CASSIS USER MANUAL

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Origin Name:	Physikalisches Institut, Universität Bern
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	Name	Signature	Date
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Document Change Record

Issue	Revision	Date	Pages, Tables, Figures affected	Modification	Initials
0	1	16 Aug 2013	All	New document	RZ
0	2	23 Sept 2013	All	Further writing	RZ
0	3	04 Dec 2013	10	Updated pointing budget	RZ
0	3	04 Dec 2013	chapter 7	AIT procedures	RZ
0	4	08 Jan 2014	Page 10	Data rates and volumes added	RZ
0	5	02 Nov 2014	All	First draft for CDR	KG
0	6	15 Sept 2015	All	Updates for ADP	RZ
	7	18 Sept 2015		AIT Procedures added	RZ
	8	06 Oct 2015	10.5.1	Updated FFT	RZ
	9	22 Oct 2015	10.5.1	Added TCs into FFT	PG
	10	23 Oct 2015		New Section: Special precautions when the CaSSIS telescope is rotated	RZ
	11	26 Oct 2015		Refined scope of document	RZ
				Added procedures for turning telescope for alignment (AIT)	RZ
				Added Rotation Log Template	RZ
				Added Hardware Breakdown	RZ
				Added Functional Diagram	RZ
				Added Configuration Item List	RZ
				Added List of Removable Items	RZ
				Added drawings for mechanical interface	RZ
				Added power and energy budget	RZ
	12	30 Oct 2015	4.4	Added grounding diagram	RZ
	12	02 Nov 2015		Updated reference documents	RZ
	13	03 Nov 2015	7.1	Added packing and unpacking procedures	RZ
			7.5	Added radiated EMC remark	RZ
			4.1	Indicated which MLI blankets are installed on	RZ

Issue	Revision	Date	Pages, Tables, Figures affected	Modification	Initials
				telescope at delivery	
			4.1	Added EGSE box	RZ
			4.1	Added configuration item codes	RZ
			2	Added more special precations	RZ
1	0	07 Nov 2015	4.2	Removable items list updated removed MLI on optical cube added connector savers	RZ
			4.1	Configuration item list updated with CICs	RZ
			2.2.6	New section (hazards)	RZ
			4.6.1	Measures masses added	RZ
			7.3.1	Updated alignment procedure added visual checks and respective images	RZ
			7.5.1	New section Limited Functional Test Procedure for TGO Conducted EMC Tests (LFTEMC)	RZ
			7.4	Updated procedure with aperture cover removalq	RZ
			4.6.1	Masses added	
			4.6.2	CoMs added	RZ
			4.6.3	Power and Energy Budget updated	RZ
1	1	11 Nov 2015	7.5, 8	Update FFT after I2R2 FFT now also executed on RED power, except rotation	RZ
1	2	13 Nov 2015	8	New TCs added to FFT	RZ, PG
1	3	14 Nov 2015	6.3	Mode diagram added paragraph added which describes CaSSIS modes and SAFEMODE behaviour	RZ
			8.1, 8.2	New LEAVE_SAFEMODE command	RZ
			7.5.1	Added new LEAVE_SAFEMODE command	RZ
			7.3.1	Added new LEAVE_SAFEMODE command to alignment procedures	RZ
1	4	01 Dec 2015	7.3.1	STEP 260 changed LEAVE_SAFEMODE command to	RZ

Issue	Revision	Date	Pages, Tables, Figures affected	Modification	Initials
				the one used in first ISST (→ no unique ID) In both procedures used for alignment	
			7.5.1	FFTNOM/FFTRED: STEP 390: changed LEAVE_SAFEMODE command to the one used in first ISST (→ no unique ID) STEP 500: updated TC STEP 560: corrected TC STEP 700-750: included S/C commands to close PDHU file in order to create a workaround for the PDHU issue with CaSSIS Corrected timing information	RZ
			7.5.	Inlcuded warning for motor over-heating.	RZ
2	0	18 Jan 2016	2.2.2	Included statement that cleanign of external MLI surfaces shall be done preferably with vacuum cleaner	RZ
			8.1, 8.2	New step 250: Included FMON and PMON New step 312: send leave safemode, same as 390! new step 395: dump HK table (this will initiate the SpW link in case it did not work at boot up.) STEP 560: updated command STEP 730: command updated	RZ
2	1	26 Jan 2016	7.3.1	Corrected TC in STEP 900	RZ

Table of Contents

List of documents

Applicable documents		
AD 01	EXM-PL-IRD-ESA-00003 Issue 2 Rev 0 TGO E-IRD (JCCB - Signed)	Experiment Interface Requirements Document

Normative References		
NR4	EXM-CA-DRW-UBE-20001	CaSSIS MICDs Iss 2, Rev 0
NR2	EXM-CA-TNO-UBE-00001	CaSSIS Interface Data Sheet Iss2, Rev 1
NR5	EXM-CA-PRC-UBE-00018	CaSSIS PFM Integration Procedure Iss 0, Rev 1
NR6	EXM-CA-PRC-UBE-00012	CaSSIS STM Integration Procedure Iss 2, Rev 2
NR7	EXM-CA-PRC-UBE-00021	CaSSIS PFM CRU Packaging Procedure Iss 1, Rev 0
NR8	EXM-CA-PRC-UBE-00022	CaSSIS PFM ELU Packaging Procedure Iss 1, Rev 0
NR9	EXM-CA-DRW-HPS-10000	CaSSIS PFM MLI Iss 2, Rev 0
NR10	EXM-CA-ANA-UBE-00003	CaSSIS Hazard Analysis Iss 1, Rev 1

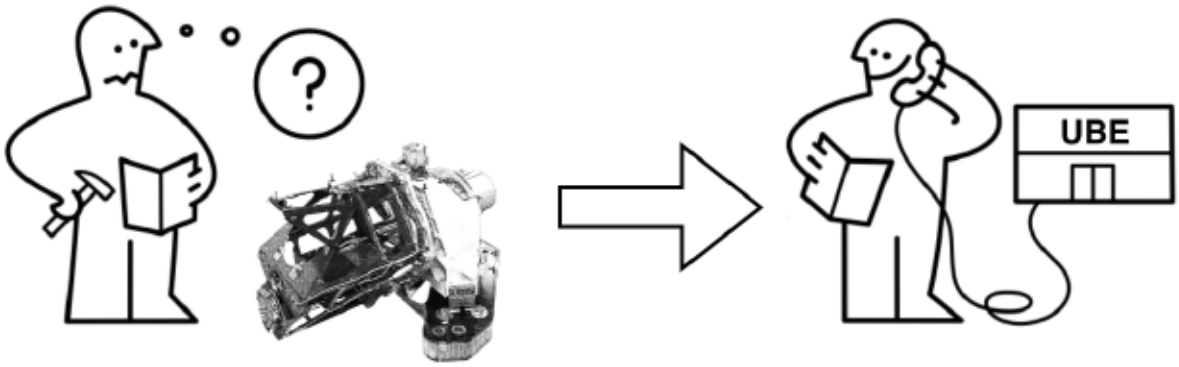
Scope of the Document

This is the Instrument User Manual for CaSSIS. It is meant for use on ground for integration on the spacecraft by TAS. A separate Flight Operations User Manual (FOUMA) for ESOC is prepared elsewhere.

The document is the handling and operational manual of the CaSSIS Instrument. It has to be read and followed in order Handle, Store, Transport and Operate the Telescope Assembly to properly.
The Document includes general instructions related to safety and defines the environmental conditions requested for a proper use of the instrument. Several separate procedures are referenced that describe the unpacking and installation of the individual units (CRU and ELU).

1 DISCLAIMER

This user manual and the local safety regulations must be strictly followed.For use of the CaSSIS instrument for activities other than described in this user manual, the UBE CaSSIS team must be asked for permission. Service work must only be performed by UBE or by personnel authorised by UBE. For use other than described in this user manual all consequential damages, all liabilities are excluded and all warranty claims expire immediately.



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2 GENERAL INSTRUCTIONS

2.1 General

Do not unpack or handle the CaSSIS instrument without first having read and understood this document. Also verify with your Data Management that you have the most recent Issue of the User Manual.

2.2 General Safety Instructions

2.2.1 ESD precautions

Only personnel that received ESD and static-awareness training are allowed to handle the hardware. Workbenches and facility where equipment is placed shall be grounded. Personnel shall be grounded and wear static safe garments. Wrist straps connected to the work station ground shall be used at all times when in proximity to the equipment. The gloves shall be conductive or static dissipative.

2.2.2 Cleanliness

The assembly shall be handled according to the provisions of the CaSSIS cleaning and contamination control specification (see [EXM-CA-PLN-UBE-00020], [EXM-CA-ANA-UBE-00006]). From the time of incoming inspection onward the instrument shall be handled and operated consistent with the above specification.

It is desired to keep the CaSSIS instrument under clean room (Clean room class ISO 5) conditions all the time. Any kind of contamination will finally result in a contamination of the optics. Dirty optics lead to:

- Loss of reflectivity
- Stray light

Note: it is strongly recommended to store the Camera Rotation Unit (CRU) as long as possible under dry Nitrogen atmosphere.
CaSSIS understands that above mentioned conditions are not available at the integration site. Therefore the aperture cover shall be used at all times if not otherwise specified in associated procedures.

CaSSIS shall be bagged during moves outside an ISO 5 cleanroom. When possible, CaSSIS should be covered with clean ESD bagging material during testing.

The CaSSIS PFM is covered in MLI, except for the radiators (at the FPA (CRU), ELU) and the mirrors. UBE suggests to clean the surfaces using a vacuum cleaner. The MLI surfaces can be wiped with IPA for cleaning, but there is risk of more MOC. The radiator surfaces shall not be touched. The mirrors can be cleaned using dry nitrogen. **UBE shall be contacted if this is deemed necessary.**

2.2.3 Environment

During all phases of the integration and handling processes, the hardware has to be maintained in a controlled environment in order to prevent degradation or contamination of the units, equipment and surfaces which could result in an operation failure.

Facility ambient condition for conducting preparation activities and handling activities shall be as follows:

- Temperature 21 ± 3°C
- Relative humidity 55 % +/- 10 %
- Cleanliness Class ISO 8 or better

Facility ambient condition shall be continuously monitored and recorded.

CaSSIS requests an Class ISO 8 or better facility for integration and test activities. It is therefore **absolutely necessary to have the telescope aperture covered at all times if not otherwise stated in respective procedures.**

2.2.4 Personnel

Only persons used to handle optical equipment shall be allowed to handle the CaSSIS CRU. They have to wear appropriate clean room suits, double gloves, boots, hats and face masks etc.
See section 2.2.1 for personnel ESD training.

2.2.5 Disposal

In the event that CaSSIS is ultimately not flown, the recommended disposal is to return the instrument and all associated material to UBE.

2.2.6 Hazards

Handling the CaSSIS hardware has no potential hazards. Some parts of the CaSSIS hardware are manufactured from AlBeMet. These parts do not pose any danger to humans when handling CaSSIS. A hazard analysis is available (see NR10).

2.3 Special Precautions

A) The CaSSIS rotation mechanism on the CRU is a life limited item. Turning the telescope in air too often will cause damage to the coating of the surfaces inside. Hence, the CaSSIS Team shall be informed and asked for permission EVERY TIME it is planned and/or needed to rotate the CaSSIS telescope.
B) It is strongly recommended to have TGO in horizontal position if the rotation mechanism is operated so the CaSSIS telescope is pointing downwards (see **Figure 1**). CaSSIS understands that this may not always be possible. In that case apply point A).
C) A rotation logbook shall be maintained. A template can be found in section 9.
D) Keep the telescope aperture covered whenever possible.
E) Remove the telescope aperture cover before launch.
F) Do not touch the radiators (i.e., white surfaces) on the CaSSIS Electronics Unit and the Focal Plane Assembly (located 'underneath' the telescope).
G) Do not put pressure on the GFRP structure surrounding the ELU Radiator.

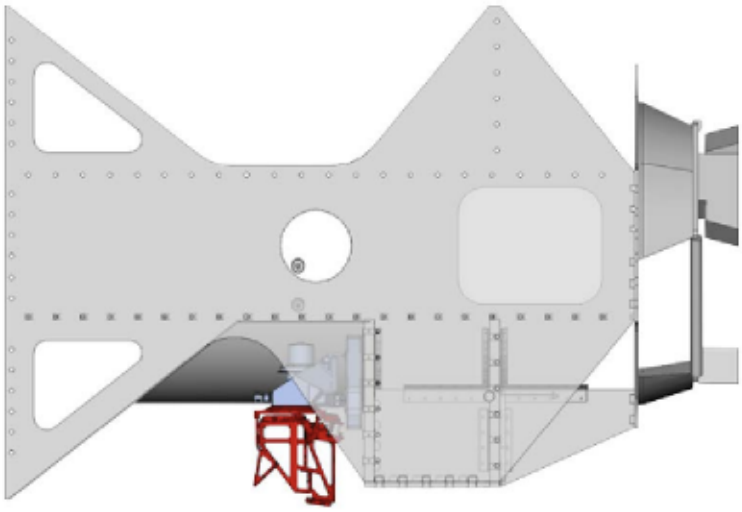


Figure 1: Preferred TGO Position if rotation of and when the CaSSIS telescope is planned.

3 EXPERIMENT GENERAL DESCRIPTION

3.1 Mission and Instrument Overview

The ESA ExoMars program consist of two stages: an orbiter (called Trace Gas Orbiter, TGO) to be launched in 2016 and a rover to be launched in 2018. The program will demonstrate key flight and in situ enabling technologies by searching for signs of past and present life on Mars, investigate the water/geochemical environment and atmospheric trace gases and their sources. The TGO will carry a camera called CaSSIS (Colour and Stereo Surface Imaging System) developed by the University of Bern, which will take high resolution stereo images in 4 colours of the Martian surface. Figure 2 illustrates the imaging concept. This imager will characterize sites which have been identified as potential sources of trace gases and investigate dynamic surface processes and certify potential future landing sites. CaSSIS will observe a 9 km wide swath thereby providing the best colour imaging acquired from Mars, so far.

CaSSIS comprises two major units: Camera Rotation Unit (CRU) and Electronics Unit (ELU). The CRU comprises the telescope (incl. focal plane and associated electronics), the rotation system, cable management system and some structure to support all of the above and mount the CRU to the spacecraft. The ELU contains the boards with the electronics required to operate the camera.

