of each frequency can be deduced of CP\_RPW\_SC\_RW[1- 4]\_F[1-4] which is set to NaN if the reaction wheel emission frequency filtering is disabled. With the IEEE-754 32 bits standard, the NaN value is coded by setting the exponent part to 0xFF * the filtering bandwidths SY\_LFR\_SC\_RW\_DELTA\_F \* SY\_LFR\_RW[1-4]\_K[1-4] associated | REQ-LFR-SRS-6000  REQ-LFR-SRS-6020  REQ-LFR-SRS-6006 | SVS-1100  SVS-1110  SVS-1102 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-751 | LFR Filtering of S/C reaction wheel emission frequencies | The LFR flight software shall report in its periodic HK packet (TM\_LFR\_HK) the available/unavailable state for each of the 16 S/C reaction wheel frequencies conveyed in the TC\_LFR\_UPDATE\_INFO packet. | REQ-LFR-SRS-6001 | SVS-1103 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-752 | LFR Filtering of S/C reaction wheel emission frequencies | Until reception of the first TC\_LFR\_UPDATE\_INFO packet, the LFR flight software shall consider as unavailable the 16 S/C reaction wheel frequencies. | REQ-LFR-SRS-6002 | SVS-0057 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-753 | LFR Filtering of S/C reaction wheel emission frequencies | Upon reception of a TC\_LFR\_LOAD\_FILTER\_PAR packet, the LFR flight software shall allow to change:   * SY\_LFR\_SC\_RW\_DELTA\_F (default value = 0.045 Hz). * the 32-bit float values of kxy factor coefficients used by the DPU to compute, from each reaction wheel fundamental frequency, the frequencies to be filtered (dimensionless) * SY\_LFR\_RWi\_K1 (default value = 1) * SY\_LFR\_RWi\_K2 (default value = 8) * SY\_LFR\_RWi\_K3 (default value = 24) * SY\_LFR\_RWi\_K4 (default value = 48)   with i=[1,4] | REQ-LFR-SRS-6003 | SVS-0096 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-754 | LFR Filtering of S/C reaction wheel emission frequencies | The LFR flight software shall report in the TM\_LFR\_PARAMETER\_DUMP packet, the following 32- bit unsigned values of the masks used for the frequency filtering process:   * PA\_LFR\_RW\_MASK\_Fi\_WORD1 * PA\_LFR\_RW\_MASK\_Fi\_WORD2 * PA\_LFR\_RW\_MASK\_Fi\_WORD3   with i=[0,2] | REQ-LFR-SRS-6004 | SVS-1109 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-755 | LFR Filtering of S/C reaction wheel emission frequencies | The LFR flight software shall be able to dump in the TM\_LFR\_PARAMETER\_DUMP packet the S/C reaction wheel filtering parameters conveyed in the TC\_LFR\_LOAD\_FILTER\_PAR packet. | REQ-LFR-SRS-6005 | SVS-0096 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-760 | LFR Basic parameters encoding | The LFR flight software shall be compliant to the following algorithm for the computation of the basic parameters engineering values PB\_i from the raw values PA\_LFR\_SC\_BP1\_PB\_F2i conveyed in the TM\_LFR\_SCIENCE\_NORMAL\_BP1\_F2 packet | REQ-LFR-SRS-5522 | CTC tests | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-761 | LFR Real Time Filtering of SWA/PAS Perturbations | If SY\_LFR\_PAS\_FILTER\_ENABLED is set to enabled, the LFR flight software shall filter its spectral matrixes according to:   * The perturbation duration SY\_LFR\_PAS\_FILTER\_TBAD, * The modulus of the coarse time defining the perturbation instant SY\_LFR\_PAS\_FILTER\_MODULUS, * The offset added for computing the perturbation instant SY\_LFR\_PAS\_FILTER\_OFFSET, * The time-shift relatively to the timecode occurrence identifying the perturbation start SY\_LFR\_PAS\_FILTER\_SHIFT,   and by taking into account the maximum amount of non-perturbated data for F0, F1 and F2. | REQ-LFR-SRS-6100 | SVS-1202  SVS-1203  SVS-1204 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-762 | LFR Real Time Filtering of SWA/PAS Perturbations | If SY\_LFR\_PAS\_FILTER\_ENABLED is set to disabled, the LFR flight software shall disable the filtering of its spectral matrixes. | REQ-LFR-SRS-6101 | SVS-1201 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-763 | LFR Real Time Filtering of SWA/PAS Perturbations | At startup, the LFR flight software shall disable the filtering of its spectral matrixes. | REQ-LFR-SRS-6102 | SVS-0057 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-764 | LFR Real Time Filtering of SWA/PAS Perturbations | Upon reception of a TC\_LFR\_LOAD\_FILTER\_PAR packet, the LFR flight software shall allow to change the values of the following parameters:   * SY\_LFR\_PAS\_FILTER\_ENABLED: the enabled/disabled state of the LFR real time filtering of SWA/PAS perturbations (default value = enabled)  1. If set to enabled, the filtering process shall be enabled 2. If set to disabled, the filtering process shall be disabled  * SY\_LFR\_PAS\_FILTER\_MODULUS: the modulus of the coarse time defining the perturbation instant (default value = 4) * SY\_LFR\_PAS\_FILTER\_TBAD: the perturbation duration (default value = 1 second) * SY\_LFR\_PAS\_FILTER\_OFFSET: the offset added for computing the perturbation instant (default value = 0) * SY\_LFR\_PAS\_FILTER\_SHIFT: the time-shift relatively to the timecode occurrence identifying the perturbation start (default value = 0.5 second) | REQ-LFR-SRS-6103 | SVS-1202  SVS-1203  SVS-1204 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-765 | LFR Real Time Filtering of SWA/PAS Perturbations | The LFR flight software shall be able to dump in the TM\_LFR\_PARAMETER\_DUMP packet the SWA/PAS perturbation filtering parameters. | REQ-LFR-SRS-6104 | SVS-0096 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-766 | LFR Real Time Filtering of SWA/PAS Perturbations | The LFR flight software shall report in its periodic HK packet (TM\_LFR\_HK) the enable / disable status of the filtering of PAS/SWA perturbations. | REQ-LFR-SRS-6105 | SVS-0057 | Fsw-3.2.0.24  ok |

## Specific V3 tests

Coverage is made through SVS scenario and tests.

For parameters configuration SY\_LFR\_N\_ASM\_P is set to 4seconds instead of the default value (3600s).

