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Prepared by	**A. GREGORIO** **LFI DPC Development Team**	**Date:** **Signature:**	**19 Jun 2008** [signature]
	M. MICCOLIS **LFI Project System Team**	**Date:** **Signature:**	**19 Jun 2008** [signature]
	F. PERROTTA **LFI DPC SGS2 Manager**	**Date:** **Signature:**	**19 Jun 2008** [signature]
	L. STRINGHETTI **LFI Project System Team**	**Date:** **Signature:**	**19 Jun 2008** [signature]

Agreed by	**R.C. BUTLER** **LFI Program Manager**	**Date:**	**19 Jun 2008**
		Signature:	[signature]
	A. ZACCHEI **LFI DPC Manager**	**Date:**	**19 Jun 2008**
		Signature:	[signature]
Approved by	**N. MANDOLESI** **LFI Principal Investigator**	**Date:**	**19 Jun 2008**
		Signature:	[signature]

DISTRIBUTION LIST

Recipient	Company / Institute	E-mail address	Sent
T. PASSVOGEL	ESA – Noordwijk	thomas.passvogel@esa.int	
G. CRONE	ESA – Noordwijk	Gerald.Crone@esa.int	
J. MARTI-CANALES	ESA – Noordwijk	Javier.Marti.Canales@esa.int	
L. TUNESI	ESA – Noordwijk	Luca.tunesi@esa.int	
M. VON HOEGEN	ESA – Noordwijk	mvhoegen@esa.int	
P. OLIVIER	ESA – Noordwijk	Pierre.olivier@esa.int	
J. TAUBER	ESA – Noordwijk	jan.tauber@esa.int	
R. LAUREIJS	ESA – Noordwijk	Rlaureij@esa.int	
C. WATSON	ESA – Darmstadt	Christopher.J.Watson@esa.int	
M. SCHMIDT	ESA – Darmstadt	Micha.Schmidt@esa.int	
B. COLLAUDIN	Thales – F – Cannes	bernard.collaudin@thalesaleniaspace.com	
J.P. CHAMBELLAND	Thales – F – Cannes	Jean-Philippe.Chambelland@thalesaleniaspace.com	
N. MANDOLESI	IASF/CNR – Bologna	reno@iasfbo.inaf.it	
C. BUTLER	IASF/CNR – Bologna	butler@iasfbo.inaf.it	
M. BERSANELLI	UNIMI – Milano	marco.bersanelli@mi.infn.it	
F. PASIAN	OAT – Trieste	pasian@oats.inaf.it	
A. ZACCHEI	OAT – Trieste	zacchei@oats.inaf.it	
E. ALIPPI	Thales – I – Vimodrone	alippi@thalesaleniaspace.com	
G. CAFAGNA	Thales – I – Vimodrone	cafagna@thalesaleniaspace.com	
M. MICCOLIS	Thales – I – Vimodrone	miccolis@thalesaleniaspace.com	
F. MONZANI	Thales – I – Vimodrone	monzani@thalesaleniaspace.com	
R. SILVESTRI	Thales – I – Vimodrone	silvestri@thalesaleniaspace.com	
P. LEUTENEGGER	Thales – I – Vimodrone	leutenegger@thalesaleniaspace.com	
LFI CO-I's			
LFI Local PM's			
LFI SPCC	IASF/CNR – Bologna	lfispcc@iasfbo.inaf.it	

CHANGE RECORD

Issue	Date	Sheet	Description of Change	Release
0.1	27/06/05	All	First working issue	===
1.0	31/01/06			
1.1	20/12/06	All	Deep revision	SGSIR
2.0	30/12/07	5.1.2, 5.2.3, 6.2, 7.1	Commissioning and CPV Phase included	
2.1	19/07/08	All		SGS-RR

TABLE OF CONTENTS

1 SCOPE

In the following, a description is given of the operation plan for the LFI instrument and the Sorption Cooler System (SCS) in the form of a separated document annexed to this one, as described in the Science Operations Implementation Plan [RD-1] and in the DPC Operations Scenario [AD-1]. Such operations will be carried out by the Instrument Operations Team (IOT), located at the DPC (Data Processing Centre) site, where Level 1 is run, with the support of a number of specialists distributed geographically and of the DPC team.

The LFI Consortium will operate with the aim of maintaining during operations an optimal scientific instrument performance; this will be done by the IOT, in close cooperation with the DPC, when relevant.

Acknowledgements:

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2 APPLICABLE/REFERENCE DOCUMENTS

2.1 ANNEX DOCUMENTS

AN-1 SCS Operation Plan Document

2.2 APPLICABLE DOCUMENTS

AD-1	Planck LFI DPC Operations Scenario	PL-LFI-OAT-PL-006
AD-2	Planck LFI User Manual	PL-LFI-PST-MA-001

2.3 REFERENCE DOCUMENTS

RD-1	LFI Science Operations Implementation Plan	PL-LFI-OAT-PL-001
RD-2	Herschel/Planck Consolidated MOC/SGS ICD List	PT-CMOC-OPS-ICD-6101-OPS-OGH
RD-3	LIFE User Manual	
RD-4	LFI Management Plan	PL-LFI-PST-PL-005
RD-5	Work-package Breakdown Structure and Description	PL-LFI-OAT-PW-001
RD-6	LFI DPC Data Processing Document	PL-LFI-OAT-SP-001
RD-7	Planck IDIS Data Model Specification	PL-COM-OAT-SP-001
RD-8a	ICD-025 DPC-PSO: Instrument Health Reports	PGS-ICD-025
RD-8b	ICD-027 DPC-PSO: Data Analysis Reports	PGS-ICD-027
RD-9a	ICD-030 DPC-DPC timelines exchange	PL-LFI-OAT-IC-001
RD-9b	ICD-031 DPC-DPC maps and power spectra exchange	PL-LFI-OAT-IC-002
RD-9c	ICD-032 DPC-DPC calibration information	PL-LFI-OAT-IC-003
RD-10	LFI DPC Hardware Design	PL-LFI-OAT-SP-005
RD-11	LFI Software Project Development Plan	PL-LFI-OAT-PL-003
RD-12	LFI DPC Internal Interface Requirements Document	PL-LFI-OAT-IR-001
RD-13	Software Standard for LFI DPC	PL-LFI-OAT-SP-003
RD-14	Planck IDIS DMC Exchange Format Design	PL-COM-OAT-SD-003
RD-15	Herschel–Planck File Transfer System Interface Control Document	PT–MCS–ICD–1001–TOS–GDS
RD-16	A Format for Preliminary Work with Planck Sky Maps: FITS files, A.J. Banday, E. Hivon, K.M. Gorski & the IDIS Working Group	
RD-17	LFI-Communications Interface Control Document	PL-LFI-PST-ID-013
RD-18	Herschel_Planck_Packet_Structure_ICD	SCI-PT-ICD-7527
RD-19	Small Gap Declaration Algorithm and Recovery Procedure	Planck/PSO/2005-000
RD-20	Planck Data Access Procedures	PL-COM-OAT-SD-004
RD-21	LFI TMH Software Specification Document	PL-LFI-GADC-SS-002
RD-22	HPDDS ICD	PT-CMOC-MDS-3108-OPS-GDS
RD-23	RTA User Requirements	PL-LFI-OAT-UR-002
RD-24	LFI TQL Software Specification Document	PL-LFI-GADC-SS-001

RD-25 Planck Mission Planning Concept PT-PMOC-OPS-TN-6602-OPS-OGHPT-PMOC-OPS-TN-6602-OPS-OGH
RD-26 Routine Phase Science Operations Plan Planck/PSO/2004-013
RD-27 Exchange Format Design Document PL-COM-SSD-IF-47
RD-28
RD-29
RD-30 Testing Plan of the LFI instrument during the Planck Commissioning and CPV phase PL-LFI-PST-PL-013

2.4 ACRONYMS LIST

AD	Applicable Document
AN	Annex Document
AO	Announcement of Opportunity
API	Application Programming Interface
ASW	Application SoftWare
ASI	Agenzia Spaziale Italiana (Italian Space Agency)
AWG	ESA's Astronomical Working Group
BBM	(DPC software) Bread-Board Model
BEM	Back End Module (LFI)
BEU	Back End Unit (LFI)
CC	Change Control
CDMS	Command and Data Management Subsystem
COBRAS	Cosmic Background Radiation Anisotropy Satellite
COTS	Commercial-Off-The-Shelf
CQM	(Instrument) Crio-Qualification Model
CRAT	Command Request Acceptance Table
CWG	Commonality Working Group
DAE	Data Acquisition Electronics (LFI)
DM	(DPC software) Development Model
DMS	Documentation Management System
DPC	Data Processing Centre (for Planck)
DPCCG	Data Processing Centres Coordination Group
DPCM	Data Processing Centre Manager
DPCT	Data Processing Centre development Team
DPU	Digital Processing Unit (LFI)

DQR	Daily Quality Report
DRS	Data Reduction Software
ECSS	European Cooperation for Space Standardization
EE	End-to-End test
EGSE	Electrical Ground Support Equipment
ERCSC	Early Release Compact Source Catalog
ESA	European Space Agency
ESOC	ESA Space Operations Centre
GSID	Ground Segment Interface Document
FD	Flight Dynamics
FEM	Front End Module (LFI)
FEU	Front End Unit (LFI)
FINDAS	FIRST Integrated Network and Data Archive System
FIRST	Far InfraRed and Submillimetre Telescope
FM	(Instrument) Flight Model
FOP	Flight Operations Plan
FOV	Field Of View
GS	Ground Segment
GSAG	Ground Segment Advisory Group
GSID	Ground Segment Interface Document
HEALPIX	Hierarchical Equal Area and Latitude PIXelisation
HFI	High Frequency Instrument
HPDDS	Herschel-Planck Data Disposition System
HPFTS	Herschel-Planck File Transfer System
H/W	Hardware
ICC	Instrument Control Centre (for Herschel)
ICD	Interface Control Document
ICS	Instrument Commands Sequence
ICT	Instrument Command Translator
ICWG	Instrument Coordination Working Group
IDIS	Integrated Data and Information System
IDIS-DT	Integrated Data and Information System Development Team
IDIS-MT	Integrated Data and Information System Management Team
IDT	Instrument Development Team

IID-B	Instrument Interface Document - part B
IIRD	Internal Interface Requirements Document
ILT	Instrument Level Test
IMT	Integrated Module Tests
IOM	Instrument Operations Manager
IOT	Instrument Operations Team
IRD	Interface Requirements Document
IS	Instrument Scientist
ISDC	Integral Science Data Centre, Geneva
IST	Integrated System Test
ITT	Integration and Test Team
IW@MOC	Instrument WorkStation at MOC
kbps	kilobits per second
L2	Lagrangian point no. 2 of the Sun-Earth-Moon gravitational system
LAN	Local Area Network
LEOP	Launch and Early Orbit Phase
LFI	Low Frequency Instrument
Mbps	Megabits per second
MIRD	Mission Implementation Requirements Document
MOC	Mission Operations Centre
MPA	Max Planck Institut fuer Astronomie, Garching
OAPd	Osservatorio Astronomico di Padova
OAT	Osservatorio Astronomico di Trieste
OM	(DPC software) Operations Model
PA	Product Assurance
PGSSG	Planck Ground Segment System Group
PSGSSC	Planck Science Ground Segment Steering Committee
PI	Principal Investigator
PM	Project Manager
PS	Project Scientist
PSO	Planck Science Office
PV	Performance Verification
RCA	Radiometers Chain Assembly
RD	Reference Document

REBA	Radiometer Electronics Box Assembly (LFI)
QA	Quality Assurance
QLA	Quick-Look Analysis
QLF	Quick-Look Facility
RAA	Radiometer Array Assembly (LFI)
RCA	Radiometer Chain Assembly (LFI)
RD	Reference Document
REBA	Radiometer Electronics Box Assembly (LFI)
RTA	Real-Time Assessment
SAMBA	Satellite for the Measurement of Background Anisotropies
SCMP	Software Configuration Management Plan
SIP	Science Implementation Plan
SIRD	Science Implementation Requirements Document
SISSA	International School of Advanced Studies, Trieste
SMP	(Planck) Science Management Plan
SPACON	SPAcecraft CONtroller
SPC	Science Programme Committee
SPPT	Survey Performance Planning Tool
SPR	Software Problem Report
SPS	Science Pipeline Software
SPU	Signal Processing Unit (LFI)
s-r	Super-Resolution (map)
ST	Science Team
SUSW	Start Up SoftWare
SVT	System Validation Test
SVVP	Software Verification and Validation Plan
S/W	Software
TBC	To Be Confirmed
TBD	To Be Defined
TBW	To Be Written
TC	TeleCommands
TM	TeleMetry
TMH	TeleMetry Handling (LFI)
TOD	Time-Ordered Data

TOI	Time-Ordered Information
TQL	Telemetry Quick-Look
MP	Mirror Provider
UAP	User's Acceptance Plan
UAR	User's Acceptance Report
UM	User's Manual
URD	Users Requirements Document
WBD	Workpackages Breakdown Document
WHR	Weekly Health Report
WP	WorkPackage
WWW	World-Wide Web

3 SYSTEM OVERVIEW

The LFI and SCS operations will be carried out by the Instrument Operations Teams (IOTs), located at the DPC (Data Processing Centre) main site, where SGS1 is run, with the support of a number of specialists distributed geographically. The LFI and SCS IOTs are two separated teams even if they will strongly collaborate. In the following, when not specified, the IOT is referring to the LFI IOT while the SCS IOT activities are described in the Annex SCS Operation Plan Document [AN-1].
The IOT is defined in the LFI SIP [RD-1]. It is formed after the delivery of the Flight Model of the LFI instrument, by the scientists and engineers forming the Instrument Development Team (IDT) and will provide instrument support to ground segment activities. Members of the IOT will be located at the MOC during the Commissioning and CPV phases of the missions, and a number of members of the IOT will be located at the SGS1 of the LFI DPC during the whole operations and post-operations periods to support the DPC staff in running instrument health checks and performance trending. The IOT will be headed by an Instrument Operations Manager (IOM), who will be leading the DPC SGS1 during the Operations phase of the mission, and will be complemented by DPC staff as appropriate. The composition of the IOT includes: - the IOT manager (IOM) - the Instrument Scientist - SCS specialists - radiometer specialists - detection electronics specialists - REBA and DAE specialists - ground equipment software and hardware specialists (DPC Team SGS1 members). As mentioned above, members of the Team will be located at the DPC main site, where SGS1 and the whole science data processing pipeline is run: there will be in principle one specialist per basic hardware subsystem. However, to complement the hardware knowledge, the staff at the DPC will be supported by a number of specialists distributed geographically who will be available on call. A rotation among staff present at the DPC is foreseen.

The DPC is defined in the LFI SIP [RD-1] and, as stated above, works in strict collaboration with the IOT. In particular it is the responsibility of the LFI DPC:
during the Development phase:

- to provide all tools (software, procedures and documentation) necessary to obtain the data products with the scientific quality necessary to achieve the objectives of the Planck mission;
- to provide infrastructure to all data and information activities related to the instrument development (databases, documentation archives, networking activities, …), the pipeline development and the scientific activities related to Planck within both Consortia;
- to provide tools, rules and recommendations for all software and data and information manipulation, and to encourage all Planck team to use them;

during the Operations and Post-operations phases:

- to run the procedures provided and obtain the data products, continuously updating the tools as necessary to achieve the required data quality;
- to share and eventually merge data with the HFI Consortium in order to use combined LFI-HFI information to produce the expected scientific results;
- to provide infrastructure, tools and resources for developing Planck Consortia scientific programs during the proprietary phase;

during the Commissioning and Performance Verification phases, to locate some members of the DPC and of the LFI IOT at the MOC to support the operations staff;
during all phases of the mission (development, operations, post-operations) to support all required activities (ground segment reviews, PSGSSC and PGSSG meetings, ST meetings, etc.).

While it is anticipated that the LFI configuration will remain stable during each sky survey, requests to the MOC for instrument mode/parameter change may happen during nominal LFI operations. Furthermore, in the case of non-nominal behaviour of spacecraft or payload (including LFI), or as the result of improvements identified during the Commissioning, Calibration and Performance Verification and/or Routine phases, changes to the instrument operations scenario may be necessary or advisable. The LFI IOT will request configuration changes to the instrument and the Sorption Cooler on the basis of specific procedures agreed before launch with the MOC, PSO and HFI. For the routine activities foreseen by these procedures that require communication between the LFI DPC and the MOC there shall be a single point of contact in the LFI DPC. Anomalous unforeseen situations involving the two instruments will be resolved by a Board, chaired by the PS, and including at least the MOC Operations Manager and the two Instrument Operations Managers. In either case the PS will retain final overall authority, except in situations which represent a threat for the satellite and/or instrument health and safety, in which case authority will be exercised by the MOC Operations Manager. This Board will also revise the procedures for requesting configuration changes during the mission in case of need. The Observation Plan is defined and can be changed/updated uniquely by the ST. The only LFI DPC task on this subject is to propose updates to the Observation Plan and, through the IOM, to possibly reach an agreement on their actual implementation with the HFI IOM and the Planck PS.

3.1 LFI INSTRUMENT AND ITS RADIOMETER ELECTRONICS BOX ASSEMBLY

For the purpose of this document it seems necessary to briefly introduce the LFI instruments and the LFI REBA (Radiometer Electronics Box Assembly) and the way it communicates. The REBA is the electronic box in charge of processing the digitized scientific data and to manage the overall instrument. It is also in charge of the communication with the spacecraft. Refer to the LFI User Manual [AD-2] chapt. 3 and 3.2.3 for a detailed description.

As shown schematically in Figure 3-1, the LFI consists of the following subsystems:

- Radiometer Array Assembly (RAA);
- Sorption Cooler Subsystem (SCS);
- Radiometer Electronics Box Assembly (REBA).

The RAA includes the Front End Unit (FEU) and the Back End Unit (BEU), connected via waveguides. The FEU is located at the focus of the telescope, as one component of the joint LFI/HFI focal assembly. The BEU is mounted on the top of the Planck SVM.
We define as Radiometer Chain Assembly (RCA) each functional unit from the feed horn to the BEM. The RAA therefore includes a set of 11 RCAs and the Data Acquisition Electronics (DAE).
The REBA and the warm parts of the Sorption Cooler System (SCS) is located on one of the lateral panels of the service module (SVM). The FEU and the Sorption Cooler Compressor (SCC) are connected by concentric stainless steel tubes.
All LFI units are linked together by the LFI harness, which also connects to the spacecraft interface.

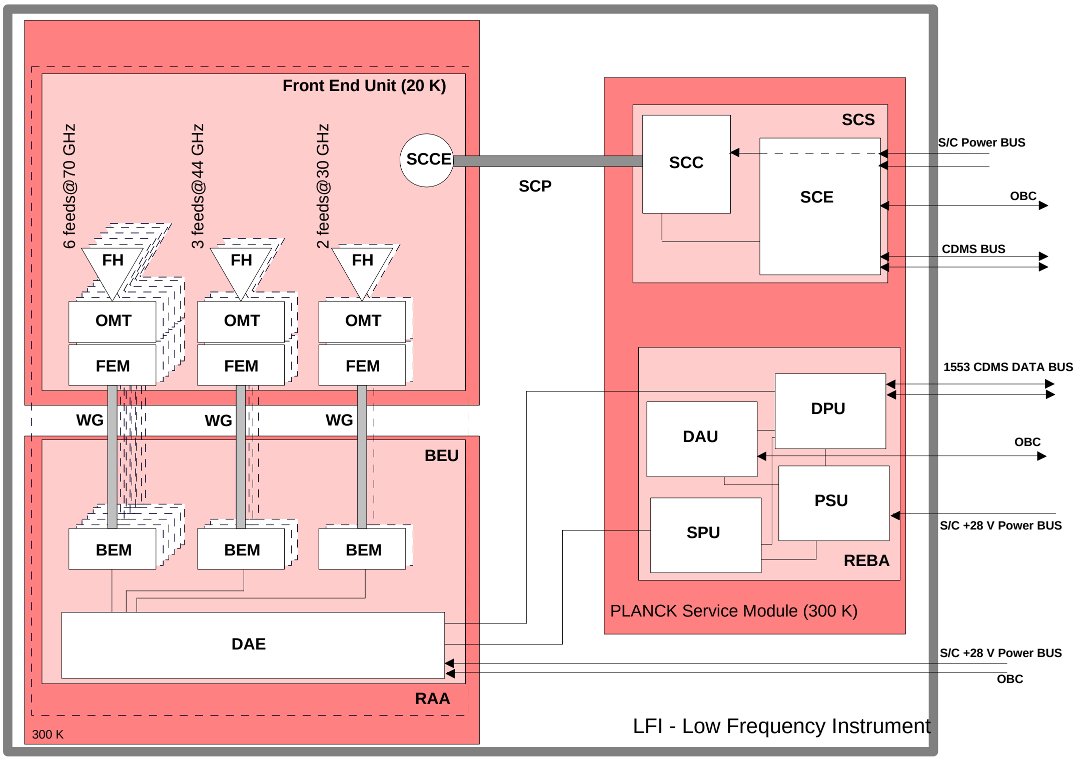


Figure 3-1 Block diagram of the LFI instrument

3.2 LFI OPERATION MODES

See the LFI User Manual [AD-2] chapt. 8 and 13.2.1 for a more detailed description of the LFI Operation Modes, a brief summary is given below. Figure 3-2 reports the scheme of the nominal transitions for LFI modes.

1. **OFF MODE:** During this operating mode the instrument is completely off for example during the launch.
2. **STAND-BY:** During this mode only the REBA can be operated. It is the first interface to the instrument whenever the LFI is switched on. When the instrument is in this mode the RAA must be OFF because no data can be received and no control is possible on the radiometer chains.
3. **DAE SET-UP:** During this mode the REBA and the DAE are ON, but no radiometer chains are active. Nevertheless science data can be generated and contain only the background noise of the instrument.
4. **NORMAL SCIENCE:** During this mode the RAA is seen by the REBA as a set of 44 independent instruments. This means that each instrument can be operated, by the same SW, in

different modes without affecting the LFI modes. Science data from the DAE are continuously acquired by the REBA that decides, on the basis of the activation table, which packets (either science or diagnostic) have to be produced. The whole set of HK is continuously acquired and sent to ground. This mode is the nominal for the LFI observation operations.

5. **EXTENDED SCIENCE:** This mode is similar to the previous except that for the total amount of telemetry sent to the ground. In fact this mode shall be used when, in particular cases, (e.g. calibration…) a larger telemetry rate is needed and made available by an agreement with HFI and the CDMS.

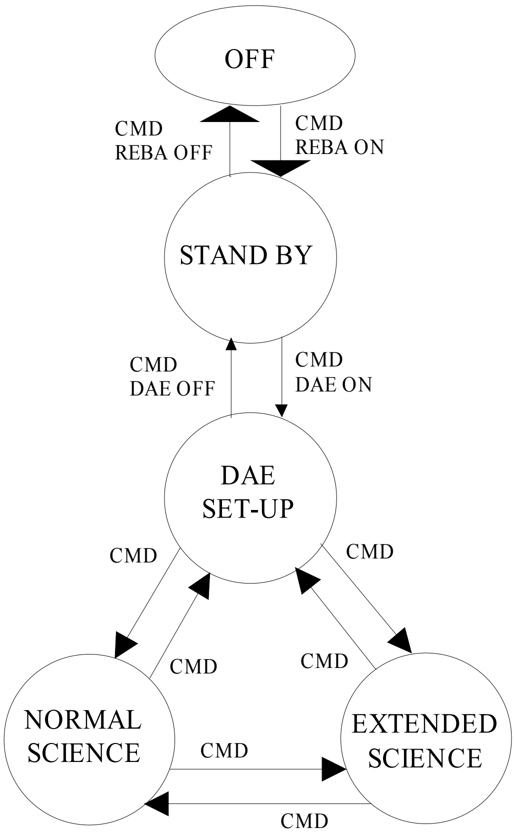


Figure 3-2 LFI Operating Modes and their nominal transitions

During launch, for contingency situations and/or to allow diagnostics of other spacecraft subsystems (e.g. HFI or others) LFI is in the OFF mode. When, upon a command from ground the REBA is powered on, the instrument is in its STAND-BY mode. A step-by-step bootstrap procedure commanded from ground documented by HK is initialized to turn the DAE on. This sets-up the internal communications, and allows the LFI subsystems to collect and deliver a full set of HK. The instrument is in DAE SET-UP mode. The following step is to upload from ground the DAE settings and processing parameters; then, to switch on the RCA on ground command. At this stage, on ground command, the acquisition of science data can start. A further step is needed to move to NORMAL SCIENCE, namely start processing and compressing the science raw data. When this is accomplished, science packets can be sent to ground.

Beyond this, it is worthwhile to mention four additional conditions the instrument can undergo.

- DEGRADED STATES: three main degraded states can be foreseen:

- Degraded State 1: In case one (or more) LFI detectors need to be switched off. This may be required if a detector fails or if, for unforeseen reasons, the physical temperature in the focal plane is unacceptably high. In this configuration the LFI is in the Normal/Extended Science Operation Mode, except that the defective or unwanted detector/detectors is/are turned off. The nature of the LFI instrument as an array ensures the redundancy of detectors in the focal plane.
- Degraded State 2: in case the HFI 4K cooler fails, the reference load will be at about 30 K (TBC). This will require adjustments in the DAE and SPU. In this configuration the LFI is in the Normal/Extended Science.
- Degraded State 3: In case the sorption coolers (the one in use or both operational and spare units) fail. The increased temperature in the focal plane (≈ 80 K) causes the low pressure nitrogen to sublimate and provide a thermal path for the power dissipated by the LFI radiometers. In this configuration the LFI array will operate in a passive-cooling mode, at an estimated temperature of about 80 K. A dedicated plan will be developed to establish how many and which detectors should be operative in this configuration to maximise the science return.

- "LFI –ONLY" CONDITION: There can be a situation in which the full telemetry rate is available for LFI during the test phase in agreement with HFI. In this condition the LFI should be allowed to use the maximum telemetry packet and bit rate up to the sum allowed to the Planck instruments. This condition is covered by the normal LFI modes (see "Extended Science Mode" in [AD-2] § 13.2.1).

- CALIBRATION: In flight calibration is performed routinely by exploiting the ± 3.5 mK signal modulation from the CMB dipole. Additional calibration and measurements of the LFI beam patterns are obtained in-flight using the signal from external planets (or other celestial sources such as galactic HII regions), as they fall in the field of view of the instrument. Jupiter and Saturn, in particular, provide an adequate microwave source for beam calibration. Calibration and beam measurements are performed with LFI in the Normal Science Operation mode (or eventually, in agreement with HFI, in the Extended Science Operation mode).

- TRANSFER PHASE: Details of the transfer trajectory are not yet available. Planck-LFI exploits as much as possible the transfer phase to perform commissioning of the instrument and scientific tests of the far sidelobe response, using the Earth and the Moon as test-sources at various off-axis angles, compatibly with the trajectory and attitude selected for the transfer to L2. To carry out these tests the LFI is fully operating.

3.3 LFI INSTRUMENT ON-BOARD SOFTWARE

See the LFI User Manual [AD-2] chapt. 10 and [RD-17] for a more detailed description of the LFI On-board Software and communications, a brief summary is given below for what regards the Telemetry and Telecommand features.

The context diagram in Figure 3-3 shows the REBA_ASW (Application SoftWare) interfaces with other subsystems.