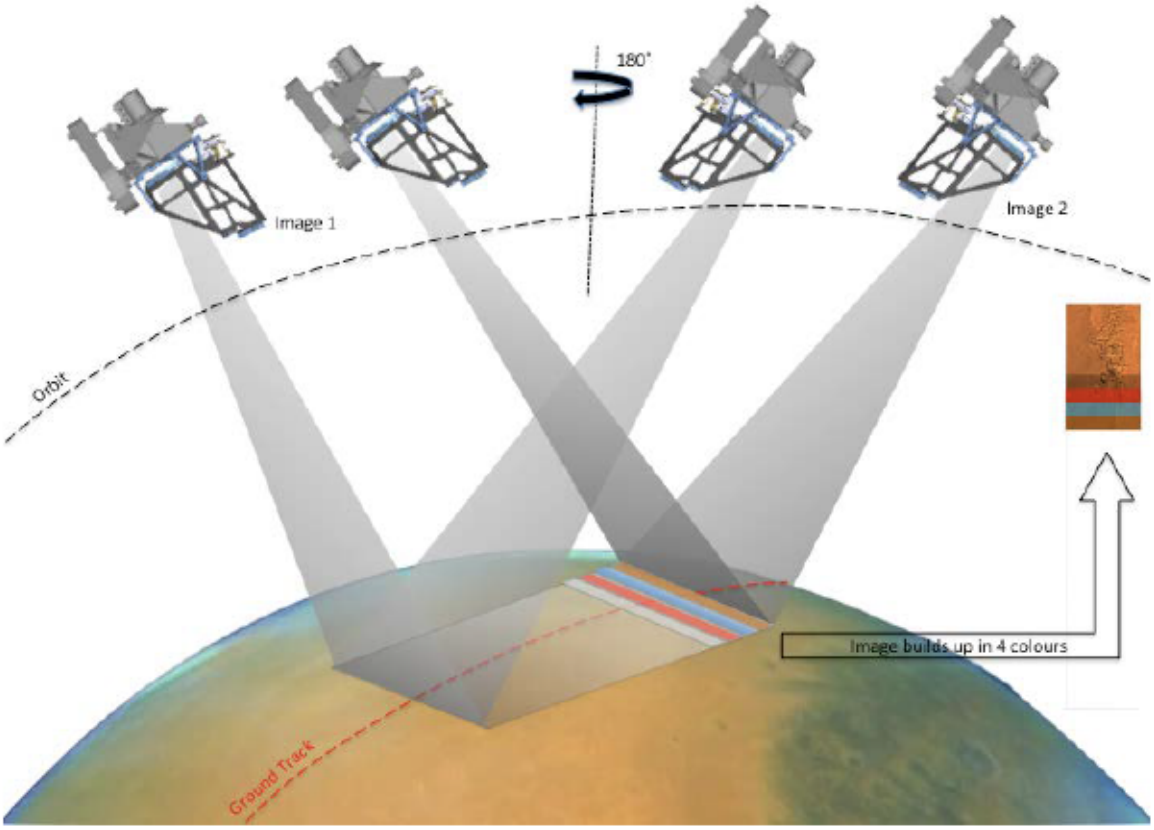


Figure 2: CaSSIS Stereo Image Acquisition

3.2 Scientific Objectives

The scientific objectives are summarized in the CaSSIS Science Requirements Document [EXM-CA-RSD-UBE-10000] and the System Requirements Document [EXM-CA-RSD-UBE-00003].This document is the formal starting point from which other CaSSIS requirements have been derived and laid down, i.e., the telescope requirements or software requirements. The top level science requirements are repeated below.

Image and analyze surface features possibly related to trace gas sources and sinks in order to better understand the broad range of processes that might be related to trace gases.

The science team will compile and prioritize a list of observation targets needed to test specific hypotheses concerning active surface processes on Mars. We will begin to address this objective early in the mission, prior to new trace-gas discoveries from EMTGO. Unusual or changing colors indicate active processes, perhaps linked to methane formation or release.

Map regions of trace gas origination as determined by other experiments to test hypotheses.

EMTGO experiments are designed to discover trace gases and study atmospheric dynamics to trace the gases back to their source regions (perhaps to tens of km). Once these discoveries are made (if that goal is realized), CaSSIS will place top priority on imaging these regions to formulate and test specific hypo-theses for the origin and/or release of trace gases.

Search for and help certify the safety of new candidate landing sites driven by *EMTGO* discoveries.

The discovery of methane has helped stimulate exploration plans in Europe and the U.S. A portion of NE Syrtis Major has recently been approved for priority *MRO* coverage as a candidate landing site for the Mars Science Laboratory; this site is at the margin of the Syrtis Major methane plume identified by Mumma et al. (2009). It is likely that the pair of NASA/ESA landers in 2019 will also consider methane areas for landing sites. At the workshop 'Habitability and Landing Sites' held in the UK (Cockell et al., 2009) the surfaces associated with methane plumes were identified as high priority exploration targets. However, the best locations will presumably be found by *EMTGO,* and *MRO/HiRISE* may or may not be able to certify new landing sites post 2017. CaSSIS cannot identify meter-scale hazards, but it can provide the 5 m scale slope information needed to complete certification of thousands of locations imaged by HiRISE, but not in stereo.

3.3 Experiment Overview

Whilst the goals and objectives of TGO are rather straightforward, the spacecraft design proposed by ESA does present some difficulties for remote-sensing. The spacecraft is generally nadir-pointing but it rotates about the nadir-pointing axis in order to maintain the solar panels orthogonal to the Sun while keeping the Sun away from spectrometer radiators. This is an issue for high resolution imaging systems. This motion can be stopped for short durations to allow imaging but the orientation of the detector lines should be orthogonal to the direction of motion over the surface, which however varies depending upon orbital position.

In order to obtain a stereo pair from one pass over an object the camera system needs to be tilted or rotated. The concept originally developed for HiSCI (McEwen et al., 2011a) is an elegant solution to the dual problem of the rotation of the platform about the nadir vector plus the requirement for stereoscopic imaging. Here it is the instrument that moves and not the whole spacecraft and rotation accomplishes not only the stereoscopic objective but also the compensation for the spacecraft attitude. There is no obvious and simple alternative to

this approach for imaging on TGO and hence it is necessary to use this approach for CaSSIS, too.

Often cameras on space missions adopt a push-broom acquisition mode: the detector is a linear array and the full bidimensional image is reconstructed by quickly scanning a one line of pixels and placing all lines side by side successively at a suitable rate determined by the spacecraft velocity. CaSSIS is required to employ a quasi-push broom mode, also called push-frame. The detector is a hybrid CMOS Active Pixel Sensor (APS) bidimensional array, so actual 2D images (frames) of the planet surface are acquired. The frames are acquired with overlap to allwo subsequent correlation, matching and stitching. Each of the two stereo image pairs will be acquired at two different moments: the forward image will be acquired from a defined area on the planet surface by pointing 10 degree ahead (off nadir), then the same area will be acquired after some time (which depends on the orbit of the S/C but is in the order of 45 seconds) by rotating the telescope 180 degrees to point 10 degrees behind. The 10 degree look angle increases the pixel scale and atmospheric path length by only 1.5%, yet provides a slightly larger than 20 degree stereo convergence angle (accounting for planetary curvature). The proper yaw orientation imaging is not precisely parallel to the ground track because Mars rotates, and this offset also ensures excellent overlap between the 2 stereo images (maximum mismatch is 3% of the swath width near the equator).

The instrument acquires colour data quasi-simultaneously. The push-frame detector is covered with the Filter Strip Assembly (FSA) which contains four filters composed of fused silica providing broad-band wavelength filtering. The diagram shows how this is combined with the stereo acquisition. At each timestep, the four colours are read-out of the detector. Image acquisition/read-out is so fast that the following image can be acquired before all of the previously observed field is out of the field of the new frame. This allows overlap and allows us to build up a continuous swath in each of the four colours.

It should be clear that colour can be acquired on both stereo frames. This would usually provide redundant information and hence only panchromatic data is actually needed for one of the two stereo shots.

3.4 Hardware Breakdown

A very basic hradware breakdown of the CaSSIS instrument can be seen in Figure 3.

3.5 Functional Diagram

The interaction of the two units including their parts is shown in Figure 4.

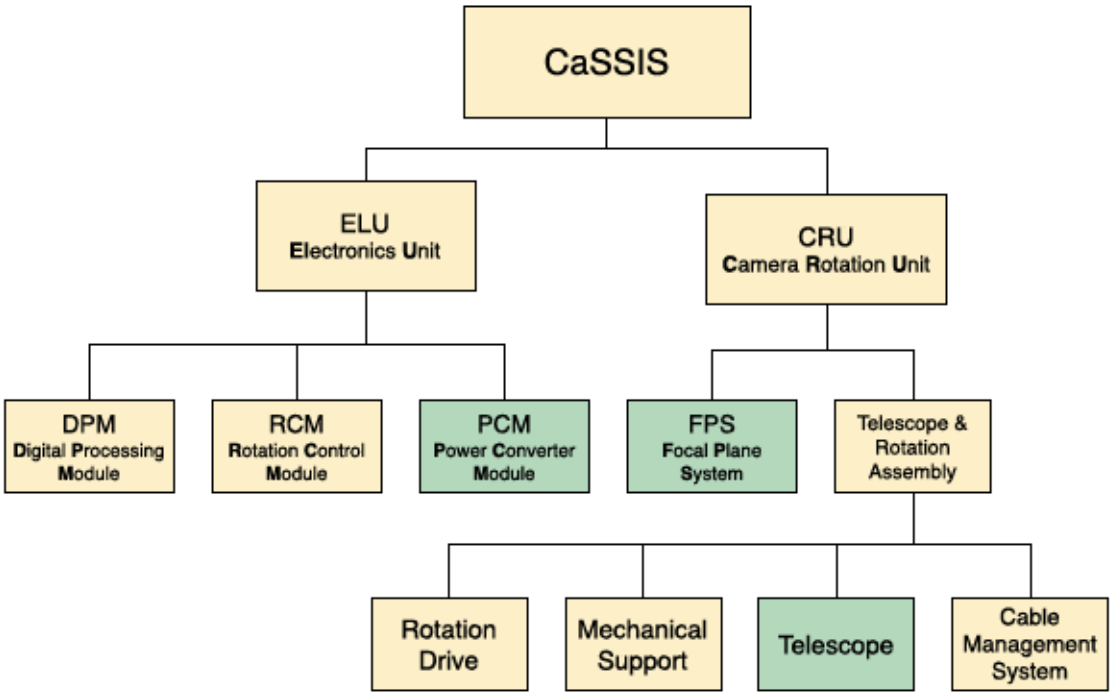


Figure 3: CaSSIS Hardware Breakdown

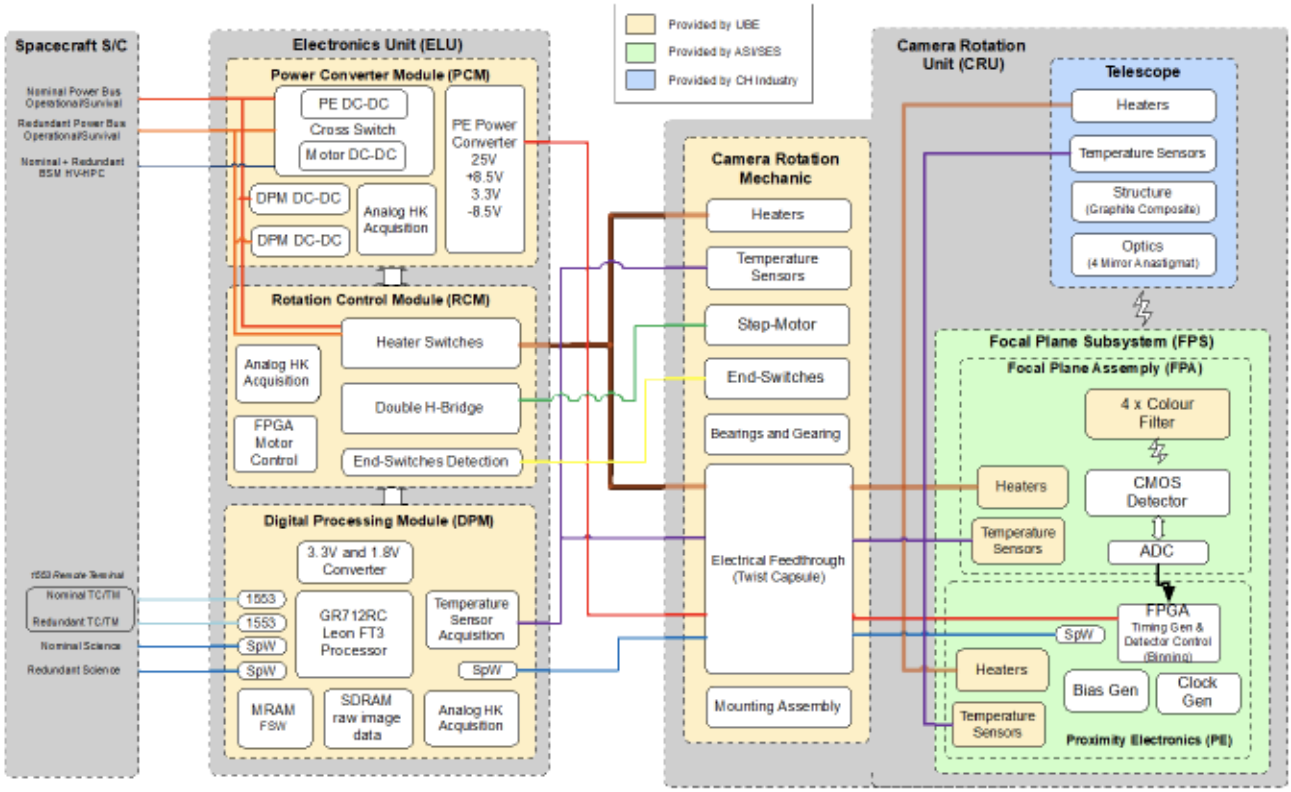


Figure 4: CaSSIS Functional Block Diagram

4 Experiment Configuration

4.1 Configuration Item List

CaSSIS will be delivered in 4 boxes. Each box contains one of the CaSSIS units (ELU, CRU) with the respective MGSE already mounted, the third box contains the MLI blankets. The CRU also has the MLI around the telescope already mounted. Figure 5 and Figure 6 show the transport containers for ELU and CRU.

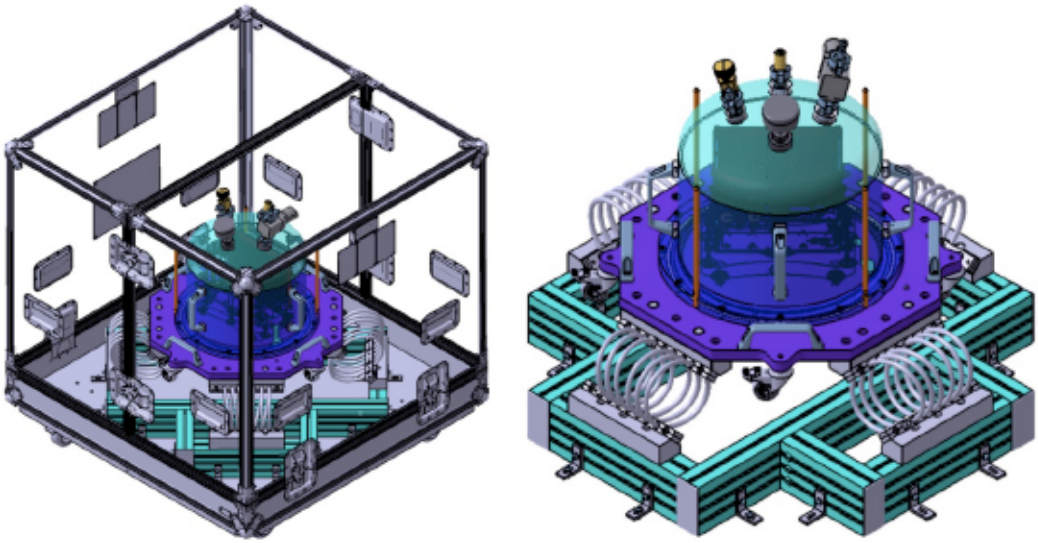


Figure 5: ELU Transport Container.
Left: Container shown transparent with ELU under bell inside.
Right: Installation of ELU inside the Bell on transport jig inside container.