SY\_LFR\_N\_SWF\_P is 300s in nominal or 22s.

| **Requirement Id** | **Object Short Text** | **RPW Software System Specification** | **ID** | **Covered by** | **Verdict** |
| --- | --- | --- | --- | --- | --- |
| SSS-CP-FS-610 | Cache configuration | The RPW Flight Software shall explicitly configure the data and instruction caches at startup | REQ-LFR-SRS-5289 | SVS-0091 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-290 | Equipment mode management | In the SBM2 mode, the equipment flight software shall produce toward the DPU two concurrent data streams:  - A low cadence data stream whose content corresponds to the NORMAL mode parameter set.  - A high cadence data stream whose content corresponds to the SBM2 mode parameter set. | REQ-LFR-SRS-5506 | SVS-0032 | Fsw-3.2.0.24  pok  [IR-10] Bug #245    step1,step11 not tested  ( long tests) |
| SSS-CP-EQS-327 | Equipment mode management | The equipment flight software shall stop to produce science packets as soon as they have sent the acknowledgment packet related to the mode transition to STANDBY. | REQ-LFR-SRS-5591 | SVS-0089 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-533 | LFR data for S/C potential computation | The LFR flight software shall report in its periodic HK packet (TM\_LFR\_HK) the availability of the electric field components sampled at f3. | REQ-LFR-SRS-5580 | SVS-0082 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-527 | LFR frequency bins internal mask | Upon reception of a TC\_LFR\_LOAD\_FBINS\_MASK, the LFR flight software shall be able to update the internal mask used for avoiding some frequency bins in the computation of the basic parameters:   * 1 mask f0 , 128 bits = 16 bytes * 1 mask f1 , 16 bytes * 1 mask f2 , 16 bytes | REQ-LFR-SRS-5581 | SVS-0083 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-528 | LFR frequency bins internal mask | The LFR flight software shall be able to dump in the TM\_LFR\_PARAMETER\_DUMP packet the internal mask of frequency bins. | REQ-LFR-SRS-5582 | SVS-0083 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-529 | LFR inter-calibration factors | Upon reception of several TC\_LFR\_LOAD\_KCOEFFICIENTS packets, the LFR flight software shall be able to update the inter-calibration factors (k-coefficients) used for computing the poynting flux and phase velocity estimators:   * 32 coefficients (coded on 4 bytes) for 36 frequencies. | REQ-LFR-SRS-5583 | SVS-0086 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-531 | LFR inter-calibration factors | Upon reception of a TC\_LFR\_DUMP\_KCOEFFICIENTS packet, the LFR flight software shall be able to dump in two TM\_LFR\_KCOEFFICIENTS\_DUMP packets the inter-calibration factors (k-coefficients). | REQ-LFR-SRS-5584 | SVS-0086 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-520 | Watchdog management | After initialization, the LFR FSW shall automatically enable the watchdog functionality. | REQ-LFR-SRS-5230 | SVS-0057 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-540 | Watchdog management | When the watchdog reaches 0, the LFR FSW shall activate a software context back-up procédure.  The LFR analyzer shall at least save the reason of reset | REQ-LFR-SRS-5232 | SVS-0058 | Fsw-3.2.0.24  ok |

## Specific V2 tests

Coverage is made through SVS scenario and tests.

For parameters configuration SY\_LFR\_N\_ASM\_P is set to 4seconds instead of the default value (3600s).

SY\_LFR\_N\_SWF\_P is 300s in nominal or 22s.

For non-regression tests, no exhaustive long stress tests have be done.

So several tests are tagged “**P**artially **T**ested” even if they are OK.

All calibration tests are not be played.

