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CHANGE RECORD

Issue	Date	Sheet	Description of Change	Release
0.1	March 31st, 2010	All	First draft	===
0.2	June 15th, 2010	All	General review, refined procedure (Table4) and limits	
0.3	June 22nd, 2010	Ch. 1.4 and 1.6	Reviewed op sequence (Table4). Contingency plan added	
0.4	June 29th, 2010	All	Comments integrated and input from MOC and Instruments included.	
1.0	July 23rd, 2010	All	Comments from July 2nd telecon integrated, general review, LFI op details included	

TABLE OF CONTENTS

Applicable and Referenced Documents

Number	Title
AD1	Planck SCS User Manual, PL-LFI-PST-MA-002, v.3.0
AD2	Planck Sorption Cooler Electronics User Manual, PL-MA-CRS-0036 v. 2.0
AD3	Planck SCE MIB User Guide UM-PSCZ-600092-LPSC 01_05
AD4	Planck Cryo-chain Operations, Planck/PSO/2007-017
AD4	Planck FOP Archive 3.0

Scope of the document

This document is intended to present a complete system-level definition of the SCS Switchover activities, specifically for the switchover of SCS FM2 to FM1. The document shall contain sufficient detail so that it can be used as the principle reference to manage the switchover and all associated activities. All criteria that are pertinent to the execution of the defined procedures shall be explicit in the sequence of events. The document shall also address Contingency scenarios and recovery operations so that, as a minimum, the first level of contingency action is defined and can be applied quickly should the need arise.

This document is not intended to present the definition and explicit criteria that shall be applied in the decision process of when to perform the SCS switchover. The document presents an overview of the cooler functions and lifetime limiting factors and parameters, but it shall remain out of the scope of this document to conclude from the cooler behaviour analysis exactly when to switch off the running cooler.

1.1. Introduction

SCS switchover is a planned contingency operation. It consists of switching OFF the running SCS unit and activating the second unit. It must be performed when running SCS unit reaches end of life or enters a failure mode that makes it inoperable.
Even if the procedures and processes described in the next pages are applicable to any switchover operation, in this technical note attention will be focused on the planned switchover from the presently operating SCS Nominal Unit (FM2), activated at the beginning of Planck operations, to the Redundant Unit (FM1).
This document is used as a reference for all evaluations needed to plan this operation, that has to be prepared in advance in terms of Instrument support, MOC support as well as ground stations availability, if extended pass need is confirmed for a smooth execution of the procedure.

1.2. Switchover Procedure

The general top level switchover sequence includes possible operations of all subsystems (instruments and spacecraft) and can be summarized in the following steps:

- LFI bias set to zero, 1.6K and 4K PID OFF, deselect 4K cooler VCS harmonics
- Shutdown SCS FM2 Nominal (do not wait for P7 monitoring, below 8bar)
- Initialise SCS FM1 Redundant
- GOTO READY MODE, enter Health Monitoring
- execute Healthcheck procedure (only in case of contingencies)
- GOTO RUN MODE
- Upload LUT values (Powers and times section mainly)
- Reactivate LFI biases and HFI PIDs, select all 4K cooler VCS harmonics
- Wait for SCS R to enter Nominal Operations
- Perform cooler tuning

1.2.1. LFI procedures

Preliminary steps of LFI include:

- disable LFI Autonomous and Monitoring Functions (to avoid triggering the LFI internal FDIR)
    - apply LFI Op Proc P_FCP_LFI_CSAD "Disable Autonomous Functions"
    - apply LFI Op Proc P_FCP_LFI_CSMD "Disable Monitoring Functions"

- set all RCA biases to 0V (this saves about 350mW of load on cold end)
    - apply LFI Op Proc P_CRP_LFI_CFMP "Perform LFI FEM passivation"

This operation is performed in MTL 6 hours before the beginning of DTCP 0 and has to be run AFTER deactivation of SCS TSA control, otherwise it would not produce any positive effect. The thermal control would automatically compensate for the missing power.

Post switchover LFI activities:

- set all RCA biases to original values when SCS High Pressure P7>27 bar
  - apply LFI Op Proc P_CRP_LFI_CFMR "Recover LFI FEM biases"

- enable LFI Monitoring and Autonomous Functions
  - apply LFI Op Proc P_FCP_LFI_CSMA "Enable Monitoring Functions"
  - apply LFI Op Proc P_FCP_LFI_CRTA "Reset Science TM Algorithm"
  - apply LFI Op Proc P_FCP_LFI_CSAA "Enable Autonomous Functions"

- ***LFI FEM bias test*** activity is loaded in MTL during DTCP Ext to be performed before the start of DTCP +1

After thermalization of LFI FPU the TSA control can be reactivated with the proper setpoint.

1.2.2. HFI procedures

Preliminary steps of HFI include:

- disable 1.6K PID control in MTL
  - apply HFI OP Proc P_FCP_HFI_CP1P "De-activate the 1.6K PID"

- disable 4K PID control in MTL
  - apply HFI OP Proc P_FCP_HFI_CP4P "De-activate the 4K PID"

Activities during switchover:

Just before SCS FM2 shutdown

- deselect all 4K cooler harmonics for VCS
  - apply P_FCP_HFI_4HFS (FreqSelVCS = 0)

After de-activation of SCS FM2

If 4K cold end temperature exceeds certain thresholds during SCS units swap the **contingency** procedures described in Par. 1.6.1 and Table 8 must be applied.

After activation of SCS FM1

If the **contingency** procedures for changing 4K Cernox calibration range (Par. 1.6.1) have been applied then, once the temperature drops below the thresholds (first 19K, then 9K), the proper range has to be recovered. Applicable procedures are described in Par. 1.6.1 and Table 8.

- When Cernox 4K (HD494280) < 5K, select all 4K harmonics for VCS
    - P_FCP_HFI_4HFS (FreqSelVCS = 255)

- enable 1.6K PID control when SCS P7>15 bar and Cernox 4K (HD494280) < 5K
    - apply HFI OP Proc P_FCP_HFI_CP1P "Re-activate the 1.6K PID"

- enable 4K PID control when SCS P7>15 bar and Cernox 4K (HD494280) < 5K
    - apply HFI OP Proc P_FCP_HFI_CP4P "Re-activate the 4K PID"

All planned HFI procedures during Switchover can be summarized in Table 1.

Operation	Procedure	Parameters / TPF	Comments
in MTL at DTCP0 -6 hours			
DPU & REU go from OBSERVATION to CONFIGURATION	P_FCP_HFI_NXCN	none	*Not needed because we're already in CONFIGURATION mode*
Deactivate the nominal and redundant 4K PID heaters	P_FCP_HFI_CP4P	TPF like PFHCP4P_PID___4K_0001.IPF (to be redelivered with updated time): parameters: PID3ConfMode3=0; PIDHeatConf3=0; PID3TermConf3=0; PID3NoPID3=3; PIDIntTime3=0; PIDSetPoint3=0; PIDP-Gain3=0; PIDPIGain3=0; PIDP-DGain3=0; PIDExp3=1; NHeatPwMsw3=0; NHeatPwLsw3=0;	*Rationale is to have 6 hours minimum liquid in the 4K pipes*

Deactivate the nominal 1.6K PID heater	P_FCP_HFI_CP1P	TPF like PFHCP1P_PID___1K_0001.IPF (to be redelivered with updated time): parameters: PID2ConfMode2=0; PIDHeatConf2=0; PID2TermConf2=0; PID2NoPID2=2; PIDIntTime2=0; PIDSetPoint2=0; PIDP-Gain2=0; PIDPIGain2=0; PIDP-DGain2=0; PIDExp2=1; NHeatPwMsw2=0; NHeatPwLsw2=0;	
during DTCP0 and just before SC FM2 shutdown			
Deselect all 4K harmonics for VCS	P_FCP_HFI_4HFS	FreqSelVCS=0	*Rationale: everything about 4K cooler has to be done in visibilty*
After cooling power resumes and when Cernox 4K HD484280 < 5K and in visibility			*Rationale: everything about 4K cooler has to be done in visibility*
Condition: if all force harmonics < 2 N (green to be given by HFI)			
Select all 4K harmonics for VCS	P_FCP_HFI_4HFS	FreqSelVCS=255	*Otherwise the VCS will not execute the TC and we'll need to run a SRT*
ASAP (green to be given by HFI)			*Rationale: the reactivation of the PIDs has to be done as soon as possible to avoid liquid accumulation in the pipes (and thus a potential 1.6K-4K instabilities)*

Reactivate the nominal and redundant 4K PID heaters	P_FCP_HFI_CP4P	TPF = PFHCP4P_PID___4K_000y (to be redelivered with updated time): parameters: PID3ConfMode3=1; PIDHeatConf3=0; PID3TermConf3=0; PID3NoPID3=3; PIDIntTime3=0; PIDSetPoint3=0; PIDP-Gain3=3000; PIDP-IGain3=150; PIDP-DGain3=0; PIDExp3=1024; NHeatPwMsw3=0; NHeatPwLsw3=0; RHeatPwMsw3=2767;	*Use the lastest configuration*
Reactivate the nominal 1.6K PID heater	P_FCP_HFI_CP1P	TPF like PFHCP1P_PID___1K_0002.IPF (to be redelivered with updated time): parameters: PID2ConfMode2=1; PIDHeatConf2=0; PID2TermConf2=0; PID2NoPID2=2; PIDIntTime2=0; PIDSetPoint2=0; PIDP-Gain2=200; PIDP-IGain2=10; PIDP-DGain2=0; PIDExp2=1024; NHeatPwMsw2=0; NHeatPwLsw2=0; RHeatPwMsw2=0;	*Use the lastest configuration*

Table 1 Summary of HFI Planned Operations during Switchover

1.2.3. SCS Switchover procedure (User Manual definition)

SCS Switchover procedure, as defined in the User Manual, is reported in Table 2.
Time from cooler OFF to cooler ON is about half an hour (TC time) but before the activated SCS starts producing enough cooling power, it can take about 1.5 - 2 hrs. In total the whole procedure can take up to 2 - 3 hrs, if only one tuning step is required to achieve quasi-steady state. Each extra tuning step can take about 30 min (up to two or three tuning step might be expected).