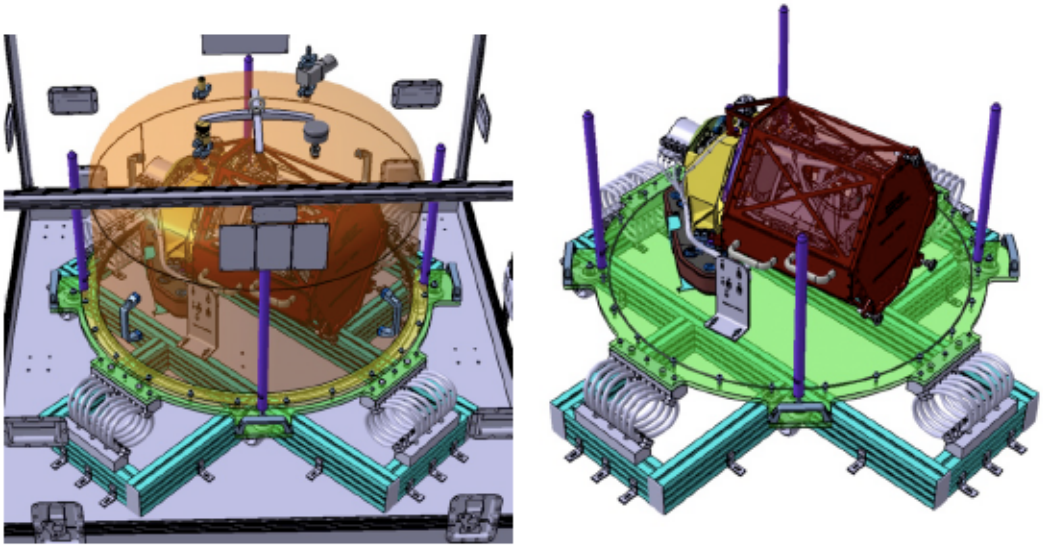


Figure 6: CRU Transport Container.
Left: Container shown transparent with CRU under bell inside.
Right: Installation of CRU on transport jig inside container (Bell not shown).

Box / Item	CIC / Reference drawing
CRU Transport box	E112135079G
CaSSIS CRU	E112134000P
CRU MGSE	E112137000G
Transport plate inside container for CRU	E112138100G
Transport bell inside container for CRU	E112138120G
Reduction Hanger (for CRU Bell-to-crane)	E112132310G
Telescope MLI mounted on CRU telescope	blankets installed: 17, 10, 8, 9, 11, 16 See [RD9]
ELU transport box	E112135078G
CaSSIS ELU	E112135000P
Radiator cover (MGSE) mounted on ELU	E112135400G
Connector savers mounted on S/C side (1 bag)	E112139000G
Transport plate inside container for ELU	E112138150G
Transport bell inside container for ELU	E112138158G
MLI Transport Box	E112135077G
MLI blankets	except 17, 10, 8, 9, 11, 16 (see [RD9])
MLI templates	n/a
EGSE transport box	E112135076G
CaSSIS EGSE Interface box	E112139201G
EGSE Harness	E112139400G
EGSE Power Supply	E112139200G
EGSE Laptop	E112139204G
EGSE Laptop Mouse	E112139203G
EGSE Laptop power supply	E112139207G
SchuKo Adaptor	E112139310G

UBE personnel will be present remove the two CaSSIS units (CRU and ELU) and the MLI blankets from their respective containers. CaSSIS expects a crane to be available to lift the bell that protects the CRU.

4.2 List of removable items

All removable items will be connected to their respective unit when shipped.

- ELU Radiator Cover
  The ELU also comes with an installation jig, which also serves as a cover to protect the radiator on the ELU nadir facing side. It will already be installed on the hardware for shipment. See **Figure 7.** for illustration. If this cover is removed **take care not to put pressure on the GFRP structure protecting the radiator. Do not touch the radiator.**
- CRU MGSE
  An installation jig to aid mounting the PFM CRU on the spacecraft is already mounted on the CRU (see **Figure 8).**
- Aperture cover
  The CaSSIS telescope will be covered with an MLI patch (see Figure 9) as protection at all times during integration and handling. It is **absolutely necessary to have the telescope aperture covered at all times if not otherwise stated in respective procedures.**
- Connector savers
  All connectors on the S/C side are protected by a respective connector saver. These will have to be removed before the S/C harness is finally connected to the CaSSIS ELU.

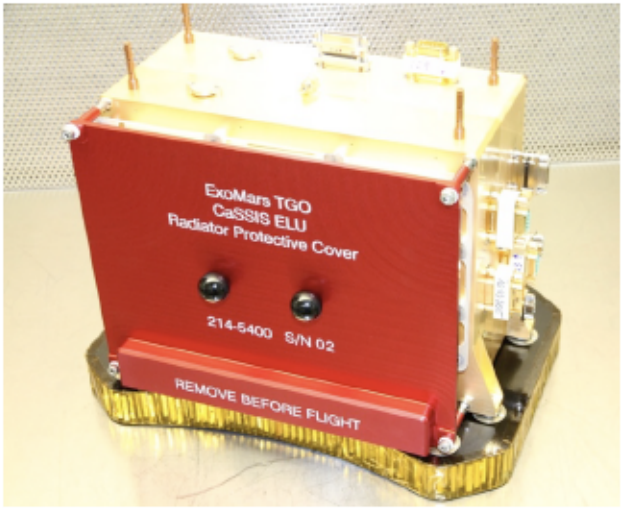


Figure 7: CaSSIS ELU with Radiator Cover installed

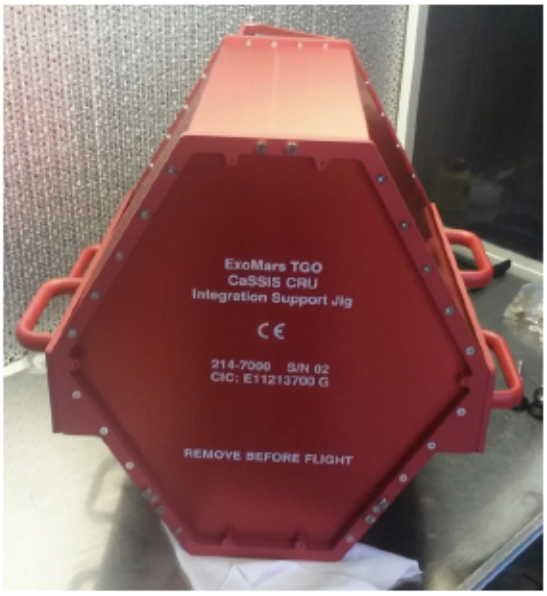


Figure 8: CaSSI CRU MGSE and telescope protective cover

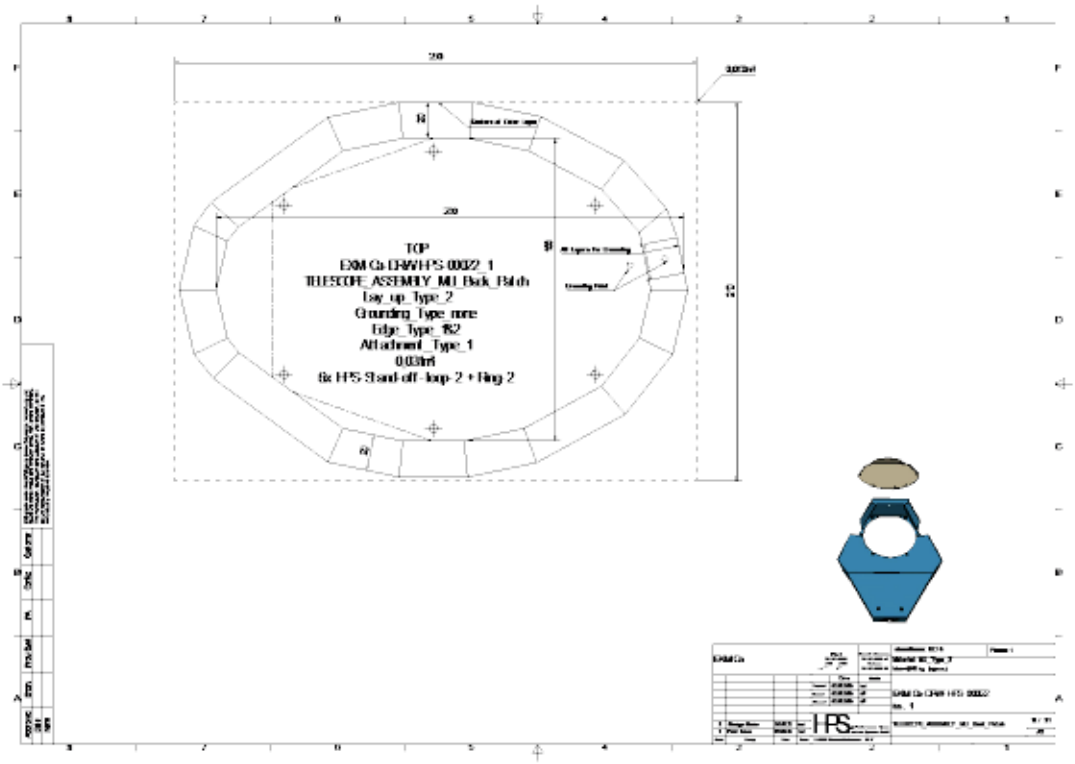


Figure 9: CaSSIS Aperture cover for telescope

4.3 Mechanical I/F

The CaSSIS ELU interfaces with the S/C lower payload deck at 4 points (see Figure 10).
The CaSSIS CRU interfaces with the S/C lower payload deck at 6 points (see Figure 11).

A more detailed drawing of the CaSSIS instrument can be found in the instrument MICD [NR1].

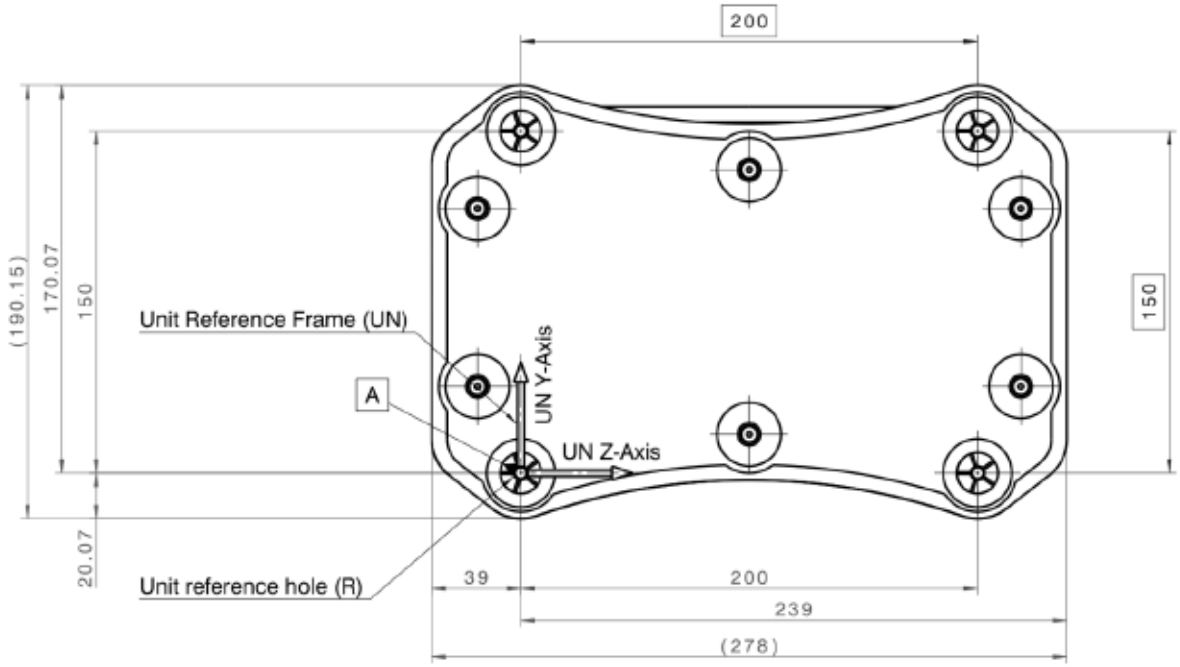


Figure 10: CaSSIS ELU mechanical interface w/ S/C

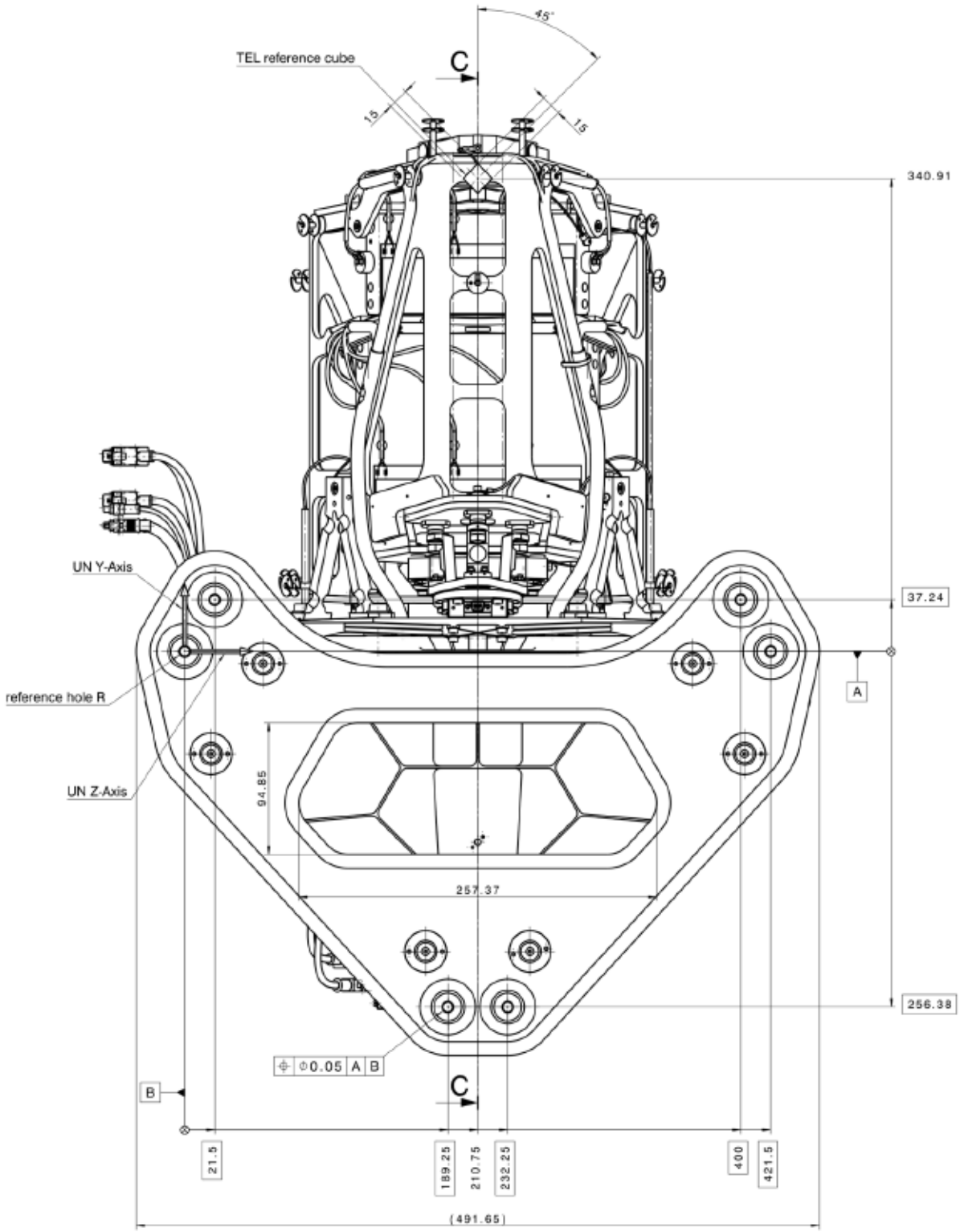


Figure 11: CaSSIS CRU mechanical interface w/ S/C

4.4 Electrical I/F and Grounding

The electrical interface is described in detail in the IDS (see [NR2]). The grounding diagram can be seen in Figure 12.

