Title: **Instrument Testing on PLM PFM and Satellite Level**

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Issue	Date	Sheet	Description of Change	Release
Draft	06.06.02	all	Draft for review and comments	
Issue 1	10.06.02	all	Initial issue	
Issue 2	03.09.04	all	Complete revision of issue 1 in the frame of the Herschel EPLM CDR (RID 11444, HP-2-ASP-MN-5091, AI 34) and reflecting the development of the programme and taking into account related comments from the instrument contractors. Insertion of a new paragraph covering the instruments mechanical and electrical integration.	

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1 Scope

This plan defines the instrument tests to be performed on PLM and satellite level during the Herschel PFM programme. This includes the instrument incoming inspections after delivery to ASED, the activities and interface tests planned for the instrument integration on the PLM PFM and the instrument related tests to be performed during the various PLM PFM 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 brief overview on the PLM PFM and satellite test programme, addresses the delivery and test configuration of the instruments and specifies any constraints to be respected for the instrument ground operations.

The document is the central document for the compilation of information concerning the instrument testing. It serves as reference document for the higher level Satellite AIT Plan (AD 6), in providing more details and more actual information with respect to instrument related subjects.

The document is based on the Instrument Interface Documents (AD 1, AD 2, AD 3 and AD 4) and the PLM AIV and Satellite AIT Requirements Specification (AD 5) and takes into account the current status of the satellite AIT planning and the information provided by the instrument contractors. The document is a ‘living document’ which will require several iteration cycles until final consolidation. The information provided herein is the basis for the instrument related PLM PFM and satellite level integration and test procedures.

Note:

The current issue 2 reflects the status as per 03.09.2004. All information available by that date has been included. Open items are indicated by TBDs or TBCs. The next update of this document is planned after the final definition of the EQM AIT programme (see RD 1) which has precedence now. Dedicated instrument AIT meetings will be performed to support this process. The currently planned delivery dates of the instrument PFMs is November 15, 2005.

2 Documents

2.1 Applicable Documents

AD 1	SCI-PT-IIDA-04624	Herschel/Planck Instrument Interface Document, Part A	Issue 3.3
AD 2	SCI-PT-IIDB/SPIRE-02124	Herschel/Planck Instrument Interface Document, Part B, Instrument “SPIRE”	Issue 3.2
AD 3	SCI-PT-IIDB/HIFI-02125	Herschel/Planck Instrument Interface Document, Part B, Instrument “HIFI”	Issue 3.2
AD 4	SCI-PT-IIDB/PACS-02126	Herschel/Planck Instrument Interface Document, Part B, Instrument “PACS”	Issue 3.2
AD 5	HP-1-ASPI-SP-0008	Herschel EPLM AIV and Herschel Satellite AIT Requirements Specification	Issue 4.2
AD 6	HP-2-ASED-PL-0026	Satellite AIT Plan, Part 2	Issue 2.1
AD 7	HP-2-ASED-PL-0007	Herschel PA Plan	Issue 2.1
AD 8	HP-2-ASED-PL-0023	Herschel Contamination Control Plan	Issue 2

2.2 Reference Documents

RD 1	HP-2-ASED-PL-0021	Instrument Testing on PLM EQM Level	Issue 3
RD 2	HP-2-ASED-TN-0076	Optical Configuration and Straylight during Ground Testing	Issue 2
RD 3	H-P-1-ASPI-IS-0121	EGSE Interface Requirements Specification	Issue 4
RD 4	HP-2-ASED-TN-0011	H-EPLM Thermal Model and Analysis	Issue 4
RD 5	HP-2-ASED-TN-0097	Herschel Alignment Methods, Plan and results	Issue 1
RD 6	SPIRE-RAL-PRC-001923	SPIRE FPU Handling and Integration Procedure	Issue 1

RD 7	empty		
RD 8	SPIRE-RAL-DOC-000768	Operating the SPIRE Instrument	Issue Draft 3
RD 9	SPIRE-RAL-DOC-001652	SPIRE Functional Test Specification	Issue 1
RD 10	SPIRE-RAL-DOC-001799	SPIRE DRCU Integration Test Specification	Issue 1
RD 11	empty		
RD 12	SPIRE-RAL-DOC-001132	SPIRE Warm Electronics Integration Plan	Issue 0.1

3 Objective of PLM PFM and Satellite AIT Programme

3.1 PLM PFM and Satellite Test Programme General Objectives

The main objective of the PLM PFM and satellite test programme is the flight acceptance of the satellite.