Step #	Description	Duration	Comments
	SCS-N (or R) is in RUN Mode		*Before starting procedure it may be requested to set LFI bias to 0 (TBC)*
1	**Execute SCS N (or R) Switch Off Procedure**	2 min	4K Cooler and Dilution stay ON (TBC)

	Including CDMS request for 5A line OFF		Now SCE N (or R) is OFF
	Wait for Event Report from S/C		Practically instantaneous
~~**1a**~~	~~**Execute cooldown process on SCS-N**~~	~~TBD~~	~~Used to depressurize and distribute gas equally to beds. Duration depends on cycle-time and how many cycles~~
2	**Execute SCS R (or N) BOOT Procedure**	3 min	CDMS request for 5A line ON
	Transfer ASW if not automatically executed		
	Wait for Event Report from S/C		Practically instantaneous
3	**Execute SCS R (or N) INIT Procedure**	3 min	ASW transfer included
	Wait for Event Report from S/C		Practically instantaneous
4	***Execute LUT upload, if needed***	20 min	
5	**Execute SCS R (or N) READY Procedure**	1 min	to Enter READY
	Wait for Event Report from S/C		Practically instantaneous
	Wait in READY Monitoring for TBD seconds	TBD	TBD can be zero
~~**5a**~~	~~***Execute HEALTHCHECK Procedure (TBC)***~~	~~1 hr~~	~~TBC if HC process is needed before activation~~
6	**Execute SCS N RUN Procedure**	1 min	to enter CONDITIONING Mode
	Wait for HP to reach Nominal Ops Value	approx 2 hrs	to enter NOMINAL Mode
7	***Execute LUT upload, if needed***	20 min	Cooler Tuning (1 or more steps could be needed)

Table 2. Switchover sequence steps according to User Manual definition

The specific SCS high-level operational procedure as indicated in the FOP is P_FCP_SOR_SN2R Sorption Cooler Switch-over (NOM to RED), that consist of the following lower level procedures:

- P_FCP_SOR_NXDN Sorption Cooler (NOM) to READY (Health Monitor)
- P_FCP_SOR_NXIF Sorption Cooler (NOM) to INIT
- P_FCP_SOR_NSOF Sorption Cooler (NOM) Power OFF from INIT
- P_FCP_SOR_ROIN Sorption Cooler (RED) OFF to INIT
- P_FCP_SOR_RXDN Sorption Cooler (RED) to READY (Health Monitor)
- P_FCP_SOR_RHCN Execute Healthcheck on SCS (RED)
- P_FCP_SOR_RDRN Sorption Cooler (RED) to RUN (Startup)
- P_FCP_SOR_CLSM Load LUT - Software
- P_FCP_SOR_CDSM Dump LUT - Software

- P_FCP_SOR_CLPM Load LUT - Powers and Times
- P_FCP_SOR_CDPM Dump LUT - Powers and Times
- P_FCP_SOR_RLRM Load LUT - Run Mode Transitions (RED)
- P_FCP_SOR_CDRM Dump LUT - Run Mode Transitions
- P_FCP_SOR_RLFM Load LUT - Fault Conditions and Bad Bed Detection (RED)
- P_FCP_SOR_CDFM Dump LUT - Fault Conditions and Bad Bed Detection
- P_FCP_SOR_RLDM Load LUT - PID and Open Loop Algorithms (RED)
- P_FCP_SOR_CDDM Dump LUT - PID and Open Loop Algorithms

These operational steps have been already tested and debugged during CSL PFM2 test and SVT2, the whole process is ready to be applied at any time during the mission in case is needed.

1.2.4. TPF Reference Time for MTL TPFs

The switchover operation will useTPFs to load specific parameters into some of the procedures (as defined in Table 4). Where the TPFs are defined as MTL Load TPFs, a UTC time reference is required in the TPF. For the SCS Switchover operation the Standard Time Reference for TPF delivery shall be **2010-10-01T00:00:00Z**.

1.3. Operational approach

The baseline for SCS switchover execution is to perform it at the expiration of SCS Nominal unit lifetime. If this happens in the middle of a sky survey, the scientific data acquisition will be stopped and held up for the time needed to recover back the cryochain operational point. For this reason, one of the tasks of the operational approach is to minimize impact on cryochain and "no-cooling" time.

From ground test results the time between SCS switch-off and dilution warm up is max 6hrs in best conditions (see Fig.1).

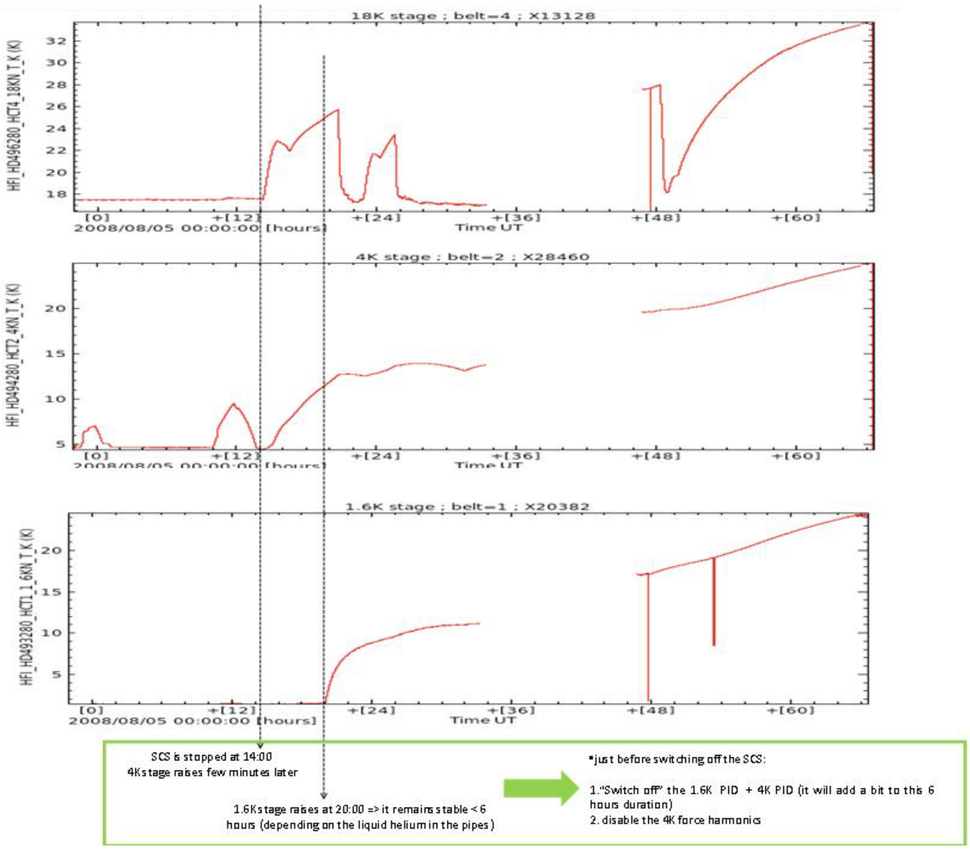

Figure 1. SCS failure test at CSL

Typical SCS cold restart time has been tested at CSL PFM2: cooler pressurization takes about 1.5hrs. The time to start producing some cooling again, with instruments ON, was about 30 min after re-start, full pressure was recovered after 1.75 hrs (see Fig.2)

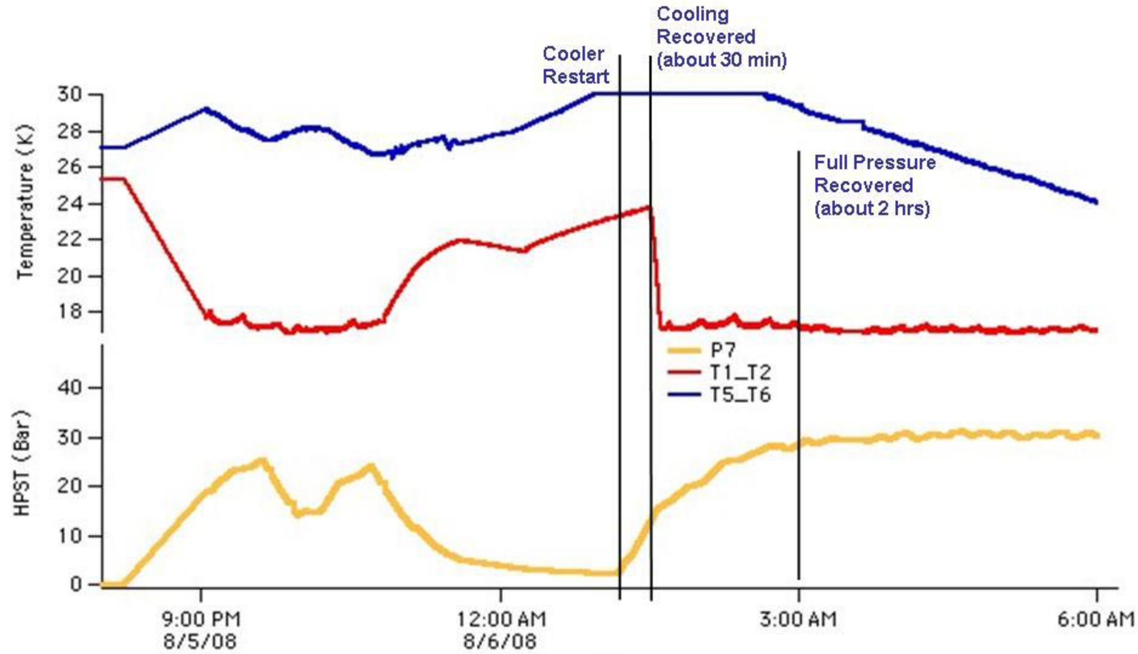

Figure 2. CSL cold restart test. Instruments, were ON.

The time to enter back Normal Operations was about 1.5 hrs after restart, but with a cooler already tuned (the same cooler, FM2, was switched OFF and back ON to perform the test).

The switchover procedure requires an extended pass or a double pass within the same OD. For example, an extended pass of 6 hours would be optimal, but also a normal visibility time of 3 hrs plus another window of 3 hrs after few (3hrs) hours would work as well.

The key input for planning the execution of the process is a realistic estimation of cooler remaining lifetime. SCS team shall be able to predict SCS-N end-of-life at least 4 weeks ahead with an error margin of a week. This will help MOC and Instruments to organize the support needed during the procedure.
Remaining lifetime evaluation is performed on the basis of the analysis of some key parameters of the system. In order to maximise cooler lifetime, the switchover procedure should be executed just before one of these parameters reaches its max limit. To define a sharp end-of-life of the SCS and fix a date is not an easy task since there is no clear transition from a working cooler to a dead cooler. The SCS keeps degrading its performance until one or more of its major requirements cannot be met. In the end cold end temperature starts drifting up and effects on the rest of cryochain show up.

Once defined the operational parameters to be checked and their limits as indicators of cooler lifetime, SCS team shall monitor the parameters and periodically provide their trends with the expected time to reach the limits. Even if possible dates for cooler switchover can be proposed and updated during 2nd SS, a realistic estimation of a date can be done only when is expected that one (or more) of the limits may be reached in a 4weeks period. This evaluation, obviously, is done only with a certain margin, defined by SCS team. Switchover process will be planned for the expected date of the first parameter to hit its limit including the margin on this evaluation.
During last few weeks before reaching EOL, the cooler will be monitored for confirmation of the estimated remaining lifetime and switchover date.

Objectives of the next paragraph are to:

- identify the cooler parameters for monitoring lifetime
- classify them in terms of importance in impacting the cryochain
- set realistic max limits (to be defined with Instruments) on these parameters
- indicate an operational approach and margin to be taken on the estimation

1.3.1. Lifetime parameters

The lifetime indicator parameters are related to the main requirements that define cooler performance. The cooler requirements are:

- Heat lift
- Input power
- Cold end temperature
- Cold End Temperature fluctuations

The cooler parameters used as direct indicators of such requirements are:

- HPST pressure P7
- Compressor Elements Input power
  - Input in LUT
  - Measurement of actual power supplied using CEs heaters voltage
- LVHX1 temperature
  - Absolute value
  - Peak-to-peak and rms fluctuations
- LVHX2
  - Absolute value
  - Peak-to-peak and rms fluctuations
- TSA
  - Absolute value
  - Peak-to-peak and rms fluctuations

For a given last pre-cooling (VGroove3) temperature, the cooler heat lift is defined primarily by the mass flow. Since gas flow is not measured in the SCS, the HPST pressure is used as flow indicator. If the pressure falls below a certain limit not enough cooling power is provided and cold end temperature starts rising.

The input power that can be supplied to each compressor element is set by hardware limitation. The power for each bed is indicated in the LUT (Powers and Time section) and the actual value is measured using the measured voltage and heaters resistance. Due to cooler degradation, during operations, more power is used to maintain high pressure. When input power reach max it is not possible to keep heat lift.

