



HERSCHEL / PLANCK

Planck Instruments Testing at PFM S/C levels

H-P-3-ASP-TN-0676

Product Code : 200000

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1. SCOPE

This plan defines the instrument tests which will be performed on Planck FM satellite level during the Planck satellite AIT programme. This includes the instrument incoming inspections after delivery to ASP, the activities and interface tests planned for the instrument integration on the satellite and the instrument related tests to be performed during the various Planck FM and satellite test phases. All these activities and tests are described per instrument and per test activity in specific form sheets.

In addition, the document gives an overview on the satellite AIT programme, addresses the delivery and test configuration of the instruments and specifies any constraints to be respected for the instrument ground operations.

The main objective of this document is to allow an early, quick and co-ordinated satellite AIT relevant information exchange as regards the instrument related aspects. Therefore this document shall be used as reference document for the iteration cycles with the parties involved in the instrument related part of the satellite AIT programme. Furthermore this document serves as reference document for the higher level Satellite AIT Plan (see RD[05]), in providing more details and more actual information with respect to instrument related subjects.

The document is based on the Instrument Interface Documents (RD[01], RD[02] and AD[01]).

This document is a living document and will be updated accordingly to exchange with HFI and LFI in order to prepare the FM test specification.

Note : This document will be updated for the system CDR.

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2. DOCUMENTATION

2.1 Applicable documents

Ref.	Reference of document	Title
AD01	SCI-PT-IIDA-04624	Instrument Interface Document IID - part A
AD03	H-P-1-ASPI-LI-0058	Hardware Matrix
AD04	H-P-1-ASPI-PL-0225	Herschel & Planck VPP

2.2 Reference documents

Ref.	Reference of document	Title
RD01	LI-PH410-300354-IAS 3.0	HFI Test Requirement Sheet List
RD02	PL-LFI-PST-PL-010 1.0	LFI Test Requirement Sheet List
RD03	SCI-PT-IIDB/HFI-04141	Instrument Interface document IID part B "HFI"
RD04	SCI-PT-IIDB/LFI-04142	Instrument Interface document IID part B "LFI"
RD05	H-P-3-ASPI-PL-0208	Planck Satellite AIT Plan

2.3 Acronyms and abbreviations

Acronyms	Keys
AD	Applicable Document
AIT	Assembly, Integration & Tests
AVM	AVionics Model
EGSE	Electrical Ground Support Equipment
ESA	European Space Agency
ESTEC	European Space research and Technology Center
GHe	Gaseous Helium
GSE	Ground Support Equipment
HFI	High Frequency Instrument
I/F(s)	Interface(s)
IID	Instrument Interface Document
ISSS-PGSE	Isotope Supply & Storage PGSE
JPL	Jet Propulsion Laboratory
LFI	Low Frequency Instrument

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Acronyms	Keys
LHe	Liquid Helium
LN2	Liquid Nitrogen
MGSE	Mechanical Ground Support Equipment
MTD	Masse en Thermal Dummy
NA	Not Applicable
NC	Not Communicated
PACE	Pipe Assembly & Cold End
PACE - GSE	PACE - Ground Support Equipment
PFM	Proto-Flight Model
PGSE	Pneumatic Ground Support Equipment
PLM	PayLoad Module
PPLM	PLANCK PayLoad Module
RD	Reference Document
S/C	Spacecraft
STM	Structural & Thermal Model
SVM	SerVice Module
TBC	To Be Confirmed
TBD	To Be Defined
TBS	To Be Specified
TF-PGSE	Tank Filling - PGSE
WU	Warm Unit

3. SATELLITE PFM AIT PROGRAMME

3.1 Objective

The main objective of the FM test program on the Planck satellite is to check the mechanical, electrical electromagnetic and thermal performances.

3.2 Planck Satellite AIT Flow

The figures here after gives an overview of the tasks which are planned to be performed during the Planck FM AIT programme (for details see RD[05]).

The FM AIT logic presented here after is based on 3 batches delivery for the SVM FM.

Batch 1: see

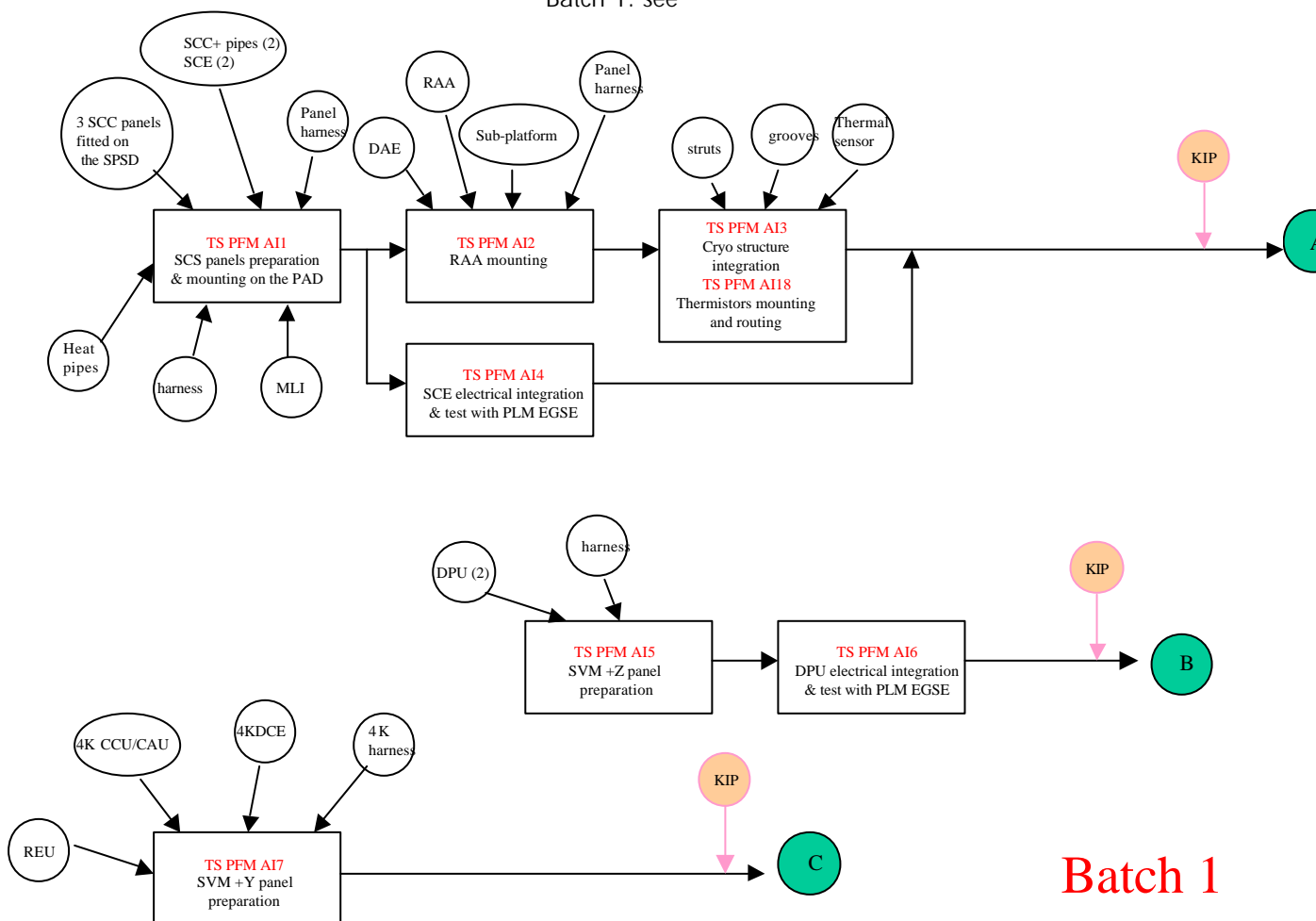


Figure 3-1.

Batch 2: see Figure 3-3.

Batch 3: Will be available for the system CDR.

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The Figure 3-4 shows the logic of the system test done at FM S/C level.

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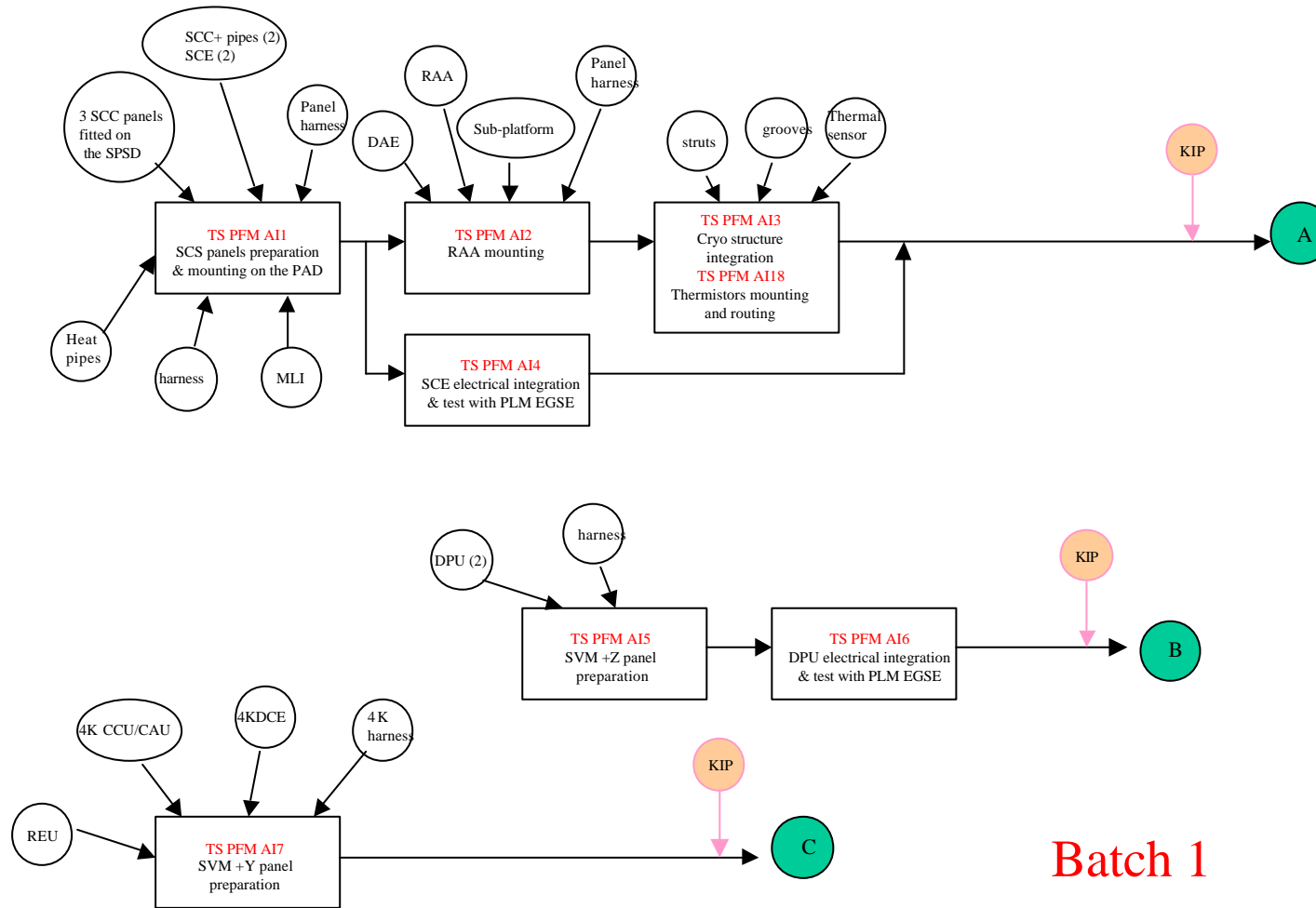