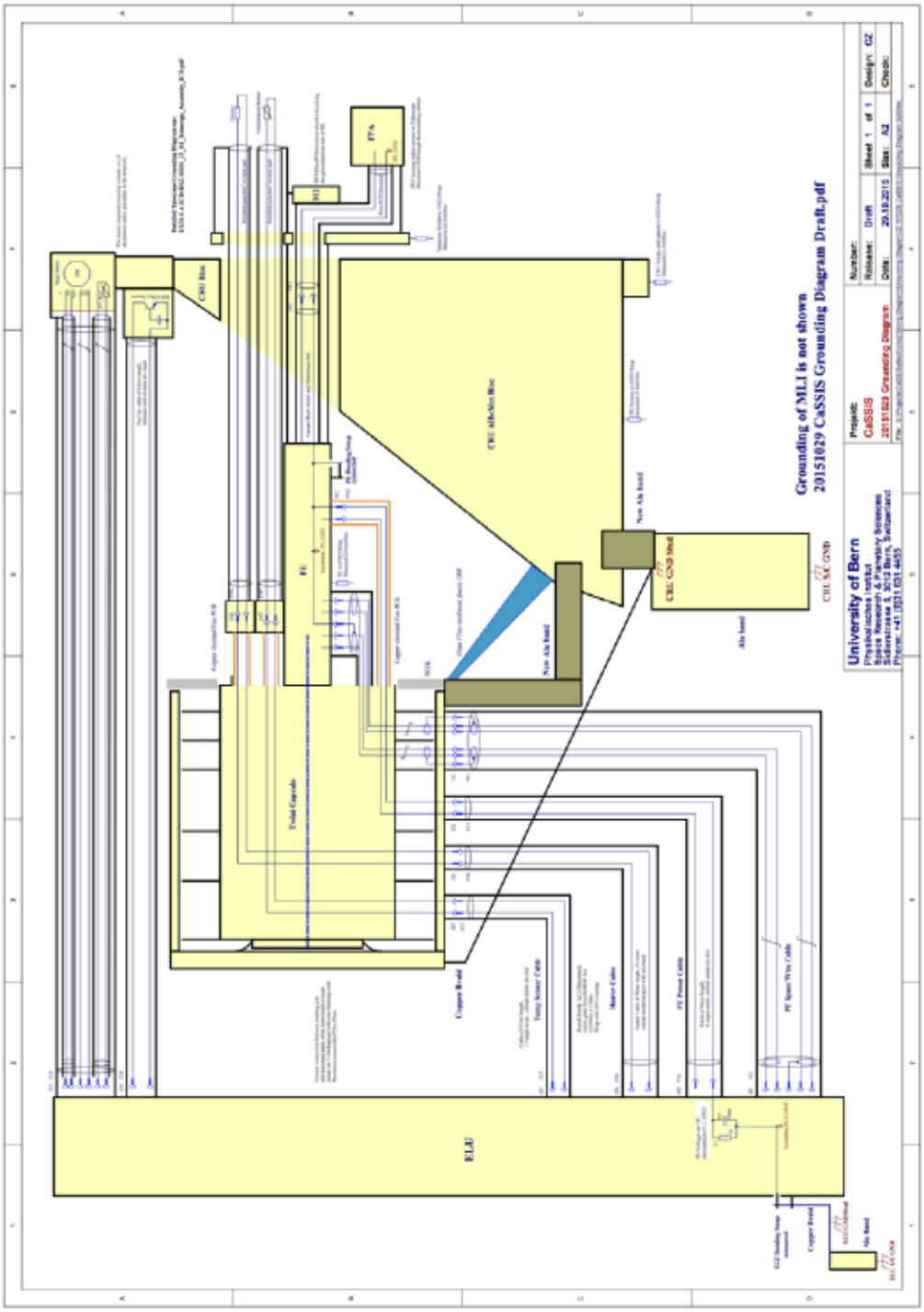


Figure 12: CaSSIS Grounding Diagram

4.5 Data Handling

The Full Functional Test shown below (see section 7.5) resembles a full operational cycle. Please note that some checks performed during FFT (for instance, SpW channels and/or MilBus channels) are not done everytime CaSSIS will operate and take images. The table shows the data rates and volumes corresponding to the FFT.

Steps	Action	Number of TCs send	TC Data Volume [byte]	SpW Data volume [Mbyte]
100	**Instrument switch-on**	0	0	0
2**	**Check survival functionality**	0	0	0
3**	**Switch CaSSIS ON** (NOM & RED)	32	2048	0
4**	**Check motor**	6	384	0
5**	**Check imaging**			
	Take single image (2048 x 2048)	7	448	8.389
	Acquire 11 frames (push-frames) 4 colours (4 x 256 x 1536)	7	448	34.603
7**	**Communication check**			
	Check MilBus Channels	0	0	0
	Check SpW NOM	1	64	0
	Check SpW RED	1	64	0
9**	**Change heating set points**	2	128	0
14**	**Instrument switch-off**	1	64	0
	FFT TOTAL	**57**	**3648**	**42.992**

4.6 Budgets

4.6.1 Mass

The masses for the CaSSIS units olus the total instrument mass are shown below. These values include the respective washers (between unit sandwich and S/C deck), the respective MLI blankets, the harness (on CRU), and optical cube.

Unit	M best estimate [g]	M predicted [g]	M measured [g]
CRU	15080	15830	15161.3
ELU	2810	2890	2848.1
TOTAL	17890	18720	18009.4

4.6.2 CoM

The Center of Gravity for the CaSSIS untis were measured as follows:

Unit	CoM X [mm]		CoM Y [mm]		CoM Z [mm]	
Reference frame	Sub-unit	Instrument (=Unit)	Sub-unit	Instrument (=Unit)	Sub-unit	Instrument (=Unit)
ELU	116.7	116.7	80.81	491.46	99.8	-644.2
CRU	196.64	196.64	-12.23	354.801	208.78	-268.47

4.6.3 Power and Energy

The following values are the as measured values during environmental tests.
The TBC and TBD will be updated in the next issue, when the full test reports are provided and the data fully analised.

Boundary Condition	Power consumption in STBY		Power consumption while FFT	
	avarage [w]	peak [W]	avarage [w]	peak [W]
Hot Operational	14.5	26.4	12.9	32.3
Cold Operational	17.3	25.8	TBD	56.7 (TBC)
Survival	8.5	16.9	N/A	N/A

4.6.4 Thermal Budget

The thermal interface and behaviour of the instrument is described in the thermal model [EXM-CA-MOD-UBE-00001] and the respective report [EXM-CA-REP-UBE-80001] as well as in the thermal-vacuum test report.

4.6.5 Pointing & Alignment

CaSSIS does not require fine alignment. The optical alignment cube is used to align the instrument against the nadir axis. See section 7.3.1 for details about alignment subsequent to integration.

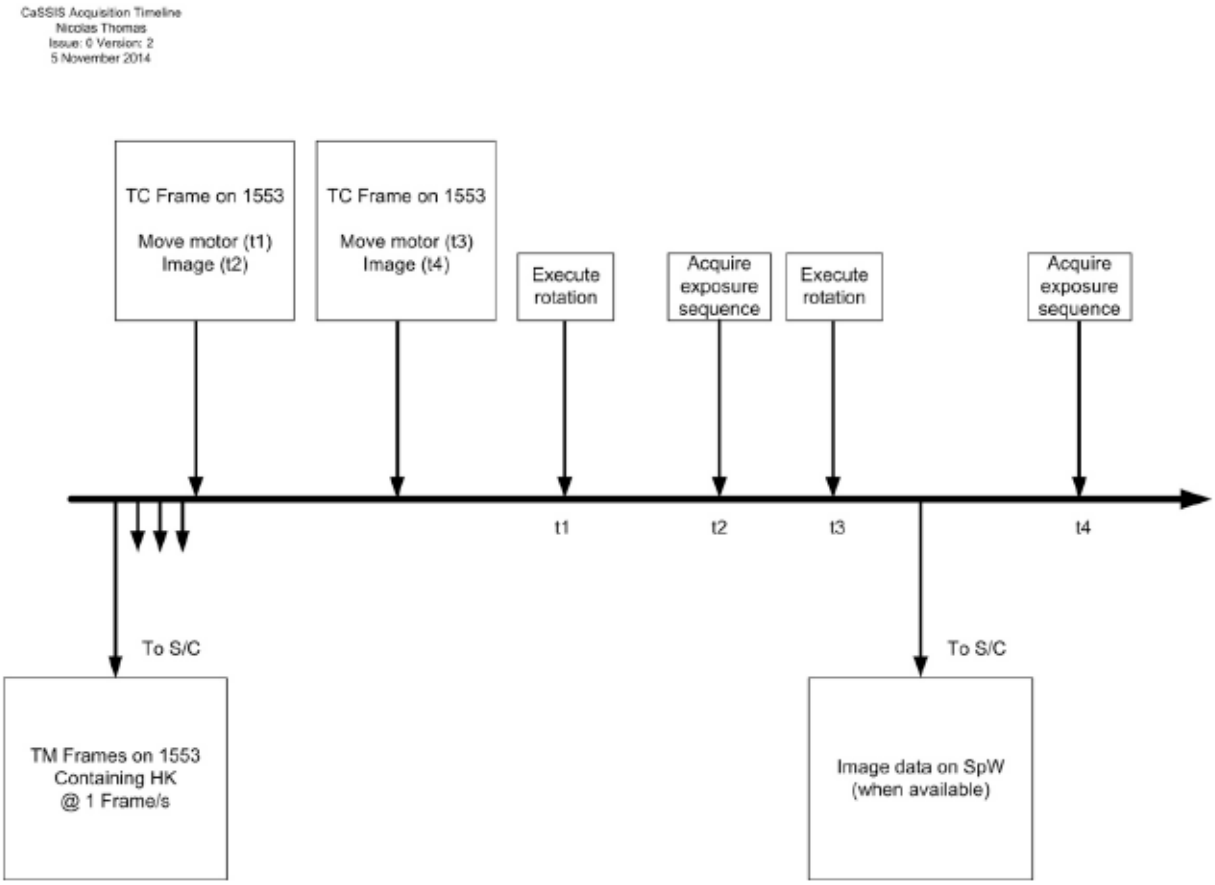
5 Experiment Operating Modes Description

The operational modes are described in the Experiment Operations Plan [EXM-CA-PLN-UBE-00024].

6 EXPERIMENT OPERATIONS

6.1 Operability Concept

The diagram below shows the basic concept of CaSSIS operations. The Instrument waits in standby for commands from the S/C. It is continuously sending H/K to the S/C via the 1553 bus.
The commands for imaging and motor movement have a time stamp based on the mission timeline. CaSSIS maintains an internal time using the mission time codes provided by the S/C on the 1553 bus, and executes the commands at the specified times. After image data is acquired, it is compressed and sent on the SpW link to the PDHU.



6.2 Operational Constraints

For the FFT shown below (see section 7.5) STEP **370** has to be executed before the TGO on board time reaches 3 hours.

6.3 Ground Operations

Please refer to section 2 and especially section 2.3 when operating CaSSIS on ground.
The rotation logbook (section 9) shall be maintained.

There are no potential hazards when operating CaSSIS.

At no time shall the instrument be touched or moved while the telescope is rotating.

In Figure 13 a mode diagram is shown. CaSSIS should always be powered off by sending a SAFEMODE command first. The next time the instrument is booted up it will be in STANDBY. In case of an unexpected power cycle the instrument will boot up in SAFEMODE, as the SAFEMODE command was not send before power off. This prevents CaSSIS from faulty commands. In SAFEMODE only very few commands are accepted. To exit SAFEMODE a command for operation mode change is needed (LEAVE_SAFEMODE).

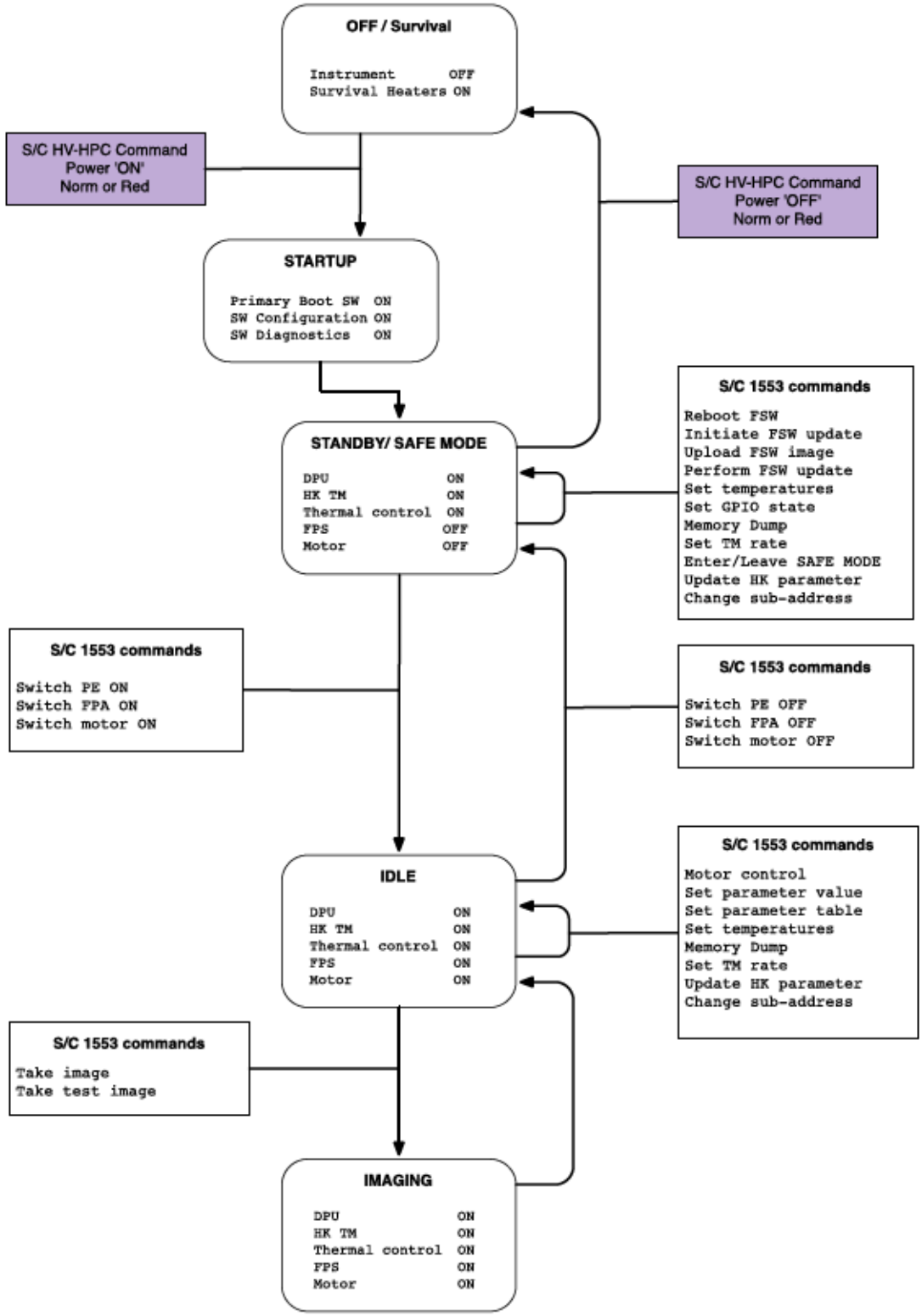


Figure 13: CaSSIS Operatinal Modes

6.4 Failure Detection and Recovery Strategy

UBE will assess all telemetry from the CaSSIS PFM operations including all failure notification.
UBE will be handling any NCRs wrt to operation.

7 AIT Procedures

7.1 Unpacking

Before installation on the S/C the two units of CaSSIS including their respective MGSE must be unpacked. UBE personnel will be present remove the two CaSSIS units (CRU and ELU) and the MLI blankets from their respective containers. CaSSIS expects a crane to be available to lift the bell that protects the CRU.

The procedure for unpacking and packing the CaSSIS PFM CRU can be found in [NR7].
The procedure for unpacking and packing the CaSSIS PFM ELU can be found in [NR8].