As regards the instruments this includes the verification of the mechanical, thermal, electrical, electromagnetic and operational compatibility of the instruments with the satellite in flight representative cryogenic conditions. Further objective is the verification of the instruments performance as far as possible in the existing ground test conditions.

3.2 Instrument Specific Test Definitions and Objectives

The following table gives an overview of the instrument tests to be carried out on PLM PFM and satellite level with their instrument related objectives.

Test	Test Objectives	Conditions	Remarks
Instrument EGSE Validation	Check of Instrument EGSE function (self-test). Check of Instrument EGSE interfaces to CCS.	Ambient	Prior to start of PLM level instrument test programme.
Instrument Alignment Check	Check of instrument alignment (as far as possible).	All	In warm and cold conditions.
Instrument Short Functional Test (SFT)	Instrument switch on and functional verification of instrument interfaces. Evaluation should preferably be based on housekeeping data. Two different types of instrument SFTs: warm and cold.	SFT warm: Ambient SFT cold: Tank temperature 4.2 K (He1) or 1.7 K (He2)	SFT warm: Before cool down of the cryostat. SFT cold: After cool down (He1) and after He2 production.

Instrument Specific Performance Test (SPT)	Verification of dedicated aspects of the performance of the integrated instrument. Tests may require a specific spacecraft configuration.	Tank temperature: 1.7 K	Scheduling depending on test set-up requirements.
Integrated Module Test (IMT)	Verification of the functional performance of the integrated instrument in all possible modes. Check of the instrument performance as far as possible with PLM configuration.	Tank temperature: 1.7 K	PLM level test.
Integrated System Test (IST)	Verification of the functional performance of the integrated instrument in all possible modes. Check of the instrument performance as far as possible with satellite configuration.	Tank temperature: 1.7 K	Before and/or after environmental tests.
EMC Test	Check of functional performance of the integrated instrument under electromagnetic worst case conditions (radiated susceptibility) and measurement of instrument electromagnetic emissions (conducted and radiated emission).	Tank temperature: 1.7 K	Instruments to be in the most sensitive mode(s) for susceptibility tests and most noisiest mode(s) for emission tests.
Sine Vibration and Acoustic Noise Test	Verification of workmanship. Verification of alignment stability.	Tank temperature: 4.2 K	
TB/TV Test	TMM validation. Verification of instrument performance in nearly flight conditions.	Tank temperature: 1.7 K, TV	In TV chamber.

System Validation Test (SVT)	Verification of instrument commanding, telemetry and science data from/to the control centre.	Tank temperature: 1.7 K	Satellite level test.

Table 3-1: Instrument related Tests on PLM PFM and Satellite Level

4 PLM PFM and Satellite AIT Flow

4.1 Activities Overview

Figure 4-1 gives an overview of the tasks which are planned to be performed during the PLM PFM and satellite AIT programme (for details see AD 6).

