Phase D: Qualification

Remote Electrical and Data Verification (REDV) Test Report

Results after Thermal Vacuum Cycling Test

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RECORD OF REVISIONS

ISS/REV	Date	Modifications	Created/modified by
1/0	24/02/09	Initial release	M. Noca
1/1	02/03/09	Inserted comments and paragraphs from N. Steiner and M. Borgeaud.	M. Noca
1/2			

1 REFERENCES

1.1 Normative references

[N1] ECSS-E-10-02A Verification (17 November 1998).pdf

[N2] ECSS-E-10-03A Testing (15 Februari 2002).pdf

1.2 Informative references

[R1] SwissCube AI&V plan: S3-C-SE-4-0-AIV_Plan.doc

[R2] SwissCube Mechanical Assembly Procedure: S3-C-1-5-Fabrication Plan (Mechanical)

[R3] CalPoly requirements: CDS_rev10.pdf

[R4] Sun Simulator calibration for qualification TVC, to be released.

[R5] SwissCube flight software manual: S3-C-ICD-1-3-Flight_Software_User_Manual_-_Functions.

[R6] SwissCube flight software manual: S3-C-ICD-1-2-Flight_Software_User_Manual_-_Housekeeping

[R7] SwissCube ground segment software: S3-B-SE-1-5-Ground Segment

[R8] SwissCube qualification mechanical tests report: S3-D-SET-1-2-Qual Mech REDV Functional test report.pdf

2 TERMS, DEFINITIONS AND ABBREVIATED TERMS

2.1 Abbreviated terms

ABF	Add-before-Flight
ADS	Antenna Deployment System
ADCS	Attitude Determination and Control System
AI&V	Assembly, Integration and Verification
CDMS	Command and Data Management System
COM	Communication
EPS	Electrical Power System
EQM	Engineering Qualification Model
FSW	Flight software
HK	Housekeeping
MT	Magnetotorquer
PL	Payload
REDV	Remote Electrical and Data Verification
RF	Radio Frequency
SRF	Satellite Reference Frame
TC	Telecommand
TM	Telemetry
TVC	Thermal Vacuum Cycling

3 INTRODUCTION

Swisscube has undergone environmental qualification testing of the Engineering Qualification Model (EQM) as described in the AI&V plan [R1]. The qualification plan included a series of vibration tests, which were performed at the DLR/Astrofeinwerk facility in Berlin. Then the EQM was moved to the thermal vacuum chamber in Bern for Thermal Vacuum Cycling (TVC). Finally, the EQM was tested with the SwissCube ground stations for and end-to-end RF Communication and Data Compatibility. The Remote Electrical and Data Verification (REDV) test demonstrates the functional behaviour and performance of the satellite. It verifies the electrical functionality, internal communication, and software data functionality.

This report summarizes the results of the REDV tests performed before, during and after Thermal Vacuum Cycling (TVC). The TVC test was performed from October 14 to October 31, 2008 at the Space Research and Planetary Sciences' laboratory at the University of Bern.

This report provides first a highlight of the test objectives, test set-up, and test procedure. Since each major qualification test has a different set-up, the REDV test procedure was adapted to the appropriate test conditions, and is therefore modular in nature. This report also summarizes the conditions in which the test really took place, the problems encountered and their resolution.

Note that this qualification TVC served as a benchmark to learn how to operate SwissCube. In that respect, most of the testing performed enabled to verify functionality and not much time was spend characterizing the performances (more thorough performance characterization was done during FM acceptance testing).

Log books can be provided on request.

Figure 3-1 summarises the qualification test flow for the EQM.

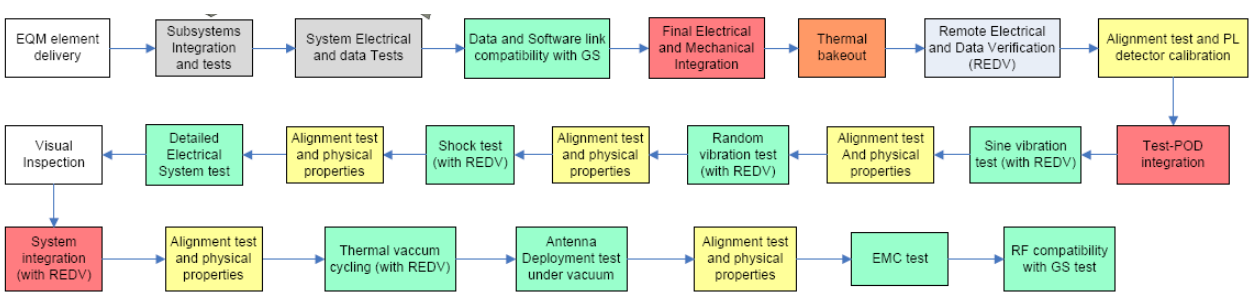

Figure 3-1: SwissCube EQM test flow.

Note also that the thermal bake-out of the satellite was performed just before TVC, not before vibration testing as mentioned in Figure 3-1.

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4 TEST SPECIFICATIONS

4.1 Objectives

The objectives of the REDV tests are primarily to:

- Verify functional behaviour of the electrical subsystems;
- Verify power, command, and telemetry lines between each electrical subsystems;
- Confirm proper telecommand and housekeeping response from all subsystems;
- Confirm proper autonomous hardware operations:
    - Start-up sequence (ADS, EPS)
    - Beacon generation
- Confirm proper autonomous software operations:
    - I2C communication (EPS, CDMS, COM, ADCS, Payload)
    - Time clock distribution (EPS, CDMS, COM, ADCS, Payload)
    - Scheduler
- Confirm proper telemetry collection and data handling in the following threads:
    - Communication (COM Uplink & Downlink, Beacon, EPS)
    - Satellite attitude control (ADCS, EPS)
    - Picture taking (Payload, ADCS, EPS)
- Verify selected set of fault scenarios (low batteries voltage, short circuits, sensor fault,…).

Note that for hardware and software delay reasons, the CDMS will be flown cold and not used. Thus this procedure will not test the CDMS.

In addition, fault scenarios were tested on the fly and no procedure ended up being written for these cases. As will be shown in the results section of this report, a number of problems appeared on the satellite during TVC that effectively extended the tests of fault scenarios.

4.2 TVC Requirements

The thermal vacuum cycling requirements are deduced from the ECSS standards and SwissCube requirements. They are summarized in Table 4-1.

Table 4-1: Thermal vacuum cycling tests at qualification and acceptance levels.

	Qualification	Acceptance
Number of cycles	8	4
Temperature MIN	Tmin = - 55 °C	Tmin = - 45 °C
Temperature MAX	Tmax = + 70 °C	Tmin = + 50 °C
Duration at Tmin	45 min	45 min
Duration at Tmax	70 min	70 min
Temperature rate (heating)	~ 2-4 °C/min (external) with sun simulator	
Temperature rate (cooling)	~0.7 - 1 °C/min	
Pressure	$< 10^{-5}$ Pa	
Stabilization criterion	1 °C/10 min	

The heating and cooling temperature rates represent the best slopes that could be achieved with the facilities and equipment. They are consistent with the ECSS requirements of temperature rate of change of < 20°C /min.

The stabilization criterion of 1°C/10 min was not satisfied for the cold temperatures as it took several hours to reach them. Rather the plateau of cold temperatures would start as soon as Tmin was reached.

5 TEST SET-UP

5.1 Facility

This test was performed at University of Bern using the thermal vacuum chamber as shown in Figure 5-1.

Internal dimension	Ø = 1000 mm, L = 1750 mm	
Size of base plate for conductive tempering	860 x 545 mm	
Cleanliness	Class 100 laminar flow clean room environment	
Pressure level	$<10^{-5}$ (turbomolecular pump) or $<10^{-8}$ Pa (titanium sublimation pump)	
Temperature level	-70 to + 200°C	
Temperature change velocity	0.3 to 1.5 °C/min	

Figure 5-1: University of Bern thermal vacuum chamber.

The following temperature control systems are installed in the chamber:

- 1 Vötsch temperature control unit servicing the FC-77 liquid, circulating in the temperature controlled shroud. Temperature range: -60°C to +150°C (lower temperature without additional specimen heat load). Temperature change velocity: 0.3 °C / min.
- 1 Huber temperature control unit servicing the VT-190 liquid, circulating in the temperature controlled specimen mounting plate. Temperature range: -70°C to +200°C (lower temperature depending on specimen heat load). Temperature change velocity: 1.5 °C / min.
- Chamber bake-out heating system for temperature up to 450°C. For bake-out above 150 °C the main flange has to be sealed with gold wire and some non-compatible equipment need to be removed. For bake-out above 200°C the FC-77 liquid in the shroud need to be removed from the shroud.

In addition, 18 Copper-Constantan Thermocouples with a Deutsch connector feedthrough are available for specimen temperature measurements.

Facility controlled temperatures are connected Web based monitoring interface.

The following pressure measurement systems are installed in the chamber:

- 1 Pirani gauge, measuring pressure down to 10^{-1} Pa.
- 1 Cold cathode gauge, measuring pressure in the 10^{-1} to 10^{-5} Pa range.

- 1 Stabil-Ion Bayard-Alpert gauge, measuring pressure in the 10^{-3} to 10^{-9} Pa range.

The cleanliness of the chamber inside is monitored with a Hiden quadrupole mass spectrometer. This spectrometer is able to measure partial pressure from 10^{-3} Pa to 10^{-12} Pa in the mass range from 0.4 to 300 amu.

5.2 Satellite configuration

The test article is the Engineering Qualification Model (EQM), thus final boards and mechanical components are included. The EQM is assembled and ready for test. The assembly procedure can be found in [R2]. The detailed hardware of the EQM can be found in Table 5-1. See also Figure 5-3 for completeness.

Table 5-1: Satellite hardware tested.

Subsystem article	Version	Comments
EPS MB	EQM	
EPS PMB	EQM	
Connection board	EQM	
Batteries	EQM	Includes two batteries, heating system and electronics
COM	EQM	
Beacon	EQM	
ADCS	EQM	Includes gyroscopes and magnetometers
Payload	EQM	Includes opto-mechnical parts and electronics
CDMS	EQM	Cold, cabled
Face +X	EQM	Includes SS and electronics
Face -X	EQM	Includes SS, MT and electronics
Face +Y	EQM	Includes SS, MT, shielding and electronics
Face -Y	EQM	Includes SS, shielding and electronics
Face +Z	EQM	Includes SS, shielding and electronics
Face -Z	EQM	Includes SS, MT, shielding and electronics
ADS	EQM	Antenna stowed
Spacers	EQM	POM/Alu/POM
ABF	EQM Test	
Test board	V1.2	(integrates N.Steiner and F. Jordan's changes)
Relay board	V1.2	(integrates N.Steiner and F. Jordan's changes)

Versions of the flight software are logged in the test procedures as the flight software was corrected and reloaded whenever possible.

5.2.1 Satellite short description and reference axis

For reference, Figure 5-2 shows the external configuration of SwissCube and Figure 5-3 the internal configuration. The dimension labelled represent the either the margin with respect to the extremity of the rails (+ Z, - Z) or the protruding dimensions with respect to the rails (+ X, - X, +Y, -Y).

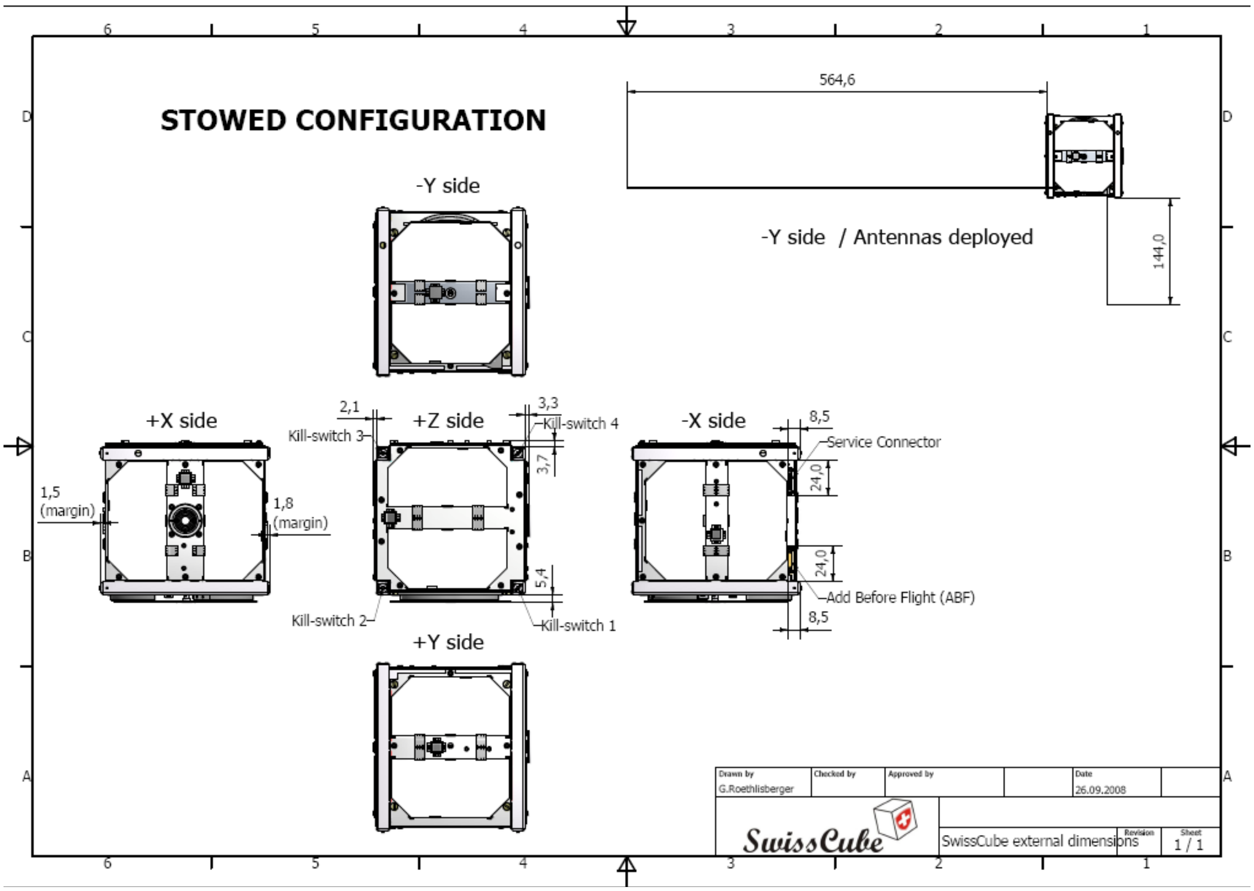


Figure 5-2: SwissCube in stowed and deployed configurations.

The satellite reference frame (SRF) is provided in Figure 5-4. In this right handed frame the payload aperture is oriented towards +X. The Z axis is parallel to the structure rails with the motherboard perpendicular to +Z, and the antenna deployment system is located in -Y. The satellite reference point (SRP) is in the geometrical center of the "cube".

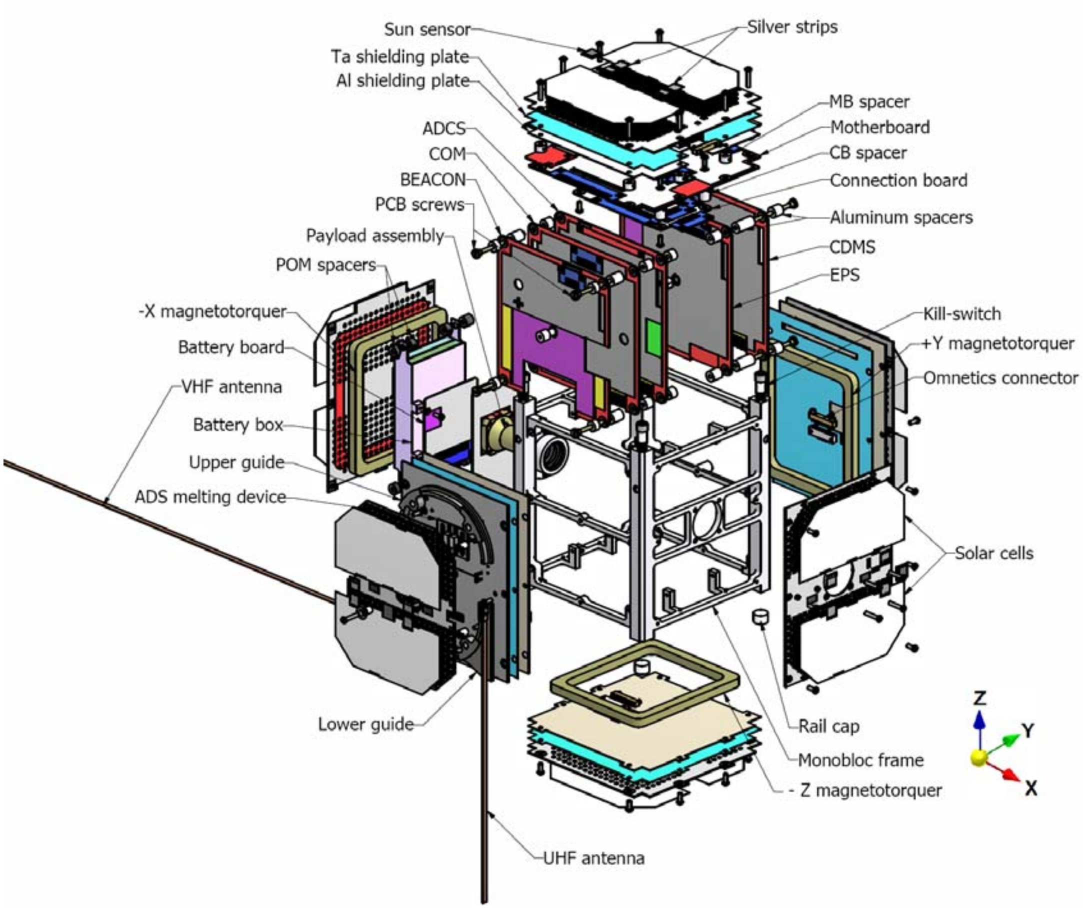
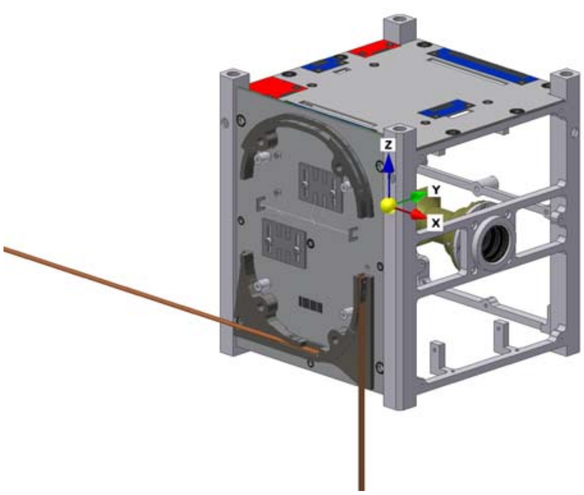


Figure 5-3: Exploded view of SwissCube and its components.