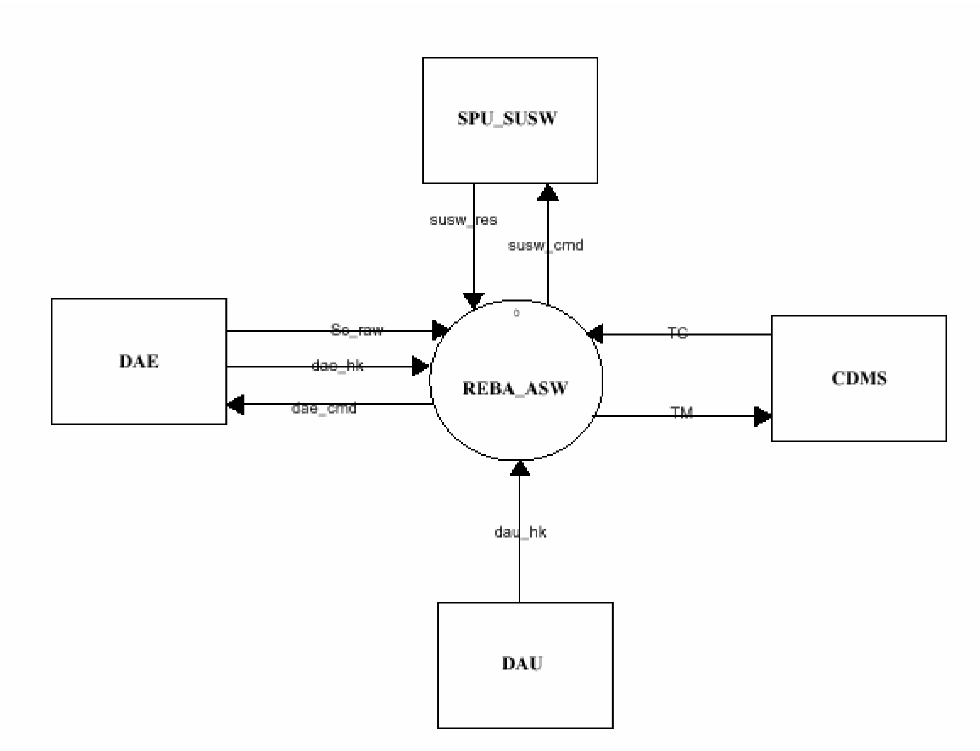


Figure 3-3 Context diagram of the REBA_ASW

3.3.1 TELEMETRY

The REBA_ASW sends to the CDMS the following TM packets:
− TC verification reports: TM(1, x)
− HK and diagnostic packets: TM(3, x)
− event reports packets: TM(5, x)
− memory management reports: TM(6, x)
− Function status reports TM(8,6)
− time reports: TM(9, 9)
− enabled packets transmission reports: TM(14, 4)
− link connection reports: TM(17,2)
− science TM packets: TM(21, x)

After initialisation, HK packets are sent periodically at any time.
Two different HK packets of "Essential HK" are also delivered. They are a copy of the REBA HK and the DAE fast HK packets to be delivered every 32s having a different APID.
There are foreseen some diagnostic HK packets that are sent only when requested by TC.
All TM packets are formatted following the rules of Herschel/Planck Packet structure ICD (PSICD).

The REBA_ASW implements at least two TM packets queues and managing the priority among them. This is to guarantee that the HK packets are always delivered, even in case of the TM queue is filled with scientific packets.

Refer to the LFI User Manual Document [AD-2] paragraph 11 for a detailed description of the LFI HK telemetry and paragraph 15 for the science telemetry.

3.3.2 TELECOMMANDS

The REBA_ASW processes all LFI TCs received from the CDMS.

The REBA_ASW validates the TCs received by sending TM verification reports to the CDMS in the following way:
• Acceptance validation: within 2 seconds after reception, it sends a TM acceptance report packet success or failure, TM(1,1) or TM(1,2).
• Start execution: before starting the execution of the TC, the REBA_ASW checks that the specific TC is allowed and its parameters are correct and eventually sends a TM execution report failure packet TM(1,8).
• Completion validation execution: after execution of the TC, the REBA_ASW sends a TM execution report success or failure, TM(1,7) or TM(1,8).

The maximum TC rate is 2 TC packets per second.
The REBA_ASW manages a queue of 16 TCs in such a way that a TC is not executed until the previous TC in the queue finalises its execution.
In case the TCs queue is full the REBA_ASW rejects the TC by sending an acceptance report failure TM(1,2).

The REBA_ASW manages some high priority TCs that are executed just after acceptance validation so they are not sent to the execution queue. These TCs are:
− Reset the SPU HW.
− Reset SMCS chips (SPU, DPU and DAE).
− Clear TC execution queue.

Refer to the LFI User Manual Document [AD-2] paragraph 12 for a detailed description of the LFI telecommands.

3.4 ASSUMPTIONS

For the scope of this document, the SGS1 term is intended to be equivalent to the Level 1 (L1). The SGS2 acronym is intended to be equivalent to the Level 2 and 3 (L2 and L3) together.

4 OPERATION PROCESSES

4.1 INFRASTRUCTURE

4.1.1 SOFTWARE

4.1.1.1 HPFTS AND SPPT

For what regards the Instrument Daily Quality and Weekly Health Reports (DQR and WHR, as defined in [RD-8], see Par. 4.1), data file transfers will be ASCII format using the FTP-based Herschel-Planck File Transfer System (HPFTS) – (agreed at PGSSG #15).
Data received via this interface is required for use by the Planck Survey Performance and Planning Tool (SPPT), currently under development within PSO.

Data file transfers between the two DPCs will be based on FITS format, with predefined keyword as defined in [RD–14] Planck IDIS DMC Exchange Format Design Document, using the designated FTP-based file transfer system [RD-9a] upon availability on the hardware/software system used at the two DPCs [RD–15].

4.1.1.2 DPC SOFTWARE

DPC SGS1 and 2 processing of science data is required for analysis information to be passed to PSO. DPC will also be required to use HKTM for trend analysis.

DPC Level 2 and Level 3 processing is requires for Maps creation based on the standard Pixelisation described by the HEALPix document [RD-16] and [RD-7].

The current software platform for LFI DPC is Linux based (refer to [RD-13]).

4.1.1.3 INSTRUMENT WORKSTATIONS AT MOC (IW@MOC)

MOC routes live instrument housekeeping TM and science data via the IW@MOC for Real-Time Analysis (RTA) and Quick Look Assessment (QLA). Essentially, the IW@MOC provides dedicated instrument telemetry processing capabilities over and above those provided by SCOS-2000 and will be running the DPC SGS1 software. It does not provide any commanding capability.

The IW@MOC is assumed to be remotely accessible from DPC through a network connection, with all security constraints set by ESOC. During commissioning the LFI IOT operating the IW@MOC will be the prime point of reference for all instrument operations. From the commencement of the

Calibration and Performance Verification (CPV) Phase, this function will pass to the LFI IOT at the DPC where a further version of the IW@MOC will be resident. The version located at MOC will be retained for the duration of the mission.

No specific assumptions are made on the maintenance of the IW@MOC by MOC personnel. It is however assumed that the basic operations needed to keep the IW@MOC functioning (reboot, etc.) will be supported. These items will be resolved in the DPC-to-MOC Interface Control Document (ICD).

4.1.1.4 ARCHIVE

The current design of the pipeline defines the following archives (see [RD-20]):

- ✓Raw Telemetry Archive;
- ✓Unscrambled Telemetry Archive;
- ✓Raw TOI Archive;
- ✓Calibrated TOI Archive;
- ✓Calibrated Frequency Maps;
- ✓Component Maps;
- ✓Auxiliary Data.

4.1.2 HARDWARE

The current hardware platform for LFI DPC is intel PCs based.

Refer to [RD-10] for a detailed description of the hardware design for the LFI DPC main site, running the Levels and the whole science data processing pipeline (LS, L1, L2, L3) of the LFI DPC.

4.1.3 INTERFACES

The interfaces between the LFI DPC and MOC, PSO and the HFI DPC are described in details in the corresponding ICD documents.
In addition reports describing the status of the LFI will be distributed on a Daily and Weekly base (see Paragraph 7.2.6 and 7.2.32).

4.1.3.1 MOC

See the corresponding Interface Control Documents [RD-2].

4.1.3.2 PSO

See the corresponding Interface Control Documents [RD-2].

4.1.3.3 HFI DPC/IOT

See the corresponding Interface Control Documents [RD-9] and [RD-2].

4.1.3.3.1 HFI/LFI DATA EXCHANGE

Data file transfers will be based on FITS format, with predefined keyword as defined in [RD–14] Planck IDIS DMC Exchange Format Design Document, using an FTP based file transfer system upon availability on the hardware/software system used at the two DPCs [RD-9a].

4.2 MANAGEMENT

The management structure of the LFI is shown in Figure 4-1, as defined in the LFI Management Plan [RD-4]. The organisation is based on national Managers, who are responsible for the participation of the related institutes in the Consortium.

A brief description of the IOT and DPC team structure has already been given at the beginning of this document in Paragraph 3.

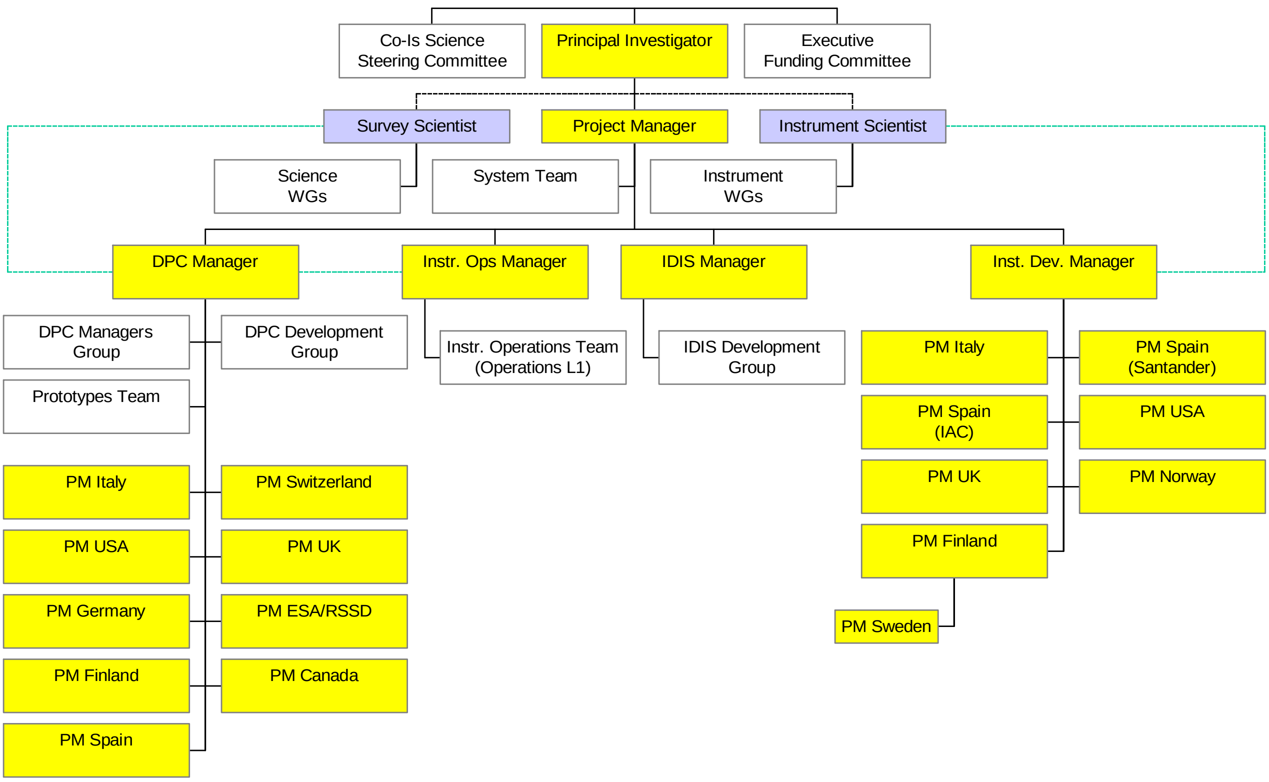


Figure 4-1 The global management structure for the LFI, including the DPC

The structure of the management will be changed during the Post-operations phase at the top level, since the Instrument Operations Manager (IOM) and the related Team (IOT) ceases its operational functions (TBC). However they will still keep in continuous contact with the DPCM to maintain the

memory of the operational phase since the DPC Development and Management Group will still be active.
The roles of National Managers and of the Integration, PA/QA and Instrument Interface Managers remain unchanged, and so do the responsibles for the maintenance of the various Levels (including continuous upgrade of functions), and for operations at the active Levels (2, 3 and 4 in this case).
The LFI Survey Scientist (SS) will continuously interact with the DPCM providing advice and support to the Post-operations phase of the DPC. During this phase, the Instrument Scientist (IS) will be aiming at the final calibration of the instrument to monitor and provide input to instrument-related activities.

4.3 STAFFING

During the Commissioning and CPV phases of the mission, IOT staff will be at least partly located at MOC, with the DPC support, 7 days/week to support real-time interaction with the spacecraft. At the same time, the IOT at the DPC will be staffed 12 hours/day, 7 days/week; shifts will be needed. Extended hours will be provided; in addition, telephone traceability of qualified personnel in the case of emergency will be provided at Levels 1 and 2 (when required) for additional 6 hours/day, 7 days/week.

During Normal Operations the IOT will be staffed 6 days/week, 8 hours/day, 5 hours on Saturdays. Extended hours can be provided during specific mission situations (contingencies). Telephone traceability of qualified personnel in the case of emergency will be provided at Levels 1 and 2, when required, for 12 hours/day, 7 days/week for the whole duration of Planck operations. A single point of contact for MOC will be available 24 hours/day throughout the mission in case of contingency need by MOC concerning instrument and SCS operation.

During Post-operations the LFI DPC will be staffed at least 8 hours/day, 5 days/week.

During all phases enough redundancy will be ensured to the LFI DPC hardware/software system to guarantee a high availability of the overall system. The baseline overall availability figure for the DPC operational systems is 90%, the goal is to reach 95%.

4.4 CONTACT INFORMATION

Instrument operations require continuous interfacing activities with other players in the Planck Scientific Ground Segment (namely, MOC, PSO and the HFI DPC/IOT).
The following key concepts are the basis of the LFI activity in this field:
- there will be a single point of contact for LFI instrument operations, located at the DPC main site during nominal operation and possibly at MOC during commissioning and CPV, to ensure that every contact with the interfaced institutions are properly traced;
- the interfacing needs and activities related to instrument operations are defined and described in appropriate ICDs with the other parties involved ([RD-2], [RD-8] and [RD-9]).

5 OPERATIONS CONTEXT

In general, the DPCs and their respective IDTs/IOTs are responsible for:

- Operating and calibrating their respective instruments;
- Daily analysis of instrument health;
- Daily analysis of science data;
- Optimisation of instrument performance;
- Provision and operation of a software maintenance facility;
- Support to the MOC where specialised payload knowledge is concerned;
- Processing of Planck data, from raw TM to deliverable scientific products;
- Delivering the final scientific products.

In addition, both DPCs are jointly responsible to establish and deliver to MOC the procedures required to consolidate all instrument related inputs. The joint responsibility reflects the fact that the two instruments have common hardware elements and furthermore that the operation of one of them may have an impact on the other's performance or operation.
The specific duties and tasks of the DPCs are described in the Planck SIRD, and the way in which these duties will be carried out is described in the LFI and HFI Science Operations Implementation Plans (SIPs) [RD-1].
The data processing activities of each DPC have been split into four "Levels" according to the type of processing required (Figure 5-1). The MOC makes available the data to the entrance point of each DPC ("Level 1"). Note however that in addition to this main line of data transfer, the DPCs are able to "listen in" to MOC via workstations (the so called IW@MOC), physically located in MOC but connected via the network to the DPCs.

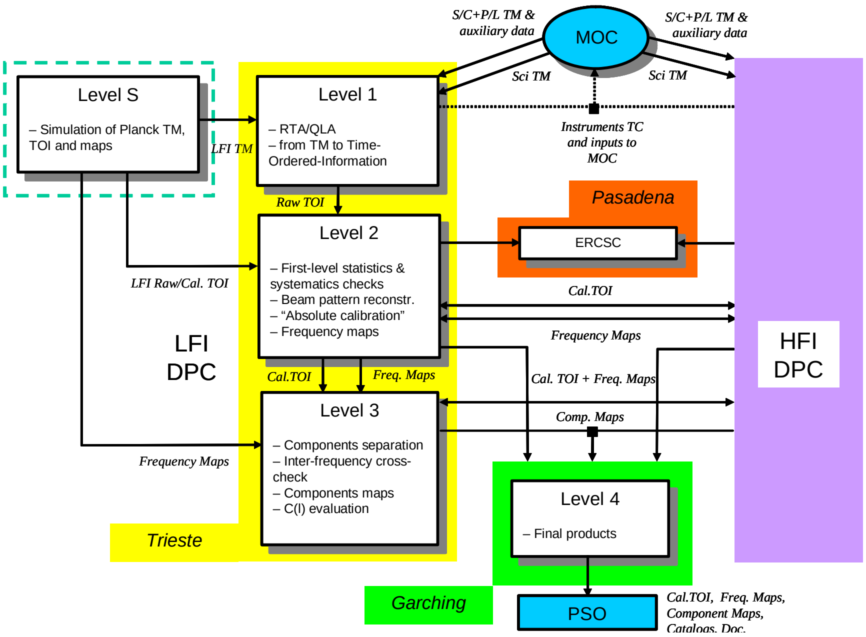


Figure 5-1 A sketch of the layout of the LFI Planck DPC. Each coloured box corresponds to a geographically separate location

The data is piped sequentially from Level 1 to Level 4, from where the final scientific data products are delivered to ESA. However, it is expected that the data reduction scheme will be iterative, such that the different Levels will be re-reducing data many times. A large amount of feedback between all the various levels is therefore required.
Similarly, it is required that the two DPCs inter-compare results at various stages in the data processing pipeline. Therefore a large amount of feedback between DPCs is also expected.
In addition to these four Levels, the DPCs also support and benefit from (scientific and technical) simulation activities, instrument-level and system-level testing activities, and instrument operations.

5.1 DATA PROCESSING AND MONITORING

5.1.1 ROUTINE ACTIVITIES

In the following, the handling of the data is briefly described. Scenarios make reference to the DPC data processing design and to the software subsystems described in the LFI DPC Data Processing Document [RD-6].

For what regards the data processing and monitoring, routine activities include:

- the checking of LFI and SCS telemetry to verify instrument health on a daily basis, including the Level 1 activities (see Figure 5-2). This is a task formally under IOT responsibility but where understanding and support by the DPC Operations staff is necessary. Note the Level 1 activities will be nominally carried out in an automatic way.
  See corresponding sheet in Paragraph 6.1.1;
- the Level 2 activities usually on daily and weekly bases (see Figure 5-3). Basic processing is performed on daily/weekly chunks of LFI TOI to extract information and first-order data reduction to remove systematics and compare with HFI data acquired during the same period. This is a task formally under the responsibility of the DPC Operations staff; support by IOT and instrument specialists is however necessary for complete understanding of instrumental effects. The Level 2 activities will be nominally carried out under the supervision of the DPC/IOT but, where possible, procedures will be implemented in an automatic way.
  See corresponding sheet in Paragraph 6.1.2;
- the Level 3 activities usually on a monthly basis (see Figure 5-4). The work is performed on monthly chunks of calibrated LFI TOI; full comparison and cross-checking with HFI data acquired during the same period is planned, and partial maps are planned to be built. This task is under the responsibility of the DPC Operations staff; support by IOT and instrument specialists is however important for a complete understanding of instrumental effects. The Level 3 activities will be carried out under the supervision of the DPC/IOT.
  See corresponding sheet in Paragraph 6.1.3.

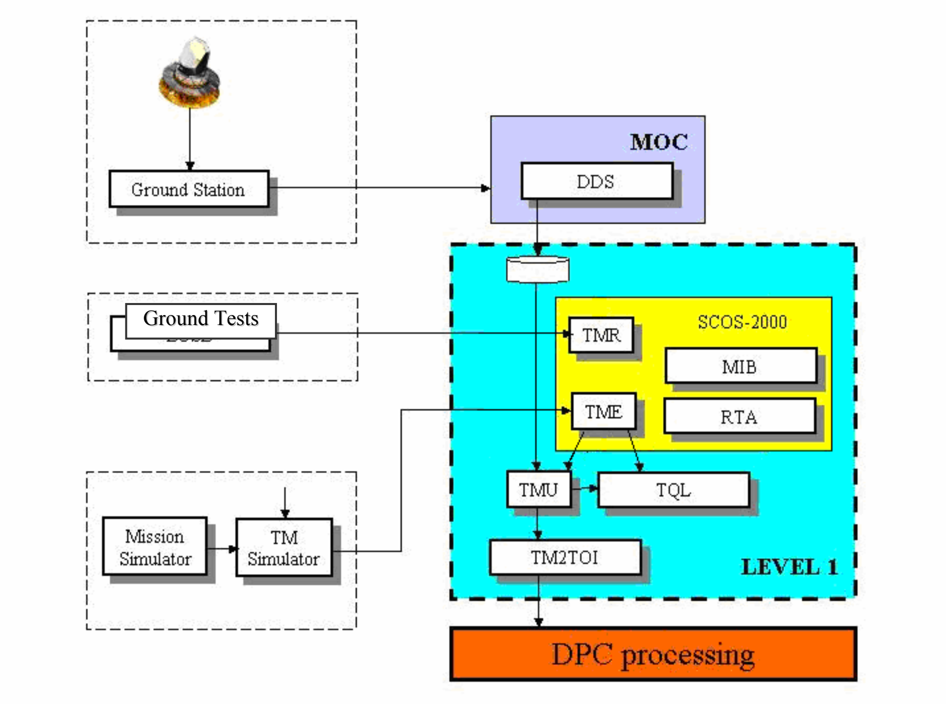


Figure 5-2 Planck LFI Level 1 Data and Software Flow Scheme.

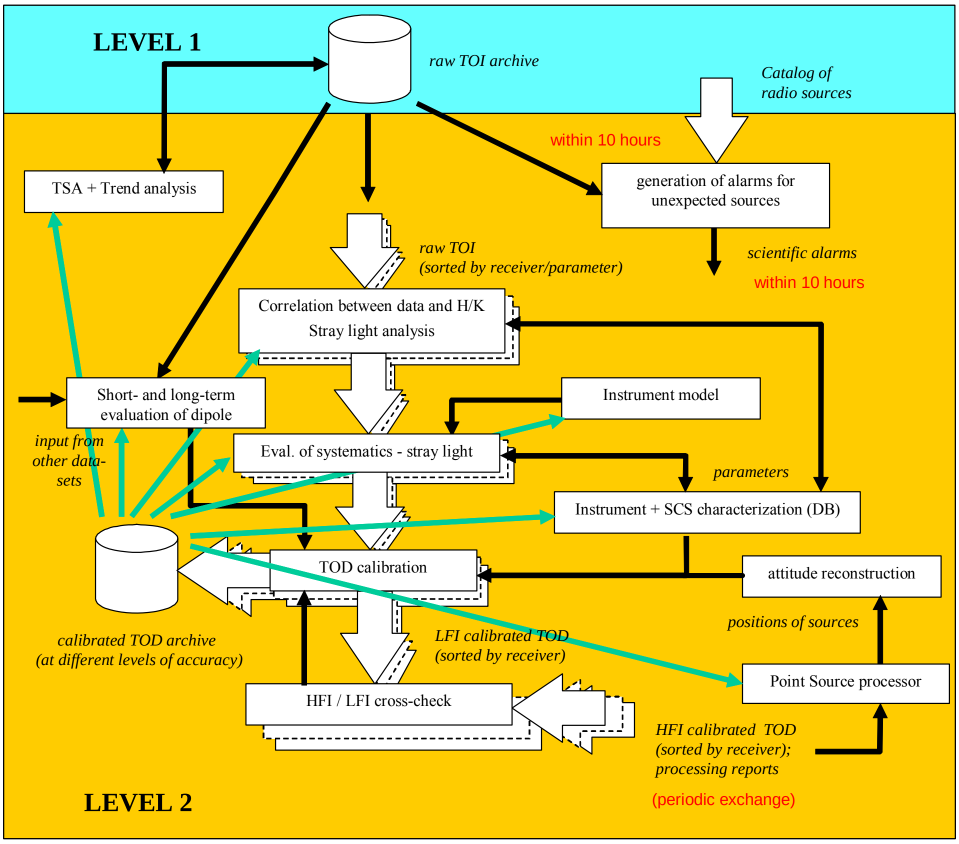


Figure 5-3 Planck LFI Level 2 Data and Software Flow Scheme

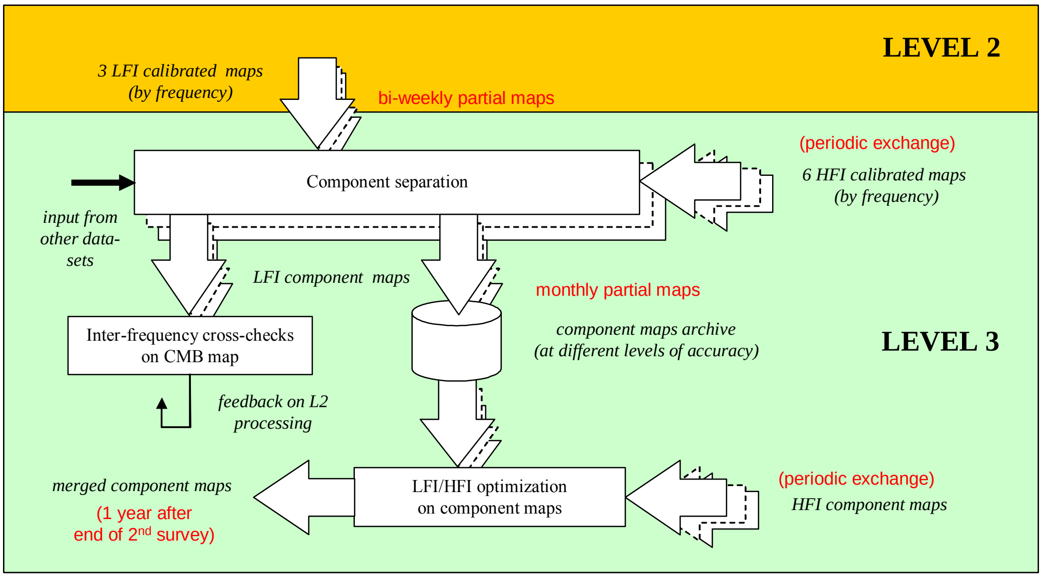


Figure 5-4 Planck LFI Level 3 Data and Software Flow Scheme

5.1.2 COMMISSIONING AND CPV OPERATIONS

Commissioning and CPV operations will be performed only partly at DPC since it is foreseen that at least part of the DPC/IOT will be located at MOC. The timeline of the operations depends strongly on the activity which is being performed and on the result of each action and it is not possible to foresee completely all the operations on a daily or weekly base.

5.1.2.1 COMMISSIONING OPERATIONS

During the Commissioning phase it is supposed to switch on the instrument and to perform a first check of the health of the instrument. A summary of the activities is given in the table in paragraph 5.2.3.1. See also Paragraph 13.1.1 in [AD-2] and Paragraph 3 in [RD-30].

During the commissioning phase, the data processing and monitoring includes (see corresponding sheet in Paragraph 6.2.1):

- Processing in real time the HK telemetry produced by the LFI in order to monitor the status of the instrument to allow a smooth going on of the procedures;
- Additional offline analysis to monitor more in detail the LFI status.
- Organization of the commissioning daily meeting.

In case of anomalies or unexpected results, the sequence (see par. 5.2.3.1) should be stopped, an NCR should be raised and an NRB meeting called, see Par. 8.2.1.

IOM or a deputy, always available during DTCP, will contact immediately specialists to analyze and solve the contingency as soon as possible. In order to optmize the problem solving process, an LFI internal meeting will be organized, see Par. 8.2.2.
According to the type of contingency, an Instrument Commanding Request could be required to put the instrument in an ad-hoc configuration and afterwards to recover from the contingency, see Par. 8.2.3.

5.1.2.2 CPV OPERATIONS

During the CPV phase, the scientific and HK data should be processed and analysed rapidly, quasi real time, in order to react immediately to the corresponding action and continue with the CPV timeline. A summary of the activities is given in the table in Paragraph 5.2.3.2.
See also Paragraph 13.1.2 in [AD-2] and Paragraph 3.1 onwards in [RD-30].

During the CPV phase, the data processing and monitoring includes (see corresponding sheet in Paragraph 6.2.2):

- As for the commissioning, at least a preliminary data analysis of some of the procedures of the CPV phase can be performed looking at TM in real time to allow a smooth going on of the procedures.
- Offline analysis by using the IW@MOC and the TQL/TMH and the LIFE software package. LIFE can be used to monitor the general behaviour of different part of the LFI instrument whenever it is necessary. In particular for the CPV tests, it will also be used to:
  o estimate noise properties;
  o tune phase switch bias, FEM Vg1 and Vg2, DAE offset and gain, REBA parameters;
  o verify tuning;
  o verify thermal response of FPU;
  o check photometric calibration (relative and absolute);
  o characterize cross-talk between receivers;
  o characterize thermal susceptibility;
  o estimate the optical calibration (main beam and sidelobe calibration, optical polarization);
  o estimate the focal plane geometry (alignement of feed pairs and focal plane, calibration of the pointing direction).
- Eventually cross check with HFI data can result to be necessary.
- Organization of the CPV daily meeting.