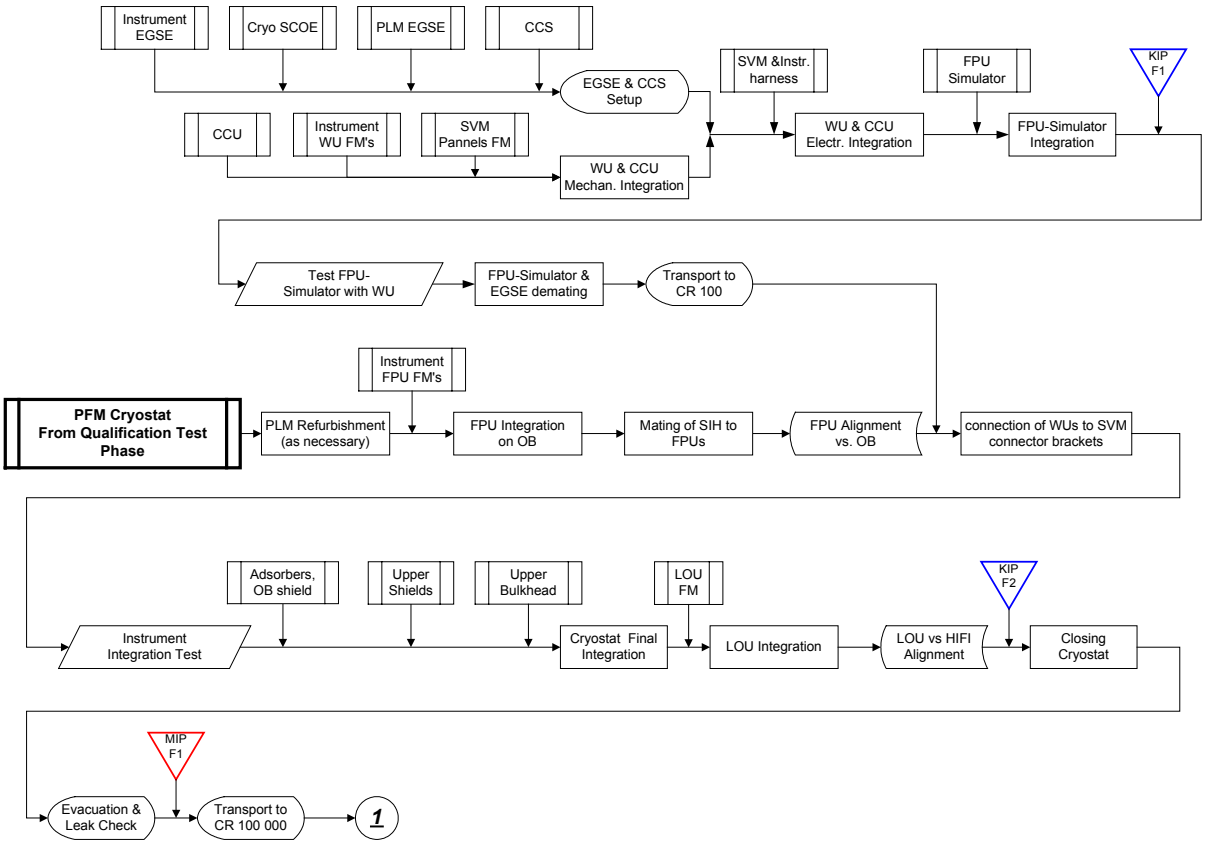

Figure 4-1: PLM PFM AIT Flow in Clean Room Class 100

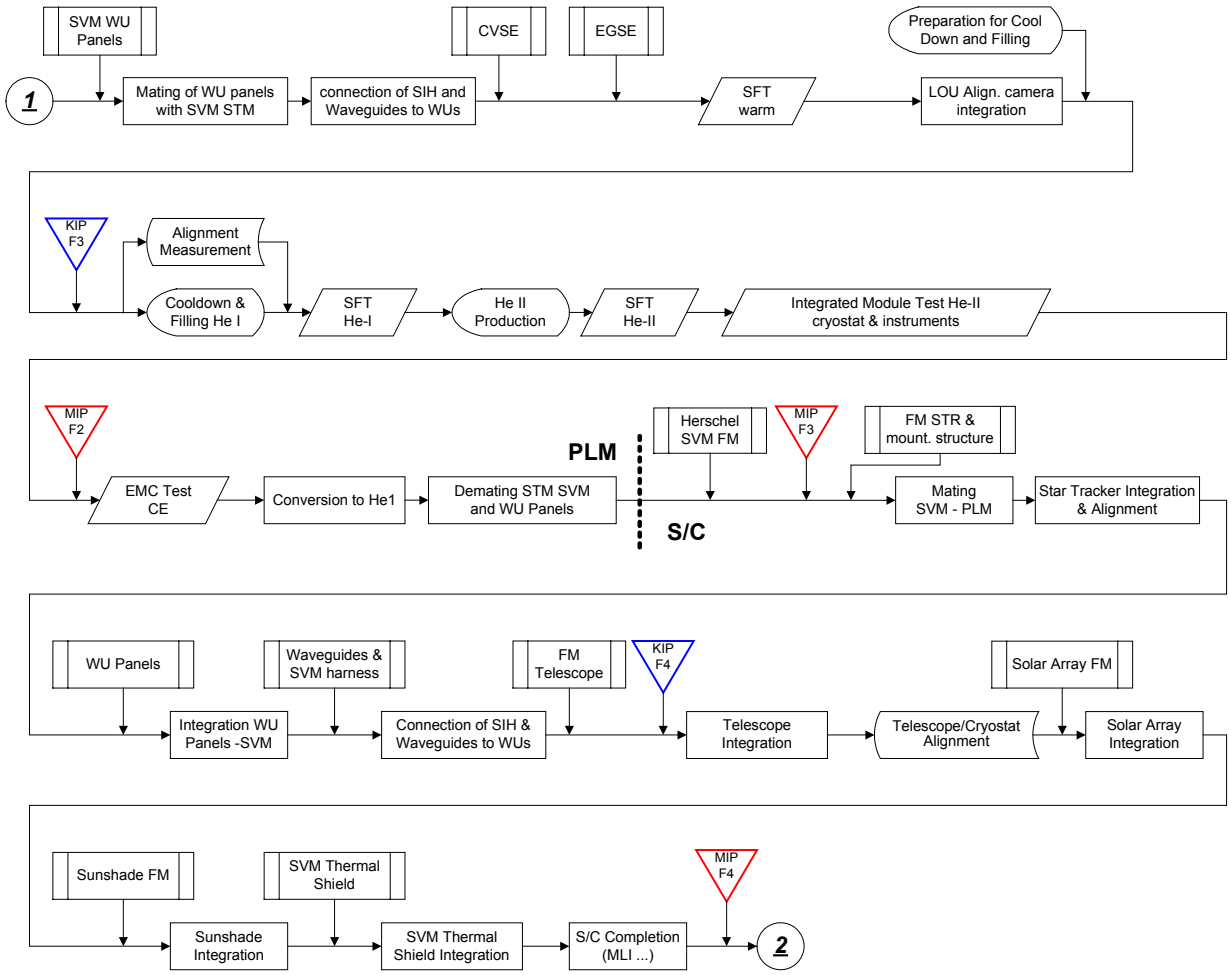

Figure 4-2: PLM PFM and Satellite AIT Flow in Clean Room 100.000

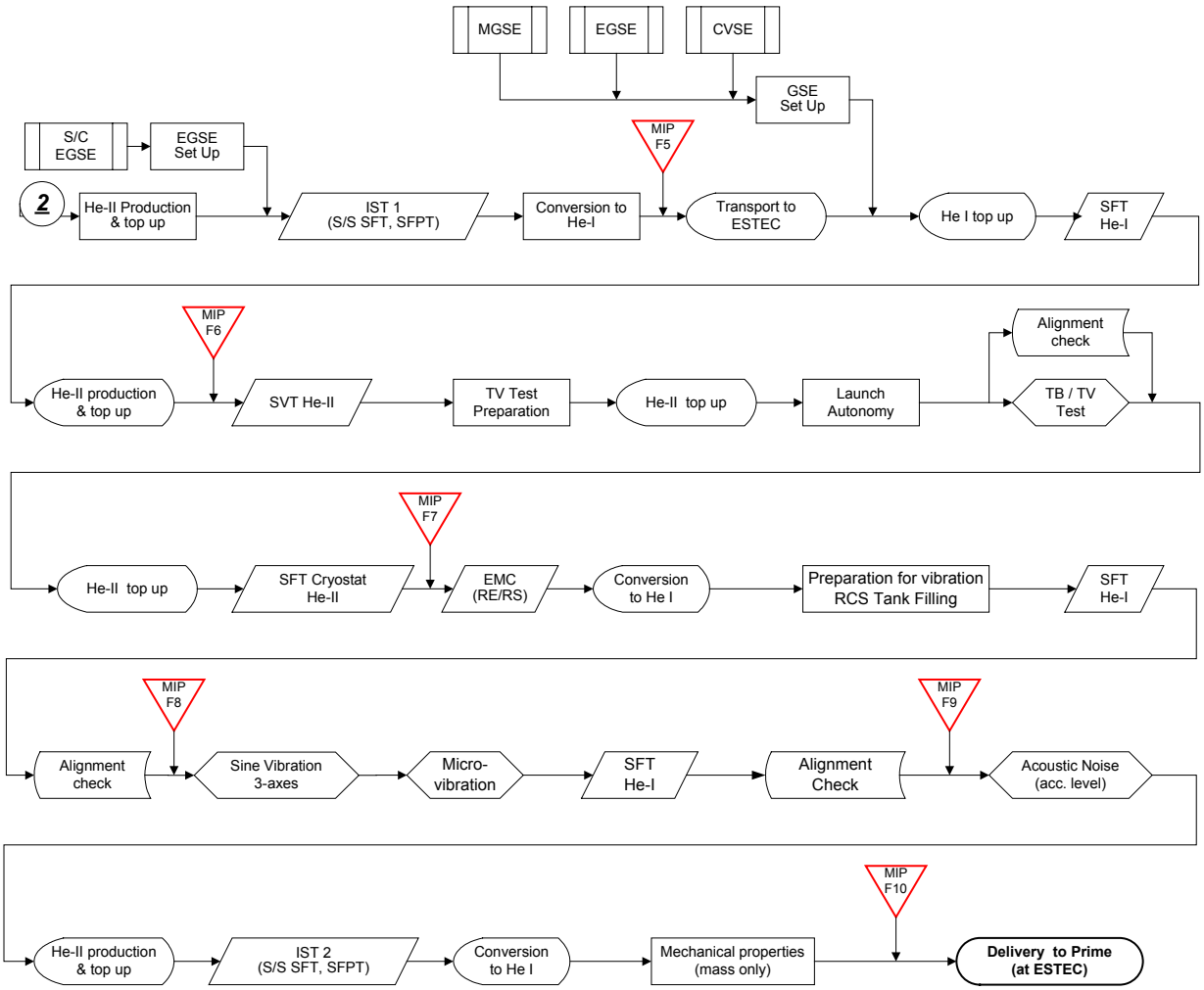

Figure 4-3: Satellite Qualification and Acceptance Test Flow

5 Instrument Integration

5.1 Incoming Inspection

The incoming inspection will be performed on all instrument items to be integrated in the PLM 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, red-tags

Documentation

- Shipping documentation
- Log sheets / historical records

- Handling, packing, transport procedures
- End Item Data Package (ICD)
- Other Documentation

Other notable defects

5.2 Pre-Integration Tests

5.2.1 General