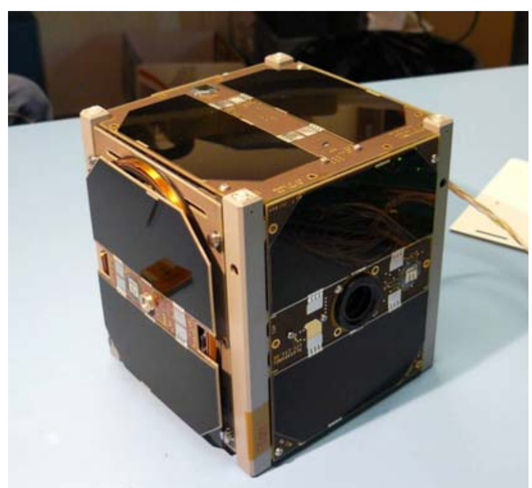


Figure 5-4: SwissCube Reference Frame (SRF) and EQM in stowed configuration.

There are no design deviations from the CalPoly specified requirements [R3].

The satellite will have antennas folded at the beginning of the test.

5.2.2 Service Connector and Add-Before-Flight

To perform functional testing, SwissCube has a service connector, which allows digital communication between the test equipment and the satellite. The service connector schematic is provided in Figure 5-5. All pins are effectively used for testing besides Vcs and Vcs_after_ABF. These pins provide information about the batteries voltage, bus voltage, beacon signal, a sniffer on the I2C data bus, and a digital link connected respectively at the input/output of the COM microcontroller (uplink/downlink).

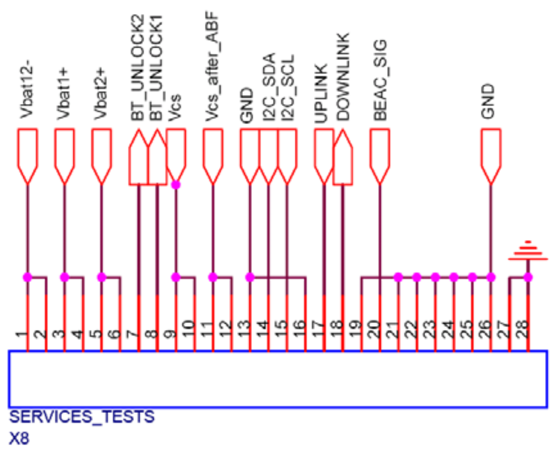
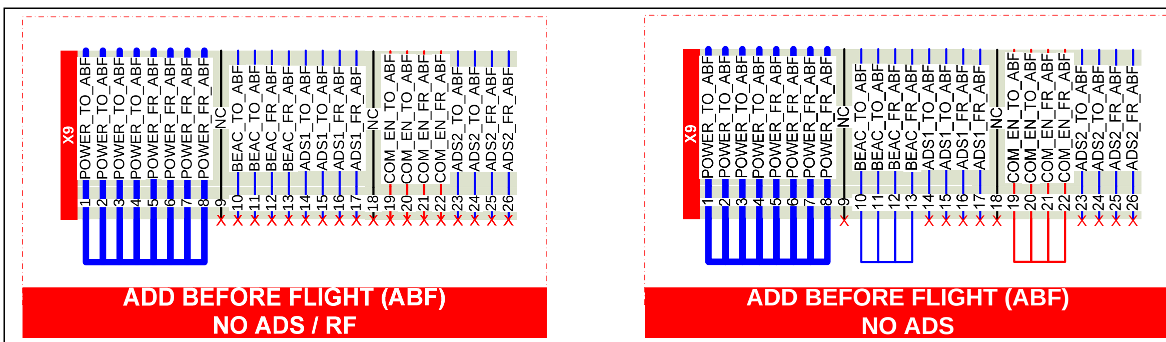


Figure 5-5: SwissCube service connector pins.

In addition to the service connector, SwissCube has an Add-before-Flight (ABF) which allows connecting or disconnecting certain parts of the satellite for tests. There are three ABF and depending on the configuration, RF transmission is connected or not, and the Antenna Deployment System (ADS) is activated or not. In all cases, signals and commands are executed by the flight software but the ABF does or does not allow the power to reach the RF or ADS parts. At the beginning of each parts of the test procedure, the ABF configuration is highlighted. The configurations of the ABF are provided in Figure 5-6 and Figure 5-7.



Test ABF #1: No ADS-No Beacon-No RF

Test ABF #2: No ADS.

Figure 5-6: Test Add-Before-Flight Configurations.

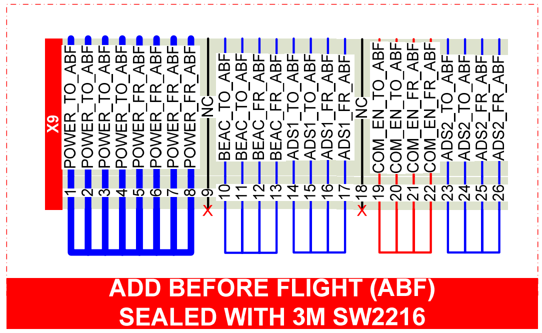


Figure 5-7: Flight Configuration of the Add-Before-Flight.

5.3 Satellite instrumentation and set-up inside the chamber

5.3.1 Configuration in vacuum chamber

The SwissCube FM is placed inside the thermal vacuum chamber on a rod attached to a rotation device (see Figure 5-8). The heating of the satellite is performed via two heating rings and a sun simulator. The cooling is done radiatively to the shroud, which is continuously kept at -70ºC. The heating rings can be warmed up to 300ºC and thus would be set to that point until the satellite's temperature almost reached Tmax. They would then be cooled down to 220-240ºC.

Furthermore a Sun Simulator is placed on one window perpendicular to the heating rings. This sun simulator is the S13-575WC from Optical Energy Technologies Inc. (USA). This solar simulator is composed of a 575W metal halide arc lamp situated at the focus of a paraboloidal mirror, designed to produce a collimated beam with a 1.0 solar constant in space (nominal 0.1357 W/cm2). The metal halide lamp provides almost 3 times the luminous efficiency of a Xenon arc lamp and has a continuum spectral response close to 6000K, with some higher spike structure above 800 nm. This higher luminous efficiency allows the sun simulator to operate without forced air lamp cooling (see Figure 5-9).

The sun simulator was calibrated before TVC by the SwissCube team. Details can be found in [R4].

A rotation device on top of the chamber allowed for an almost 340 deg. rotation around the Z-axis of the satellite. After 340 deg., the satellite would turn in the opposite direction. The rotation velocity was about 1 deg/sec as expected in flight.

Figure 5-10 shows the test configuration in the warm-up ramp.

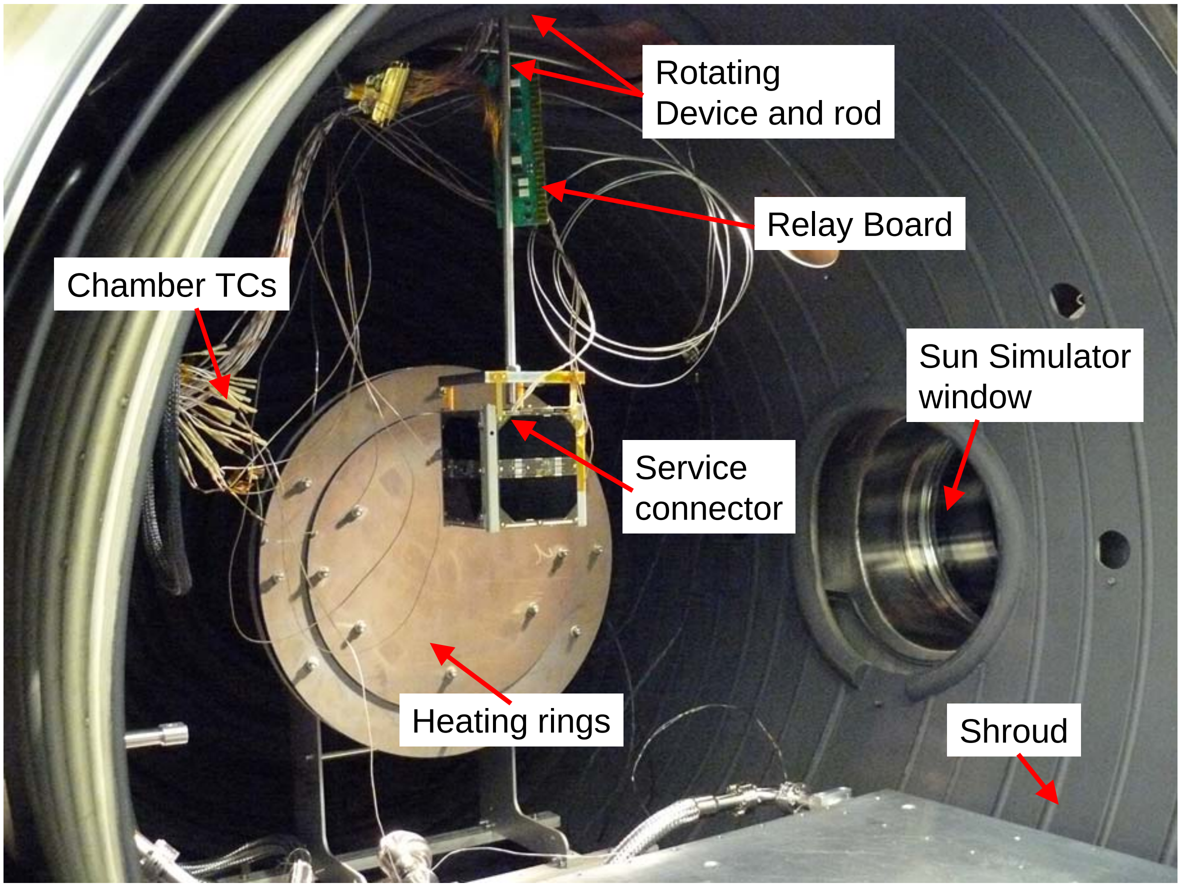


Figure 5-8: SwissCube set-up inside the vacuum chamber.

Figure 5-9: Optical Energy Technologies 1-AU equivalent sun simulator.

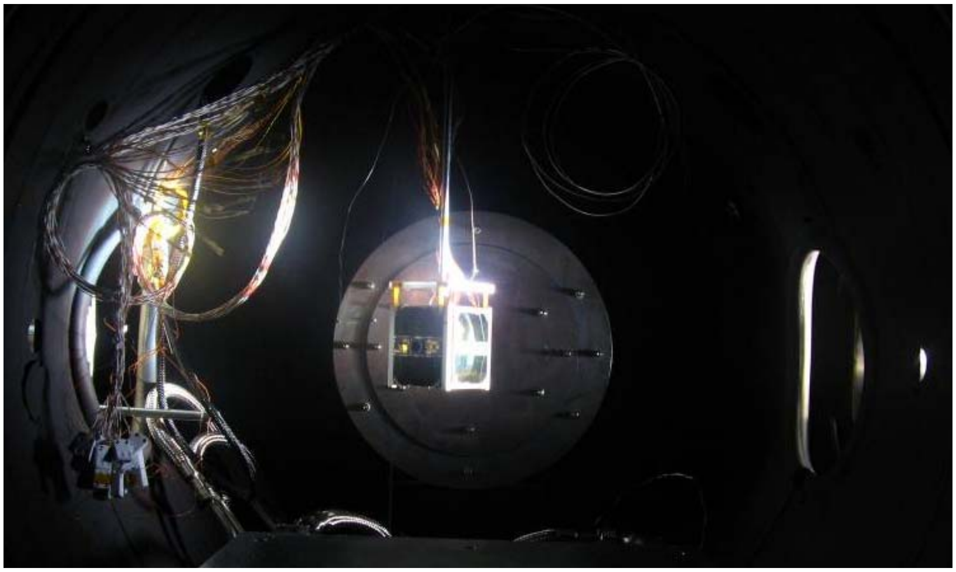


Figure 5-10: Illuminated satellite during test.

5.3.2 Thermocouples

Four thermocouples (TC) connected to the facilities' temperature control system were inserted within the satellite as shown in Figure 5-11. The first TC was connected to the communication power amplifier's heat dissipation structure. The second on the –X face (or panel). The third on the exterior of the battery box, and the fourth between the motherboard and the frame supporting it. The location of these four TC was a compromise between the most interesting places to have data from and the ease of installation within the satellite (without opening too many panels).

Two additional thermocouples were placed under the heating plate (the heating plate was passive during the whole test, and represents a large thermal mass).

According to the facility manager, the whole chain of temperature measurement is precise to +/- 1ºC.

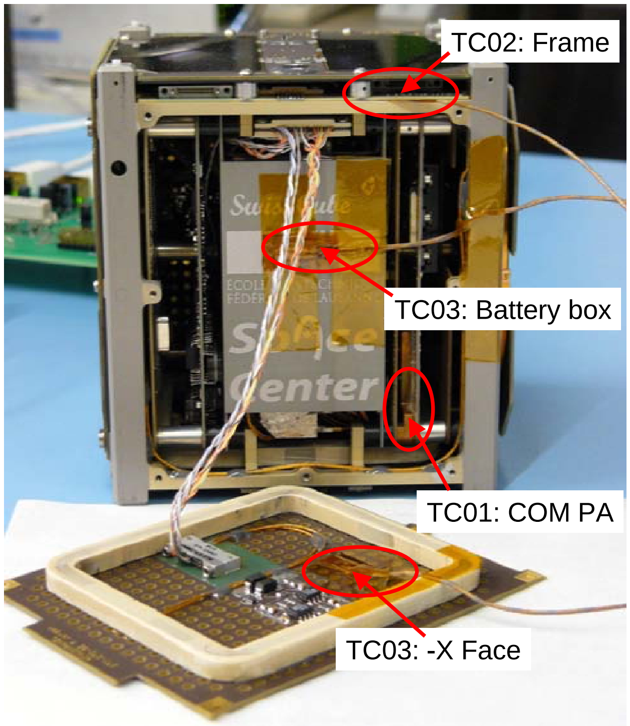


Figure 5-11: Location of the test thermocouples.

TC 1 : COM PA thermal sink temperature

TC 2 : Frame temperature (clamped between the MB and the frame)

TC 3 : Battery Box temperature

TC 4 : -X face temperature

TC 5 : Bottom of the chamber thermal plate.

TC 6 : Top of the chamber thermal plate.

5.4 Ground test equipment and instrumentation

Testing of the satellite is done both via the service connector and via RF. Two PCs serve as interface with the test operator to send telecommands and acquire data from the satellite (see Figure 5-12 and diagram in Figure 5-13). One PC (PC1) is dedicated to the RF link while the other PC is used for the digital link. Each PC has the mission control software (Mission Data Client Monitoring, MCS, TM/TC front End), which will be used to transmit TC and receive TM during flight. Additional interface software with the test equipment is also present (MixW on PC1 and Test Bridge on PC2). In addition, PC2 has a I2C data bus sniffer that connects directly to the test equipment. The sniffer as well as the reading of the batteries voltage has a human interface software called "Vbat & I2C Viewer".

As the PC connected to the service connector does not act as a subsystem (no specific port number defined for it), command and telemetries will be done via the uplink/downlink pins of the service connector and by listening to the I2C bus via the appropriate pins on the service connector.

The test board provides the digital/analog signal interfaces between the service connector and the USB ports on PCs. This board also allows for charging the satellite's batteries.

As the satellite can be remotely placed (a few meters) of the test board, a protection board with optocouplers is inserted between the satellite's service connector and the test board.

The RF communication link is ensured by two transceivers, a TNC, attenuators and antenna inside the chamber. Details regarding the test equipment set-up can be found in Appendix J.

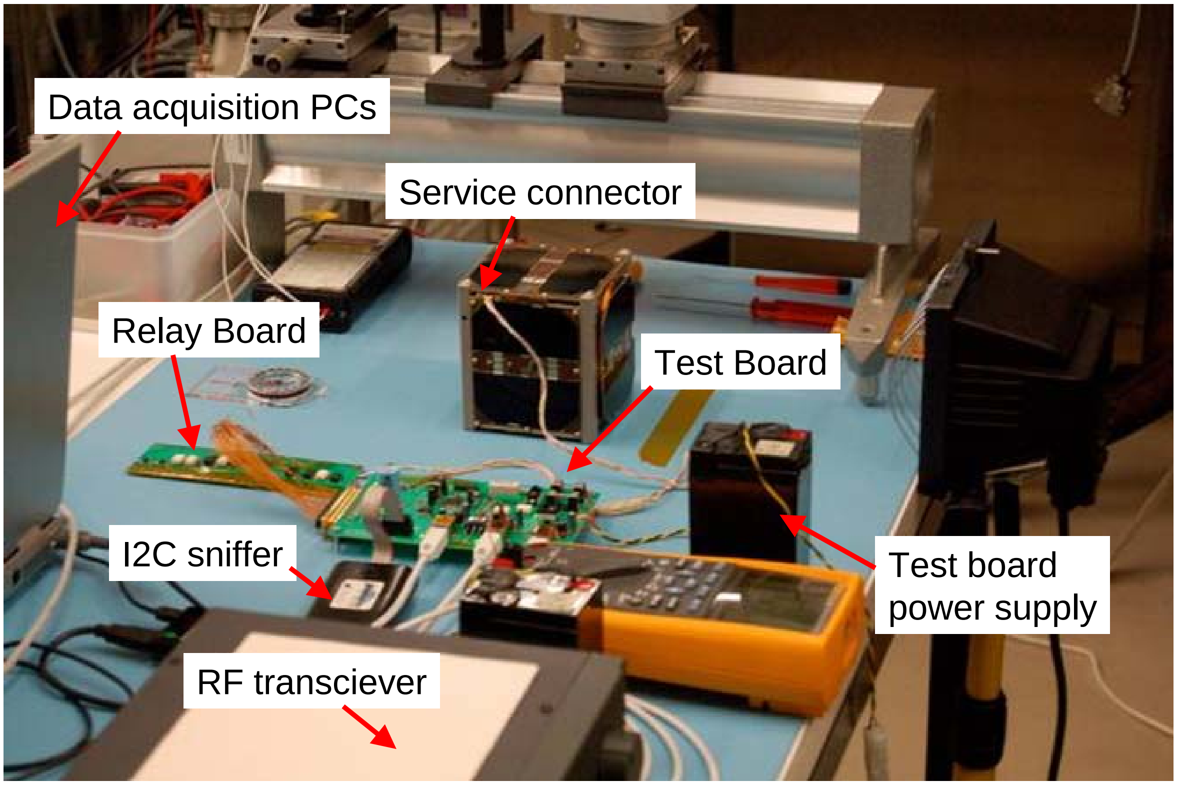


Figure 5-12: Test equipment and configuration for qualification.