7.2 Instrument Integration at S/C

7.2.1 Panel access

CaSSIS assumes that the TGO configuration for CaSSIS integration is the horizontal configuration with –Y facing the floor (see Figure 14). MLI is integrated after both units are mounted on the TGO lower payload deck.

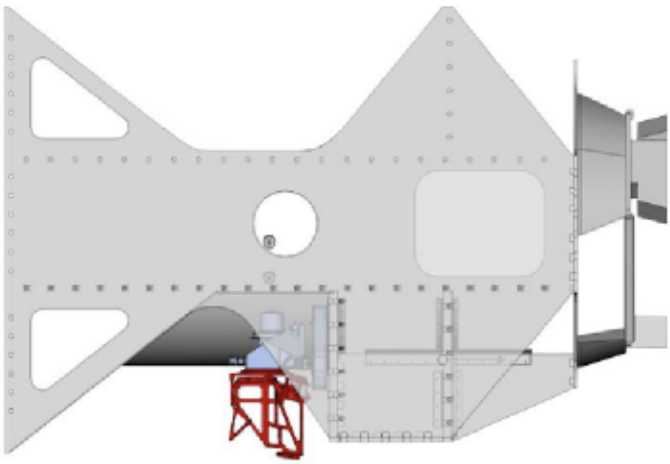


Figure 14: Illustration of TGO orientation for CaSSIS PFM integration

The CaSSIS design guarantees access from the –Y direction with standard and right angle tools.
The access to the ELU for connecting the S/C harness is from the -Z direction with standard tools.

CASSIS will deliver the harness pre-installed on CRU fixed to the baseplate. This implies that there is no need to install harness to the deck successively. The CRU and ELU need to be connected, this is described in detail in the CaSSIS PFM Integration Procedure (EXM-CA-PRC-UBE-00018) [NR5].

7.3 Integration of PFM

Should the STM still be mounted on the S/C, it must be removed first before the CaSSIS PFM can be installed. The respective procedure can be found in section 3 of the STM integration procedure ([NR6]).

For the integration of the CaSSIS instrument please see the CaSSIS PFM Integration Procedure ([NR5]).

No extra hardware except removable items (see section 4.2) will have to be installed.

7.3.1 Alignment

CaSSIS' Electronics Unit (ELU) does not need any alignment at.

The CaSSIS Camera Rotation Unit is delivered with an optical alignment cube (OAC) and associated cover installed (see Figure 15). The alignment characterization and measurement is done with this cube. The patch needs to be removed for alignment and attached afterwards. The cube is not removable and will fly.

The following paragraph explains how the orientation of the instrument optical cube with respect to the spacecraft coordinate system is done. Is is assumed that ELU and CRU are mounted onto the S/C according to the Integration Procedure in [NR5]. Before executing the procedure, make sure UBE is informed about the planned rotation of the telescope.

1. Remove MLI patch on cube by removing the clips and lift the MLI off.
2. Check if the MLI skirts on the CRU baseplate do not 'bulge' and partially obscure the cube. Should that be the case, use silicon based kapton tape to temporarily hold the MLI on.
3. The telescope needs to be rotated to one of the possible 90 degree positions as otherwise both faces of the optical alignment cube will not be visible. A procedure to turn the telescope is shown below (see Table 1). **The successful execution of the procedure shall be checked visually (see respective steps in procedure below).**
4. Theodolites shall be used to measure the instrument reference cube.
5. The orientation of the instrument reference cube with respect to the spacecraft coordinate system shall be computed. TAS standard approach is acceptable.
6. If the orientation of the instrument reference cube is not within the tolerance for the nadir-pointing, it is understood that there will be no fine alignment procedure to follow during integration of the PFM CRU.
7. The telescope needs to be rotated back into launch position. A procedure can be found in Table 2.
8. Remove the kapton tape, if used in step 2.
9. Attach the MLI patch (see Figure 15) onto the optical cube, fix the clips on the MLI stand-offs.
10. Track the executed telescope rotations in the logbook (section 9).

STEP-BY-STEP Procedure Dictionary

STEP #: identifies the step number
Description: short description of the purpose of each step
Time: time at which the telecommand shall be executed, it is assumes T_0=0 is the time the S/C is booted, up and running and prepared to start the FFT. This is NOT the OBT. The time is given in format HH:MM:SS. If multiple commands are specified for one timestamp they shall be sent one after the other in the specified order.
Telecommand 64 byte: shows the first bytes of the 64 byte long telecommand noted as octet string. The remainder shall be set 0 if the telecommand is less than 64 bytes long. The last 2 bytes of each telecommand octet string represent a checksum to protect against transcription errors and must be sent as well.

NOTE: TCs that do not have a total length of 64byte should be filled with zeros.

Table 1: Procedure for turning the CaSSIS telescope into a 90 degree position to ensure visibility of the optical alignment cube.

STEP	Description	Time	Telecommand Parameters	Telecommand in 64byte string
100	The S/C should be ON and booted up CaSSIS is switched off	00:00:00	None	none
200	Switch CaSSIS ON NOM (the CaSSIS FSW will now boot up)	00:01:00	S/C command	S/C command
260	Send CaSSIS LEAVE Safemode command	00:03:00	CHANGE_OPERATION_MODE UNIQUE_ID = -- PATTERN = 0x5a00a500	F0 0E A3 0C 71 04 00 00 00 00 8F 04 5A 00 A5 00 E8 30
300	Switch motor ON	00:05:00	SWITCH_MOTOR_POWER UNIQUE_ID = 300 TIMESTAMP = 0 STATE_MOTOR = 1	f0 15 20 13 71 04 00 00 01 2c 73 08 00 00 00 00 00 00 00 ba 01 01 78 c8
400	Homing to Zero 1, speed 32 (8 RPS), Power 1, Profile 0	00:06:00	MOVE_MOTOR_ABSOLUTE UNIQE_ID = 400 ABSOLUTE_POSITION = 0 TIMESTAMP = 0 POWER_PROFILE = 1 MOVEMENT_PROFILE = 0 SPEED = 32	f0 24 02 22 71 04 00 00 01 90 86 04 00 00 00 00 73 08 00 00 00 00 00 00 00 00 bc 02 00 01 bd 02 00 00 be 02 00 20 b4 dc
500	Visually check if the CaSSIS telescope is at the home position (see Figure 18)			
600	Move to Position 90 deg, speed 40 (10 RPS), Power 1, Profile 3	00:08:00	MOVE_MOTOR_ABSOLUTE UNIQE_ID = 600 ABSOLUTE_POSITION = 90000 TIMESTAMP = 0 POWER_PROFILE = 1 MOVEMENT_PROFILE = 3 SPEED = 40	f0 24 02 22 71 04 00 00 02 58 86 04 00 01 5f 90 73 08 00 00 00 00 00 00 00 00 bc 02 00 01 bd 02 00 03 be 02 00 28 ef 6d
700	Visually check if the CaSSIS telescope is at the 90 degree position (see Figure 17)			
800	Switch motor OFF	00:11:00	SWITCH_MOTOR_POWER UNIQUE_ID = 800 TIMESTAMP = 0 STATE_MOTOR = 0	f0 15 20 13 71 04 00 00 03 20 73 08 00 00 00 00 00 00 00 ba 01 00 33 fe
900	Switch instrument to SAFEMODE	00:15:00	CHANGE_OPERATION_MODE UNIQUE_ID = 900 PATTERN = 0x0fa55a00	f0 0e a3 0c 71 04 00 00 03 84 8f 04 0f a5 5a 00 d6 97
1000	Power CaSSIS OFF	00:17:00	S/C command	S/C command

Table 2: Procedure for turning the CaSSIS telescope back into launch position after alignment.

STEP	Description	Time	Telecommand Parameters	Telecommand in 64byte string
100	The S/C should be ON and booted up CaSSIS is switched off	00:00:00	None	none
200	Switch CaSSIS ON NOM (the CaSSIS FSW will now boot up)	00:01:00	S/C command	S/C command
250	Visually check if the CaSSIS telescope is at the 90 degree position (see Figure 17)			
260	Send CaSSIS LEAVE Safemode command	00:03:00	CHANGE_OPERATION_MODE UNIQUE_ID = -- PATTERN = 0x0fa55a00	F0 0E A3 0C 71 04 00 00 00 00 8F 04 5A 00 A5 00 E8 30
300	Switch motor ON	00:05:00	SWITCH_MOTOR_POWER UNIQUE_ID = 300 TIMESTAMP = 0 STATE_MOTOR = 1	f0 15 20 13 71 04 00 00 01 2c 73 08 00 00 00 00 00 00 00 ba 01 01 78 c8
400	Homing to Zero 1, speed 32 (8 RPS), Power 1, Profile 0	00:06:00	MOVE_MOTOR_ABSOLUTE UNIQE_ID = 400 ABSOLUTE_POSITION = 0 TIMESTAMP = 0 POWER_PROFILE = 1 MOVEMENT_PROFILE = 0 SPEED = 32	f0 24 02 22 71 04 00 00 01 90 86 04 00 00 00 00 73 08 00 00 00 00 00 00 00 00 bc 02 00 01 bd 02 00 00 be 02 00 20 b4 dc
500	Visually check if the CaSSIS telescope is at the home position (see Figure 18)			
600	Move to launch position (180°), Speed 70 (17.5 RPS), Power 1, Profile 3	00:10:00	MOVE_MOTOR_ABSOLUTE UNIQE_ID = 600 ABSOLUTE_POSITION = 180000 TIMESTAMP = 0 POWER_PROFILE = 1 MOVEMENT_PROFILE = 3 SPEED = 70	f0 24 02 22 71 04 00 00 02 58 86 04 00 02 bf 20 73 08 00 00 00 00 00 00 00 00 bc 02 00 01 bd 02 00 03 be 02 00 46 dc c3
700	Visually check if the CaSSIS telescope is at the launch position (see Figure 16)			
800	Switch motor OFF	00:11:00	SWITCH_MOTOR_POWER UNIQUE_ID = 800 TIMESTAMP = 0 STATE_MOTOR = 0	f0 15 20 13 71 04 00 00 03 20 73 08 00 00 00 00 00 00 00 ba 01 00 33 fe
900	Switch instrument to SAFEMODE	00:10:00	CHANGE_OPERATION_MODE UNIQUE_ID = 900 PATTERN = 0x0fa55a00	f0 0e a3 0c 71 04 00 00 03 84 8f 04 0f a5 5a 00 d6 97
1000	Power CaSSIS OFF	00:15:00	S/C command	S/C command

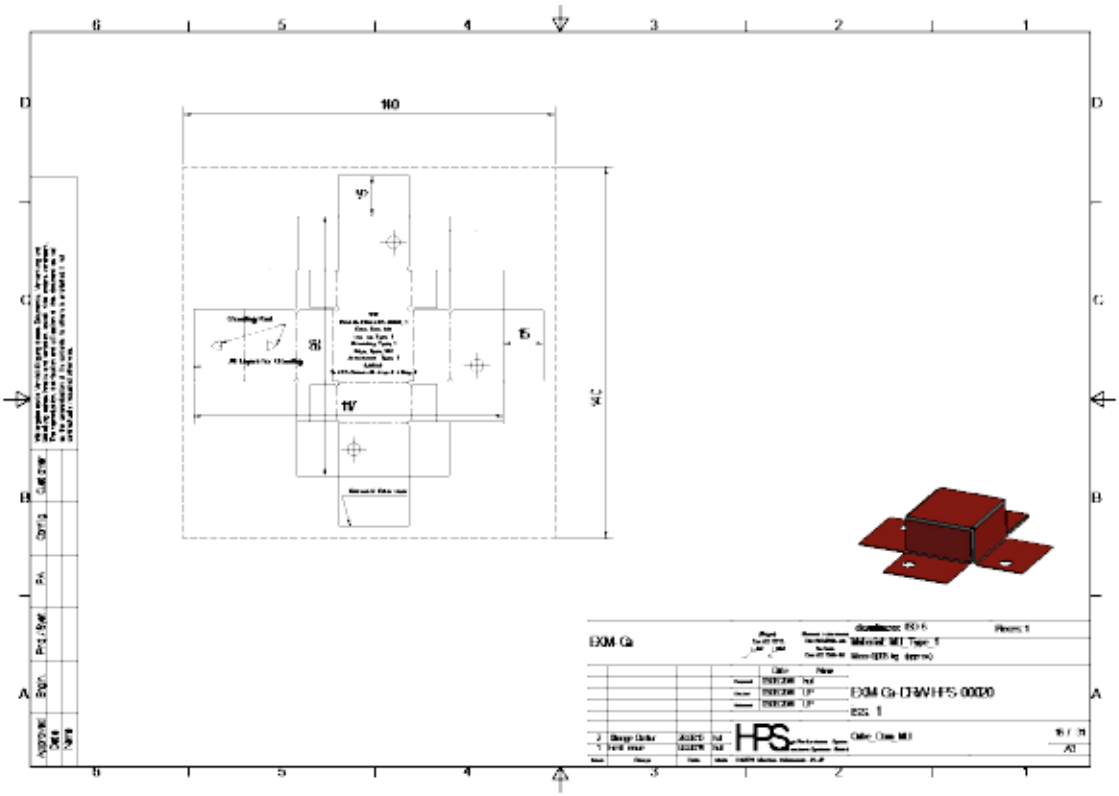


Figure 15: CaSSIS optical alignment cube MLI cover

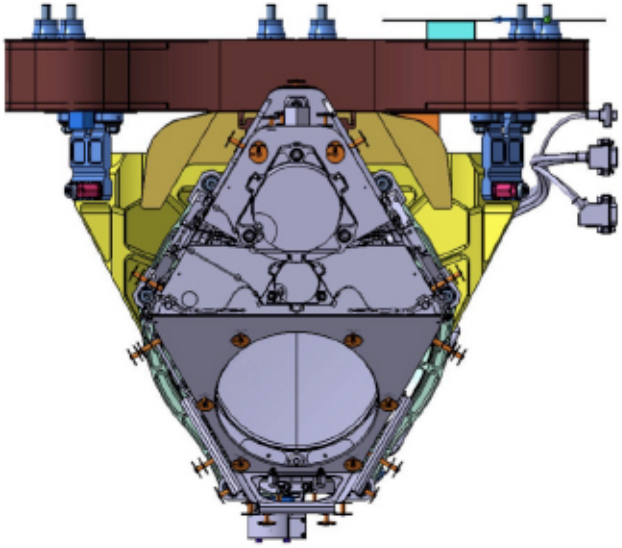


Figure 16: CaSSIS CRU with the telescope in launch position

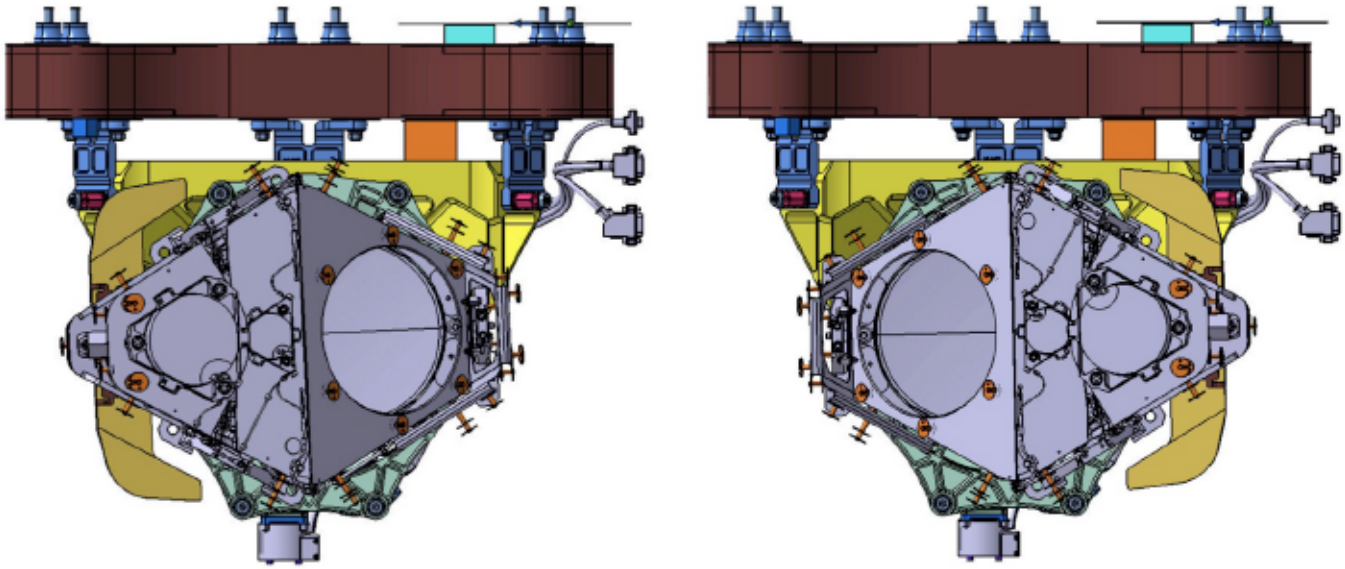


Figure 17: CaSSIS CRU with the telescope in 90 degree position for alignment. Both orientations are valid.