Instruments requirement set max Cold End temperature absolute value. SCS interface to HFI is LVHX1 whose temperature sets the pre-cooling stage for the 4K JT cooler. Above a certain max value, 4K cooler is not able to provide required cooling power. LFI FPU temperature is set by the TSA setpoint through the thermal transfer function across the main frame. Max LFI front end temperature is defined by:

- instrument max operating temperature
- max T allowed at FPU to HFI mech interface for parasitics load on 4K stage

Max temperature allowed on the FPU is then set by the minimum of the two above listed values. For these reasons, indicators for max SCS cold end temperature are:

- LVHX1 T
- TSA setpoint
- LFI FPU T measured at closest nodes to HFI interface (sensors TSR1, TSR6, TSL4)

Since cold end stability is considered a key issue for the instruments scientific performance, LVHX1 and TSA fluctuations (p2p and rms) have to be monitored and evaluated. It may happen that with cooler degrading cold end oscillations become unacceptable for required instruments operation. This also can be a limiting factor for cooler lifetime.

In general it is expected that heat lift maintenance and input power trend will be the primary limiting factors of cooler lifetime. High pressure and bed desorption power (higher than heat-up) will be the key parameters for EOL prediction and switchover planning.

The parameters to be used for cooler remaining lifetime indicators can then be summarized in the following table:

Requirement	**SCS indicator**	**Parameters**	**Impact on PPLM**	
			Cooling	Science
Heat Lift	HPST pressure	P7	NO	NO
Input power	Value set in LUT, CE heaters Voltage	28V, variable heaters V	NO	NO
Cold End T	LVHX1 T, TSA T, FPU T	T1, T5, TSR1, TSR6, TSL4	YES/NO	NO
Cold End T stability	LVHX1 T, TSA T	T1, T5	YES	NO

Table 3. SCS parameters and impact on cryochain

The scope of this document is to define the basic set of criteria and conditions internal to the SCS that trigger the switchover process, independently from the operational scenario selected to maximize FM2 lifetime. The running cooler performances evolution indicate that actual EOL limits will be the primary ones: heat-lift (defined by system high pressure) and input power (desorption). For both parameters a limit has to be defined (see Table 4): this value indicates the threshold defining the cooler EOL with some margin, after which the system is no longer considered performing within requirements.

Parameter	**ID**	**Limit**	**Margin**
HPST pressure, P7	SM050540	27 bar	0.3 bar
Input power (DE)	LUT, SM052540	265W	10W

Table 4. SCS parameters limit

1.4. *Integrated Operation Sequence*

The overall sequence of operations is based on the assumption of having an extended visibility window fully dedicated to switchover operations. The normal pass of 3 hours will be used for all routine operations plus switchover process start. An extra pass shall be available (6 hrs at least) for specific switchover procedures, as described in Figure 3. In such a way a total time window of about 9hrs should be available for the whole switchover operation.
The two DTCPs are considered contiguous and there is no sharp transition with respect to operational steps. The only requirement on time for the successful conclusion of the switchover process is the completion before the end of the DTCP Ext. It is anyway possible to define a coarse distribution of activities among the two visibility windows. The goal of the presented process is to

- proceed with the deactivation of running unit (FM2) and activation of FM1 within the "nominal" DTCP0
- wait for system pressurization and transition into Normal plus perform system tuning in DTCP Ext

All activities needed for the process, from preparatory operations to the post-switchover adjustments, will span over 2-3 ODs and shall be run according to the sequence and timing described in Figure 3 and Table 5.

The switchover operation first objective is to minimize no-cooling time and the time needed to recover the nominal state. For this reason, several steps of Table 2 official sequence will be rearranged as follows:

1. Skip Step1a of Table 2, FM2 depressurization will be done passively
2. Enter RUN with FM1 in the shortest possible time, LUT upload is done while pressure builds up (Step4 of Table 2 is partially postponed after Step6)
3. Step5a is skipped, Health-check process can be limited to real-time sensor monitoring in RUN Mode
4. LUT fine tuning steps may follow pressurization to ensure transition in Normal Op

With this readjustment, switchover process from FM2 OFF to partial recovery of cooling with new unit may take around 1.5-2 hrs. Transition into Normal Ops should be verified either in the extended pass or, in worst case, in the next visibility window (DTCP+1). LUT fine tuning can be performed in DTCP Ext or in the following DTCP+1.

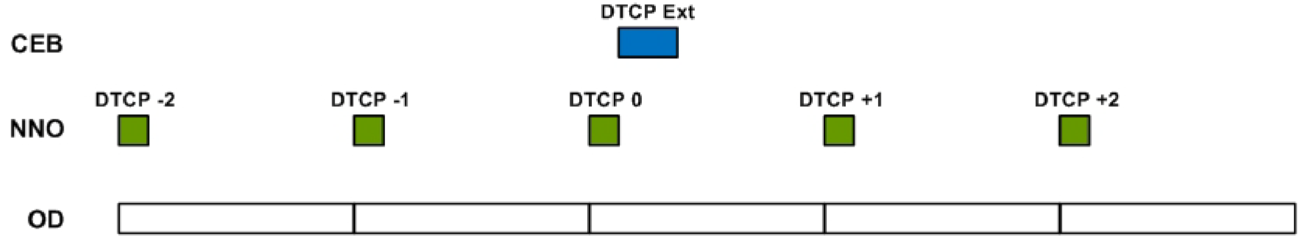

Figure 3. DTCPs availability

Table 5 shows the expected step-by-step sequence of operations planned for SCS FM2 to FM1 switchover. **The entire process is driven by the FOP Procedure P_FCP_SOR_SN2R**.

Step #	Procedure	Description	Condition for Execution	Duration	Comments
					Start of DTCP -1
1.1	**P_FCP_SOR_CLSM**	**Load LUT - Software**	FM2 in RUN - Normal	1 min	***Switch OFF TSA***
1.2	**P_FCP_SOR_CDSM**	**Dump LUT - Software**	Step 1.1 completed		
1.3	**P_FCP_LFI_CSAD**	Disable Autonomous Functions	Step 1.1 completed	10 min	disable LFI Autonomous and Monitoring Functions to avoid triggering the LFI internal FDIR
1.4	**P_FCP_LFI_CSMD**	Disable Monitoring Functions	Step 1.3 completed	10 min	disable LFI Autonomous and Monitoring Functions to avoid triggering the LFI internal FDIR
					End of DTCP -1
1.5	**P_CRP_LFI_CFMP**	**LFI biases down to 0V**	Step 1.3 & 1.4 completed	30 min	***Passivate FPU.*** *MTL activity (6hrs before DTCP0). Uploaded in DTCP-1*
1.6	**P_FCP_HFI_CP1P**	Deactivate 1.6K PID in MTL	MTL activity, clock based	10 min	*MTL activity (6hrs before DTCP0). Uploaded in DTCP-1.* ***Check Table 1 for parameters***
1.7	**P_FCP_HFI_CP4P**	Deactivate 4K PID in MTL	MTL activity, clock based	10 min	*MTL activity (6hrs before DTCP0). Uploaded in DTCP-1.* ***Check Table 1 for parameters***
					Start of DTCP 0
1.8	**P_FCP_HFI_4HFS (FreqSelVCS = 0)**	**Deselect all 4K harmonics for VCS**	Before FM2 shutdown	1.5 min	*To be executed just before SCS FM2 shutdown.* ***Check Table 1 for parameters***

2	P_FCP_SOR_NXDN	**FM2 from RUN to READY**	**1.1 and 1.2 executed (TBC)**	3 min	*Cooldown cycles are skipped, de-pressurization is achieved passively.* ***DO NOT wait for de-pressurization monitoring, for P7 to go below 8 bar***
3	P_FCP_SOR_NXIF	**FM2 from READY to INIT**	**Step 2 completed**	3 min	*CDMS request for 20A line OFF*
4	P_FCP_SOR_NSOF	**FM2 OFF**	**Step 3 completed**	3 min	*CDMS request for 5A line OFF. Now FM2 is OFF*
5	P_FCP_SOR_ROIN	**FM1 ON - BOOT to INIT**	**Step 4 completed**	10 min	*FM1 now ON. 5A line ON*
6	P_FCP_SOR_RXDN	**FM1 in READY**	**Step 5 completed**	3 min	*20A line is activated. HealthCheck step is skipped to save time, check is done on real time data by operator.*
7	P_FCP_SOR_CLPM	**Load LUT - Powers and Times**	**Step 6 completed**	5 min	*To upload optimized HU and DE power values for Conditioning/Normal and for gap jumping.*
7.1	P_FCP_SOR_CDPM	**Dump LUT - Powers and Times**	**Step 7 completed**		
8	P_FCP_SOR_RLFM	**Load LUT - Fault Conditions**	**Step 5 completed**	5 min	*To change Fault Values for Bad Bed Detection Algorithms*
8.1	P_FCP_SOR_CDFM	**Dump LUT - Fault Conditions**	**Step 8 completed**		
9	P_FCP_SOR_RDRN	**FM1 to RUN**	**Step 8 completed**	3 min	*System enters Conditioning Mode with Launch LUTs except for Powers. While pressure starts building up optimized LUT values are loaded*

10	P_FCP_SOR_RLRM	Load LUT - RUN Mode Transitions	Step 9 completed	5 min	*To set best values for from/to Normal/Conditioning transition*
10.1	P_FCP_SOR_CDRM	Dump LUT - RUN Mode Transitions	Step 10 completed		
11	***Wait for system pressurization***			1.5 - 2 hrs	***Wait for high pressure and temperature limits that trigger steps 12-14***
	If during SCS cold end warm up HFI Cernox 4K (HD494280) value exceeds 9K and 19K limit apply contingency procedure defined in Par. 1.6.1 and Table 8				
12	P_FCP_HFI_4HFS (FreqSelVCS = 255)	Select all 4K harmonics for VCS	SCS in RUN Mode. SCS High pressure SM050540 > 15bar and Cernox 4K (HD494280) < 5K	1.5 min	***Green light to be agreed by HFI. Check Table 1 for parameters***
13.1	P_FCP_HFI_CP1P	Reactivate 1.6K PID	SCS in RUN Mode. SCS High pressure SM050540 > 15bar and Cernox 4K (HD494280) < 5K	1.5 min	***Old setpoints will be used. No PID settings change. Check Table 1 for parameters***
13.2	P_FCP_HFI_CP4P	Reactivate 4K PID	SCS in RUN Mode. SCS High pressure SM050540 > 15bar and Cernox 4K (HD494280) < 5K	1.5 min	***Old setpoints will be used. No PID settings change. Check Table 1 for parameters***
					End of DTCP0
					Start of DTCP Ext

14	**P_FCP_LFI_CFMR**	**Recover LFI FEM biases**	**SCS in RUN Mode. High pressure SM050540 > 27bar**	30 min	
15	**P_FCP_SOR_RLDM**	**Load LUT - PID and OL Algorithms**	**Check LVHX2 T to define TSA setpoint. Step 14 must be completed**	5 min	Wait for FPU thermalization to select setpoint (about 1.5hrs)
15.1	**P_FCP_SOR_CDDM**	**Dump LUT - PID and OL Algorithms**	**Step 15 completed**		
16	***Switchover process holding point***			**1.5-2 hrs**	***Wait for system transition into Normal Ops before activating TSA and performing next tuning steps***
17	**P_FCP_SOR_CLSM**	**Load LUT - Software**	**SCS in Normal Ops. SM732530 = NORMAL**	5 min	
17.1	**P_FCP_SOR_CDSM**	**Dump LUT - Software**	**Step 17 completed**		
					Extra Tuning steps may be required before end of DTCP Ext
18	**LFI bias tests**		**Step 17 completed**	9hrs	**This activity is loaded and executed in MTL**
					End of DTCP Ext
					Start of DTCP +1
19	**P_FCP_SOR_CLPM**	**Load LUT - Powers and Times**	**Step 17 completed**	5 min	*Fine tuning for Input power, cycletime, LPSB*
19.1	**P_FCP_SOR_CDPM**	**Dump LUT - Powers and Times**	**Step 19 completed**		

20	**P_FCP_SOR_RLDM**	**Load LUT - PID and OL Algorithms**		5 min	*TSA may need tuning*
20.1	**P_FCP_SOR_CDDM**	**Dump LUT - PID and OL Algorithms**	**Step 20 completed**		
21.1	**P_FCP_LFI_CSMA**	**Enable Monitoring Functions**	**Step 19 completed**	10 min	*To be performed in visibility. If not enough time, it could be delayed to the next DTCP without compromising normal science acquisition*
21.2	**P_FCP_LFI_CRTA**	**Reset Science TM Algorithm**	**Step 21.1 completed**	1 min	
21.3	**P_FCP_LFI_CSAA**	**Enable Autonomous Functions**	**Step 21.2 completed**	10 min	
					End of DTCP +1

Table 5. Sequence of Switchover process

1.5. Switchover Planning

As discussed in Par. 1.3.1 the two major parameters for planning the switchover operation are:

- Input power
- High pressure (heat-lift)

There is a maximum available on-board power that can be supplied to the compressor elements heater and a minimum pressure value needed to maintain cold end temperature.