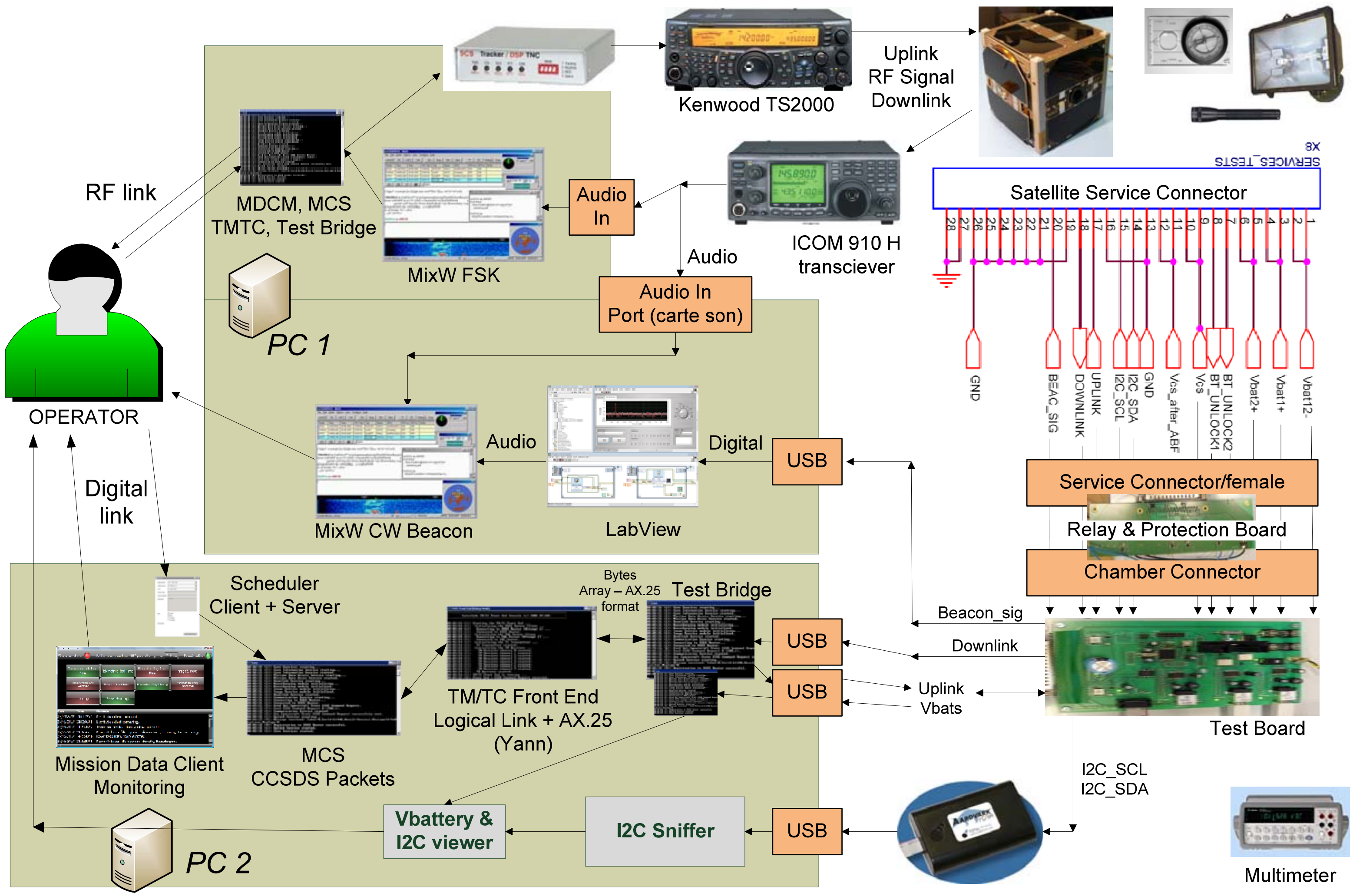


Figure 5-13: REDV hardware and software test set-up.

5.5 Data acquisition

Communication with the satellite can be done either via the service connector digital link or via the RF link or both. The digital link (Uplink/Downlink) is directly connected to the input (for uplink) and output (for downlink) pins of the COM microcontroller, the same pins that are used for the RF. Thus all downlink information received via the service connector is also transmitted to the RF transmitter of the communication board. For the uplink, a switch on the test board allows either command to be sent via RF or digital.

The software used for data acquisition is the same software as for the ground system with an interface bridge with the satellite test board. Additional test chamber data will be provided by the test facility set-up.

The user manual for the Ground System software is provided in [R5, R6, R7].

6 TEST PROCEDURE

This section summarizes the test procedures used for the REDV test before, during and after TVC.

6.1 Test flow

Figure 6-1 provides a general flow for the REDV test during TVC. To allow for more flexibility, the test procedure was divided in different section which can be found in Appendix A-H. The test flow starts with a "full" REDV during which all subsystems are checked and performance recorded. Simultaneous to the PL check, the optical alignment test is performed. The chamber was then closed, vacuum pumped and at cold temperature a cold start performed. During the various cycles, the subsystems were checked for functionality and for some parameters, the performances would be recorded. A specific test procedure was therefore run during cycling. At the end of the cycles, the antenna deployment check was done, after which the chamber could be re-opened. The test was completed with another "full" REDV.

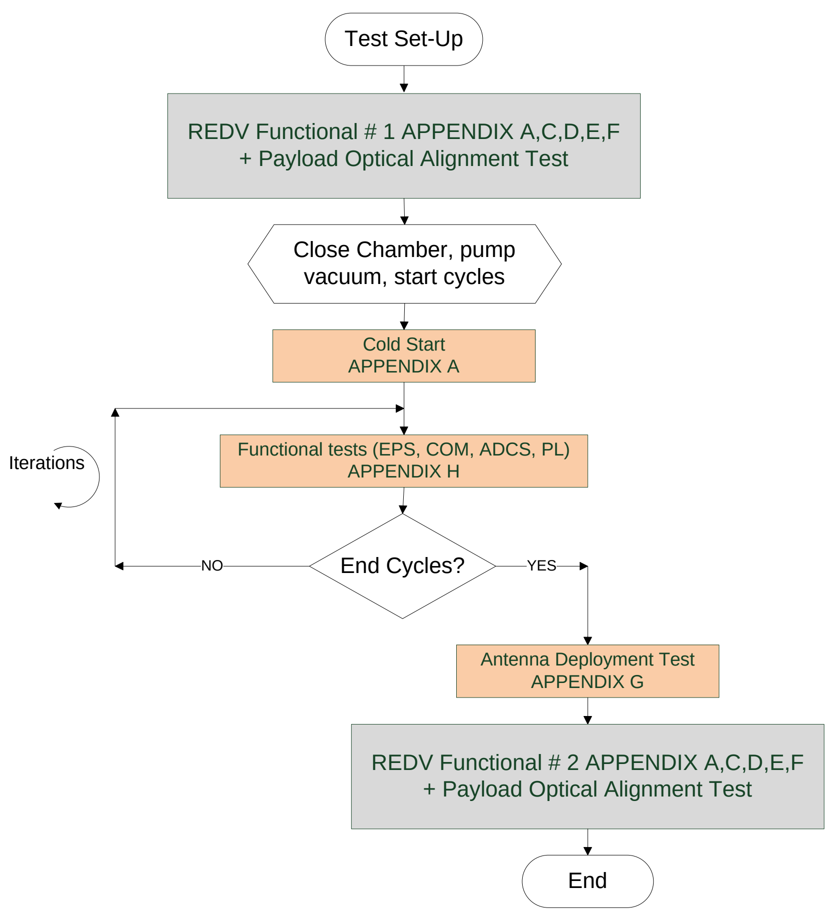


Figure 6-1: REDV test flow specific to the qualification TVC.

Figure 6-2: TVC test overview.

Figure 6-2 shows the theoretical TVC test overview with timing for the pressure, temperature and sun simulator cycles.

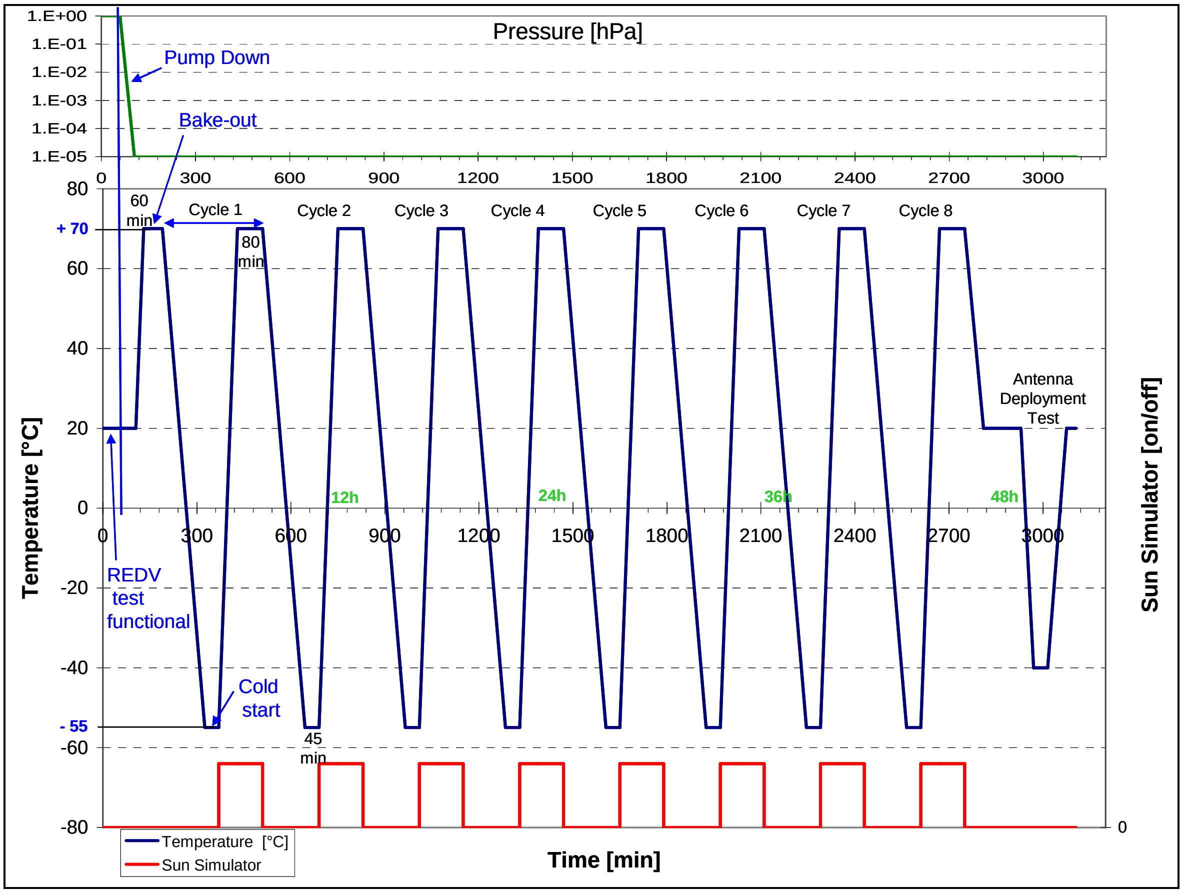


Figure 6-2: TVC test overview.

6.2 Test preparations

6.2.1 Test equipment

Besides the EQM, the equipment needed to perform the REDV test is provided in the list in Appendix I.

To prepare the test equipment for the test, follow Appendix J.

6.3 Step by step instruction for operation

This REDV test will execute sequences as described in the test flow in Figure 6-1. At the end of each sequence (appendix), the procedure lead will go back to that test flow to execute the following one.

GO TO:	APPENDIX A	QA	____________
	APPENDIX C	QA	____________
	APPENDIX D	QA	____________
	APPENDIX E	QA	____________
	APPENDIX F	QA	____________
	APPENDIX G	QA	____________
	APPENDIX H	QA	____________

6.4 Pass-fail criteria

Pass criteria: Pass Appendix A through H successfully.

Fail criteria: Hardware or software critical (unrecoverable) failure during test.

6.5 Safety and security instructions

No risk identified. Regular/conventional safety checks should be followed.

6.6 Personnel required

The test shall be run with at least two persons from the SwissCube project. Another person from the test facilities should be present.

For each appendix of the procedure run, the names of the responsible and present persons were recorded.

Michael Gerber from the University of Bern participated in the test as facility engineer.

7 TEST DATA

This section describes the timeline, measurements, and environmental conditions during the test.

7.1 First two cycles: No RF

Table 7-1: Timeline for the first two TVC cycles.

Date	Step n°	Cycle	Activity	Time [hh:mm]	Comments
10/14/2008	1		REDV BERN TVC #1	19:08	
	2		Pump Down	20:30	
10/15/2008	3		Bake Out - Warm Up	8:20 9:53	
	4		Bake Out	9:53 11:15	
	5	1 1	Cool Down	11:15 15:35	
	6	1 1 1	Stay cold 45 min (fluid temp set to -74, shroud ~-69) REDV Cold Start TVC #2	15:35 ~16:00 17:02	Cold start successful
	7	1 1	Warm Up	17:02 18:47	
	8	1 1	Stay warm 80 min	19:50	
10/16/2008	9	2	Cool Down	~8:20	
		2 2	REDV Cold Start TVC #3 Stay cold 45 min	10:18 13:00	Cold start successful
	10	2 2	Warm Up	15:57 17:58	Full HK Problem with relay board and sun simulator, sat OK
	11	2	Stay warm 80 min / last CMD sent	19:23	
10/17/2008	12		Chamber at 32-35, satellite at 35 deg. Chamber re-pressurization Chamber open ~25 deg	8:15 9:33 10:40	
	13		REDV RF TVC #4	16:50	

The TVC started on Oct. 14, 2008. At that point, the test was performed only with the digital link, as the RF uplink had not yet been demonstrated. The first two cycles were planned to utilize only the digital link and thus the appropriate ABF was inserted. Table 7-1 describes the timeline for this first part of the test.

After the full REDV, the satellite underwent thermal bake-out at 70°C for 1 hour. At that point the satellite was off. Then the first cycle started with, at the coldest temperature of -55°C, the verification of the cold start.

As shown in Figure 7-1, the problems that happened during the second cycle were related to the relay board and the sun simulator. Depending on the orientation of the satellite, one wire between the service connector and the relay board would disconnect and no communication would be established with the operator. These problems were solved by changing the length of the wires between the satellite and the relay board, changing the location of the relay board inside the chamber (higher up to avoid strong thermal cycles for which it was not designed), and by letting the sun simulator cool down before turning it on again.

To fix these problems, and leave time for the RF uplink to be analysed, the chamber was re-pressurized after the second cycle and opened on Oct. 17.

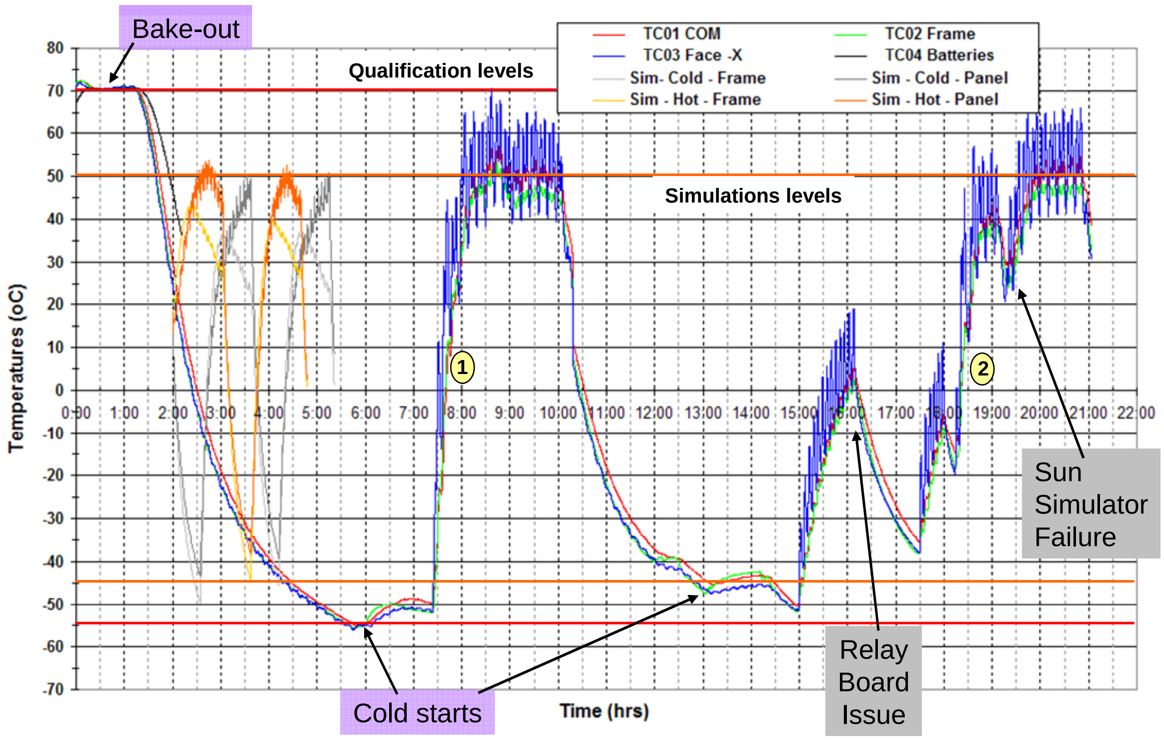


Figure 7-1: Test data for the first two cycles.

The RF uplink problem appeared during the REDV test before the vibration test. For reasons explained in the mechanical vibration and shock test report [R8], this problem could not be resolved on site in Berlin. At the return from Berlin, the equipment to test the communication system was not available until later on. It was thus decided to start the TVC test without the RF link. The problem itself is summarized in the Encountered Problems section.

On Oct. 17, the satellite was brought back to EPFL. On the 18, 20, 21 and 22, the RF uplink problem was analyzed ad resolved, the relay board fixed. Another problem regarding the thermal path to the solar panel on the –Y face (the Antenna Deployment panel) appeared and was resolved.

On Oct. 23, a second full REDV test was performed back at the University of Bern and the TVC resumed on the 24th.

The few cycles between 2 and 5 hours on Figure 7-1 represent the results of the simulations for the panel and frame temperature. These are the basis for the qualification temperature levels. Note that on the two first cycles, the temperature of the +X and -Y panel were closely monitored to make sure they did not reach a critical point for the bonding of the solar cells. The –Y panel being the most sensitive as its thermal path goes through the antenna deployment system, its temperature would drive the overall upper temperature set in the chamber (heating rings). To avoid overheating, these first two cycles were limited to a maximum temperature of 60-65°C. This thermal bonding was increased after these two first cycles and the next cycles could go up to 70°C as planned.

7.2 Cycles 3 to 8: RF link.

Table 7-2: Timeline for cycles 3 to 8.