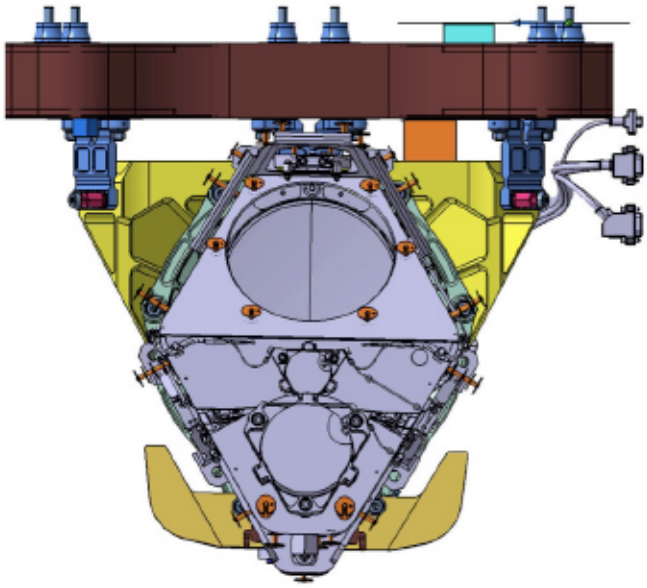


Figure 18: CaSSIS CRU with the telescope in home position

7.3.2 Bonding

The CaSSIS electrical and limited functional test will be performed by CaSSIS as part of TAS incoming inspection before System integration.

7.4 Covers

The aperture of the telescope will be covered with a red-tag cover. Nominally this cover is expected to be present at all times during testing unless otherwise specified. This cover provides a good seal, as it is a special MLI patch to be secured on the stand-offs with clips. CaSSIS wishes this cover to be left on as long as possible, as otherwise the mirrors will suffer from contamination and exceed their allowable budget.

CaSSIS understands that it is difficult to remove with one hand, especially when this has to be done through the hatch in the fairing. Hence CaSSIS allows this cover to be removed at T-12days before launch, just before fairing encapsulation. Visual inspection will be carried out (using images from outgoing inspection report (EXM-CA-REP-UBE-00021) for reference), any particulate contamination detected on the optics or baffles will be removed with compressed, dry nitrogen.

A loose fitting bag shall be placed over the telescope, for removal at T-8days through the fairing hatch. CaSSIS will confirm the design and procedure for removal of this bag after tests with the returned STM have been carried out.

7.5 Functional Test after instrument integration at S/C

Environment requirements for test at spacecraft level

- CaSSIS expects the red-tag cover on the aperture to be present at all times during testing unless otherwise specified.
- CaSSIS expects a class ISO8 clean room environment or better.
- CaSSIS expects UBE staff to be present for FFT.

The table below gives a short principle overview on how the Full Functional Test (FFT) shall be conducted and what the objectives of each step are. After conduction of the I2R2 it was agreed to run this FFT in two major steps: on the nominal and on the redundant power bus (FFTNOM and FFTRED). Also the MilBUS channel is A for FFTNOM and B for FFTRED However, only the FFT on the main power bus (FFTNOM) will contain motor operations. Both procedures can be found in section 8.

WARNING: if for some reason the test is paused while the motor is still on, it will become hot even when it is not rotating. The CaSSIS motor shall not be switched on for longer than 10 minutes.

Steps	Action	Objective
100	**Instrument switch-on** **FFTNOM** = B1553PLBUS A **FFTRED** = B1553PLBUS B	
2**	**Check survival functionality** on nominal and redundant power line	power up the instrument in survival mode verify power consumption

		verify correct heater regulation to survival temperature levels
3**	**Switch CaSSIS ON** **FFTNOM** = nominal power **FFTRED** = redundant power	power up the instrument in operational mode verify correct boot process of the FSW into STBY mode expected functionality: - Heating up to default operational temperature - Correct time synchronization to on board time provided via MilBus1553 - Providing HK and software status data and on MilBus1553
4**	**Check motor (*Warning: only in FFTNOM!*)**	verify correct motor operation and positioning of the telescope
	Homing to zero1	
	Move to 30deg	
	Move by 180deg	
	Move to launch position	
5**	**Check imaging**	verify correct acquisition of images including motor movement in-between
	Take single image	
	Acquire 11 frames (as a push-frames) in 4 colours (4 x 256 x 1536)	
7**	**Communication check**	verify correct communication on MilBus and SpW lines as well as the automatic switch over from main to redundant in case of failure
	Enable SpW NOM Disable SpW RED	
	Take single image	
	Disable SpW NOM Enable SpW RED	
	Enable SpW NOM Disable SpW RED	
8**	**Reset to factory settings (*only in FFTRED*)**	Reset all heater thresholds and setpoints to their nominal value.
9**	**Change heating set points (*only in FFTNOM!*)**	verify correct heater regulation to set temperature
10**	**Instrument switch-off**	

STEP-BY-STEP Procedure Dictionary

STEP #: identifies the step number
Description: short description of the purpose of each step
Time: time at which the telecommand shall be executed, it is assumes T_0=0 is the time the S/C is booted, up and running and prepared to start the FFT. This is NOT the OBT. The time is given in format HH:MM:SS. If multiple commands are specified for one timestamp they shall be sent one after the other in the specified order.
Telecommand 64 byte: shows the first bytes of the 64 byte long telecommand noted as octet string. The remainder shall be set 0 if the telecommand is less than 64 bytes long. The last 2 bytes of each telecommand octet string represent a checksum to protect against transcription errors and must be sent as well.

TM frame: shows the respective telemetry frame that needs to be checked
Expected value: shows the actual value the respective TM frame should have
Measured value: in this column the observed value needs to be filled on
OK/NOK: if expected and measured value are the same this column is ok and thenext step can be executed. If NOK, the CaSSIS team needs to be consulted.

NOTE: TCs that do not have a total length of 64byte should be filled with zeros.

Step 370 is meant to test that the on-board-time (OBT) is correctly written into CaSSIS HK data. It is understood that it is difficult to know in advance when this step will exactly be reached. Hence several commands with an absolute time as parameter are prepared. It is agreed with TAS that the respective operator will make an interactive decision which telecommand from the list is used according to the time passed test start.

7.5.1 Limited Functional Test Procedure for TGO Conducted EMC Tests (LFTEMC)

Environment requirements for test at spacecraft level

- CaSSIS expects the red-tag cover on the aperture to be present at all times during testing unless otherwise specified.
- CaSSIS expects a class ISO8 clean room environment or better.
- CaSSIS expects UBE staff to be informed before this procedure is carried out.
- UBE has to give authorisation to perform the LFTEMC procedure, as the telescope will be rotated during this test
- After completion of the test the executed telescope rotations are to be tracked in the logbook (section 9).
- ***Note: CaSSIS understands that TAS may want to repeat certain measurements. This is possible for steps 560-610. The steps involving motor rotation shall not be repeated.***

NOTE: TCs that do not have a total length of 64byte should be filled with zeros.

Table 3: STEP-BY-STEP Procedure for LFTEMC

STEP	Description	Time	Telecommand Parameters	Telecommand in 64byte string
100	The S/C should be ON and booted up CaSSIS is switched off	00:00:00	None	none
200	Switch CaSSIS ON NOM (the CaSSIS FSW will now boot up)	00:01:00	S/C command	S/C command
390	Send CaSSIS LEAVE Safemode command	00:03:00	CHANGE_OPERATION_MODE UNIQUE_ID = -- PATTERN = 0x0fa55a00	F0 0E A3 0C 71 04 00 00 00 00 8F 04 5A 00 A5 00 E8 30
400	Switch motor ON	00:05:00	SWITCH_MOTOR_POWER UNIQUE_ID = 400 TIMESTAMP = 0	f0 15 20 13 71 04 00 00 01 90 73 08 00 00 00 00 00 00 00 00 ba 01 01 62 40

STEP	Description	Time	Telecommand Parameters	Telecommand in 64byte string
			STATE_MOTOR = 1	
410	Homing to Zero 1, speed 32 (8 RPS), Power 1, Profile 0	00:06:00	MOVE_MOTOR_ABSOLUTE UNIQE_ID = 410 ABSOLUTE_POSITION = 0 TIMESTAMP = 0 POWER_PROFILE = 1 MOVEMENT_PROFILE = 0 SPEED = 32	f0 24 02 22 71 04 00 00 01 9a 86 04 00 00 00 00 73 08 00 00 00 00 00 00 00 00 bc 02 00 01 bd 02 00 00 be 02 00 20 b2 e6
415	Visually check if the CaSSIS telescope is at the home position (see Figure 18)			
420	Move to Position 30 deg, speed 40 (10 RPS), Power 1, Profile 3	00:08:00	MOVE_MOTOR_ABSOLUTE UNIQE_ID = 420 ABSOLUTE_POSITION = 30000 TIMESTAMP = 0 POWER_PROFILE = 1 MOVEMENT_PROFILE = 3 SPEED = 40	f0 24 02 22 71 04 00 00 01 a4 86 04 00 00 75 30 73 08 00 00 00 00 00 00 00 00 bc 02 00 01 bd 02 00 03 be 02 00 28 52 40
430	Visually check if the CaSSIS telescope is turned by roughly 30 degrees			
470	Move to launch position (180°), Speed 70 (17.5 RPS), Power 1, Profile 3	00:10:00	MOVE_MOTOR_ABSOLUTE UNIQE_ID = 470 ABSOLUTE_POSITION = 180000 TIMESTAMP = 0 POWER_PROFILE = 1 MOVEMENT_PROFILE = 3 SPEED = 70	f0 24 02 22 71 04 00 00 01 d6 86 04 00 02 bf 20 73 08 00 00 00 00 00 00 00 00 bc 02 00 01 bd 02 00 03 be 02 00 46 be bc
480	Visually check if the CaSSIS telescope is at the launch position (see Figure 16)			
490	Switch motor OFF	00:12:00	SWITCH_MOTOR_POWER UNIQUE_ID = 490 TIMESTAMP = 0 STATE_MOTOR = 0	f0 15 20 13 71 04 00 00 01 ea 73 08 00 00 00 00 00 00 00 ba 01 00 1f 4f
560	Prepare parameter table with 4 windows each 256 x 1536, number of exposures = 11	00:14:00	SET_PARAMETER_TABLE 2 ROIC FREQ= 5 MHz INTEGRATION TIME = 105 x 0.96us EXPOSURES = 11 INTERVAL = 1 ms WINDOWS: 4	f0 3c 07 3a 74 01 02 79 35 00 69 0b 00 05 99 98 00 04 00 10 00 08 02 c4 f7 e4 f4 08 05 90 f7 e7 90 08 08 30 f7 ea 30 08 0a da f7 ec da 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 c9 d1
570	Switch PE ON, Main/Redundant Power, No Temp/Voltage Override	00:16:00	SWITCH_PE_POWER UNIQUE_ID = 570 TIMESTAMP = 0 STATE_PE = 1 TEMPERATURE_OVERRIDE_PE = 0 POWER_LINE = 2	f0 1b 10 19 71 04 00 00 02 3a 73 08 00 00 00 00 00 00 00 00 b0 01 01 b1 01 00 b6 01 02 3b 14
580	Switch Detector ON	00:18:00	SWITCH_PE_DETECTOR UNIQUE_ID = 580 TIMESTAMP = 0 STATE_DET = 1 TEMPERATURE_OVERRIDE_DET = 0	f0 1b 11 19 71 04 00 00 02 44 73 08 00 00 00 00 00 00 00 b2 01 01 b3 01 00 17 01 00 c9 30

STEP	Description	Time	Telecommand Parameters	Telecommand in 64byte string
			DETECTOR_TEST_MODE = 0	
590	Take Image with parameter table 2	00:20:00	PREPARE_IMAGE UNIQUE_ID = 590 TIMESTAMP = 0 TABLE REFERENCE = 2	f0 15 12 13 71 04 00 00 02 4e 73 08 00 00 00 00 00 00 00 74 01 02 ee 71
600	Switch Detector OFF	00:22:00	SWITCH_PE_DETECTOR UNIQUE_ID = 600 TIMESTAMP = 0 STATE_DET = 0 TEMPERATURE_OVERRIDE_DET = 0 DETECTOR_TEST_MODE = 0	f0 1b 11 19 71 04 00 00 02 58 73 08 00 00 00 00 00 00 00 b2 01 00 b3 01 00 17 01 00 71 77
610	Switch PE OFF, Main/Redundant Power, No Temp/Voltage Override	00:24:00	SWITCH_PE_POWER UNIQUE_ID = 610 TIMESTAMP = 0 STATE_PE = 0 TEMPERATURE_OVERRIDE_PE = 0 POWER_LINE = 2	f0 1b 10 19 71 04 00 00 02 62 73 08 00 00 00 00 00 00 00 b0 01 00 b1 01 00 b6 01 02 e8 f2
1000	Switch instrument to SAFEMODE	00:26:00	CHANGE_OPERATION_MODE UNIQUE_ID = 1000 PATTERN = 0x0fa55a00	f0 0e a3 0c 71 04 00 00 03 e8 8f 04 0f a5 5a 00 37 e6
1100	Power CaSSIS OFF	00:28:00	S/C command	S/C command

8 FFT STEP-BY-STEP PROCEDURE

8.1 FFTNOM

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
100	S/C ON with B1553PLBUS A activated, PDHU 1 ON, SpW1 NOM enabled, SpW1 RED disabled, Open File TC issued CaSSIS is switched off FMON/PMON switched off	00:00:00	None	none		
CHECK SURVIVAL FUNCTIONALITY ON NOMINAL LINE						
200	Power CaSSIS over the nominal survival power line	00:05:00	S/C command	S/C command	None	($T_{Ambient}$ > 0°C) Power < 2.8W
250	If S/C requires Switch ON FMON/PMON					
CHECK CORRECT BOOT UP OF INSTRUMENT ON NOMINAL LINE						
300	Switch CaSSIS ON NOM (the CaSSIS FSW will now boot up)	00:08:00	S/C command	S/C command	0x01: FSW_VERSION 0x03: FSW_MODE 0x50: U_05V_REF	 0xF0 0x01BC