In case of anomalies or unexpected results, the sequence (see par. 5.2.3.2) should be stopped, an NCR should be raised and an NRB meeting called, see Par. 8.2.1.
IOM or a deputy, always available during DTCP, will contact immediately specialists to analyze and solve the contingency as soon as possible. In order to optmize the problem solving process, an LFI internal meeting will be organized, see Par. 8.2.2.
According to the type of contingency, an Instrument Commanding Request could be required to put the instrument in an ad-hoc configuration and afterwards to recover from the contingency, see Par. 8.2.3.

5.1.3 NON-ROUTINE ACTIVITIES

Non-routine operations consist of:
- Planet Scanning Operations;
- Small Gap Recovery Operations.

5.1.3.1 PLANET SCANNING OPERATIONS

As described in Planck Science Operations Routine Phase Plan [RD-26], a certain number of Solar System Objects will be scanned in a regular pattern in order to map the beams. The objects will include some major planets (Jupiter, Saturn, Mars TBC) which are found within the sky visibility window at widely separated times. The operation will consist of a pre-agreed pattern of pointings, likely spaced by different (narrower or wider) angular separations than the nominal 2' used for the Scanning Law, depending on which beams are being mapped. If the whole focal plane is being mapped, then this operation could require many days.
This procedure has an impact on the statistical behaviour of the signal and thus on the Level 2 data processing.
See corresponding sheet in Paragraph 6.3.1

5.1.3.2 SMALL GAP RECOVERY PROCESSING OPERATIONS

After a small gap has been triggered, schedule and applied (see [RD-19]), the dwell time of the data from a "small gap recovery" will be shorter than the nominal one. On one side this implies that the typical number of pointings per OD will be larger than the nominal one but this should not create any problem on the Level 1 data processing. On the other side, the statistical behaviour of the data acquired during the whole procedure will be different, thus this operation will have an impact on the Level 2 data processing.
See corresponding sheet in Paragraph 6.3.2.2.

5.1.4 CONTINGENCY ACTIVITIES

During a transition phase from one LFI operational mode to another, or due to a more general problem, a contingency condition could happen.
According to the type, the entity and the duration of the problem which caused the contingency, it could turn out to be necessary to deal with special care the data acquired during the corresponding period. Eventually a dedicated data flow, different from the nominal one, should be applied.
In the LFI User Manual, [AD-2] Paragraph.13.3, a complete list of contingencies is described.
All these activities are treated in the dedicated chapter 8.
If necessary, eventually an NCR should be raised and an NRB meeting called, see Par. 8.2.1.
IOM or a deputy, always available during DTCP, will contact immediately specialists to analyze and solve the contingency as soon as possible. In order to optmize the problem solving process, an LFI internal meeting will be organized, see Par. 8.2.2.

According to the type of contingency, an Instrument Commanding Request could be required to put the instrument in an ad-hoc configuration and afterwards to recover from the contingency, see Par. 8.2.3.

5.2 INSTRUMENT TELE-COMMANDING

The LFI IOT team is in charge of sending to the MOC the required telecommands to correctly operate the LFI, see the next paragraphs (5.2.1 to 5.2.4) for more details. The command sequence should be prepared to be up-linked before the next DTCP.
During the routine phase, the agreed mechanism is the ICR (Instrument Commanding Request) that will be posted by email as defined in [RD-2]. In case of controversial ICRs, the CRAT mechanism will be used.
During Commissioning and CPV phases, the detailed timeline will be defined before launch and constitutes the master timeline of commissioning and CPV activities.

In addition the DPC interacts with the PSO for the development of the Science-MTL. The PSO passes this to the MOC where it is first processed and augmented by Flight Dynamics before being released to the Flight Control Team for final processing and uplinking during a DTCP.

5.2.1 ROUTINE OPERATIONS

The TC routine operations consist mainly in varying a few parameters to enhance the performance of the LFI instrument, as changing a TM monitoring parameter or the Calibration channel switching. See corresponding sheet in Paragraph 6.1.1, item 6.

The other routine operations that will be performed only once, when the LFI is switched ON for the first time, correspond to the nominal transition procedures (see § 3.2), detailed in the following paragraph.

5.2.1.1 NOMINAL PROCEDURES

The table below reports a summary of all the transition procedures, with the corresponding reference to the detailed description in the LFI User Manual [AD-2] Paragraph 13.2, that are required to bring the LFI from the OFF to the Normal or Extended Science Modes and viceversa.

PROCEDURE NAME	DESCRIPTION	PROCEDURE	NOTE
REBA ASW INIT	Paragraph 13.2.2	Table 13-20	
REBA SYNCHRONIZATION	Paragraph 13.2.3	Table 13-22	
RAA ON CHECK AND CONNECTION TO REBA	Paragraph 13.2.4	Table 13-24	
RAA SYNCHRONIZATION	Paragraph 13.2.5	Table 13-26	
RCA ACTIVATION, RCA DE-ACTIVATION	Paragraph 13.2.6	Table 13-28	
UPDATE OF THE RCA PARAMETERS	Paragraph 13.2.7	Table 13-30	
UPDATE OF THE DEFAULT RCA SETTINGS	Paragraph 13.2.8	Table 13-32	
SCIENCE ACTIVATION	Paragraph 13.2.9	Table 13-34	
CHANGE SCIENCE PROCESSING PARAMETERS	Paragraph 13.2.10	Table 13-36	

SCIENCE DE-ACTIVATION	Paragraph 13.2.11	Table 13-38	
DEFINITION OF THE SCIENCE PROCESSING PARAMETERS	Paragraph 13.2.12	Table 13-40	
STARTING THE MONITORING FUNCTIONS	Paragraph 13.2.13	Table 13-42	
VERIFYING THE MONITORING FUNCTIONS	Paragraph 13.2.14	Table 13-44	
ENABLING THE AUTONOMOUS FUNCTIONS	Paragraph 13.2.15	Table 13-46	
TESTING THE AUTONOMOUS FUNCTIONS	Paragraph 13.2.16	Table 13-48	
SETTING THE TELEMETRY RATE	Paragraph 13.2.17	Table 13-50	
DISABLING THE AUTONOMOUS FUNCTIONS	Paragraph 13.2.18	Table 13-52	
DISABLING THE MONITORING FUNCTIONS	Paragraph 13.2.19	Table 13-54	
EVENT PACKETS ENABLING	Paragraph 13.2.20	Table 13-56	
SCIENCE DC-DC SWITCH OFF	Paragraph 13.2.21	Table 13-58	
RAA OFF CHECK	Paragraph 13.2.22	Table 13-60	
REBA AND RAA POWER ON/OFF BY THE SATELLITE	Paragraph 13.2.23	Table 13-61	

Table 5-1 Summary of the LFI nominal operations

5.2.1.2 ADDITIONAL NOMINAL OPERATIONS

A number of maintainance operations could be implemented in order to optimize the performance of the LFI instrument. As mentioned at the beginning of par. 5.2, these operations will be dealt through the ICR mechanism [RD-2]. All these operations are already defined in the FOP (Flight Operations Plan). If an operation is considered as a possible cause of inter-instrument interference (controversial operation), the so-called Command Request Acceptance Table (CRAT) is used as part of the ICR process.

5.2.2 NON-ROUTINE OPERATIONS

Non-routine operations consist of:
- Planet Scanning Operations;
- Small Gap Recovery Operations.

5.2.2.1 PLANET SCANNING OPERATIONS

No special TC, with respect to the nominal operations, is foreseen to be sent before or during a planet scanning. TBC

5.2.2.2 SMALL GAP RECOVERY REQUEST OPERATIONS

Not all gaps are identifiable at MOC or eventually by PSO, and instruments may also request small gap recovery, if the data loss is only detectable within science TM for example.
The validity of a pointing will be based on several factors:
− instruments operational modes;
− instrument health;
− quality of the data;
− frequency coverage;
− polarisation coverage.

All the above information will be provided by the DPCs/IOTs mainly through the DQR (see 7.2.6). Whether a missed pointing (or series of pointings) constitute a small gap will be decided according to the PSO's assessment of achieved coverage, this will in turn depend on which survey is being carried out. PSO's assessment will be based on thresholds and criteria proposed by the DPCs and endorsed by the Science Team, according to guidelines set out in [RD-19].
Small gap recovery request shall unambiguously specify the pointings to be recovered (this is TBC and could be through pointing identifiers, or through execution times).
Before sending the request, the DPC/IOT shall guarantee the cause of the gap has been fully understood and solved.

5.2.3 COMMISSIONING AND CPV OPERATIONS

As already explained in Paragraph 5.1.2, the timeline of the Commissioning and CPV phases is too complex to be described here and can be found in the LFI test plan [RD-30].
The point when LFI Commissioning phase is over and CPV phase can start is defined in the LFI test plan [RD-30]. Anyway the two phases are compenetrating one into the other and the Commissioning will smoothly end towards the CPV phase in order to achieve the best perfomance of the LFI instrument.

For what regards instrument telecommanding, a brief summary of Commissioning and CPV operations is given in the two following paragraphs. All the procedures, the corresponding test sequence and the required TPF files should be well prepared and checked. See corresponding sheet in Paragraph 6.2.1 and 6.2.2 and again the LFI test plan [RD-30].

A summary of Commissioning (COMM-1 and COMM-2) and CPV (LFI-01 to LFI-27) activities is given in the table below.

Nr.	Step	Ref. # [RD-30]	Description of Activity	Required time (hr)	Notes
COMM-1	LFI in Stand-by	3.1	- Switch on the REBA unit - Performn DPU memories commissioning - Start the DPU ASW - Perform SPU memories commissioning - Start the SPU ASW - Perform REBA Synchronization	< 1	
COMM-2	LFI in DAE-Set Up	3.2	- Switch on the DAE unit - Perform DAE synchronization - Perform DAE memories commissioning	< 1	
LFI-01	LFI Switch On and Basic Health Check	3.3	- LFI go to DAE setup - Spike characterisation - FEM functionality	~10	LFI in Normal Science
LFI-02	LFI Functionality Test	3.4	- Acquire data while P/S status is changed - Spike check		
LFI-25	Spike characterization test #2	3.5	- Spike characterisation	16	
LFI-03	Stability Check	3.6	- Acquiring data	12	
LFI-04	Phase switch bias tuning	4.2.1	- Apply a bias matrix set of P/S currents	8	

			for LFI 30 and 44 GHz to optimize P/S balancing		
LFI-05	ACA gate 1and 2 voltage tuning	4.2.2	- Apply a matrix of Vg1 and Vg2 biases to seek for the optimal noise and gain balance in each radiometer	3×8	
LFI-07	ACAs gate 1 voltage tuning verification	4.2.3	- Apply a set of Vg1 biases to verify the optimal noise and gain balance in each radiometer	8 (TBC)	
LFI-26	ACAs gate 2 voltage contingency plan	4.2.4	- Apply a set of Vg2 biases to verify the optimal noise and gain balance in each radiometer	24	
LFI-08	Functionality Reference Point	4.3	- Fix a reference point with the radiometers in tuned conditions	8	
LFI-14	Blanking Time Verification	4.4	- Receiver noise properties with different blanking times	6	
LFI-26	Spike characterization test #3	4.5	- Spike characterisation	16	
LFI-13	Verification of DAE offset calibration table	4.6.1	- Exercise the DAE offsets to verify the consistency with calibrated values	24	
LFI-09	Tuning of DAE parameters	4.6.2	- Exercise and optimize the DAE parameters	2	
LFI-10	Tuning of REBA parameters	4.6.3	- Exercise the REBA parameters and verify optimization	8 (TBC)	
LFI-11	REBA check	4.6.4	- Verify the optimal REBA parameters are compliant with LFI TM budget	24	
LFI-12	Long time stability check	4.6.5	- Acquiring data	N/A	
LFI-15	Steady State Temperature Distribution	5.2	- Acquiring data	24	
LFI-16	Dynamic Thermal Response	5.3	- FPU is excited with known T variations (TSA)	24	
LFI-17	Dependency of Focal Plane Temperature Distribution as a Function of 3rd V-Groove Temperature	5.4	- Change VG3 T and monitor FPU sensors (TBC)	24	
LFI-18	LFI noise properties – phase switches off	6.1.1	- Switch off 4KHz switching to verify the noise properties in all the different P/S configurations	24	
LFI-19	LFI noise properties – phase switches on	6.1.2	- Switch on 4KHz switching in all the different configurations to verify the noise properties	48	
LFI-20	Photometric Calibration	6.2	- Acquiring data to check photometric calibration stability and absolute calibration	24 (TBC)	
LFI-21	Internal EMC	6.3	- Switching on/off LFI receivers	6 (TBC)	
LFI-22	Crosstalk Between Receivers	6.4	- Acquiring data during planet scans	2×11	
LFI-23	Thermal Susceptibility	6.5	- Acquiring data with TSA on and off	24	
LFI-24	Main Beam Calibration	7.1	- Acquiring data during planet scans or bright sources observations	TBD	
LFI-25	Sidelobes Calibration	7.2	- Acquiring data during moon or sun sidelobe observations	TBD	
LFI-26	Optical Polarisation	7.3	- Acquiring data during polarized sources observations	TBD	
LFI-27	Focal plane geometry reconstruction	8	- Acquiring data during planet scans or bright sources observations	TBD	

Note that during the Commissioning and CPV phases, all the commanding activites (a part when explicitely specified) will be performed during the visibility window (DTCP).

Both for commissioning and CPV activities, as defined in the LFI Commissioning and CPV plan [RD-30], pass fail criteria are defined.

5.2.3.1 COMMISSIONING OPERATIONS

During the Commissioning phase it is supposed to switch on the instrument and to verify the correct functioning of the LFI instrument. See also Paragraph 13.1.1 in [AD-2] and Paragraph 3 in [RD-30].
The HK telemetry produced by the LFI will be processed in order to monitor the status of the instrument and pass fail criteria will be verified (see par. 5.1.2.1).
In case these pass fail criteria are not met, an NCR should be raised and an NRB meeting called, see Par. 8.2.1. IOM or a deputy, always available during DTCP, will contact immediately specialists to analyze and understand the results of the test and the reasons why the pass/fail criteria are not met. In order to optmize the process, an LFI internal meeting will be organized, see Par. 8.2.2.

In case of a failure or a contingency, the sequence should be stopped, an NCR should be raised and an NRB meeting called, see Par. 8.2.1. IOM or a deputy, always available during DTCP, will contact immediately specialists to analyze and solve the contingency as soon as possible. In order to optmize the problem solving process, an LFI internal meeting will be organized, see Par. 8.2.2.
According to the type of contingency, an Instrument Commanding Request could be required to put the instrument in an ad-hoc configuration and afterwards to recover from the contingency, see Par. 8.2.3.

5.2.3.2 CPV OPERATIONS

During the CPV phase, the LFI instrument will be calibrated and its performance will be verified. All the operations to be performed are described in details in the LFI User Manual, [AD-2], Paragraph 13.1.2 and in the LFI test plan, [RD-30], Paragraph 3.1 onwards.

The HK and Scientific telemetry produced by the LFI will be processed in order to monitor the status of the instrument and pass fail criteria will be verified (see par. 5.1.2.2).
In case these pass fail criteria are not met, an NCR should be raised and an NRB meeting called, see Par. 8.2.1. IOM or a deputy, always available during DTCP, will contact immediately specialists to analyze and understand the results of the test and the reasons why the pass/fail criteria are not met. In order to optmize the process, an LFI internal meeting will be organized, see Par. 8.2.2.

In case of a failure or a contingency, the sequence should be stopped, an NCR should be raised and an NRB meeting called, see Par. 8.2.1. IOM or a deputy, always available during DTCP, will contact immediately specialists to analyze and solve the contingency as soon as possible. In order to optmize the problem solving process, an LFI internal meeting will be organized, see Par. 8.2.2.

According to the type of contingency, an Instrument Commanding Request could be required to put the instrument in an ad-hoc configuration and afterwards to recover from the contingency, see Par. 8.2.3.

Eventually, if there is no safety issue, as specified in the LFI test plan [RD-30] for each specific test in the row "action in case of failure/anomalies", additional tests can be performed while solving the contingency.

5.2.4 CONTINGENCY ACTIVITIES

During a transition phase from one LFI operational mode to another, or due to a more general problem, a contingency condition could happen that need to be recovered.
According to the type of problem which caused the contingency, an ad-hoc recovery operation has to be applied. Eventually, if the recovery operation has not succeeded, another procedure to put the instruments into the best condition to work has to be found. The solution will depend on a case to case basis.
The TC to be sent to the instrument depend on the type of problem. In the LFI User Manual, [AD-2] Paragraph.13.3, a complete list of contingencies and the corresponding recovery actions is detailed.
All the contingency items are treated in the dedicated chapter 8.

If necessary, eventually an NCR should be raised and an NRB meeting called, see Par. 8.2.1. IOM or a deputy, always available during DTCP, will contact immediately specialists to analyze and solve the contingency as soon as possible In order to optmize the problem solving process, an LFI internal meeting will be organized, see Par. 8.2.2.
According to the type of contingency, an Instrument Commanding Request could be required to put the instrument in an ad-hoc configuration and afterwards to recover from the contingency, see Par. 8.2.3.

5.3 SOFTWARE MAINTENANCE

The LFI DPC will be properly maintained: staffing for this purpose has been foreseen at all Principal Sites, thus for all Levels of data processing. Maintenance will be performed on the general DPC infrastructure, as well as on both the DPC hardware and software infrastructures. Regular preventive hardware maintenance, including installation when necessary of new versions of operating systems and other relevant COTS software, will be supported; routine S/W and data backups will be performed. The DPC documentation, including a central list of all DPC Software Problems Reports (to support software Configuration Control) will be maintained. It is to be clarified that maintenance to the data processing software includes upgrades, e.g. the integration in the pipeline structure of prototype software developed to react to features discovered in raw or pre-processed data. To allow homogeneous processing of data, the upgraded software will follow standard PA/QA and configuration management procedures before being used in operations. In the Software Maintenance Plan [RD-11], software maintenance for instrument simulators and on-board software, for each of the Levels and for the global integrated system, is explicited.

5.4 NEW SOFTWARE RELEASE OR END-OF-SURVEY

5.4.1 NEW SOFTWARE RELEASE

The procedure for a new release of the software version is different for the SGS1 and the SGS2.
In the case of the SGS1, there exists an exact copy, hardware and software, and the two systems are under strict configuration control. The new version is first released on the SGS1 copy and here it is then validated. After the validation, the new software is released on the SGS1.
The SGS2 is too big to maintain a complete copy of it. For this reason only a representative part of it, again under strict configuration control, will be used to validate the new version. After the validation, the new software is released on the SGS2.

5.4.2 END OF SURVEY

Additional operations include the processing to be performed to produce a set of homogeneous results. This actually happens in the nominal case at the end of a survey, but is necessary as well whenever a new release of the pipeline software is issued. This task is under the responsibility of the DPC Operations staff; support by instrument specialists is however important for a complete understanding of residual instrumental effects.
Operations include the following steps:
• Read all data from one detector (max 24 GB) in chunks;
• Perform removal of systematics, first-order calibration, etc., dipole calibration if end-of-survey;
• Build partial or full-sky frequency maps (using “best” algorithm), see corresponding sheet in Paragraph 6.1.4;
• Run Level 3 to extract full-sky component maps and power spectrum (see Paragraph 6.1.3).

The real bulk of the work is given by the need to re-process all data acquired up to that moment with the new version of software being released, to create a homogeneous data set. This is particularly understandable at the end of a survey, but is equally important whenever a new version of the LFI pipeline is released, to allow the DPC to offer to the Planck collaboration all LFI calibrated data in a stable and configured status. This scenario is particularly demanding in terms of computing power required. There is the need to minimize backlogs in processing, thus the use of “shadow” hardware (i.e. not fully dedicated to Planck, as described in [RD-10]) will be necessary. Although the computer system described in [RD-10] will be used in its full capacity, the computing power will probably still be not sufficient for certain processing items; therefore, certain steps will probably use supercomputers or grid.

The production of an Early Release Compact Source Catalogue (ERCSC) has also been envisaged and endorsed by the Planck Science Team (see Paragraph 7.2.43). LFI TOD, calibrated both photometrically and astrometrically at the best of the current knowledge will be transferred to the ERCSC group with procedures to be defined in a separate ICD (requirements in definition). The production of the ERCSC will be run as a separate data processing system in Pasadena; in any case, the ERCSC will be released by the Level 2 of both DPCs (see paragraph 6.4.1).

5.5 ARCHIVE DEVELOPMENT

The Data Archive at DPC will be based on Oracle system and split in two separated archives, the SGS1 archive and the SGS2 archive.
The SGS1 Archive will contains all the telemetry and auxiliary data as they were get from the HPDDS and HPFTS system, only the machine in charge of getting these data will have the permission to write on this archive.
The SGS2 archive will have a more flexible form to allow, in case it is necessary, to rebuild the calibrated timelines and scientific results.
Each archive will be mirrored to be able to reconstruct it in fast way after a failure.

6 NOMINAL OPERATIONS

In this paragraph all the nominal operations are listed with a short description and a reference to the corresponding procedure.

6.1 ROUTINE PHASE SHEETS

6.1.1 DAILY OPERATIONS SHEET

Daily operations include the following procedures:

1. Download one observation day of consolidated LFI, HFI (selected), SCS and S/C (selected) TM and required auxiliary information data sets from HPDDS and HPFTS at MOC: see Procedure Par. 7.2.1;
2. Run SGS1 software (see Figure 5-2):
   - Real Time Assessment – RTA: see Procedure Par. 7.2.2;
   - Telemetry Quick Look – TQL: see Procedure Par. 7.2.3;
   - TeleMetry Handling - TMH (TMU + TM2TOI or eventually TMU + ADD_AUX + TM2TOI) to decompress/expand/convert the telemetry, both HK and Sci and complement with auxiliary information: see Procedure Par. 7.2.4.
3. Run the LIFE system (compute R and evaluate the knee frequency, subtract the sky signal and, if needed, point sources or glitch signals, produce trends, Data Quality, Flags): see Procedure Par. 7.2.5;
4. Compile the reports generated by LIFE into a Daily Quality Report (DQR) to be sent to PSO: see Procedure Paragraph 7.2.6;
5. Export LFI/SCS data in EFDD format [RD-27] according to the ICD [RD-9]: see Procedure Par.7.2.7;
6. On demand compare with HFI data:
   - retrieve data from HFI data storage: see Procedure Paragraph 7.2.8;
   - cross-check LFI - HFI data: see Procedure Paragraph 7.2.9.
7. Prepare, compile, and transmit the information available at DPC for uplink operations towards the instrument:
   - Setting the Telemetry Rate to pass from the Normal Science to the Extended Science Mode and viceversa, Calibration channel switching, change RCA, Science Processing or TM Monitoring parameters, Upload REBA patching: see Procedure Paragraph **Errore. L'origine riferimento non è stata trovata.**;
   - Small gap recovery requests: see Paragraph 7.2.11;
8. Eventually provide support to the scientific team running the Quick-Alarm system for the detection of flaring radio sources: see Procedure Paragraph 7.2.12;
9. Run the 1st part of Level 2 pipeline:
   - Merge Circles: see Procedure Paragraph 7.2.13;
   - Compute R and evaluate the knee frequency: see Procedure Paragraph 7.2.14;

- o Subtract the sky signal: see Procedure Paragraph 7.2.15;
- o Subtract point sources or glitch signals (if needed): see Procedure Paragraph 7.2.16 and 7.2.17;
- o Trends, Data Quality, Flags: see Procedure Paragraph 7.2.18.

10. First look for systematics, perform first-order calibration, cleaning, write processed "circles": see Procedure Paragraph 7.2.19;
11. Organize the daily meeting: see Procedure Paragraph 7.2.20.

6.1.2 WEEKLY OPERATIONS SHEET

Weekly operations include the following procedures:

1. Read one week of LFI data from archive: see Procedure Paragraph 7.2.21;
2. Run data checking and trend analysis:
   - o merge "circles" into weekly streams for each detector: see Procedure Paragraph 7.2.13;
   - o for every set of weekly data look for trends, define quality, assign flags: see Procedure Paragraph 7.2.18;
3. Export LFI data in EFDD format [RD-27] according to the ICD [RD-9]: see Procedure Par.7.2.22;
4. When needed, compare with HFI data:
   - o retrieve data from HFI data storage: see Procedure Paragraph 7.2.23;
   - o cross-check LFI - HFI data: see Procedure Paragraph 7.2.24;
5. Perform initial calibration on LFI data:
   - o Iterative calibration of radiometers: see Procedure Paragraph 7.2.25;
   - o 2-D evaluation of beam: see Procedure Paragraph 7.2.26;
   - o stray-light effects: see Procedure Paragraph 7.2.27;
   - o Focal Plane reconstruction: see Procedure Paragraph 7.2.28;
   - o Attitude reconstruction after combined analysis of HFI and LFI data, improve MOC-provided pointing: see Procedure Paragraph 7.2.29;
6. Map making (temperature): Procedure Paragraph 7.2.30;
7. Map making (polarisation): Procedure Paragraph 7.2.31;
8. Compile the Weekly Health Report (WHR) to be sent to PSO: see Procedure Paragraph 7.2.32;
9. Organize the weekly meeting: see Procedure Paragraph 7.2.33.

These operations include the running of the Level 2, a scheme of the data and software flow is shown in Figure 5-3. Processing to take place at Level 2 of the pipeline will deal with the LFI-specific aspects of data reduction. DPC staff located at the Level 2 site will have proper instrument knowledge to be able to support operations. The software items will be run iteratively to produce calibrated time series (TOD), performances and beam of each detector, flagging information, variance estimation for each pixel, and updates to the Calibration Database. Maps of the sky in the observed bands will be also produced gradually, while the Planck survey progresses, together with maps of the sky per detector, maps of the systematic effects, and a preliminary point-source catalogue associated with the sky maps. Iteration is required to continuously improve the data processing algorithms and continuously refine the scientific data products. In this perspective, procedures to cross-check data and systematic between HFI and LFI will be run regularly. Transfer of TOD to/from the HFI DPC will be performed with procedures defined in separate low-level ICDs (see [RD-9] and [RD-12]).

A week is nominally starting on Wednesday but eventually it can be shifted to another week day.

6.1.3 MONTHLY OPERATIONS SHEET

Monthly operations include the following procedures:

1. Read one month of calibrated LFI TOD from TOD archive: see Procedure Paragraph 7.2.34;
2. Build partial frequency maps and compare: see Procedure Paragraph 7.2.35;
3. Export LFI frequency maps in EFDD format [RD-27] according to the ICD [RD-9]: see Procedure Par.7.2.36;
4. Retrieve HFI frequency maps from HFI DPC: see Procedure Paragraph 7.2.37;
5. Possibly, run Level 3 (see Figure 5-4):
    - component separation: see Procedure Paragraph 7.2.38;
    - inter-frequency cross-checks on CMB maps: see Procedure Paragraph 7.2.39;
    - component maps archive: see Procedure Paragraph 7.2.40;
    - merge component maps: see Procedure Paragraph 7.2.41.
6. LFI/HFI optimization on component maps: see Procedure Paragraph 7.2.42;

In order to be consistent with the weekly operations (Par. 6.1.2), the month is nominally starting on the first Wednesday (TBC) of each month but eventually it can be shifted to another week day.

6.1.4 END OF SURVEY: MAP PRODUCTION

End of survey operations consist in the Map Production and include the following procedures:

1. Component separation and optimization: see Procedure Paragraph 7.2.36;
2. Intercomparison and cross-checks: see Procedure Paragraph 7.2.24 and 7.2.39.

6.1.4.1 COMPONENTS SEPARATION AND OPTIMIZATION

At Level 3 already during the Operations phase and especially after the first survey, initial attempts will be made to transform by means of pipeline processing the preliminary frequency maps produced by both instruments into maps of the underlying astrophysical components, by using data from both instruments, properly shared. This work will be implemented independently by LFI staff to allow the amount of redundancy and cross-checking required in [RD-4].