Figure 3-1: Planck S/C AIT Plan – Batch 1

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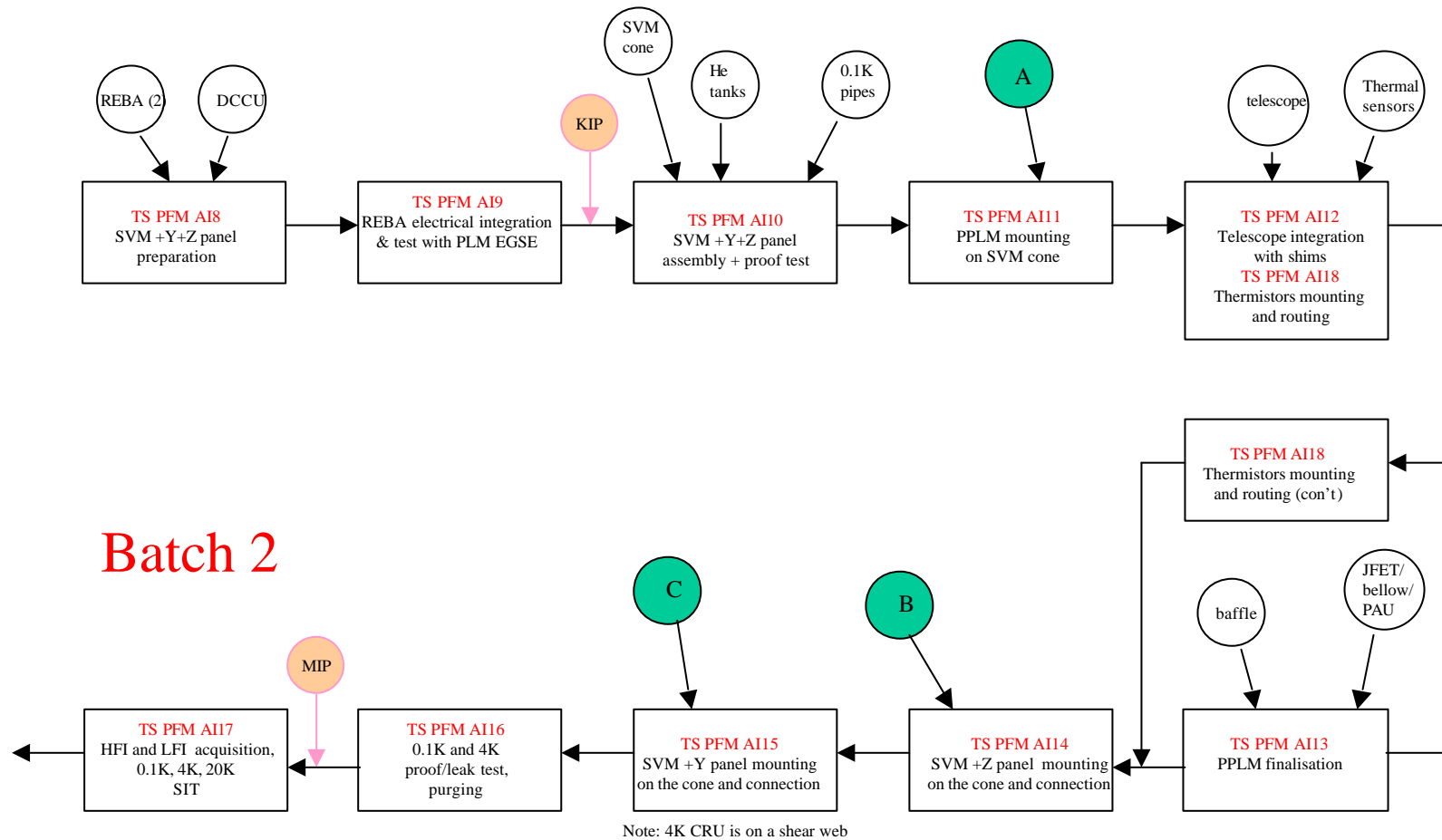


Figure 3-3: Planck S/C AIT Plan – Batch 2

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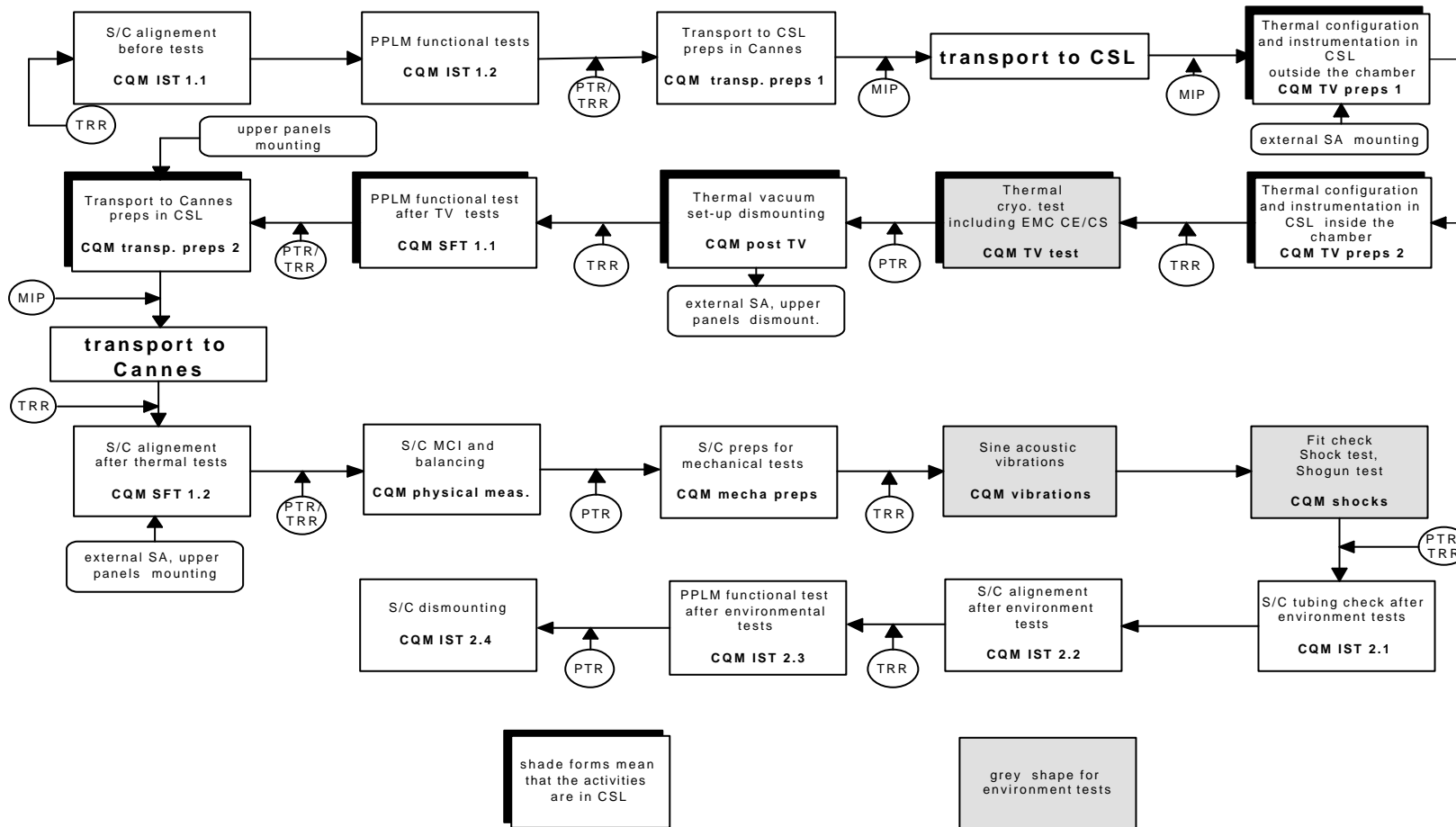


Figure 3-4: System Tests at Planck S/C test level.

3.3 Instrument Specific Test Activities

3.3.1 Incoming Inspection

After the formal delivery by ESA, the incoming inspection will be performed by Alcatel on all instrument items to be integrated in the PPLM in order to assure their quality. The incoming inspection covers the visual inspection of the hardware, the cleanliness control and the check of the documentation. The following items will be verified:

- Packing undamaged?
 - Seals and straps intact?
 - Correct labelling?
- Transportation container, inner packing
 - Correct identification (see heading)?
 - Equipment correctly and safely packed?
 - Equipment hermetically sealed?
 - Packed with desiccants?
 - Packed with humidity-indicators?
 - Packed with shock-indicators?
 - Packed with temperature-indicators?
 - Container reusable and stackable?
- Equipment
 - Identification correct?
 - Screw sealing not broken?
 - Surface finish undamaged and clean?
 - Connector identification correct?
 - Connector with protective caps ?
 - Connector pins clean and undamaged?
 - Mounting area clean and undamaged?
 - Accessories, bonding points, covers?
- Documentation
 - Shipping documentation?
 - Log sheets / historical records?
 - Handling, packing, transport procedures?
 - End Item Data Package (ICD)?
 - Other Documentation
- Other notable defects?

Note: There is no functional verification during incoming inspection.

3.3.2 Instrument EGSE Validation

The Instrument EGSE validation will comprise a stand-alone test of the Instrument EGSE (self-test). Secondly, after connection to the CCS lite, an interface check will be performed (PIPE protocol). Its objective is to check the proper electrical EGSE – CCS connections and the correct functioning of the EGSE – CCS interface drivers.

For the specific check-out equipment dedicated validation will be performed, as required.

3.3.3 Integration & Test (I&T)

3.3.3.1 Mechanical Integration

Hardware release

Hardware release for integration will be controlled. Parts required for a particular integration activity will be kited to reflect the requirements of the governing procedure prior to the need date. This kiting operation shall include an inspection according to the system/module assembly drawing and subsystem manufacturing drawings to ensure that all parts materials are available and that obvious anomalies are found prior to the beginning of integration activities.

Handling

The handling activities of module and system hardware, in the various integration and testing facilities shall only be carried out using the dedicated MGSE and by trained personnel having the necessary experience.

Only authorised crane operators will operate in particular, overhead crane.

3.3.3.2 Electrical integration

All electrical interfaces (flight connectors) will be protected by savers (on flight models only) during integration, so mating/demating will be made by breaking non-flight hardware interfaces. Through an official record all flight connector connections/disconnections shall be traced during the AIT activities. The record shall state :

- unit and harness connectors identification: reference and type
- connection/disconnection dates for:
 - harness connector to saver
 - unit connector to saver
 - harness connector to unit connector
 - torquing of fixing screws
 - marking (or eventually sticking) of fixing screws

The Alcatel QC will manage this document.

Electronic units

This section (and the next ones) concerns the electrical integration of the P.PLM units regarding the as-built ref. AD[03].

The verification of all the unit interfaces before box connection is done through the verification of the received unit data-package documentation : box interface data sheets w.r.t. harness list.

After unit mechanical fitting and fixing bolts torque, a bonding measurement (or insulation as required) between unit case and structure reference grounding point is performed.

Then the electrical integration takes place to make sure that :

- the interfaces are compatible
- the unit, then the overall subsystem are working properly.

The system integration will be performed according to the same principles : electrical interface verification completed by functional checks after final connection as explained here under.

Integration task - Interface checks

Electrical integration will be automated to the maximum extent as is reasonable, and will systematically control all interfaces of a unit being integrated. Before and after connection of harness to dedicated unit connector, the electrical interfaces will be tested. The following tests will be performed to verify the electrical interface compatibility, avoiding any degradation of flight units:

- grounding verification through grounding measurements at unit and harness connector level
- safety hardware verification of output signals by measurement at emitter unit / harness connector level in unloaded configuration (or test loads) before harness connection to the receiver unit. Such a verification will be restricted to high level signal (power supply - high level command when mixed with other signals on the same connector) and to signals for which a specific measurement is required due to the risk encountered by receiver units and will be detailed in the dedicated subsystem test plans at system level
- standard interface verification of unit before connection to harness
- specific verifications will be detailed in critical signals TRS
- after suppression of break-out boxes/tee adapter, final connection of each harness connector and torquing of fixation screws.

3.3.4 Unit function checks (UFT)

Electrical integration of units and subsystems will be completed by execution of simplified functional tests. An automatic crosscheck is run to validate as far as possible all the TM/TC. Test equipment and procedures will be reused as elements of subsequent IST (integrated system test).

3.3.5 Unit integration test (SFT)

Functional check of integrated unit before continuing the next unit integration operations. This kind of functional checks is restricted to the minimum and only allow to verify that the unit can be powered, commanded, and monitored in advance to the next IST.

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3.3.6 System Integrated Test (SIT)

At electrical integration complexation, a global functional test is performed on each module (PLM and SVM) . Its aim is to demonstrate subsystem or functional chains compatibilities .

3.3.7 Integrated Module Test (IMT)

The objective of the IMT is to validate the performance of the integrated instrument and their measurement performance in operational environment.

Some HFI TRS haven't taken into account in the IMT table (see here after) for the following reasons:

TRS-P-HFI-UFT-27	The facility cool down is not in the scope of HFI.
TRS-P-HFI-UFT-12	The collection of temperature data during the cool down is not in the scope of HFI.
TRS-P-HFI-UFT-13	The TRS of HFI active cool covers the step 2 to step 13 in the IMT table.
TRS-P-HFI-UFT-28	The Facility warm-up is in the scope of Alcatel, but the HFI warm-up description shall be describe in this TRS.

Note: The warm-up of LFI is not described by LFI.