Date	Step n°	Cycle	Activity	Time [hh:mm]	Comments
10/24/2008	14	3	Cool Down	8:40	
		3	Get_HK_EPS	10:20	
		3		11:26	
	15	3	Stay cold 45 min	11:26	
		3	Get_HK_EPS	11:45	COM microC shuts down
		3	SAT EPS and COM Off	11:55	COM is OFF
	16	3	Warm Up	12:10	EPS alive
		3	Get_HK_EPS	12:17	
		3	Get_HK_COM	12:19	No sign of life from COM
		3	stop charge	12:28	
		3	stopped sun sim	12:34	
		3	stopped heating rings	12:36	Try to totally discharge batteries
		3	Plug 2.2 Ohm resistor, reset sat, then charged bat	13:35	Satellite EPS reset
	17	3	Stay warm 60 min	15:24	Reach 88°C max on -Y face
		3	start test procedure	15:51	
		3	Sat power failure	16:10	
10/27/2008	18		Bake Out (reference @ 70°C)	20:47	
			Reach 70°C on the frame	23:25	
			Bake Out (reference @ 50°C)	23:30	
			Reach 50°C on the frame	1:00	
10/28/2008	19	4	Cool Down	7:30	Sat is OFF
	20	4	Stay cold 45 min	9:45	
		4	Start-up (charged batt, all digital, EPS-COM-RF)	10:15	
		4	HK EPS	10:22	Sat ON
		4	Changed PB battery, HK EPS	10:25	
	21	4	Warm Up, 300 deg for 20 min	10:42	
		4	Turn ON ADCS, get HK	11:34	ADCS ON
	22	4	Stay warm 80 min	11:36	
		4	Get HK EPS	12:02	All OK
		4	Get HK EPS	12:12	MT well turn on, HK via RF
		4	Get HK EPS RF	12:45	
	23	5	Cool Down	12:45	
		5	Get HK EPS	14:11	RF downlink
		5	Power Up PL, take image, get image info and line	14:22	
		5	End image get image line	14:58	
	24	5	Stay cold 45 min	15:35	
		5	Stopped charge	16:15	
	25	5	Warm Up, 300 deg for 20 min, started charge	16:17	
		5	Get HK EPS	16:53	Only EPS COM on, EPS reset
		5	set to 230°C	17:26	
	26	5	Stay warm 80 min (no charge)	17:26	
		5	Get HK EPS	17:31	EPS and COM good
		5	Get HK EPS	17:50	HK EPS: ADCS, PL all good
		5	Take Image	17:54	Image taken
		5	Turned off sun sim and HP	18:36	
10/29/2008	27	6	Cool Down	8:00	
	28	6	Stay cold 45 min	9:41	
		6	Start-up (charged batt, EPS-COM-RF)	10:09	
	29	6	Warm Up, 300 deg for 20 min	10:30	
		6	set to 230°C	11:47	
	30	6	Stay warm 60 min	11:47	
		6	Get_HK_EPS digital	12:02	Digital uplink not working
	31	7	Cool Down	12:47	
		7	Tried new RF uplink	13:37	PC/VM crashed -> reboot
		7	COM is at -20°C	14:20	
	32	7	Stay cold 45 min	14:53	
	33	7	Warm Up, 300 deg for 20 min	15:15	
		7	set to 220°C	16:21	
	34	7	Stay warm 60min	16:29	
		7		16:50	PC1 hard drive failure
		7	Turned off sun sim and HP	17:02	
	35	7		17:10	
		7		17:11	
		7	Get_HK_EPS digital	18:00	

(table continues next page…)

Date	Step n°	Cycle	Activity	Time [hh:mm]	Comments
10/30/2008	36	8	Cool Down (no charge)	8:45	
		8	HK EPS digital	10:53	No response from sat
	37	8	Stay cold 45 min	11:00	
		8		~11:10	Sat OFF
	38	8	Warm Up, 300 deg for 30 min	11:45	
		8	Charge batt with PB bat	12:13	Bat temp at 10 deg
		8	set to 230°C	12:49	
	39	8	Stay warm 80min	12:49	
		8	HK EPS digital	13:19	Digital downlink works correctly
		8	Uplink RF + Downling RF is working well	14:24	
		8	Problems with PC1	14:31	PC1 crashed, rebooted
	40	8	Cool Down - Stop Heating and Sun sim.	14:33	
		8	Take a picture	14:39	
		8	Picture 33 downloaded	14:46	
		8	END test	15:10	PC1 hard drive failure

Cycles 3 to 8 were performed with both digital and RF links. A switch on the test board allowed for either a digital uplink or an RF uplink. As can be seen in the timeline (Table 7-2), several problems occurred during tests. During Cycle 3, a capacitor failure on the satellite implied to re-open the chamber, change capacitors on the motherboard and replace omnetics wires on the battery board (removed two faces to do this), and then perform another bake-out before resuming tests two days later. The remaining of the cycles was punctuated with problems mostly related to the ground test equipment.

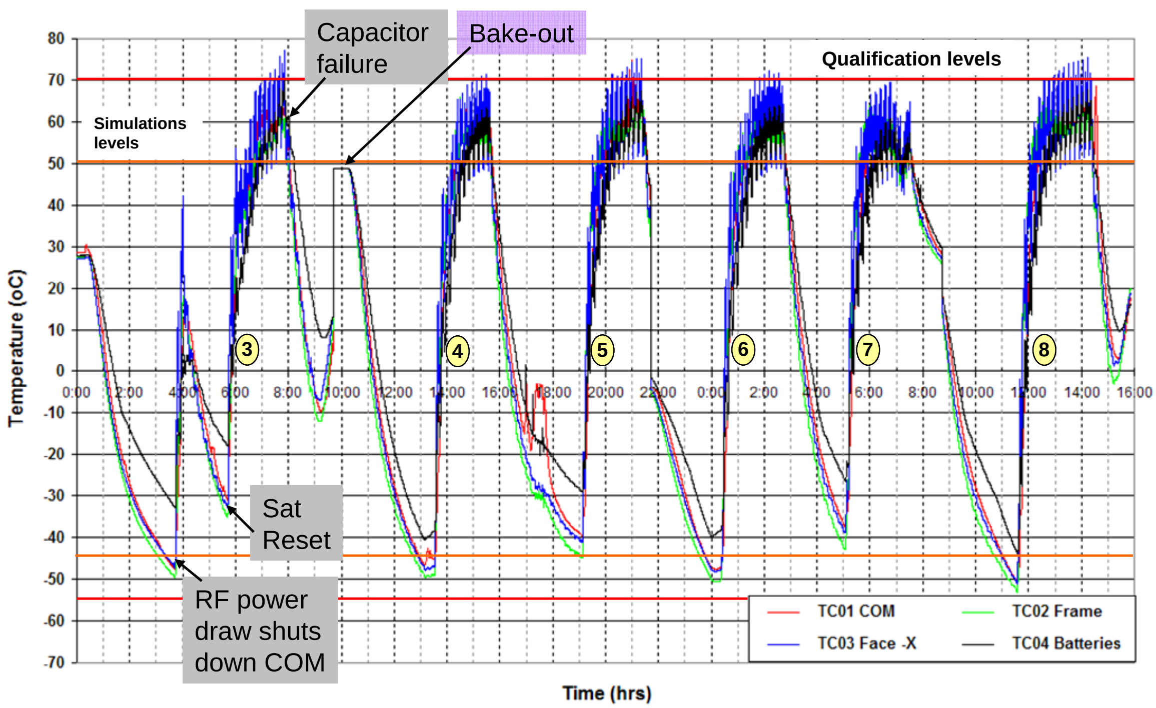


Figure 7-2: Test data for cycles 3 to 8.

As can be seen in Figure 7-2, the minimum temperature Tmin was moved up to -40°C in order to complete two cycles in a day. This decision was taken as it was really difficult to reach these very low temperature with the satellite turned on. At each dip, the batteries would have to be drained to reach

-55 ºC in 5 hours. Thus the new criterion for the cold plateau was to count 45 min after the frame temperature reached -40ºC. The satellite would then operate (when batteries were charged enough) below -40ºC (down to -50ºC) for 45 minutes.

7.3 Antenna deployment test

The last day of TVC was reserved to the antenna deployment test. To do this, the chamber was opened and the FM ABF was inserted in the satellite.

There are several instances of deployment commands after separation from the satellite deployer. A first deployment, autonomously commanded via software starts after 15 min. A second deployment, hardware generated, happens between 17 and 18 minutes (depending on the tolerance of the hardware counter). A third and fourth software deployments are commanded after 20 minutes and 3 hours. As the first three deployments would not be performed at low temperature in the chamber because of the time it takes for the chamber and satellite to cool down, the plan was to turn on the satellite at ambient pressure (not enough current in the wire to melt at ambient pressure), close the chamber, pump vacuum and cool down as fast as possible the chamber to reach at least -20ºC for the 3-hr deployment.

Table 7-3: Timeline for the antenna deployment test.

10/31/2008			ADS (antenna deployment) DAY		
			Charge batt with new Pb Bat (6.8V)	9:40	
			Changed ABF - version: flight	10:38	reset the satellite
			Beacon HW	10:55	
			Beacon SW	10:58	
			Chamber closed, vacuum started	11:13	
			Cool down chamber	11:49	Pressure 2x10-4
			Stopped charge	11:52	
			Antenna Deployment	13:38	

After 3 hours, the antennas deployed as planned and Table 7-4 summarizes the conditions at which deployment happened.

Table 7-4: Environment during antenna deployment.

Pressure	< 2×10^{-4}mbar
Frame temperature	-35°C
Battery Box temperature	-19°C
Time to deployment	3h±30sec

8 TESTS RESULTS

The purpose of the REDV test is to verify that all electronics components of the satellite are still functional during and after TVC. To verify this without disassembling the satellite, the subsystems are subject to a series of commands that requires all electronics to function correctly to provide a non-faulty response. Appendixes of the test procedure are run one after another. They include the required telecommands to send, telemetries and manipulations on the satellite to verify the subsystem functions.

8.1 Results of the verification of functions and performances

Table 8-1 and Table 8-2 provide a list off all subsystems and system functions to verify, and performance characterization. All functions of the satellite could be verified during the tests. As previously stated, due to lack of time, the performances could not be characterized in a systematic way.

As stated in section 7.3, the antenna deployment happened as expected at temperatures close to -35ºC. This temperature corresponds to the expected worst case simulation temperatures for a deployment that would happen 15 minutes after release from the satellite deployer.

Legend for the tables:

Done and functional		(green)
Not done		(white)
Done and not functional		(red)
Not applicable to this test		N/A
Problem appeared - resolved		(yellow)
Problem appeared - not resolved		(orange)

Table 8-1: REDV TVC functions and performance characterizations (1/2)

Subsystem		REDV #1	REDV #2	REDV #3	Comments
EPS					
Solar cells	Functional				
	Perf. characterization				
Battery charge and discharge	Functional				
	Perf. characterization				
Power distribution	Functional				
	Perf. characterization				
Dissipation system	Functional				
	Perf. characterization				
Antenna deployment sequence	Software				Verification that the order/current for deployment is sent
	Hardware				Verification of the autonomous deployment
Start-up sequence	Functional				Verification of kill switches, EPS and COM start-up
Battery heating system	Functional				
	Perf. characterization				
EPS Software functions	Functional				
EPS Software TC, TM	Functional				
I2C Communication	Functional				
	Perf. characterization				
Time clock distribution	Functional				
PL image scheduling	Functional				
HK collection	Functional				
Time stamping	Functional packets				
Temperature sensors	Functional				
	Perf. characterization				
Voltage measures	Functional				
	Perf. characterization				
COM					
Data management/streaming	Functional				
RF downlink	Functional				
	Perf. characterization				
RF uplink	Functional				
	Perf. characterization				
I2C communication	Functional				
Time stamping	Functional packets				
	Functional frames				
UHF Antenna	Functional				
VHF Antenna	Functional				
Temperature sensors	Functional				
	Perf. characterization				
Beacon					
Hardware beacon generation	Functional				Verification of timing and signal generation
	Perf. characterization				Verification of message validity
Software beacon generation	Functional				Verification of timing and signal generation
	Perf. characterization				Verification of message validity
RF signal generation	Functional				Frequency, modulation
	Perf. characterization				

Table 8-2: REDV TVC functions and performance characterizations (2/2)

Subsystem		REDV #1	REDV #2	REDV #3	Comments
ADCS					
Power up, power down	Functional				
Magnetometers	Functional				
	Perf. characterization				
Sun sensors	Functional				
	Perf. characterization				
Gyroscopes	Functional				
	Perf. characterization				
Magnetotorquers	Functional				
	Perf. characterization				
Temperature sensors	Functional				
	Perf. characterization				
Voltage measures	Functional				
	Perf. characterization				
ADCS Software functionalities	Functional				Includes timing, error flags, regulation, …
ADCS Software TC, TM	Functional				
I2C communication	Functional				
HK collection	Functional				
Bdot controller	Functional				
	Perf. characterization				
PAYLOAD					
Power up, power down	Functional				
Detector	Functional				
	Perf. characterization	N/A	N/A	N/A	
Optical system	Functional				
	Perf. characterization				
Temperature sensors	Functional				
	Perf. characterization				
Voltage measures	Functional				
	Perf. characterization				
PL Software functionalities	Functional				
PL Software TC, TM	Functional				
I2C communication	Functional				
HK collection	Functional				
ADS					
Deployment	Functional				Antenna deployment after 3 hrs

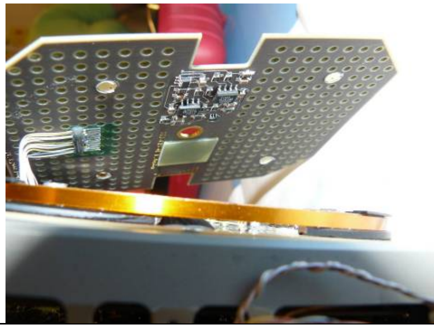
8.2 Encountered problems

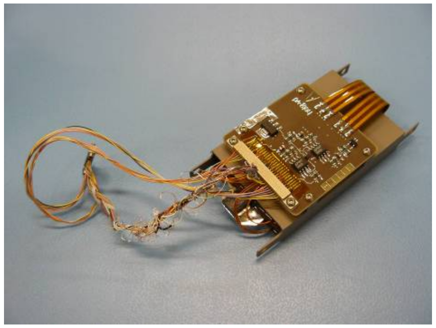
Table 8-3 summarizes the problems that have been encountered during the TVC and REDV tests in Bern and the measures and actions that have been taken to solve them. About half of the problems encountered and listed in this table were related to satellite problems, the other half to the test equipment. This table does not provide a list of all problems encountered on the test equipment, especially not the ones encountered with the test PCs.

One critical failure happened on the satellite (see description and resolution in the table, ID#6) that create a total loss of power and shut down the satellite. That failure is related to a capacitor manufacture default. It also brought back the question of how redundancy was handled on the satellite. Careful evaluation of the problem and additional tests were performed to ensure a reliable resolution. However, one should keep in mind that the components used at off-the-shelf components not necessarily designed to operate under the stringent conditions of a qualification campaign. These sorts of problems, even though designed for, can be expected.

Table 8-3: List of encountered problems during the TVC.

ID#	Title Date, time, hour, Cycle #	Description	Origin	Measures taken
1	**No RF Uplink** Oct 14-21, 2008	Tried to send commands via the RF uplink. No response from the satellite.	Modem clock enable bit set at "0".	Added a line of code to the COM software to enable the Modem clock. Worked all fine after that.
2	**COM Current limitator Error** C1 and C2 Warm and cold Oct 15 and 16, 2008	Error !22 showed up in the EPS HK ABF: no ADS/no RF	Short circuit on COM?	Reset the error flag. No other measures taken. Verification of measure chain of the COM CL state. Verified the influence of the pin on the chamber that was touching the ground. No influence proven. Verified the EPS Software. No problem found. Verify pull down on Enable after ABF. Not done. No hardware short circuit could be identified. Problem did not happen again.
3	**Beacon decoding** Oct 17, 2008	Missing one dot.	Ambiant noise added in signal.	Tuned MixW better and the signal could be decoded correctly.
4	**Face –Y bonding** Oct 17, 2008	The four aluminium nuts glued on the –Y face were broken after Cycle 2. The face remained attached to the ADS panel via the	Could be due either to pyro shocks or first thermal cycle.	"Bonded" the four aluminium nuts on EQM with solder alloy to finish the qualification tests with a good thermal contact.

		central screw.		Modified the FM: nuts. Machined them in copper to be able to solder them on the PCB.
5	**COM microcontroller not responding** C3 cold plateau Oct. 24, 2008	After about 20 minutes on the cold plateau, the EPS HK command stuck the COM microcontroller. No activity of the COM could be seen on the I2C bus via the sniffer.	Batteries were rather low (3.46 – 3.67V) and the command required sudden high current to the RF part.	Completely discharged the batteries via the external 2.2 Ohm resistor connected on the bus. This drained the whole bus down and stopped the EPS. And when the discharge resistor was removed, the satellite powered up again. COM was reset that way and then worked afterward. On the FM, modified the hardware so the EPS can reset the COM if the COM microcontroller does not respond to the EPS after 5 minutes. Pull down are placed to activate the COM by default. Tested COM board with low voltage to investigate response. Microcontroller works down to 2V. On the FM, decided not to

				perform communication with battery voltages lower than 3.9V to avoid a voltage drop too strong that could perturb the bus regulation. On the FM a modification has been made on the software so that the microcontroller increases the output power of the RF PA in three steps to avoid a very high current step on the bus.
6	**Loss of power/short circuit on Battery 2** C3, hot plateau Oct 24, 2008 16h10 	Sudden freeze and loss of power in the satellite, while on the high-temperature plateau. Temperatures were typically around 60°C. Strong out gassing peak.	Omnetics wires (connecting the battery board to the connection board) melted. 3 wires of 1 A each to accommodate a satellite theoretical demand of 1-1.5 A. Each wire graded for 1 A. 9 wires melted. On the Mother Board, capacitor (C16 22uF) on the battery 2 side of the step down went into short circuit (cracks could be seen on that capacitor).	Modifications on EQM: changed the 4 capacitors of 22uF 10V connected on the batteries by two capacitors 10uF 16V in parallel. Worked afterward. Tested the 22uF 10V removed capacitors (100 thermal shocks with 4.2V 15 min @ 90°C 15min @ -58°C). Not a single capacitor failed. Looked for spikes on the capacitors. Results: signal very clean. QM: Omnetics connector going from the battery board to the connection board was changed. FM and QM: changed wiring twisting of the Omnetics wires to

				avoid a coupling between the two batteries and avoid all wires to melt in case of a new failure (to keep redundancy). Verified space with face +Z in case of a contact during pyro-shocks. The space is large enough. Modifications on FM: Changed all 22uF 10V by 22uF 16V to increase derating.
7	**Battery Unlock not functional** C4 Oct 28, 2008	When pushed 4 kill switches, and activated Battery Unlock on the test board, the batteries did not get disconnected from the satellite.	Optocouplers on the relay board were dead.	Replaced the optocouplers on the relay board.
8	**No digital downlink** C4, all the time (since beginning of the day) Oct 28, 2008	Downlink digital is not responding. Uplink and downlink RF are functional.	Test software issues. Most probably due to the FTDI initialisation.	Restarted all software at the end of the next day (Oct 29, 2008) and the digital link worked again.
9	**EPS resets** C4, warm plateau Oct 28, 2008 16:53 and 18:15	EPS did a reset twice as we sent the Get_EPS_HK command. These reset could be seen because both times the ADCS and PL were turned OFF.	Cause unknown. Could be related to a bus voltage drop.	Satellite kept on working after reset. No action taken.
10	**No RF communication** C5 Oct 29, 2008	No RF communication. Link, signal but not decodable Beacon switch alternating between	Pb on EPS, pb on COM	Nothing done, but all went back to nominal (digital link worked after restarting the test bridge, but RF did not work)

		HW and SW – Not decodable		Next day: all worked fine again, RF and digital.
11	**Vbat Viewer**	Vbat viewer not providing voltages at low temperatures.	Measure of voltage on test board was not working.	Replaced the operational amplifiers on the relay board.
12	**Set ADC COM to allow downlink**	Downlink cannot be decoded. Problem at test board level.	Sampling rate of the FTDIs in the test board sometimes too low to decode signal correctly.	Changed ADC setpoints to 0-2.5V.
13	**ADCS error when ADCS turned ON for first time**	Error on 464	Turn on time for ADCS component not long enough (capacitor charge).	Turned ADCS ON, OFF and back ON, no more error 464. Worked everytime.
14	**Voltage drop of the power bus**	When voltage of batteries are too low, or demand on the current is too high and sudden, bus voltage is perturbed.	Resistance of the power chain from the batteries to the subsystems is too high. DC/DC does not have enough voltage difference to provide constant 3.3 V (would need to define a limit under which no COM is done)	Resistance of the line is around 150mΩ. No RF communication can be done when both batteries are lower than 3.9V

8.3 Lessons learned

One of the main results of the TVC test was to learn how to operate the satellite. Several EPS resets or COM shut-down were experienced and were related to the way the power demand is managed on the power bus. With the RF, a housekeeping command meant that the RF power amplifier (big current draw) was very rapidly turned on, which implied a voltage drop on the bus and thus the EPS or COM resets. This was especially true for cold temperatures where the batteries were discharged. This behaviour was corrected by respecting better the flight operational scenarios, where telecommunication is done with fully charged batteries. The ramp-up time for the PA was also changed to accommodate a few steps in current. The PA was also not turned on/off at each command but kept on for 2 minutes after the first command. These changes made a significant difference on the functional behaviour of the satellite.