| **Requirement Id** | **Object Short Text** | **RPW Software System Specification** | **ID** | **Covered by** | **Verdict** |
| --- | --- | --- | --- | --- | --- |
| SSS-IF-DPS-EQ-190 | Command packets (DPU SW to RPW Analyzer SW) | The Analyzer Flight Software shall be able to process the maximum rate of command packets given below:  - LFR: SY\_LFR\_TC\_MAX\_RATE = 5 commands per second  - TNR-HFR: SY\_THR\_TC\_MAX\_RATE = 5 commands per second  - TDS: SY\_TDS\_TC\_MAX\_RATE = 5 commands per second | REQ-LFR-SRS-5303 | SVS-0022 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-032 | Command management | The execution of every telecommand shall be verifiable through a resulting change in the value of a Telemetry parameter. | REQ-LFR-SRS-5234 | SVS-0003 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-040 | Command acceptance stage | The RPW Flight Software shall validate the received commands prior to their execution (acceptance stage). | REQ-LFR-SRS-5203 | SVS-0005  And  SVS-0009 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-050 | Command acceptance stage | |  | | --- | | Upon the reception of any command packet, the LFR FSW shall verify if the packet can be accepted by:   Checking the following items  in this specific order :   APID (PID, CAT)   Length of the received pack  et should match packet\_length field  contained in packet header   service type and  service subtype   source ID   Length\_packet field value  is relevant with expected length  considering definition of the  sub-type.   packet error control (CRC)  . The algorithm to compute the  packet error control is specified in  the [AD10], appendix 6.  If at least one of this criteria fails  TM\_LFR\_EXE\_CORRUPTED  packet is emitted with failure  code 42005 | | REQ-LFR-SRS-5204 | SVS-0007 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-055 | Command acceptance stage | The LFR Flight Software shall compute the CRC on the CCSDS Telecommand Source Packet part of the received packet.  There is no conclusive evidence for this elementary req. | REQ-LFR-SRS-5236 | SVS-0003  (step2 to 19) | Fsw-3.2.0.24  ok |
| SSS-CP-FS-065 | Command acceptance stage | If the acceptance of the command fails, the equipment flight software shall systematically generate a Telecommand Execution Completed Failure Report (TM\_xxx\_TC\_EXE\_CORRUPTED or TM\_xxx\_TC\_EXE\_NOT\_EXECUTABLE) conforming to the PUS telecommand verification service [ES1] (type = 1, subtype = 8), whatever the value of the acknowledgment flag in the command packet header.  - This requirement does not apply to the following packets: TC\_xxx\_UPDATE\_INFO, TC\_xxx\_UPDATE\_TIME. | REQ-LFR-SRS-5205 | SVS-0007 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-075 | Command acceptance stage | The LFR Flight Software shall start the execution of the commands only if they have been accepted, otherwise the commands shall be discarded. | REQ-LFR-SRS-5206 | SVS-0003, SVS-0005,  SVS-0007, SVS-0008,  SVS-0009 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-080 | Command execution stage | If the execution of the command fails, the RPW Flight Software shall generate a Telecommand Execution Completed Failure Report conforming to the PUS telecommand verification service [ES1] (type = 1, subtype = 8) even if this has not been requested in the execution acknowledgment flag in the telecommand packet header.  - This requirement does not apply to the following packets: TC\_xxx\_UPDATE\_INFO, TC\_xxx\_UPDATE\_TIME. | REQ-LFR-SRS-5207 | SVS-0008 | Fsw-3.2.0.24  ok  TM\_LFR\_TC\_EXE\_ERROR  Is only verifiable by inspection (see RD05) |
| SSS-CP-FS-085 | Command execution stage | The LFR FSW shall manage the following criteria that can be the cause of the failure of the command execution:   If TC has a wrong or inconsistent data field (section APPLICATION\_DATA) e.g. the command parameters are not correctly encoded nor within their range of values or non coherent with another value : a TM\_LFR\_TC\_EXE\_INCONSISTENT is emitted. This is only applicable to those following TC : TC\_LFR\_LOAD\_NORMAL\_PAR, TC\_LFR\_LOAD\_BURST\_PAR, TC\_LFR\_LOAD\_SBM1\_PAR, TC\_LFR\_LOAD\_SBM2\_PAR, TC\_LFR\_ENTER\_MODE.   The command cannot be executed at this time or the commands parameters are not valid for the current mode (see tab 5.2) : a TM\_LFR\_TC\_EXE\_NOT\_EXECUTABLE is emitted.   The execution functionality is not implemented yet : a TM\_LFR\_TC\_EXE\_NOT\_IMPLEMENTED is emitted.   A malfunction or an error is detected during the execution : a TM\_LFR\_TC\_EXE\_NOT\_EXECUTABLE is emitted. | REQ-LFR-SRS-5208 | SVS-0059 | Fsw-3.2.0.24  ok  All TC are implemented  so TM\_LFR\_TC\_EXE\_NOT\_IMPLEMENTED cannot be generated |
| SSS-CP-FS-090 | Command execution stage | When a command has been properly executed, the RPW Flight Software shall generate a report of successful completion for the execution stage conforming to the PUS telecommand verification service [ES1] (Telecommand Execution Completed Report – Success, type = 1, subtype = 7)  - only if this has been requested in the execution acknowledgment flag in the telecommand packet header, in the case of the DPU software,  - systematically, whatever the value of the acknowledgment flag in the command packet header (i.e. this flag shall be ignored), in the case of the equipment software.  - This requirement does not apply to the following packets: TC\_xxx\_UPDATE\_INFO, TC\_xxx\_UPDATE\_TIME. | REQ-LFR-SRS-5209 | SVS-0009 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-095 | Command execution stage | Each equipment flight software shall only produce one single acknowledgment report including the acceptance step and the execution step. | REQ-LFR-SRS-5210 | SVS-0009  SVS-0059 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-100 | Command start/progress stage | According to [AD6] and [AD5], the LFR Flight Software shall not generate reports (failure reports or success reports) concerning the start or the progress of telecommand execution. - The acknowledgment flags in the telecommand packet header related to the start of execution and to the progress of execution shall be ignored. | REQ-LFR-SRS-5202 | SVS-0008 SVS-0009 SVS-0059 (step1) | Fsw-3.2.0.24  ok |
| SSS-CP-FS-110 | Content of the verification reports | The TC acceptance / execution success report shall contain:  - a copy of the TC Packet ID field  - a copy of the TC Packet Sequence Control field | REQ-LFR-SRS-5211 | SVS-0010 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-120 | Content of the verification reports | The TC acceptance / execution failure report shall contain:  - a copy of the TC Packet ID field  - a copy of the TC Packet Sequence Control field  - a failure code: the failure code, which is an identifier for interpreting the failure, is     mandatory  - some parameters (auxiliary data) to identify the nature and cause of the telecommand failure; the parameters are optional | REQ-LFR-SRS-5212 | SVS-0007  SVS-0008 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-131 | Response time | The RPW Flight Software shall generate the TC execution report (success or failure) not longer than SY\_RPW\_ACK\_RESPONSE\_TIME = 4 seconds from the completion of the TC execution. | REQ-LFR-SRS-5302 | SVS-0021 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-201 | HK counter management | All the counters (error counters, packet counters, etc.) managed by the RPW Flight Software shall restart at 0 when they have reached their maximum value. | REQ-LFR-SRS-5241 | SVS-0026 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-340 | Time management | The RPW Flight Software shall maintain a local time with:  - a resolution of at least SY\_RPW\_TIME\_RESOLUTION = 1 ms and a relative accuracy of SY\_RPW\_TIME\_ACCURACY = 500 µs for the DAS and the three analyzers.  - a resolution of at least SY\_DPU\_DBS\_TIME\_RESOLUTION = 10 ms and a relative accuracy of SY\_DPU\_DBS\_TIME\_ACCURACY = 1 ms for the DBS. | REQ-LFR-SRS-5300 | SVS-0020 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-360 | Time management | After initialization, the RPW Flight Software shall set the most significant bit of its local time to 1 and all other bits to 0. | REQ-LFR-SRS-5218 | SVS-0011 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-370 | Time management | The RPW Flight Software shall synchronize its local time with the Central Time Reference (CTR) distributed as a SpaceWire command packet coupled to a SpaceWire time code.  - The CTR SpaceWire time code is transmitted every one second (SY\_RPW\_CTR\_FREQUENCY = 1 s)  - The CTR SpaceWire command packet containing the CTR is not necessarily sent by the DMS every one second.  - When it is generated, the CTR SpaceWire command packet is transmitted > SY\_RPW\_CTR\_MIN\_DELAY = 300 msec prior to the time code itself (see [AD1]).  - The CTR SpaceWire command packet is distributed thanks to the “Accept Time Update” command (service type = 9, service subtype = 129).  - The SpaceWire time code contains the least significant bits of the CTR coarse time part. | REQ-LFR-SRS-5219 | SVS-0012 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-380 | Time management | Upon the reception of the CTR SpaceWire time code sent by DPU, the LFR FSW shall:   If a CTR command packet has been received prior to the time code:   Update the coarse time part of its local time with the coarse time value previously transmitted in a CTR command packet. The SpaceWire time code contains the 6 least significant bits of the CTR coarse time part   if a CTR command packet has not been received prior to the time code:   update following HK fields if time code is valid : HK\_LFR\_DPU\_SPW\_TICK\_OUT\_CNT and HK\_LFR\_DPU\_SPW\_LAST\_TIMC. Management and processing of the time code is done exclusively by Spacewire IP (VHDL). Behavior is completely described in [AD18] and [RD03].  Also, the Spacewire IP will set the fine time part of its local time to 0 upon the reception of the CTR SpaceWire time code sent by DPU. | REQ-LFR-SRS-5220 | SVS-0013 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-405 | Time management | On successful time synchronization (i.e. when a CTR Time Update command packet followed by a SpaceWire time code were received), the RPW Flight Software shall set the most significant bit of its local time to 0. | REQ-LFR-SRS-5238 | SVS-0014 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-410 | Time management | If no SpaceWire time code is received by the RPW Flight Software for a period greater than SY\_RPW\_DELAY\_WITHOUT\_CTR = 60 seconds, the RPW Flight Software shall indicate this by setting the most significant bit of its local time to 1. | REQ-LFR-SRS-5222 | SVS-0076 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-590 | Telemetry management | The RPW Flight Software shall maintain, for each couple of APID and Destination ID, a TM sequence counter incremented by 1 when a packet is released.  - The sequence counters shall wrap around from 2^14-1 to zero.  - The sequence counter shall start at zero at startup. | REQ-LFR-SRS-5240 | SVS-0019 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-020 | Startup phase | After successful time synchronization, the equipment flight software shall enable the generation of its periodic housekeeping reports. | REQ-LFR-SRS-5531 | SVS-0055 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-110 | Equipment Event reporting | The equipment flight software shall report the normal progress of operations and activities having an operational significance by updating the value of the suitable status parameter in its periodic HK report. | REQ-LFR-SRS-5540 | SVS-0061 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-120 | Equipment Event reporting | The equipment flight software shall also report anomalies and errors (including SpaceWire errors) by using its periodic HK report and by managing the following parameters: - Low level error counter: incremented each time a new low level error / anomaly is detected by the equipment flight software. - Medium level error counter: incremented each time a new medium level error / anomaly is detected by the equipment flight software. -High level error counter: incremented each time a new high level error / anomaly is detected by the equipment flight software. - Last error report id: the error report id corresponds to the category of the error (AHB, SpaceWire, Buffer management, etc.); the last error report id parameter contains the id of the last error that has occurred. - Last error code: in a given error category, each error or anomaly that can occur is identified by an error code; the last error code parameter contains the code of the last error that has occurred. -Time of the last error. - Individual error counters: each individual error identified by its category and its code is associated to a specific error counter. | REQ-LFR-SRS-5541 | SVS-0037 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-130 | Equipment Event reporting | The equipment flight software shall report the three levels of severity: low, medium and high. | REQ-LFR-SRS-5542 | SVS-0037 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-140 | Equipment command feedback | The equipment flight software shall acknowledge all the commands it receives from the DPU excepted the both following commands for which no TM\_xxx\_TC\_EXE\_yyy packets shall be generated: TC\_xxx\_UPDATE\_INFO, TC\_xxx\_UPDATE\_TIME.  - The parameters HK\_xxx\_EXE\_TC\_CNT to HK\_xxx\_LAST\_REJ\_TC\_TIME shall not be updated upon reception of TC\_xxx\_UPDATE\_INFO and TC\_xxx\_UPDATE\_TIME. | REQ-LFR-SRS-5543 | SVS-0081 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-141 | Equipment command feedback | Upon reception of a TC\_xxx\_UPDATE\_INFO packet, the equipment flight software shall increment the HK\_LFR\_UPDATE\_INFO\_TC\_CNT counter only if the packet is correct and has been accepted. | REQ-LFR-SRS-5574 | SVS-0077 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-142 | Equipment command feedback | Upon reception of a TC\_xxx\_UPDATE\_TIME packet, the equipment flight software shall increment the HK\_LFR\_UPDATE\_TIME\_TC\_CNT counter only if the packet is correct and has been accepted. | REQ-LFR-SRS-5572 | SVS-0078 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-150 | Equipment command feedback | The equipment flight software shall produce, depending on the final status of the execution and the possible encountered errors, the following command acknowledgment packets (which are compliant to the PUS service n°1):  - TM\_LFR\_TC\_EXE\_SUCCESS in case of execution success.  - TM\_LFR\_TC\_EXE\_CORRUPTED in case of error detected during the acceptance stage verifications (Illegal APID, Illegal packet type, Illegal packet subtype, wrong CRC, wrong or incomplete length).  - TM\_LFR\_TC\_EXE\_INCONSISTENT in case of wrong or inconsistent field in the data fields.  - TM\_LFR\_TC\_EXE\_NOT\_EXECUTABLE in case of command that can not be executed at this time.  - TM\_LFR\_TC\_EXE\_NOT\_IMPLEMENTED in case of command not implemented.  - TM\_LFR\_TC\_EXE\_ERROR if a malfunction or an error is detected during the execution. | REQ-LFR-SRS-5544 | SVS-0059 | Fsw-3.2.0.24  ok  All TC are implemented  so TM\_LFR\_TC\_EXE\_NOT\_IMPLEMENTED should not be generated  TM\_LFR\_TC\_EXE\_ERROR  [IR-10] Bug #181] |
| SSS-CP-EQS-153 | SpaceWire link monitoring | After the loss of the SpaceWire connection, if the analyzer has failed to (re-)establish the  connection with the DPU within a SY\_xxx\_DPU\_CONNECT\_TIMEOUT timeout period, then the  equipment flight software shall:  **** Reset the SpaceWire interface(inspection)   Reset the connection timeout period (inspection)   **Start again the connection process (by test)** | REQ-LFR-SRS-5561 | SVS-0062 | Fsw-3.2.0.24  ok  EM1 used  No UPB\_UART on EM1  FSW software must be in debug mode |
| SSS-CP-EQS-154 | SpaceWire link monitoring | The equipment flight software shall perform up to SY\_xxx\_DPU\_CONNECT\_ATTEMPT attempts  of connection with the DPU. | REQ-LFR-SRS-5562 | SVS-0063 | Fsw-3.2.0.24  OK  EM1 used  No UPB\_UART on EM1  FSW software must be in debug mode |