The maximum on-board power depends on the combination of maximum voltage/current available on the 28V line with intrinsic limitations of the SCE hardware. The higher power needs for cooler operations at EOL may also have an impact on the 28V level available at SCE. This feedback loop makes difficult to have a detailed estimation of the final max power. Based on present data and extrapolating the trend, the maximum power that the SCE can provide to the TMU should be in the range 255W-265W. This is an average value, depending on each heater actual resistance.
For switchover planning purposes we consider 255W as max power worst case value keeping a 10W margin.

To sustain the cryochain the minimum pressure needed to produce required cooling power is 27 bar.

SCS is tuned weekly to maintain required pressure by using input power. Switchover process must be performed when:

- at 255W average max power per bed, calculated on the basis of fixed and variable voltage readings (SM052540, SM004540-SM009540) and heaters resistances (reported in a dedicated LUT section), the high pressure value P7 (SM050540) falls below 27.3 bar (limit plus margin)

At present rate of input power consumption (2-4W per week) limit should be reached at the end August 2010 (see Table 6). Cooler high pressure should then be maintained for another week or two (depending on P7 absolute value at the time and rate of decay). This sets a worst case expected date for SCS switchover in the first half of September 2010. This estimation will be confirmed at least 2 weeks in advance.

Date	Cycle-time (s)	Heatup power (W)	Desorption power (W)
15/07/2010	565	184	228
22/07/2010	555	187	231
29/07/2010	545	190	234
05/08/2010	535	193	237
12/08/2010	525	196	240
19/08/2010	515	199	243
26/08/2010	505	202	246
02/09/2010	495	205	249
09/09/2010	485	208	252
16/09/2010	475	211	255

Table 6. Next LUT expected adjustments

More lifetime may be available if average bed max power margin (10W) can be relaxed going over the 255W worst case.

An extra week can be gained by excluding from cooler cycle the most power consuming bed (CE4) and running 5beds operations. This option is not baseline at the moment but can be considered as a back up to increase margin on switchover operation planning. Procedure to be applied is P_CRP_SOR_CBSA Set Bed State.

1.6. Contingency Operations

This chapter summarizes possible events, specific to the switchover process, that can occur during the de-activation of FM2 and activation of FM1.

Two major categories of contingencies can be identified:

a) the ones that prevents FM1 from starting and/or running

b) the ones that can occur when FM1 is already running and that do not stop cooler cycling

Corresponding recovery strategies:

a) If telecommand fails, then repeat TC. If root cause cannot be identified and solved before the end of DTCP then switch OFF FM1 SCE (if ON) and reactivate FM2 with previous settings. FM2 should still have about 1week of lifetime remaining that can be used to decide new operational strategy

b) For this kind of occurrences the nominal FMECA as defined in the SCS User Manual can be applied

The summary of such events is reported in Table 7.

Event Description	Recovery Op	Op reference
SCE FM1 not activating	Restart FM2. If root cause cannot be identified and solved within the end of DTCP	Par. 1.6.2
FM1 not entering RUN Mode	Restart FM2. If root cause cannot be identified and solved within the end of DTCP	Par. 1.6.2
FM1 not stable in RUN Mode	Restart FM2. If root cause cannot be identified and solved within the end of DTCP	Par. 1.6.2
FM1 bad bed issue	FM1 in 5 or 4 beds operation. Monitor performance and take decision on op strategy	Par. 1.6.3
For all other issues that do not prevent FM1 from running nominally	Make reference to SCS User Manual Chapter 7 (FMECA)	N/A

Table 7. Switchover specific contingency cases

1.6.1. HFI Contingency Operations

During Switchover process, after deactivation of FM2, the SCS cold end temperature will start rising, finally dragging the 4K cooler cold end (see Figure 1). If this temperature exceeds certain thresholds (9K and 19K) then a contingency procedure has to be applied to adjust the T readout chain to the new range.

After deactivation of SCS FM2

- If Cernox 4K (HD494280) > 9K, reconfigure Cernox 4K and Cernox 4K-1.6K SW for 9-19K range (**Contingency**)
  - P_FCP_HFI_CX2P
  - P_FCP_HFI_CX3P

- If Cernox 4K (HD494280) > 19K, reconfigure Cernox 4K and Cernox 4K-1.6K SW for new range 19-40K (**Contingency**)
    - o P_FCP_HFI_CX2P
    - o P_FCP_HFI_CX3P

After activation of SCS FM1

If the **contingency** procedures for changing 4K Cernox calibration range have been applied then, once the temperature drops below the thresholds (first 19K, then 9K), the proper range has to be selected again:

- When Cernox 4K (HD494280) < 19K, reconfigure Cernox 4K and Cernox 4K-1.6K SW for previous range 9-19K
    - o P_FCP_HFI_CX2P
    - o P_FCP_HFI_CX3P

- When Cernox 4K (HD494280) < 9K, reconfigure Cernox 4K and Cernox 4K-1.6K SW for range< 9K
    - o P_FCP_HFI_CX2P
    - o P_FCP_HFI_CX3P

The HFI contingency procedures and parameters for 4K thermometers range adjustment are summarized in the following table:

CONTINGENCY: 4K temp. over read-out range limit		**Procedure**	**Parameters / TPF**
if 9K < Cernox 4K HD484280 < 19K			
	set Cernox 4K configuration 9-19K	**P_FCP_HFI_CX2P**	**Nblanck=15, Gamp=0, BiasI=250**
	set Cernox SW 4K-1.6K configuration 9-19K	**P_FCP_HFI_CX3P**	**Nblanck=15, Gamp=0, BiasI=250**
if Cernox 4K HD484280 > 19K			
	set Cernox 4K configuration 19-40K	**P_FCP_HFI_CX2P**	**Nblanck=15, Gamp=0, BiasI=500**
	set Cernox SW 4K-1.6K configuration 19-40K	**P_FCP_HFI_CX3P**	**Nblanck=15, Gamp=0, BiasI=500**
Once recovered previous range			
if 9K < Cernox 4K HD484280 < 19K			
	set Cernox 4K configuration 9-19K	**P_FCP_HFI_CX2P**	**Nblanck=15, Gamp=0, BiasI=250**

	set Cernox SW 4K-1.6K configuration 9-19K	P_FCP_HFI_CX3P	Nblanck=15, Gamp=0, BiasI=250
if (Cernox 4K HD484280 < 9K)			
	set Cernox 4K configuration < 9K	P_FCP_HFI_CX2P	Nblanck=15, Gamp=0, BiasI=100
	set Cernox SW 4K-1.6K configuration < 9K	P_FCP_HFI_CX3P	Nblanck=15, Gamp=0, BiasI=100

Table 8. HFI thermometers contingency procedures

1.6.2. Recovery operations: FM1 not running

The following table lists all steps needed in case of all unresolved occurrences that prevent FM1 from being operated in RUN Mode. If FM1 cannot be operated in RUN Mode steadily before the end of DTCP Ext, the FM2 has to be reactivated and operated into RUN until a final decision on a new operational strategy has been taken.

The process is executed according to the FOP Procedure P_FCP_SOR_SR2N

1	P_FCP_SOR_RXDN	FM1 from RUN to READY		3 min	*If FM1 was in RUN Mode*
2	P_FCP_SOR_RXIF	FM1 from READY to INIT	Step 1 completed	3 min	*If FM1 was active*
3	P_FCP_SOR_RSOF	FM1 OFF	Step 2 completed	3 min	*If FM1 was active*
4	P_FCP_SOR_NOIN	FM2 ON - BOOT to INIT	Step 3 completed	10 min	*FM2 now back ON. 5A line ON*
5	P_FCP_SOR_NXDN	FM2 in READY	Step 4 completed	3 min	
6	P_FCP_SOR_NDRN	FM2 to RUN	Step 5 completed	3 min	*System enters Conditioning Mode with last LUTs. While pressure starts building up optimized LUT values may be loaded*

7	**P_FCP_SOR_CLPM**	**Load LUT - Powers and Times**	**Step 6 completed**	5 min	*If needed, for cooler extra tuning*
7.1	**P_FCP_SOR_CDPM**	**Dump LUT - Powers and Times**	**Step 7 completed**		
8	**P_FCP_SOR_NLRM**	**Load LUT - RUN Mode Transitions**		5 min	*If needed, to maximize Normal Ops duration*
8.1	**P_FCP_SOR_CDRM**	**Dump LUT - RUN Mode Transitions**			
9				1.5 - 2 hrs	***Wait for system pressurization***
10a	**P_FCP_HFI_CX2P** (HCT2Nblanck = 15, HCT2Gamp = 0, HCT2Bias I = 250)	**Reconfigure Cernox 4K SW for 9-19K range**	**Cernox 4K (HD494280) > 9K**	1.5 min	
10b	**P_FCP_HFI_CX3P** (HCT3Nblanck = 15, HCT3Gamp = 0, HCT3Bias I = 250)	**Reconfigure Cernox 4K-1.6K SW for 9-19K range**	**Cernox 4K (HD494280) > 9K**	1.5 min	
11a	**P_FCP_HFI_CX2P** (HCT2Nblanck = 15, HCT2Gamp = 0, HCT2Bias I = 100)	**Reconfigure Cernox 4K SW for <9K range**	**Cernox 4K (HD494280) < 9K**	1.5 min	
11b	**P_FCP_HFI_CX3P** (HCT3Nblanck = 15, HCT3Gamp = 0, HCT3Bias I = 100)	**Reconfigure Cernox 4K-1.6K SW for <9K range**	**Cernox 4K (HD494280) < 9K**	1.5 min	
12	**P_FCP_HFI_4HFS (FreqSelVCS = 255)**	**Select all 4K harmonics for VCS**	**SCS High pressure SM050540 > 15bar and Cernox 4K (HD494280) < 5K**	1.5 min	
13a	**P_FCP_HFI_CP1P**	**Reactivate 1.6K PID**	**SCS High pressure SM050540 > 15bar and Cernox 4K (HD494280) < 5K**	1.5 min	***Old setpoints will be used. No PID settings change***

13b	P_FCP_HFI_CP4P	Reactivate 4K PID	SCS High pressure SM050540 > 15bar and Cernox 4K (HD494280) < 5K	1.5 min	*Old setpoints will be used. No PID settings change*
14	P_FCP_LFI_CFMR	Recover LFI FEM biases	High pressure SM050540 > 27bar	30 min	*TBC by MRB process outcome*
15	*Switchover process holding point*			1.5-2 hrs	*Wait for system transition into Normal Ops before activating TSA and performing next tuning steps*
16					Extra Tuning steps may be required according to operational strategy decisions

Table 9. FM2 contingency restart

At the time of SCS FM2 reactivation the MRB conclusions should define a new mission operational strategy, selecting between two possible scenarios:

Both instruments ON

According to present estimations on SCS EOL, at switchover FM2 will be deactivated with a margin of about a week on remaining lifetime. In principle, the SCS nominal unit can support both instruments for few days of operations. In this case, FM2 would be restarted with the latest loaded input power and cycletime settings for RUN-Nominal Mode. Only RUN-Startup power values should be updated for EOL levels, by loading the values reported in the table below.