On another note, the test equipment failed many times during the test, always leaving the uncertainty that it could be a satellite failure. One of the reasons for this happening was that the test equipment was designed and fabricated in a very short time, and poorly tested. The relay board was not designed for vacuum and temperature cycles. More attention should be brought to these aspects early on in the project.

Another lesson learned was the management of the people during tests. As half of the core team was working on assembly of the flight model, staffing for the TVC test quickly became an issue. Thus resources were called from less experienced students/team members. Although instructions would be provided, decision taking or resolution of problems would be a more difficult process.

9 CONCLUSIONS

The REDV functional tests performed before, during and after Thermal Vacuum Cycling test of EQM version of SwissCube show that the satellite performed well before and after tests. The problems encountered during the REDV and TVC tests could be resolved either during the test or once back at EPFL. Most of the problems encountered were related to the test equipment. The problems related to the satellite were resolved and did not reappear during the remaining of the test.

This TVC test allowed for the first time to operate the satellite and understand its real behaviour. In that respect, this test was very fruitful. All the modifications were implemented on the FM.

Thus the thermal, vacuum and functional design of SwissCube has been validated through qualification testing.

PROJECT PARTNER LABORATORIES

The following partner laboratories are involved in the SwissCube Project:

EPFL
ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

EPFL LMTS Laboratoire des Microsystèmes pour les Technologies Spatiales	Space Center	LMAF	Laboratoire d'Automatique	LMIS3
LCSM Laboratoire de Conception de Systèmes Mécaniques	Electronics Laboratory leg	LTCM	LEMA Laboratoire d'Electromagnétisme et d'Acoustique	LTC
LAI	lap AQUA	LPM		

Hes·so and n|w Fachhochschule Nordwestschweiz

HEVs	heig-vd Haute Ecole d'Ingénierie et de Gestion du Canton de Vaud	haute école neuchâtel berne jura arc	Ecole d'ingénieurs et d'architectes de Fribourg Hochschule für Technik und Architektur Freiburg

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ISIS

Appendix A Start-up sequence, COM-EPS-Beacon-ADS checks, safe mode

This section turns on the satellite and initiates the start-up sequence. It also verifies the basic functions of the electrical subsystems powered up during initialization of the satellite: COM, EPS, and Beacon. Only COM and EPS are powered up in this procedure. The Beacon board is disconnected as well as the ADS. The commands to activate these boards from EPS will be tested, but the function themselves on the boards will not be activated.

The assumption is that:

- The kill switches are OFF (pressure on the satellite)
- The service connector is connected
- Chronometer ready
- Expected values are at 20 deg.C
- ABF is plugged in: see version of ABF
- The test computer is on ready to send commands.
- The 500 W lamp has been installed at the following distance: **Lamp distance:**

ABF Test #1:	**Users**	**ON**	**OFF**
	ADS	**ON**	**OFF**
	Beacon	**ON**	**OFF**
	RF	**ON**	**OFF**

Personnel involved:

OPERATOR	OPE	Nicolas Steiner	________
Computer 1 (COM)	PC1	Florian George	________
Computer 2 (MCS)	PC2	Yann Voumard	________
Procedure run	PRO	Muriel Noca	________
Engineer EPS	EPS	Nicolas Steiner	________
Engineer COM	COM	Ted Choueiri	________
Engineer ADCS	ADCS	Laurent Hauser	________
Engineer PL	PL	Noémy Scheidegger	________
Safety/QA	QA	Fabien Jordan	________

Start Procedure:

Set-up done + QA ____ ____ ***Date:*** ________ ***Time*** ________

0) Verify battery voltage

A 0-1	OPE	Verify BT1+	3.5-4.2 V	______________
A 0-2	OPE	Verify BT2+	3.5-4.2 V	______________
A 0-3	PC2	Verify Vbat Viewer Vbat1+	3.5-4.2 V	______________
A 0-4	PC2	Verify Vbat Viewer Vbat2+	3.5-4.2 V	______________

1) Release kill switches and time operations

A 1-1	OPE	Release switches & start chronometer	OK	______________
A 1-2	PC2	Verify Vcs (CHARGE_1/2)	3.07-3.53 V	______________
A 1-3	PC2	Verify Vcs_after_ABF (SUPPLY 1/2)	3.07-3.53 V	______________

2) Hardware beacon signal verification

The operator has 2 minutes to verify that the HW Beacon runs correctly. It should be heard 5 times.

A 2-1	PC1	Verify BEAC_SIG right after A 1-7	Time	______________
			HB9EG/1	______________
A 2-2	OPE	Verify delta-time between 2 BEAC_SIG	Time	______________
			56 sec	______________

3) After 20 minutes: ADS deployment and SW Beacon

A 3-1	PC1	Verify BEAC_SIG right after 20 minutes	Time	______________
			SW Signal 0	______________
			SW Signal 1	______________
			SW Signal 2	______________
			SW Signal 3	______________
A 3-2	OPE	Verify delta-time between 2 BEAC_SIG	Time	______________
			30 sec	______________

4) Verify COM operations

(This can be done in parallel with steps 1)-2)-3))

A 4-1	PC2	Send FCT_COM_GENERATE_HK	No parameter		______________
A 4-2	PC2	Verify in TCRealTime all TC Acknow are (if not green, try **once** to send TC again)	© Green	QA	______________
A 4-3	PC2	Verify in TCRealTime date/time	Date/time		______________
A 4-4	PC2	Verify in COM HKViewer date/time	Date/time		______________
A 4-5	PC2	Verify in HKViewer all COM HK green:		QA	______________
A 4-6	PC2	Verify detailed COM default values and parameters:	XLS	QA	______________

5) Verify EPS operations and safe mode (EPS and COM HK)

A 5-1	PC2	Send FCT_EPS_GENERATE_HK	No Param.		______________
A 5-2	PC2	Verify in TCRealTime all TC Acknow are (if not green, try **once** to send TC again)	© Green	QA	______________
A 5-3	PC2	Verify in TCRealTime date/time	Date/time		______________

We expect to see 2 packets: one for EPS and one for COM

A 5-4	PC2	Verify in EPS HKViewer date/time	Date/time		______________
A 5-5	PC2	Verify in HKViewer all EPS HK green:		QA	______________
A 5-6	PC2	Verify detailed EPS default values and parameters:	XLS	QA	______________
A 5-7	PC2	Verify 13 EPS temperature readings are consistent (values should be close to each other)		QA	______________
A 5-8	PC2	Verify Spacecraft Mode (143) is SAFE		QA	______________
A 5-9	PC2	Verify in COM HKViewer date/time	Date/time		______________
A 5-10	PC2	Verify in HKViewer all COM HK green:		QA	______________
A 5-11	PC2	Verify detailed COM default values and parameters:	XLS	QA	______________
A 5-12	PC2	Verify 3 COM temperature readings are consistent (values should be close to each other)		QA	______________

6) Verify operations of Solar Cells/Panels

A 6-1	OPE	Turn ON Lamp on +X face	No Param.		______________
A 6-2	PC2	Send FCT_EPS_GENERATE_HK	No Param.		______________
A 6-3	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
A 6-4	PC2	Verify in TCRealTime date/time	Date/time		______________
A 6-5	PC2	Verify in EPS HKViewer date/time	Date/time		______________
A 6-6	PC2	Verify in HKViewer all EPS HK green:		QA	______________
A 6-7	PC2	Verify detailed EPS default values and parameters:	XLS	QA	______________
A 6-8	PC2	Solar Cell +X current (119)		QA	______________
A 6-9	PC2	Solar Cell +X temperature (125)		QA	______________
A 6-10	OPE	Turn ON Lamp on +Y face	No Param.		______________
A 6-11	PC2	Send FCT_EPS_GENERATE_HK	No Param.		______________
A 6-12	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
A 6-13	PC2	Verify in TCRealTime date/time	Date/time		______________
A 6-14	PC2	Verify in EPS HKViewer date/time	Date/time		______________
A 6-15	PC2	Verify in HKViewer all EPS HK green:		QA	______________
A 6-16	PC2	Verify detailed EPS default values and parameters:	XLS	QA	______________
A 6-17	PC2	Solar Cell +Y current (121)		QA	______________
A 6-18	PC2	Solar Cell +Y temperature (127)		QA	______________
A 6-19	OPE	Turn ON Lamp on -X face	No Param.		______________
A 6-20	PC2	Send FCT_EPS_GENERATE_HK	No Param.		______________
A 6-21	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
A 6-22	PC2	Verify in TCRealTime date/time	Date/time		______________
A 6-23	PC2	Verify in EPS HKViewer date/time	Date/time		______________
A 6-24	PC2	Verify in HKViewer all EPS HK green:		QA	______________
A 6-25	PC2	Verify detailed EPS default values and parameters:	XLS	QA	______________
A 6-26	PC2	Solar Cell -X current (118)		QA	______________
A 6-27	PC2	Solar Cell +X temperature (124)		QA	______________
A 6-28	OPE	Turn ON Lamp on -Y face	No Param.		______________
A 6-29	PC2	Send FCT_EPS_GENERATE_HK	No Param.		______________
A 6-30	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________

A 6-31	PC2	Verify in TCRealTime date/time	Date/time		______________
A 6-32	PC2	Verify in EPS HKViewer date/time	Date/time		______________
A 6-33	PC2	Verify in HKViewer all EPS HK green:		QA	______________
A 6-34	PC2	Verify detailed EPS default values and parameters:	XLS	QA	______________
A 6-35	PC2	Solar Cell -Y current (120)		QA	______________
A 6-36	PC2	Solar Cell +X temperature (126)		QA	______________
A 6-37	OPE	Turn ON Lamp on +Z face	No Param.		______________
A 6-38	PC2	Send FCT_EPS_GENERATE_HK	No Param.		______________
A 6-39	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
A 6-40	PC2	Verify in TCRealTime date/time	Date/time		______________
A 6-41	PC2	Verify in EPS HKViewer date/time	Date/time		______________
A 6-42	PC2	Verify in HKViewer all EPS HK green:		QA	______________
A 6-43	PC2	Verify detailed EPS default values and parameters:	XLS	QA	______________
A 6-44	PC2	Solar Cell +Z current (123)		QA	______________
A 6-45	PC2	Solar Cell +X temperature (129)		QA	______________
A 6-46	OPE	Turn ON Lamp on -Z face	No Param.		______________
A 6-47	PC2	Send FCT_EPS_GENERATE_HK	No Param.		______________
A 6-48	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
A 6-49	PC2	Verify in TCRealTime date/time	Date/time		______________
A 6-50	PC2	Verify in EPS HKViewer date/time	Date/time		______________
A 6-51	PC2	Verify in HKViewer all EPS HK green:		QA	______________
A 6-52	PC2	Verify detailed EPS default values and parameters:	XLS	QA	______________
A 6-53	PC2	Solar Cell -Z current (122)		QA	______________
A 6-54	PC2	Solar Cell +X temperature (128)		QA	______________

7) Verify battery voltage

A 7-1	OPE	Verify BT1+	3.5-4.2 V	______________
A 7-2	OPE	Verify BT2+	3.5-4.2 V	______________
A 7-3	PC2	Verify Vbat Viewer Vbat1+	3.5-4.2 V	______________
A 7-4	PC2	Verify Vbat Viewer Vbat2+	3.5-4.2 V	______________

8) End sequence

A 8-1 PRO If HK correct go back to Paragraph **Error! Reference source not found.** ________________

A 8-2 PRO If HK NOT correct STOP ________________

Appendix B COM Functions

This section will verify all functions of the COM.

This section has also been imbedded in Appendix A, F, G. It can be run independently if needed.

Assumptions:

- Satellite is in safe mode
- Wired as described in appendix A

ABF Test #1:	**Users**	**ON**	**OFF**
	ADS	**ON**	**OFF**
	Beacon	**ON**	**OFF**
	RF	**ON**	**OFF**

Personnel involved:

OPERATOR	OPE	Nicolas Steiner	____________
Computer 1 (COM)	PC1	Florian George	____________
Computer 2 (MCS)	PC2	Yann Voumard	____________
Procedure run	PRO	Muriel Noca	____________
Engineer EPS	EPS	Nicolas Steiner	____________
Engineer COM	COM	Ted Choueiri	____________
Engineer ADCS	ADCS	Laurent Hauser	____________
Engineer PL	PL	Noémy Scheidegger	____________
Safety/QA	QA	Fabien Jordan	____________

Start Procedure:

Set-up done + QA ____ ____ ***Date:*** ________ ***Time*** ________

1) Verify HK capability of the COM board

B 1-1 PC2 Send FCT_COM_GENERATE_HK No parameter ______________

B 1-2 PC2 Verify in TCRealTime all TC Acknow are Green QA ______________

(if not green, try **once** to send TC again)

B 1-3 PC2 Verify in COM HKViewer date/time Date/time ______________

B 1-4 PC2 Verify in HKViewer all COM HK green: QA ______________

B 1-5 PC2 Verify following COM default values and parameters: QA ______________

B 1-6 PC2 Verify 3 COM temperature readings are consistent QA ______________

2) Verify emergency safe mode

This test is performed in Appendix F.

3) Verify SW parameters configuration

This test is assumed to have been performed during SW check-out tests.

B 3-1 PRO Check SW check-out has been done Florian? ______________

4) End sequence

A 4-1 PRO If HK correct go back to Paragraph **Error! Reference source not found.** ______________

A 4-1 PRO If HK NOT correct STOP ______________

Appendix C EPS Functions

This section will verify all functions of the EPS, will turn ON ADCS, Payload, get telemetry. It will then turn OFF ADCS, Payload.

This section has been inserted into Appendix A, D, E.

Appendix D ADCS Functions

This section will verify all functions (besides internal to the software) of the ADCS board. This test will also characterize the performance of the sensors and verify their calibration.

Assumptions:

- Satellite is in safe mode
- Wired as described in appendix A
- The compass is ready to be used
- The Maglight is ready to be used
- Face +Z on top.

TEST ABF #1:	**Users**	**ON**	**OFF**
	ADS	**ON**	**OFF**
	Beacon	**ON**	**OFF**
	RF	**ON**	**OFF**

Personnel involved:

OPERATOR	OPE	Nicolas Steiner	_______________
Computer 1 (COM)	PC1	Florian George	_______________
Computer 2 (MCS)	PC2	Yann Voumard	_______________
Procedure run	PRO	Muriel Noca	_______________
Engineer EPS	EPS	Nicolas Steiner	_______________
Engineer COM	COM	Ted Choueiri	_______________
Engineer ADCS	ADCS	Laurent Hauser	_______________
Engineer PL	PL	Noémy Scheidegger	_______________
Safety/QA	QA	Fabien Jordan	_______________

Start Procedure:

Set-up done + QA ____ ____ ***Date:*** _________ ***Time*** _________

1) Power up ADCS board and verification of default configuration and parameter values

D 1-1	PC2	Send FCT_EPS_PWR_UP_SS (script: PowerUpADCS)	para: ADCS	______________
D 1-2	PC2	Verify in TCRealTime all TC Acknow are (if not green, try **once** to send TC again)	© Green	QA______________
D 1-3	OPE	Wait for 20 seconds		______________
D 1-4	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 1-5	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA______________
D 1-6	PC2	Verify in TCRealTime date/time	Date/time	______________
D 1-7	PC2	Verify in ADCS HKViewer date/time	Date/time	______________
D 1-8	PC2	Verify in HKViewer all ADCS HK green:		QA ______________
D 1-9	PC2	Verify detailed COM default values and parameters:	XLS	QA ______________
D 1-10	PC2	Verify detailed EPS default values and parameters:	XLS	QA ______________
D 1-11	PC2	Verify detailed ADCS default values and parameters:	XLS	QA ______________
D 1-12	PC2	Verify EPS 134-ST_ADCS		QA ______________

2) Verification of MM

D 2-1	PC2	Verify ADCS 440-MM_X_MEAS		QA ______________
D 2-2	PC2	Verify ADCS 441-MM_Y_MEAS		QA ______________
D 2-3	PC2	Verify ADCS 442-MM_Z_MEAS		QA ______________

3) Verification of Sun Sensors

Face - X

D 3-1	OPE	Place flashlight perpendicular to face –X, + Z on top		QA ______________
D 3-2	OPE	Turn ON flashlight		QA ______________
D 3-3	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 3-4	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA______________
D 3-5	PC2	Verify in TCRealTime date/time	Date/time	______________
D 3-6	PC2	Verify in ADCS HKViewer date/time	Date/time	______________
D 3-7	PC2	Verify in HKViewer all ADCS HK green:	XLS	QA ______________
D 3-8	PC2	Verify ADCS 402-SS_XN_R1		QA ______________

D 3-9	PC2	Verify ADCS 404-SS_XN_R2 (values should increase)		QA ______________
D 3-10	OPE	Turn OFF flashlight		QA ______________
D 3-11	OPE	Place flashlight to the down-right corner		QA ______________
D 3-12	OPE	Turn ON flashlight		QA ______________
D 3-13	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 3-14	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA______________
D 3-15	PC2	Verify in TCRealTime date/time	Date/time	______________
D 3-16	PC2	Verify in ADCS HKViewer date/time	Date/time	______________
D 3-17	PC2	Verify in HKViewer all ADCS HK green:	XLS	QA ______________
D 3-18	PC2	Verify EPS 401-SS_XN_A1		QA ______________
D 3-19	PC2	Verify EPS 403-SS_XN_A2 (values should increase)		QA ______________
D 3-20	OPE	Turn OFF flashlight		QA ______________
D 3-21	OPE	Place flashlight to the top-right corner		QA ______________
D 3-22	OPE	Turn ON flashlight		QA ______________
D 3-23	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 3-24	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA______________
D 3-25	PC2	Verify in TCRealTime date/time	Date/time	______________
D 3-26	PC2	Verify in ADCS HKViewer date/time	Date/time	______________
D 3-27	PC2	Verify in HKViewer all ADCS HK green:	XLS	QA ______________
D 3-28	PC2	Verify EPS 401-SS_XN_A1		QA ______________
D 3-29	PC2	Verify EPS 403-SS_XN_A2 (values should change)		QA ______________
D 3-30	OPE	Turn OFF flashlight		QA ______________

<u>Face + X</u>

D 3-31	OPE	Place flashlight perpendicular to face +X, + Z on top		QA ______________
D 3-32	OPE	Turn ON flashlight		QA ______________
D 3-33	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 3-34	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA______________
D 3-35	PC2	Verify in TCRealTime date/time	Date/time	______________