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Step	Instrument		Coolers				Coolers ON/OFF criteria	Requested Procedure	Time / Task		
	HFI	LFI	20K	4K	0.1K	0.1K Pre-cool.			HFI	LFI	Max
1	Off	Off	Off	Off	Off	Off					
2	Off	Off	Off	Off	Off	On	No condition	Pre-Cooling loop Switch-On Proc.			
3	Off	Off	On	Off	Off	On	LR2 < 150K	20K Switch-On Proc.			
4	Off	On	On	Off	Off	On	T° of LR1 & LR2 stabilised < 20K	LFI Switch On Proc.			
5	Off	TRS-P-LFI-UFT-4	On	Off	Off	On			1	1	
6	Off	On	On	Off	Off	Off		Pre-cooling Switch-Off Proc.			
7	Off	On	On	On	Off	Off	JT4K < 26K	4K Switch-On Proc.			
8	Off	On	On	On	On	Off	JT4K < 5K	0.1K Switch-On Proc.			
9	Off	TRS-P-LFI-UFT-6	On	On	On	Off			1	1	
10	Off	TRS-P-LFI-UFT-7	On	On	On	Off			1	1	
11	Off	TRS-P-LFI-UFT-8	On	On	On	Off			1	1	
12	Off	TRS-P-LFI-UFT-9	On	On	On	Off			1	1	
13	On	On	On	On	On	Off	T° of HFI Bolometers = 100mK	HFI Switch-On Proc.			
14	TRS-P-HFI-UFT-14	TRS-P-LFI-UFT-14	On	On	On	Off			3	3	
15	TRS-P-HFI-UFT-15	TRS-P-LFI-UFT-10	On	On	On	Off			4	4	
16	On	Off	On	On	On	Off	TRS-P-LFI-UFT-15				
17	TRS-P-HFI-UFT-17	Off	On	On	On	Off			2	1	
18	On	On	On	On	On	Off	TRS-P-LFI-UFT-16				
19	TRS-P-HFI-UFT-16	TRS-P-HFI-UFT-16	On	On	On	Off			0,5	0,5	
20	TRS-P-HFI-UFT-18	TRS-P-LFI-UFT-11	On	On	On	Off			1	1	
21	On	TRS-P-LFI-UFT-12	On	On	On	Off			1	1	
22	On	On	On	On	Off	Off		0.1K Switch-Off Proc.			
23	TRS-P-HFI-UFT-19	On	On	On	Off	Off			0,5	0,5	
24	On	On	On	On	On	Off					
25	On	On	On	Off	On	Off		4K Switch-Off Proc.			
26	TRS-P-HFI-UFT-19	TRS-P-LFI-UFT-17	On	Off	On	Off			0,5	1	
27	On	On	On	On	On	Off					
28	TRS-P-HFI-UFT-19	TRS-P-LFI-UFT-18	On	On	On	Off			0,5	0,5	
29	On	On	Off	On	On	Off		20K Switch-Off Proc.			
30	TRS-P-HFI-UFT-19	TRS-P-LFI-UFT-13	Off	On	On	Off			0,5	0,5	
31	On	On	Off	On	Off	Off					
32	On	On	Off	Off	Off	Off					
33	On	On	Off	Off	Off	On					
34	Off	On	Off	Off	Off	On					
35	Off	Off	Off	Off	Off	On					
36	Off	Off	Off	Off	Off	Off					
37	Off	Off	Off	Off	Off	Off					

LR1: PACE PRECOOLER LR1

LR2: PACE PRECOOLER LR2

JT4K: Joule Thomson of 4K Cooler

Table 3-1: FM IMT

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4. INSTRUMENT CONFIGURATIONS

See AD[03].

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5. INSTRUMENT TEST ACTIVITY DESCRIPTIONS

The HFI TRS given in §5.1 are directly based on from RD[01].

The LFI TRS given in §5.2 are extracted from RD[02] and updated by Alcatel.

The Table 5-1 summarises the status the available HFI TRS & the applicability (see RD[01]) for the FM test for ASP point of view.

The Table 5-2 summarises the status the available LFI TRS & the applicability (see RD[02]) for the FM test for ASP point of view.

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ASP N°	HFI TRS N°	Description	Model				nb days	Comments
			CQM	STM	AVM	PFM		
TRS-P-HFI-UFT-01	-	Warm Unit I&T	X	X	X	X	5	Included in TRS-P-HFI-UFT-25
TRS-P-HFI-UFT-02	H-P-HFI-TRS-0007	4K Cooler Pneumatic Integration on Planck	X	X		X	5	
TRS-P-HFI-UFT-03	H-P-HFI-TRS-0008	0.1K Cooler Pneumatic Integration on Planck	X	X		X	5	
TRS-P-HFI-UFT-04	H-P-HFI-TRS-0009	HFI ambient temperature individual commissioning	X	X		X	2	
TRS-P-HFI-UFT-05	H-P-HFI-TRS-0010	Payload Combined Fonctionnal test at room temperature				X	2	TBC
TRS-P-HFI-UFT-06	H-P-HFI-TRS-0011	On board software maintenance	X		X	X	2	
TRS-P-HFI-UFT-07	H-P-HFI-TRS-0012	FPU vs Telescope alignment check		X		X	?	
TRS-P-HFI-UFT-08	H-P-HFI-TRS-0013	Prior to Vibrartion 0.1K Cooler tanks filling		X		X	2	
TRS-P-HFI-UFT-09	H-P-HFI-TRS-0014	01.K coolers leak test	X	X		X	0,5	
TRS-P-HFI-UFT-10	H-P-HFI-TRS-0015B	Short fonctionnal test at ambient condition	X	X	X	X	0,5	Numbering Problem
TRS-P-HFI-UFT-11	H-P-HFI-TRS-0016	Mechanical testing at system level		X		X	1	TBC
TRS-P-HFI-UFT-12	H-P-HFI-TRS-0019	Thermal response for thermal model correlation	X			X	2	
TRS-P-HFI-UFT-13	H-P-HFI-TRS-0020	Progressive active cooldown	X			X	8	
TRS-P-HFI-UFT-14	H-P-HFI-TRS-0021	Fonctionnal test in flight like condition	X			X	3	
TRS-P-HFI-UFT-15	H-P-HFI-TRS-0022	Cold EMC conductive test	X			X	4	
TRS-P-HFI-UFT-16	H-P-HFI-TRS-0023	HFI/LFI compatibility test in cold condition				X	0,5	ASP Assumption
TRS-P-HFI-UFT-17	H-P-HFI-TRS-0024	HFI auto-compatibility test in cold condition	X			X	2	
TRS-P-HFI-UFT-18	H-P-HFI-TRS-0025	HFI susceptibility to SCS radiator T° change				X	1	New Task
TRS-P-HFI-UFT-19	H-P-HFI-TRS-0026	HFI cooler failure test	X			X	0,5	0,5 Day per Cooler
TRS-P-HFI-UFT-20	H-P-HFI-TRS-0001	Incoming unpacking and inspection	X		X	X		Covered by TRS-P-HFI-UFT-22
TRS-P-HFI-UFT-21	H-P-HFI-TRS-0002	Incoming hardware autonomous test	X		X	X	3	
TRS-P-HFI-UFT-22	H-P-HFI-TRS-0003	HFI units interface incoming verification	X		X	X	NA	Off line
TRS-P-HFI-UFT-23	H-P-HFI-TRS-0004	EGSE integration with CCS	X	X	X	X	1	TBC
TRS-P-HFI-UFT-24	H-P-HFI-TRS-0005	HFI WU mechanical integration with SVM (extended PPLM)	X	X		X	-	Covered by TRS-P-HFI-UFT-01
TRS-P-HFI-UFT-25	H-P-HFI-TRS-0006	HFI FPU integration with LFI one LFI FPU STM for CQM	X	X		X	5	
TRS-P-HFI-UFT-26	H-P-HFI-TRS-0017	Cryogenic Test Preparation	X			X	NA	Off line
TRS-P-HFI-UFT-27	H-P-HFI-TRS-0018	Cryogenic Facility Cool down	X			X	NA	Off line
TRS-P-HFI-UFT-28	H-P-HFI-TRS-0027	HFI Cryo Facility warm-up	X			X	NA	Off line
TRS-P-HFI-UFT-29	H-P-HFI-TRS-0028	HFI Hardware removal from Cryo Facility	X			X	NA	Off line
TRS-P-HFI-UFT-30	H-P-HFI-TRS-0029	HFI CQM dismounting, packing & shipping	X			X	NA	Off line
TRS-P-HFI-UFT-31	H-P-HFI-TRS-0015A	4K Cooler Leak Test	X	X		X	0,5	

Table 5-1: HFI TRS synthesis

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N°	Description	nb days	Comments
TRS-P-LFI-UFT-1	Warm Unit Electrical Integration	5	ref. AIV Specification
TRS-P-LFI-UFT-3	Knee frequency variation from 20K to 4K	1	
TRS-P-LFI-UFT-4	Functional test in flight like condition	1	
TRS-P-LFI-UFT-5	LFI end-to-end Functional Test at ambient	2	
TRS-P-LFI-UFT-6	Noise and Stability Check	1	
TRS-P-LFI-UFT-7	System Noise measurement, linearity and Isolation check	1	
TRS-P-LFI-UFT-8	Long term measurement, stability and kee frequency estimatio	1	
TRS-P-LFI-UFT-9	Interference between receiver ON/OFF	1	
TRS-P-LFI-UFT-10	Cold EMC Conductive Test	4	
TRS-P-LFI-UFT-11	LFI Susceptibility to SCS Radiator Change	1	New Task
TRS-P-LFI-UFT-12	LFI PID Controller Test	1	New Task
TRS-P-LFI-UFT-13	20 K Cooler failure Test	0,5	
TRS-P-LFI-UFT-14	Specific REBA Functionnal Test	3	
TRS-P-LFI-UFT-15	LFI-Switch off	1	
TRS-P-LFI-UFT-16	LFI Switch-on Again	0	
TRS-P-LFI-UFT-17	LFI 4K Cooler failure test – Cooler OFF	1	
TRS-P-LFI-UFT-18	LFI 4K Cooler -On	0,5	

Table 5-2: LFI TRS synthesis

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5.1 HFI TRS

Title: **Incoming unpacking and inspection**

TRS-P-HFI-UFT-20 (H-P-HFI-TRS-0001)

Experiment: **Planck HFI**

Objectives:

To check that all shipped HFI boxes and deliverables are present.

To check that delivered items are apparently okay.

Test Description:

HFI Instrument Operation Team shall perform unpacking activities along instrument provided procedures and maintain the delivered units / instrument log book.

Instrument Configuration:

Packed HFI units are delivered at Alcatel or its contractor premises. A list of delivered units is available as part of the Acceptance Data Package, as well as pre-packing visual inspection status.

Specific Requirements on PLM :

Proper area accommodation has to be available for HFI foreseen delivery.

Particular Environmental Constraints :

Class 100 000 clean area is required for units incoming inspection activities.

Class 100 clean area is required for CQM and PFM FPU

Success Criteria:

All shipment listed deliverables should be present.

No change should be detected between before and after shipment instrument or GSE aspect.

This inspection success shall allow going to the following step of AIT: incoming hardware autonomous test for example.

Duration:

A few days

Applicable:

CQM	<input checked="" type="checkbox"/>
STM	<input checked="" type="checkbox"/>
AVM	<input checked="" type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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Title: Incoming hardware autonomous test

TRS-P-HFI-UFT-21 (H-P-HFI-TRS-0002)

Experiment: Planck HFI

Objectives:

To demonstrate as much as possible at instrument level that under comparable conditions delivered hardware functionality has not been modified by transportation to delivery point.

Test Description:

A progressive test of individual units main performances shall be performed.

Where applicable this activity sequence shall repeat the instrument turn-on, representative mode(s) and switch-off sequences validated before delivery.

After HFI EGSE (and simulators as applicable) switch-on sequence this test shall include:

- switch on,
- Time delivery (TBC),
- HSK production and verification,
- Individual TC sending, acknowledge and verification,
- Different types of TM packets verification,
- EGSE operational validation.

HFI Instrument Operation Team shall perform these tests and maintain the units / instrument log books. For educational purpose ESA /Alcatel representatives are welcome to witness these tests.

All produced data shall be recorded by the appropriate EGSE, processed for real time assessment and finally archived by HFI.

Instrument Configuration:

Instrument units and GSE unpacking and incoming inspection have been successful.

These autonomous tests shall be performed after successful electrical inter-connection of hardware chains tested prior to delivery.

- HFI units with the HFI provided unit EGSE, interface simulators or spacecraft simulator,
- instrument units interconnection (to be detailed),...

Specific Requirements on PLM :

For this activity a TBD table area has to be made available to HFI IOT.

Particular Environmental Constraints :

HFI delivered units identified as CQM, STM or PFM shall be maintained in class 100 000 or better.

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Success Criteria:

No difference should be detected between prior to and after delivery test data.

This autonomous test success shall allow going to the following step of AIT such as formal delivery to ESA/Alcatel.

Duration:

Two to three days

Applicable:

CQM

STM

AVM

PFM

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Title: HFI units interface incoming verification

TRS-P-HFI-UFT-22 (H-P-HFI-TRS-0003)

Experiment: Planck HFI

Objectives:

To physically demonstrate delivered hardware compliance to IIDs / Data package data.

Test Description:

HFI units test shall be performed either at ESA/Contractor or PI team premises, or could be splitted between different locations.

Performed test list is to be agreed with ESA and Alcatel and may include:

- Units identifiers check,
- Visual inspection,
- Particulate cleanliness verification,
- Isolation test,
- In-rush current measurement ,...

HFI Instrument Operation Team shall be present during the verification and shall maintain the delivered instrument log book.