POWER and TIMES				
Pos	**Parameter Name**	**Description**	**Eng**	**Units**
0x30	POWER_HEATUP_BEDS	Bed 0 Heatup power for normal operation	**211**	W
0x31	POWER_HEATUP_BEDS+1	Bed 1 Heatup power for normal operation	**211**	W
0x32	POWER_HEATUP_BEDS+2	Bed 2 Heatup power for normal operation	**211**	W
0x33	POWER_HEATUP_BEDS+3	Bed 3 Heatup power for normal operation	**211**	W
0x34	POWER_HEATUP_BEDS+4	Bed 4 Heatup power for normal operation	**211**	W
0x35	POWER_HEATUP_BEDS+5	Bed 5 Heatup power for normal operation	**211**	W
0x36	POWER_DESORB_BED	Bed 0 Desorb power for normal operation	**255**	W

0x37	POWER_DESORB_BED+1	Bed 1 Desorb power for normal operation	**255**	W
0x38	POWER_DESORB_BED+2	Bed 2 Desorb power for normal operation	**255**	W
0x39	POWER_DESORB_BED+3	Bed 3 Desorb power for normal operation	**255**	W
0x3A	POWER_DESORB_BED+4	Bed 4 Desorb power for normal operation	**255**	W
0x3B	POWER_DESORB_BED+5	Bed 5 Desorb power for normal operation	**255**	W
0x3C	POWER_HEATUP_BEDS_STARTUP	Bed 0 Heatup power for startup operation	**211**	W
0x3D	POWER_HEATUP_BEDS_STARTUP+1	Bed 1 Heatup power for startup operation	**211**	W
0x3E	POWER_HEATUP_BEDS_STARTUP+2	Bed 2 Heatup power for startup operation	**211**	W
0x3F	POWER_HEATUP_BEDS_STARTUP+3	Bed 3 Heatup power for startup operation	**211**	W
0x40	POWER_HEATUP_BEDS_STARTUP+4	Bed 4 Heatup power for startup operation	**211**	W
0x41	POWER_HEATUP_BEDS_STARTUP+5	Bed 5 Heatup power for startup operation	**211**	W
0x42	POWER_DESORB_BEDS_STARTUP	Bed 0 Desorb power for startup operation	**255**	W
0x43	POWER_DESORB_BEDS_STARTUP+1	Bed 1 Desorb power for startup operation	**255**	W
0x44	POWER_DESORB_BEDS_STARTUP+2	Bed 2 Desorb power for startup operation	**255**	W
0x45	POWER_DESORB_BEDS_STARTUP+3	Bed 3 Desorb power for startup operation	**255**	W
0x46	POWER_DESORB_BEDS_STARTUP+4	Bed 4 Desorb power for startup operation	**255**	W
0x47	POWER_DESORB_BEDS_STARTUP+5	Bed 5 Desorb power for startup operation	**255**	W
0x48	POWER_LPSB	Low Pressure Stabilization Bed Power	**1,19**	W
0x49	TIME_CYCLE_NORMAL	Cycle Time in Normal Mode	**475**	s
0x4A	TIME_GASGAP_ON_BEDS	Time delay for GGA switch ON	**0**	s
0x4B	TIME_GASGAP_ON_BEDS+1	Time delay for GGA switch ON	**0**	s
0x4C	TIME_GASGAP_ON_BEDS+2	Time delay for GGA switch ON	**0**	s
0x4D	TIME_GASGAP_ON_BEDS+3	Time delay for GGA switch ON	**0**	s
0x4E	TIME_GASGAP_ON_BEDS+4	Time delay for GGA switch ON	**0**	s
0x4F	TIME_GASGAP_ON_BEDS+5	Time delay for GGA switch ON	**0**	s
0x50	TIME_GASGAP_OFF_BEDS	Anticipated GGA switch OFF Time	**60**	s
0x51	TIME_GASGAP_OFF_BEDS+1	Anticipated GGA switch OFF Time	**60**	s
0x52	TIME_GASGAP_OFF_BEDS+2	Anticipated GGA switch OFF Time	**60**	s
0x53	TIME_GASGAP_OFF_BEDS+3	Anticipated GGA switch OFF Time	**60**	s
0x54	TIME_GASGAP_OFF_BEDS+4	Anticipated GGA switch OFF Time	**60**	s
0x55	TIME_GASGAP_OFF_BEDS+5	Anticipated GGA switch OFF Time	**60**	s

Table 10. Power and Times settings in case of FM2 reactivation with LFI and HFI ON

HFI only

In case the FM2 has to support the HFI only (LFI OFF), the heat-lift requirement drops to the point that a high pressure of about 19 bar is enough to support the cryochain. To reach and work with this pressure a lower desorption power will be needed and the cooler will be tuned to that operating point by disabling the TSA and by loading the settings reported in the table below. Ten W are removed from the max desorption power value reached at EOL: this should drop the pressure down to a point closer to the required pressure. Once the pressure has stabilized around its new value, another power decrease will be performed to reach the required 19 bar. A finer tuning (few iterations of LUT upload) will then be needed to adjust the system to the optimal operating point. From here a new weekly LUT adjustment strategy will be implemented.

POWER AND TIMES				
Pos	**Parameter Name**	**Description**	**Eng**	**Units**
0x30	POWER_HEATUP_BEDS	Bed 0 Heatup power for normal operation	**211**	W
0x31	POWER_HEATUP_BEDS+1	Bed 1 Heatup power for normal operation	**211**	W
0x32	POWER_HEATUP_BEDS+2	Bed 2 Heatup power for normal operation	**211**	W
0x33	POWER_HEATUP_BEDS+3	Bed 3 Heatup power for normal operation	**211**	W
0x34	POWER_HEATUP_BEDS+4	Bed 4 Heatup power for normal operation	**211**	W
0x35	POWER_HEATUP_BEDS+5	Bed 5 Heatup power for normal operation	**211**	W
0x36	POWER_DESORB_BED	Bed 0 Desorb power for normal operation	**245**	W
0x37	POWER_DESORB_BED+1	Bed 1 Desorb power for normal operation	**245**	W
0x38	POWER_DESORB_BED+2	Bed 2 Desorb power for normal operation	**245**	W
0x39	POWER_DESORB_BED+3	Bed 3 Desorb power for normal operation	**245**	W
0x3A	POWER_DESORB_BED+4	Bed 4 Desorb power for normal operation	**245**	W
0x3B	POWER_DESORB_BED+5	Bed 5 Desorb power for normal operation	**245**	W
0x3C	POWER_HEATUP_BEDS_STARTUP	Bed 0 Heatup power for startup operation	**211**	W
0x3D	POWER_HEATUP_BEDS_STARTUP+1	Bed 1 Heatup power for startup operation	**211**	W
0x3E	POWER_HEATUP_BEDS_STARTUP+2	Bed 2 Heatup power for startup operation	**211**	W
0x3F	POWER_HEATUP_BEDS_STARTUP+3	Bed 3 Heatup power for startup operation	**211**	W
0x40	POWER_HEATUP_BEDS_STARTUP+4	Bed 4 Heatup power for startup operation	**211**	W
0x41	POWER_HEATUP_BEDS_STARTUP+5	Bed 5 Heatup power for startup operation	**211**	W
0x42	POWER_DESORB_BEDS_STARTUP	Bed 0 Desorb power for startup operation	**245**	W
0x43	POWER_DESORB_BEDS_STARTUP+1	Bed 1 Desorb power for startup operation	**245**	W
0x44	POWER_DESORB_BEDS_STARTUP+2	Bed 2 Desorb power for startup operation	**245**	W
0x45	POWER_DESORB_BEDS_STARTUP+3	Bed 3 Desorb power for startup operation	**245**	W
0x46	POWER_DESORB_BEDS_STARTUP+4	Bed 4 Desorb power for startup operation	**245**	W
0x47	POWER_DESORB_BEDS_STARTUP+5	Bed 5 Desorb power for startup operation	**245**	W
0x48	POWER_LPSB	Low Pressure Stabilization Bed Power	**1,19**	W
0x49	TIME_CYCLE_NORMAL	Cycle Time in Normal Mode	**475**	s
0x4A	TIME_GASGAP_ON_BEDS	Time delay for GGA switch ON	**0**	s
0x4B	TIME_GASGAP_ON_BEDS+1	Time delay for GGA switch ON	**0**	s
0x4C	TIME_GASGAP_ON_BEDS+2	Time delay for GGA switch ON	**0**	s
0x4D	TIME_GASGAP_ON_BEDS+3	Time delay for GGA switch ON	**0**	s
0x4E	TIME_GASGAP_ON_BEDS+4	Time delay for GGA switch ON	**0**	s
0x4F	TIME_GASGAP_ON_BEDS+5	Time delay for GGA switch ON	**0**	s
0x50	TIME_GASGAP_OFF_BEDS	Anticipated GGA switch OFF Time	**60**	s
0x51	TIME_GASGAP_OFF_BEDS+1	Anticipated GGA switch OFF Time	**60**	s
0x52	TIME_GASGAP_OFF_BEDS+2	Anticipated GGA switch OFF Time	**60**	s
0x53	TIME_GASGAP_OFF_BEDS+3	Anticipated GGA switch OFF Time	**60**	s
0x54	TIME_GASGAP_OFF_BEDS+4	Anticipated GGA switch OFF Time	**60**	s
0x55	TIME_GASGAP_OFF_BEDS+5	Anticipated GGA switch OFF Time	**60**	s

Table 11. Power and Times settings in case of FM2 reactivation with HFI only ON

1.6.3. Recovery Operations: FM1 in 5/4 beds operations

In case of unresolved issues with one or two beds during the activation of FM1, the baseline operation is to proceed with 5/4 beds operations. In such a way basic performance of SCS can be ensured until a final decision on a new operational strategy has been taken.
If bed removal is not done autonomously (see SCS UM FMECA, Ch. 7) it can be done manually following the procedure in Table 12. This procedure is used to declare a bed as "bad"/"good" to remove/insert it from/into the cycle.

Step #	Description	Type	Action	Result
1	Set Bed State (SC015530)	TC(8.4)	SC015530, SID 401, Set Bed id Bits 0...3: Bed Number (0 to 5) to Bit 4..5: bed state (0=bad, 1=Run Normal Mode only, 2 or 3= good)	Check SA012540 for Bed status, SM893540-SM898540 and SM870540-SM875540 SM001540, SM002540
1.1	Wait for TC acknowledgment TM(1.1) and/or TM(1.3)	TM(1.1) & TM(1.3)	1 - TM(1.1)	TM(1.1) - CV_ID=1

Table 12. Manual bad bed detection

TC SC015530 can be send from any Mode except BOOT.
Only a max of two beds can be removed from cooler cycle. A third bed detection (or telecommand) sends the system automatically in READY Mode.
This operation is fully defined in FOP reference P_CRP_SOR_CBSA.