Also in this case, iteration is required to continuously improve data processing algorithms and scientific data products. In this perspective, procedures to cross-check data and systematic between HFI and LFI will be run regularly. Transfer of maps to/from the HFI DPC will be performed with procedures to be defined in a separate ICD (requirements defined in [RD-12]).

6.1.4.2 INTERCOMPARISON AND CROSS-CHECK

It is worthwhile to stress that the LFI DPC will compare at regular intervals, intermediate scientific products with equivalent products from the HFI DPC; the exchange of data will occur according to the rules defined in the DPC-DPC ICDs [RD-9]. Inter-comparison and cross-check are necessary at three levels: at level 1, on demand, to verify and understand possible influences between the two instruments; at Level 2, to improve data calibration and therefore to obtain better frequency maps; at Level 3, to achieve a proper combination of the measurements from both instruments, in order to produce merged and integrated component maps. This implies that all data products obtained by the pipeline (both deliverable and internal) shall be exchangeable at intermediate stages of processing. While both Consortia intend to be flexible about visibility of the respective pipeline products, care should be taken to avoid sharing of data at an inadequate level of processing, since this would affect the quality and reliability of data. The production of the maps for each diffuse component is planned to be performed in a preliminary form at Level 3, during both the Operations and Post-operations phases; the merging of the final component maps will be performed (under ST supervision) during the Post-operations phase.

6.2 COMMISSIONING AND CPV OPERATIONS SHEET

Commissioning and CPV operations are not subdivided in daily, weekly or monthly operations since during these two phases there are no routine operations to carry on and every Operational Day will result to be different from the others. A daily meeting will however be organized, both for Commissioning and CPV, in order to review the status of the tests.
The daily quality (par. 7.2.6) and weekly health reports (par. 7.2.32) will be generated but this will not be representative of the status and health of the LFI instrument since the LFI will not be in its nominal configuration.

6.2.1 COMMISSIONING OPERATIONS SHEET

The commissioning operations include the following procedures:
1. Online data analysis: see Procedure Paragraph 7.1.1;
2. Offline data analysis: see Procedure Paragraph 7.1.2;
3. Prepare and check the test sequence for the following test: see Procedure Paragraph 7.1.4;
4. Organize the Commissioning Daily Meeting: see Procedure Paragraph 7.1.5.

6.2.2 CPV OPERATIONS

The CPV operations include the following procedures:
1. Online data analysis: see Procedure Paragraph 7.1.1;
2. Offline data analysis: see Procedure Paragraph 7.1.2;
3. Eventually cross check with HFI data when necessary: see Procedure Paragraph 7.1.3;
4. Prepare and check the test sequence for the following test: see Procedure Paragraph 7.1.4;
5. Organize the Commissioning Daily Meeting: see Procedure Paragraph 7.1.5.

6.3 NON-ROUTINE OPERATIONS SHEET

6.3.1 PLANET SCANNING OPERATIONS SHEET

Due to the different statistical behaviour of the data acquired during a Planet Scanning, after a Planet Scanning the data processing pipeline on a weekly base should run again.
This corresponds to apply again the procedures of Paragraph 7.2.21, 7.2.13 7.2.18, 7.2.25 to 7.2.32. If needed the HFI data should be also compared: 7.2.23 and 7.2.24.

6.3.2 SMALL GAP OPERATIONS

As described previously, small gap operations include two sheets:

- Small Gap recovery request;
- Small Gap recovery processing.

6.3.2.1 SMALL GAP RECOVERY REQUEST SHEET

After a small gap has been identified, a recovery request should be sent to MOC.
See also context in Paragraph 5.1.3.2 and procedure in Paragraph 7.2.11.

6.3.2.2 SMALL GAP RECOVERY PROCESSING SHEET

Due to the different statistical behaviour of the data acquired during a small gap recovery, after a small gap the data processing pipeline on a weekly base should run again.
This corresponds to apply again the procedures of Paragraph 7.2.21, 7.2.13, 7.2.18, 7.2.25 to 7.2.32. If needed the HFI data should be also compared: 7.2.23 and 7.2.24.
See also context in Paragraph 5.2.2.2.

6.4 SINGLE TIME OR OCCASIONAL OPERATIONS SHEET

There is just a few single time or occasional operations to be performed for the LFI.
These could be related to a contingency, where there could be on one side TC to be sent to the instruments to recover it from the problem and on the other side the scientific data should be treated with a special care. These items are all discussed in the dedicated chapter 8.
Another single time operation is the production of the Early Release Compact Source Catalogue.

6.4.1 OTHERS

Every six months it is foreseen to produce the Early Release Compact Source Catalogue (ERCSC): see Procedure Paragraph 7.2.43.

7 NOMINAL OPERATION PROCEDURES

7.1 COMMISSIONING AND CPV OPERATIONS

7.1.1 REAL TIME HK DATA ANALYSIS

Context:
See Par. 5.1.2.1 and 5.1.2.2

Responsible Person:
Instrument Operation Manager and corresponding test point of contact

Estimated Duration:
5 hours (DTCP duration)

Inputs:
HK TM real time data

Outputs:
Pass/fail criteria output, test sequence prosecution

Procedures:
Verification that values and TM are within specifications and requirements

Description:
By looking at real time HK data produced by the LFI, it should be confirm that the implemented procedure is going on in the correct way, that is to say that REBA autocheck is succesfull, REBA and DAE memories dump packets as expected, REBA and DAE power consumptions are compliant with specification and requirements, the application software is producing HK telemetry as expected, REBA and DAE synchronizations are achieved.

7.1.2 OFFLINE DATA ANALYSIS

Context:
See Par. 5.1.2.1 and 5.1.2.2

Responsible Person:
Instrument Operation and calibration Managers and corresponding test point of contact

Estimated Duration:
The duration depends on the test and are defined in [RD-30].
Start automatically when first chunk of data is downloaded at IW@MOC

Inputs:
Chuncks of LFI data at IW@MOC: HK and scientific TM

Outputs:
Pass/fail criteria output, test sequence prosecution
Instrument alarms and reports are automatically generated.

Procedures:
Refer to TQL document [RD-24], TMH SSD [RD-21] and to the LIFE User Manual [RD-3])

Description:
Run TQL on packets to identify suspicious Sci TM, verify the performance of the detectors and the overall health of the LFI instrument.
Run TMH, TMU + TM2TOI, to decompress/expand/convert the telemetry, both HK and Scientific or eventually TMU + ADD_AUX + TM2TOI to complement with auxiliary information.
Run the LIFE system to:

- o estimate noise properties;
- o tune phase switch bias, FEM Vg1 and Vg2, DAE offset and gain, REBA parameters;
- o verify tuining;
- o verify thermal response of FPU;
- o check photometric calibration (relative and absolute);
- o characterize cross-talk between receivers;
- o characterize thermal susceptibility;
- o estimate the optical calibration (main beam and sidelobe calibration, optical polarization);
- o estimate the focal plane geometry (alignement of feed pairs and focal plane, calibration of the pointing direction).

In addition LIFE can be used to monitor the general behaviour of different part of the LFI instrument whenever it is necessary.

For every test single commissioning and CPV test (see list in par. 5.2.3), the required software data analysis tools and the pass/fail criteria are defined in details in the LFI commissioning and CPV test plan [RD-30].

7.1.3 CROSS-CHECK LFI AND HFI DATA

Context:
See Par. 5.1.2.2

Responsible Person:

Instrument Operation and DPC Managers

Estimated Duration:
TBW

Inputs:
LFI and HFI converted timelines and HK information

Outputs:
TBW

Procedures:
Run the KST tool to cross-correlate HFI and LFI data (Detailed procedures will be defined after the CSL tests where the tool will be verified).

Description:
For some of the tests, it could turn out to be necessary a comparison between LFI and HFI data. At this point some flexibility is required and it is not possible to identify all the cases where this could happen.

7.1.4 UPLINK OPERATIONS: CHECK INSTRUMENT PROCEDURE

Context:
See Par. 5.2.3, 5.2.3.1 and 5.2.3.2

Responsible Person:
Instrument Operation Manager and corresponding test point of contact

Estimated Duration:
Dependent on the test (see LFI Commissioning and CPV test plan [RD-30])

Inputs:
Test sequence

Outputs:
Test sequence verified

Procedures:
IOM verifying the test sequence

Description:
For each test during the commissioning and CPV phases, a number of telecommand procedures, parameters and TPF files should be ready to be uploaded by MOC. Prior to the tests, it should be checked that every command sequence and TPF file is ready for the corresponding operation.

7.1.5 COMMISSIONING AND CPV DAILY MEETING

Context:
See Par. 5.1.2.1 and 5.1.2.2

Responsible Person:
Instrument Operation Manager

Estimated Duration:
Less than 1 hour
The meeting starts after the DTCP, as soon as data analysis required for the pass/fail criteria of the corresponding test and for prosecution of the following tests is completed.

Inputs:
Previous and current status of Commissioning and CPV tests. Results of data analysis for the tests just concluded.

Outputs:
Minutes of the Daily Meeting, eventually the uplink command sequence ready for the next tests.

Procedures:
Organization of the daily meeting

Description:
Organize the daily meeting to discuss the previous OD test results, discussion about the sequence for the prosecution of the test phase and eventually preparation of the command sequence and TPF files to be up-linked during next DTCP. It will be organized after the DTCP, as soon as data analysis required for the pass/fail criteria of the corresponding test and for prosecution of the following tests is completed.

7.2 ROUTINE OPERATIONS

See very preliminary timeline hypothesis in Paragraph 7.4.
The “Mid case” timeline is considered as a reference here, but the estimated scheduled time of each operation could change depending on the real DTCP time which is planned well in advance.

7.2.1 READ ONE DAY DATA

Context:
See Par.5.1

Responsible Person:
DPC SGS1 Manager

Estimated Duration:
3 hours
Start automatically when consolidated data are available at MOC: at about 16:30 CET

Inputs:
Consolidated LFI, HFI (selected TM), SCS (selected TM) and S/C (selected TM) data available at MOC

Outputs:
Chunks of LFI, HFI (selected TM), SCS (selected TM) and S/C (selected TM) data at DPC

Procedures:
Refer to TQL/TMH Software Specification [RD-24] and [RD-21] and HPDDS [RD-22] documents.

Description:
Download one observation day of consolidated LFI TM from HPDDS and HPFTS at MOC (estimated maximum size: 400 MB), retrieval from MOC of the HFI, SCS and Spacecraft HK selected TM.
Additional daily work can derive from ~one-week-old LFI telemetry and additional auxiliary information gathered from MOC.

7.2.2 REAL TIME ASSESSMENT (RTA)

Context:
See Par.5.1

Responsible Person:
DPC SGS1 Manager

Estimated Duration:
Less than 8 hours
Start when first chunk of data is downloaded at DPC: at about 16:30 CET

Inputs:
Chunks of LFI data at DPC (see output § 7.2.1): HK TM

Outputs:
Instrument alarms and logs are automatically generated.

Procedures:
Refer to RTA UR [RD-23] and SCOS2K User Manual

Description:
Run RTA to detect out-of-range HK TM values to identify suspicious HK TM.

Alarms and logs are automatically generated.
Note that this operation is independent from the TM handling

7.2.3 TELEMETRY QUICK LOOK (TQL)

Context:
See Par.5.1

Responsible Person:
DPC SGS1 Manager

Estimated Duration:
Less than 8 hours
Start automatically when first chunk of data is downloaded at DPC: at about 16:30 CET

Inputs:
Chunks of LFI data at DPC: HK and Scientific TM (see output § 7.2.1), alarms and logs generated by RTA (see output § 7.2.2)

Outputs:
Instrument alarms and reports are generated.

Procedures:
Refer to TQL document [RD-24]

Description:
Run TQL on packets to verify suspicious HK TM and possibly identify suspicious Sci TM, verify the performance of the detectors and the overall health of the LFI instrument. Based on anomalous alarms possibly generated during § 7.2.2, the TQL will be aimed to understand the non nominal behaviour of the instrument monitoring parameters and identify possible effects on science parameters.
Reports are generated under request.
Note that this operation is independent from the TM handling

7.2.4 TELEMETRY HANDLING (TMH)

Context:
See Par.5.1

Responsible Person:
DPC SGS1 Manager

Estimated Duration:

Between 4 and 5 hours (data retrieval included)
Start automatically when first chunk of data is downloaded at DPC: at about 16:30 CET

Inputs:
Chunks of LFI data at DPC (see output § 7.2.1): HK and Scientific TM

Outputs:
The output is a TOI data set in the order of 5 GB:

- HK TM is ordered by time and covering a whole day and possibly transformed in engineering values;
- Sci TM is ordered by time and is subdivided per detector in chunks of TBD hours and transformed in physical values;
- Ingest TOI to MPA-DMC.

Procedures:
Refer to TMH SSD [RD-21]

Description:
Run TMH, TMU + TM2TOI, to decompress/expand/convert the telemetry, both HK and Scientific or eventually TMU + ADD_AUX + TM2TOI to complement with auxiliary information.
HK and Scientific data are flagged following predefined rules (e.g. Out Of Limits - OOL).

7.2.5 LIFE SYSTEM

Context:
See Par.5.1

Responsible Person:
DPC SGS1 Manager

Estimated Duration:
Less than 4 hours
Start automatically when the complete set of OD data and their related auxiliary information will be available at DPC: at about 21:30 CET

Inputs:
TOI from MPA-DMC (see output § 7.2.4), attitude history file (automatically received through the HPFTS system)

Outputs:
The output is the Daily Quality Report ready to be reviewed before being sent to PSO/MOC/HFI.

Procedures:
Refer to the LIFE User Manual [RD-3])

Description:
Run the LIFE system to:

- o Compute R and evaluate the knee frequency;
- o Subtract the sky signal;
- o Subtract point sources or glitch signals (if needed);
- o Trends, Data Quality, Flags.

The results, produced per pointing, will be automatically included in the Daily Quality Report (see next § 7.2.6).

7.2.6 DAILY QUALITY REPORTS

Context:
See Par.5.1

Responsible Person:
IOT and DPC Manager

Estimated Duration:
Less than 1 hour
Start after the LIFE has run (see Par. 7.2.5).

Inputs:
Reports generated automatically during LIFE processing (see Par. 7.2.5)

Outputs:
Final Daily Quality Report (DQR).

Procedures:
Run the LIFE module to generate the DQR

Description:
Compile the reports generated by LIFE (see §7.2.5) into a daily quality report (DQR) based on scientific data received at the DPCs during that day, as defined in [RD-8b].
The report is automatically generated during the LIFE running, it should be checked and sent to PSO, after the daily meeting. The DQR will be ready within 12 (TBC) hours after consolidated data are available at MOC, at about 04:30 CET, see timeline in Paragraph 7.4.
On Sunday the Daily Quality Report will be reviewed on the next day, after the Monday daily meeting. If no problem resulted from either the LIFE analysis or other tools (checking the "event reports" TM(5,x) or the TM packets production rate), the DQR generated by LIFE will be automatically sent to PSO. If necessary, after the Monday review, a new version of the Sunday DQR will be sent to PSO. If a problem appeared, the DPC/IOT person on duty will be in charge of reviewing the DQR as soon as possible in order to understand and possibly solve the problem (see

contingency activities described in Paragraph 8). In this case the DQR will not be sent automatically to PSO but it will be sent by the DPC/IOT person on duty after he/she reviewed it.

7.2.7 LFI/SCS CONVERTED DATA EXPORT VS HFI DPC

Context:
See Par.5.1

Responsible Person:
DPC Manager

Estimated Duration:
About 1 hour

Inputs:
LFI /SCS converted data in DMC format

Outputs:
LFI/SCS converted data in EFDD format ready to be downloaded by HFI

Procedures:
Ad hoc software

Description:
Export LFI/SCS converted data in EFDD format [RD-27] according to the ICD [RD-9].

7.2.8 COMPARISON WITH HFI: DOWNLOAD HFI CONVERTED DATA

Context:
See Par.5.1

Responsible Person:
DPC Manager

Estimated Duration:
TBW

Inputs:
HFI converted data available at HFI DPC

Outputs:
HFI converted data at LFI DPC

Procedures:
Run FTP script to download the HFI HK and science converted timelines

Description:
Retrieve converted scientific and housekeeping data from HFI data storage as defined in the DPC-DPC ICD [RD-9].

7.2.9 COMPARISON WITH HFI: CROSS-CHECK LFI AND HFI CONVERTED DATA

Context:
See Par.5.1

Responsible Person:
DPC Manager

Estimated Duration:
TBW

Inputs:
LFI and HFI data (see output § 7.2.4 and 7.2.8)

Outputs:
TBW

Procedures:
Run KST tool to cross-correlate HFI and LFI converted data

Description:
Compare, e.g. verify existence of features similar to those identified on LFI data, check for possible cross-talk, etc.

7.2.10 UPLINK OPERATIONS: INSTRUMENT PROCEDURE REQUESTS

Context:
See Par.5.2

Responsible Person:
Instrument Operation Manager

Estimated Duration:
Depending on the instrument procedure, see LFI User Manual [AD-2]

Inputs:

Request for the procedure

Outputs:
ICR ready to be sent to PSO/MOC/HFI with the telecommand procedure request after the daily meeting (see input/output § 7.2.20)

Procedures:
Write the Instrument Commanding Request

Description:
Request an instrument procedure.
In order to either enhance the performance of the instrument, better monitor the LFI Instrument or recover from a contingency, it could turns out that some parameters need to be changed. In particular:

- RCA parameters (for example the Gain, Offset or Voltages) can be updated. All these operations are included in the "RCA Activation and De-Activation" procedure defined in the LFI User Manual [AD-2], Paragraph 13.2.6, Table 13-27 and 13-28;
- Science Processing parameters (for example N_average, GMF 1 and 2) can be changed. All these operations are included in the "Change Science Processing Modes" procedure defined in the LFI User Manual [AD-2], Paragraph 13.2.10, Table 13-35 and 13-36;
- Science TM monitoring parameters (for example the TM rate Tau or Period) can be changed or the Science TM counter needs to be reset (every DTCP if the corresponding autonomous function is enabled). All these operations are included in the "Verifying the monitoring functions" procedure defined in the LFI User Manual [AD-2], Paragraph 13.2.14, Table 13-43 and 13-44;
- In order to pass from the Normal Science to the Extended Science Mode and viceversa, after this operation has been agreed both by HFI and PSO, the corresponding procedure of "Setting the Telemetry Rate", described in detail in the LFI User Manual [AD-2], Paragraph 13.2.1.9 and 13.2.1.10, Table 13-17 and Table 13-18, Par. 13.2.17 Table 13-49 and Table 13-50, can be applied;
- In order to change the calibration channel or to start/stop the calibration channel switching, the corresponding procedure of "RCA Activation And De-Activation", described in detail in the LFI User Manual [AD-2], Paragraph 13.2.6 Table 13-27 and Table 13-28, can be applied;
- Following an LFI on-board software problem, a REBA patch is required to be uploaded.

7.2.11 UPLINK OPERATIONS: SMALL GAP RECOVERY REQUESTS

Context:
See Par.5.2 (5.2.2.2)

Responsible Person:
Instrument Operation Manager

Estimated Duration:
TBW

Inputs:
LFI missing pointing

Outputs:
ICR ready to be sent to MOC with the small gap procedure request after the daily meeting (see input/output § 7.2.20)

Procedures:
TBW

Description:
Prepare and send to PSO a request for a small gap recovery (see Par. 5.2.2.2).

7.2.12 QUICK-ALARM SYSTEM: SUPPORT TO THE SCIENTIFIC TEAM

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
Less than 10 hours
Start in parallel with Level 1 running, when first TOIs are produced by L1: at about 04:30 CET

Inputs:
TOIs produced by Level 1 (see output § 7.2.4), Catalogue of Radio Sources

Outputs:
Generation of alarms for unexpected sources

Procedures:
The Quick Detection System (QDS) software is to detect peaks caused by point sources in the signal data from LFU and produce alerts for the program operator on those peaks that are "interesting", i.e. peaks corresponding to new sources, sources brighter than ever, or sources showing flares (fast rise in flux).

Description:
The algorithm will provide support to the scientific team running the Quick-Alarm system for the detection of flaring radio sources. It will first de-slope the rings, normalize them, average rings from different detectors, and apply a filter to remove large-scale structures from the signal. Then, it

finds all peaks in the filtered signal above a certain threshold and match the groups of detection against the database of known sources. If a detection is determined to be interesting, an alert is produced for the operator.

7.2.13 TIME SERIES ANALYSIS – MERGE CIRCLES

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
TBW

Inputs:
TOIs to be merged (see output § 7.2.4 or 7.2.21) and attitude history file

Outputs:
Input files for the sky subtraction (see input § 7.2.14)

Procedures:
The module co-adds TOIs of the SGS2 Pipeline and produces a linear combination of a given number of TOIs with specified weights.

Description:
Merge "circles" into daily or weekly streams for each detector (<400 MB).
The TOIs (eventually from the TOI archive) will be separated into Ring Sets consisting of the 60 repeated observations of a given scan circle in the 1 hour stable pointing period. For certain applications, Ring Sets will be folded to obtain Averaged Rings. Two possibilities are envisaged: the first one implies re-sampling of the data since there is not an integer number of samplings along a given scan circle and there is not a perfect overlapping of samplings of different circles within a given 1 hour observing period. The other one will make use of the natural phases of samples along a scan circle and binning them in phase.

7.2.14 R COMPUTATION AND EVALUATION OF THE KNEE FREQUENCY

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
Less than two hours.

Inputs:
TOI from MPA-DMC (see output § 7.2.4)

Outputs:
R and differentiated data into MPA-DMC

Procedures:
The SGS2 LFI Pipeline modules r_param, noise_ps, fitnoise_GT, whittle, have been implemented to compute the gain modulation factor and estimate the knee frequency of the 1/f noise.

Description:
The module r_param in the SGS2 LFI Pipeline computes the gain modulation factor R, from individual sky and load time streams. The ratio between the average sky signal and the average load signal, both affected by a certain amount of noise, provides an estimate of R. The knee frequency of the 1/f noise is obtained from the Fourier power spectrum of a given time line: the fit of this spectrum will also output the best fit of the 1/f slope and of the white noise level.
Note that this procedure and the following one (§ 7.2.15) are correlated and the final product will be the result of an iteration process between these two.

7.2.15 SKY SUBTRACTION

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
TBW

Inputs:
TOIs already merged (see output § 7.2.13)

Outputs:
Input files for the trend analysis (see input § 7.2.18)

Procedures:
Remove the 1/f noise to obtain a cleaned map. Run the map2TOD to rescan the produced map and obtain a TOD that is signal dominated. Finally run the coaddTOI to remove the signal estimation from the initial data and thus estimate the noise.

Description:
Before applying the trend analysis (see § 7.2.18), the sky signal should be subtracted.
Note that this procedure and the previous one (§ 7.2.14) are correlated and the final product will be the result of an iteration process between these two.

7.2.16 POINT SOURCES SUBTRACTION

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
TBW

Inputs:
TOIs already merged, sky already subtracted (see output § 7.2.14)

Outputs:
Input files for the trend analysis (see input § 7.2.18)

Procedures:
TBW

Description:
If a point source is present on the focal plane, the corresponding signal should be identified and subtracted before applying the trend analysis (see § 7.2.18).

7.2.17 GLITCH SUBTRACTION

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
TBW

Inputs:
TOIs already merged, sky already subtracted (see output § 7.2.14 and 7.2.16)

Outputs:
Input files for the trend analysis (see input § 7.2.18)

Procedures:
TBW

Description:
This is an ad-hoc algorithm that eventually identifies the presence of a glitch on one or more detectors on the focal plane. The glitch could increase the white noise, thus it should be subtracted in order to avoid false alarms before applying the trend analysis (see § 7.2.18).

7.2.18 TIME SERIES ANALYSIS - TRENDS, DATA QUALITY, FLAGS

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
Less than 1 hour

Inputs:
Files already merged (see output § 7.2.14, 7.2.16 and 7.2.17)

Outputs:
Data quality flags.

Procedures:
Data are automatically flagged with respect to their limits and according to their pointing non-stability

Description:
For every set of "rings" define quality flags. Alarms are also generated.

7.2.19 SYSTEMATICS AND CALIBRATION: FIRST LOOK

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
Less than 20 hours
Start in parallel with Level 1 running, when first TOIs are produced by L1: at 18:30 CET

Inputs:
TOIs produced by Level 1 (see output § 7.2.4).
In order to start to study the systematic effects, rings corresponding to one pointing period are used.

Outputs:
Calibrated TOD files to MPA DMC.

Procedures:
For each stable pointing period, the gain modulation factor R has been determined (see § 7.2.16 output).
This allows producing a differential time stream, whose residual 1/f noise component is removed through the SGS2 Pipeline destriping algorithm gdestri_xx. This cleaning process can be done whenever the residual 1/f behaves as a baseline, i.e. has a almost constant level over each ring.
The calibration constant to convert input TOIs (in Level 1 format) to antenna temperature, is determined, for each pointing period, with the parallel code calib in the same pipeline. The archive of the calibration constants is used to check the instrumental stability.

Description:
Give a first look for systematics, perform first-order calibration, cleaning, write processed "circles".
Currently foreseen steps include:

- o for each pixel, check distribution of Vpix; remove spikes + glitches;
- o evaluate noise components for each detector;
- o comparison of data relative to various coordinate systems;
- o control of gain drifts for each receiver;
- o control possible thermal drifts of reference load;
- o correlation of SCI and H/K data;
- o identification of any systematic behaviour.

7.2.20 DAILY MEETING

Context:
See Par.5.1

Responsible Person:
DPC Manager

Estimated Duration:
1 hour
The meeting start at 9 AM (TBC) hour

Inputs:
Previous and current OD DQR ready (Par. 7.2.6), next DTCP Uplink command sequence prepared (Par. **Errore. L'origine riferimento non è stata trovata.**, **Errore. L'origine riferimento non è stata trovata.**, 7.2.10, 7.2.11, **Errore. L'origine riferimento non è stata trovata.**).

Outputs:
Minutes of the Daily Meeting, send to PSO/MOC the DQR (§7.2.6) and eventually the uplink command sequence (§ **Errore. L'origine riferimento non è stata trovata.**, **Errore. L'origine riferimento non è stata trovata.**, 7.2.10, 7.2.11 and **Errore. L'origine riferimento non è stata trovata.**).

Procedures:
TBW

Description:
Organize the daily meeting to discuss the previous OD DQR (already sent to PSO), the results of DQR on current OD and the command sequence to be up-linked during next DTCP. It will be organized after the current OD DQR is ready (at about 04:30 CET in the "Mid case" of paragraph 7.4), possibly in the morning, around 09:00 CET. On Saturday the daily meeting will be organized possibly at 10 AM. No meeting is supposed to take place on Sunday.

7.2.21 READ ONE WEEK DATA

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
1 hour

Inputs:
LFI archive (see output § 7.2.15, 7.2.16, 7.2.17 and 7.2.19)

Outputs:
LFI TOD available for Level 2 analysis

Procedures:
Read the data through the MPA DMC

Description:
Read one week of LFI data from archive (35 GB).
A week is nominally starting on Wednesday but eventually it can be shifted to another week day.

7.2.22 LFI REDUCED DATA EXPORT VS HFI DPC

Context:
See Par.5.1

Responsible Person:
DPC Manager

Estimated Duration:
TBD

Inputs:
LFI reduced data in DMC format

Outputs:
LFI reduced data in EFDD format ready to be downloaded by HFI

Procedures:
Ad hoc software

Description:
Export LFI reduced data in EFDD format [RD-27] according to the ICD [RD-9].

7.2.23 COMPARISON WITH HFI: DOWNLOAD HFI REDUCED DATA

Context:
See Par.5.1

Responsible Person:
DPC Manager

Estimated Duration:
TBW

Inputs:
HFI reduced data available at HFI DPC

Outputs:
HFI reduced data at LFI DPC

Procedures:

Run FTP script to download the HFI science reduced timelines

Description:
Retrieve reduced scientific data from HFI data storage with procedures defined in the DPC-DPC ICD [RD-9].

7.2.24 COMPARISON WITH HFI: CROSS-CHECK LFI AND HFI REDUCED DATA

Context:
See Par.5.1

Responsible Person:
DPC Manager

Estimated Duration:
TBW

Inputs:
LFI (see output § 7.2.19) and HFI (see output § 7.2.23) reduced data

Outputs:
TBW

Procedures:
Run KST tool to cross-correlate HFI and LFI reduced data

Description:
Compare, e.g. verify existence of features similar to those identified on LFI data, check for possible cross-talk, etc.