All produced data shall be recorded for later HFI archiving.

Note that the splitting of initial CQM activities into PLM CQM, SAT STM and AVM activities may drive to split the performance of these tests at different stages.

Instrument Configuration:

Instrument is being formally delivered to ESA/Alcatel.

These tests shall be performed before actual mechanical and electrical integration of instrument delivered hardware with PLM / SVM or its representative simulator.

Specific Requirements on PLM :

As applicable, spacecraft powered thermistors and (compensation) heaters shall be installed on HFI units by ESA Contractor prior to the end of this interface verification activities. Note that no such instrument mounted items are presently foreseen.

Particular Environmental Constraints :

HFI delivered CQM, STM and PFM shall be maintained in class 100 000 or better.

Success Criteria:

Measured parameters should be compliant with specified range.

This interface verification success is one of the prerequisites allowing to go to the following step of AIT such as integration on Planck spacecraft.

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Duration:
ESA/ASPI defined

<i>Applicable:</i>	CQM	<input checked="" type="checkbox"/>
	STM	<input checked="" type="checkbox"/>
	AVM	<input checked="" type="checkbox"/>
	PFM	<input checked="" type="checkbox"/>

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Title: **EGSE integration with CCS**

TRS-P-HFI-UFT-23 (H-P-HFI-TRS-0004)

Experiment: **Planck HFI**

Objectives:

To demonstrate electrical and software compatibility between HFI provided EGSE and Planck CCS or its representative simulator.

Note that concerning the AVM, as HFI EGSE integration with spacecraft CCS is supposed to have already been performed at CQM delivery, following data should apply only in the case in which described activities need to be repeated.

Test Description:

HFI EGSE shall be the only new hardware tested during this phase.

A progressive test of all electrical / software interface shall be performed.

After HFI EGSE and CCS or simulator switch-on sequence it shall include:

- A ping test,
- Dummy HSK and Science packets exchange and verification (TBC).

A global test shall be performed with LFI and SCS EGSE after their individual integration with the CCS.

HFI Instrument Operation Team shall be present during the test and maintain the EGSE log book.

All produced data shall be recorded.

Instrument Configuration:

HFI EGSE has been successfully delivered, unpacked and auto-tested.

This test shall be performed after successful electrical integration of HFI EGSE with local mains and LAN.

Specific Requirements on PLM :

This test shall be performed after successful electrical integration of Planck CCS with mains and LAN.

Particular Environmental Constraints :

A TBD working area with agreed furniture and connection facilities shall be made available by ESA Contractor / Sub-contractor to accommodate HFI EGSE, documentation and IOT during coming System testing. Such a requirement applies to the different AIT locations: Cannes, Liège, ...

No specific cleanliness constraints. In fact having the instrument EGSE located outside of clean areas shall ease the HFI team work conditions.

Success Criteria:

LAN connection has been proven successful, HFI EGSE and CCS are able to "understand" each other.

This EGSE integration test success is one of the prerequisites allowing to go to the following step of AIT such as instrument functional testing.

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Duration:

ESA/ASPI defined (one day TBC repeated after each ground segment integration)

Applicable:

CQM	<input checked="" type="checkbox"/>
STM	<input checked="" type="checkbox"/>
AVM	<input checked="" type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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**Title: HFI WU mechanical integration with SVM
(extended PPLM)**

TRS-P-HFI-UFT-24 (H-P-HFI-TRS-0005)

Experiment: Planck HFI

Objectives:

To construct Planck "extended" PLM.

To demonstrate mechanical compatibility between HFI and Planck hardware.

Please note that 4K and 0.1K cooler pneumatic integration are addressed in specific TRSs.

Note also that 2 Dilution Cooler Tanks not present on the CQM have to be mounted prior to STM mechanical testing. While the 4K Cooler 4KCCU + 4K CAU ensemble, the 4KCCR and the 4KCDE shall be dismantled and shall not participate in the STM mechanical tests. The 4KCDE shall be packed and shipped to Alenia for integration in the AVM.

Test Description:

After unit identification check, and using HFI provided MGSE when applicable, mechanical integration of HFI delivered warm units on extended PPLM or its representative simulator shall be performed along Alcatel / HFI agreed procedures.

At this stage "spacecraft powered" if any thermistors and heaters shall be present or represented.

After connectors identification check shall be performed the connection of harnesses and bounding straps along Alcatel provided procedure.

HFI Instrument Operation Team shall be represented during these activities and the instrument and connectors mating log books shall be maintained.

All produced information shall be recorded by ESA/Alcatel.

Instrument Configuration:

This integration shall be performed after successful:

- interface verification,
- incoming hardware autonomous test,
- connectors savers or covers retrieval.

Specific Requirements on PLM :

To be agreed with ESA/Alcatel.

All integration items (bolts, bonding straps) not provided by HFI shall be available.

Particular Environmental Constraints :

Planck CQM, STM and PFM shall be maintained in class 100 000 or better.

Alcatel provided particulate and molecular contamination witness plates shall be used to record accumulated deposits.

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Success Criteria:

No physical mating problem of hardware should be detected.

This physical integration success is one of the prerequisites allowing to go to the following step of AIT i.e. instrument system level testing.

Duration:

ESA/ASPI defined

Applicable:

CQM

STM

AVM

PFM

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Title: HFI FPU integration with LFI one or LFI FPU STM for the CQM

TRS-P-HFI-UFT-25

(H-P-HFI-TRS-0006 number to be checked)

Experiment: Planck HFI

Objectives:

To integrate mechanically HFI Focal Plane Unit into LFI one prior to formal delivery of the PFM.

In the case of HFI FPU PLM CQM – SAT STM: LFI FPU not being available this activity shall be performed using Alcatel procured LFI RAA Simulator(s).

Test Description:

Performing this activity at Alcatel premises as decided shall save a sequence of transportation to another place, unpacking and packing again, which duration is between 2 weeks and one month.

Using dedicated instruments provided MGSE and Alcatel provided lifting crane : HFI FPU shall be introduced into "LFI" one (or Alcatel provided simulator) and bolted on it.

Co-alignment of units shall be checked.

Ad hoc contamination protecting cover(s) shall be re-installed before the end of this activity.

Instrument Configuration:

Both instruments Focal plane Units and associated on-board and ground support equipments have been delivered at Alcatel, unpacked and checked as per HFI-TRS-0001 and equivalent for LFI or LFI RAA Simulator.

Specific Requirements on PLM :

Concerning the CQM, integration of the FPU from « inside » the telescope is foreseen along Alcatel provided procedure.

Particular Environmental Constraints :

CQM - STM and PFM Focal Plane Units shall be maintained in class 100 000 or better, 10 000 when protection cover(s) are not present.

Alcatel provided particulate and molecular contamination witness plates shall be used to record accumulated deposits.

Success Criteria:

HFI and LFI RAA Simulator(s) have been successfully integrated mechanically and are thus ready for integration on PLM CQM or SAT STM.

HFI and LFI Focal Plane PFM Units have been successfully integrated mechanically and are thus ready for formal delivery to ESA/Alcatel.

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Duration:

About 2 weeks for FM

Probably less for CQM

Applicable:

CQM

STM

AVM

PFM

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Title: **4K Cooler pneumatic integration on Planck**

TRS-P-HFI-UFT-2

(H-P-HFI-TRS-0007 – Number to be checked)

Experiment: **Planck HFI**

Objectives:

To assemble Planck 4K Cooler helium circuit.

To perform a cooler relevant functional test at ambient condition.

Please refer also to "Installation of the 4K Cooler on the Spacecraft – Preliminary Assessment" (TN-PHD-011101-RAL).

Test Description:

Please refer to "Installation of the 4K Cooler on the Spacecraft – Preliminary Assessment" (TN-PHD-011101-RAL).

Note that the level of integration to be performed shall be:

- # complete for the PLM CQM and PFM,
- # reduced to self-standing pipes and harnesses for the SAT STM,
- # reduced to 4KCCR, 4KCDE, and Compressor simulator in the case of the AVM.

HFI 4K Cooler Team shall perform / support these activities. The instrument and connections mating log books shall be maintained.

A proof test of the integrated helium circuit shall be performed before any other operation on the Cooler.

All produced information shall be recorded by the HFI Instrument Operation Team.

Instrument Configuration:

This integration shall be performed after successful:

- incoming hardware unpacking and autonomous test,
- interface verification.

HFI provided 4K Cooler GSE must also be available.

Specific Requirements on PLM :

Access etc,... to be agreed with Alcatel.

Particular Environmental Constraints :

Planck CQM, STM and PFM shall be maintained in class 100 000 or better at least locally.

Alcatel provided particulate and molecular contamination witness plates shall be used to record accumulated deposits.

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Success Criteria:

No mating problem of hardware should be detected.

No He leak should be detected at the specified rate.

This 4K Cooler physical integration success is one of the prerequisites allowing to go to the following step of AIT.

Duration:

Less than a week (TBC).

Please also note that other Planck AIT activities can be on-going in the meantime.

Applicable:

CQM

STM

AVM

PFM

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Title: 0.1K Cooler pneumatic integration on Planck
TRS-P-HFI-UFT-3 (H-P-HFI-TRS-0008)

Experiment: Planck HFI

Objectives:

To assemble Planck 0.1K Cooler helium circuits, clean them and pre-fill them.

To perform a cooler functional test at ambient condition.

Please also refer to draft "Installation of the 0.1K Dilution Cooler on the Spacecraft".

Test Description:

Please also refer to "Installation of the 0.1K Dilution Cooler on the Spacecraft".

Note that the level of integration to be performed:

will not include the Helium on-board storage units for the PLM CQM,

complete for the SAT STM,

complete for the PLM PFM.

HFI 0.1K Cooler Team shall perform / support these activities with Alcatel. The instrument and connections mating log books shall be maintained.

A proof test of the integrated helium storage circuit shall be performed before any other operation on the Cooler.

Tanks shall be filled up to 20bars, helium lock-up circuit 30/40 bars (SAT;STM).

All fluidic connections shall be leak tested.

All produced information shall be recorded by the Instrument team.

Instrument Configuration:

This integration shall be performed after successful:

- incoming hardware autonomous test
- and interface verification.

HFI delivered 0.1K Cooler GSE must be available, including the Tank Filling PGSE for SAT STM & PFM, and the Isotopes Supply Unit for the PLM CQM.

Leak test detector and vacuum pump

Specific Requirements on PLM :

Access etc,... to be agreed with Alcatel.

Access to 18K dilution connector for CQM.

Access to 300K dilution connector for CQM and PFM.

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Particular Environmental Constraints :

Planck CQM, STM and PFM shall be maintained in class 100 000 or better at least locally.

Alcatel provided particulate and molecular contamination witness plates shall be used to record accumulated deposits.

Success Criteria:

No mating problem of hardware should be detected.

He leak rate should be less than TBD.

This 0.1K Cooler physical integration success is one of the prerequisites allowing to go to the following step of AIT.

Duration:

One week.

However a stored helium pressure measurement involving CCS and HFI switch on shall be needed to check leaks after a week or two.

Please also note that other Planck AIT activities can be on-going in the meantime.

Applicable:

CQM

STM

AVM

PFM

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Title: HFI ambient temperature individual commissioning

TRS-H-HFI-UFT-4 (H-P-HFI-TRS-0009)

Experiment: Planck HFI

Objectives:

To demonstrate electrical and software compatibility between HFI and Planck SVM or its simulator during an end-to-end functional test.

To validate timing signal exchanges, TM/TC interface and database.

Test Description:

A progressive test of all electrical and software functionalities shall be performed.

This activity sequence shall repeat the instrument turn-on, representative run mode(s) and switch-off sequences validated at instrument level.

After SVM or simulator switch-on sequence the HFI commissioning shall include:

- DPU switch on and boot,
- On-Board Time delivery & acknowledge,
- HSK packets production and verification,
- Individual TCs systematic sending (by the CCS), acknowledgement and verification,
- Time-tagged sample procedures sending, commands acknowledgment and verification (TBC),
- Different types of TM packets verification (all of them),
- End-to-end (TBC) database verification:

All TCs,

All TM parameters,

Yellow/Red limits (TBC),

Transfer functions (TBC),

CCS RTA validation (TBC)

- All baseline procedures running (including soft shut down one at the end).

Level of test may vary between CQM, AVM and FM.

HFI Instrument Operation Team shall be present during the test and maintain the instrument log book.

All produced data including sent commands shall be recorded, archived by the CCS and transmitted on-line to the delivered HFI EGSE for real time assessment by HFI IOT team and archiving.

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Instrument Configuration:

This commissioning shall be performed after successful mechanical and electrical integration:

- of all HFI units with the PPLM & SVM or its representative simulator,
- of HFI delivered EGSE with the CCS or its representative simulator.

HFI shall be the only new on-board hardware tested during this phase.

This test being performed at room temperature: Coolers operation shall be limited both in representativeness or duration for both 4K and 0.1K.

Specific Requirements on PLM :

To be written by Alcatel.