| SSS-CP-EQS-155 | SpaceWire link monitoring | After SY\_xxx\_DPU\_CONNECT\_ATTEMPT unsuccessful attempts of connection with the DPU, the  equipment flight software shall:   Enter into STANDBY. | REQ-LFR-SRS-5563 | SVS-0064 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-200 | Equipment mode management | A science sub-mode parameter set that is in use cannot be changed.  Normal sub-mode parameter can’t be changed if current mode is NORMAL, SBM1, SBM2.  Burst sub-mode parameter can’t be changed if current mode is burst.  SBM1sub-mode parameter can’t be changed if current mode is SBM1.  SBM2sub-mode parameter can’t be changed if current mode is SBM2.  A TM\_LFR\_EXE\_NOT\_EXECUTABLE is generated in this case. | REQ-LFR-SRS-5549 | SVS-0008 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-210 | Equipment mode management | Additionally, the LFR FSW, depending on the features of the equipment, shall have one command for configuring the parameters not directly linked to the science sub-mode configuration.  Common parameters: TC\_LFR\_LOAD\_COMMON\_PAR  This command configures 6 parameters coded on bit  SY\_LFR\_BW  SY\_LFR\_SP0  SY\_LFR\_SP1  SY\_LFR\_R0  SY\_LFR\_R1  SY\_LFR\_R2  This command can be perform in any mode. | REQ-LFR-SRS-5550 | SVS-0095 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-215 | Equipment parameter dump | The equipment flight software shall allow to dump in a TM\_xxx\_PARAMETER\_DUMP packet, upon the reception of a TC\_xxx\_DUMP\_PAR command, all their functional and operational configuration parameters (software and hardware). | REQ-LFR-SRS-5551 | SVS-0065 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-220 | Software reset | Upon reception of a TC\_LFR\_RESET command, the LFR FSW shall terminate by performing an exit(0) command. | REQ-LFR-SRS-5552 | SVS-0066 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-230 | Equipment mode management | The LFR FSW shall handle the following modes:  STANDBY mode: no measurements are performed.  SCIENCE mode: measurements are performed. The SCIENCE mode is split in four sub-modes:  NORMAL  BURST  SBM1  SBM2 | REQ-LFR-SRS-5500 | SVS-0028 to SVS-0032 | Fsw-3.2.0.24  Partially Tests  SVS-0029  step 11 and step12 not tested  (long tests)  SVS-0030  step 9 not tested  (long tests)  SVS-0031  step1 and step 11 not tested  (long tests)  SVS-0032  step 1 and step 11 not tested  (long tests) |
| SSS-CP-EQS-240 | Equipment mode management | When LFR FSW enters the STANDBY mode, it shall stop the acquisitions if they are active. | REQ-LFR-SRS-5501 | SVS-0089 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-250 | Equipment mode management | In the STANDBY mode, the equipment flight software shall accept commands to configure the hardware and the software, in particular, the command allowing to configure the different science sub-mode parameter sets. | REQ-LFR-SRS-5502 | SVS-0028 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-270 | Equipment mode management | In the BURST mode, the equipment flight software shall produce toward the DPU one single data stream whose content corresponds to the BURST mode parameter set. | REQ-LFR-SRS-5504 | SVS-0030 | Fsw-3.2.0.24  Partially Tests  step 9 not tested  (long tests) |
| SSS-CP-EQS-280 | Equipment mode management | In the SBM1 mode, the equipment flight software shall produce toward the DPU two concurrent data streams:  - A low cadence data stream whose content corresponds to the NORMAL mode parameter set.  - A high cadence data stream whose content corresponds to the SBM1 mode parameter set. | REQ-LFR-SRS-5505 | SVS-0031 | Fsw-3.2.0.24  Partially Tests  step1 and step 11 not tested  (long tests) |
| SSS-CP-EQS-320 | Equipment mode management | The equipment flight software shall ensure, using their internal time, the synchronization of the equipment mode transition on the due date. | REQ-LFR-SRS-5509 | SVS-0034 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-321 | Equipment mode management | LFR FSW shall execute the mode transition on the next sharp second (current coarse time +1) if the time given in parameter of the TC\_LFR\_ENTER\_MODE packet is equal to 0. | REQ-LFR-SRS-5565 | SVS-0069 | Fsw-3.2.0.24  pok  [IR-10] #627 |
| SSS-CP-EQS-322 | Equipment mode management | The equipment flight software shall reject the TC\_xxx\_ENTER\_MODE packet if the time given in parameter is lower than the current time. | REQ-LFR-SRS-5566 | SVS-0070 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-323 | Equipment mode management | The equipment flight software shall reject the TC\_xxx\_ENTER\_MODE packet if the CP\_xxx\_ENTER\_MODE\_TIME parameter is greater than the current time plus 3 seconds. | REQ-LFR-SRS-5571 | SVS-0074 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-325 | Equipment mode management | The equipment flight software shall accept all the transition between modes excepting:  - If the destination mode is equal to the source mode.  - Between low-frequency LFM mode and nominal HF modes (NORMAL, BURST, SBMx) in case of TDS only. | REQ-LFR-SRS-5567 | SVS-0071 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-326 | Equipment mode management | Upon reception of a TC\_LFR\_ENTER\_MODE(SBM1) / TC\_LFR\_ENTER\_MODE(SBM2), LFR FSW shall not re-initialize the NORMAL data flow for waveform products if this one was already active to ensure waveform centering with other instruments. Spectral products dataflow from the NORMAL dataflow could be re-initialize because there is no synchronization constraints with other instruments.  Upon reception of a TC\_LFR\_ENTER\_MODE(NORMAL), LFR FSW should reject the transition with TM\_LFR\_TC\_EXE\_NOT\_EXECUTABLE if NORMAL mode is already active so NORMAL dataflow will not be impacted. | REQ-LFR-SRS-5590 | SVS-0088 | Fsw-3.2.0.24(StarDundee)  pok  [IR-10] Bug #553 |
| SSS-CP-EQS-328 | Equipment mode management | The equipment flight software shall ignore the synchronization bit of the CP\_LFR\_ENTER\_MODE\_TIME parameter (most significant bit) when they handle a TC\_LFR\_ENTER\_MODE command. | REQ-LFR-SRS-5592 | SVS-0034  SVS-0069 | Fsw-3.2.0.24(StarDundee)  ok |
| SSS-CP-EQS-340 | Acquisition synchronization | The equipment flight software shall ensure that the waveform acquisitions are synchronized on the second, with a precision higher than 500 μs, by using the SpaceWire time code. | REQ-LFR-SRS-5511\_Ed1 | SVS-0035 | Fsw-3.2.0.24  POK  [IR-10] Bug #554  Waiting for decision at system level concerning RD06 |
| SSS-CP-EQS-350 | Acquisition synchronization | Considering waveform snapshots, the LFR FSW shall centre, with a precision higher than 1 ms, the snapshot time window on the reference time that is transmitted as a parameter of the TC\_LFR\_ENTER\_MODE command. Following snapshots will be centered on T0+n\*p where T0 is the reference time transmitted by TC\_LFR\_ENTER\_MODE command, n is an integer and p the period between 2 snapshots (specified by SY\_LFR\_N\_SWF\_P value). | REQ-LFR-SRS-5512\_Ed1 | SVS-0035 | Fsw-3.2.0.24  POK  [IR-10] Bug #245 |