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
	Accquire housekeeping Check Time Syncronization on Milbus				0x51: I_3V3_DPM 0x52: U_3V3_DPM 0x53: I_1V8 0x54: U_1V8 0x55: U_5V_OP 0x56: U_5V_ANA 0x57: I_5V_ANA 0x58: I_3V3_FPGA 0x59: U_3V3_FPGA 0x5A: I_1V2_FPGA 0x5B: U_1V2_FPGA	 0x0BBC 0x0674 0x08D2 0x08D7 0x0BC6 0x0466
310	Send CaSSIS SAFEMODE command	00:10:00	CHANGE_OPERATION_MODE UNIQUE_ID = 310 PATTERN = 0x0fa55a00	f0 0e a3 0c 71 04 00 00 01 36 8f 04 0f a5 5a 00 cb a6	0x03: FSW_MODE	0x0F
312	Send CaSSIS LEAVE SAFEMODE command	00:11:00	CHANGE_OPERATION_MODE UNIQUE_ID = 0000 PATTERN = 0x5a00a500	f0 0e a3 0c 71 04 00 00 00 00 8f 04 5a 00 a5 00 e8 30		
315	Verify main Heaters All Heaters Switched ON	00:12:00	Switch PE heater to manual mode	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 40 a1 01 03 a2 01 03 e8 dc		
			Switch PE heater on	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 40 a1 01 80 a2 01 80 0f d3		
			Switch FPA heater to manual mode	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 44 a1 01 03 a2 01 03 29 1a		
			Switch FPA heater on	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 44		

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
				a1 01 80 a2 01 80 ce 15		
			Switch RB heater to manual mode	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 48 a1 01 03 a2 01 03 7b 71		
			Switch RB heater on	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 48 a1 01 80 a2 01 80 9c 7e		
			Switch FB heater to manual mode	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 4c a1 01 03 a2 01 03 ba b7		
			Switch FB heater on	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 4c a1 01 80 a2 01 80 5d b8		Power = 30W
			Switch RCM heater to manual mode	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 50 a1 01 03 a2 01 03 df a7		
			Switch RCM heater on	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 50 a1 01 80 a2 01 80 38 a8		
370	REBOOT_FSW with timestamp Will be executed at T = 00:45:00 T = 01:00:00 T = 01:15:00 T = 01:30:00 T = 01:45:00 T = 02:00:00	00:22:00	REBOOT_FSW UNIQUE_ID = 370 TIMESTAMP = 2f00002a30000000 RESET_TYPE = 1 BOOT_TARGET = 0xFF	45': f0 18 ff 16 71 04 00 00 01 72 73 08 2f 00 00 0a 8c 00 00 00 90 01 01 91 01 ff 4a 6f 1:00': f0 18 ff 16 71 04 00 00 01 72 73 08 2f 00 00 0e 10 00 00 00 90 01 01 91 01 ff 8c f4		Reboot at times: 00:45:00 01:00:00 01:15:00 01:30:00 01:45:00 02:00:00 02:15:00

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
	T = 02:15:00 T = 02:30:00 T = 02:45:00 T = 03:00:00			1:15': f0 18 ff 16 71 04 00 00 01 72 73 08 2f 00 00 11 94 00 00 00 90 01 01 91 01 ff 1b fb 1:30' f0 18 ff 16 71 04 00 00 01 72 73 08 2f 00 00 15 18 00 00 00 90 01 01 91 01 ff 49 f6 1:45' f0 18 ff 16 71 04 00 00 01 72 73 08 2f 00 00 18 9c 00 00 00 90 01 01 91 01 ff 2b 77 2:00' f0 18 ff 16 71 04 00 00 01 72 73 08 2f 00 00 1c 20 00 00 00 90 01 01 91 01 ff d4 e1 2:15' f0 18 ff 16 71 04 00 00 01 72 73 08 2f 00 00 1f a4 00 00 00 90 01 01 91 01 ff e5 1a 2:30' f0 18 ff 16 71 04 00 00 01 72 73 08 2f 00 00 23 28 00 00 00 90 01 01 91 01 ff ea de 2:45' f0 18 ff 16 71 04 00 00 01 72 73 08 2f 00 00 26 ac 00 00 00 90 01 01 91 01 ff 2a d1 3:00' f0 18 ff 16 71 04 00 00 01 72 73		02:30:00 02:45:00 03:00:00

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
				08 2f 00 00 2a 30 00 00 00 90 01 01 91 01 ff 4e c4		
CHECK MOTOR						
380	Verify CaSSIS ON, boot up and not in Safemode	00:30:00			0x03: FSW_MODE	0xF0
390	Send CaSSIS LEAVE Safemode command	00:32:00	CHANGE_OPERATION_MODE UNIQUE_ID = 0000 PATTERN = 0x0fa55a00	f0 0e a3 0c 71 04 00 00 00 00 8f 04 5a 00 a5 00 e8 30	0x03: FSW_MODE	0xF0
395	Dump HK table over SpW	00:33:00	DUMP UNIQUE_ID = 395 DUMP_TYPE = 0xD2	F0 1A 0B 18 71 04 00 00 01 8B 98 01 D2 99 01 00 9A 04 00 00 00 00 9B 04 00 00 00 00 F8 D9		
400	Switch motor ON	00:34:00	SWITCH_MOTOR_POWER UNIQUE_ID = 400 TIMESTAMP = 0 STATE_MOTOR = 1	f0 15 20 13 71 04 00 00 01 90 73 08 00 00 00 00 00 00 00 00 ba 01 01 62 40	0x5C:U_24V_MOT_1 0x5D:U_24V_MOT_2	0x0873 0x0873
410	Homing to Zero 1, speed 32 (8 RPS), Power 1, Profile 0	00:35:00	MOVE_MOTOR_ABSOLUTE UNIQE_ID = 410 ABSOLUTE_POSITION = 0 TIMESTAMP = 0 POWER_PROFILE = 1 MOVEMENT_PROFILE = 0 SPEED = 32	f0 24 02 22 71 04 00 00 01 9a 86 04 00 00 00 00 73 08 00 00 00 00 00 00 00 00 bc 02 00 01 bd 02 00 00 be 02 00 20 b2 e6	0x80:TSCP_ACTUAL_POS 0x82:SCP_ROT_STAT	0 During rotation: 3 After rotation: 1
420	Move to Position 30 deg, speed 40 (10 RPS), Power 1, Profile 3	00:36:00	MOVE_MOTOR_ABSOLUTE UNIQE_ID = 420 ABSOLUTE_POSITION = 30000 TIMESTAMP = 0	f0 24 02 22 71 04 00 00 01 a4 86 04 00 00 75 30 73 08 00 00 00 00 00 00 00 00 bc 02 00 01 bd 02	0x80:TSCP_ACTUAL_POS 0x82:TSCP_ROT_STAT	30000 Before rotation: 1

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
			POWER_PROFILE = 1 MOVEMENT_PROFILE = 3 SPEED = 40	00 03 be 02 00 28 52 40		During rotation: 6 After rotation: 0
430	Move +180 deg forward, Speed 70 (17.5 RPS), Power 1, Profile 3	00:37:00	MOVE_MOTOR_RELATIVE UNIQE_ID = 430 DIRECTION = 0 RELATIVE_DISPLACEMENT = 180000 TIMESTAMP = 0 POWER_PROFILE = 1 MOVEMENT_PROFILE = 3 SPEED = 70	f0 27 01 25 71 04 00 00 01 ae 84 01 00 85 04 00 02 bf 20 73 08 00 00 00 00 00 00 00 00 bc 02 00 01 bd 02 00 03 be 02 00 46 fc 5b	0x80:TSCP_ACTUAL_POS 0x82:TSCP_ROT_STAT	240000 Before rotation: 0 During rotation: 6 After rotation: 0
470	Move to launch position (180°), Speed 70 (17.5 RPS), Power 1, Profile 3	00:38:00	MOVE_MOTOR_ABSOLUTE UNIQE_ID = 470 ABSOLUTE_POSITION = 180000 TIMESTAMP = 0 POWER_PROFILE = 1 MOVEMENT_PROFILE = 3 SPEED = 70	f0 24 02 22 71 04 00 00 01 d6 86 04 00 02 bf 20 73 08 00 00 00 00 00 00 00 00 bc 02 00 01 bd 02 00 03 be 02 00 46 be bc	0x80:TSCP_ACTUAL_POS 0x82: TSCP_ROT_STAT	180000 Before rotation: 0 During rotation: 6 After rotation: 0
490	Switch motor OFF	00:42:00	SWITCH_MOTOR_POWER UNIQUE_ID = 490 TIMESTAMP = 0 STATE_MOTOR = 0	f0 15 20 13 71 04 00 00 01 ea 73 08 00 00 00 00 00 00 00 00 ba 01 00 1f 4f	0x5C:U_24V_MOT_1 0x5D:U_24V_MOT_2	0 0
	ACQUIRE SINGLE IMAGE (2048x2048)					

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
500	Prepare Parameter for acquisition of 1 single frame (2048x2048)	00:43:00	SET_PARAMETER_TABLE 2 ROIC FREQ= 1.25 MHz INTEGRATION TIME = 105 x 9.6us EXPOSURES = 1 INTERVAL = 400 ms WINDOWS: 1 (0..2047/1..2047)	f0 3c 07 3a 74 01 02 79 35 00 69 01 00 06 1a 80 02 01 00 00 00 00 00 00 ff ef fe 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 b1 3e		
505	Dump Parameter tables	00:44:00	DUMP UNIQUE_ID = 505 DUMP_TYPE = 0xD1	f0 1a 0b 18 71 04 00 00 01 f9 98 01 d1 99 01 00 9a 04 00 00 00 00 9b 04 00 00 00 00 2d 18		
510	Switch PE ON, Main/Redundant Power, No Temp/Voltage Override	00:45:00	SWITCH_PE_POWER UNIQUE_ID = 510 TIMESTAMP = 0 STATE_PE = 1 TEMPERATURE_OVERRIDE_PE = 0 POWER_LINE = 2	f0 1b 10 19 71 04 00 00 01 fe 73 08 00 00 00 00 00 00 00 00 b0 01 01 b1 01 00 b6 01 02 54 75	0x5E: U_3V3_PE 0x60: U_8V5_PE 0x62 : U_N_8V5_PE 0x64 : U_25V_PE	1310-1440 1000-1240 1180-1460 1465-2160
520	Switch Detector ON	00:46:00	SWITCH_PE_DETECTOR UNIQUE_ID = 520 TIMESTAMP = 0 STATE_DET = 1 TEMPERATURE_OVERRIDE_DET = 0 DETECTOR_TEST_MODE = 0	f0 1b 11 19 71 04 00 00 02 08 73 08 00 00 00 00 00 00 00 00 b2 01 01 b3 01 00 17 01 00 1f 28	0x70: PE_HK_STAT	0bxxxxxx1
530	Acquire image, Parameter Table 2	00:47:00	PREPARE_IMAGE UNIQUE_ID = 530 TIMESTAMP = 0 TABLE REFERENCE = 2	f0 15 12 13 71 04 00 00 02 12 73 08 00 00 00 00 00 00 00 00 74 01 02 15 f7		

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
540	Switch Detector OFF	00:48:00	SWITCH_PE_DETECTOR UNIQUE_ID = 540 TIMESTAMP = 0 STATE_DET = 0 TEMPERATURE_OVERRIDE_DET = 0 DETECTOR_TEST_MODE = 0	f0 1b 11 19 71 04 00 00 02 1c 73 08 00 00 00 00 00 00 00 00 b2 01 00 b3 01 00 17 01 00 1a d6	0x70: PE_HK_STAT	0bxxxxxx0
550	Switch PE OFF, Main/Redundant Power, No Temp/Voltage Override	00:49:00	SWITCH_PE_POWER UNIQUE_ID = 550 TIMESTAMP = 0 STATE_PE = 0 TEMPERATURE_OVERRIDE_PE = 0 POWER_LINE = 2	f0 1b 10 19 71 04 00 00 02 26 73 08 00 00 00 00 00 00 00 00 b0 01 00 b1 01 00 b6 01 02 83 53	0x5E: U_3V3_PE 0x60: U_8V5_PE 0x62 : U_N_8V5_PE 0x64 : U_25V_PE	< 50 < 50 < 50 < 50
	Acquire 11 frames (as push-frames) in 4 colours (4 x 256 x 1536)					
560	Prepare parameter table with 4 windows each 256 x 1536, number of exposures = 11 PAN: 366-622 | 256-1792 RED: 712-968 | 256-1792 NIR: 1048-1304 | 256-1792 BLU: 1389-1645 | 256-1792	00:50:00	SET_PARAMETER_TABLE 2 ROIC FREQ= 5.0 MHz INTEGRATION TIME = 105 x 0.96us EXPOSURES = 11 INTERVAL = 400 ms WINDOWS: 4	F0 3C 07 3A 74 01 02 79 35 00 69 0B 00 06 1A 80 00 04 00 00 00 20 02 DC E0 04 DC 20 05 90 E0 07 90 20 08 30 E0 0A 30 20 0A DA E0 0C DA 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 74 6A		
570	Switch PE ON, Main/Redundant Power, No Temp/Voltage Override	00:51:00	SWITCH_PE_POWER UNIQUE_ID = 570 TIMESTAMP = 0 STATE_PE = 1 TEMPERATURE_OVERRIDE_PE = 0 POWER_LINE = 2	f0 1b 10 19 71 04 00 00 02 3a 73 08 00 00 00 00 00 00 00 00 b0 01 01 b1 01 00 b6 01 02 3b 14	0x5E: U_3V3_PE 0x60: U_8V5_PE 0x62 : U_N_8V5_PE 0x64 : U_25V_PE	1310-1440 1000-1240 1180-1460 1465-2160

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
580	Switch Detector ON	00:52:00	SWITCH_PE_DETECTOR UNIQUE_ID = 580 TIMESTAMP = 0 STATE_DET = 1 TEMPERATURE_OVERRIDE_DET = 0 DETECTOR_TEST_MODE = 0	f0 1b 11 19 71 04 00 00 02 44 73 08 00 00 00 00 00 00 00 00 b2 01 01 b3 01 00 17 01 00 c9 30	0x70: PE_HK_STAT	0bxxxxxx1
590	Take Image with parameter table 2	00:53:00	PREPARE_IMAGE UNIQUE_ID = 590 TIMESTAMP = 0 TABLE REFERENCE = 2	f0 15 12 13 71 04 00 00 02 4e 73 08 00 00 00 00 00 00 00 00 74 01 02 ee 71		Picture data received via SpW
600	Switch Detector OFF	00:54:00	SWITCH_PE_DETECTOR UNIQUE_ID = 600 TIMESTAMP = 0 STATE_DET = 0 TEMPERATURE_OVERRIDE_DET = 0 DETECTOR_TEST_MODE = 0	f0 1b 11 19 71 04 00 00 02 58 73 08 00 00 00 00 00 00 00 00 b2 01 00 b3 01 00 17 01 00 71 77	0x70: PE_HK_STAT	0bxxxxxx0
610	Switch PE OFF, Main/Redundant Power, No Temp/Voltage Override	00:55:00	SWITCH_PE_POWER UNIQUE_ID = 610 TIMESTAMP = 0 STATE_PE = 0 TEMPERATURE_OVERRIDE_PE = 0 POWER_LINE = 2	f0 1b 10 19 71 04 00 00 02 62 73 08 00 00 00 00 00 00 00 00 b0 01 00 b1 01 00 b6 01 02 e8 f2	0x5E: U_3V3_PE 0x60: U_8V5_PE 0x62 : U_N_8V5_PE 0x64 : U_25V_PE	< 50 < 50 < 50 < 50
COMMUNICATION CHECK						
700	Close PDHU file	00:56:00	S/C command	S/C command		
710	Disable SpW NOM	00:57:00	S/C command	S/C command		