Particular Environmental Constraints :

HFI delivered CQM - STM and PFM hardware shall be maintained in class 100 000 or better.

Alcatel provided particulate and molecular contamination witness plates shall be used to record accumulated deposits.

Success Criteria:

No difference should be detected between instrument level test data and commissioning data / instrument behaviour.

This commissioning success shall allow going to the following step of AIT i.e. Planck payload combined test.

Duration:

ESA/ASPI defined (two days should be enough)

Could be in parallel with some other activity.

Applicable:

CQM

STM

AVM

PFM

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Title: Payload combined functional test at room temperature

TRS-P-HFI-UFT-5 (H-P-HFI-TRS-0010)

Experiment: **Planck HFI**

Objectives:

To demonstrate electrical and software compatibility between HFI and Planck SVM with LFI and Sorption Cooler running in parallel.

To validate delivered database under such condition.

To demonstrate Planck and Central Check-out System ability to manage Instruments loads in terms of TM and TC traffic, power, real time analysis,...

Unfortunately, present hardware foreseen availability shall postpone this test to AVM and PFM ones.

Test Description:

Sorption Cooler, LFI and HFI shall be sequentially turned on during this phase.

A progressive test of all HFI electrical interface and performance shall be performed.

This activity sequence shall repeat the instrument individual commissioning sequences as previously validated. Test sequences shall be simplified in order to shorten them and avoid duplication (no full database validation,...).

After SVM or simulator switch-on, Sorption Cooler switch on and LFI switch on sequence (which is the most probable flight turn-on sequence) it shall include:

- HFI DPU switch on and boot,
- Simultaneous On-Board Time delivery to all "users" & acknowledge,
- Simultaneous HSK packets production and verification,
- "Simultaneous" Individual TC sending, acknowledge and verification,
- Simultaneous Time tagged Procedure sending to all instruments, acknowledgment and verification (TBC),
- Different types of TM packets verification,
- CCS RTA validation (TBC).

HFI Instrument Operation Team shall be present during the test and shall maintain the instrument log book.

All produced data including all sent commands shall be recorded by the CCS and transmitted on-line to the delivered HFI EGSE for real time assessment. These data shall be further on archived in HFI DPC database.

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Instrument Configuration:

This combined test shall be performed:

- after successful mechanical and electrical integration:
- successful individual commissioning of HFI, LFI and Sorption Cooler with the SVM or its representative simulator,
- successful integration of the HFI, LFI and Sorption Cooler delivered EGSE with the CCS or its representative simulator.

Specific Requirements on PLM :

A few days duration can be foreseen for this complex test, one way to save a large amount of time would be to run it non-stop, day and night, thus saving daily start-up and switch off of involved hardware.

Particular Environmental Constraints :

HFI delivered CQM - STM and PFM hardware shall be maintained in class 100 000 or better.

Alcatel provided particulate and molecular contamination witness plates shall be used to record accumulated deposits.

Success Criteria:

No difference should be detected between instrument individual commissioning test data and payload combined test data / instrument behaviour.

Duration:

ESA/ASPI defined (a few days TBC)

<i>Applicable:</i>	CQM	<input type="checkbox"/>
	STM	<input type="checkbox"/>
	AVM	<input checked="" type="checkbox"/>
	PFM	<input checked="" type="checkbox"/>

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Title: **On-Board Software Maintenance**
TRS-P-HFI-UFT-6 (H-P-HFI-TRS-0011)

Experiment: **Planck HFI**

Objectives:

This activity objective is three fold:

- to demonstrate the ability to dump, compare, patch / re-load HFI on-board software,
- to validate involved data buses traffic capabilities and transfer durations evaluation,
- to check instruments and spacecraft software new versions compatibility (TBC) prior to installation on more advanced PPLM/SVM models.

Test Description:

This activity sequence shall repeat the instrument software maintenance sequences validated at instrument level.

After SVM or simulator switch-on, Sorption Cooler switch on and LFI switch on sequence *

(which is the most probable flight turn-on sequence) it shall include:

- HFI, DPU switch on and boot,
- On-Board Time delivery & acknowledge,
- HSK packets production and verification,
- HFI resident on-board software dump and verification,
- Validated software or patch uploading, acknowledgment and completion verification,
- New on-board software dump and verification,
- Restart HFI with modified on-board software,
- Perform shortened instrument functional test.

HFI Instrument Operation Team shall be present during this test first performance and maintain the instrument log book. For further new on-board software compatibility checks HFI could provide a de-located support.

All produced data including commanding shall be recorded by the CCS and transmitted on-line to the delivered HFI local EGSE or IAS resident one for real time assessment and archiving.

* LFI and SCS being on even if not mandatory for HFI software up / down loading, is needed to check that loads on both involved hardware and software are supported in what is the nominal use mode.

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Instrument Configuration:

This activity shall be performed after successful electrical integration of HFI with the SVM or its representative simulator and of HFI provided EGSE with the CCS (the same being true for LFI and the SCS).

HFI provided patch shall have undergone the full agreed software validation process successfully.

Specific Requirements on PLM :

This activity shall be performed: after successful electrical integration of HFI, LFI and SCS, delivered EGSE with the CCS or its representative simulator including database transfer functionalities.

Particular Environmental Constraints :

HFI delivered CQM and PFM shall always be maintained in class 100 000 or better.

There are no cleanliness requirements on AVM if performed after CQM AIT completion.

Alcatel provided particulate and molecular contamination witness plates shall be used to record accumulated deposits.

Success Criteria:

TM/TC traffic shall have been successfully supported by all involved buses.

After required database update no change in compatibility between HFI and SVM should be observed when running the new up-loaded software.

If applicable the new software should provide correction to detected fault.

Duration:

Two days TBC by Alcatel

Applicable:

CQM (TBC)	<input checked="" type="checkbox"/>
STM	<input type="checkbox"/>
AVM	<input checked="" type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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Title: FPU versus Telescope Alignment Check

TRS-P-HFI-UFT-7 (H-P-HFI-TRS-0012)

Experiment: Planck HFI

Objectives:

The check objectives are to measure and if necessary adjust HFI FPU (through LFI one) location and orientation versus Planck telescope optical focal plane.

For detailed figures on measurement and adjustment accuracies please refer also to HFI / Planck Instrument Alignment Plan (annex to IID-A).

Test Description:

To be written by Alcatel.

HFI Instrument Operation Team shall be present during this test first performance and shall maintain the instrument log book as needed.

All produced data shall be recorded by Alcatel and transmitted to HFI IOT for assessment / archiving.

Instrument Configuration:

HFI FPU has been integrated in PPLM.

Specific Requirements on PLM :

This activity shall be performed after successful PPLM mechanical integration, including telescope and HFI/LFI FPU compound.

Particular Environmental Constraints :

HFI delivered CQM - STM and PFM shall always be maintained in class 100 000 or better.

Alcatel provided particulate and molecular contamination witness plates shall be used to record accumulated deposits.

Success Criteria:

After required adjustments if any, alignment measurements are within specification.

For detailed figures on measurement and adjustment accuracies please refer also to TBD applicable Alignment Plan

Duration:

To be defined by ESA/ASPI

Applicable:	CQM	<input checked="" type="checkbox"/>
	STM	<input checked="" type="checkbox"/>
	AVM	<input type="checkbox"/>
	PFM	<input checked="" type="checkbox"/>

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Title: **Prior to Vibration 0.1K Cooler tanks filling**

TRS-P-HFI-UFT-8 (H-P-HFI-TRS-0013)

Experiment: **Planck HFI**

Objectives:

The objective is to fill HFI Dilution Cooler different volumes up to the 30/40 bars required to put the Dilution storage system in vibration compatible configuration.

Test Description:

Dilution Cooler temperatures and pressures shall be monitored during filling up operation.

Filling speed shall be slow enough to avoid tanks / pipes temperature raising above 40°C.

Final pressure shall be recorded with tank temperature.

Instrument Configuration:

This activity shall be performed after successful mechanical integration of the HFI Dilution Cooler and Dilution Cooler proof test.

Dedicated 0.1K PGSE, (TF-PGSE) as well as HFI EGSE shall be used.

Specific Requirements on PLM :

Due to low pressure involved in this activity it is not foreseen to imply any specific safety requirement.

HFI shall be powered up in order to monitor Helium pressure and temperature measurements included into instrument HK TM.

Particular Environmental Constraints :

HFI delivered SAT STM and PFM shall always be maintained in class 100 000 or better.

Particulate and molecular contamination witness plates shall used to record accumulated deposits.

During Instrument to PGSE connection activity local particulate cleanliness shall be better than TBD.

Alcatel provided particulate and molecular contamination witness plates shall be used to record accumulated deposits.

Success Criteria:

Room temperature in tanks pressure measurements shall be as specified for allowing vibration testing, (or long duration storage,...).

Duration:

Two days TBC

Applicable:

CQM	<input type="checkbox"/>
STM	<input checked="" type="checkbox"/>
AVM	<input type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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Title: **0.1K Cooler Leak Test**

TRS-P-HFI-UFT-9 (H-P-HFI-TRS-0014)

Experiment: **Planck HFI**

Objectives:

To check that once integrated on Planck there are no leaks in HFI Dilution Cooler helium circuits.

Test Description:

An Helium detector sniffer shall be used at the level of dilution cooler pneumatic connectors.

Precision pressure and temperature measurements included in instrument HSK telemetry packets shall be used to monitor stored helium quantity.

Instrument Configuration:

HFI provided PGSE is available.

Dilution Cooler is integrated on Planck.

This test may have to be run at different occasions during AIT: during integration, just after HFI cooler integration, after vibration, before cryo-test, after cryo-test,... before launch.

Specific Requirements on PLM :

Pneumatic connectors have to be accessed to by the sniffer.

Spacecraft and HFI have to be switched on to measure stored helium pressure.

Other tests may be going on during this phase.

Particular Environmental Constraints :

HFI delivered CQM - STM and PFM shall always be maintained in class 100 000 or better.

Alcatel provided particulate and molecular contamination witness plates shall be used to record accumulated deposits.

Success Criteria:

Leak rate is lower than TBD

Duration:

A few hours to be confirmed by ESA/ASPI

<i>Applicable:</i>	CQM	<input checked="" type="checkbox"/>
	STM	<input checked="" type="checkbox"/>
	AVM	<input type="checkbox"/>
	PFM	<input checked="" type="checkbox"/>

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Title: 4K Cooler Leak Test

TRS-P-HFI-UFT-31 (H-P-HFI-TRS-0015A)

Experiment: **Planck HFI**

Objectives:

To check that once integrated on Planck there are no leaks in HFI 4K helium circuits.

Test Description:

An Helium detector sniffer shall be used at the level of dilution cooler pneumatic connectors.

Precision pressure and temperature measurements included in instrument HSK telemetry packets shall be used to monitor stored helium quantity.

Instrument Configuration:

Dilution Cooler is integrated on Planck.

This test may have to be run at different occasions during AIT: during integration, just after HFI cooler integration.

Specific Requirements on PLM :

Pneumatic connectors have to be accessed to by the sniffer.

Other tests may be going on during this phase.

Particular Environmental Constraints :

HFI delivered CQM - STM and PFM shall always be maintained in class 100 000 or better.

Alcatel provided particulate and molecular contamination witness plates shall be used to record accumulated deposits.

Success Criteria:

Leak rate is lower than TBD

Duration:

A few hours to be confirmed by ESA/ASPI

Applicable:

CQM	<input checked="" type="checkbox"/>
STM	<input checked="" type="checkbox"/>
AVM	<input type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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Title: **HFI Short Functional Test**

TRS-P-HFI-UFT-10

(H-P-HFI-TRS-0015B -Numberging problem)

Experiment: **Planck HFI**

Objectives:

The objectives are:

- to establish an instrument status template that shall be used as a reference to which compare HFI parameters and functionalities after each important step of AIT program,
- to replay the same validated test after different steps of AIT and compare obtained performances with reference ones.

This HFI SFT shall thus be run again at different occasions during AIT.

Test Description:

A predefined command sequence shall be run.

This sequence shall have been previously validated at instrument level.

Minor change(s) may have to be introduced to take into account lessons learned during payload combined functional test.

Instrument Configuration:

HFI must have been electrically integrated and tested on S/C.

HFI EGSE is integrated with CCS and is ready to be operated.

No specific hardware preparation should be required.

Specific Requirements on PLM :

No specific requirement

SVM (and CCS) shall be ready to be operated.

Particular Environmental Constraints :

HFI delivered CQM – STM and PFM shall always be maintained in class 100 000 or better.

Alcatel provided particulate and molecular contamination witness plates shall be used to record accumulated deposits.

Success Criteria:

No change is observed in HFI functionalities and parameters value.

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Duration:

2 hours, half a day with EGSE/CCS and S/C start-up and switch-off TBC by Alcatel/Alenia

Applicable:

CQM	<input checked="" type="checkbox"/>
STM	<input checked="" type="checkbox"/>
AVM	<input checked="" type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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Title: Eigen modes identification and vibration tests

TRS-P-HFI-UFT-11 (H-P-HFI-TRS-0016)

Experiment: Planck HFI

Objectives:

The objective are:

- to verify that no structural change caused by environment testing has appeared in HFI identified areas,
- to perform required environment mechanical tests.