| SSS-CP-EQS-351 | Inter-equipment shared data | The equipment flight software shall be able to receive and process the shared status/HK distributed by the DPU at regular time intervals (≤ 2000 ms) as TC\_xxx\_UPDATE\_INFO packets. | REQ-LFR-SRS-5553 | SVS-0036 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-353 | Inter-equipment shared data | The equipment flight software shall extract the relevant parameters from the shared status/HK  packets for inserting them into their scientific TM packets.   In particular, the LFR and TDS (LF backup mode) flight software shall systematically reflect the BIAS Unit outputs configuration into their scientific TM packets. | REQ-LFR-SRS-5555 | SVS-0038 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-354 | Inter-equipment shared data | The equipment flight software shall not acknowledge the TC\_xxx\_UPDATE\_INFO packets. | REQ-LFR-SRS-5564 | SVS-0003  SVS-0077  SVS-0081 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-400 | Science data acquisition and processing | The equipment flight software shall use their internal time to time-stamp all the packets (HK or science data) they transmit to the DPU. | REQ-LFR-SRS-5517 | SVS-0067 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-410 | Science data acquisition and processing | Each data packet generated by the equipment flight software shall contain the absolute time (SCET) of the first sample contained in the packet (acquisition time). The time of the other samples are deduced from the time of the first sample.  - The absolute time value shall be copied twice: 1) in the time field of the TM packet data field header (PUS header) and 2) in the TM packet source data auxiliary header (data fields).  - If needed, some relative timestamps can be added in the data packet to tag data blocks. | REQ-LFR-SRS-5518 | SVS-0090 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-415 | Science data acquisition and processing | The equipment flight software shall always set the segmentation grouping flag of the scientific TM packets to the value “Stand-alone packet”. | REQ-LFR-SRS-5573 | SVS-0040 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-431 | LFR data products - waveform snapshots | The LFR flight software shall be able to change the value of SY\_LFR\_N\_SWF\_L and SY\_LFR\_N\_SWF\_P parameters upon reception of the TC\_LFR\_LOAD\_NORMAL\_PAR packet. | REQ-LFR-SRS-5575 | SVS-0073 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-440 | LFR data products - averaged spectral matrixes | The LFR flight software shall be able to generate averaged spectral matrixes:  - In NORMAL mode and SBM modes, every 3600 seconds:  - Averaged spectral matrix from the EM data stream at f0: ASM\_f0  - Averaged spectral matrix from the EM data stream at f1: ASM\_f1  - Averaged spectral matrix from the EM data stream at f2: ASM\_f2 | REQ-LFR-SRS-5521 | SVS-0043 | Fsw-3.2.0.24  Partially Tested  step7 and step 9 not tested  (long tests) |
| SSS-CP-EQS-450 | LFR data products - basic parameters set 1 | The LFR flight software shall be able to generate the following set of basic parameters (set 1):  − In NORMAL mode and SBM modes, every 4 seconds:  − Basic parameter 1 at f0: PE\_f0, PB\_f0, nvec\_f0, ellip\_f0, dop\_f0, Sz\_f0, Vphi\_f0  − Basic parameter 1 at f1: PE\_f1, PB\_f1, nvec\_f1, ellip\_f1, dop\_f1, Sz\_f1, Vphi\_f1  − Basic parameter 1 at f2: PE\_f2, PB\_f2, nvec\_f2, ellip\_f2, dop\_f2, Sz\_f2, Vphi\_f2  − In BURST mode and SBM2 mode, every 1 second:  − Basic parameter 1 at f0: PE\_f0, PB\_f0, nvec\_f0, ellip\_f0, dop\_f0, Sz\_f0, Vphi\_f0  − Basic parameter 1 at f1: PE\_f1, PB\_f1, nvec\_f1, ellip\_f1, dop\_f1, Sz\_f1, Vphi\_f1  − In SBM1 mode, every 0.25 seconds:  − Basic parameter 1 at f0: PE\_f0, PB\_f0, nvec\_f0, ellip\_f0, dop\_f0, Sz\_f0, Vphi\_f0  Where:  − PE\_fn is the spectral power of E field from the electric data stream (2E) at fn ; the number of bins is specified in [RD16].  − PB\_fn is the spectral power of B field from the magnetic data stream (3B) at fn ; the number of bins is specified in [RD16].  − nvec\_fn is the wave normal vector from the magnetic data stream (3B) at fn ; the number of bins is specified in [RD16].  − ellip\_fn is the wave ellipticity from the magnetic data stream (3B) at fn ; the number of bins is specified in [RD16].  − dop\_fn is the degree of polarization from the magnetic data stream (3B) at fn ; the number of bins is specified in [RD16].  − Sz\_fn is the normalized z-Poynting flux from the EM data stream (2E +3B) at fn ; the number of bins is specified in [RD16].  − Vphi\_fn is the phase speed from the EM data stream (2E +3B) at fn ; the number of bins is specified in [RD16]. | REQ-LFR-SRS-5522 | SVS-0044 | Fsw-3.2.0.24  Partially tested  step 7 step9 step 11 not tested  (long tests) |
| SSS-CP-EQS-460 | LFR data products - basic parameters set 2 | The LFR flight software shall be able to generate the following set of basic parameters (set 2):  − In NORMAL mode and SBM modes, every 20 seconds:  − Basic parameter 2 at f0: auto\_f0, cross\_f0  − Basic parameter 2 at f1: auto\_f1, cross\_f1  − Basic parameter 2 at f2: auto\_f2, cross\_f2  − In BURST mode and SBM2 mode, every 5 second:  − Basic parameter 2 at f0: auto\_f0, cross\_f0  − Basic parameter 2 at f1: auto\_f1, cross\_f1  − In SBM1 mode, every 1 second:  − Basic parameter 2 at f0: auto\_f0, cross\_f0  Where:  − auto\_fn corresponds to 5 autovariances from the EM data stream (2E +3B) at fn ; the number of bins is specified in [RD16].  − cross\_fn corresponds to 10 complex cross correlations from the EM data stream (2E +3B) at fn ; the number of bins is specified in [RD16]. | REQ-LFR-SRS-5523 | SVS-0045 | Fsw-3.2.0.24  Partially tested  step 7 step9 step 11 not tested  (long tests) |
| SSS-CP-EQS-490 | LFR data packets - averaged spectral matrixes | The LFR flight software shall transmit to the DPU the averaged spectral matrixes in the following data packets:  - In NORMAL mode and SBM modes: TM\_LFR\_SCIENCE\_NORMAL\_ASM\_F0, TM\_LFR\_SCIENCE\_NORMAL\_ASM\_F1, TM\_LFR\_SCIENCE\_NORMAL\_ASM\_F2 | REQ-LFR-SRS-5526 | SVS-0043 | Fsw-3.2.0.24  Partially Tested  step7 and step 9 not tested  (long tests) |
| SSS-CP-EQS-500 | LFR data packets - basic parameters set 1 | The LFR flight software shall transmit to the DPU the set of basic parameters 1 in the following data packets:  - In NORMAL mode and SBM modes: TM\_LFR\_SCIENCE\_NORMAL\_BP1\_F0, TM\_LFR\_SCIENCE\_NORMAL\_BP1\_F1, TM\_LFR\_SCIENCE\_NORMAL\_BP1\_F2  - In BURST mode: TM\_LFR\_SCIENCE\_BURST\_BP1\_F0, TM\_LFR\_SCIENCE\_BURST\_BP1\_F1  - In SBM1 mode: TM\_LFR\_SCIENCE\_SBM1\_BP1\_F0  - In SBM2 mode: TM\_LFR\_SCIENCE\_SBM2\_BP1\_F0, TM\_LFR\_SCIENCE\_SBM2\_BP1\_F1 | REQ-LFR-SRS-5527 | SVS-0044 | Fsw-3.2.0.24  Partially tested  step 7 step9 step 11 not tested  (long tests) |
| SSS-CP-EQS-510 | LFR data packets - basic parameters set 2 | The LFR flight software shall transmit to the DPU the set of basic parameters 1 in the following data packets:  - In NORMAL mode and SBM modes: TM\_LFR\_SCIENCE\_NORMAL\_BP2\_F0, TM\_LFR\_SCIENCE\_NORMAL\_BP2\_F1, TM\_LFR\_SCIENCE\_NORMAL\_BP2\_F2  - In BURST mode: TM\_LFR\_SCIENCE\_BURST\_BP2\_F0, TM\_LFR\_SCIENCE\_BURST\_BP2\_F1  - In SBM1 mode: TM\_LFR\_SCIENCE\_SBM1\_BP2\_F0  - In SBM2 mode: TM\_LFR\_SCIENCE\_SBM2\_BP2\_F0, TM\_LFR\_SCIENCE\_SBM2\_BP2\_F1 | REQ-LFR-SRS-5528 | SVS-0045 | Fsw-3.2.0.24  Partially tested  step 7 step9 step 11 not tested  (long tests) |
| SSS-CP-EQS-522 | LFR Calibration function | Upon reception of a TC\_LFR\_ENABLE\_CALIBRATION, the LFR flight software shall enable the LFR calibration function (generation of the calibration signal for the SCM). | REQ-LFR-SRS-5556 | SVS-0053 | Fsw-3.2.0.24  ok  See results in §7 (ANNEXES) |
| SSS-CP-EQS-523 | LFR Calibration function | Upon reception of a TC\_LFR\_DISABLE\_CALIBRATION, the LFR flight software shall disable the LFR calibration function (generation of the calibration signal for the SCM). | REQ-LFR-SRS-5557 | SVS-0053 | Fsw-3.2.0.24  ok  See results in §7 (ANNEXES) |
| SSS-CP-EQS-524 | LFR Calibration function | The LFR flight software shall report in its periodic HK packet (TM\_LFR\_HK) the enable / disable status of the calibration function in this dedicated field : HK\_LFR\_CALIB\_ENABLED. | REQ-LFR-SRS-5558 | SVS-0053 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-525 | LFR NORMAL / BURST mode transition | When it performs a mode transition, the LFR flight software shall stop the acquisition processing which is in progress if any. | REQ-LFR-SRS-5568 | SVS-0079 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-526 | LFR data for S/C potential computation | Each second, the LFR flight software shall put in its periodic HK packet (TM\_LFR\_HK) a mean of the16 last values of the electric field components sampled at f3: V\_f3, E1\_f3, E2\_f3. | REQ-LFR-SRS-5569 | SVS-0080  + CTC-800 | Fsw-3.2.0.24  ok  See results in [RD04] |