D 3-36	PC2	Verify in ADCS HKViewer date/time	Date/time		_______________
D 3-37	PC2	Verify in HKViewer all ADCS HK green:	XLS	QA	_______________
D 3-38	PC2	Verify ADCS 406-SS_XP_R1		QA	_______________
D 3-39	PC2	Verify ADCS 408-SS_XP_R2		QA	_______________
		(values should increase)			
D 3-40	OPE	Turn OFF flashlight		QA	_______________
D 3-41	OPE	Place flashlight to the down-right corner		QA	_______________
D 3-42	OPE	Turn ON flashlight		QA	_______________
D 3-43	PC2	Send FCT_EPS_GENERATE_HK	No Parameter		_______________
D 3-44	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	_______________
D 3-45	PC2	Verify in TCRealTime date/time	Date/time		_______________
D 3-46	PC2	Verify in ADCS HKViewer date/time	Date/time		_______________
D 3-47	PC2	Verify in HKViewer all ADCS HK green:	XLS	QA	_______________
D 3-48	PC2	Verify EPS 405-SS_XP_A1		QA	_______________
D 3-49	PC2	Verify EPS 407-SS_XP_A2		QA	_______________
		(values should increase)			
D 3-50	OPE	Turn OFF flashlight		QA	_______________
D 3-51	OPE	Place flashlight to the top-right corner		QA	_______________
D 3-52	OPE	Turn ON flashlight		QA	_______________
D 3-53	PC2	Send FCT_EPS_GENERATE_HK	No Parameter		_______________
D 3-54	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	_______________
D 3-55	PC2	Verify in TCRealTime date/time	Date/time		_______________
D 3-56	PC2	Verify in ADCS HKViewer date/time	Date/time		_______________
D 3-57	PC2	Verify in HKViewer all ADCS HK green:	XLS	QA	_______________
D 3-58	PC2	Verify EPS 405-SS_XP_A1		QA	_______________
D 3-59	PC2	Verify EPS 407-SS_XP_A2		QA	_______________
		(values should change)			
D 3-60	OPE	Turn OFF flashlight		QA	_______________

<u>Face - Y</u>

D 3-61	OPE	Place flashlight perpendicular to face –Y, + Z on top	QA	_______________
D 3-62	OPE	Turn ON flashlight	QA	_______________

D 3-63	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 3-64	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA______________
D 3-65	PC2	Verify in TCRealTime date/time	Date/time	______________
D 3-66	PC2	Verify in ADCS HKViewer date/time	Date/time	______________
D 3-67	PC2	Verify in HKViewer all ADCS HK green:	XLS	QA ______________
D 3-68	PC2	Verify ADCS 410-SS_YN_R1		QA ______________
D 3-69	PC2	Verify ADCS 412-SS_YN_R2		QA ______________
		(values should increase)		
D 3-70	OPE	Turn OFF flashlight		QA ______________
D 3-71	OPE	Place flashlight to the down-right corner		QA ______________
D 3-72	OPE	Turn ON flashlight		QA ______________
D 3-73	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 3-74	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA______________
D 3-75	PC2	Verify in TCRealTime date/time	Date/time	______________
D 3-76	PC2	Verify in ADCS HKViewer date/time	Date/time	______________
D 3-77	PC2	Verify in HKViewer all ADCS HK green:	XLS	QA ______________
D 3-78	PC2	Verify EPS 409-SS_YN_A1		QA ______________
D 3-79	PC2	Verify EPS 411-SS_YN_A2		QA ______________
		(values should increase)		
D 3-80	OPE	Turn OFF flashlight		QA ______________
D 3-81	OPE	Place flashlight to the top-right corner		QA ______________
D 3-82	OPE	Turn ON flashlight		QA ______________
D 3-83	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 3-84	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA______________
D 3-85	PC2	Verify in TCRealTime date/time	Date/time	______________
D 3-86	PC2	Verify in ADCS HKViewer date/time	Date/time	______________
D 3-87	PC2	Verify in HKViewer all ADCS HK green:	XLS	QA ______________
D 3-88	PC2	Verify EPS 409-SS_YN_A1		QA ______________
D 3-89	PC2	Verify EPS 411-SS_YN_A2		QA ______________
		(values should change)		
D 3-90	OPE	Turn OFF flashlight		QA ______________

Face + Y

D 3-91	OPE	Place flashlight perpendicular to face +Y, + Z on top	QA	________
D 3-92	OPE	Turn ON flashlight	QA	________
D 3-93	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	________
D 3-94	PC2	Verify in TCRealTime all TC Acknow are	© Green QA	________
D 3-95	PC2	Verify in TCRealTime date/time	Date/time	________
D 3-96	PC2	Verify in ADCS HKViewer date/time	Date/time	________
D 3-97	PC2	Verify in HKViewer all ADCS HK green:	XLS QA	________
D 3-98	PC2	Verify ADCS 414-SS_YP_R1	QA	________
D 3-99	PC2	Verify ADCS 416-SS_YP_R2 (values should increase)	QA	________
D 3-100	OPE	Turn OFF flashlight	QA	________
D 3-101	OPE	Place flashlight to the down-right corner	QA	________
D 3-102	OPE	Turn ON flashlight	QA	________
D 3-103	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	________
D 3-104	PC2	Verify in TCRealTime all TC Acknow are	© Green QA	________
D 3-105	PC2	Verify in TCRealTime date/time	Date/time	________
D 3-106	PC2	Verify in ADCS HKViewer date/time	Date/time	________
D 3-107	PC2	Verify in HKViewer all ADCS HK green:	XLS QA	________
D 3-108	PC2	Verify EPS 413-SS_YP_A1	QA	________
D 3-109	PC2	Verify EPS 415-SS_YP_A2 (values should increase)	QA	________
D 3-110	OPE	Turn OFF flashlight	QA	________
D 3-111	OPE	Place flashlight to the top-right corner	QA	________
D 3-112	OPE	Turn ON flashlight	QA	________
D 3-113	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	________
D 3-114	PC2	Verify in TCRealTime all TC Acknow are	© Green QA	________
D 3-115	PC2	Verify in TCRealTime date/time	Date/time	________
D 3-116	PC2	Verify in ADCS HKViewer date/time	Date/time	________
D 3-117	PC2	Verify in HKViewer all ADCS HK green:	XLS QA	________
D 3-118	PC2	Verify EPS 413-SS_YP_A1	QA	________
D 3-119	PC2	Verify EPS 415-SS_YP_A2 (values should change)	QA	________

D 3-120 OPE	Turn OFF flashlight		QA ______________

Face - Z

D 3-121 OPE	Place flashlight perpendicular to face –Z, + X on top		QA ______________
D 3-122 OPE	Turn ON flashlight		QA ______________
D 3-123 PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 3-124 PC2	Verify in TCRealTime all TC Acknow are	© Green	QA______________
D 3-125 PC2	Verify in TCRealTime date/time	Date/time	______________
D 3-126 PC2	Verify in ADCS HKViewer date/time	Date/time	______________
D 3-127 PC2	Verify in HKViewer all ADCS HK green:	XLS	QA ______________
D 3-128 PC2	Verify ADCS 418-SS_ZN_R1		QA ______________
D 3-129 PC2	Verify ADCS 420-SS_ZN_R2		QA ______________
	(values should increase)		
D 3-130 OPE	Turn OFF flashlight		QA ______________
D 3-131 OPE	Place flashlight to the down-right corner		QA ______________
D 3-132 OPE	Turn ON flashlight		QA ______________
D 3-133 PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 3-134 PC2	Verify in TCRealTime all TC Acknow are	© Green	QA______________
D 3-135 PC2	Verify in TCRealTime date/time	Date/time	______________
D 3-136 PC2	Verify in ADCS HKViewer date/time	Date/time	______________
D 3-137 PC2	Verify in HKViewer all ADCS HK green:	XLS	QA ______________
D 3-138 PC2	Verify EPS 417-SS_ZN_A1		QA ______________
D 3-139 PC2	Verify EPS 419-SS_ZN_A2		QA ______________
	(values should increase)		
D 3-140 OPE	Turn OFF flashlight		QA ______________
D 3-141 OPE	Place flashlight to the top-right corner		QA ______________
D 3-142 OPE	Turn ON flashlight		QA ______________
D 3-143 PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 3-144 PC2	Verify in TCRealTime all TC Acknow are	© Green	QA______________
D 3-145 PC2	Verify in TCRealTime date/time	Date/time	______________
D 3-146 PC2	Verify in ADCS HKViewer date/time	Date/time	______________
D 3-147 PC2	Verify in HKViewer all ADCS HK green:	XLS	QA ______________

D 3-148 PC2	Verify EPS 417-SS_ZN_A1		QA ______________
D 3-149 PC2	Verify EPS 419-SS_ZN_A2		QA ______________
	(values should change)		
D 3-150 OPE	Turn OFF flashlight		QA ______________

Face + Z

D 3-151 OPE	Place flashlight perpendicular to face + Z		QA ______________
D 3-152 OPE	Turn ON flashlight		QA ______________
D 3-153 PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 3-154 PC2	Verify in TCRealTime all TC Acknow are	© Green	QA______________
D 3-155 PC2	Verify in TCRealTime date/time	Date/time	______________
D 3-156 PC2	Verify in ADCS HKViewer date/time	Date/time	______________
D 3-157 PC2	Verify in HKViewer all ADCS HK green:	XLS	QA ______________
D 3-158 PC2	Verify ADCS 422-SS_ZP_R1		QA ______________
D 3-159 PC2	Verify ADCS 424-SS_ZP_R2		QA ______________
	(values should increase)		
D 3-160 OPE	Turn OFF flashlight		QA ______________
D 3-161 OPE	Place flashlight to the down-right corner		QA ______________
D 3-162 OPE	Turn ON flashlight		QA ______________
D 3-163 PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 3-164 PC2	Verify in TCRealTime all TC Acknow are	© Green	QA______________
D 3-165 PC2	Verify in TCRealTime date/time	Date/time	______________
D 3-166 PC2	Verify in ADCS HKViewer date/time	Date/time	______________
D 3-167 PC2	Verify in HKViewer all ADCS HK green:	XLS	QA ______________
D 3-168 PC2	Verify EPS 421-SS_ZP_A1		QA ______________
D 3-169 PC2	Verify EPS 423-SS_ZP_A2		QA ______________
	(values should increase)		
D 3-170 OPE	Turn OFF flashlight		QA ______________
D 3-171 OPE	Place flashlight to the top-right corner		QA ______________
D 3-172 OPE	Turn ON flashlight		QA ______________
D 3-173 PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 3-174 PC2	Verify in TCRealTime all TC Acknow are	© Green	QA______________

D 3-175	PC2	Verify in TCRealTime date/time	Date/time		______________
D 3-176	PC2	Verify in ADCS HKViewer date/time	Date/time		______________
D 3-177	PC2	Verify in HKViewer all ADCS HK green:	XLS	QA	______________
D 3-178	PC2	Verify EPS 421-SS_ZP_A1		QA	______________
D 3-179	PC2	Verify EPS 423-SS_ZP_A2 (values should change)		QA	______________
D 3-180	OPE	Turn OFF flashlight		QA	______________

4) Verification of Gyros

Rotation around Z Clockwise (+Z on top)

D 4-1	OPE	Rotate satellite slowly around + Z Clockwise (180 deg in 60 sec = 3 deg/sec)	QA		______________
D 4-2	PC2	Send FCT_EPS_GENERATE_HK	No Parameter		______________
D 4-3	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
D 4-4	PC2	Verify in TCRealTime date/time	Date/time		______________
D 4-5	PC2	Verify in ADCS HKViewer date/time	Date/time		______________
D 4-6	PC2	Verify in HKViewer all ADCS HK green:	XLS	QA	______________
D 4-7	PC2	Verify ADCS 445-GYRO_Z_MEAS (values should increase, and be positive)		QA	______________
D 4-8	OPE	Stop rotation, set satellite back on table		QA	______________

Rotation around Z CounterClockwise (+Z on top)

D 4-9	OPE	Rotate satellite slowly around + Z Clockwise (180 deg in 60 sec = 3 deg/sec)	QA		______________
D 4-10	PC2	Send FCT_EPS_GENERATE_HK	No Parameter		______________
D 4-11	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
D 4-12	PC2	Verify in TCRealTime date/time	Date/time		______________
D 4-13	PC2	Verify in ADCS HKViewer date/time	Date/time		______________
D 4-14	PC2	Verify in HKViewer all ADCS HK green:	XLS	QA	______________
D 4-15	PC2	Verify ADCS 445-GYRO_Z_MEAS (values should increase, and be positive)		QA	______________
D 4-16	OPE	Stop rotation, set satellite back on table		QA	______________

Rotation around X Clockwise (+X on top)

D 4-17	OPE	Rotate satellite slowly around + Z Clockwise (180 deg in 60 sec = 3 deg/sec)	QA	________
D 4-18	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	________
D 4-19	PC2	Verify in TCRealTime all TC Acknow are	© Green QA	________
D 4-20	PC2	Verify in TCRealTime date/time	Date/time	________
D 4-21	PC2	Verify in ADCS HKViewer date/time	Date/time	________
D 4-22	PC2	Verify in HKViewer all ADCS HK green:	XLS QA	________
D 4-23	PC2	Verify ADCS 443-GYRO_X_MEAS (values should increase, and be positive)	QA	________
D 4-24	OPE	Stop rotation, set satellite back on table	QA	________

Rotation around X CounterClockwise (+X on top)

D 4-25	OPE	Rotate satellite slowly around + Z Clockwise (180 deg in 60 sec = 3 deg/sec)	QA	________
D 4-26	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	________
D 4-27	PC2	Verify in TCRealTime all TC Acknow are	© Green QA	________
D 4-28	PC2	Verify in TCRealTime date/time	Date/time	________
D 4-29	PC2	Verify in ADCS HKViewer date/time	Date/time	________
D 4-30	PC2	Verify in HKViewer all ADCS HK green:	XLS QA	________
D 4-31	PC2	Verify ADCS 443-GYRO_X_MEAS (values should increase, and be positive)	QA	________
D 4-32	OPE	Stop rotation, set satellite back on table	QA	________

Rotation around Y Clockwise (+Y on top)

D 4-33	OPE	Rotate satellite slowly around + Z Clockwise (180 deg in 60 sec = 3 deg/sec)	QA	________
D 4-34	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	________
D 4-35	PC2	Verify in TCRealTime all TC Acknow are	© Green QA	________
D 4-36	PC2	Verify in TCRealTime date/time	Date/time	________
D 4-37	PC2	Verify in ADCS HKViewer date/time	Date/time	________
D 4-38	PC2	Verify in HKViewer all ADCS HK green:	XLS QA	________
D 4-39	PC2	Verify ADCS 444-GYRO_Y_MEAS (values should increase, and be positive)	QA	________
D 4-40	OPE	Stop rotation, set satellite back on table	QA	________

Rotation around Y CounterClockwise (+Y on top)

D 4-41	OPE	Rotate satellite slowly around + Z Clockwise (180 deg in 60 sec = 3 deg/sec)		QA	______________
D 4-42	PC2	Send FCT_EPS_GENERATE_HK	No Parameter		______________
D 4-43	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
D 4-44	PC2	Verify in TCRealTime date/time	Date/time		______________
D 4-45	PC2	Verify in ADCS HKViewer date/time	Date/time		______________
D 4-46	PC2	Verify in HKViewer all ADCS HK green:	XLS	QA	______________
D 4-47	PC2	Verify ADCS 444-GYRO_Y_MEAS (values should increase, and be positive)		QA	______________
D 4-48	OPE	Stop rotation, set satellite back on table		QA	______________

5) Verification of MT

D 5-1	PC2	Send FCT_ADCS_SET_MSP_MODE	Parameter: 0		______________
D 5-2	PC2	Send FCT_EPS_GENERATE_HK	No Parameter		______________
D 5-3	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
D 5-4	PC2	Verify in TCRealTime date/time	Date/time		______________
D 5-5	PC2	Verify in ADCS HKViewer date/time	Date/time		______________
D 5-6	PC2	Verify in HKViewer all ADCS HK green:		QA	______________
D 5-7	OPE	Bring compass to - X face, needle align perpendicular to face (red goes out face)		QA	______________
D 5-8	PC2	Send FCT_ADCS_SET_MT_OFFSET	P: 127, 127, 127		______________
D 5-9	PC2	Send FCT_EPS_GENERATE_HK	No Parameter		______________
D 5-10	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
D 5-11	PC2	Verify in TCRealTime date/time	Date/time		______________
D 5-12	PC2	Verify in ADCS HKViewer date/time	Date/time		______________
D 5-13	PC2	Verify in HKViewer all ADCS HK green:	XLS	QA	______________
D 5-14	PC2	Verify ADCS 463-MSP_MODE	0	QA	______________
D 5-15	PC2	Verify ADCS 449-BD_X_OFFSET	12700	QA	______________
D 5-16	PC2	Verify ADCS 450-BD_Y_ OFFSET	12700	QA	______________
D 5-17	PC2	Verify ADCS 451-BD_Z_ OFFSET	12700	QA	______________

D 5-18	PC2	Verify ADCS 457-MT_X_MEAS	QA	______________
D 5-19	OPE	Note deviation MT -X	red out of face	______________
D 5-20	PC2	Send FCT_ADCS_SET_MT_OFFSET	P: 0, 0, 0	______________
D 5-21	OPE	Bring compass to + Y face, needle align perpendicular to face (red goes out face)	QA	______________
D 5-22	PC2	Send FCT_ADCS_SET_MT_OFFSET	P: 127, 127, 127	______________
D 5-23	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 5-24	PC2	Verify in TCRealTime all TC Acknow are	© Green QA	______________
D 5-25	PC2	Verify in TCRealTime date/time	Date/time	______________
D 5-26	PC2	Verify in ADCS HKViewer date/time	Date/time	______________
D 5-27	PC2	Verify ADCS 458-MT_Y_MEAS	QA	______________
D 5-28	OPE	Note deviation MT + Y	red out of face	______________
D 5-29	PC2	Send FCT_ADCS_SET_MT_OFFSET	P: 0, 0, 0	______________
D 5-30	OPE	Bring compass to - Z face, needle align perpendicular to face (red goes in face)	QA	______________
D 5-31	PC2	Send FCT_ADCS_SET_MT_OFFSET	P: 127, 127, 127	______________
D 5-32	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 5-33	PC2	Verify in TCRealTime all TC Acknow are	© Green QA	______________
D 5-34	PC2	Verify in TCRealTime date/time	Date/time	______________
D 5-35	PC2	Verify in ADCS HKViewer date/time	Date/time	______________
D 5-36	PC2	Verify ADCS 459-MT_Z_MEAS	QA	______________
D 5-37	OPE	Note deviation MT + Y	red in face	______________
D 5-38	PC2	Send FCT_ADCS_SET_MT_OFFSET	P: 0, 0, 0	______________

6) Power down ADCS Board

D 6-1	PC2	Send FCT_EPS_PWR_DOWN_SS (script: PowerDownADCS)	para: ADCS	______________
D 6-2	PC2	Verify in TCRealTime all TC Acknow are	© Green QA	______________
D 6-3	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
D 6-4	PC2	Verify in TCRealTime all TC Acknow are	© Green QA	______________
D 6-5	PC2	Verify in TCRealTime date/time	Date/time	______________

D 6-6	PC2	Verify in ADCS HKViewer date/time	Date/time	________
D 6-7	PC2	Verify in HKViewer all EPS HK green:	QA	________
D 6-8	PC2	Verify detailed COM default values and parameters: XLS	QA	________
D 6-9	PC2	Verify detailed EPS default values and parameters: XLS	QA	________
D 6-10	PC2	Verify detailed ADCS default values and parameters: (should see no packet)	QA	________
D 6-11	PC2	Verify EPS 134-ST_ADCS	QA	________

7) End sequence

D 7-1 PRO If HK correct go back to Paragraph **Error! Reference source not found.** ________

D 7-2 PRO If HK NOT correct STOP ________

8) Verification of the ADCS functions (Software functions)

D 8-1 PRO Check if SW functions have been tested Laurent? QA ________

FCT_ADCS_SET_BD_ILIMIT 0x51

FCT_ADCS_CHANGE_MT_SIGN 0x52

FCT_ADCS_SET_MT_GAIN 0x53

FCT_ADCS_ENABLE_MSP_COMPONENT 0x56

FCT_ADCS_DISABLE_MSP_COMPONENT 0x57

FCT_ADCS_SET_BD_LAMBDA 0x58

FCT_ADCS_SET_BD_THRESHOLD 0x59

(All sensors should be enabled)

Appendix E PL Functions

This section will verify all functions of the Payload. This test procedure is also applicable for the PL alignment test. It will first power up ADCS after again with PL, and will take a picture and download it. This picture will be used for the alignment test. This procedure will also verify the COM-Emergency Safe Mode. This function will turn both ADCS and PL off.