1.7. SCS FM1 LUT loaded before Launch

SOFTWARE					
Pos	Parameter Name	Description	Engineering Values		
			bit	SCS-Red Flight	Units
0x00	SW_AUTO_FUNCTIONS Autonomous functions that can be enabled or disabled	Boot Mode ASW Transfer EEPROM→RAM	0	**0**	N/A
		Boot Auto Hardware Tests	1	**1**	N/A
		ASW Auto Hardware Tests	2	**1**	N/A
		Run Diagnostic Sorption Cooler	3	**1**	N/A
		Run Diagnostic Electronics	4	**1**	N/A
		Run Diagnostic Bad Heaters	5	**1**	N/A
		Run Diagnostic Bad ADC	6	**1**	N/A
		Run Diagnostic Bad Sensors	7	**1**	N/A
		Auto GoTo Startup	8	**1**	N/A
		Auto GoTo Defrost	9	**0**	N/A
		Auto GoTo Off-Normal	10	**1**	N/A
		TSA PID Regulation Enable	11	**0**	N/A
		OPEN LOOP Enable	12	**0**	N/A
0x01	SW_ASW_ADR	Base address of the applicative software to use		**8005000**	Hexadecimal
0x02	SW_CHECKSUM_1_ADR	Base address of the eeprom 1 checksums		**8003000**	Hexadecimal
0x03	SW_CHECKSUM_N_ADR	Base address of the eeprom n checksums		**8007000**	Hexadecimal
0x04	SW_TEST_EXT_TIMER_LENGTH	Test external timers duration		**1**	s
0x05	SW_TEST_FPGA_TIMER_LENGTH	Test fpga timer duration		**62.5**	ns
0x06	SENSORS_MEAN_T	Number of read to average sensor T1		**30**	decimal
0x07	SENSORS_MEAN_T+1	Number of read to average sensor T2		**30**	decimal
0x08	SENSORS_MEAN_T+2	Number of read to average sensor T3		**30**	decimal
0x09	SENSORS_MEAN_T+3	Number of read to average sensor T4		**30**	decimal
0x0A	SENSORS_MEAN_T+4	Number of read to average sensor T5		**30**	decimal
0x0B	SENSORS_MEAN_T+5	Number of read to average sensor T6		**30**	decimal
0x0C	SENSORS_MEAN_T+6	Number of read to average sensor T7		**30**	decimal
0x0D	SENSORS_MEAN_T+7	Number of read to average sensor T8		**30**	decimal
0x0E	SENSORS_MEAN_T+8	Number of read to average sensor T9		**30**	decimal
0x0F	SENSORS_MEAN_T+9	Number of read to average sensor T10		**30**	decimal
0x10	SENSORS_MEAN_T+10	Number of read to average sensor T11		**30**	decimal
0x11	SENSORS_MEAN_T+11	Number of read to average sensor T12		**30**	decimal
0x12	SENSORS_MEAN_T+12	Number of read to average sensor T13		**30**	decimal
0x13	SENSORS_MEAN_T+13	Number of read to average sensor T14		**30**	decimal
0x14	SENSORS_MEAN_T+14	Number of read to average sensor T15		**30**	decimal
0x15	SENSORS_MEAN_T+15	Number of read to average sensor T16		**30**	decimal
0x16	SENSORS_MEAN_T+16	Number of read to average sensor T17		**30**	decimal
0x17	SENSORS_MEAN_T+17	Number of read to average sensor T18		**30**	decimal
0x18	SENSORS_MEAN_T+18	Number of read to average sensor T20		**30**	decimal
0x19	SENSORS_MEAN_T+19	Number of read to average sensor T21		**30**	decimal
0x1A	SENSORS_MEAN_T+20	Number of read to average sensor T22		**30**	decimal

0x1B	SENSORS_MEAN_T+21	Number of read to average sensor T23		**30**	decimal
0x1C	SENSORS_MEAN_T+22	Number of read to average sensor T24		**30**	decimal
0x1D	SENSORS_MEAN_T+23	Number of read to average sensor T25		**30**	decimal
0x1E	SENSORS_MEAN_T+24	Number of read to average sensor T26		**30**	decimal
0x1F	SENSORS_MEAN_T+25	Number of read to average sensor T27		**30**	decimal
0x20	SENSORS_MEAN_T+26	Number of read to average sensor T28		**30**	decimal
0x21	SENSORS_MEAN_T+27	Number of read to average sensor T29		**30**	decimal
0x22	SENSORS_MEAN_T+28	Number of read to average sensor T30		**30**	decimal
0x23	SENSORS_MEAN_P	Number of read to average sensor P1		**30**	decimal
0x24	SENSORS_MEAN_P+1	Number of read to average sensor P2		**30**	decimal
0x25	SENSORS_MEAN_P+2	Number of read to average sensor P3		**30**	decimal
0x26	SENSORS_MEAN_P+3	Number of read to average sensor P4		**30**	decimal
0x27	SENSORS_MEAN_P+4	Number of read to average sensor P5		**30**	decimal
0x28	SENSORS_MEAN_P+5	Number of read to average sensor P6		**30**	decimal
0x29	SENSORS_MEAN_P+6	Number of read to average sensor P7		**30**	decimal
0x2A	SENSORS_MEAN_P+7	Number of read to average sensor P8		**30**	decimal
0x2B	SENSORS_MEAN_TEST	Number of read to average sensor VGAIN		**30**	decimal
0x2C	SENSORS_MEAN_TEST+1	Number of read to average sensor VOFF		**30**	decimal
0x2D	SENSORS_MEAN_TEST+2	Number of read to average sensor CAL1		**30**	decimal
0x2E	SENSORS_MEAN_TEST+3	Number of read to average sensor CAL2		**30**	decimal
0x2F	SENSORS_TRESEHOLD	Used for software averaged sensors : the first 'tresehold' values will not be taken into account		**5**	decimal

POWER AND TIMES

Pos	Parameter Name	Description	Engineering Values	
			SCS-Red Flight	Units
0x30	POWER_HEATUP_BEDS	Bed 0 Heatup power for normal operation	**134**	W
0x31	POWER_HEATUP_BEDS+1	Bed 1 Heatup power for normal operation	**134**	W
0x32	POWER_HEATUP_BEDS+2	Bed 2 Heatup power for normal operation	**134**	W
0x33	POWER_HEATUP_BEDS+3	Bed 3 Heatup power for normal operation	**134**	W
0x34	POWER_HEATUP_BEDS+4	Bed 4 Heatup power for normal operation	**134**	W
0x35	POWER_HEATUP_BEDS+5	Bed 5 Heatup power for normal operation	**134**	W
0x36	POWER_DESORB_BED	Bed 0 Desorb power for normal operation	**130**	W
0x37	POWER_DESORB_BED+1	Bed 1 Desorb power for normal operation	**130**	W
0x38	POWER_DESORB_BED+2	Bed 2 Desorb power for normal operation	**130**	W
0x39	POWER_DESORB_BED+3	Bed 3 Desorb power for normal operation	**130**	W
0x3A	POWER_DESORB_BED+4	Bed 4 Desorb power for normal operation	**130**	W
0x3B	POWER_DESORB_BED+5	Bed 5 Desorb power for normal operation	**130**	W
0x3C	POWER_HEATUP_BEDS_STARTUP	Bed 0 Heatup power for startup operation	**134**	W
0x3D	POWER_HEATUP_BEDS_STARTUP+1	Bed 1 Heatup power for startup operation	**134**	W
0x3E	POWER_HEATUP_BEDS_STARTUP+2	Bed 2 Heatup power for startup operation	**134**	W
0x3F	POWER_HEATUP_BEDS_STARTUP+3	Bed 3 Heatup power for startup operation	**134**	W
0x40	POWER_HEATUP_BEDS_STARTUP+4	Bed 4 Heatup power for startup operation	**134**	W
0x41	POWER_HEATUP_BEDS_STARTUP+5	Bed 5 Heatup power for startup operation	**134**	W
0x42	POWER_DESORB_BEDS_STARTUP	Bed 0 Desorb power for startup operation	**130**	W
0x43	POWER_DESORB_BEDS_STARTUP+1	Bed 1 Desorb power for startup operation	**130**	W
0x44	POWER_DESORB_BEDS_STARTUP+2	Bed 2 Desorb power for startup operation	**130**	W
0x45	POWER_DESORB_BEDS_STARTUP+3	Bed 3 Desorb power for startup operation	**130**	W
0x46	POWER_DESORB_BEDS_STARTUP+4	Bed 4 Desorb power for startup operation	**130**	W
0x47	POWER_DESORB_BEDS_STARTUP+5	Bed 5 Desorb power for startup operation	**130**	W
0x48	POWER_LPSB	Low Pressure Stabilization Bed Power	**1.35**	W
0x49	TIME_CYCLE_NORMAL	Cycle Time in Normal Mode	**940**	s
0x4A	TIME_GASGAP_ON_BEDS	Time delay for GGA switch ON	**0**	s
0x4B	TIME_GASGAP_ON_BEDS+1	Time delay for GGA switch ON	**0**	s
0x4C	TIME_GASGAP_ON_BEDS+2	Time delay for GGA switch ON	**0**	s
0x4D	TIME_GASGAP_ON_BEDS+3	Time delay for GGA switch ON	**0**	s
0x4E	TIME_GASGAP_ON_BEDS+4	Time delay for GGA switch ON	**0**	s
0x4F	TIME_GASGAP_ON_BEDS+5	Time delay for GGA switch ON	**0**	s
0x50	TIME_GASGAP_OFF_BEDS	Anticipated GGA switch OFF Time	**60**	s
0x51	TIME_GASGAP_OFF_BEDS+1	Anticipated GGA switch OFF Time	**60**	s
0x52	TIME_GASGAP_OFF_BEDS+2	Anticipated GGA switch OFF Time	**60**	s
0x53	TIME_GASGAP_OFF_BEDS+3	Anticipated GGA switch OFF Time	**60**	s
0x54	TIME_GASGAP_OFF_BEDS+4	Anticipated GGA switch OFF Time	**60**	s
0x55	TIME_GASGAP_OFF_BEDS+5	Anticipated GGA switch OFF Time	**60**	s

HEALTHCHECK REGENERATION				
Pos	Parameter Name	Description	Engineering Values	
			SCS-Red Flight	Units
0x56	HEALTHCHECK_DELTA_P_LP	Delta pressure low pressure	**0.001**	bar
0x57	HEALTHCHECK_TIME_LIMIT	Health check time out	**120**	s
0x58	HEALTHCHECK_TLPSB	LPSB temperature limit	*******	K
0x59	HEALTHCHECK_MAX_POWER	Maximum Power	**130**	W
0x5A	HEALTHCHECK_MIN_POWER	Minimum Power	**5**	W
0x5B	HEALTHCHECK_TBED_LIMIT	Bed temperature limit	**305**	K
0x5C	HEALTHCHECK_PBED_LIMIT	Bed pressure limit	**1.38**	bar
0x5D	HEALTHCHECK_DELTAT_COLD	Delta temperature cold	**0.5**	K
0x5E	HEALTHCHECK_TIME_LIMIT_COLD	Cold End Heaters Time-out	**2**	s
0x5F	REGENERATION_POWER	CE heater power to run the regeneration procedure	**150**	W
0x60	REGENERATION_TEMPERATURE	Temperature to be maintained for the regeneration process	**350**	K
0x61	REGENERATION_MAX_PRESSURE	Maximum pressure in the HPST not to be exceeded	**5**	bar
0x62	REGENERATION_TIME	Time needed to maintain the CE at REGEN_TEMPERATURE to complete the regeneration process	**180**	s
0x63	REGENERATION_MAX_TIME	Maximum time allowed during a regeneration process	**72000**	s
0x64	REGENERATION_GGON_TEMPERATURE	maximum CE temperature that allows the GGA to be turned ON	**320**	K
0x65	REGENERATION_DELTAT	set bang-bang level	**2**	K