In addition to the incoming inspection as described above a series of stand-alone tests will be conducted by the instrument personnel prior to integration in the PLM in order to ensure that no damage has occurred during transit. The pre-integration tests will take place in a clean room class 100 000 in the integration facility at EADS Astrium GmbH FN. The layout of the integration facility is shown in Figure 8-1. The testing on the FPUs is limited to continuity and isolation tests only. Limited function testing can be carried out on the warm electronics. Any equipment required for these tests (e. g. IEGSE, test harness, CDMS simulator, FPU simulator) will be supplied by the instruments.

5.2.2 HIFI Pre-Integration Tests

TBD by HIFI.

5.2.3 PACS Pre-Integration Tests

TBD by PACS.

5.2.4 SPIRE Pre-Integration Tests

5.2.4.1 FPU Testing

In addition to visual inspection continuity and isolation tests will be performed. The following equipment will be required and supplied by SPIRE for these tests:

- FPU and JFETs
- Test leads
- Breakout boxes

Expected test duration: 1/2 day.

5.2.4.2 Warm Units Testing

The Warm Units pre-integration tests on instrument level comprise the following limited function tests:

- SPIRE DRCU Integration Test (see RD 10)
- SPIRE warm short functional test (subset of full warm functional test) (see RD TBD by SPIRE)

The following equipment will be required and supplied by SPIRE (TBC by SPIRE):

- DPU PFM
- DCU PFM
- FCU PFM
- IEGSE (already at ASED)
- CDMS simulator
- FPU simulator
- WIH (test harness)
- Test Harness

Expected test duration: 1/2 day.

5.3 Mechanical Integration

5.3.1 HIFI Mechanical Integration

TBD by HIFI.

5.3.2 PACS Mechanical Integration

TBD by PACS.