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
	Enable SpW RED					
720	Open PDHU file	00:58:00	S/C command	S/C command		
730	Dump HK table over SpW	00:59:00	DUMP UNIQUE_ID = 730 DUMP_TYPE = 0xD2	F0 1A 0B 18 71 04 00 00 02 DA 98 01 D2 99 01 00 9A 04 00 00 00 00 9B 04 00 00 00 00 89 3A		
740	Close PDHU file	01:00:00	S/C command	S/C command		
750	Endable SpW NOM Disable SpW RED	01:01:00	S/C command	S/C command		
CHANGE HEATING SET POINTS						
900	Set all temperatures to Min=30°C, Max=40°C, Set=35°C	01:03:00		f0 35 09 33 71 04 00 00 00 02 7a 01 01 7b 04 08 26 08 f2 7c 01 01 7d 04 08 26 08 f2 7e 01 01 7f 04 08 26 08 f2 80 01 01 81 04 08 26 08 f2 82 01 01 83 04 08 26 08 f2 e8 6f	After 1 minute: 0x20: Z1_CALC_TEMP 0x21: Z2_CALC_TEMP 0x22: Z3_CALC_TEMP 0x23: Z4_CALC_TEMP 0x24: Z5_CALC_TEMP	After 1 minute: Increasing Increasing Increasing Increasing Increasing
950	Set all temperatures to operational values # PE: -30/-20 # FPA: -5/5 # M1: 15/25 # M2: 15/25 # RCM: -30/-20 # RB/FB: -25/45	01:04:00		f0 35 09 33 71 04 00 00 00 00 7a 01 01 7b 04 03 5c 04 29 7c 01 01 7d 04 05 5b 06 27 7e 01 01 7f 04 06 f3 07 bf 80 01 01 81 04 06 f3 07 bf 82 01 01 83 04 03 5c 04 29 34 19	0x25: Z1_MIN_TEMP 0x26: Z2_MIN_TEMP 0x27: Z3_MIN_TEMP 0x28: Z4_MIN_TEMP 0x29: Z5_MIN_TEMP 0x2a: Z1_MAX_TEMP 0x2b: Z2_MAX_TEMP 0x2c: Z3_MAX_TEMP 0x2d: Z4_MAX_TEMP	0x035C 0x055B 0x06F3 0x06F3 0x035C 0x0429 0x0627 0x07BF 0x07BF

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
					0x2e: Z5_MAX_TEMP 0x92: Z31_MIN_TEMP 0x93: Z41_MIN_TEMP 0x94: Z31_MAX_TEMP 0x95: Z41_MAX_TEMP	0x0429 0x03C3 0x03C3 0x0958 0x0958
Power OFF						
1000	Switch instrument to SAFEMODE	01:05:00	CHANGE_OPERATION_MODE UNIQUE_ID = 1000 PATTERN = 0x0fa55a00	f0 0e a3 0c 71 04 00 00 03 e8 8f 04 0f a5 5a 00 37 e6	0x03: FSW_MODE	0xF0
1050	Power CaSSIS OFF	01:07:00	S/C command	S/C command		

8.2 FFTRED

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
100	S/C ON with B1553PLBUS B activated, PDHU 1 ON, SpW1 RED enabled, SpW1 NOM disabled, Open File TC issued CaSSIS is switched off FMON/PMON switched off	00:00:00	None	none		
CHECK SURVIVAL FUNCTIONALITY ON NOMINAL LINE						
200	Power CaSSIS over the redundant survival power line	00:05:00	S/C command	S/C command	None	($T_{Ambient}$ > 0°C) Power < 2.8W
250	If S/C requires Switch ON FMON/PMON					
CHECK CORRECT BOOT UP OF INSTRUMENT ON NOMINAL LINE						
300	Switch CaSSIS ON RED (the CaSSIS FSW will now boot up) Accquire housekeeping Check Time Syncronization on Milbus	00:08:00	S/C command	S/C command	0x01: FSW_VERSION 0x03: FSW_MODE 0x50: U_05V_REF 0x51: I_3V3_DPM 0x52: U_3V3_DPM 0x53: I_1V8 0x54: U_1V8	 0xF0 0x01BC 0x0BBC 0x0674

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
					0x55: U_5V_OP 0x56: U_5V_ANA 0x57: I_5V_ANA 0x58: I_3V3_FPGA 0x59: U_3V3_FPGA 0x5A: I_1V2_FPGA 0x5B: U_1V2_FPGA	0x08D2 0x08D7 0x0BC6 0x0466
310	Send CaSSIS Safemode command	00:10:00	CHANGE_OPERATION_MODE UNIQUE_ID = 310 PATTERN = 0x0fa55a00	f0 0e a3 0c 71 04 00 00 01 36 8f 04 0f a5 5a 00 cb a6	0x03: FSW_MODE	0x0F
312	Send CaSSIS LEAVE SAFEMODE command	00:11:00	CHANGE_OPERATION_MODE UNIQUE_ID = 0000 PATTERN = 0x5a00a500	f0 0e a3 0c 71 04 00 00 00 00 8f 04 5a 00 a5 00 e8 30		
315	Verify main Heaters All Heaters Switched ON	00:12:00	Switch PE heater to manual mode	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 40 a1 01 03 a2 01 03 e8 dc		
			Switch PE heater on	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 40 a1 01 80 a2 01 80 0f d3		
			Switch FPA heater to manual mode	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 44 a1 01 03 a2 01 03 29 1a		
			Switch FPA heater on	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 44 a1 01 80 a2 01 80 ce 15		
			Switch RB heater to manual mode	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 48		

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
				a1 01 03 a2 01 03 7b 71		
			Switch RB heater on	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 48 a1 01 80 a2 01 80 9c 7e		
			Switch FB heater to manual mode	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 4c a1 01 03 a2 01 03 ba b7		
			Switch FB heater on	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 4c a1 01 80 a2 01 80 5d b8		Power = 30W
			Switch RCM heater to manual mode	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 50 a1 01 03 a2 01 03 df a7		
			Switch RCM heater on	f0 14 0d 12 71 04 00 00 00 00 a0 04 20 00 00 50 a1 01 80 a2 01 80 38 a8		
370	REBOOT_FSW	00:22:00	REBOOT_FSW UNIQUE_ID = 370 TIMESTAMP = 0 RESET_TYPE = 1 BOOT_TARGET = 0xFF	f0 18 ff 16 71 04 00 00 01 72 73 08 00 00 00 00 00 00 00 00 90 01 01 91 01 ff 4d ba		
LEAVE SAFEMODE						
	Verify CaSSIS ON, boot up and not in Safemode	00:32:00			0x03: FSW_MODE	0xF0
390	Send CaSSIS LEAVE Safemode	00:33:00	CHANGE_OPERATION_MODE UNIQUE_ID = 0000	f0 0e a3 0c 71 04 00 00 00 00 8f 04 5a 00 a5 00 e8 30	0x03: FSW_MODE	0xF0

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
	command		PATTERN = 0x0fa55a00			
395	Dump HK table over SpW	00:33:00	DUMP UNIQUE_ID = 395 DUMP_TYPE = 0xD2	F0 1A 0B 18 71 04 00 00 01 8B 98 01 D2 99 01 00 9A 04 00 00 00 00 9B 04 00 00 00 00 F8 D9		
	ACQUIRE SINGLE IMAGE (2048x2048)					
500	Prepare Parameter for acquisition of 1 single frame (2048x2048)	00:35:00	SET_PARAMETER_TABLE 2 ROIC FREQ= 1.25 MHz INTEGRATION TIME = 105 x 9.6us EXPOSURES = 1 INTERVAL = 400 ms WINDOWS: 1 (0..2047/1..2047)	f0 3c 07 3a 74 01 02 79 35 00 69 01 00 06 1a 80 02 01 00 00 00 00 00 00 ff ef fe 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 b1 3e		
505	Dump Parameter tables	00:36:00	DUMP UNIQUE_ID = 505 DUMP_TYPE = 0xD1	f0 1a 0b 18 71 04 00 00 01 f9 98 01 d1 99 01 00 9a 04 00 00 00 00 9b 04 00 00 00 00 2d 18		
510	Switch PE ON, Main/Redundant Power, No Temp/Voltage Override	00:37:00	SWITCH_PE_POWER UNIQUE_ID = 510 TIMESTAMP = 0 STATE_PE = 1 TEMPERATURE_OVERRIDE_PE = 0 POWER_LINE = 2	f0 1b 10 19 71 04 00 00 01 fe 73 08 00 00 00 00 00 00 00 00 b0 01 01 b1 01 00 b6 01 02 54 75	0x5E: U_3V3_PE 0x60: U_8V5_PE 0x62 : U_N_8V5_PE 0x64 : U_25V_PE	1310-1440 1000-1240 1180-1460 1465-2160
520	Switch Detector ON	00:38:00	SWITCH_PE_DETECTOR UNIQUE_ID = 520 TIMESTAMP = 0	f0 1b 11 19 71 04 00 00 02 08 73 08 00 00 00 00 00 00 00 00 b2 01 01 b3	0x70: PE_HK_STAT	0bxxxxxx1

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
			STATE_DET = 1 TEMPERATURE_OVERRIDE_DET = 0 DETECTOR_TEST_MODE = 0	01 00 17 01 00 1f 28		
530	Acquire image, Parameter Table 2	00:39:00	PREPARE_IMAGE UNIQUE_ID = 530 TIMESTAMP = 0 TABLE REFERENCE = 2	f0 15 12 13 71 04 00 00 02 12 73 08 00 00 00 00 00 00 00 00 74 01 02 15 f7		
540	Switch Detector OFF	00:40:00	SWITCH_PE_DETECTOR UNIQUE_ID = 540 TIMESTAMP = 0 STATE_DET = 0 TEMPERATURE_OVERRIDE_DET = 0 DETECTOR_TEST_MODE = 0	f0 1b 11 19 71 04 00 00 02 1c 73 08 00 00 00 00 00 00 00 00 b2 01 00 b3 01 00 17 01 00 1a d6	0x70: PE_HK_STAT	0bxxxxxx0
550	Switch PE OFF, Main/Redundant Power, No Temp/Voltage Override	00:41:00	SWITCH_PE_POWER UNIQUE_ID = 550 TIMESTAMP = 0 STATE_PE = 0 TEMPERATURE_OVERRIDE_PE = 0 POWER_LINE = 2	f0 1b 10 19 71 04 00 00 02 26 73 08 00 00 00 00 00 00 00 00 b0 01 00 b1 01 00 b6 01 02 83 53	0x5E: U_3V3_PE 0x60: U_8V5_PE 0x62 : U_N_8V5_PE 0x64 : U_25V_PE	< 50 < 50 < 50 < 50
	Acquire 11 frames (as push-frames) in 4 colours (4 x 256 x 1536)					
560	Prepare parameter table with 4 windows each 256 x 1536, number of exposures = 11 PAN: 366-622 | 256-1792 RED: 712-968 | 256-1792 NIR: 1048-1304 | 256-1792	00:42:00	SET_PARAMETER_TABLE 2 ROIC FREQ= 1.25 MHz INTEGRATION TIME = 105 x 0.96us EXPOSURES = 11 INTERVAL = 400 ms WINDOWS: 4	F0 3C 07 3A 74 01 02 79 35 00 69 0B 00 06 1A 80 00 04 00 00 00 20 02 DC E0 04 DC 20 05 90 E0 07 90 20 08 30 E0 0A 30 20 0A DA E0 0C DA 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 74		

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
	BLU: 1389-1645 | 256-1792			6A		
570	Switch PE ON, Main/Redundant Power, No Temp/Voltage Override	00:43:00	SWITCH_PE_POWER UNIQUE_ID = 570 TIMESTAMP = 0 STATE_PE = 1 TEMPERATURE_OVERRIDE_PE = 0 POWER_LINE = 2	f0 1b 10 19 71 04 00 00 02 3a 73 08 00 00 00 00 00 00 00 00 b0 01 01 b1 01 00 b6 01 02 3b 14	0x5E: U_3V3_PE 0x60: U_8V5_PE 0x62 : U_N_8V5_PE 0x64 : U_25V_PE	1310-1440 1000-1240 1180-1460 1465-2160
580	Switch Detector ON	00:44:00	SWITCH_PE_DETECTOR UNIQUE_ID = 580 TIMESTAMP = 0 STATE_DET = 1 TEMPERATURE_OVERRIDE_DET = 0 DETECTOR_TEST_MODE = 0	f0 1b 11 19 71 04 00 00 02 44 73 08 00 00 00 00 00 00 00 00 b2 01 01 b3 01 00 17 01 00 c9 30	0x70: PE_HK_STAT	0bxxxxxx1
590	Take Image with parameter table 2	00:45:00	PREPARE_IMAGE UNIQUE_ID = 590 TIMESTAMP = 0 TABLE REFERENCE = 2	f0 15 12 13 71 04 00 00 02 4e 73 08 00 00 00 00 00 00 00 00 74 01 02 ee 71		Picture data received via SpW
600	Switch Detector OFF	00:46:00	SWITCH_PE_DETECTOR UNIQUE_ID = 600 TIMESTAMP = 0 STATE_DET = 0 TEMPERATURE_OVERRIDE_DET = 0 DETECTOR_TEST_MODE = 0	f0 1b 11 19 71 04 00 00 02 58 73 08 00 00 00 00 00 00 00 00 b2 01 00 b3 01 00 17 01 00 71 77	0x70: PE_HK_STAT	0bxxxxxx0
610	Switch PE OFF, Main/Redundant Power, No Temp/Voltage Override	00:47:00	SWITCH_PE_POWER UNIQUE_ID = 610 TIMESTAMP = 0	f0 1b 10 19 71 04 00 00 02 62 73 08 00 00 00 00 00 00 00 00 b0 01 00 b1	0x5E: U_3V3_PE 0x60: U_8V5_PE	< 50 < 50

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
			STATE_PE = 0 TEMPERATURE_OVERRIDE_PE = 0 POWER_LINE = 2	01 00 b6 01 02 e8 f2	0x62 : U_N_8V5_PE 0x64 : U_25V_PE	< 50 < 50
COMMUNICATION CHECK						
700	Close PDHU file	00:48:00	S/C command	S/C command		
710	Disable SpW RED Enable SpW NOM	00:50:00	S/C command	S/C command		
720	Open PDHU file	00:52:00	S/C command	S/C command		
730	Dump HK table over SpW	00:59:00	DUMP UNIQUE_ID = 730 DUMP_TYPE = 0xD2	F0 1A 0B 18 71 04 00 00 02 DA 98 01 D2 99 01 00 9A 04 00 00 00 00 9B 04 00 00 00 00 89 3A		
740	Close PDHU file	00:56:00	S/C command	S/C command		
750	Disable SpW NOM Endable SpW RED	00:58:00	S/C command	S/C command		
RESTORE TO FACTORY SETTINGS						
800	Reset all heater thresholds to nominal	01:00:00		f0 35 09 33 71 04 00 00 00 00 7a 01 01 7b 04 03 5c 04 29 7c 01 01 7d 04 05 5b 06 27 7e 01 01 7f 04 06 f3 07 bf 80 01 01 81 04 06 f3 07 bf 82 01 01 83 04 03 5c 04 29 34 19		
Power OFF						
1000	Switch instrument to SAFEMODE	01:01:00	CHANGE_OPERATION_MODE UNIQUE_ID = 1000	f0 0e a3 0c 71 04 00 00 03 e8 8f 04 0f a5 5a 00	0x03: FSW_MODE	0xF0

STEP #	Description	Time	Telecommand Parameters	Telecommand in 64byte string	Telemetry (checked by CaSSIS Team)	
					TM Frame	Expected Value
			PATTERN = 0x0fa55a00	37 e6		
1050	Power CaSSIS OFF	01:03:00	S/C command	S/C command		

9 ROTATION LOGBOOK

			Logbook			Project: CaSSIS		
Step	Activity description	Location	Results / where documented (test report, integration procedure, etc...)	Date	Start at ; Duration	Operator(s) name | Signature	date	QA

10 CONTACTS

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