*** LPSB T limit parameter (HEALTHCHECK_TLPSB) must be set to T17 + 0.5K **just before** executing the test

RUN MODE TRANSITION				
Pos	Parameter Name	Description	Engineering Values	
			SCS-Red Flight	Units
0x66	STARTUP_TIME_ADJUST_MDP	Conditioning Maximum Desorption Pressure	**34.5**	bar
0x67	STARTUP_TIME_ADJUST_MDT	Maximum Desorbing temperature	**460**	K
0x68	STARTUP_TIME_ADJUST_MHT	Maximum Heatup Temperature	**420**	K
0x69	STARTUP_TIME_ADJUST_MCTFIRST	Maximum cycle time (first cycle)	**390**	s
0x6A	STARTUP_TIME_ADJUST_MCTNEXT	Maximum cycle time (next cycles)	**1200**	s
0x6B	STARTUP_ENTER_DEFROST_MTP	Maximum Tank Pressure	**54**	bar
0x6C	STARTUP_ENTER_DEFROST_MJT_T7	Maximum JT Temperature (using T7)	**100**	K
0x6D	STARTUP_ENTER_DEFROST_MJT_T30	Maximum JT Temperature (using T30)	**100**	K
0x6E	STARTUP_ENTER_DEFROST_FLOW	Condition to enter in defrost : Flow Expected	**65535**	decimal
0x6F	STARTUP_EXIT_DEFROST_TIME	Defrost Time out (maximum defrost duration)	**1000**	s
0x70	STARTUP_EXIT_DEFROST_MJT_T7	Exit Defrost Condition (using T7)	**80**	K
0x71	STARTUP_EXIT_DEFROST_MJT_T30	Exit Defrost Condition (using T30)	**80**	K
0x72	STARTUP_ENTER_NORMAL_MCONJT_T7	Maximum startup JT Temperature (using T7)	**22**	K
0x73	STARTUP_ENTER_NORMAL_MCONJT_T30	Maximum startup JT Temperature (using T30)	**22**	K
0x74	STARTUP_ENTER_NORMAL_MINCONJT	Minimum Tank Pressure In Startup operation	**28.3**	bar
0x75	STARTUP_ENTER_NORMAL_MAXCONJT	Maximum Tank Pressure In Startup operation	**36.5**	bar
0x76	NORMAL_ENTER_STARTUP_MINNTP	Minimum Tank Pressure in Normal operation	**26.5**	bar
0x77	NORMAL_ENTER_STARTUP_MAXNTP	Maximum Tank Pressure in Normal operation	**37.2**	bar
0x78	NORMAL_ENTER_STARTUP_MNCET	Maximum Normal compressor element temperature	**480**	K
0x79	NORMAL_ENTER_STARTUP_MNJT_T7	Maximum normal JT Temperature (using T7)	**23**	K
0x7A	NORMAL_ENTER_STARTUP_MNJT_T30	Maximum normal JT Temperature (using T30)	**23**	K
0x7B	STARTUP_LPSB_HIGH_TEMPERATURE_LIMIT	LPSB ‘bang bang’ procedure higher limit	**296**	K
0x7C	STARTUP_LPSB_LOW_TEMPERATURE_LIMIT	LPSB ‘bang bang’ procedure lower limit	**295**	K
0x7D	STARTUP_HPST_PRESSURE_LIMIT	Startup HPST Pressure Limit	**28**	bar
0x7E	NORMAL_H8_RATE_IF_H7_BAD	H8 on % when H7 is bad (see FMECA 6.2.4 ID#3)	**5**	dec %

FAULTS

Pos	Parameter Name	Description	Engineering Values	
			SCS-Red Flight	**Units**
0x7F	FAULT_COND_BED_TEMPERATURE_LIMIT	Fault condition bed temperature limit	**525**	K
0x80	FAULT_COND_BED_PRESSURE_LIMIT	Fault condition bed pressure limit	**54.1**	bar
0x81	FAULT_COND_LPSB_TEMPERATURE_LIMIT	Fault condition lpsb temperature limit	**350**	K
0x82	FAULT_COND_PRT_TEMPERATURE_DEFAULT	Default temp. for all PRTs sensors in case of failure	**270**	K
0x83	FAULT_COND_JT_TEMPERATURE_DEFAULT	Default temp. for JT sensors in case of failure	**23**	K
0x84	BAD_BED_DETECT_COOL_TEMP_LIMIT	Bad Bed Detection : cooldown bed must be removed if its temperature is higher than this limit	**330**	K
0x85	BAD_BED_DETECT_COOL_PRESSURE_LIMIT	Bad Bed Detection : cooldown bed must be removed if its pressure is higher than this limit	**7.58**	bar
0x86	BAD_BED_DETECT_HEATUP_TEMP_LIMIT	Bad Bed Detection : heatup bed must be removed if its temperature is higher than this limit	**330**	K
0x87	BAD_BED_DETECT_HEATUP_PRESSURE_LIMIT	Bad Bed Detection : heatup bed must be removed if its pressure is higher than this limit	**7.58**	bar
0x88	BAD_BED_DETECT_CYCLE_PERIOD	Bad Bed Detection : Bad Bed Detection is enabled if cycle time is below this limit	**390**	s
0x89	FAULT_ELECTRONIC_28V_DEFAULT	If 28 volts is wrong use this value to calculate the power	**27.5**	V
0x8a	FAULT_ELECTRONIC_28V_UP_LIMIT	If 28 volts is greater than this value, 28 volts is wrong	**32**	V
0x8b	FAULT_ELECTRONIC_28V_LOW_LIMIT	If 28 volts is lower than this value, 28 volts is wrong	**25**	V
0x8c	FAULT_ELECTRONIC_12V_UP_LIMIT	If 12 volts is greater than this value, 12 volts is wrong	**13**	V
0x8d	FAULT_ELECTRONIC_12V_LOW_LIMIT	If 12 volts is lower than this value, 12 volts is wrong	**11**	V
0x8e	FAULT_ELECTRONIC_12V_TIME	See FMECA 6.3.2	**120**	s
0x8f	FAULT_ELECTRONIC_TEMP_FIRST	See FMECA 6.3.1	**333**	K
0x90	FAULT_ELECTRONIC_TEMP_SECOND	See FMECA 6.3.1	**353**	K
0x91	FAULT_ELECTRONIC_ADC_REF	Digital output from reference sensor shall be compared to this value +- delta	**60800**	decimal
0x92	FAULT_ELECTRONIC_ADC_DELTA	Digital output from reference sensor shall be compared to reference value +- this parameter	**250**	decimal
0x93	FAULT_HEATERS_H2I_ON	Gas Gaps current must be up this limit when active	**0.5**	A
0x94	FAULT_HEATERS_H2I_OFF	Gas Gap current must be lower than this limit when inactive	**0.1**	A
0x95	FAULT_HEATERS_H7	I measured on H7 must be equal to I applied (from DAC value) ± this parameter	**0.1**	A
0x96	FAULT_HEATERS_H31	I measured on H31/H32 must be equal to I applied (from DAC value) ± this parameter	**0.1**	A
0x97	FAULT_HEATERS_H8	If T17 and T18 temperature are above this limit, H8 is always on (Failure from FDIR)	**320**	K
0x98	FAULT_HEATERS_H34_H35_T_UP_T7	H33/H34 bad if JT temperature up this limit (using T7)	**110**	K
0x99	FAULT_HEATERS_H34_H35_T_UP_T30	H33/H34 bad if JT temperature up this limit (using T30)	**110**	K
0x9a	FAULT_HEATERS_H34_H35_DELTA_T	H33/H34 bad if this value is not reached within ‘rise time’	**25**	K
0x9b	FAULT_HEATERS_H34_H35_RISE_TIME	H33/H34 bad if ‘delta T’ is not reached within this time value	**180**	s

PID				
Pos	**Parameter Name**	**Description**	**Engineering Values**	
			SCS-Red Flight	**Units**
0x9c	PID_SETPOINT_T5	Set Point of the L3 PID regulator (using T5)	**18.05**	K
0x9d	PID_SETPOINT_T6	Set Point of the L3 PID regulator (using T6)	**18.05**	K
0x9e	PID_P	P parameter of the L3 PID regulator	**500**	decimal
0x9f	PID_I	I parameter of the L3 PID regulator	**15**	decimal
0xa0	PID_D	D parameter of the L3 PID regulator	**0**	decimal
0xa1	PID_RATE	Sampling rate of the L3 PID regulator	**1**	decimal
0xa2	PID_UPPER_LIMIT	Upper Limit of the L3 PID regulator	**22**	K
0xa3	PID_LOWER_LIMIT	Lower Limit of the L3 PID regulator	**0**	K
0xa4	PID_TEMPERATURE_LIMIT_T5	Temperature Limit of the L3 PID regulator (using T5)	**22**	K
0xa5	PID_TEMPERATURE_LIMIT_T6	Temperature Limit of the L3 PID regulator (using T6)	**22**	K
0xa6	OPEN_LOOP_R1	R1 value from the open loop algorithm	**1.63**	K/W
0xa7	OPEN_LOOP_N	Number of previous Q_LFI value to average from open loop	**60**	decimal

RESISTORS

Pos	Parameter Name	Description	Engineering Values	
			SCS-Red Flight	**Units**
0xa8	HW_HEATERS_RB	Loss resistor ‘rb’ for bed 0 power calculation	**5.00**	□
0xa9	HW_HEATERS_RB+1	Loss resistor ‘rb’ for bed 1 power calculation	**5.00**	□
0xaa	HW_HEATERS_RB+2	Loss resistor ‘rb’ for bed 2 power calculation	**5.10**	□
0xab	HW_HEATERS_RB+3	Loss resistor ‘rb’ for bed 3 power calculation	**5.00**	□
0xac	HW_HEATERS_RB+4	Loss resistor ‘rb’ for bed 4 power calculation	**5.00**	□
0xad	HW_HEATERS_RB+5	Loss resistor ‘rb’ for bed 5 power calculation	**4.90**	□
0xae	HW_HEATERS_RBL	Loss resistor ‘rbl’ for bed 0 power calculation	**5.10**	□
0xaf	HW_HEATERS_ RBL+1	Loss resistor ‘rbl’ for bed 1 power calculation	**5.10**	□
0xb0	HW_HEATERS_RBL+2	Loss resistor ‘rbl’ for bed 2 power calculation	**5.20**	□
0xb1	HW_HEATERS_RBL+3	Loss resistor ‘rbl’ for bed 3 power calculation	**5.10**	□
0xb2	HW_HEATERS_RBL+4	Loss resistor ‘rbl’ for bed 4 power calculation	**5.10**	□
0xb3	HW_HEATERS_RBL+5	Loss resistor ‘rbl’ for bed 5 power calculation	**5.00**	□
0xb4	HW_HEATERS_RV	Loss resistor ‘rv’ for bed 0 power calculation	**5.40**	□
0xb5	HW_HEATERS_RV+1	Loss resistor ‘rv’ for bed 1 power calculation	**5.40**	□
0xb6	HW_HEATERS_RV+2	Loss resistor ‘rv’ for bed 2 power calculation	**5.40**	□
0xb7	HW_HEATERS_RV+3	Loss resistor ‘rv’ for bed 3 power calculation	**5.20**	□
0xb8	HW_HEATERS_RV+4	Loss resistor ‘rv’ for bed 4 power calculation	**5.40**	□
0xb9	HW_HEATERS_RV+5	Loss resistor ‘rv’ for bed 5 power calculation	**5.30**	□
0xba	HW_HEATERS_RVL	Loss resistor ‘rvl’ for bed 0 power calculation	**5.50**	□
0xbb	HW_HEATERS_RVL+1	Loss resistor ‘rvl’ for bed 1 power calculation	**5.50**	□
0xbc	HW_HEATERS_RVL+2	Loss resistor ‘rvl’ for bed 2 power calculation	**5.50**	□
0xbd	HW_HEATERS_RVL+3	Loss resistor ‘rvl’ for bed 3 power calculation	**5.30**	□
0xbe	HW_HEATERS_RVL+4	Loss resistor ‘rvl’ for bed 4 power calculation	**5.50**	□
0xbf	HW_HEATERS_RVL+5	Loss resistor ‘rvl’ for bed 5 power calculation	**5.40**	□
0xc0	HW_HEATERS_RH7	H7 resistor for LPSB power H7 calculation	**32.60**	□
0xc1	HW_HEATERS_RH31	H31 resistor for LR3 (nominal) power calculation	**488.00**	□
0xc2	HW_HEATERS_RH32	H32 resistor for LR3 (redundant) power calculation	**488.00**	□