7.2.25 CALIBRATION OF RADIOMETER

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
TBW

Inputs:
TOD data (see output § 7.2.21)

Outputs:
Calibrated TOD

Procedures:
The calibration procedure calib of the Level 2 Pipeline will be used on a larger amount of data, using the additional input about flagged data.

Description:
The motion of the satellite in its orbit around L2 and the Sun, introduces a modulation of the CMB dipole that will be visible in sky maps. Since the satellite velocity is known with high accuracy, the amplitude of this modulation can be known precisely and can be used as another source of data calibration. From calibrated receiver maps it will be also possible to produce a source catalogue to be compared with the one produced using calibrated TOD.
This procedure performs iterative calibration of radiometers:

- flagging of "suspicious" data from housekeeping info;
- based on instrument model and characterization;
- check for cross-talk effects;
- evaluation and removal of cooler effects;
- evaluation and removal of spikes;
- dipole fit of one-hour chunks + long range (dipole modulation).

Since the cosmic CMB dipole is always observed within a given scan period, it serves as an absolute calibrator allowing to convert data into physical units.

7.2.26 EVALUATION OF BEAM

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
For the 1st evaluation 1 month is roughly required (see Par. 7.2.29), aftterwards roughly 2 days

Inputs:
Relatively calibrated TOD (see output § 7.2.25, absolute calibration could help but it is not required at accurate level) from planet and bright source transits on each beam. Simulated beams for each beam from optical studies. On ground measured beams for each beam.

Outputs:
Calibrated TOD beam shape reconstructed in flight. Comparison of the beam shape reconstructed in flight with simulated and in-ground measured beams. Parametric description of beam shapes.

Procedures:
Parametric fit and beam mapping form TOD during planet and bright source transits.

Description:
This task is devoted to the recostruction in flight of the beam shapes, of their parametrization through appropriate functional forms (for example elliptical Gaussian shapes), and of the comparison of the in-flight reconstructed beams with optical simulation and measure results to provide optimized beam descriptions for data analysis purposes. It will be also relevant to check for a possible time dependence of the beam shape.

7.2.27 STRAYLIGHT EFFECT REMOVAL

Context:
See Par.5.1

Responsible Person:
WP Manager

Estimated Duration:
2 days

Inputs:
LFI TOD files (see output § 7.2.25), LFI maps for each and coupled surveys when available (at least one month in nominal operations for the first maps), LFI simulated full beams, LFI in-ground measured full beams. Bright point source (fixed, moving - stable, variable) catalogues.

Outputs:
Reassessment of LFI full beams; TOD and maps with straylight removal at acceptable levels.

Procedures:
Full sky convolvers (in harmonic and real space) coupled to mission simulators including the real reconstructed spacecraft attitude during the mission. Minimization tools for blind full beams assessment.

Description:
This task is devoted to the removal of the straylight effect from TOD and maps due to both diffuse and point-like components.

7.2.28 FOCAL PLANE RECONSTRUCTION

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
About 1 month for each up-dating, if agreement between LFI & HFI DPCs, otherwise proper telecons/meetings/actions have to be taken.

Inputs:
Relatively calibrated TOD (see output § 7.2.26, only very rough absolute calibration is required, albeit availability of good absolute calibration could be a good not required input), HFI data (HFI updated SIAM, see [RD-9c] TBC), Bright Point Source Catalogue

Outputs:
SIAM matrices

Procedures:
LFI send its nominal focal plane and timelines ([RD-9c]) to HFI. HFI processes it together with HFI focal plane within one week. Then HFI gives the complete focal plane assessment back to LFI for a check that takes one more week. If all is approved, the LFI- HFI combined SIAM matrix is sent to PSO by HFI.
The procedure to compare and combine the LFI/HFI/FD results to get the focal plane reconstruction is still under discussion.

Description:
The activity foresees the geometrical calibration of the focal plane. This is also linked to the production of an accurate Bright Point Source Catalogue supported as much as possible with positions taken on ground. This would be a task for HFI due to its higher angular resolution (and therefore pointing reliability) and number of expected sources.

7.2.29 ATTITUDE RECONSTRUCTION

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
TBW

Inputs:
Attitude History file,, Calibrated TOD (see output § 7.2.26), Focal Plane Reconstruction (see output § 7.2.28), HFI data

Outputs:
Pointing information into MPA DMC

Procedures:
TBW

Description:
Perform attitude reconstruction after combined analysis of HFI and LFI data, improve MOC-provided pointing.
In order to fully exploit the CMB dipole calibration, accurate pointing information is required. This is basically of two forms. On the one side some pointing parameters can be derived directly from the star tracker data such as mean spin-axis position, nutation parameters, mean spin velocity and acceleration. Therefore this can be done using H/K TM. However this would simply define some set of satellite axes with respect to the star tracker. On the other side the full pointing calibration i.e. position, scale and orientation of each individual feed horn on the focal plane with respect to these axes can only come from analysis of TOD and iterations in the process may be required.

7.2.30 MAP MAKING (TEMPERATURE)

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
The analysis will be running on a bi-weekly (or monthly TBC) basis.

Inputs:
Relatively calibrated TOD (see output § 7.2.26 and 7.2.29, albeit availability of good absolute calibration could be a good not required input during first phases of data analysis and a necessary input during the last running of the codes). Time ordered pointing information (bore sight direction for each horn). Noise covariance estimates (however, if the latter are not available, the map making code ROMA can provide self consistent noise estimates).

Outputs:
Temperature maps for each radiometer. Noise covariance estimates if required.

Procedures:
Map making will be performed with different approaches.
The first one uses the Madam code. This method is built on the destriping technique, but unlike ordinary destriping it also uses information about the noise spectrum. Although this method is non-optimal in accuracy, it is fast and stable.. The outputs are then individual detector maps, and the difference in weights to be used for optimal combination. The second approach uses the GLS map

making ROMA. The maps done by ROMA are optimal in the sense that they are minimum variance and are built taking into account exact pixel-pixel covariance. . A critical point is the construction of maps for each detector: differences between maps from detectors of the same harm of a radiometer may give hints on a possible band mismatch between them.

Description:
After the production of calibrated TOD it is possible to move to the creation of calibrated frequency maps (sorted by receiver). In order to do this, pointing information will be encoded into Time-Ordered Pixels i.e. pixel numbers in a given pixelisation scheme (HEALPix is the baseline for Planck) identifying a given pointing direction ordered in time.
On this temperature TOD a map-making algorithm will be applied to produce a receiver map. By products of the map-making are information on the detector noise properties. The instrument model will allow to check and control systematic effects, quality of the removal performed by map-making and calibration of the receiver's map. Receiver maps cleaned from systematic effects at different levels of accuracy will be stored into a calibrated maps archive. This will be populated every two days with, of course, partial maps. The calibrated receiver maps are co-added by frequency using the single maps covariance matrices. The GLS map making (ROMA) also gives information on the detector noise properties.
Methods to deal with the detailed beam shape in the map making are under investigation.
Destriping codes are able to release also TOD de-drifted by long term systematic effects (1/f noise, thermal fluctuations, periodic fluctuations).

7.2.31 MAP MAKING (POLARISATION)

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
The analysis will be running on a bi-weekly (or monthly TBC) basis.

Inputs:
Relatively calibrated TOD (see output § 7.2.26, 7.2.29 and 7.2.30, albeit availability of good absolute calibration could be a good not required input during first phases of data analysis and a necessary input during the last running of the codes). Time ordered pointing information (bore sight direction and the orientation of the linear polarization directions for each horn). Noise covariance estimates. Estimates of the level of cross polarization for each radiometer.

Outputs:
Q and U maps for each couple of paired horns, other non degenerate combination of different horns.

Procedures:

The same destriping technique of § 7.2.30 can be used for polarization maps.
Optimal GLS polarization map making is also feasible with ROMA.

Description:
The same principle of Temperature map making can be applied to polarization, provided the data model is properly modified. Both destriping and GLS map makers can deal with polarized data. Due to the lack of enough redundancy in detector orientation, it will not be possible to produce single radiometer polarization maps. Normally, at least four properly chosen (i.e., with optimal relative orientation) radiometer timelines are needed to make Q and U maps.
Methods to deal with the detailed beam shape in the map making are under investigation.

7.2.32 WEEKLY HEALTH REPORTS

Context:
See Par.5.1

Responsible Person:
DPC Manager

Estimated Duration:
Less than 3 hours

Inputs:
All Daily Quality Reports (see § 7.2.6) and eventually Error Reports of the whole preceding week, Weekly Health Report produced by LIFE

Outputs:
Final Weekly Health Report

Procedures:
LIFE module to produce the Weekly Health Report

Description:
Combine the reports generated by LIFE trend analysis and daily reports (see § 7.2.18, 7.2.6) into a Weekly Health Report (WHR) to be sent to PSO/MOC/HFI. As defined in [RD-8a], the WHR contains the instrument health status, trend and prediction information as a minimum (more items may be specified as SPPT development proceeds and the exact nature of the data required by PSO and available from the DPCs is refined) to ensure that the survey performance can be accurately planned and monitored by PSO.

7.2.33 WEEKLY MEETING

Context:

See Par. 5.1.

Responsible Person:
DPC Manager

Estimated Duration:
1 hour

Inputs:
All Daily Quality Reports (see § 7.2.6), minutes of the Daily meetings (see § 7.2.20) and eventually Error Reports of the whole preceding week, Weekly Health Report (see § 7.2.32), minutes of the last weekly meeting.

Outputs:
Minutes of the Weekly Meeting, send to PSO/MOC the WHR

Procedures:
TBW

Description:
Organize the weekly meeting on Wednesday morning at about 10 AM, after the daily meeting.

7.2.34 READ ONE MONTH DATA

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
TBW

Inputs:
LFI calibrated TOD archive. Noise covariance estimates for each radiometer.

Outputs:
LFI TOD available for Level 3 running

Procedures:
Read one month of data

Description:
Read one month of calibrated LFI TOD from TOD archive.

The month is nominally starting on the first Wednesday of each month but eventually it can be shifted to another week day.

7.2.35 PARTIAL FREQUENCY MAPS

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
TBW

Inputs:
LFI TOD (see output § 7.2.34)

Outputs:
Partial Frequency maps in MPA DMC.

Procedures:
The individual detector maps produced by Madam (§7.2.31) are added together with inverse noise weight by the procedure coadd_maps in the SGS2 Pipeline, to produce horn maps and frequency maps. The difference in weights to be used for optimal combination is also determined by the single-detector map making code.
With ROMA (GLS map making) the maps are added considering the correct pixel-pixel covariance, in addition to the noise weight.

Description:
Build partial frequency maps and compare. In order to create calibrated frequency maps (sorted by receiver), pointing information will be encoded into Time-Ordered Pixels i.e. pixel numbers in a given pixelisation scheme (HEALPix is the baseline for Planck) identifying a given pointing direction ordered in time.
Madam and ROMA allow to jointly solve for temperature and polarization (I, Q, U) maps from several timelines. In particular, the best signal to noise, (I, Q, U) map for a given frequency band can be produced by combining all the radiometric timelines available at that frequency.

7.2.36 LFI MAPS EXPORT VS HFI DPC

Context:
See Par.5.1

Responsible Person:

DPC Manager

Estimated Duration:
TBD

Inputs:
LFI maps in DMC format

Outputs:
LFI maps in EFDD format ready to be downloaded by HFI

Procedures:
Ad hoc software

Description:
Export LFI maps in EFDD format [RD-27] according to the ICD [RD-9].

7.2.37 DOWNLOAD HFI FREQUENCY MAPS

Context:
See Par.5.1

Responsible Person:
DPC Manager

Estimated Duration:
1 month

Inputs:
HFI maps/power spectra at HFI DPC

Outputs:
HFI maps/power spectra at LFI DPC

Procedures:
TBW

Description:
Download HFI maps/power spectra (at Level 3) from HFI DPC (see [RD-9b]).

7.2.38 COMPONENT SEPARATION

Context:

See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
TBW

Inputs:
LFI TOD files, LFI and HFI frequency maps

Outputs:
CMB frequency maps; diffuse foreground frequency maps (synchrotron, dust, free-free)

Procedures:
Several different algorithms (FastICA, MEM, WienerFiltering, CCA, SMICA..) have been developed with the aim of separating independent components in astrophysical maps.
As a general rule, the number of frequencies for which the sky maps are available should not be less than the number of components to be separated. For this reason, we expect to be able to separate CMB and foregrounds with LFI and HFI data. These algorithms are included in the Level 3 of the SGS2 Pipeline, and are going to be scientifically validated through end-to-end tests.

Description:
Starting from total (CMB and galactic or extragalactic foregrounds) sky maps or TOD files, both for temperature and polarization, produces maps relative to the single component. It may be necessary, in most cases, to apply masks to the sky regions where one of the emitting sources dominates over the CMB. Some algorithm is “blind” (FastICA), some other will require particular assumptions on the spectral index (or other properties) of the foreground components.

7.2.39 INTER-FREQUENCY CROSS-CHECKS ON CMB MAPS

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
About 2 months after the end of data analysis of each survey (or of both surveys) through data analysis tools working before this step. Here 2 months means "if reiteration of data analysis tools does not appear necessary after this check". If reiteration of data analysis tools are asked for, further about 2 months will be needed.

Inputs:

Absolutely calibrated LFI TOD files (see output § 7.2.26, 7.2.28, 7.2.29), absolutely calibrated LFI maps files (see output §7.2.30, 7.2.31).

Outputs:
The same as input, but with possible correction factors. Significantly up-dated absolutely calibrated LFI TOD files, absolutely calibrated LFI maps files if this work step asks for revision of input.

Procedures:
Frequency/receiver maps (possibly in a spatial dependent approach, because of foregrounds); tools for cross-checking the frequency behaviour of frequency CMB maps and of component foregrounds maps (in this case in a spatial dependent approach) derived trough component separation methods; methods for the analysis of low multipoles; methods for cross-checking of systematics, in particular of those relevant at low multipoles, an then for calibration, both in temperature & polarization.

Description:
This activity is the analogous of a pre-level 4 activity, but concerning LFI data only. The goal of this activity is:
i) to verify the consistency of the various maps produced at each frequency from the various receivers;
ii) to verify the consistency of the various frequency maps for the all LFI frequencies;
iii) to verify the consistency of the calibration (both in temperature and polarization);
iv) to verify the absence (or at a negligible level) of residual systematic effects;
v) call for further data analysis, or for revision of some steps of the data analysis cascade, if necessary;
vi) re-iteration of above points, if necessary.

7.2.40 COMPONENT MAPS ARCHIVE

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
1 week

Inputs:
LFI maps (see output § 7.2.38).

Outputs:
Same ad input, in the LFI archive.

Procedures:

TBW

Description:
Consolidation of LFI data produced during the previous steps (see par. 7.2.38 and 7.2.39) ready to be archived.

7.2.41 MERGE COMPONENT MAPS

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
About 2 weeks to 1 month TBC

Inputs:
LFI and HFI maps (see output § 7.2.40) to be merged.

Outputs:
LFI and HFI merged maps.

Procedures:
TBW

Description:
Merging of LFI and HFI maps resulting from previous steps (see par. 7.2.37 and 7.2.40).

7.2.42 COMPARISON WITH HFI: LFI/HFI OPTIMIZATION ON COMPONENT MAPS

Context:
See Par.5.1

Responsible Person:
DPC SGS2 Manager

Estimated Duration:
TBW

Inputs:
LFI and HFI component maps

Outputs:
Planck component maps

Procedures:
TBW

Description:
LFI and HFI component maps are compared and common Planck component maps are produced. Dedicated common coreteam meeting is under defnition.

7.2.43 EARLY RELEASE COMPACT SOURCE CATALOGUE

Context:
See Par.5.4.2

Responsible Person:
ERCSC Manager

Estimated Duration:
TBW

Inputs:
Calibrated TOD and frequency LFI maps (see output § 7.2.29 and 7.2.35)

Outputs:
Early Release Compact Source Catalogue (ERCSC)

Procedures:
TBW

Description:
TBW

7.3 POST-OPERATIONS

TBW

7.4 TIMELINE

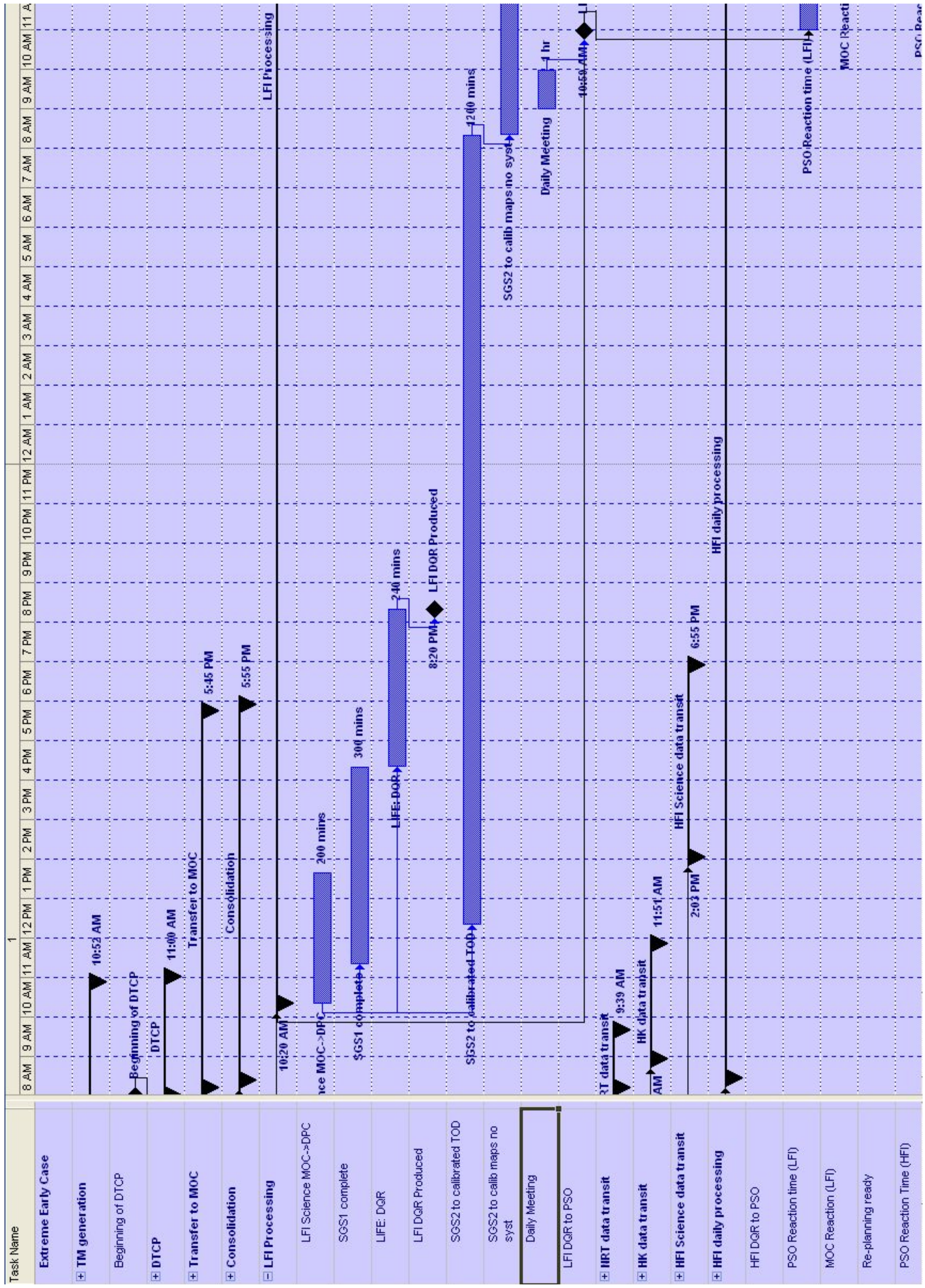
Hypothesis assumed to build the timeline for Routine Operations related to a single Operational Day (OD) are given in the table and figures below. Note that some activities are running in parallel. For what regards weekly operations, it is assumed that the first week starts on Wednesday; for monthly operations, it is assumed that the month starts the first Wednesday of the month.

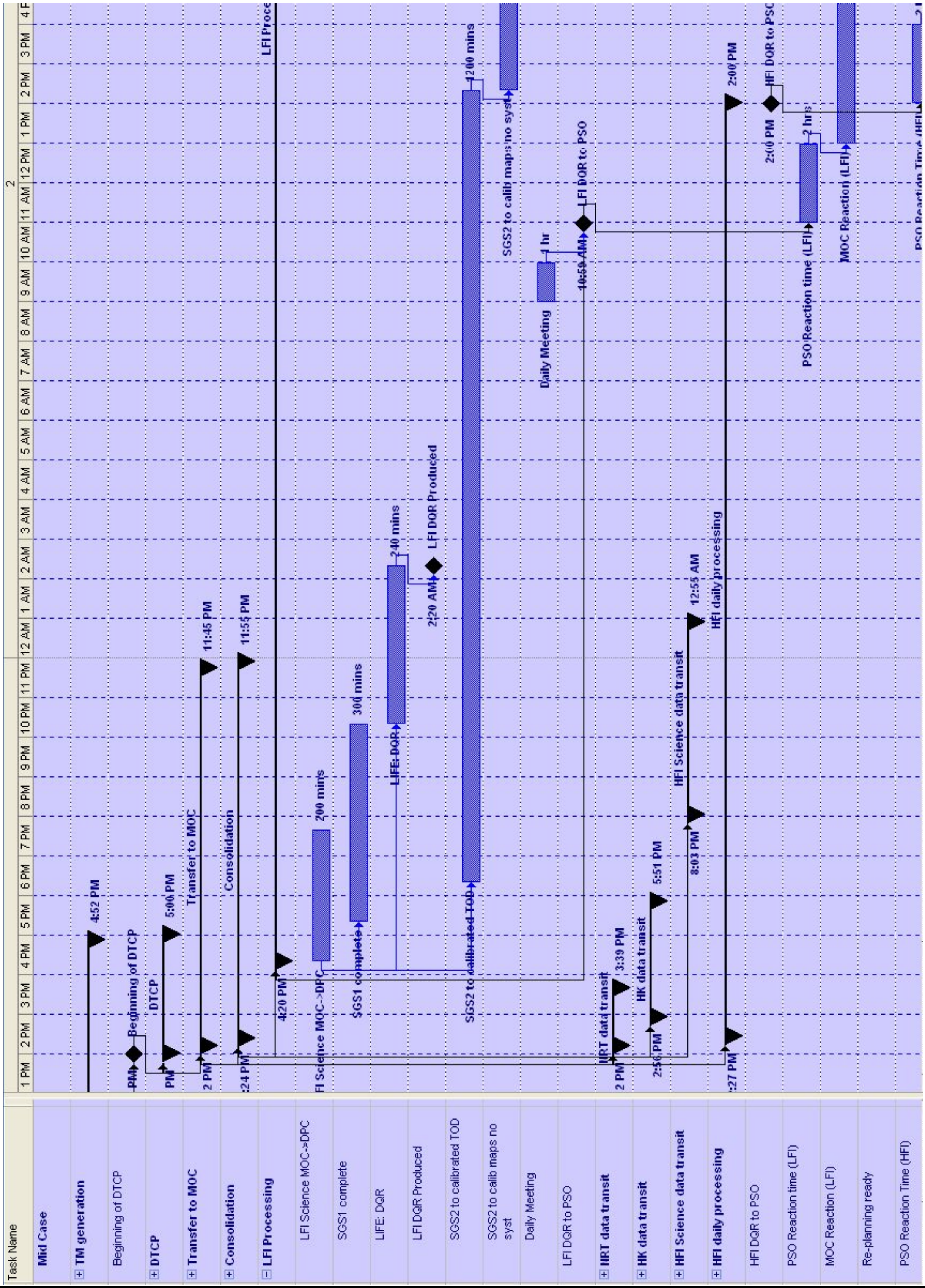
Operation	Average duration (hr)
Operational Day	24
Daily TeleCom Period	3
LFI sci data @MOC	4.2
Consolidation	2.9
LFI data @DPC	3.3
Level1 complete	5
DQR	4
Level2 to calibrated TOD	20
Level2 to calib maps no syst	26

Three different situations have been considered according to the foreseen Data Tele-Commanding Period (DTCP):

- the “Mid case”, corresponding to a DTCP starting at 14:00 CET;
- the “Extreme early” case, corresponding to a DTCP starting 6 hours before the mid case, at 08:00 CET;
- the “Extreme late” case, corresponding to a DTCP starting 6 hours after the mid case, at 20:00 CET.

The resulting timelines are shown in the figures below. Note that the nominal 8 working hours, during which DPC/IOT will be available in Trieste, are from 8:00 to 12:00 AM and from 1:00 to 5:00 PM (CET) (TBC) from Monday to Friday. On Saturday the working hours will be from 9:00 AM to 2:00 PM. On Sunday a DPC/IOT person will be on duty. See Paragraph 4.3 for a detailed description.
Note also that timelines non-dependent by LFI are indicated in black, LFI operations are in light blue.


Task Name
Extreme Early Case
TM generation
Beginning of DTCP
DTCP
Transfer to MOC
Consolidation
LFI Processing
LFI Science MOC->DPC
SGS1 complete
LIFE: DQR
LFI DQR Produced
SGS2 to calibrated TOD
SGS2 to calib maps no syst
Daily Meeting
LFI DQR to PSO
HRT data transit
HK data transit
HFI Science data transit
HFI daily processing
HFI DQR to PSO
PSO Reaction time (LFI)
MOC Reaction (LFI)
Re-planning ready
PSO Reaction Time (HFI)
10:52 AM
11:00 AM
5:45 PM
5:55 PM
10:20 AM
200 mins
300 mins
240 mins
8:20 PM
1200 mins
1 hr
10:59 AM
9:39 AM
11:51 AM
2:03 PM
6:55 PM


Task Name
Mid Case
TM generation
Beginning of DTCP
DTCP
Transfer to MOC
Consolidation
LFI Processing
LFI Science MOC->DPC
SGS1 complete
LIFE: DQR
LFI DQR Produced
SGS2 to calibrated TOD
SGS2 to calib maps no syst
Daily Meeting
LFI DQR to PSO
IRT data transit
HK data transit
HFI Science data transit
HFI daily processing
HFI DQR to PSO
PSO Reaction time (LFI)
MOC Reaction (LFI)
Re-planning ready
PSO Reaction Time (HFI)

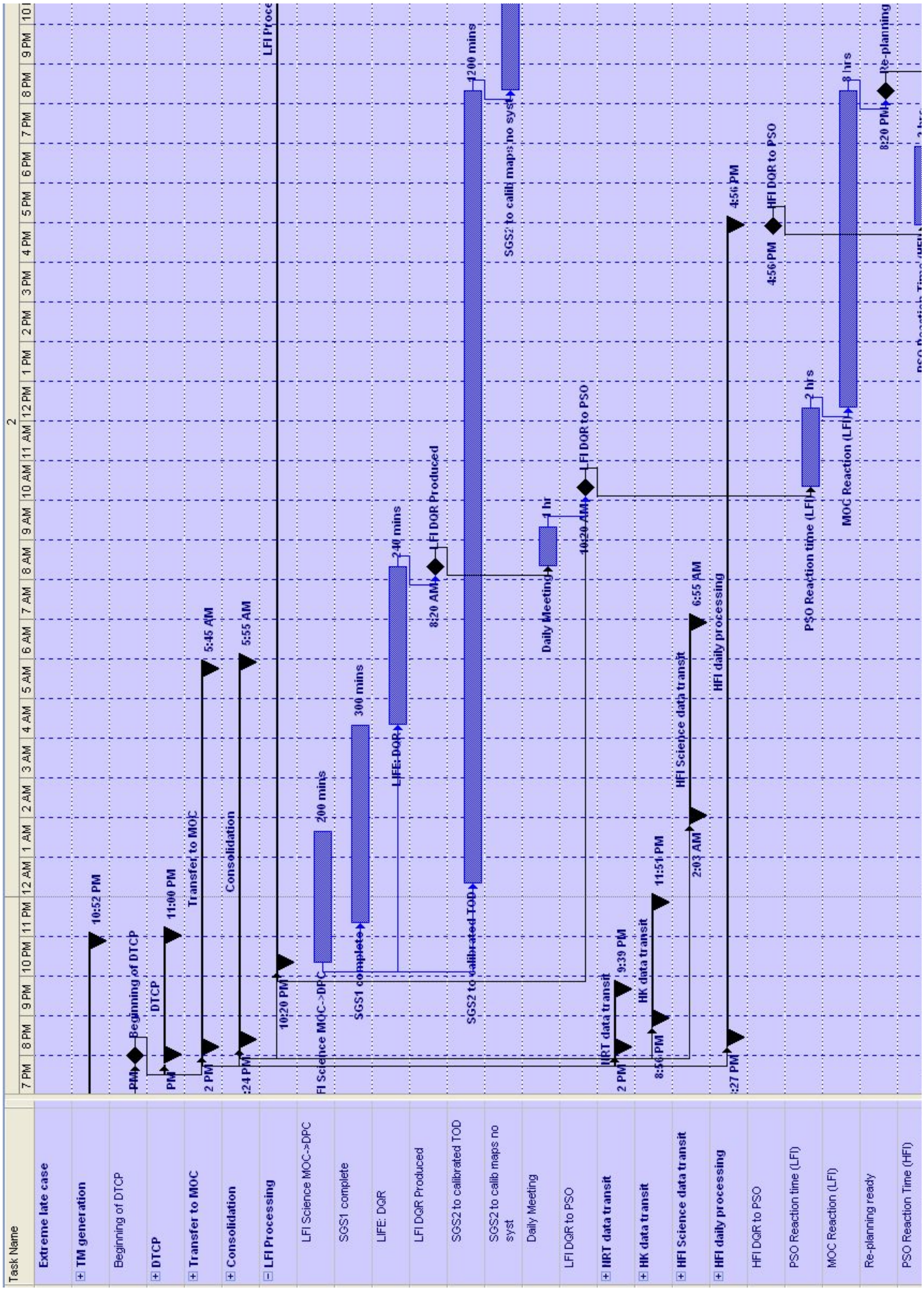

Task Name
Extreme late case
TM generation
Beginning of DTCP
DTCP
Transfer to MOC
Consolidation
LFI Processing
LFI Science MOC->DPC
SGS1 complete
LIFE: DQR
LFI DQR Produced
SGS2 to calibrated TOD
SGS2 to calib maps no syst
Daily Meeting
LFI DQR to PSO
IRT data transit
HK data transit
HFI Science data transit
HFI daily processing
HFI DQR to PSO
PSO Reaction time (LFI)
MOC Reaction (LFI)
Re-planning ready
PSO Reaction Time (HFI)

Figure 7-1 LFI DPC/IOT timelines in the three cases considered: Extremely Early (on the top), Mid case (in the middle) and Extremely Late (bottom). Note that timelines non-dependent by LFI are in black, LFI operations in light blue.