Assumptions:

- Satellite is in safe mode
- Satellite on Optical Bench if alignment test
- EPS, COM are ON
- ADCS is OFF
- Chronometer.

188 pixels in one line, about 250 bytes

COM: RF 150 bytes/sec

120 lines, 120 x 250 /150, in other words 3 min 20 sec of reception

Set-up:

In the Mission Data Client, open Image Service Open QA ______________

TEST ABF #1:	**Users**	**ON**	**OFF**
	ADS	**ON**	**OFF**
	Beacon	**ON**	**OFF**
	RF	**ON**	**OFF**

Personnel involved:

OPERATOR	OPE	Nicolas Steiner	______________
Computer 1 (COM)	PC1	Florian George	______________
Computer 2 (MCS)	PC2	Yann Voumard	______________
Procedure run	PRO	Muriel Noca	______________
Engineer EPS	EPS	Nicolas Steiner	______________

Engineer COM	COM	Ted Choueiri	________
Engineer ADCS	ADCS	Laurent Hauser	________
Engineer PL	PL	Noémy Scheidegger	________
Safety/QA	QA	Fabien Jordan	________

Start Procedure:

Set-up done + QA ____ ____ ***Date:*** ________ ***Time*** ________

1) Power up ADCS and PL board

E 1-1	PC2	Send FCT_EPS_PWR_UP_SS (script: PowerUpADCS)	para: ADCS		________
E 1-2	PC2	Verify in TCRealTime all TC Acknow are (if not green, try **once** to send TC again)	© Green	QA	________
E 1-3	OPE	Wait for 20 seconds			________
E 1-4	PC2	Send FCT_EPS_PWR_UP_SS (Script: PowerUpPL)	para: PL		________
E 1-5	PC2	Verify in TCRealTime all TC Acknow are (if not green, try **once** to send TC again)	© Green	QA	________
E 1-6	OPE	Wait for 10 seconds			________
E 1-7	PC2	Send FCT_EPS_GENERATE_HK	No Parameter		________
E 1-8	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	________
E 1-9	PC2	Verify in TCRealTime date/time	Date/time		________
E 1-10	PC2	Verify in PL HKViewer date/time	Date/time		________
E 1-11	PC2	Verify detailed COM default values and parameters:	XLS	QA	________
E 1-12	PC2	Verify detailed EPS default values and parameters:	XLS	QA	________
E 1-13	PC2	Verify detailed ADCS default values and parameters:	XLS	QA	________
E 1-14	PC2	Verify detailed PL default values and parameters:	XLS	QA	________
E 1-15	PC2	Verify EPS 134-ST_ADCS	ON	QA	________
E 1-16	PC2	Verify EPS 133-ST_PL	ON	QA	________
E 1-17	PC2	Verify EPS 144-Error_Code	0	QA	________
E 1-18	PC2	Verify EPS 111-PBUS_D_V		QA	________
E 1-19	PC2	Verify EPS 112-PBUS_A_V		QA	________

E 1-20	PC2	Verify Vbat Viewer Vbat1+	3.5-4.2 V		______________
E 1-21	PC2	Verify Vbat Viewer Vbat2+	3.5-4.2 V		______________

2) Execute script to take a picture: (to do the alignment of the PL)

This script sends a telecommand that makes the EPS turn on the camera, take the picture and turn off camera.

E 2-1	PC2	Send script TakePicture	No Parameter		______________
E 2-2	PC2	Verify in TCRealTime all TC Acknow are (if not green, try **once** to send TC again)	© Green	QA	______________
E 2-3	PC2	Verify SNIFFER, activity on I2C bus		QA	______________
E 2-4	PC2	Send FCT_EPS_GENERATE_HK	No Parameter		______________
E 2-5	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
E 2-6	PC2	Verify in TCRealTime date/time	Date/time		______________
E 2-7	PC2	Verify in PL HKViewer date/time	Date/time		______________
E 2-8	PC2	Verify detailed COM all green		QA	______________
E 2-9	PC2	Verify detailed EPS default values and parameters:	XLS	QA	______________
E 2-10	PC2	Verify detailed ADCS all green		QA	______________
E 2-11	PC2	Verify detailed PL default values and parameters:	XLS	QA	______________
E 2-12	PC2	Verify PL 306-IMAGE_READY	YES	QA	______________

3) Retrieve picture information

This script gets from EPS the information about the image just captured.

E 3-1	PC2	Send script GetImageInfo	No Parameter		______________
E 3-2	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
E 3-3	PC2	Verify in TRACING the two messages in white:			
		"IMAGE SERVICE": AVAILABLE_IMAGE_REPORT received		QA	______________
		"IMAGE SERVICE": IMAGE added received		QA	______________
		(ID is a number that gets incremented, Time should be current time)			
E 3-3	PC2	In IMAGE Service, verify image number	Number?		______________
E 3-4	PC2	In IMAGE Service, verify image time	Time?		______________
E 3-5	PC2	In IMAGE Service, select image		QA	______________

4) Retrieve picture data

This script asks EPS to send down each line of the PL image.

E 4-1	PC2	Send script GetImage	No Parameter	____________
E 4-2	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA ____________
E 4-3	OPE	Every 45 sec, send following CMD: (to keep from time_out COM)		QA ____________
E 4-4	PC2	Send FCT_COM_GENERATE_HK	No Parameter	____________
E 4-5	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA ____________
E 4-6	PC2	In IMAGE Service, verify reception image (Can check in Tracing each line downloaded) (If image partially received, try GetImage script again)		QA ____________
E 4-7	PC2	In IMAGE Service, select image (right click), choose Export Image, save file		QA ____________
E 4-8	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	____________
E 4-9	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA____________
E 4-10	PC2	Verify in TCRealTime date/time	Date/time	____________
E 4-11	PC2	Verify in PL HKViewer date/time	Date/time	____________
E 4-12	PC2	Verify detailed COM all green		QA ____________
E 4-13	PC2	Verify detailed EPS default values and parameters:	XLS	QA ____________
E 4-14	PC2	Verify detailed ADCS all green		QA ____________
E 4-15	PC2	Verify detailed PL default values and parameters: (verify PL hasn't changed, values should be as expected)	XLS	QA ____________
E 4-16	PC2	Verify PL 306-IMAGE_READY	YES	QA ____________

5) Perform Emergency Safe Mode

(this will turn ADCS and PL off)

E 5-1	PC2	Send script FCT_COM_EMGCY_SAFE	No Parameter	____________
E 5-2	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA ____________
E 5-3	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	____________
E 5-4	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA____________
E 5-5	PC2	Verify in TCRealTime date/time	Date/time	____________

E 5-6	PC2	Verify in EPS HKViewer date/time	Date/time		______________
E 5-7	PC2	Verify detailed COM all green		QA	______________
E 5-8	PC2	Verify detailed EPS default values and parameters:	XLS	QA	______________
E 5-9	PC2	Verify EPS 134-ST_ADCS	OFF	QA	______________
E 5-10	PC2	Verify EPS 133-ST_PL	OFF	QA	______________
E 5-11	PC2	Verify EPS 144-Error_Code	!20	QA	______________
E 5-12	PC2	Send script RESET_ERROR_CODE	No Parameter		______________
E 5-13	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
E 5-14	PC2	Send FCT_EPS_GENERATE_HK	No Parameter		______________
E 5-15	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
E 5-16	PC2	Verify in TCRealTime date/time	Date/time		______________
E 5-17	PC2	Verify in EPS HKViewer date/time	Date/time		______________
E 5-18	PC2	Verify detailed COM all green		QA	______________
E 5-19	PC2	Verify detailed EPS default values and parameters:	XLS	QA	______________
E 5-20	PC2	Verify EPS 134-ST_ADCS	OFF	QA	______________
E 5-21	PC2	Verify EPS 133-ST_PL	OFF	QA	______________
E 5-22	PC2	Verify EPS 144-Error_Code	0	QA	______________

6) End sequence

A 6-1 PRO If HK correct go back to Paragraph **Error! Reference source not found.** ______________

A 6-2 PRO If HK NOT correct STOP ______________

Appendix F Communication Thread

This section verifies that the RF signal is correctly emitted from the satellite (downlink) and that the satellite receives the signal correctly (uplink). This procedure can be applied to deployed or stowed antennas. The subsystems involved are: COM; EPS, Beacon. The ABF used in this procedure is the Test ABF #2, which actually connects the RF part of the COM board and connects the Beacon board.

This section can also be combined with Appendix G during TVC with the flight ABF.

It can also be used repeatedly during TVC to check the variation in frequency of the transmitter as a function of temperature.

There is an additional set-up to perform for this procedure.

The assumptions are:

- the kill switches are OFF (pressure on the satellite)
- the service connector is connected
- Chronometer ready
- Expected values are at 20 deg.C
- ABF is plugged in: see version of ABF
- the test computer is on ready to send commands.

TEST ABF #2:	**Users**	**ON**	**OFF**
	ADS	**ON**	**OFF**
	Beacon	**ON**	**OFF**
	RF	**ON**	**OFF**

Additional set-up:

1) Connect ICOM to Power Supply (red and black big wires) QA Hardware _______________
2) Power Supply: voltage button up to middle value (round shape) QA Hardware _______________
3) On ICOM: plug in small antenna (10 cm) on "Antenna In" connector
   QA Hardware _______________
4) On ICOM: plug in AudioJack (back)
   QA Hardware _______________

5) Plug other jack in PC1 Microphone connector QA Hardware _______________
6) On ICOM: set volume Audio very close to "0" (left down) QA Hardware _______________
7) On ICOM: verify AF – RF squelch to center (top) QA Hardware _______________
8) On ICOM: verify USB written on display. If not change with SSB/CW button
QA Hardware _______________

For BEACON:

9) Turn ON Power Supply and ICOM QA Hardware _______________
10) Select frequency to 437.502 MHz QA Hardware _______________
11) On PC1: Open Labview in "Beacon Test Program" file "FTDI-Morse-Coding-3-1".
QA Software _______________
12) On PC1: Labview: hit "run continuously" QA Software _______________
13) On PC1: Select file name or name new one Add.txt QA Software _______________
14) On PC1: Verify FT_OK in both selections QA Software _______________
15) On PC1: Open MixW QA Software _______________
16) On PC1: MixW: go to Mode, select CW QA Software _______________
17) On PC1: MixW: Click on green line to place the Delta on the signal
QA Software _______________
18) Wait for signal emission; QA Software _______________

For COM downlink:

19) On PC1: Open in folder "S3 GS" the virtual computer QA Software _______________
20) On PC1: Open 1., 2., 3. QA Software _______________
21) On PC1: In Mission Data Client, open HK Overview QA Software _______________
22) On PC1: Open "MixW Manager" on desktop QA Software _______________
23) On PC1: Touch F5, a window opens QA Software _______________
24) On PC1: Open MixW (the one used for the Beacon) QA Software _______________
25) On PC1: MixW: go to Mode, select Packet QA Software _______________
26) On PC1: MixW: go to Mode Settings, verify in "General" that Emulate Kiss TNC is selected
QA Software _______________
27) On PC1: MixW: go to Mode Settings, verify in "Modem" that VHF 1200 Baud (standard) is selected
QA Software _______________
28) On PC1: MixW: go to Configure: TNC emulation: Port Com 13
QA Software _______________

29) On PC1: MixW: go to Configure: Echo + HW Flow Control ON
QA Software ____________

30) On PC1: MixW: go to Configure: Disable device OFF QA Software ____________

31) Wait for signal emission. QA Software ____________

Personnel involved:

OPERATOR	OPE	Nicolas Steiner	____________
Computer 1 (COM)	PC1	Florian George	____________
Computer 2 (MCS)	PC2	Yann Voumard	____________
Procedure run	PRO	Muriel Noca	____________
Engineer EPS	EPS	Nicolas Steiner	____________
Engineer COM	COM	Ted Choueiri	____________
Engineer ADCS	ADCS	Laurent Hauser	____________
Engineer PL	PL	Noémy Scheidegger	____________
Safety/QA	QA	Fabien Jordan	____________

Start Procedure:

Set-up done + QA ____ ____ ***Date:*** ________ ***Time*** ________

1) Start-up sequence, time operations, hardware beacon signal verification

F 1-1	OPE	Release switches & start chronometer	OK	____________
F 1-2	OPE	Verify Vcs (CHARGE_1/2)	3.07-3.53 V	____________
F 1-3	OPE	Verify Vcs_after_ABF (SUPPLY 1/2)	3.07-3.53 V	____________
F 1-4	PC1	Verify BEAC_SIG right after 17 min 25 sec	Time	____________
			HB9EG/1	____________

The operator has 2 minutes to verify that the HW Beacon runs correctly. It should be heard 5 times.

F 1-5	OPE	Verify delta-time between 2 BEAC_SIG	Time	____________
			Time	____________
			Time	____________
			56 sec	____________

2) After 20 minutes: SW Beacon

F 2-1 PC1 Verify BEAC_SIG right after 20 min Time ____________
SW Signal 0 ____________
SW Signal 1 ____________
SW Signal 2 ____________
SW Signal 3 ____________

F 2-2 OPE Verify delta-time between 2 BEAC_SIG Time ____________
30 sec ____________

SW Signal	Content
Part 0	HB9EG/1
Part 1	1 S 0 1
Part 2	2 Vbat1 Vbat2
Part 3	3 cellx6 TBat1

3) Verification of the downlink

F 3-1 PC2 Send FCT_COM_GENERATE_HK 5 times No Parameter ____________
F 3-2 PC2 Verify in TCRealTime all TC Acknow are © Green QA ____________
F 3-3 OPE Tune frequencies on ICOM until good signal reception
Frequency? ____________
F 3-4 PC1 Verify reception of COM packet on MixW QA ____________
F 3-5 PC1 Verify in TCRealTime date/time Date/time ____________
F 3-6 PC1 Verify in COM HKViewer date/time Date/time ____________
F 3-7 PC1 Verify detailed COM all green QA ____________
F 3-8 PC1 Verify detailed COM default values and parameters: XLS QA____________

At this point the frequency should be selected correctly.

F 3-9 PC2 Send FCT_EPS_GENERATE_HK 1 time No Parameter ____________
F 3-10 PC2 Verify in TCRealTime all TC Acknow are © Green QA ____________
F 3-11 PC1 Verify reception of EPS packet on MixW QA ____________

F 3-12	PC1	Verify in TCRealTime date/time	Date/time	_______________
F 3-13	PC1	Verify in EPS HKViewer date/time	Date/time	_______________
F 3-14	PC1	Verify in HKViewer all COM HK green:	QA	_______________
F 3-15	PC1	Verify detailed COM default values and parameters: XLS	QA	_______________
F 3-16	PC1	Verify detailed EPS default values and parameters: XLS	QA	_______________

3) Verification of the uplink

To be implemented.

4) End sequence

F 4-1 PRO If HK correct go back to Paragraph **Error! Reference source not found.**

____

F 4-2 PRO If HK NOT correct STOP _______________

Additional notes

To be verified in COM Qual test: in addition to COM and EPS, we should verify ADCS and PL operations (EMC might get very interesting, turn on MT full power)

COM test during TVC

Set values of the DAC: FCT_COM_SET_TX_DAC

Reinitialize DAC values

Appendix G ADS Deployment

This procedure will verify proper Antenna Deployment. It is divided into two different sections. The first section (A) will initiate antenna deployment immediately. The second section (B) will follow the initial start-up sequence. This last section can be combined with the RF COM test (thread).

Section A will be used to verify proper deployment at the end of the Vibration tests. Section B will be used during TVC.

The assumptions for section B are:

- 4 wires are connected to both ADS heaters (2 wires on each heater): Vads1 (SW), Vads2 (HW)
- these 4 wires are connected to 2 voltmeters VM on the other end(outside chamber)
- the kill switches are OFF (pressure on the satellite)
- the service connector is connected (not a requirement if combined with RF test)
- Chronometer ready
- Expected values are at 20 deg.C
- ABF is plugged in: see version of ABF
- the test computer is on ready to send commands.

The assumptions for section A are the same as for Option B but:

- the satellite is in Safe mode.

ABF Flight version:	**Users**	**ON**	**OFF**
	ADS	**ON**	**OFF**
	Beacon	**ON**	**OFF**
	RF	**ON**	**OFF**

Personnel involved:

OPERATOR	OPE	Nicolas Steiner	______________
Computer 1 (COM)	PC1	Florian George	______________
Computer 2 (MCS)	PC2	Yann Voumard	______________

Procedure run	PRO	Muriel Noca	______________
Engineer EPS	EPS	Nicolas Steiner	______________
Engineer COM	COM	Ted Choueiri	______________
Engineer ADCS	ADCS	Laurent Hauser	______________
Engineer PL	PL	Noémy Scheidegger	______________
Safety/QA	QA	Fabien Jordan	______________

Start Procedure:

Set-up done + QA ____ ____ ***Date:*** ________ ***Time*** ________

SECTION: ***A*** ***B***

Section A

1) Verify battery voltage and execute command

G 1-1	PC2	Verify Vbat Viewer Vbat1+	3.5-4.2 V	______________
G 1-2	PC2	Verify Vbat Viewer Vbat2+	3.5-4.2 V	______________
G 1-3	PC2	Verify Vcs_after_ABF (SUPPLY 1/2)	3.07-3.53 V	______________
G 1-4	PC2	Send script FCT_EPS_ANTENNA_DEPLOY		______________
G 1-5	PC2	Verify in TCRealTime all TC Acknow are (if not green, try **once** to send TC again)	© Green QA	______________
G 1-6	OPE	Verify SW burn-up duration Vads1	3.07-3.53 V	______________
			start time	______________
			end time	______________
			Diff. 16 sec	______________
G 1-7	OPE	Verify Soft Deployment successful		______________

Section B

0) Verify battery voltage and execute command

G 0-1	PC2	Verify Vbat Viewer Vbat1+	3.5-4.2 V	______________
G 0-2	PC2	Verify Vbat Viewer Vbat2+	3.5-4.2 V	______________
G 0-3	OPE	Verify Vcs_after_ABF (SUPPLY 1/2)	0 V	______________

1) Release kill switches and time operations

G 1-1	OPE	Release switches & start chronometer	OK	______________
G 1-2	PC2	Verify Vcs_after_ABF (SUPPLY 1/2)	3.07-3.53 V	______________
G 1-3	OPE	Verify Soft Deployment after 15 min Vads1	3.07-3.53 V	______________
			15 min	______________
G 1-4	OPE	Verify burn-up duration	start time	______________
			end time	______________
			Diff. 16 sec	______________
G 1-5	OPE	Verify Hard Deployment after 17 min 25 sec Vads2		
			3.07-3.53 V	______________
			17 min 25 sec	______________
G 1-6	OPE	Verify burn-up duration	start time	______________
			end time	______________
			Diff. 16 sec	______________

2) After 20 minutes: SW ADS deployment

G 2-1	OPE	Verify Soft Deployment after 20 min Vads1	3.07-3.53 V	______________
			20 min	______________
G 2-2	OPE	Verify burn-up duration	start time	______________
			end time	______________
			Diff. 16 sec	______________