CALIBRATION 1				
Pos	**Parameter Name**	**Description**	**Engineering Values**	
			SCS-Red Flight	**Units**
0xc3	HW_CAL_ADC_V31	Calibration ADC to volts for 31 volts	**1310.7**	decimal
0xc4	HW_CAL_ADC_V28	Calibration ADC to volts for 28 volts	**2184.5**	decimal
0xc5	HW_CAL_ADC_V12	Calibration ADC to volts for 12 volts	**3276.75**	decimal
0xc6	HW_CAL_GAIN_H7	GAINh7 part of Ih7 = GAINh7 + OFFSETh7	**0.9736**	decimal
0xc7	HW_CAL_OFFSET_H7	OFFSETh7 part of Ih7 = GAINh7 + OFFSETh7	**0**	decimal
0xc8	HW_CAL_GAIN_H31	GAINh31 part of Ih31 = GAINh31 + OFFSETh31	**0.0812**	decimal
0xc9	HW_CAL_OFFSET_H31	OFFSETh31 part of Ih31 = GAINh31 + OFFSETh31	**0**	decimal
0xca	HW_CAL_GAIN_H32	GAINh32 part of Ih32 = GAINh32 + OFFSETh32	**0.0812**	decimal
0xcb	HW_CAL_OFFSET_H32	OFFSETh32 part of Ih32 = GAINh32 + OFFSETh32	**0**	decimal
0xcc	HW_CAL_T3_R0	T3(ADC) → T3(K). Resistance = T3(ADC) * R0 / 65535 + R1	**4418.24**	decimal
0xcd	HW_CAL_T3_R1	T3(ADC) → T3(K). Resistance = T3(ADC) * R0 / 65535 + R1	**122.32**	decimal
0xce	HW_CAL_T3_ZL	T3(ADC) → T3(K). Chebychev ZL coefficient	**2.907696155**	decimal
0xcf	HW_CAL_T3_ZU	T3(ADC) → T3(K). Chebychev ZU coefficient	**4.03298032**	decimal
0xd0	HW_CAL_T3_A0	T3(ADC) → T3(K). Chebychev A0 coefficient	**11.962971**	decimal
0xd1	HW_CAL_T3_A1	T3(ADC) → T3(K). Chebychev A1 coefficient	**-11.194584**	decimal
0xd2	HW_CAL_T3_A2	T3(ADC) → T3(K). Chebychev A2 coefficient	**3.515801**	decimal
0xd3	HW_CAL_T3_A3	T3(ADC) → T3(K). Chebychev A3 coefficient	**-0.783545**	decimal
0xd4	HW_CAL_T3_A4	T3(ADC) → T3(K). Chebychev A4 coefficient	**0.113076**	decimal
0xd5	HW_CAL_T3_A5	T3(ADC) → T3(K). Chebychev A5 coefficient	**-0.006186**	decimal
0xd6	HW_CAL_T4_R0	T4(ADC) → T4(K). Resistance = T4(ADC) * R0 / 65535 + R1	**4417.24**	decimal
0xd7	HW_CAL_T4_R1	T4(ADC) → T4(K). Resistance = T4(ADC) * R0 / 65535 + R1	**122.35**	decimal
0xd8	HW_CAL_T4_ZL	T4(ADC) → T4(K). Chebychev ZL coefficient	**2.76194118**	decimal
0xd9	HW_CAL_T4_ZU	T4(ADC) → T4(K). Chebychev ZU coefficient	**3.938180357**	decimal
0xda	HW_CAL_T4_A0	T4(ADC) → T4(K). Chebychev A0 coefficient	**11.837288**	decimal
0xdb	HW_CAL_T4_A1	T4(ADC) → T4(K). Chebychev A1 coefficient	**-11.036423**	decimal
0xdc	HW_CAL_T4_A2	T4(ADC) → T4(K). Chebychev A2 coefficient	**3.529423**	decimal
0xdd	HW_CAL_T4_A3	T4(ADC) → T4(K). Chebychev A3 coefficient	**-0.86858**	decimal
0xde	HW_CAL_T4_A4	T4(ADC) → T4(K). Chebychev A4 coefficient	**0.169652**	decimal
0xdf	HW_CAL_T4_A5	T4(ADC) → T4(K). Chebychev A5 coefficient	**-0.026502**	decimal
0xe0	HW_CAL_T4_A6	T4(ADC) → T4(K). Chebychev A6 coefficient	**0.003555**	decimal

Calibration 2				
Pos	Parameter Name	Description	Engineering Values	
			SCS-Red Flight	Units
0xe1	HW_CAL_T5_R0	T5(ADC) → T5(K). Resistance = T5(ADC) * R0 / 65535 + R1	**1764.12**	decimal
0xe2	HW_CAL_T5_R1	T5(ADC) → T5(K). Resistance = T5(ADC) * R0 / 65535 + R1	**665.29**	decimal
0xe3	HW_CAL_T5_ZL	T5(ADC) → T5(K). Chebychev ZL coefficient	**2.822024226**	decimal
0xe4	HW_CAL_T5_ZU	T5(ADC) → T5(K). Chebychev ZU coefficient	**3.759289252**	decimal
0xe5	HW_CAL_T5_A0	T5(ADC) → T5(K). Chebychev A0 coefficient	**11.86822**	decimal
0xe6	HW_CAL_T5_A1	T5(ADC) → T5(K). Chebychev A1 coefficient	**-11.125414**	decimal
0xe7	HW_CAL_T5_A2	T5(ADC) → T5(K). Chebychev A2 coefficient	**3.568656**	decimal
0xe8	HW_CAL_T5_A3	T5(ADC) → T5(K). Chebychev A3 coefficient	**-0.809943**	decimal
0xe9	HW_CAL_T5_A4	T5(ADC) → T5(K). Chebychev A4 coefficient	**0.107181**	decimal
0xea	HW_CAL_T5_A5	T5(ADC) → T5(K). Chebychev A5 coefficient	**0.003469**	decimal
0xeb	HW_CAL_T5_A6	T5(ADC) → T5(K). Chebychev A6 coefficient	**-0.004578**	decimal
0xec	HW_CAL_T5_A7	T5(ADC) → T5(K). Chebychev A7 coefficient	**0.000383**	decimal
0xed	HW_CAL_T6_R0	T6(ADC)→T6(K). Resistance = T6(ADC) * R0 / 65535 + R1	**1765.74**	decimal
0xee	HW_CAL_T6_R1	T6(ADC)→T6(K). Resistance = T6(ADC) * R0 / 65535 + R1	**665.51**	decimal
0xef	HW_CAL_T6_ZL	T6(ADC) → T6(K). Chebychev ZL coefficient	**2.995075652**	decimal
0xf0	HW_CAL_T6_ZU	T6(ADC) → T6(K). Chebychev ZU coefficient	**4.313704991**	decimal
0xf1	HW_CAL_T6_A0	T6(ADC) → T6(K). Chebychev A0 coefficient	**11.714016**	decimal
0xf2	HW_CAL_T6_A1	T6(ADC) → T6(K). Chebychev A1 coefficient	**-11.039031**	decimal
0xf3	HW_CAL_T6_A2	T6(ADC) → T6(K). Chebychev A2 coefficient	**3.722686**	decimal
0xf4	HW_CAL_T6_A3	T6(ADC) → T6(K). Chebychev A3 coefficient	**-0.938237**	decimal
0xf5	HW_CAL_T6_A4	T6(ADC) → T6(K). Chebychev A4 coefficient	**0.158954**	decimal
0xf6	HW_CAL_T6_A5	T6(ADC) → T6(K). Chebychev A5 coefficient	**-0.007817**	decimal
0xf7	HW_CAL_T6_A6	T6(ADC) → T6(K). Chebychev A6 coefficient	**-0.00354**	decimal
0xf8	HW_CAL_T7_R0	T7(ADC) → T7(K). Resistance = T7(ADC) * R0 / 65535 + R1	**4423.38**	decimal
0xf9	HW_CAL_T7_R1	T7(ADC) → T7(K). Resistance = T7(ADC) * R0 / 65535 + R1	**122.53**	decimal
0xfa	HW_CAL_T7_A	T7(K) from T7(ADC). R=ADC * R0 / 65535 + R1. X = log R. T (Kelvin) = exp(A – B . x)	**9.1952**	decimal
0xfb	HW_CAL_T7_B	T7(K) from T7(ADC). R=ADC * R0 / 65535 + BR1 X = log R. T (Kelvin) = exp(A – B . x)	**0.824**	decimal
0xfc	HW_CAL_T30_R0	T30(ADC) → T30(K). Resistance = T30(ADC) * R0 / 65535 + R1	**4415.3**	decimal
0xfd	HW_CAL_T30_R1	T30(ADC) → T30(K). Resistance = T30(ADC) * R0 / 65535 + R1	**122.36**	decimal
0xfe	HW_CAL_T30_A	T30(K) from T3(ADC). R=ADC * R0 / 65535 + R1. X = log R. T (Kelvin) = exp(A – B . x)	**9.2067**	decimal
0xff	HW_CAL_T30_B	T30(K) from T3(ADC). R=ADC * R0 / 65535 + R1. X = log R. T (Kelvin) = exp(A – B . x)	**0.824**	decimal
0x100	HW_CAL_TBED_UVA	UVA term for bed temperature calculation : uV = tThermocouple * UVA / 65535 - UVB	**20**	decimal
0x101	HW_CAL_TBED_UVB	UVB term for bed temperature calculation : uV = tThermocouple * UVA / 65535 - UVB	**1.3954**	decimal
0x102	HW_CAL_TBED_TRA	TRA term for bed temp. calc. r = tReferenceK * TRA / 65535 - (tReferenceK -65535)* TRB / 65535	**139**	decimal
0x103	HW_CAL_TBED_TRB	TRB term for bed temp. calc. r = tReferenceK * TRA / 65535 - (tReferenceK -65535)* TRB / 65535	**78.8**	decimal
0x104	RATE_BED_POWER_ADJUST	Bed heaters power readjustment frequencey (number of sensors set between two power adjustment)	**3**	decimal