Test Description:

Vibrations shall be injected at a level agreed with ESA/Alcatel.

An "HFI Short Functional Test" shall be performed at different stages between the mechanical test sequences.

Instrument Configuration:

HFI mechanical (and electrical) integration has been successfully completed.

HFI is passive during mechanical tests.

As FS units the 4KCCR, 4KCDE, 4KCCU & 4KCAU "CQMs" are not involved in STM mechanical tests.

Specific Requirements on PLM :

Prior to these tests a TBD number of three axes accelerometers shall have been installed at to be agreed locations.

Particular Environmental Constraints :

HFI delivered STM and PFM shall always be maintained in class 100 000 or better.

Alcatel provided particulate and molecular contamination witness plates shall be used to record accumulated deposits.

Success Criteria:

No significant change is observed in HFI Eigen mode frequencies between before and after environment individual tests (Sine, Random, Acoustic.)

Duration:

ESA/ASPI defined

Applicable:

CQM	<input type="checkbox"/>
STM	<input checked="" type="checkbox"/>
AVM	<input type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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Title: Cryogenic Test Preparation

TRS-P-HFI-UFT-26 (H-P-HFI-TRS-0017)

Experiment: Planck HFI

Objectives:

To have HFI and necessary ground equipment ready for Cryo-test to start.

Test Description:

To have HFI necessary ground equipment delivered, unpacked, verified.

To have HFI and this equipment connected and verified.

To validate all added sensors functionality (T°, vibration and micro-vibration, heaters,...).

This includes connection on HFI of the pre-cooling circuit and of the dilution exhaust mixture retrieval pipe(s) + 2 extra pipes for He3 and He4.

To have HFI dilution cooler (CQM TBC and) PFM tanks filled with necessary helium quantity.

"HFI Short Functional Test" is run.

The compliance of micro-vibrations generated by the cryo-facility with HFI IIDB specification is verified.

Instrument Configuration:

HFI agreed configuration for CQM / FM is integrated in Planck.

HFI provided EGSE/PGSE have been successfully delivered, unpacked and autonomously tested, connected and tested.

Specific Requirements on PLM :

To be written by Alcatel

Particular Environmental Constraints :

HFI delivered CQM and PFM shall always be maintained in class 100 000 or better.

Alcatel provided particulate and molecular contamination witness plates shall be used to record accumulated deposits.

Success Criteria:

HFI is okay for Cyro-facility door closure.

Duration:

ESA/ASPI defined

A few days for HFI activities

Applicable:

CQM	<input checked="" type="checkbox"/>
STM	<input type="checkbox"/>
AVM	<input type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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Title: Cryogenic Facility Cool down

TRS-P-HFI-UFT-27 (H-P-HFI-TRS-0018)

Experiment: Planck HFI

Objectives:

To simulate in-flight passive cooldown of PPLM.

To validate passive cooldown duration / modelling.

To cool down the Cryo test facility from room temperature without contaminating instrument units particularly the Focal Plane Unit(s).

Success of this sequence applied to CQM shall validate it for PFM application.

Test Description:

To cool down the Cryo test facility from room temperature without contaminating instrument units particularly the Focal Plane Unit(s).

The HFI / LFI Focal Plane Unit shall be maintain warmer than the environment during all facility cool down sequence.

Instrument Configuration:

HFI DPU and REU shall be switched on in order to monitor FPU cool-down. .

Specific Requirements on PLM :

To be written by Alcatel.

Particular Environmental Constraints :

Molecular contamination witness plates shall be used to record accumulated deposits in different locations of HFI (TBC) and of the test facility.

As for flight, in order to avoid any plugging : Helium shall be circulated in the Dilution pipes during all cooldown.

Success Criteria:

Alcatel provided molecular contamination witness plate analysis demonstrate that no contamination of HFI occurred.

Dynamic cool down profiles modelling is validated.

Procedure run for CQM is approved for application to PFM.

Duration:

2 weeks (ESA/ASPI defined)

Applicable:

CQM	<input checked="" type="checkbox"/>
STM	<input type="checkbox"/>
AVM	<input type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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Title: Low Temperature Passive Test
TRS-P-HFI-UFT-12 (H-P-HFI-TRS-0019)

Experiment: **Planck HFI**

Objectives:

To collect necessary data to validate PPLM / SVM thermal modelling for this specific situation (and in Liege facility condition) as input to Planck and HFI thermal modelling.

Test Description:

Collect temperature measurements during spacecraft passive cool-down and stabilization.

Instrument Configuration:

HFI is either off, or partly powered as during passive cooldown (i.e. DPU and REU).

Specific Requirements on PLM :

To be written by Alcatel.

Particular Environmental Constraints :

Alcatel provided molecular contamination witness plates shall be used to record accumulated deposits on HFI (TBC) and at different locations of the test facility.

As for flight, in order to avoid any plugging : Helium shall be circulated in the Dilution pipes during all cooldown.

Success Criteria:

Collected data is understood and transmitted to HFI.

Duration:

2 days (ESA/ASPI defined)

Applicable:

CQM	<input checked="" type="checkbox"/>
STM	<input type="checkbox"/>
AVM	<input type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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Title: HFI Active Cooldown

TRS-P-HFI-UFT-13 (H-P-HFI-TRS-0020)

Experiment: Planck HFI

Objectives:

To perform cryo-chain end-to-end functional test.

To collect data necessary to validate HFI cryo-chain transitory phase modelling.

Test Description:

HFI cryo chain including the Sorption Cooler, or simulated one, shall be progressively activated along a flight type scenario but for the HFI Focal Plane Unit pre-cooling loop not to be used in flight. The sequence shall include the temporary activation of HFI heat switches.

Instrument Configuration:

HFI is switched on.

HFI EGSE is on.

HFI PGSE is used.

Specific Requirements on PLM :

PPLM / SVM passive cooling is finished, temperature drift has been lower than to TBD for two days (to be written by Alcatel).

Commands shall be sent to the Sorption Cooler and HFI by the CCS.

For the CQM test the PACE shall be operated through the proper PGSE.

Particular Environmental Constraints :

HFI delivered CQM and PFM shall always be maintained in class 100 000 or better.

Alcatel provided particular and molecular contamination witness plates shall be used to record accumulated deposits on HFI and at facility different locations.

As for flight, in order to avoid any plugging : Helium shall be circulated in the Dilution pipes during all cooldown.

Success Criteria:

HFI detectors have been cooled down to required level i.e. 100mK +/- 5mK.

Planck payload active cool down sequence adapted to ground testing has been validated.

Duration:

About 16days (about 8 days if pre-cooling loop is used during TRS0018)

Applicable:	CQM	<input checked="" type="checkbox"/>
	STM	<input type="checkbox"/>
	AVM	<input type="checkbox"/>
	PFM	<input checked="" type="checkbox"/>

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Title: HFI Cold Functional Test

TRS-P-HFI-UFT-14 (H-P-HFI-TRS-0021)

Experiment: **Planck HFI**

Objectives:

To evaluate HFI detection performance in integrated flight like configuration.

Test Description:

To measure signal detected by different HFI 0.1K detectors (absolute level and variations).

To observe HFI Focal Plane Unit temperatures : absolute level, monotonic drift and periodic variations.

Instrument Configuration:

HFI in nominal observation mode.

HFI provided EGSE and PGSE are in operation.

Specific Requirements on PLM :

SVM/PPLM in steady state. If present LFI is not operating.

Particular Environmental Constraints :

Alcatel provided molecular contamination witness plates shall be used to record accumulated deposits on HFI and at different locations of the test facility.

Success Criteria:

HFI performance are as predicted (established by prior to delivery test and calibration modelling)

Duration:

3 days

Applicable:

CQM

STM

AVM

PFM

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Title: HFI Cold EMC Conductive Test

TRS-P-HFI-UFT-15 (H-P-HFI-TRS-0022)

Experiment: Planck HFI

Objectives:

Perform as realistic as possible HFI susceptibility to conducted perturbations under cold environment.

Test Description:

To be agreed and written with Alcatel: i.e. perturbations / limit levels are injected on the different lines from outside of the cryo chamber for the CQM test and for PFM.

Ways to inject inside the chamber have to be defined.

Some dedicated current probes shall be placed at a TBD location on lines/pipes to measure the injected current spectrum from the S/C to the experiment.

Instrument Configuration:

HFI is running in nominal observation mode.

HFI EGSE and PGSE are in operation.

Specific Requirements on PLM :

The electrical grounding of the spacecraft and the related electrical units shall be isolated from the TV chamber grounding, as shown in the figure hereafter.

Particular Environmental Constraints :

Alcatel provided molecular contamination witness plates shall be used to record accumulated deposits on HFI and at different locations of the test facility.

Success Criteria:

HFI performs as predicted.

Duration:

4 days

Applicable:

CQM

STM

AVM

PFM

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Title: HFI – LFI Cold Compatibility Test

TRS-P-HFI-UFT-16 (H-P-HFI-TRS-0023)

Experiment: Planck HFI

Objectives:

To evaluate in cold conditions HFI sensitivity while LFI is running in different modes.

Test Description:

HFI and SVM being in steady state, LFI different modes shall be exercised:

- # Stop TSA activity then restore it,
- # Stop phase switches individually then re-activate them,
- # Stop all phase switches,
- # Switch BEU power off,
- # Switch REBA power off.

Instrument Configuration:

HFI is running in stable observation mode.

HFI EGSE and PGSE are in operation.

Specific Requirements on PLM :

Planck is in steady state running mode

LFI non-op compensation heaters are progressively activated as units are powered off.

Particular Environmental Constraints :

Alcatel provided molecular contamination witness plates shall be used to record accumulated deposits on HFI and at different locations of the test facility.

Success Criteria:

Well established periods of running LFI in different modes have been recorded.

As LFI is off at the end of it, it is suggested to run "HFI Cold Stand Alone Test" at the issue of this compatibility test.

Duration:

ESA/ASPI defined

Applicable:

CQM	<input type="checkbox"/>
STM	<input type="checkbox"/>
AVM	<input type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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Title: HFI Cold Stand Alone Test
TRS-P-HFI-UFT-17 (H-P-HFI-TRS-0024)

Experiment: Planck HFI

Objectives:

As part of compatibility with LFI the objective is to characterize HFI performances in stand alone condition.

Test Description:

LFI is switched off.

LFI non-op compensation heaters are powered.

Planck SVM is running in steady state. Some Spacecraft subsystems may be switched off and on temporarily to identify possible interference

Instrument Configuration:

HFI is running in nominal steady observation mode.

HFI EGSE and PGSE are in steady operation.

Specific Requirements on PLM :

To be written by Alcatel.

Particular Environmental Constraints :

Alcatel provided molecular contamination witness plates shall be used to record accumulated deposits on HFI and at different locations of the test facility.

Success Criteria:

HFI baseline sensitivity has been determined and shall be compared to that when LFI running.

Interferences (or preferably !) no interferences have been detected in the SVM different modes.

Duration:

One day

Applicable:

CQM	<input checked="" type="checkbox"/>
STM	<input type="checkbox"/>
AVM	<input type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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Title: HFI Susceptibility to SCS radiator T° change Test

TRS-P-HFI-UFT-18 (H-P-HFI-TRS-0025)

Experiment: Planck HFI

Objectives:

To measure under as realistic as possible conditions the effect of the Sorption Cooler warm radiator temperature variation on instrument pre-cooling temperature and stability and on HFI detectors.

Test Description:

Sorption Cooler radiator shall be changed by steps (at least 2 TBC) of a few degrees.

Stabilisation shall be waited after each change.

HFI FPU and other units temperature shall be recorded as well as spacecraft temperatures.

Instrument Configuration:

HFI is in nominal observation mode.

Detectors temperature is stabilized (drift is lower than 1mK per day TBC).

HFI EGSE and PGSE are in operation.

Specific Requirements on PLM :

Change of radiator temperature shall be:

performed without other dissipation change on PPLM and SVM,

monitored / measured.

Particular Environmental Constraints :

Alcatel provided molecular contamination witness plates shall be used to record accumulated deposits on HFI and at different locations of the test facility.

Success Criteria:

Temperature measurements have been collected and transmitted to HFI team in order to validate the modelling, HFI detector's too.

Duration:

One day (ESA/ASPI defined)

Applicable:

CQM	<input checked="" type="checkbox"/>
STM	<input type="checkbox"/>
AVM	<input type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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Title: HFI Coolers Failure Test

TRS-P-HFI-UFT-19 (H-P-HFI-TRS-0026)

Experiment: **Planck HFI**

Objectives:

To validate modelling for different cooler failure impact on instrument thermal behaviour for warm-up and recovery.

To evaluate effect of coolers operation on HFI noise level in detectors signal.

Test Description:

Each cooler shall be individually stopped for a limited duration.