In the “Mid case”, the DQR is produced at about 02:30 CET, ready to be reviewed during the next Daily meeting at 09:00 AM and in time to be sent to MOC before the next DTCP at 14:00 CET.
In the “Extreme early” case, the DQR is produced at about 20:30 CET. The DQR will be reviewed during the next Daily meeting at 09:00 AM and sent to MOC after that.
In the “Extreme late” case, the DQR is produced at about 8:30 AM, ready to be reviewed immediately after during the next Daily meeting at 9:00 AM and well in time to be sent to MOC before the next DTCP at 20:00 CET.

From this scenario it can be concluded that the DQR will be ready to be sent to MOC before the next DTCP in the “Mid” and in the “Extreme late” cases. If no problem occurs, the DQR will be sent about 4 to 10 hours before the next DTCP to allow PSO and MOC eventually to react to it.
In the “Extreme early” case this will not be possible. In this case the limit is given by the Daily meeting that should review the report before sending it to PSO. Even trying to push the Daily meeting early in the morning, it seems difficult to produce it in time to allow PSO and MOC eventually to react to it.

Note that on Sunday the Daily Quality Report will be reviewed on the next day, after the Monday daily meeting. If no problem appears from the data processing, the DQR will be automatically sent to PSO as soon as it is generated. If necessary, a new version of the Sunday DQR will be sent to PSO after the Monday review. If a problem occurs, the DPC/IOT person on duty will be in charge of reviewing the DQR as soon as possible and he/she will send the DQR to the PSO.

Of course if a contingency or a gap seems to be present, the timeline could be somewhat different. Anyway if the problem can be understood and solved rapidly, in the “Mid” and “Extreme late” cases there is still some time to react and possibly, with some effort, this can still be the case for the “Extreme early” situation.
On the contrary if the problem requires a dedicated analysis and as a consequence more time to be understood and solved, probably it is necessary to wait at least one day before reacting to it.

In order to understand the solidity of the timelines, especially for what regards the DQR production, a number of situations which can create a delay in the release of the DQR have been analysed. It has to be pointed out that the goal is still to send the DQR to the PSO on a daily base and as soon as possible but the LFI IOT/DPC wants to avoid to send to the PSO a DQR that for any reason is not reflecting the real conditions of the instrument and eventually could trigger a false gap. A first list of these situations, changing the nominal timeline, is the following (see Paragraph 8 for a detailed description):

- Glitches or Alarms: if a glitch appears in one or more detectors, this should be removed with an ad-hoc analysis and the data should be reprocessed. If this is due to a cosmic ray, probably the glitch is restricted to a short and well defined time interval and only the corresponding chunk of data should be reprocessed (Level 1). Expected delay: TBD

- Sky subtraction: if for some reason the sky has not been subtracted correctly, the reason should be understood and the corresponding data should be re-processed again accordingly (SGS2). Expected delay: TBD
- Point sources subtraction: if a point sources has not been subtracted correctly, the reason should be understood and the corresponding data should be re-processed again accordingly (SGS2). Expected delay: TBD

Other contingency situations that can create a general delay in the timelines are the following:

- Small Gap Recovery triggered: if the quality of the data triggers a Small Gap recovery, the cause of the problem should be first understood and then solved. The time required to achieve this depends on the type of problem. Probably if this is not a trivial problem, this will create a rather long delay.
- A more general gap: if there is an instrument problem, depending on the type of problem, the DPC/IOT will react sending an ICR to PSO/MOC/HFI with an ad-hoc TC procedure to recover the LFI from it. Again the time required to take a decision about this depends on the type of problem. See also the LFI User Manual [AD-2], Paragraph 13.3.1.
- HFI comparison: if it is required to compare the LFI with the HFI data, the HFI data should be retrieved and then analysed. Expected delay: TBD

7.5 SUMMARY OF ACTIVITIES AND TASKS

The table below reports a summary of all the procedures that will be performed by the LFI DPC/IOT and the corresponding reference sheet in the document, separated for the Commissioning and CPV and Routine operations.

For Commissioning and CPV Operations:

Nr	Procedure Name	Reference §
1	REAL TIME HK DATA ANALYSIS	7.1.1
2	OFFLINE DATA ANALYSIS	7.1.2
3	CROSS-CHECK LFI AND HFI DATA	7.1.3
4	UPLINK OPERATIONS: CHECK INSTRUMENT PROCEDURE	7.1.4
5	COMMISSIONING AND CPV DAILY MEETING	7.1.5
6	CONTINGENCY REACTION: NCR AND NRB	8.2.1
7	CONTINGENCY REACTION: LFI INTERNAL MEETING	8.2.2
8	CONTINGENCY REACTION: INSTRUMENT PROCEDURE REQUESTS	8.2.3

For Routine Operations:

Nr	Procedure Name	Reference §
1	READ ONE DAY DATA	7.2.1
2	REAL TIME ASSESSMENT (RTA)	7.2.2
3	TELEMETRY QUICK LOOK (TQL)	7.2.3
4	TELEMETRY HANDLING (TMH)	7.2.4
5	LIFE SYSTEM	7.2.5
6	DAILY QUALITY REPORTS	7.2.6
7	LFI/SCS CONVERTED DATA EXPORT VS HFI DPC	7.2.7
8	COMPARISON WITH HFI: DOWNLOAD HFI CONVERTED DATA	7.2.8
9	COMPARISON WITH HFI: CROSS-CHECK LFI AND HFI CONVERTED DATA	7.2.9

10	UPLINK OPERATIONS: INSTRUMENT PROCEDURE REQUESTS	7.2.10
11	UPLINK OPERATIONS: SMALL GAP RECOVERY REQUESTS	7.2.11
12	QUICK-ALARM SYSTEM: SUPPORT TO THE SCIENTIFIC TEAM	7.2.12
13	TIME SERIES ANALYSIS – MERGE CIRCLES	7.2.13
14	R COMPUTATION AND EVALUATION OF THE KNEE FREQUENCY	7.2.14
15	SKY SUBTRACTION	7.2.15
16	POINT SOURCES SUBTRACTION	7.2.16
17	GLITCH SUBTRACTION	7.2.17
18	TIME SERIES ANALYSIS - TRENDS, DATA QUALITY, FLAGS	7.2.18
19	SYSTEMATICS AND CALIBRATION: FIRST LOOK	7.2.19
20	COMPARISON WITH HFI: DOWNLOAD HFI REDUCED DATA	7.2.23
21	COMPARISON WITH HFI: CROSS-CHECK LFI AND HFI REDUCED DATA	7.2.24
26	CALIBRATION OF RADIOMETER	7.2.25
27	EVALUATION OF BEAM	7.2.26
28	STRAYLIGHT EFFECT REMOVAL	7.2.27
29	FOCAL PLANE RECONSTRUCTION	7.2.28
30	ATTITUDE RECONSTRUCTION	7.2.29
31	MAP MAKING (TEMPERATURE)	7.2.30
32	MAP MAKING (POLARISATION)	7.2.31
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34	WEEKLY MEETING	7.2.33
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37	COMPONENT SEPARATION	7.2.36
38	DOWNLOAD HFI FREQUENCY MAPS	7.2.37
39	COMPONENT SEPARATION	7.2.38
40	INTER-FREQUENCY CROSS-CHECKS ON CMB MAPS	7.2.39
41	COMPONENT MAPS ARCHIVE	7.2.40
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43	COMPARISON WITH HFI: LFI/HFI OPTIMIZATION ON COMPONENT MAPS	7.2.42
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45	CONTINGENCY REACTION: NCR AND NRB	8.2.1
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8 CONTINGENCY OPERATIONS

TBW

8.1 CONTINGENCY OPERATIONS SHEETS

TBW

8.2 CONTINGENCY OPERATIONS PROCEDURE

8.2.1 CONTINGENCY REACTION: NCR AND NRB

Context:
See Par. 5.1.2.1 and 5.1.2.2, Par. 5.1.4 and 5.2.4

Responsible Person:
Instrument Operation Manager

Estimated Duration:
Start immediately after an anomaly occurs during a test sequence. The duration will depend on the contingency

Inputs:
Anomaly description

Outputs:
NCR raised, NRB meeting called, specialists informed, contingency solved.

Procedures:
Contact immediately specialists (by phone and via e-mail), raise an NCR, call an NRB meeting (via e-mail). The problem should be understood and then possibly solved. An LFI internal meeting or a phone conference should be organized if this would help solving the anomalous result.

Description:
In case of a failure/anomalies or unexpected results, the test sequence should be stopped, an NCR should be raised and an NRB meeting called.
IOM or a deputy, always available on call, will contact immediately specialists to analyze and solve the contingency as soon as possible.

8.2.2 CONTINGENCY REACTION: LFI INTERNAL MEETING

Context:
See Par. 5.1.2.1 and 5.1.2.2, Par. 5.1.4 and 5.2.4

Responsible Person:
Instrument Operation Manager

Estimated Duration:
Start immediately after an anomaly occurs. The duration will depend on the contingency

Inputs:
Anomaly description

Outputs:
Possibly contingency understood and solved.

Procedures:
Organize the meeting with specialists (in place or by phone).

Description:
IOM or a deputy, always available on call, contacts specialists and organize an LFI internal meeting to analyze and solve the contingency as soon as possible.

8.2.3 CONTINGENCY REACTION: INSTRUMENT PROCEDURE REQUESTS

Context:
See Par.5.2

Responsible Person:
Instrument Operation Manager

Estimated Duration:
Depending on the instrument procedure, see LFI User Manual [AD-2]

Inputs:
Request for the procedure

Outputs:
ICR ready to be sent to PSO/MOC/HFI with the telecommand procedure request

Procedures:
Write the Instrument Commanding Request

Description:
Request an instrument procedure to react as soon as possible to the contingency and afterwards, to recover from it

ANNEX A: SORPTION COOLER SYSTEM OPERATION PLAN

TITLE:

Sorption Cooler System *Operation Plan*

DOC. TYPE: Operation Plan

PROJECT REF.: PL-LFI-PST-PL-011 ANNEX I **PAGE:** 48

ISSUE/REV.: 1.0 **DATE:** July 2008

Prepared by	**G. MORGANTE** **LFI - Project System Team** **SCS – System Engineer**	Date: Signature:	
Agreed by	**C. BUTLER** **LFI - Program Manager** **A. ZACCHEI** **LFI DPC Manager**	Date: Signature:	
Approved by	**N. MANDOLESI** **LFI - Principal Investigator**	Date: Signature:	

DISTRIBUTION LIST

Recipient	Company / Institute	E-mail address
T. PASSVOGEL	ESA – Noordwijk	tpassvog@estec.esa.nl
G. CRONE	ESA – Noordwijk	Gerald.Crone@esa.int
P. OLIVIER	ESA – Noordwijk	Pierre.olivier@esa.int
J. TAUBER	ESA – Noordwijk	jtauber@rssd.esa.int
L. PEREZ CUEVAS	ESA – Noordwijk	leticia.perez.cuevas@esa.int
O. PIERSANTI	ESA – Noordwijk	Osvaldo.Piersanti@esa.int
C. DAMASIO	ESA – Noordwijk	Claudio.Damasio@esa.int
R. LAUREIJS	ESA – Noordwijk	Rlaureij@esa.int
C. WATSON	ESA – Darmstadt	Christopher.J.Watson@esa.int
M. SCHMIDT	ESOC – Darmstadt	Micha.Schmidt@esa.int
S. FOLEY	ESOC – Darmstadt	Steve.Foley@esa.int
PGSSG	Ground Segment WG	pgssg@rssd.esa.int
ICWG	Instrum. Coord. WG	icwg@rssd.esa.int
COWG	Cryo Ops WG	cowg@ rssd.esa.int
B. COLLAUDIN	AAS – Cannes	Bernard.Collaudin@thalesaleniaspace.com
J.P. CHAMBELLAND	AAS – Cannes	Jean-Philippe.Chambelland@thalesaleniaspace.com
D. PEARSON	JPL – Pasadena	David.P.Pearson@jpl.nasa.gov
U. ISRAELSSON	JPL – Pasadena	Ulf.E.Israelsson@jpl.nasa.gov
C. LAWRENCE	JPL – Pasadena	Charles.Lawrence@jpl.nasa.gov
D. SANTOS	LPSC - Grenoble	Daniel.Santos@lpsc.in2p3.fr
P. STASSI	LPSC - Grenoble	stassi@lpsc.in2p3.fr
F. MELOT	LPSC - Grenoble	frederic.melot@lpsc.in2p3.fr
C. BUTLER	IASF – Bologna	butler@iasfbo.inaf.it
A. ZACCHEI	OATS –Trieste	zacchei@oats.inaf.it
A. GREGORIO	UniTS – Trieste	anna.gregorio@ts.infn.it
L. TERENZI	IASF – Bologna	terenzi@iasfbo.inaf.it
N. MANDOLESI	IASF/CNR – Bologna	reno@iasfbo.inaf.it
C. BUTLER	IASF/CNR – Bologna	butler@iasfbo.inaf.it
M. BERSANELLI	UNIMI – Milano	marco.bersanelli@mi.infn.it
LFI System PCC	IASF – Bologna	lfispcc@iasfo.inaf.it

CHANGE RECORD

Issue	Date	Sheet	Description of Change
0.1	25/09/2006	All	First draft of document
0.3	30/10/2006	Ch 2,3	Review of Chapter 2 and 3
0.5	20/12/2006	All	General integration and revision
1.0	08/07/2008	All	Chapters 4, 5, 6, 7 update and general revision

TABLE OF CONTENTS

1. SCOPE

This document, Annex to the LFI Operation Plan PL-LFI-PST-PL-011 [RD-1], describes the in-flight planned operations for the Planck Sorption Cooler System (SCS) as defined in the Science Operations Implementation Plan [RD-2] and in the DPC Operations Scenario [RD-3]. Sorption Cooler operations will be under the responsibility of the SCS Instrument Operations Team (SCS IOT), located at the LFI DPC (Data Processing Centre) site, where Level 1 is run, with the support of the DPC team and of a number of specialists distributed geographically.

Three main statements identify the SCS operation environment (see Chapter 5):

1. The SCS operational main task is to provide the most efficient and stable temperature reference to the HFI and LFI.

2. For all data analysis purposes SCS TM is considered HK.

3. All SCS activities at LFI DPC are part of the Level 1 only

LIST of ACRONYMS

ABCL	As-Built Configuration List
ACK	Acknowledgement
ACMS	Attitude Control Management System
AD	Applicable Document
AIV	Assembly, Integration and Verification
ASI	Agenzia Spaziale Italiana (Italian Space Agency)
ASPI	Alcatel SPace Industry
ASW	Application SoftWare
AVM	Avionics Verification Model
AWG	ESA's Astronomical Working Group
BBM	(DPC software) Bread-Board Model
BEM	Back End Module (LFI)
BEU	Back End Unit (LFI)
BIN, bin	Binary
BOL	Begin of Life
CC	Change Control
CCB	Configuration Control Board
CCE	Central Check-out Equipment
CCS	Central Check-out System
CDMS	Command and Data Management Subsystem
CDMU	Central Data Management Unit
CFRP	Carbon Fiber Reinforced Plastic
CIDL	Configuration Item Data List
CoG	Centre of Gravity
CQM	Cryogenic Qualification Model
CRC	Cyclic Redundancy Check
CS	Conducted Susceptibility
CSL	Centre Spatial de Liege
CTE	Coefficient of thermal expansion
CTR	Central Time Reference
DAE	Data Acquisition Electronics (LFI)
DC	Direct Current
DDID	Data Distribution Interface Document
DDS	Data Distribution System
DEC, dec.	Decimal
DFE	Data Front End
DM	(DPC software) Development Model
DMS	Documentation Management System
DPC	Data Processing Centre
DPU	(Data (or Digital) processing Unit
DRS	Data Reduction Software
DS	Data Server
DTCP	Daily Telecommunication Period
ECR	Engineering Change Request
EE	End to End test

EEPROM	Electrically Erasable PROM
EGSE	Electrical Ground Support Equipment
EM	Engineering Model
EMC	Electro-Magnetic Compatibility
EMI	Electro-Magnetic Interference
EOL	End of Life
EPS	Electrical Power Subsystem
EQM	Engineering-Qualification Model
ESA	European Space Agency
ESD	Electro Static Discharge
ESOC	European Space Operations Centre
ESTEC	European Space Technology and Research Centre
FCS	Flight Control System
FCU	Focal Plane Control Unit (SPIRE)
FDIR	Failure Detection, Isolation and Recovery
FEM	Front End Module (LFI)
FEU	Front End Unit (LFI)
FID	Function Identifier
FM	Flight Model
FMECA	Failure-Modes, Effects and Criticality Analysis
FOP	Flight Operations Plan
FOV	Field Of View
FPA	Focal Plane Assembly
FPS	Focal Plane structure
FPU	Focal Plane Unit
FS	Flight Spare
FTS	File Transfer System
GS	Ground Segment
H/W	Hardware
HEX, hex.	Hexadecimal
HFI	High Frequency Instrument (Planck)
HK	House Keeping (data)
HPFTS	Herschel-Planck File Transfer System
HPLM	Herschel Payload Module
IAP	Institut d'AstroPhysique
IAS	Institut d'Astrophysique Spatiale
ICD	Interface Control Document
ICS	Instrument Commands Sequence
ICWG	Instrument Coordination Working Group
ID	Identifier
IDT	Instrument Development Team
IID	Instrument Interface Document
IID-B	Instrument Interface Document - part B
ILT	Instrument Level Test
IMT	Integrated Module Tests
IOM	Instrument Operations Manager
IOT	Instrument Operations Team
IRD	Interface Requirements Document
IST	Integrated System Test
ITT	Integration and Test Team

JPL	Jet Propulsion Laboratory
JT	Joule Thompson
kbps	kilobits per second
LCL	Latch Current Limiter
LEOP	Launch and Early Operations Phase
LFI	Low Frequency Instrument (Planck)
LGA	Low Gain Antenna
LL	Low Limit
LPSC	Laboratoire Physic Subatomic et Cosmologie
LSB	Least Significant Bit
LVHX	Liquid-Vapour Heat eXchanger
Mbps	Megabits per second
MCC	Mission Control Centre
MGSE	Mechanical Ground Support Equipment
MIB	Mission Information Base (database)
MLI	Multilayer Insulation
MOC	Mission Operations Centre
MoI	Moment of Inertia
MOS	Margin Of Safety
MPS	Mission Planning System
MSB	Most Significant Bit
MTL	Mission Time Line
N/A, n.a.	Not Applicable
NaN	Not a Number
NCR	Non Conformance Report
NRT	Near-Real-Time
OATs	Osservatorio Astronomico di Trieste
OBCP	On-Board Control Procedure
OBSM	On-Board Software Maintenance
OD	Operational Day
OIRD	Operations Interface Requirements Document
OM	(DPC software) Operations Model
OOL	Out-of-Limits
PA	Product Assurance
PC	Pre-Cooler
PCDU	Power Control & Distribution Unit
PCS	Power Control Subsystem
PEC	Packet Error Control
PFM	Proto Flight Model
PGSSG	Planck Ground Segment System Group
PID	Parameter Identifier
PLFEU	Planck LFI Front End Unit (FEU)
PLM	Payload Module
PM	Project Manager
PPLM	Planck Payload Module
PR	Primary Reflector
PROM	Programmable Read Only Memory
PS	Project Scientist
PSO	Planck Science Office
PSS	Procedures, Specifications and Standards

PSVM	Planck Service Module
PV	Performance Verification
QA	Quality Assurance
QLA	Quick Look Analysis (software)
RAM	Random Access Memory
RD	Reference Document
RF	Radio Frequency
RFW	Request for Waiver
RLA	Register Load Address
ROM	Read Only Memory
RT	Real Time
RTA	Real-Time Analysis
RTU	Remote Terminal Unit
S/C	Spacecraft
S/W	Software
SAA	Solar Aspect Angle
SC	SpaceCraft
SCC	Sorption Cooler Compressor
SCCE	Sorption Cooler Cold End
SCE	Sorption Cooler Electronics
SCOE	Special Check Out Equipment
SCOS	Spacecraft Control and Operations System
SCP	Sorption Cooler Pipes
SCS	Sorption Cooler Subsystem (Planck)
SDE	Software Development Environment
SDU	Service Data Unit
SFT	Short Functional Test
SID	Structure Identifier
SLE	Standard Laboratory Equipment
SPACON	SPAcecraft CONtroller
SPR	Software Problem Report
SR	Secondary Reflector
SSMM	Solid State Mass Memory
SS	Stainless Steel
ST	Science Team
STM	Structural/Thermal Model
STMM	Simplified Thermal Model
SVM	SerVice Module
SVT	System Validation Test
TA	Telescope Assembly
TBC	To Be Confirmed
TBD	To Be Defined
TBS	To Be Specified
TBW	To Be Written
TC	TeleCommand
TCE	Telecommand Encoder
TCS	Thermal Control System
TID	Task Identifier
TM	Telemetry
TMM	Thermal Mathematical Model

TMP	Telemetry Processor
TMU	Thermo Mechanical Unit (Sorption cooler)
TOD	Time-Ordered Data
TOI	Time-Ordered Information
TQL	Telemetry Quick-Look
UM	User's Manual
URD	Users Requirements Document
UTC	Universal Time Coordinate(d)
VG	V-Groove radiator
WU	Warm Units

2. APPLICABLE & REFERENCED DOCUMENTS

2.1.1. Applicable Documents

Ref.	Doc. Ref. Nr.	Issue/ Rev	Document Title
AD-01	PT-IID-A-04624	4.0	CREMA
AD-02	PT-LFI-04142	2.1	FIRST/PLANCK INSTRUMENT INTERFACE DOCUMENT – PART B
AD-03	PL-LFI-PST-ID-002	3.1	Planck Sorption Cooler ICD
AD-04	ES518265	B1	TMU Specification Document
AD-05	PL-MA-CRS-0036	2.0	Planck Sorption Cooler Electronics User Manual
AD-06	Planck/PSO/2007-017	1.0	Planck Cryo Chain Operations
AD-07	PL-LFI-OAT-PL-001	1.5	Science Operations Implementation Plan

2.1.2. Referenced Documents

Ref.	Doc. Reference Nr	Issue/Rev	Document Title
RD-01	PL-LFI-PST-PL-011	2.1	Planck LFI Operation Plan
RD-02	PL-LFI-PST-MA-002	1.0	Planck SCS User Manual
RD-03	PL-LFI-OAT-SP-005	1.0	LFI DPC HW Design & Implementation Plan
RD-04	PL-LFI-OAT-IC-001		ICD_030 DPC-DPC Timelines Exchange
RD-05	PGS-ICD-025		DPC-PSO: Instrument Health Reports

3. SYSTEM OVERVIEW

3.1. The Planck Sorption Cooler System

The Planck Sorption Cooler System (SCS) is a closed-cycle continuous cryocooler designed to provide >1 Watt of heat lift at a temperature of <20K using isenthalpic expansion of hydrogen through a Joule-Thompson valve (J-T). Some of this heat lift will be provided to cool the Low-Frequency Instrument (LFI) onboard the Planck spacecraft. The remaining heat lift will be used as a pre-cooling stage for two further cryogenic refrigerators (He J-T cooler to 4K; Dilution cooler to 0.1K) that will in turn maintain the High-Frequency Instrument (HFI) at 100mK.

The sorption cooler performs a simple thermodynamic cycle based on hydrogen compression, gas pre-cooling by three passive radiators, further cooling due to the heat recovery by the cold low pressure gas stream, expansion through a J-T expansion valve and evaporation at the cold stage. A schematic of the Planck Sorption Cooler System (SCS) is shown in Fig. 3-1.

The Sorption Cooler System is composed of the Thermo-Mechanical Unit (TMU), the Sorption Cooler Electronics (SCE) and the internal harness.

The TMU is the closed fluid circuit that, circulating H_2, produces the required cooling. It is composed by the Sorption Cooler Compressor (SCC) and the Piping and Cold End (PACE) that can be split into two subsections, the Piping (SCP) and the Cold End (SCCE): a schematic of the TMU is shown in Fig. 3-1. The TMU also includes all the sensors and heaters needed for control and monitoring.
The SCE is the hardware/software system that allows TMU operation, control and monitoring. It is the “interface” between the TMU and the Operator.

Two complete SC Systems (TMU + SCE, Nominal and Redundant) are present onboard the Spacecraft in order to provide full redundancy during the 18-month mission. For the purposes of the SCS Operation Plan they can be considered practically identical. All the information, procedures and operations described in this Manual apply equally to both Units unless specifically mentioned.

The SCC and PACE in each of the nominal and redundant coolers forms an all-welded, principally stainless steel assembly of fluid loop components which, with associated permanently installed wiring and adapter brackets, is handled and installed as a single, non-separable unit.