## Specific V1 tests

All tests of V1 (32) have been explicitly replayed and analyzed

SY\_LFR\_N\_ASM\_P is set to 4seconds instead of the default value (3600s).

For non-regression tests, no exhaustive long stress tests have be done.

So several tests are tagged “**P**artially **T**ested” even if they are OK.

All calibration tests are not be played.

| **Requirement Id** | **Object Short Text** | **RPW Software System Specification** | **ID** | **Covered by** | **Verdict** |
| --- | --- | --- | --- | --- | --- |
| SSS-CP-FS-020 | Command management | The Equipment Flight Software shall receive and process the command packets transmitted by the DPU. | REQ-LFR-SRS-5200 | SVS-0001 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-031 | Command management | The RPW Flight Software shall be able to receive, process and execute the command packets without affecting its other running independent processes. | REQ-LFR-SRS-5233 | SVS-0002 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-150 | Hk reporting | Each HK report shall be identified by a unique identifier called a SID (Structure Identification). - The SID of the HK report is the first field in the packet source data after the packet data field header. | REQ-LFR-SRS-5214 | SVS-0057  This req is covered globally for every test by an automatic rule in verif\_fields.py (hk\_reporting rule) | Fsw-3.2.0.24  ok |
| SSS-CP-FS-160 | Command management | The mode of housekeeping packet generation shall be the periodic mode. | REQ-LFR-SRS-5215 | SVS-0057  This req is covered globally for every test by an automatic rule in verif\_fields.py (hk\_reporting rule) | Fsw-3.2.0.24  ok |
| SSS-CP-FS-170 | Command management | The HK report generation period (collection interval) shall be configured during the flight to be greater or equal to SY\_RPW\_HK\_REPORT\_PERIOD\_MIN = 1 second. | REQ-LFR-SRS-5216 | SVS-0057  This req is covered globally for every test by an automatic rule in verif\_fields.py (hk\_reporting rule) | Fsw-3.2.0.24  ok |
| SSS-CP-FS-376 | Time management | The Equipment Flight Software shall not acknowledge the “Accept Time Update” packet. | REQ-LFR-SRS-5237 | SVS-0003 | Fsw-3.2.0.24  ok |
| SSS-CP-FS-580 | Telemetry management | When building a TM packet, the RPW Flight Software shall set the Destination ID field by complying with the following rules:   * For telemetry generated as an answer to a command, the Destination ID shall be the copy of the command Source ID field with exception of all TM packets having the packet category = 2 (HK essential), = 3 (Table), = 4 (HK routine), = 8 (diagnostic) and = 9 (dump), for which the Destination ID shall always be set to zero, meaning Ground. * For telemetry resulting from a process designed to produce data for another process in another SW item it shall contain the Destination ID of the receiving process. * For telemetry not covered by the above cases, the field shall be set to zero, meaning Ground | REQ-LFR-SRS-5239 | SVS-0018 | Fsw-3.2.0.24  ok |
| SSS-IF-DPS-EQ-071 | DPU/Analyzer SpW interface | The logical address of the DPU SpaceWire interface toward LFR shall be SY\_DPU\_LFR\_LA = 0x01. | REQ-LFR-SRS-5411 | SVS-0027 | Fsw-3.2.0.24  ok |
| SSS-IF-DPS-EQ-072 | DPU/Analyzer SpW interface | The logical address of the LFR SpaceWire interface toward DPU shall be SY\_LFR\_DPU\_LA = 0xFE. | REQ-LFR-SRS-5412 | SVS-0027 | Fsw-3.2.0.24  ok |
| SSS-IF-DPS-EQ-160 | DPU / RPW Analyzer SW communication protocol | The DPU Application Software and the LFR analyzer flight software shall communicate by the mean of command packets and data packets formatted according to [ES1] (Telecommand and Telemetry Packet Utilization Standard). -The commands from DPU to RPW equipments shall be seen as Telecommand source packets. - The science data and HK data generated by the RPW equipments to the DPU shall be seen as Telemetry source packets. | REQ-LFR-SRS-5407 | SVS-0003  SVS-0090 | Fsw-3.2.0.24  ok |
| SSS-IF-DPS-EQ-175 | DPU / RPW Analyzer SW communication protocol | |  | | --- | | According to [ES6], the SpaceWire  protocol header of the packets  exchanged between DPU and  the RPW analyser flight software  shall be made up of 4 bytes :   * Target Logical Address * Protocol ID = 0x02   meaning CCSDS   * Reserved byte = 0x00 * User Application byte = 0x00 | |  | | REQ-LFR-SRS-5413 | SVS-0027 | Fsw-3.2.0.24  ok |
| SSS-IF-DPS-EQ-180 | DPU / RPW Analyzer SW communication protocol | The Analyzer Flight Software shall receive commands from the DPU Software as Telecommand Source Packets according to [ES1] with a maximum length given below for each analyzer: - LFR: SY\_LFR\_TC\_MAX\_LEN = 228 bytes (i.e. 216 bytes of application data) | REQ-LFR-SRS-5409 | SVS-0003 (step 30 and 31) | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-010 | Startup phase | The equipment flight software shall be ready to accept commands within SY\_xxx\_DELAY\_ACC\_TC milliseconds after the boot process has been completed. | REQ-LFR-SRS-5530 | SVS-0054 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-030 | Startup phase | If no time synchronization has occurred within SY\_xxx\_TIME\_SYN\_TIMEOUT milliseconds, the equipment flight software shall initiate the generation of its housekeeping reports using a non-synchronized time value. | REQ-LFR-SRS-5532 | SVS-0056 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-040 | Equipment HK reporting | The equipment flight software shall provide periodically to the DPU a TM\_xxx\_HK packet (HK report) reflecting the status of the equipment. | REQ-LFR-SRS-5533 | SVS-0057 | Fsw-3.2.0.24  ok  Several HK fields are not filled and will never be. There are detailed in [RD07]. No RFD needed approved by CNES (JIRA RPWSWR-634). |
| SSS-CP-EQS-050 | Equipment HK reporting | Each equipment HK report shall contain:  The software status of the equipment:  -Software version  -Current mode  -Error counter, last error code, time of the last error, auxiliary information about the error -Reason of the reset   -Other status specific to the equipment  The hardware status of the equipment: -State of the SpaceWire interface (received packet counter, sent packet counter, link state, etc.)  -Watchdog status - SEU counters (counter of the correctable errors and a counter of the not correctable errors detected by the EDAC)  -Last failing address (last address impacted by error) - Temperatures  -Other hardware status specific to the equipment | REQ-LFR-SRS-5534 | SVS-0057 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-060 | Equipment HK reporting | The equipment flight software shall send its HK report as a packet compliant to the PUS service  n°3. | REQ-LFR-SRS-5535 | SVS-0055  SVS-0056  SVS-0057 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-070 | Equipment HK reporting | The generation period of the HK equipment report packets is fixed to SY\_xxx\_HK\_SAMPLING\_PER = 1 second. | REQ-LFR-SRS-5536 | SVS-0060 | Fsw-3.2.0.24  Partially Tested  step 2 step3 not tested  (long tests) |