3) After 3 hours: SW ADS deployment

G 3-1	OPE	Verify SW deployment after 3 hrs Vads1	SW:3.07-3.53 V	______________
			3 hrs	______________
G 3-2	OPE	Verify burn-up duration	start time	______________
			end time	______________
			Diff. 16 sec	______________

4) End sequence

A 4-1	PRO	If HK correct go back to Paragraph Paragraph J-2	________________
A 4-2	PRO	If HK NOT correct STOP	________________

Appendix H Functional TVC

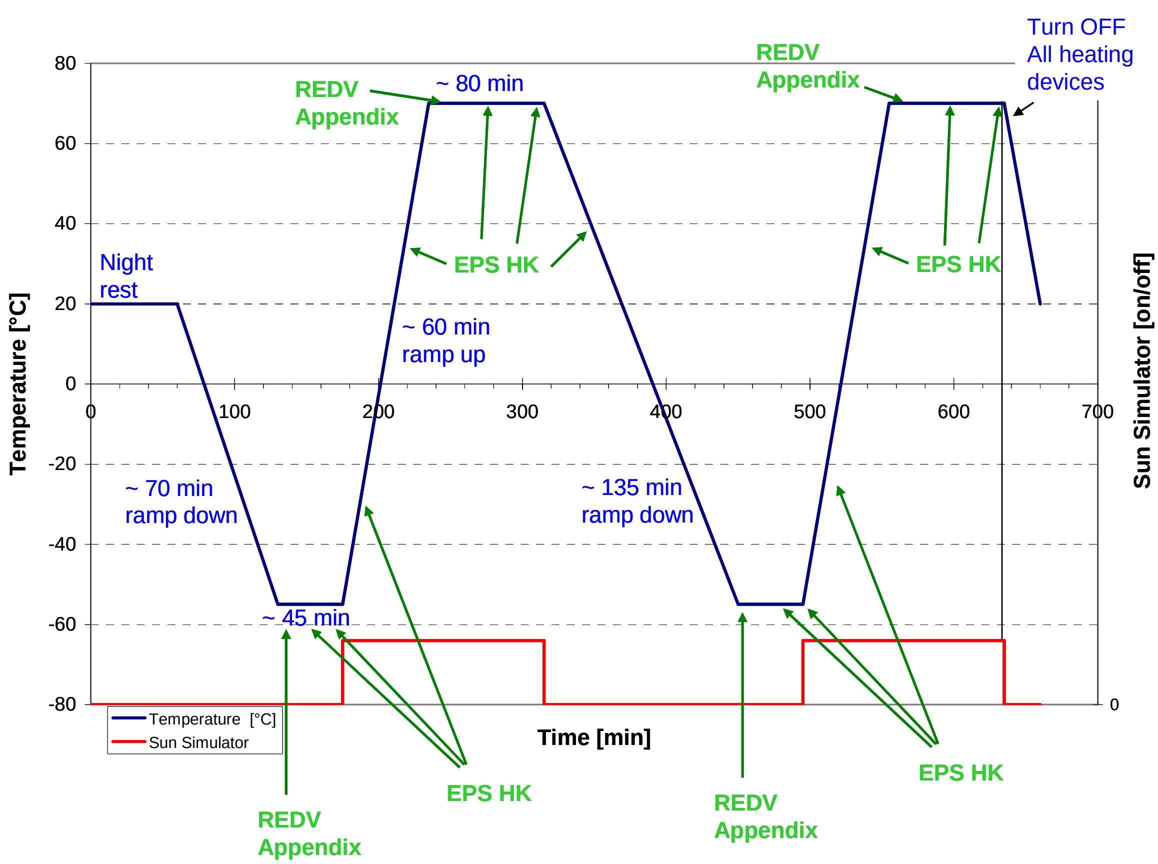
This procedure is specific to the TVC test in Bern and to the tests that can be done while the satellite is in the vacuum chamber. This part does not include any ADS or RF communication.

The assumptions are:

- the kill switches are ON (the satellite is operational)
- the service connector is connected
- ABF is plugged in: see version of ABF
- the test computer is on ready to send commands.

Please Note: the HK data is saved in the XLS file "S3-D-SET-1-3-REDV_HK_record" under the Appendix A Tab.

This procedure shall be used during each cycle as such:



Note: In the nominal case, the batteries should be charged and the cold cycle starts. When the chamber reaches its minimum temperature (on the table and shroud), then we start counting 45 minutes for the cold plateau. The satellite will cool down slowly as the battery board will keep the batteries running until the whole power bus goes below 3.7 V. At that point, the whole satellite shuts down and cools to lower temperature. The temperature records will verify the correct operations of the battery board.

TEST ABF #2:	**Users**	**ON**	**OFF**
	ADS	**ON**	**OFF**
	Beacon	**ON**	**OFF**
	RF	**ON**	**OFF**

Personnel involved:

OPERATOR	OPE	Nicolas Steiner	________
Computer 1 (COM)	PC1	Florian George	________
Computer 2 (MCS)	PC2	Yann Voumard	________
Procedure run	PRO	Muriel Noca	________
Engineer EPS	EPS	Nicolas Steiner	________
Engineer COM	COM	Ted Choueiri	________
Engineer ADCS	ADCS	Laurent Hauser	________
Engineer PL	PL	Noémy Scheidegger	________
Safety/QA	QA	Fabien Jordan	________

Start Procedure:

Set-up done + QA ____ ____ ***Date:*** ________ ***Time*** ________

0) Verify battery voltage

H 0-1	PC2	Verify Vbat Viewer (IBV) Vbat1+	3.5-4.2 V	________
H 0-2	PC2	Verify Vbat Viewer (IBV) Vbat2+	3.5-4.2 V	________
H 0-3	OPE	Verify Vcs_after_ABF (SUPPLY 1/2)	3.07-3.53 V	________

1) Verify Beacon signal

H 1-1	PC1	Verify BEAC_SIG (4 diff. messages)	Time	____________
			SW Signal 0	____________
			SW Signal 1	____________
			SW Signal 2	____________
			SW Signal 3	____________

2) Verify EPS and COM operations and safe mode (EPS and COM HK)

H 2-1	PC2	Send FCT_EPS_GENERATE_HK	No Param.	____________
H 2-2	PC2	Verify in TCRealTime all TC Acknow are (if not green, try **once** to send TC again)	© Green QA	____________
H 2-3	PC2	Verify in TCRealTime date/time	Date/time	____________

We expect to see 2 packets: one for EPS and one for COM

H 2-4	PC2	Verify in COM HKViewer date/time	Date/time	____________
H 2-5	PC2	Verify in HKViewer all COM HK green:	QA	____________
H 2-6	PC2	Verify detailed COM default values and parameters:	XLS QA	____________
H 2-7	PC2	Verify 3 COM temperature readings are consistent (values should be close to each other)	QA	____________
H 2-8	PC2	Verify in EPS HKViewer date/time	Date/time	____________
H 2-9	PC2	Verify in HKViewer all EPS HK green:	QA	____________
H 2-10	PC2	Verify detailed EPS default values and parameters:	XLS QA	____________
H 2-11	PC2	Verify 13 EPS temperature readings are consistent (values should be close to each other)	QA	____________
A 2-12	PC2	Verify Spacecraft Mode (143) is SAFE	QA	____________

3) Verify operations of Solar Cells/Panels

H 3-1	OPE	When Sat +X panel faces Sun Sim:	No Param.	____________
H 3-2	PC2	Send FCT_EPS_GENERATE_HK	No Param.	____________
H 3-3	PC2	Verify in TCRealTime all TC Acknow are	© Green QA	____________
H 3-4	PC2	Verify in TCRealTime date/time	Date/time	____________
H 3-5	PC2	Verify in EPS HKViewer date/time	Date/time	____________

H 3-6	PC2	Verify in HKViewer all EPS HK green:		QA	______________
H 3-7	PC2	Verify detailed EPS default values and parameters:	XLS	QA	______________
H 3-8	PC2	Solar Cell +X current (119)		QA	______________
H 3-9	PC2	Solar Cell +X temperature (125)		QA	______________
H 3-10	OPE	When Sat +Y panel faces Sun Sim:	No Param.		______________
H 3-11	PC2	Send FCT_EPS_GENERATE_HK	No Param.		______________
H 3-12	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
H 3-13	PC2	Verify in TCRealTime date/time	Date/time		______________
H 3-14	PC2	Verify in EPS HKViewer date/time	Date/time		______________
H 3-15	PC2	Verify in HKViewer all EPS HK green:		QA	______________
H 3-16	PC2	Verify detailed EPS default values and parameters:	XLS	QA	______________
H 3-17	PC2	Solar Cell +Y current (121)		QA	______________
H 3-18	PC2	Solar Cell +Y temperature (127)		QA	______________
H 3-19	OPE	When Sat -X panel faces Sun Sim:	No Param.		______________
H 3-20	PC2	Send FCT_EPS_GENERATE_HK	No Param.		______________
H 3-21	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
H 3-22	PC2	Verify in TCRealTime date/time	Date/time		______________
H 3-23	PC2	Verify in EPS HKViewer date/time	Date/time		______________
H 3-24	PC2	Verify in HKViewer all EPS HK green:		QA	______________
H 3-25	PC2	Verify detailed EPS default values and parameters:	XLS	QA	______________
H 3-26	PC2	Solar Cell -X current (118)		QA	______________
H 3-27	PC2	Solar Cell +X temperature (124)		QA	______________
H 3-28	OPE	When Sat -Y panel faces Sun Sim:	No Param.		______________
H 3-29	PC2	Send FCT_EPS_GENERATE_HK	No Param.		______________
H 3-30	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	______________
H 3-31	PC2	Verify in TCRealTime date/time	Date/time		______________
H 3-32	PC2	Verify in EPS HKViewer date/time	Date/time		______________
H 3-33	PC2	Verify in HKViewer all EPS HK green:		QA	______________
H 3-34	PC2	Verify detailed EPS default values and parameters:	XLS	QA	______________
H 3-35	PC2	Solar Cell -Y current (120)		QA	______________
H 3-36	PC2	Solar Cell +X temperature (126)		QA	______________

4) Verify ADCS

IF ADCS NOT ON THEN:

H 4-1	PC2	Send FCT_EPS_PWR_UP_SS (script: PowerUpADCS)	para: ADCS	______________
H 4-2	PC2	Verify in TCRealTime all TC Acknow are (if not green, try **once** to send TC again)	© Green	QA______________
H 4-3	OPE	Wait for 20 seconds and go to OTHERWISE		______________

OTHERWISE:

H 4-4	PC2	Send FCT_EPS_GENERATE_HK	No Parameter	______________
H 4-5	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA______________
H 4-6	PC2	Verify in TCRealTime date/time	Date/time	______________
H 4-7	PC2	Verify in ADCS HKViewer date/time	Date/time	______________
H 4-8	PC2	Verify in HKViewer all ADCS HK green:		QA ______________
H 4-9	PC2	Verify detailed COM default values and parameters:	XLS	QA ______________
H 4-10	PC2	Verify detailed EPS default values and parameters:	XLS	QA ______________
H 4-11	PC2	Verify detailed ADCS default values and parameters:	XLS	QA ______________
H 4-12	PC2	Verify ADCS 440-MM_X_MEAS		QA ______________
H 4-13	PC2	Verify ADCS 441-MM_Y_MEAS		QA ______________
H 4-14	PC2	Verify ADCS 442-MM_Z_MEAS		QA ______________
H 4-15	PC2	Verify ADCS 12 SS_xN_A1 and 2		QA ______________
H 4-16	PC2	Verify ADCS 12 SS_xR_R1 and 2 (values should change)		QA ______________
H 4-17	PC2	Verify ADCS 3 GYRO_x_MEAS (values should change)		QA ______________

5) Verify PL and Take Pictures

You can take one or several pictures with this sequence.

H 5-1	PC2	In the Mission Data Client, open Image Service	QA ______________

H 5-2	PC2	Send FCT_EPS_PWR_UP_SS (Script: PowerUpPL)	para: PL		________
H 5-3	PC2	Verify in TCRealTime all TC Acknow are (if not green, try **once** to send TC again)	© Green	QA	________
H 5-4	OPE	Wait for 10 seconds			________
H 5-5	PC2	Send FCT_EPS_GENERATE_HK	No Parameter		________
H 5-6	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	________
H 5-7	PC2	Verify in TCRealTime date/time	Date/time		________
H 5-8	PC2	Verify in PL HKViewer date/time	Date/time		________
H 5-9	PC2	Verify detailed COM default values and parameters:	XLS	QA	________
H 5-10	PC2	Verify detailed EPS default values and parameters:	XLS	QA	________
H 5-11	PC2	Verify detailed ADCS default values and parameters:	XLS	QA	________
H 5-12	PC2	Verify detailed PL default values and parameters:	XLS	QA	________
H 5-13	PC2	Send script TakePicture	No Parameter		________
H 5-14	PC2	Verify in TCRealTime all TC Acknow are (if not green, try **once** to send TC again)	© Green	QA	________
H 5-15	PC2	Send script GetImageInfo	No Parameter		________
H 5-16	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	________
H 5-17	PC2	In IMAGE Service, verify image number	Number?		________
H 5-18	PC2	In IMAGE Service, verify image time	Time?		________
H 5-19	PC2	In IMAGE Service, select image		QA	________
H 5-20	PC2	Send script GetImageLine	No Parameter		________
H 5-21	PC2	Verify in TCRealTime all TC Acknow are	© Green	QA	________
H 5-22	PC2	In IMAGE Service, verify reception image (Can check in Tracing each line downloaded) (If image partially received, try GetImageLine script again)		QA	________
H 5-23	PC2	In IMAGE Service, select image (right click), choose Export Image, save file		QA	________
H 5-24	PC2	Send FCT_EPS_PWR_DOWN_SS	para: PL		________

		(Script: PowerDownPL)		
H 5-25	PC2	Verify in TCRealTime all TC Acknow are (if not green, try **once** to send TC again)	© Green	QA ______________

You can EPS_GET_HK to verify that everything works correctly here.

6) Verify battery voltage

H 6-1	PC2	Verify Vbat Viewer Vbat1+	3.5-4.2 V	______________
H 6-2	PC2	Verify Vbat Viewer Vbat2+	3.5-4.2 V	______________

7) End sequence

H 7-1	PRO	If HK correct go back to TVC procedure	______________
H 7-2	PRO	If HK NOT correct STOP and call us	______________

Appendix I Test Equipment List

For interfacing with the satellite:

- ❒ Anti-static carpet, bracelets and ground connector
- ❒ Relay board
- ❒ Connection wires/cables and connectors between relay board and test board
- ❒ Test board
- ❒ 3 USB ports and wires/cables between test board and PCs
- ❒ 2 rechargeable batteries for test board
- ❒ 1 charger for test board batteries
- ❒ 1 Aardwark I2C/USB interface device with associated cables
- ❒ Test chamber connectors and wires
- ❒ 1 multimeter
- ❒ 1 oscilloscope
- ❒ One chronometer
- ❒ One 500 W lamp
- ❒ Tools (screw drivers…)
- ❒ Internet cables
- ❒ Plug adapter for DE plugs
- ❒ Procedure notebook.

For data acquisition, processing and commanding:

- ❒ 1 PC with: MCS software (two windows: distribution, core), TM/TC front end, Mission Data Client (telecommand real-time, HK overview), Vbat viewer (IBV), Scheduler (server, client), I2C sniffer, test bridge, and MixW FSK
- ❒ 1 PC with: Labview, MixW CW

For the RF tests:

- ❒ ICOM 910 H transceiver
- ❒ ICOM power supply
- ❒ Kenwood K2000 transciever
- ❒ Audio in connectors and cables

Appendix J Test preparation

Date:

Test ID:

Time:

Location:

The test set-up is shown in Figure 5-13. The following are set-by-step instructions on how to perform the set-up.

<u>Hardware set-up</u>

1) Lay satellite (-Z down) and test board on anti-static carpet QA Hardware ______________

2) Connect HUB USB on PC2 QA Hardware ______________

2) Connect HUB USB on test board (2 white cables: uplink and downlink)
QA Hardware ______________

3) Connect HUB USB on test board (1 black cable: Aardvark)
QA Hardware ______________

4) Start PC2 QA Hardware ______________

5) Connect Beacon USB on PC1 QA Hardware ______________

6) Start PC1 QA Hardware ______________

7) Connect Microphone output to Audio input on PC1 QA Hardware ______________

<u>Software set-up</u>

ON PC2:

1) Start SwissCube Ground Segment QA Software ______________

2) Wait for SwissCube Ground Segment to be ready QA Software ______________

3) Start Test Bridge QA Software ______________

4) Wait for Test Bridge to be ready (Running…) QA Software ______________

5) Start I2C Sniffer QA Software ______________

6) When asked for, write "y" to activate power pins QA Software ______________

7) Verify test board LEDs – I2C ON	QA Software	______________
8) Connect test board battery	QA Software	______________
9) Power UP test board – black switch	QA Software	______________
10) On virtual computer start 1. MCS	QA Software	______________
11) On virtual computer start 2. TM/TC Front End	QA Software	______________
12) On virtual computer start 3. Mission Data Client	QA Software	______________
13) In Mission Data Client start Telecommand Real Time	QA Software	______________
14) In Mission Data Client start HK Overview	QA Software	______________
15) In Mission Data Client start Tracing	QA Software	______________
16) On virtual computer start 4. Scheduler Server	QA Software	______________
17) On virtual computer start 5. Scheduler Client	QA Software	______________
18) On virtual computer start 6. IBV	QA Software	______________

ON PC1:

1) Start MixW (Code CW, Mode settings 1800 Hz)	QA Software	______________
2) Wait for MixW to be ready	QA Software	______________
3) Start Labview FTDI+Morse Coding-3.vi	QA Software	______________
4) Wait for Labview to be ready	QA Software	______________

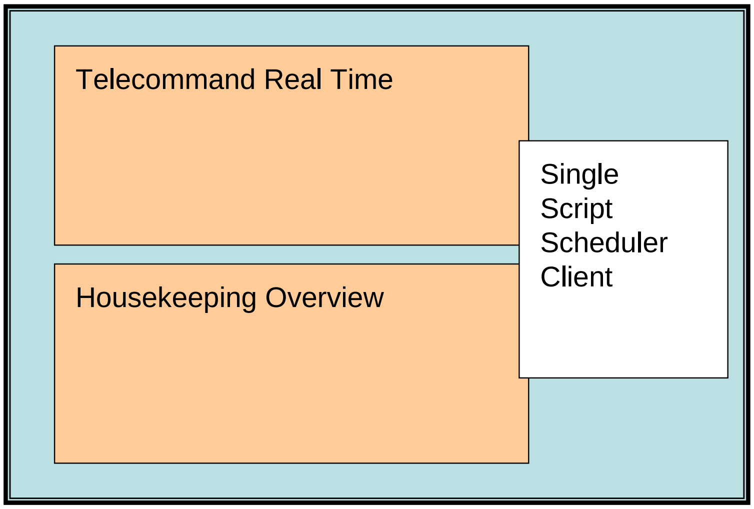
Satellite set-up

1) Satellite should be with face –Z down (kill switches open)	QA	______________
2) Once all electrical connections verified (grounding, isolation), plug in Service Connector.	QA	______________

Verify that USB cables are powered up, Sniffer I2C, test board powered up, relay board connected, all green leds are green, all red leds are OFF

QA ______________

The software on the virtual computer should look like this:



Test preparation (plug in service connector, labview interface, continuity, grounding, and isolation test, quality and safety sign-off (checking of the cabling by someone else who has done the mounting)).