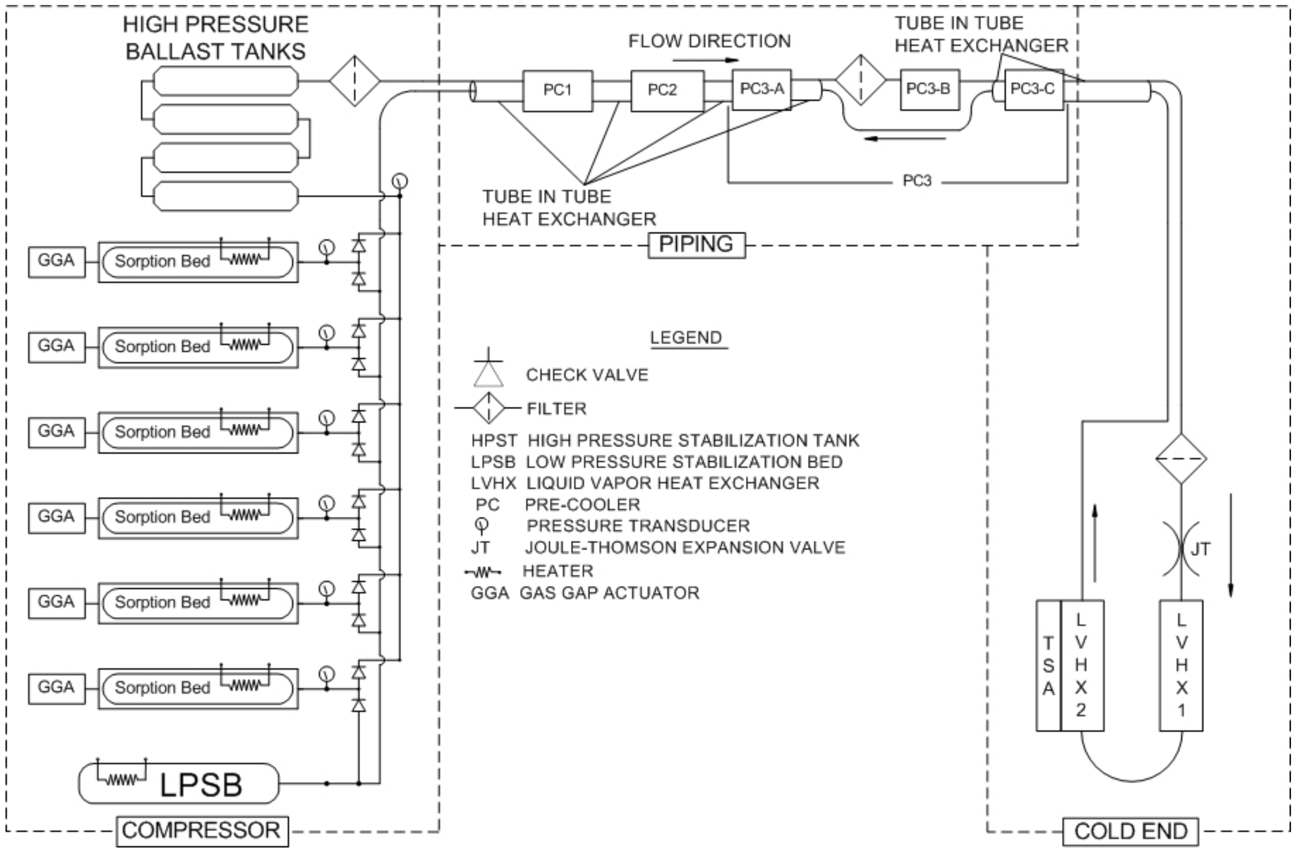

Figure 3-1 TMU schematic

3.1.1. THE SORPTION COOLER COMPRESSOR (SCC)

- Stores the H_2 gas
- Generates the high-pressure gas to be expanded in the Cold End
- Absorbs the returning low-pressure gas
- Stabilizes P fluctuations in both gas lines

3.1.2. THE SORPTION COOLER PACE

- Conveys hydrogen gas to and from the cold end
- Pre-cools the H_2 by tube-in-tube heat exchangers and thermal contact with passive radiators
- Expands the gas to form liquid
- Stores the liquid in reservoirs to provide a T reference for the Instruments
- Stabilizes by an active controller the T at the LFI I/F

3.1.3. THE SORPTION COOLER ELECTRONICS (SCE)

- Controls the TMU by
  - switching control for the sorption bed heaters
  - switching control to the heat switches
  - timing signals for the switching
  - controlling of power to the compressor elements in the "desorbing" state
  - controlling the T of the Temperature Stabilization Assembly (TSA) in the PACE.
- Detect abnormal situations and react
- Read temperature, voltage and intensity sensors from sorption cooler electronic.
- Receive commands from CDMU sent by users from ground
- Send housekeeping data to CDMU that will be transmitted to ground by telemetry.

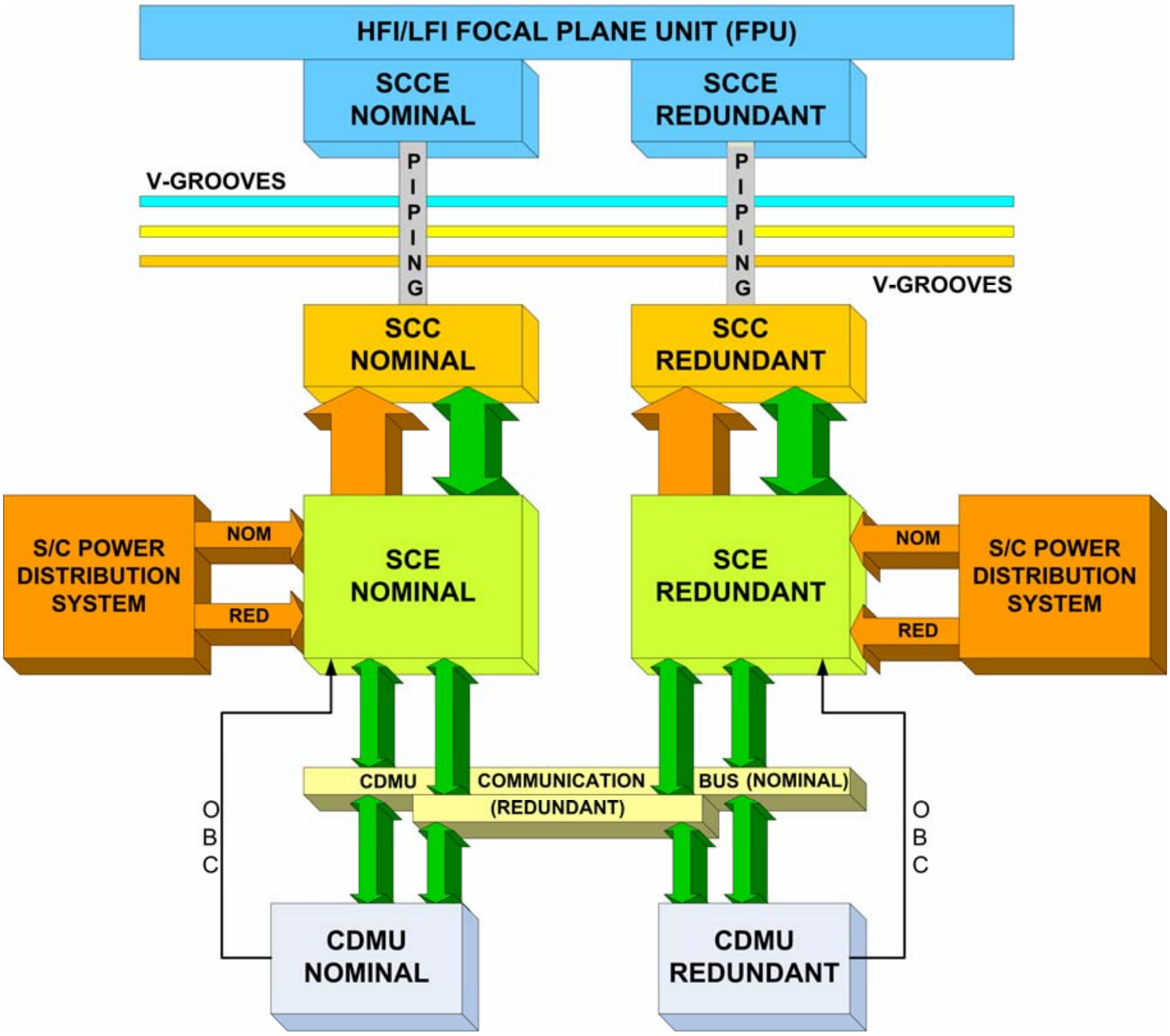

Figure 3-2 Planck SCS (TMU+SCE) Block Diagram

Data are received, processed and released to the S/C through the CDMS buses (Nominal and Redundant). The interface with the spacecraft will be able to handle a baseline data rate of 2 kbit/s and will be compliant with the MIL-STD-1553B standard, with the SCE acting as a remote terminal and the CDMS as the bus controller.

3.2. SCS OPERATION MODES

Figure 3-3 illustrates the whole diagram of the SCS Operation Modes and the possible transitions between them.

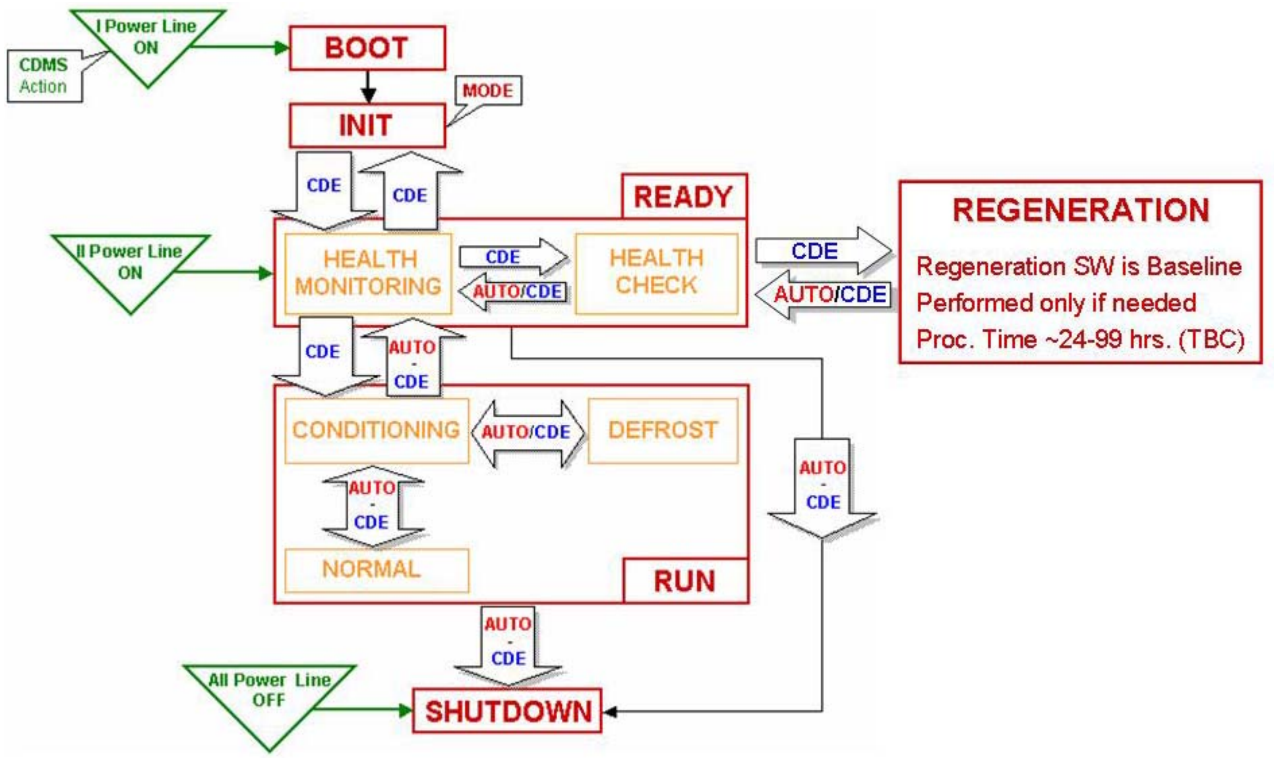

Figure 3-3 Cooler Operations Diagram

The table below shows the ***status*** of the Sorption Cooler Subsystem units in the main modes of operation. Details of each Mode are listed in Table 3-2.

Unit	Launch or OFF	Boot	Init	Ready		Run			Shutdown
				Health Monitoring	Health Check	Start-up	Defrost	Normal	
TMU	OFF	OFF	OFF	ON	ON	ON	ON	ON	OFF
SCE	OFF	ON	ON	ON	ON	ON	ON	ON	ON
HK	NO	YES	YES	YES	YES	YES	YES	YES	YES

Table 3-1 Status of SCS subsystems in Op Modes

Notes:

1) *ON= Operational;*
2) *OFF= Inactive;*
3) *Reminder: There is no mode of operation in which units of both the Nominal and Redundant Sorption Cooler Subsystem operates simultaneously*.

MODES	STATES	OPERATIONS	COMMANDS
OFF	**OFF**	None: System can be handled and transported safely	
BOOT		Perform system boot up	ARE YOU ALIVE
		Initialize 1553	GOTO BOOT
		Acquire CDMS Command/Telemetry clock and timing signal	GOTO INIT
		Check PROM, RAM and EPROM	MEMORY UPLOAD
		Transfer Program from EPROM to RAM	MEMORY DUMP
		Check Software Transfer	
		One housekeeping at the end (Electronics and Software parameters)	
INIT		Soft reboot of the System	ARE YOU ALIVE
		Re-initialize 1553	GOTO INIT
		Housekeeping (Electronics and Software parameters)	GOTO READY
			SET INITIAL CE STATE
			MEMORY UPLOAD
			MEMORY DUMP
READY	**Health Monitoring**	The 2nd power line is requested from the CDMS	ARE YOU ALIVE
		Health Monitoring is automatically performed when enters READY Mode	GOTO INIT
		Check if P and T sensors are correct. Bad sensors are removed from Health Check	GOTO READY
	Healthcheck	Check Compressor Assembly and Cold End by performing actions	GOTO SHUTDOWN
	Regeneration	Bed hydrides are heated up to high temperature to restore the ab/de-sorbing capacity	GOTO HEALTHCHECK
			GOTO REGENERATION
			SET INITIAL CE STATE
			MEMORY UPLOAD
			MEMORY DUMP

RUN	Conditioning	Executed each time the cooler is starting up or is trying to solve some faults before transitioning to Normal State	GOTO READY
		Jump to this State automatically when enters in RUN Mode	GOTO RUN
		Able to run with 6, 5 and 4 beds	GOTO SHUTDOWN
	Defrost	JT and Particle Filter heaters ON for a certain time or until a certain T	MEMORY UPLOAD
		If necessary Defrost is launched automatically from Conditioning	MEMORY DUMP
	Normal Operations	Normal Ops. Beds are powered following the defined sequence	
		Initiation of Normal Ops State is allowed only after one cycle into Conditioning State is completed	
		Each State of the RUN Mode is operated for an integer number of cycle ≥ 1. Fractional cycles are precluded ecept for critical emergency response. Can exit during mid-cycle to Conditioning State	
		Able to run with 6, 5 and 4 beds	
		LR3 PID + OPEN LOOP regulation every second (1Hz)	
SHUTDOWN		READY-like Mode with GGA OFF, bed heaters OFF, LR3 OFF, etc.	
		Cooling is stopped, cooler's return to ambient conditions is monitored via housekeeping data	
		When P's return to ambient limits, the CDMS is requested to remove the 2nd Power Line	
		When T's return to ambient limits, the CDMS is requested to remove 1st Power Line	
		Receive/Acknowledge software/values patching instructions (lookup table, etc.)	
		Control and Monitor heated beds cool-down	
		Monitor System and Report Alarm/Fault Conditions	
		High data rate housekeeping	
		System Monitoring executed for TBD min. After SHUTDOWN	
		End of SHUTDOWN Mode corresponds to READY Mode with Power Lines OFF	

Table 3-2 SCS Op Modes processes and actions list

4. OPERATION PROCESSES

4.1. INFRASTRUCTURE

4.1.1. SOFTWARE

4.1.1.1. Data transfer (Between DPC's and to PSO)

File transfer format and protocol for SCS activities fully complies with the LFI DPC patterns.

SCS Daily Quality Report and Weekly Health Reports (DQR and WHR) data file transfers will be ASCII format using the FTP-based Herschel-Planck File Transfer System (HPFTS).

Data file transfers between the two DPC's will be based on FITS format, with predefined keyword as defined in [RD–14] Planck IDIS DMC Exchange Format Design Document and according to the procedures defined in [RD-05] ICD38.

4.1.1.2. DPC SOFTWARE

SCS software is part of LFI DPC Level 1 only and is implemented on Linux platform. SCS HK processing is required for system health and performance evaluation. Data analysis information are made available to the instruments for scientific data reduction (Level 2 and 3) and to PSO. SCS Level 1 activities are also required to use HKTM for trend analysis.

4.1.1.3. INSTRUMENT WORKSTATIONS AT MOC (IW@MOC)

MOC will feed housekeeping TM data to the SCS IW@MOC for Real-Time Analysis (RTA) and Quick Look Assessment (QLA). Basically, the IW@MOC provides a dedicated instrument telemetry processing environment greatly enhancing the capabilities of the SCOS-2K. This platform will basically be running a simplified version of the DPC Level 1 software. It will not provide any commanding capability.

The SCS IW@MOC is assumed to be remotely accessible from LFI DPC through network connection, fulfilling all security constraints set by ESOC. During commissioning the SCS IOT operating the IW@MOC will be the reference for all cooler operations. From CPV Phase throughout the mission except for contingency situations, this function will be sustained by the SCS IOT at the LFI DPC, where a SCS dedicated workstation will be resident. The SCS IW located at MOC will be retained for the whole duration of the mission.

No maintenance activities will be required by MOC personnel except for basic functioning of the machine (reboot, etc).

4.1.1.4. ARCHIVE

SCS TM storage is implemented in the following archives:

- Raw Telemetry Archive
- Unscrambled Telemetry Archive
- Calibrated TOI Archive

4.1.2. HARDWARE

The SCS hardware at the DPC will be based on the same kind of LFI Intel based PC's.

4.1.3. INTERFACES

The interfaces between the LFI DPC and MOC, PSO and the HFI DPC are described in details in dedicated ICD documents and are summarized in Chapter 4 of the LFI Operation Plan [RD-1].

4.2. MANAGEMENT

The LFI management structure is shown in the LFI Operation Plan [RD-1].

The SCS IOT is a section of the LFI Operation Team, located at the LFI DPC. The SCS Operation Manager (OM) is responsible for all related SCS activities and operations. SCS OM interfaces to HFI DPC, MOC and PSO through the LFI OM.

4.3. STAFFING

During Commissioning and CPV phases, part of SCS IOT staff will be located at the MOC, with LFI DPC assistance, 7 days/week to support real-time interaction with the spacecraft. At the same time, SCS personnel at the LFI DPC will be staffed 12 hours/day, 7 days/week, working shifts. In addition, telephonic availability of qualified personnel in case of contingencies will be required.

During Normal Operations the SCS IOT will be staffed 6 days/week, 8 hours/day, 5 hours on Saturdays. Telephonic availability of qualified personnel will be required for 12 hours/day and 7 days/week for the whole duration of Planck operations. The SCS IOM (or deputy), the single contact point, will be available 24 hours/day throughout the mission in case of contingency need by MOC concerning SCS operation.

During Post-operations only a reduced SCS IOT will be present at the LFI DPC, staffed 8 hours/day, 5 days/week.

4.4. CONTACT INFORMATION

SCS operations require continuous interaction with other Planck Scientific Ground Segment units (MOC, PSO and the HFI DPC/IOT).

The basic concepts for SCS activities interfaces are:

► A single contact point, the SCS IOM, will be the reference for all SCS related issues, through the LFI IOM, for LFI DPC, HFI DPC, MOC and PSO.

► Interaction processes are defined and regulated in the dedicated ICD's

5. OPERATIONS CONTEXT

The SCS main operational task is to provide a stable temperature reference to the HFI and LFI throughout the mission, operating the cooler in a safe state while ensuring optimized performance.

For all data analysis purposes SCS TM is considered HK.

All SCS activities at LFI DPC are part of the Level 1 only (see Figure 5.1).

In general, the SCS IOT supports the LFI IOT and DPC for all SCS related issues and is responsible for:

- SCS operations definition
- SCS operating procedures implementation
- Daily analysis of SCS health
- Daily analysis of SCS performance
- Strategy for SCS performance optimisation
- Software maintenance and update
- Support to the MOC for SCS related issues
- Support to LFI (and HFI) DPC for SCS data analysis
- Release of DQR and WHR

All the above mentioned activities are carried on in collaboration with the LFI IOT and DPC and have to be agreed with or reported to the HFI DPC, MOC and PSO. In particular, SCS operating procedures have to be agreed by the HFI DPC and PSO since they might have an impact on hardware and scientific data.
As part of the LFI DPC, the SCS IOT fulfils all the requirements defined in the in the Planck SIRD when they apply, following the processes described in the LFI Science Operations Implementation Plan (SIP) [AD-9].

SCS Level 1 product will be the cooler parameters TOD. These will be made available for next levels of scientific data analysis or simulations activities. Considerable amount of feedback between all parties involved will be required.

A cross-check with LFI and HFI HK data will be necessary in order to improve confidence on analysis results. SCS and 4K cooler data will be exchanged daily between the two DPC's [RD-04] and [RD-05]; availability of LFI and HFI thermal sensors HK will be required.

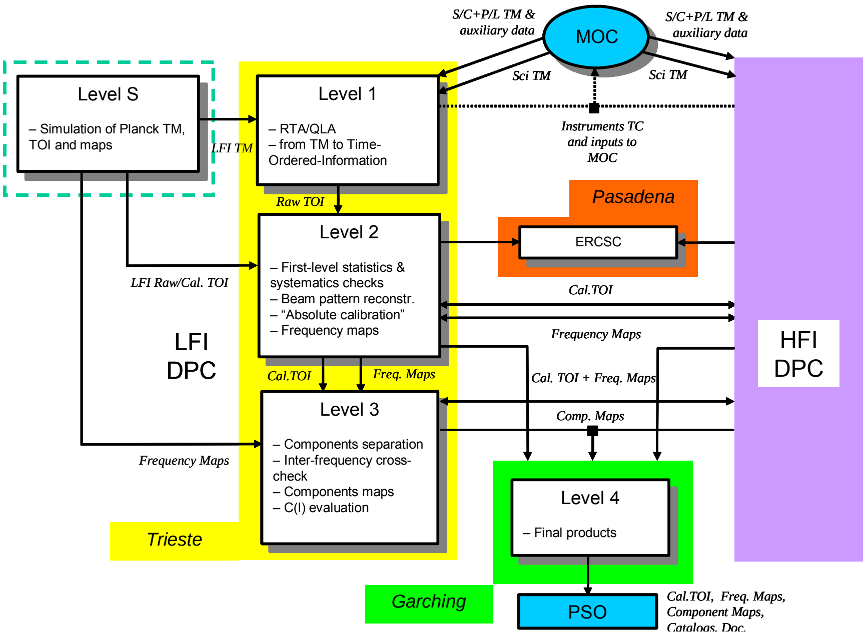

Figure 5-1 Layout of the LFI DPC.

5.1. DATA PROCESSING AND MONITORING

5.1.1. ROUTINE ACTIVITIES

In this paragraph, SCS routine activities are summarized. For their integration with the LFI DPC general activities see the LFI Operation Plan [RD-1]. Scenarios make reference to the DPC data processing design and to the software subsystems described in the LFI DPC Data Processing Document [RD-6].

For what concerns the data processing and monitoring, SCS Routine Activities include:

- Monitoring of SCS telemetry to verify cooler health on a daily basis, including the Level 1 activities (see Figure 5-2). This task is under SCS IOT responsibility with support by the LFI DPC Operations staff
- Monitoring of SCS TM to evaluate cooler performances
- Assessment of performance trend in order to prepare or consolidate operational scenarios (this activity will be carried out on a several weeks/months timescale)

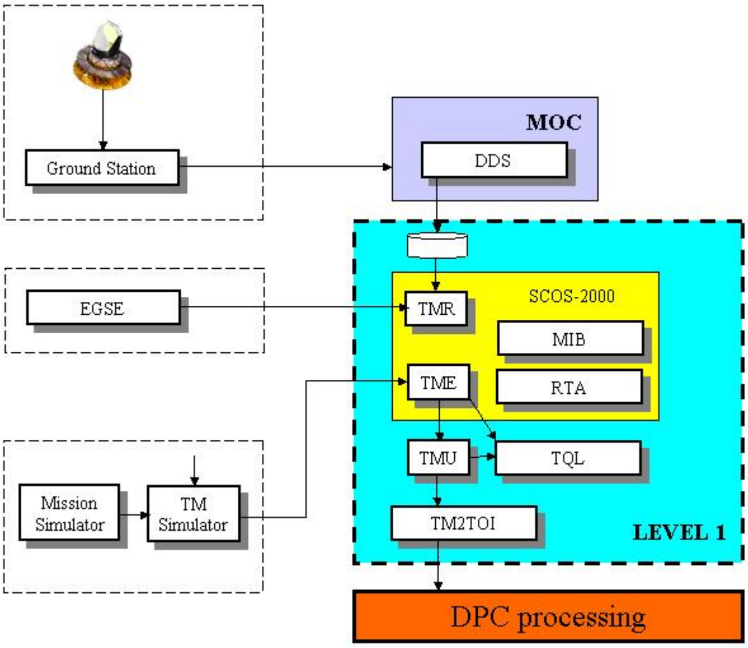

Figure 5-2 Planck LFI Level 1 Data and Software Flow Scheme

5.1.2. COMMISSIONING AND CPV OPERATIONS

During Commissioning and CPV phases the SCS IOT will be partially located at MOC.
SCS Commissioning is aimed to prepare the system for start-up while CPV task is to take the cooler down to operating temperature and into Nominal and steady state operations.
From the SCS point of view, CPV phase activities after cooldown are not different from routine operations. Only difference might be the higher frequency of tuning steps required to take the cooler in Nominal Mode.

5.1.2.1. COMMISSIONING OPERATIONS

Commissioning of the SCS consist of system switch-on (power lines activation) and the verification of its health by the “HealthCheck” procedure. This process can be done at any time during the mission and in any thermal conditions (warm or cryo). The successful completion of the procedure insures that the system is in good health and ready to be started as soon as the required boundary thermal conditions are reached. The procedure is fully automatic and its parameters are defined in the LUT. The HK TM to be processed is exactly the same of system monitoring in nominal operations. A detailed description of SCS Healthcheck procedure can be found in the SCS UM [RD-2].
SCS Commissioning Operations end at the beginning of cooler cooldown, when its CPV phase starts.

5.1.2.2. CPV OPERATIONS

The CPV Phase is dedicated to the calibration and verification of the instruments, so the SCS operations in this phase are dedicated to cooler start-up and tuning to lead it into the best stable conditions needed for instruments verification. During this phase, extended monitoring of the

system might be required and HK data should be processed in quasi real time to rapidly converge to stable conditions.
Basically, for what concerns the SCS, CPV operations do not differ from Routine operations: with the exception of few, dedicated tests performed at the beginning of the phase, the cooler will be tuned and run in the same operative envelope of the Nominal phase of the mission.

5.1.3. CONTINGENCY ACTIVITIES

In case of contingencies occurrence, as in Routine operations, the system is robust enough to react with the proper response according to the severity of the discrepancy: this automatic action can go from a simple red flag raised to the operator to a system shutdown in case safety limits are passed.
The event of such occurrence will be notified in TM and proper action will be requested from ground after cooler autonomous reaction.
For a complete description of SCS failure analysis, see Chapter 7 of SCS User Manual [RD-2].

5.1.4. NON-ROUTINE ACTIVITIES

Non-routine operations include:

- SCS switchover
- SCS regeneration

5.2. INSTRUMENT TELE-COMMANDING

The SCS IOT team is in charge of provide the MOC with the TC’s required to safely and correctly operate the SCS. Each TC sequence should be ready for upload before the next DTCP.

In the Routine Phase, this process will be based on the ICR (Instrument Commanding Request) that will be circulated by email.

In Commissioning or CPV phases, detailed timeline will be prepared in advance and will provide the main reference for execution of activities.

5.2.1. ROUTINE OPERATIONS

SCS routine operations basically consist of TM analysis (SCS health and performance), data quality check, data cross-check (with LFI thermal sensors and HFI 4K cooler TM) and cooler tuning to ensure optimized performance throughout all the mission. For this reason, the only TC’s expected to be executed during routine operations are the periodical (baseline is weekly) LookUpTable upload, by dedicated TC.
The procedures for this activity are summarized in Chapter 7.