| SSS-CP-EQS-160 | Equipment configuration management | The equipment flight software shall handle two kinds of parameters: - Parameters (software or hardware) associated to the configuration of the science submodes managed by the equipment (NORMAL, BURST, SBM1, SBM2, LFM). These parameters can be, for example, the list of the enabled products, the number of samples per second, the number of points per snapshots, the measurement time, the spectrum frequency count, etc.  -Other parameters (software or hardware), independent of the Science sub-mode configuration (so-called common parameters). | REQ-LFR-SRS-5545 | SVS-0029  to  SVS-0032  SVS-0095 | Fsw-3.2.0.24  Partially Tests  SVS-0029  step 11 and step12 not tested  (long tests)  SVS-0030  step 9 not tested  (long tests)  SVS-0031  step1 and step 11 not tested  (long tests)  SVS-0032  step 1 and step 11 not tested  (long tests) |
| SSS-CP-EQS-170 | Equipment configuration management | The equipment flight software shall concurrently handle as many distinct configuration parameter sets as science sub-modes (NORMAL, BURST, SBM1, SBM2, LFM) it manages. | REQ-LFR-SRS-5546 | SVS-0003 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-190 | Equipment configuration management | The equipment flight software shall handle commands for configuring the different science  submode parameter sets.   * Normal mode parameters:   TC\_LFR\_LOAD\_NORMAL\_PAR   * BURST mode parameters:   TC\_LFR\_LOAD\_BURST\_PAR   * SBM1 mode parameters: TC\_LFR\_LOAD\_SBM1\_PAR * SBM2 mode parameters: TC\_LFR\_LOAD\_SBM2\_PAR | REQ-LFR-SRS-5548 | SVS-0029  to  SVS-0032 | Fsw-3.2.0.24  Partially Tests  SVS-0029  step 11 and step12 not tested  (long tests)  SVS-0030  step 9 not tested  (long tests)  SVS-0031  step1 and step 11 not tested  (long tests)  SVS-0032  step 1 and step 11 not tested  (long tests) |
| SSS-CP-EQS-260 | Equipment mode  management | In the NORMAL mode, the equipment flight software shall produce toward the DPU one single data stream whose content corresponds to the NORMAL mode parameter set. | REQ-LFR-SRS-5503 | SVS-0029 | Fsw-3.2.0.24  ok  step 11 and step12 not tested  (long tests) |
| SSS-CP-EQS-300 | Equipment mode  management | A mode transition shall correspond to the activation by the equipment flight software of the set of configuration parameters corresponding to the mode. | REQ-LFR-SRS-5507 | SVS-0033 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-310 | Equipment mode  management | The equipment flight software shall have one TC\_xxx\_ENTER\_MODE command for activating the modes, with the two following parameters:  -One parameter for selecting the mode: STANDBY, NORMAL, BURST, SBM1 (excepted TNR-HFR), SBM2 (excepted TNR-HFR), LFM (only TDS) -One parameter giving the time at which the transition has to take place, i.e. when the set of parameters corresponding to the mode shall be activated. This time parameter always corresponds to the occurrence of a SpaceWire time code. This time parameter is also used as a reference time for the synchronization of the acquisitions (adjustment of the equipment sampling times). | REQ-LFR-SRS-5508 | SVS-0033 SVS-0034 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-360 | Science data acquisition and processing | The equipment flight software shall receive the data acquired or pre-processed by the hardware part of the equipment. | REQ-LFR-SRS-5513 | SVS-0041 to  SVS-0043 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-370 | Science data acquisition and processing | The equipment flight software shall perform the suitable treatments on the acquired data in order to generate the data products expected in the current working mode. | REQ-LFR-SRS-5514 | SVS-0029  to  SVS-0032 | Fsw-3.2.0.24  ok  Partially Tests  SVS-0029  step 11 and step12 not tested  (long tests)  SVS-0030  step 9 not tested  (long tests)  SVS-0031  step1 and step 11 not tested  (long tests)  SVS-0032  step 1 and step 11 not tested  (long tests) |
| SSS-CP-EQS-380 | Science data acquisition and processing | The equipment flight software shall transmit the science data to the DPU as packets compliant to the PUS service n°21. | REQ-LFR-SRS-5515 | SVS-0040 | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-390 | Science data acquisition and processing | The structure and content of the source data fields of the science data packets generated by the flight software equipment shall be compliant to the RPW IDB. | REQ-LFR-SRS-5516 | SVS-0040 and verif\_fields.py (icd verification ) | Fsw-3.2.0.24  ok |
| SSS-CP-EQS-420 | LFR data products – continuous waveforms | The LFR flight software shall be able to generate continuous waveforms containing the following components:   In NORMAL mode and SBM modes:  Electric field components sampled at f3: V\_f3, E1\_f3, E2\_f3  Magnetic field components sampled at f3: B1\_f3, B2\_f3, B3\_f3   In BURST mode and SBM2 mode:  Electric field components sampled at f2: V\_f2, E1\_f2, E2\_f2  Magnetic field components sampled at f2: B1\_f2, B2\_f2, B3\_f2   In SBM1 mode:  Electric field components sampled at f1: V\_f1, E1\_f1, E2\_f1  Magnetic field components sampled at f1: B1\_f1, B2\_f1, B3\_f1 | REQ-LFR-SRS-5519 | SVS-0041 | Fsw-3.2.0.24  Partially tested  step 11 step 13 step 15 not tested  (long tests) |
| SSS-CP-EQS-430 | LFR data products –waveform snapshots | The LFR flight software shall be able to generate waveform snapshots containing the following components:   In NORMAL mode and SBM modes, SY\_LFR\_N\_SWF\_L samples every SY\_LFR\_N\_SWF\_P seconds:  Electric field components sampled at f0: V\_f0, E1\_f0, E2\_f0  Magnetic field components sampled at f0: B1\_f0, B2\_f0, B3\_f0  Electric field components sampled at f1: V\_f1, E1\_f1, E2\_f1  Magnetic field components sampled at f1: B1\_f1, B2\_f1, B3\_f1  Electric field components sampled at f2: V\_f2, E1\_f2, E2\_f2  Magnetic field components sampled at f2: B1\_f2, B2\_f2, B3\_f2   SY\_LFR\_N\_SWF\_L = 2048 samples (nominal value)   SY\_LFR\_N\_SWF\_P = 300 seconds (nominal value) | REQ-LFR-SRS-5520 | SVS-0042 | Fsw-3.2.0.24  Partially tested  step 8 not tested  (long tests) |
| SSS-CP-EQS-470 | LFR data products –continuous waveforms | The LFR flight software shall transmit to the DPU the continuous waveforms in the following data packets:   In NORMAL mode and SBM modes: TM\_LFR\_SCIENCE\_NORMAL\_CWF\_F3 or TM\_LFR\_SCIENCE\_NORMAL\_CWF\_LONG\_F3 depending on the LFR configuration specified in TC\_LFR\_LOAD\_NORMAL\_PAR   In BURST mode : TM\_LFR\_SCIENCE\_BURST\_CWF\_F2   In SBM1 mode: TM\_LFR\_SCIENCE\_SBM1\_CWF\_F1   In SBM2 mode: TM\_LFR\_SCIENCE\_SBM2\_CWF\_F2  Where F1, F2 or F3 identify the sampling frequency. | REQ-LFR-SRS-5524 | SVS-0041 | Fsw-3.2.0.24  Partially tested  step 11 step 13 step 15 not tested  (long tests) |
| SSS-CP-EQS-480 | LFR data products –waveform snapshots | The LFR flight software shall transmit to the DPU the waveform snapshot in the following data packets:   In NORMAL mode and SBM modes: TM\_LFR\_SCIENCE\_NORMAL\_SWF\_F0, TM\_LFR\_SCIENCE\_NORMAL\_SWF\_F1, TM\_LFR\_SCIENCE\_NORMAL\_SWF\_F2  Where F0, F1 or F2 identify the sampling frequency. | REQ-LFR-SRS-5525 | SVS-0042 | Fsw-3.2.0.24  Partially tested  step 8 not tested  (long tests) |

# ANNEXES

## LFR Calibration signal

Here are the output of LFR calibration signal for SCM with ENABLED and DISABLED states. We clearly see :

f1 = 625 Hz with amplitudes of 500 mV and f2 = 10 kHz with amplitudes of 1V pp.