Warm up shall be monitored up to TBD temperature it shall then be returned to operation.

Temperatures shall be recorded during the warm-up and the following re-cooling.

HFI detectors output shall be monitored / recorded.

Instrument Configuration:

HFI is in nominal observation mode,

HFI EGSE and PGSE are in operation.

Duration of each cooler stopping as evaluated from models runing is available.

Specific Requirements on PLM :

To be written by Alcatel including management of coolers compensation heaters.

Particular Environmental Constraints :

Alcatel provided molecular contamination witness plates shall be used to record accumulated deposits on HFI and at different locations of the test facility.

Success Criteria:

Warm-up duration modelling is confirmed at least during an initial part of it.

CQM involved procedures are validated and applicable to PFM.

Duration:

A few days (derived from modelling)

Applicable:

CQM	<input checked="" type="checkbox"/>
STM	<input type="checkbox"/>
AVM	<input type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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Title: HFI Cryo Facility warm-up
TRS-P-HFI-UFT-28 (H-P-HFI-TRS-0027)

Experiment: Planck HFI

Objectives:

To return Cryo test facility to room temperature without contaminating instrument units, particularly the Focal Plane Unit.

Warm-up data shall be collected to validate corresponding modelling.

Success of this sequence applied to CQM shall validate it for PFM application.

Test Description:

The HFI / LFI (or LFI STM for CQM) Focal Plane Unit shall be maintained warmer than the environment during all facility warm-up sequence.

Instrument Configuration:

HFI is switched off.

HFI EGSE and PGSE are available in case of need.

Specific Requirements on PLM :

To be written by Alcatel.

Particular Environmental Constraints :

Alcatel provided molecular contamination witness plates shall be used to record accumulated deposits on HFI and at different locations of the test facility.

Success Criteria:

Molecular contamination witness plate analysis demonstrate that no contamination of HFI occurred. Procedure run for CQM is approved for application to PFM.

Warm-up Spacecraft and facility temperature measurements have been transmitted to HFI team.

Duration:

5 days (ESA/ASPI defined) if pre-cooling loop is used for focal plane unit warm-up

Applicable:	CQM	<input checked="" type="checkbox"/>
	STM	<input type="checkbox"/>
	AVM	<input type="checkbox"/>
	PFM	<input checked="" type="checkbox"/>

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Title: HFI Hardware removal from Cryo Facility

TRS-P-HFI-UFT-5 (H-P-HFI-TRS-0028)

Experiment: Planck HFI

Objectives:

To remove all test hardware mounted either on the facility or on Planck and pack it.

To retrieve / pack Dilution Cooler Pneumatic GSE and EGSE.

Test Description:

HFI team shall witness / participate into HFI EGSE / PGSE related activities.

Test piping shall be purged from helium prior to be dismantled.

Instrument Configuration:

HFI is mounted on Planck.

HFI is passive.

Specific Requirements on PLM :

To be written by Alcatel.

Particular Environmental Constraints :

Alcatel provided molecular contamination witness plates shall be used to record accumulated deposits on HFI and at different locations of the test facility.

Success Criteria:

All peripheric hardware has been removed.

Planck is removed from the cryo-facility.

Duration:

ESA/ASPI defined

Applicable:

CQM	<input checked="" type="checkbox"/>
STM	<input type="checkbox"/>
AVM	<input type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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Title: HFI CQM dismounting, packing & shipping

TRS-P-HFI-UFT-30 (H-P-HFI-TRS-0029)

Experiment: Planck HFI

Objectives:

To dismount, pack and ship all HFI CQM / STM units that participated into Planck CQM / STM AIT activities as required.

Test Description:

All HFI CQM units are dismounted from Planck PLM CQM JIG one by one. They are then retained for SAT STM testing or packed and shipped either to PI team or to Alenia for those becoming "AVM".

HFI team could be directly involved in specific operations of dismounting / packing.

Dilution Cooler circuits are purged prior to dismounting.

Instrument Configuration:

Instrument is switched off.

Specific Requirements on PLM :

CQM AIT activities are completed.

To be written by Alcatel

Particular Environmental Constraints :

Alcatel provided molecular contamination witness plates shall be used to record accumulated deposits on HFI.

Success Criteria:

HFI CQM units are delivered as agreed either to SAT STM AIT team, to PI team or to Alenia.

Duration:

ESA/ASPI defined

Applicable:

CQM	<input checked="" type="checkbox"/>
STM	<input checked="" type="checkbox"/>
AVM	<input type="checkbox"/>
PFM	<input type="checkbox"/>

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5.2 LFI TRS

Title: **Warm Unit Inegration**
TRS-P-LFI-UFT-1

Experiment: **Planck LFI**

Objectives:
Perform the warm unit electrical inegration

Test Description:
TBD

Instrument Configuration:
TBD

Specific Requirements on PLM :
TBD

Particular Environmental Constraints :
TBD

Success Criteria:
TBD

Duration:
TBD

Applicable:

CQM	<input type="checkbox"/>
STM	<input type="checkbox"/>
AVM	<input checked="" type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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Title: **Knee Frequency variation from 20K to 4K**

TRS-P-LFI-UFT-3

Experiment: **Planck LFI**

Objectives:

- Check receiver susceptibility to variations in reference signal
- Check variation in knee frequency when reference load temperature changes from 20K to 4.8K

Test Description:

Sequence

- Science and HK data are acquired continuously during 4K cool-down

Data analysis

- Correlate differential output and total power outputs with temperature of 4K loads
- Evaluate susceptibility to variation in 4K reference signal, compare with results obtained during RCA testing
- Evaluate knee frequency at some points during cool down

Remarks

- It is necessary to know the slope of the temperature cool-down, so that it will be possible to reproduce the same trend in the RCA.
- It is necessary to verify that this phase can be considered representative of the 4K cooldown as it will happen in flight.
- It must be checked that the temperature does not vary too much in the timescale necessary for the calculation of the knee frequency.

Instrument Configuration:

- Sky temperature at 4K
- Load temperature varying from 20K to ~ 4K
- Front-end at 20K
- Back-end at 300K

Specific Requirements on PLM :

TBD

Particular Environmental Constraints :

TBD

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Success Criteria:

TBD

Duration:

1 day

Applicable:

CQM

STM

AVM

PFM

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Title: **Functionnal Test in flight Condition**

TRS-P-LFI-UFT-4

Experiment: **Planck LFI**

Objectives:

- Switch on the LFI instrument
- Verify RCA functionality after facility pump-down and cool-down (including LFI temperature sensors)
- Verify temperature distribution in the instrument
- Evaluate receiver performance in failure case scenario of the HFI 4K cooler (in particular the receiver knee frequency with 20K reference signal)

Test Description:

Sequence

- Perform LFI switch-on sequence, verify that sequence completes successfully, start with phase switches OFF
- Set bias to front-end amps to nominal values
- Check HK data relative to receiver functionality (including temperature sensors)
- Acquire data for TBC minutes from all channels simultaneously
- Switch ON phase switches
- Acquire data for TBC minutes from all channels simultaneously
- Switch OFF phase switches
- Acquire data for TBC minutes from all channels simultaneously
- Switch ON phase switches again
- Acquire data for TBC minutes from all channels simultaneously
- Acquire data from temperature sensors

Data analysis

- Check temperature HK data and verify functionality of temperature sensors
- Check absolute levels and noise properties in all channels
 - Check that signal levels and noise rms are similar in detectors in the same frequency channel
 - Check that signal properties before and after phase switches turn off are the same
- Evaluate radiometer performances with 20K reference signal and compare with similar results obtained at RCA level.
- Verify temperature distribution and compare with thermal model predictions

Remark

- Needed time for analysis TBD

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Instrument Configuration:

- Sky signal at ~4K
- Load signal at ~20K
- Front-end at ~20K
- Back-end at ~300K

Specific Requirements on PLM :

TBD

Particular Environmental Constraints :

TBD

Success Criteria:

TBD

Duration:

1 day.

Applicable:

CQM	<input type="checkbox"/>
STM	<input type="checkbox"/>
AVM	<input type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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**Title LFI end-to-end Functionnal test at
ambient condition**

TRS-P-LFI-UFT-5

Experiment: Planck LFI

Objectives:

- Perform a switch-on, switch-off sequence
- Verify RCA functionality
 - Check that channels in same frequency chain have similar noise level
 - Check that phase switches work properly
 - Check functionality of LFI temperature sensors

Test Description:

Test Sequence

- Perform LFI switch-on sequence, verify that sequence completes successfully, start with phase switches OFF
- Set bias to front-end amps to avoid saturation.
- Check HK data relative to receiver functionality (including temperature sensors)
- Acquire data for TBC minutes from all channels simultaneously
- Switch ON phase switches
- Acquire data for TBC minutes from all channels simultaneously
- Switch OFF phase switches
- Acquire data for TBC minutes from all channels simultaneously
- Switch ON phase switches again
- Acquire data for TBC minutes from all channels simultaneously
- Perform LFI switch-off sequence, verify that sequence completes successfully

Data analysis

- Check absolute levels and noise properties in all channels
- Check that signal levels and noise properties are similar in detectors in the same frequency channel and comparable to the results obtained during RCA and LFI testing phases (tests at room temperature)
- Check that signal properties before and after phase switches turn off are the same
- Check that switching frequency is as set by DAE for all channels

Remarks

- The possibility to operate all the LFI radiometers at room temperature is still to be verified for some frequency channels.

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Instrument Configuration:

TBD

Specific Requirements on PLM :

The possibility to operate all the LFI radiometers at room temperature is still to be verified for some frequency channels

Particular Environmental Constraints :

TBD

Success Criteria:

TBD

Duration:

2 days

Applicable:

CQM

STM

AVM

PFM

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Title: **Noise and Stability Check**

TRS-P-LFI-UFT-6

Experiment: **Planck LFI**

Objectives:

- Noise and Stability check, verification of bias parameters

Test Description:

Sequence

- Check noise spectrum and knee frequency at initial conditions
- Verify bias values. Change FEM bias above and below their nominal setting by a fixed, pre-defined quantity (TBD) for all the radiometric chains simultaneously. After each change, data are monitored and collected undisturbed for a pre-defined amount of time (TBD). Then the bias settings are switched back to the nominal value for all FEMs.
- Induce slight (values TBD) variations in the satellite power supply to evaluate susceptibility of the radiometric response.

Data analysis

- Calculate gain, noise properties and power consumption at beginning of test (with nominal bias values).
- Recalculate gain, noise properties and power consumption after each bias change. Verify that the radiometers respond correctly and in a repeatable way to bias changes. Verify that the nominal values correspond to the optimal values with regards to gain, noise performances and power consumption.
- Recalculate noise properties after each change in the satellite power supply; evaluate susceptibility of the radiometric output to such changes; verify that the radiometers respond correctly and in a repeatable way to power supply changes.

Remarks

- ❖ Need to verify feasibility of induced controlled changes in the satellite power supply and quantify such changes in relation to the expected variations.

Instrument Configuration:

- Sky at 4K
- Load temperature at ~ 4.8K (stable)
- Front-end at 20K
- Back-end at 300K

Specific Requirements on PLM :

TBD

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Particular Environmental Constraints :

TBD

Success Criteria:

TBD

Duration:

1 day

Applicable:

CQM

STM

AVM

PFM

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Title: System Noise measurement, linearity and Isolation check

TRS-P-LFI-UFT-7

Experiment: Planck LFI

Objectives:

- System noise measurement, linearity and isolation check

Test Description:

Sequence

- Check noise spectrum and knee frequency at initial conditions
- Linearity and isolation check
 - Temperature of sky target is varied in a ramp of TBD values alternated between 4K and TBD K. At each temperature data are acquired with phase switches ON.
 - Response linearity is verified analysing signal response as a function of the input temperature
 - For each radiometer the isolation of between the two channels is verified to be the same of that measured during the LFI testing campaign
- T_{sys} measurement
 - Temperature of sky target is alternated between 4K and TBD K TBD times. At each temperature data are acquired with phase switches ON.
 - Receiver system temperature is calculated following the Y factor method

Data analysis

- Calculate T_{sys} according to the Y factor method and compare with results from RCA and testing phases
- Verify linearity of signal level versus input signal and compare with results from RCA and testing phases
- Check variation of signal level in the reference load branch when varying the input signal in the sky arm. Estimate channel isolation and compare with estimates from the RCA and LFI testing campaigns

Remarks

- Duration of a single test (i.e. of a set of measurements to calculate T_{sys} , linearity and isolation) must be such that effects from amplifier instabilities are small. This duration time will be known from the results of the RCA and LFI test campaigns and is currently estimated to be TBD minutes
- The sky temperatures used in the tests will be the same used in RCA tests

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Instrument Configuration:

- Sky at 4K
- Load temperature at ~ 4.8K (stable)
- Front-end at 20K
- Back-end at 300K

Specific Requirements on PLM :

TBD

Particular Environmental Constraints :

TBD

Success Criteria:

TBD

Duration:

1 day

Applicable:

CQM	<input type="checkbox"/>
STM	<input type="checkbox"/>
AVM	<input type="checkbox"/>
PFM	<input checked="" type="checkbox"/>

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Title: Long term measurement, stability and knee frequency estimation

TRS-P-LFI-UFT-8

Experiment: Planck LFI

Objectives:

- Long term measurement, stability and knee frequency estimation

Test Description:

Sequence

- Set sky target at 4K, acquire data at nominal conditions for TBD hours from all radiometers simultaneously

Data analysis

- For each detector calculate noise spectrum of total power and differential radiometric output
- Calculate gain modulation factor r from data of different lengths, evaluate "stability" of the optimal r
- Evaluate knee frequency of differential data, check consistency with results from RCA testing campaign, compare with knee frequency evaluated at the end of the 4K stage cooldown
- Check HK temperature data and correlate behaviour with measured signal

Remarks

- It is intended to be a long-term test in which data acquisition runs undisturbed for several hours. This will allow a precise determination of the radiometer knee frequency and the recognition of possible drifts (on the hour time scale) in the measured signal to be correlated with HK data
- Needed availability of 4K load temperature sensor HK
- Need to know the sensitivity and stability characteristics of the temperature of the 4K target

Instrument Configuration:

- Sky at 4K
- Load temperature at ~ 4.8K (stable)
- Front-end at 20K
- Back-end at 300K

Specific Requirements on PLM :

TBD

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Particular Environmental Constraints :

TBD

Success Criteria:

TBD

Duration:

1 day

Applicable:

CQM

STM

AVM

PFM

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Title: **Interference between receiver ON/OFF**

TRS-P-LFI-UFT-9

Experiment: **Planck LFI**

Objectives:

- Interference test between receivers

Test Description:

Sequence

- Acquire data from single receivers (with all the others in OFF state, i.e. with no biases to amplifiers and no data acquisition)

Data analysis

- For each detector calculate noise properties (signal level, rms, spectrum) and compare with the same properties measured with all the instrument ON
- Highlight detectors that show noticeably different properties that may be due to EM interaction with other RCAs. Compare with results obtained during the LFI testing phase.

Remarks

- When the various detectors are switched off there is a perturbation in the focal plane temperature that alters the response of the detector that remains on. The effect must be evaluated (maybe also from dedicated tests at the LFI level) and corrected for in the analysis.

Instrument Configuration:

- Sky at 4K
- Load temperature at ~ 4.8K (stable)
- Front-end at 20K
- Back-end at 300K

Specific Requirements on PLM :

Particular Environmental Constraints :

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Success Criteria:

Duration:

1 day

Applicable:

CQM

STM

AVM

PFM

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Title: **Cold EMC Conductive Test**

TRS-P-LFI-UFT-10

Experiment: **Planck LFI**

Objectives:

- Verify EMC behaviour between LFI and HFI

Test Description:

Sequence

- TBD

Data analysis

- TBD

Remarks

- The EMC tests need to be defined jointly between the LFI and HFI instrument teams
- In principle the concept of the test is to run HFI in a stable configuration and switch the LFI on and off

Instrument Configuration:

- Sky at ~ 4K (stable)
- Load temperature at ~ 4.8K (stable)
- Front-end at 20K
- Back-end at 300K
- Dilution cooler ON, HFI ON and working

Specific Requirements on PLM :

TBD

Particular Environmental Constraints :

TBD

Success Criteria:

TBD

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Duration:

4 days

Applicable:

CQM

STM

AVM

PFM

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Title: LFI Susceptibility to SCS Radiator Change

TRS-P-LFI-UFT-11

Experiment: Planck LFI

Objectives:

Check receiver noise performances versus focal plane temperature

Test Description:

Sequence

- Science and HK data are acquired continuously without any change in radiometer parameters.

Data analysis

- Science and HK data are checked in real time to highlight possible malfunctions. In particular focal plane and back end temperatures are monitored in correspondence to variations in the SCC radiator temperature
- The radiometer noise properties is calculated from the differential output and correlated with the temperature changes in the focal plane

Remarks

- SCC radiator temperature data must be available to LFI team during the test

Instrument Configuration:

- Sky at ~ 4K (stable)
- Load temperature at ~ 4.8K (stable)
- Front-end at ~ 20K (temperature variable according to radiator temperature changes)
- Back-end at ~ 300K
- Dilution cooler ON, HFI ON and working

Specific Requirements on PLM :

TBD

Particular Environmental Constraints :

TBD

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Success Criteria:

TBD

Duration:

TBD

Applicable:

CQM

STM

AVM

PFM

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Title: LFI PID Controller Test

TRS-P-LFI-UFT-12

Experiment: Planck LFI

Objectives:

Check functionality of the PID controller on the LR2 Sorption Cooler cold-end

Test Description:

Sequence

- Science and HK data are continuously acquired during the test
- The PID controller is switched OFF and ON TBD times. The time interval between two different PID states will be of TBD hours, during which data will be collected and analysed
- The PID parameters will be slightly changed from the nominal values to verify the response of the PID system to such changes

Data analysis

- Data will be monitored in real-time to identify possible malfunctions in the instrument and/or in the PID system
- Temperature data collected at the various thermal interfaces (LR2, PID stage, FPU, V-grooves) in the different PID states (ON and OFF) will be analysed to verify the correct and repeatable behaviour of the PID controller
- Temperature data collected at the various thermal interfaces (LR2, PID stage, FPU, V-grooves) with the PID working with different parameters will be analysed to verify that the controller responds to such changes and that the nominal parameters correspond to the optimal configuration in terms of temperature stability and power consumption.
- Radiometer noise properties will be calculated in the different PID stated and will be correlated with the focal plane temperature behaviour.

Remarks

- 1 extra testing day is assumed to be added to the current Alcatel testing plan.
- Sorption Cooler HK data are assumed to be readily available during the test
- The PID parameters are assumed to be changeable during the test

Instrument Configuration:

- Sky at ~ 4K (stable)
- Load temperature at ~ 4.8K (stable)
- Front-end at ~ 20K
- Back-end at ~ 300K

Specific Requirements on PLM :

TBD

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Particular Environmental Constraints :

TBD

Success Criteria:

TBD

Duration:

1 day

Applicable:

CQM

STM

AVM

PFM

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Title **20 K Cooler failure Test**

TRS-P-LFI-UFT-13

Experiment: **Planck LFI**

Objectives:

- Analyse system performances in absence of Sorption Cooler temperature fluctuations

Test Description:

Sequence

- Science and HK data are acquired continuously during this phase

Data analysis

- The first chunk of data (where the FEU and reference loads temperatures are still close to nominal) will be analysed and compared with data taken in nominal conditions to separate the contribution from Sorption Cooler temperature instabilities.
- The performance degradation of LFI with increasing temperatures in the Focal Plane and in the reference loads will be monitored
- Estimated duration for LFI: 0.5 days

Remarks

Instrument Configuration:

- Sky at ~ 4 K
- Load temperature increasing from nominal conditions because of loss of cooling power in 4 K cooler
- Front-end temperature increasing from ~ 20 K because of Sorption Cooler switch off
- Back-end at ~ 300 K

Specific Requirements on PLM :

TBD

Particular Environmental Constraints :

TBD

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Success Criteria:

TBD

Duration:

0,5 day

Applicable:

CQM

STM

AVM

PFM

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Title Specific REBA Functionnal Test

TRS-P-LFI-UFT-14

Experiment: Planck LFI

Objectives:

- Collect uninterrupted data from all receivers over a long period of time (3 days estimated)
- Characterise long term drifts
- Test REBA processing

Test Description:

Sequence

- LFI receivers are operated with nominal parameters; no changes at the level of the detectors during HFI tests. Science and HK data are collected and stored for all detectors.
- REBA functions are tested (e.g. change second quantisation step, switch between different REBA processing types)

Data analysis

- On-line data monitoring to identify possible instabilities due to HFI tests or radiometer malfunctions.
- Off-line data analysis of long term data to characterise drifts and low frequency noise properties (correlating also with radiometer and reference load temperature stability)

Remarks

- Note that this data collection happens during the HFI testing phase, so that the system may not completely "undisturbed". Care will be taken to check for radiometer instabilities occurring in correspondence to changes in the HFI state. (In fact this may serve as a test of LFI in presence of configuration changes in HFI)
- Exchange of information with the HFI team is needed to be able to predict in advance possible interactions between the LFI receivers and the operations foreseen during the HFI testing.
- Other possible LFI tests in this phase:
 - Small bias variations (verify optimisations)

Instrument Configuration:

- Sky at ~ 4K (stable)
- Load temperature at ~ 4.8K (stable)
- Front-end at 20K
- Back-end at 300K
- Dilution cooler ON, HFI ON and working

Specific Requirements on PLM :

TBD

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Particular Environmental Constraints :

TBD

Success Criteria:

TBD

Duration:

3 days

Applicable:

CQM

STM

AVM

PFM

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Title **LFI-Switch off**

TRS-P-LFI-UFT-15

Experiment: **Planck LFI**

Objectives:

- Switch off LFI to Test HFI alone

Test Description:

Sequence

- Perform LFI switch-off sequence, verify that sequence completes successfully

Data analysis

- NA

Remarks

- NA

Instrument Configuration:

- Sky at ~ 4K (stable)
- Load temperature at ~ 4.8K (stable)
- Front-end at 20K
- Back-end at 300K
- Dilution cooler ON, HFI ON and working

Specific Requirements on PLM :

TBD

Particular Environmental Constraints :

TBD

Success Criteria:

TBD

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Duration:

1 day

Applicable:

CQM

STM

AVM

PFM

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Title **LFI Switch-on Again**

TRS-P-LFI-UFT-16

Experiment: **Planck LFI**

Objectives:

- Perform the LFI Switch-on

Test Description:

Sequence

- Perform LFI switch-on sequence, verify that sequence completes successfully

Data analysis

- N/A

Remarks

- N/A

Instrument Configuration:

- ❖ Sky at ~ 4K (stable)
- ❖ Load temperature at ~ 4.8K (stable)
- ❖ Front-end at 20K
- ❖ Back-end at 300K
- ❖ Dilution cooler ON, HFI ON and working

Specific Requirements on PLM :

TBD

Particular Environmental Constraints :

TBD

Success Criteria:

TBD

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<i>Duration:</i> NA

<i>Applicable:</i>	CQM	<input type="checkbox"/>
	STM	<input type="checkbox"/>
	AVM	<input type="checkbox"/>
	PFM	<input checked="" type="checkbox"/>

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Title **LFI 4K Cooler failure test – Cooler OFF**
TRS-P-LFI-UFT-17

Experiment: **Planck LFI**

Objectives:

- Check LFI performances in case of 4K cooler failure, cross-check with results obtained in the case with the 4K cooler in off state (see TRS-P-LFI-UFT-04)
- Separate the contribution of the 4K cooler fluctuations from the contribution of the Sorption Cooler fluctuations in the 4K reference load temperature.

Test Description:

Sequence

- Science and HK data are acquired continuously during the entire test.
- When reference load temperature is stable after 4K cooler switch-off then acquired data are flagged for subsequent noise properties analysis. Acquisition with a stable reference signal at ~ 20 K for at least 5 hours (TBC) is foreseen in this test.

Data analysis

- Science and HK data are checked in real time to highlight possible malfunctions.
- The radiometer noise properties are calculated for the the temperature in the sky shroud.
- The 4K reference load temperature data with the 4K cooler OFF are analysed and correlated with the temperature data obtained with the 4K cooler ON to recognise and separate the contribution of the 4K cooler to temperature fluctuations

Remarks

Instrument Configuration:

- Sky at ~ 4 K
- Load temperature at ~ 20 K (stable)
- Front-end at ~ 20 K
- Back-end at ~ 300 K
- 4K cooler OFF

Specific Requirements on PLM :

TBD

Particular Environmental Constraints :

TBD

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Success Criteria:

TBD

Duration:

1 day (TBC)

Applicable:

CQM

STM

AVM

PFM

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Title **LFI 4K Cooler failure test - Cooler ON**

TRS-P-LFI-UFT-18

Experiment: **Planck LFI**

Objectives:

- Compare receiver response to change in reference load temperature with data acquired in the TRS-P-LFI-UFT-03

Test Description:

Sequence

- Science and HK data are acquired continuously during 4K cooler cool-down

Data analysis

- Correlate differential output and total power outputs with temperature of 4K loads
- Evaluate susceptibility to variation in 4K reference signal, compare with results obtained during the TRS-P-LFI-UFT-03
- Evaluate knee frequency at some points during cool down

Remarks

Instrument Configuration:

- Sky at ~ 4 K
- Load temperature varying from ~ 20 K to nominal conditions (~ 4.8 K)
- Front-end at ~ 20 K
- Back-end at ~ 300 K

Specific Requirements on PLM :

TBD

Particular Environmental Constraints :

TBD

PLANCK INSTRUMENTS TESTING AT PFM S/C LEVELS

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Success Criteria:

TBD

Duration:

1 days

Applicable:

CQM

STM

AVM

PFM