SCS tuning is performed only by updating and uploading the LUT control values by the following dedicated TC's:

TC Name	TC Description
SC501530	TC 6_2 Load LUT Software – FM1, FM2, PFM1 and PFM2
SC502559	TC 6_2 Load LUT Powers and Times – FM1, FM2, PFM1 and PFM2
SC503559	TC 6_2 Load LUT health Check and Regeneration – FM2
SC504559	TC 6_2 Load LUT Run Mode transitions – FM2
SC505559	TC 6_2 Load LUT Fault Conditions and Bad Bed Detection – FM2
SC506559	TC 6_2 Load LUT PID and Open Loop Algorithms – FM2
SC507559	TC 6_2 Load LUT Heaters Resistances – FM1, FM2, PFM1 and PFM2
SC508530	TC 6_2 Load LUT Calibrations 1 – FM1, FM2, PFM1 and PFM2
SC509530	TC 6_2 Load LUT Calibrations 2 – FM1, FM2, PFM1 and PFM2
SC510559	TC 6_2 Load LUT health Check and Regeneration – FM1
SC511559	TC 6_2 Load LUT Run Mode transitions – FM1
SC512559	TC 6_2 Load LUT Fault Conditions and Bad Bed Detection – FM1
SC513559	TC 6_2 Load LUT PID and Open Loop Algorithms – FM1
SC514559	TC 6_2 Load LUT health Check and Regeneration – PFM2
SC515559	TC 6_2 Load LUT Run Mode transitions – PFM2x
SC516559	TC 6_2 Load LUT Fault Conditions and Bad Bed Detection – PFM2
SC517559	TC 6_2 Load LUT PID and Open Loop Algorithms – PFM2
SC518559	TC 6_2 Load LUT health Check and Regeneration – PFM1
SC519559	TC 6_2 Load LUT Run Mode transitions – PFM1
SC520559	TC 6_2 Load LUT Fault Conditions and Bad Bed Detection – PFM1
SC521559	TC 6_2 Load LUT PID and Open Loop Algorithms – PFM1

5.2.1.1. COMPRESSOR TUNING

In order to achieve best performance, the compressor should be tuned. Parameters like Heatup and Desorption Power, cycle time, LPSB power, gas-gap actuators timing can be adjusted to control required heat lift, insure limited pressure fluctuations and maximise cooler lifetime.

This tuning process will be performed at the beginning of cooler operations, in CPV phase, and in any other situation that could present an unbalance of the reached thermal conditions of the whole cryogenic chain.

During one sky survey a constant cycle time will be maintained, in order to simplify Planck scientific data reduction. The slow degradation of compressor capacity with time will be taken into account by adjusting input power. This tuning will be performed on the basis of the degradation capacity trend that will be continuously assessed during the cooler data analysis. Before the cooler capacity can fall below the required cooling power, the input power will be incremented to oppose this degradation. Baseline for typical time scale of this adjustment will be weekly.

5.2.1.2. COLD END TUNING

One of the most important requirements of the SCS is the temperature stability of the cold end. This is achieved not only by proper compressor tuning but also by taking advantage of the Temperature Stabilization Assembly (TSA) inserted between LVHX2 and the LFI main frame. The TSA is an actively controlled stage that can be operated on the basis of a PID control and/or open loop response. To perform the tuning, the parameters of the control stage, T set point and gains, have to be properly tuned to insure required stability.
The tuning will be operated at the beginning of cooler operations and will be repeated only in case of thermal conditions change.
TSA tuning is performed by updating and uploading the LUT control values.

5.2.2. NON-ROUTINE OPERATIONS

SCS Non-routine operations consist of:

- Cooler Switch-over
- Regeneration

5.2.2.1. COOLER SWITCH-OVER

This procedure is used to deactivate the working unit and to start the “sleeping” one. Such process will be used not only to transition between the two units (Nominal and Redundant), if needed, in case of failure but also as a tool to optimise both cooler lifetime ensuring maximised mission duration. Obviously, system switchover will be planned in advance according to cooler performance and mission constraints.

The general sequence for SCS switchover can be summarized in the following steps:

- Switch OFF LFI (4K cooler and Dilution stay ON, TBC)
- Shutdown SCS Nominal
- Initialise SCS Redundant
- GOTO READY MODE, enter Health Monitoring
- GOTO RUN MODE
- Wait for SCS R to enter Nominal Operations
- Perform cooler tuning

The whole procedure, can take up to 2 - 3 hrs (TBC), is detailed in the SCS UM [RD-2]

5.2.2.2. REGENERATION

Regeneration process is used to restore SCS bed hydrides ab/de-sorption capacity. By taking the compressor elements to very high temperatures it is possible to recover up to more than 90% of their BOL capacity. The execution of regeneration is not considered as baseline but only as a possible tool to extend cooler, and mission, lifetime.

The procedure is fully automatic and it is started by TC "GOTO Regeneration". The system, at the end of the sequence, automatically returns into READY Mode - Health Monitor. It it also possible to interrupt this process forcing the system to go back to READY by TC.
Regeneration process is described in the SCS User Manual.

5.2.3. COMMISSIONING AND CPV OPERATIONS

As already mentioned, an operational timeline for Commissioning and CPV phases can not be foreseen at present since the operation sequence at S/C level has not been defined yet.

5.2.3.1. COMMISSIONING OPERATIONS

SCS Commissioning Operations include:

- SCS-Nom unit activation
- SCS-Nom unit initialization
- SCS-Nom unit in READY Mode
- SCS-Nom unit in Healthcheck
- SCS-Nom unit switch-off
- SCS-Red unit activation
- SCS-Red unit initialization
- SCS-Red unit in READY Mode
- SCS-Red unit in Healthcheck
- SCS-Red ready to be started

5.2.3.2. CPV OPERATIONS

SCS CPV planned operations are:

- Start-up of SCS-Red
- SCS-Red enters NOMINAL Mode
- Perform Cooler and TSA tuning
- …Instruments CPV…
- Switch-over from Red to Nom
- Start-up of SCS-Nom
- SCS-Nom enters NOMINAL Mode
- Perform Cooler and TSA tuning

- SCS-Nom ready for first sky survey

5.2.4. CONTINGENCY ACTIVITIES

With “Contingency Activities” sheet are indicated all those activities that are requested in response to a system anomaly or degraded performance. They can be divided in two main categories:

1. unexpected events (such as failures or malfunctions) that require both on board autonomous recovery and ground reactions
2. “planned” recovery actions to react to system typical degradation with lifetime. Such actions are scheduled in advance in particular mission phases in order to minimize impact on observations.

In the second group, cooler switchover and regeneration are the two expected processes.

In case of anomaly detection on the SCS, on board SW is able to autonomously react to different contingency situations. Nevertheless, after the on-board automatic anomaly detection and response, immediate action will be needed from ground. If needed a NCR will be raised and the typical chain of NRB’s and meetings will be triggered by the SCS OM, or the deputy, that will also involve in the required specialists in the investigation.

5.3. SOFTWARE MAINTENANCE

The SCS software maintenance will be executed according to the general LFI DPC SW maintenance procedures (see [RD-1]).

5.3.1. NEW SOFTWARE RELEASE

SCS activities are part of SGS1 only. SCS HW and SW at DPC are cloned in two redundant identical copies under configuration control. In case of new software release, the code is first verified on the redundant unit and then installed on the nominal HW.

5.3.2. END OF SURVEY

Additional operations at the end of survey will be needed for final cooler data analysis: a general assessment of SCS performance, degradation and behaviour during the survey will be provided.
SCS IOT resources will mainly be required to support scientific data analysis for evaluating the impact and the possible removal techniques of cooler effects and thermal systematics on science.

5.4. ARCHIVE DEVELOPMENT

LFI DPC data archiving is based on Oracle system and is divided in two main archives: one for SGS1 and one for SGS2. SCS data will obviously be stored in the SGS1 archive and mirrored for fast recovery in case of problems. For details, see LFI Operation Plan [RD-1].

6. NOMINAL OPERATIONS

This paragraph summarizes all SCS nominal operations.
Description and details of procedures are reported in Chapter 7.

6.1. SCS ROUTINE PHASE SHEETS

6.1.1. SCS DAILY OPERATIONS SHEET

Daily operations include the following procedures (see Chapter 7):

1. Download one observation day of consolidated SCS and eventually related S/C or HFI TM (from HPDDS at MOC)

2. Run Level 1 software (see Figure 5-2):
   - Real Time Assessment – RTA;
   - Telemetry Quick Look – TQL;
   - TeleMetry Handling - TMH (TMU + TM2TOI) to expand/convert the telemetry and complement with auxiliary information.
3. Check SCS TM parameters of last OD:
   - Verify State Vector: cycle time, HU & DE Power, GGA delay/advance, LPSB Power, TSA set-point & power, Gas-Gap Actuators Current
   - Check Boundary Conditions: I/F compressor beds T, V-Grooves T
   - SCS Monitor: compressor beds T's and P's, High Pressure Line , Low Pressure Line, LPSB T, LVHX's T, TSA T
   - SC Electronics: V28, V15, V5, SCE panels T, 28 V line Current

4. Compute SCS Performance: mass flow & heat lift, LVHX's absolute T drift, peak to peak T fluctuations and their frequency spectrum

5. Evaluate Data Quality: check presence of glitches or instabilities

6. Comparison with HFI (4k Cooler) and LFI (FPU T sensors) data for cross-checking:
   - Check LFI HK TM
   - Retrieve data from HFI data storage

7. Compile the reports generated by LIFE (for LFI) and SCS Analysis dedicated software into a Daily Quality Report (DQR) to be sent to PSO

8. Organize the daily meeting for SCS related issues: in routine operations it will be part of LFI daily meeting.

6.1.2. WEEKLY OPERATIONS SHEET

Weekly operations include the following procedures (see Chapter 7):

1. Read one week of SCS data from archive
2. Run SCS Analysis dedicated SW for data checking and analysis. Compute trend analysis of:
    - High Pressure line
    - Heat lift
    - Low Pressure line
    - Cold End T's
    - Cold End T peak to peak fluctuations
    - Cold End T frequency spectrum
3. Evaluate long term cooler performance in terms of system degradation and remaining lifetime. Expected cooler behaviour in next weeks and propose/confirm planned operational activities.
4. Upload new LUT (Look Up Table) parameters for SCS "routine" tuning
5. Compare with LFI and HFI data for cross-checking
6. Compile the reports generated by SCS SW trend analysis and daily reports into a Weekly Health Report (WHR) to be sent to PSO
7. Report in WHR cooler operational parameters (LUT) to be loaded next week for system tuning
8. Organize the weekly meeting for SCS related issues, together with LFI.

A week is nominally starting on Wednesday but eventually it can be shifted to another week day.

6.1.3. MONTHLY OPERATIONS SHEET

Monthly operations include the following procedures (see Chapter 7):

1. Read one month of SCS data from archive
2. Run SCS Analysis dedicated SW for data checking and analysis. Compute trend analysis of:
    - High Pressure line
    - heat lift
    - Low Pressure line
    - Cold End T's

- Cold End T peak to peak fluctuations
- Cold End T frequency spectrum

3. Evaluate long term cooler performance in terms of system degradation and remaining lifetime. Expected cooler behaviour in next weeks and propose/confirm planned operational activities.
4. Report cooler operational parameters (Look Up Table) to be loaded next week for system tuning
5. Compare with LFI and HFI data for cross-checking
6. Compile the reports generated by SCS SW trend analysis and daily reports into a Weekly Health Report (WHR) to be sent to PSO
7. Organize the weekly meeting for SCS related issues, together with LFI.

To be consistent with the weekly operations, the month is nominally starting on the first Wednesday of each month but eventually it can be shifted to another week day.

6.2. COMMISSIONING AND CPV OPERATIONS SHEET

During Commissioning and CPV operations, activities are not divided in daily, weekly and monthly as activities performed will be different every day. Commissioning includes all operations needed to evaluate system health and prepare it for start-up. CPV is the mission phase in which the cooler reaches Nominal Mode and its performance are checked and evaluated.

6.2.1. COMMISSIONING OPERATIONS SHEET

From the ground segment point of view, Commissioning activities can be summarized in:

- Online cooler data analysis
- Offline cooler data analysis
- Evaluation of system health
- Verify parameters for cooler start-up
- Collaborate to Commissioning Daily Meeting organization

6.2.2. CPV OPERATIONS

- Online cooler data analysis
- Offline cooler data analysis
- Evaluation of system performance

- Verify parameters for cooler optimization
- Cooler tuning for performance optimization (LUT upload)
- Collaborate to CPV Daily Meeting organization

6.3. NON-ROUTINE OPERATIONS SHEET

6.3.1. CONTINGENCY RESPONSE

As described in Par.5.2.4, in case of contingency, response from ground will be needed to evaluate anomaly and OBSW autonomous actions. After investigation of the problem, according to the anomaly level, it may be required to send TC for:

- uploading a new LUT to adapt to new conditions
- taking the cooler into stand-by operations
- taking the cooler into shutdown
- restarting the cooler after problem solution

6.3.2. COOLER SWITCH-OVER

Switch-over procedure (see SCS UM [RD-2]) will be executed and system will be monitored for health and functionality evaluation.

6.3.3. REGENERATION

Regeneration procedure (see SCS UM [RD-2]) will be executed and system will be monitored for health and functionality evaluation.

7. NOMINAL OPERATION PROCEDURES

The main reference for SCS operating procedures is the SCS User Manual [RD-2].

7.1. COMMISSIONING AND CPV OPERATIONS

7.1.1. REAL TIME HK DATA ANALYSIS

Responsible Person:
SCS Operation Manager and SCS engineers

Estimated Duration:
5 hours (DTCP duration)

Inputs:
HK TM real time data

Outputs:

- System status assessment

Procedures:
Verification that values and TM are within specifications and requirements

Description:
By checking real time HK data produced by the SCS, the evaluation of cooler performance, health and stability will be performed.

7.1.2. OFFLINE DATA ANALYSIS

Responsible Person:
SCS Operation and SCS engineers

Estimated Duration:
Variable, depending on the amount of data or on the particular analysis requested
Automatically started when first chunk of data is downloaded at IW@MOC

Inputs:
Chunks of HK SCS data at IW@MOC.

Outputs:

- System status assessment
- SCS alarms and reports are automatically generated

Procedures:
Refer to TQL, TMH SSD and to the LIFE User Manual references in LFI Operation Plan [RD-1].

Description:
Run TQL on TM packets, verify the performance and the overall health of the SCS.
Run TMH, TMU + TM2TOI, to decompress/expand/convert the HK telemetry.
Run the LIFE system to:

- Check SCS TM parameters of last OD:
  - Verify State Vector: cycle time, HU & DE Power, GGA delay/advance, LPSB Power, TSA set-point & power, Gas-Gap Actuators Current
  - Check Boundary Conditions: I/F compressor beds T, V-Grooves T
  - SCS Monitor: compressor beds T's and P's, High Pressure Line , Low Pressure Line, LPSB T, LVHX's T, TSA T
  - SC Electronics: V28, V15, V5, SCE panels T, 28 V line Current
- Compute SCS Performance: mass flow & heat lift, LVHX's absolute T drift, peak to peak T fluctuations and their frequency spectrum

7.1.3. CROSS-CHECK SCS AND HFI THERMAL DATA

Responsible Person:
SCS Operation and DPC Managers

Estimated Duration:
Variable, depending on the amount of data or on the particular analysis requested

Inputs:
LFI and HFI HK thermal-related converted timelines

Outputs:
Analysis result might be reported in SCS status assessment or on dedicated reports for specific thermal issues.

Procedures:
Run the KST tool to cross-correlate SCS, HFI and LFI data. For data exchange see [RD-4].

Description:
For the general thermal analysis of the Planck PLM, different kinds of data cross-checks could be needed. This will require for flexibility in data handling and analysis.

7.1.4. UPLINK OPERATIONS: CHECK INSTRUMENT PROCEDURE

Responsible Person:
SCS Operation Manager

Estimated Duration:
Dependent on the uplink operations (number of parameters to be changed)

Inputs:
Look Up Tables

Outputs:
Cooler performance and health report

Procedures:
Correct procedures and parameters to be uploaded verification by SCS OM

Description:
All along the duration of commissioning and CPV phases, a number of TPF files should be ready to be uploaded by MOC.

7.1.5. COMMISSIONING AND CPV DAILY MEETING

Responsible Person:
SCS Operation Manager

Estimated Duration:
Less than 1 hour. The meeting is held just before or after the LFI one and starts after the DTCP, as soon as data analysis is completed.

Inputs:
Previous and current status of Commissioning and CPV tests. Results of data analysis for the tests just concluded.

Outputs:
Minutes of the Daily Meeting including possible Action Items assigned.

Procedures:
Organization of the daily meeting

Description:
Organize the daily meeting to discuss the previous OD data analysis and, if needed, the definition of TPF files to be up-linked during next DTCP.

7.2. ROUTINE OPERATIONS

The SCS timeline is integrated in the LFI one and the general scenario is reported in the LFI Operations Plan [RD-1]. The “Mid case” timeline is considered to be the reference, even if the estimated time of each operation might change depending on the real DTCP time.

7.2.1. READ ONE DAY DATA

Responsible Person:
DPC SGS1 Manager

Estimated Duration:
1 hour. Process starts automatically when consolidated data are available at MOC: at about 16:30 CET

Inputs:
Consolidated SCS TM available at MOC

Outputs:
Chunks of SCS data at DPC

Procedures:
Refer to TQL/TMH and HPDDS Software Specification documents (see [RD-1]).

Description:
Download one observation day of consolidated SCS TM from HPDDS and HPFTS at MOC. Additional daily work might be needed for old SCS telemetry retrieval.

7.2.2. REAL TIME ASSESSMENT (RTA)

Responsible Person:
DPC SGS1 Manager

Estimated Duration:
Less than 1 hour. Start when first chunk of data is downloaded at DPC: at about 16:30 CET

Inputs:
Chunks of SCS data at DPC

Outputs:
SCS alarms and logs are automatically generated.

Procedures:
Refer to LFI RTA and SCOS2K User Manual

Description:
Run RTA to detect out-of-range HK TM values to identify suspicious TM.
Alarms and logs are automatically generated.
Note that this operation is independent from the TM handling.

7.2.3. TELEMETRY QUICK LOOK (TQL)

Responsible Person:
DPC SGS1 Manager

Estimated Duration:
Less than 2 hours. Start automatically when first chunk of data is downloaded at DPC: at about 16:30 CET

Inputs:
Chunks of SCS data at DPC: HK, alarms and logs generated by RTA.

Outputs:
Instrument alarms and reports are generated

Procedures:
Refer to TQL Spec document in [RD-1]

Description:
Run TQL on packets to verify suspicious HK TM.
Verify the performance and the overall health of the SCS.
If alarms were generated during RTA session, TQL analysis will focus on anomaly data.
Reports are generated under request.
Note that this operation is independent from the TM handling

7.2.4. TELEMETRY HANDLING (TMH)

Responsible Person:
DPC SGS1 Manager

Estimated Duration:
About 2 hours (data retrieval included)
This process starts automatically when first chunk of data is downloaded at DPC: at about 16:30 CET

Inputs:
Chunks of SCS HK data at DPC

Outputs:
The output is TOI data set of few hundreds of Mb.
- SCS HK TM is time-ordered, covering one whole day and calibrated to engineering values
- SCS TOD are stored

Procedures:
Refer to TMH SSD doc, see [RD-1]

Description:
Run TMH, TMU + TM2TOI, to decompress/expand/convert HK telemetry. HK data are also flagged according to possible predefined occurrences (e.g. Out Of Limits - OOL).

7.2.5. LIFE SYSTEM ANALYSIS

Responsible Person:
DPC SGS1 Manager

Estimated Duration:
Less than 2 hours

Analysis starts automatically when the complete set of OD data and their related auxiliary information will be available at DPC: at about 21:30 CET

Inputs:
SCS HK TOI from DPC

Outputs:
The output is the Daily Quality Report ready to be reviewed before being sent to PSO/MOC/HFI.

Procedures:
Refer to the LIFE User Manual, see reference in [RD-1].

Description:
Run the LIFE system to:

- Report system events and errors, if any
- SCS main Op parameters (Compressor P and T, cold end T, electronics)
- Evaluate SCS mass flow, cooling power, T control stage power
- Calculate average values and fluctuations of above parameters

The results will be automatically included in the Daily Quality Report.

7.2.6. DAILY QUALITY REPORTS

Responsible Person:
SCS OT and DPC Manager

Estimated Duration:
Less than 1 hour. This process follows the LIFE system analysis (see previous paragraph).

Inputs:
Reports generated automatically during LIFE processing

Outputs:
Final Daily Quality Report (DQR).

Procedures:
Run the LIFE module to generate the DQR.

Description:
Compile the reports generated by LIFE into a daily quality report (DQR, see [RD-5]) based on cooler HK data received at the DPCs during that day. SCS DQR is annex to the LFI one.
The report is automatically generated during the LIFE running, it should be checked and sent to PSO, after the daily meeting. The DQR will be ready within 12 (TBC) hours after consolidated data are available at MOC, at about 04:30 CET.
On Sunday the Daily Quality Report will be reviewed on the next day, after the Monday daily meeting. In case no problems resulted from previous steps of analysis (including checks on the "event reports" TM(5,x) or the TM packets production rate), the DQR generated by LIFE will be automatically sent to PSO. After the Monday review the Sunday DQR, or a review in case of discrepancies, will be sent to PSO as an annex to the LFI one.

If a problem is detected, the DPC/IOT person on duty will be in charge of reviewing the DQR as soon as possible in order to understand and possibly solve the problem (see contingency activities described in Par. 5.2.4 and 6.3.1**Errore. L'origine riferimento non è stata trovata.**). In this case the DQR will not be sent automatically to PSO but it will be sent by the DPC/IOT person on duty after review.

7.2.7. SCS CONVERTED DATA EXPORT VS HFI DPC

Responsible Person:
DPC Manager

Estimated Duration:
About 1 hour

Inputs:
SCS converted data in DMC format

Outputs:
SCS converted data in EFDD format ready to be downloaded by HFI

Procedures:
Ad hoc software

Description:
Export SCS converted data in EFDD format according to the ICD [RD-4].

7.2.8. COMPARISON WITH HFI THERMAL: DOWNLOAD HFI HK DATA

Responsible Person:
DPC Manager

Estimated Duration:
Variable.

Inputs:
HFI converted thermal data available at HFI DPC

Outputs:
HFI converted data at LFI DPC

Procedures:
Run FTP script to download the HFI thermal HK timelines.

Description:
Retrieve converted housekeeping data from HFI data storage as defined in the DPC-DPC ICD [RD-4].

7.2.9. UPLINK OPERATIONS: INSTRUMENT PROCEDURE REQUESTS

Responsible Person:
SCS Operation Manager

Estimated Duration:
Depending on system procedure, see SCS User Manual [RD-2]

Inputs:
Request for the procedure.

Outputs:
ICR ready to be sent to PSO/MOC/HFI with the TC procedure request after the daily meeting.

Procedures:
Prepare Instrument Commanding Request

Description:
Request a cooler procedure to either enhance the performance, improve system monitoring or recover from a contingency. In order to proceed some system parameters need to be changed. In particular:

- SCS input (Heat-up and Desorption) power
- SCS cycle time
- Compressor heat switches timing
- Low Pressure Bed operating point
- Cold End stabilization stage PID parameters or setpoint

All the values to be changed, after approval path, are prepared and checked in advance, filled in a TPF and transmitted to MOC for upload in the next DTCP.

7.2.10. DAILY MEETING

Responsible Person:
DPC Manager

Estimated Duration:
1 hour. To be started at 9 AM (TBC) hour.

Inputs:
Previous and current OD DQR ready, next DTCP Uplink command sequence prepared.

Outputs:
Minutes of the Daily Meeting, DQR transmission to MOC/PSO and uplink command sequence, if any.

Procedures:
To be defined.

Description:
Organize the daily meeting to discuss the previous OD DQR (already sent to PSO), the results of DQR on current OD and the command sequence to be up-linked during next DTCP. It will be organized after the current OD DQR is ready (at about 04:30 CET in the "Mid case"), in the morning, around 09:00 CET. On Saturday the daily meeting will be organized one hour later (TBC) at 10 AM. No meeting is supposed to take place on Sunday.

7.2.11. READ ONE WEEK DATA

Responsible Person:
DPC SGS1 Manager

Estimated Duration:
1 hour

Inputs:
SCS archive at DPC

Outputs:
SCS TOD available for weekly analysis

Procedures:
Read the data form archive

Description:
Read one week of SCS data from archive (around 1 GB).
A week is nominally starting on Wednesday but eventually it can be shifted to another week day.

7.2.12. SCS REDUCED DATA EXPORT VS HFI DPC

Responsible Person:
DPC Manager

Estimated Duration:
Variable, depending on length of TOD file.

Inputs:
SCS reduced data in DMC format (see [RD-4])

Outputs:
SCS reduced data in EFDD format ready to be downloaded by HFI

Procedures:
Ad hoc software

Description:
Export SCS reduced data in EFDD format according to the ICD [RD-4].

7.2.13. WEEKLY HEALTH REPORTS

Responsible Person:
DPC Manager

Estimated Duration:
Less than 2 hours

Inputs:
All Daily Quality Reports and eventually Error Reports of the whole week, Weekly Health Report just produced by LIFE

Outputs:
Final Weekly Health Report

Procedures:
LIFE module to produce the Weekly Health Report

Description:
Combine the reports generated by LIFE trend analysis and daily reports into a Weekly Health Report (WHR) to be sent to PSO/MOC/HFI. As defined in [RD-5], the WHR contains the cooler health status, trend and prediction information, to ensure that the survey performance can be accurately planned and monitored by PSO.

7.2.14. WEEKLY MEETING

Responsible Person:
DPC Manager

Estimated Duration:
1 hour

Inputs:
All Daily Quality Reports, minutes of the Daily meetings, Error Reports of the week, Weekly Health Report, minutes of the last weekly meeting.

Outputs:
Minutes of the Weekly Meeting, WHR sent to PSO/MOC with the LFI one

Procedures:
To be defined

Description:
Organize the weekly meeting on Wednesday morning at about 10 AM, after the daily meeting.

7.2.15. READ ONE MONTH DATA

Responsible Person:
DPC SGS1 Manager

Estimated Duration:
TBD

Inputs:
SCS calibrated TOD archive.

Outputs:
SCS TOD available for trend analysis

Procedures:
Read one month of data

Description:
Read one month of calibrated SCS TOD from TOD archive.
The month is nominally starting on the first Wednesday of each month but eventually it can be shifted to another week day.

7.3. TIMELINE

Timeline sequence is shown in the LFI Operation Plan (see [RD-1]), SCS activities are carried out in the framework of the LFI ones. SCS data, being HK TM, are early available, during the DTCP, from MOC. LFI DPC will download them at the beginning of the Data Transfer (TBC).

7.4. SUMMARY OF ACTIVITIES AND TASKS

8. CONTINGENCY OPERATIONS

8.1. CONTINGENCY REACTION: NCR AND NRB

Responsible Person:
SCS Operation Manager

Estimated Duration:
Process starts right after an anomaly is detected during TM analysis. The duration will depend on the contingency.

Inputs:
Anomaly description

Outputs:
NCR raised, NRB meeting called, specialists informed, contingency solution plan.

Procedures:
Contact specialists (by phone and via e-mail) as soon as possible, raise an NCR, call an NRB meeting (via e-mail). A SCS internal meeting or a tele-conference should be organized to prepare a plan for anomaly investigation and recovery.

Description:
In case of a failure/anomaly or unexpected results, a NCR should be raised and an NRB meeting called. SCS OM or a deputy, always available on call, will contact immediately specialists to analyze and solve the contingency as soon as possible.

8.2. CONTINGENCY REACTION: SCS INTERNAL MEETING

Responsible Person:
SCSOperation Manager

Estimated Duration:
Start immediately after an anomaly occurs. The duration will depend on the contingency

Inputs:
Anomaly description

Outputs:
Plan for contingency investigation and solution.

Procedures:
Organize the meeting with specialists (in person or by phone).

Description:
SCS OM or a deputy, always available on call, contacts specialists and organize a SCS internal meeting to analyze and solve the contingency as soon as possible. This meeting will not

required the presence of LFI IOT members unless involved with the investigation or unless they wish to participate.

8.3. CONTINGENCY REACTION: INSTRUMENT PROCEDURE REQUESTS

Responsible Person:
SCS Operation Manager

Estimated Duration:
Depending on the instrument procedure, see SCS User Manual [RD-2]

Inputs:
Request for the procedure

Outputs:
ICR ready to be sent to PSO/MOC/LFI/HFI with TC procedure request

Procedures:
Write the Instrument Commanding Request

Description:
Request a procedure for quick reaction to the contingency and, after a solution is found, for recovery.