5.3.3 SPIRE Mechanical Integration

5.3.3.1 FPU and JFETs

Caution:

- The bipod legs on two corners of the instrument are very thin section and easily damaged. Care must be taken at all times not to put side loads into these items. These are at risk, when not attached to a rigid plate.
- The FPU is supplied with the alignment cube fitted, and should be left in place until all alignment activities are complete.
- The FPU aperture cover (red tag item) is fitted and shall be removed prior to installation of the instrument shields and the closure of the cryostat.
- Interface surfaces of L0 straps are flat and soft gold plated, these surfaces can easily be damaged and the thermal performance of the instrument may suffer as a result.

Pre-conditions:

- The detector L0 thermal strap will be removed before integration of the Herschel OBA.
- A specific lifting gear (MGSE) is supplied for the integration of SPIRE FPU and JFET assembly on the OBA.
- When delivered, the JFET units will be fitted with shorting connectors and/covers to protect the detectors. These should be left in place during the mechanical integration.
- The FPU is supplied attached to a baseplate together with the JFETs and the JFET harness already integrated. I. e. the JFETs will be fitted to the spacecraft together with the FPU.

Major integration steps:

- Fix the FPU cone to the Herschel OBA.
- Fix the Spectrometer JFET studs (2 off) to the OBA.
- Lift the FPU and JFETs using the lifting gear from the SPIRE transportation baseplate onto the OBA.
- Flexible ends of the L0 straps are unsupported at this stage and need to be guided by hand.
- Note: The cone is very this walled section and large moments can be applied if the FPU is not lowered with its interface plane parallel to the OBA.
- When all units are rested on the OBA fit the attachment screws to the bipod feet as for the cone mount.
- L0 cooler and evaporator straps are fitted to the L0 S/C pod interfaces.
- The L0 detector strap is fitted to the FPU according the SPIRE provided procedure (see RD6) and fitted to L0 S/C pod interface.
- The two L1 thermal strap interfaces are fitted to the FPU.
- Fit the two L3 straps to the JFETs.
- Perform an isolation test.

For details see RD 6.

5.3.3.2 Warm Units

The SPIRE Warm Units consist of the DPU, DCU and FCU.

The major integration steps for the SPIRE Warm Units are:

- TBD by SPIRE

5.4 Electrical Integration

5.4.1 General

The instrument electrical integration comprises the check of

- The connection between the Warm Units and the satellite, represented by the PLM EGSE.
- The connection between the FPU/LOU and the Warm Units.

The Warm Units internal interconnections will be indirectly checked in their entity per instrument after their integration on the SVM. This check consists of an instrument functional test TBD by HIFI/PACS/SPIRE. The FPU simulators, as far as necessary, will be connected to the Warm Units with the instrument provided test harness.

Prior to the instrument electrical integration test the cryoharness will be separately checked in the following way:

1. Check of the cryoharness electrical design versus the instrument test harness.
   This check will be performed by automatic pin-to-pin measurements of the instrument test harness and the cryoharness and an automatic comparison of the measurement results (consistency check). This will be accomplished by a computer supported data acquisition system (IDAS) using the cryoharness manufacturing database. The measurement of the instrument test harness versus the database will be performed at the instrument premises prior to the start of the cryoharness integration (as far as possible) in order to detect potential database errors. This check has already been performed in the frame of the EQM programme and might be no more needed (TBC).
2. Continuity check of the integrated cryoharness.
   Before connecting the cryoharness to instrument FPU/LOU and/or Warm Units a continuity check of integrated cryoharness will be done. The objective is to detect potential broken lines, short circuits or incorrect plug-and-socket connection (at SVM connector bracket, CVV feed through or instrument units).

Note 1: The check of the HIFI cryoharness coax cables will be manually performed using a network analyser or an equivalent device.

Note 2: Measurements of electrical characteristics of FPU/LOU or Warm Units input/output lines are not planned.

5.4.2 HIFI Electrical Integration

5.4.2.1 FP Subsystem

The following steps are proposed:

1. Connection of FCU SCOE to FCU.
2. Check of FCU with FCU SCOE.
3. Removal of FCU termination plugs (if any) and connection of cryoharness to FCU.
4. Connection of cryoharness (incl. coax cables) to FPU.
5. Warm Check of FPU plus FCU with FCU SCOE.
6. Disconnection of FCU SCOE and test harness.

Note 1: FCU SCOE will run as stand-alone EGSE (to be operated by HIFI). The test harness to connect FCU SCOE with FPU will be provided by HIFI. Termination plugs for FCU open connectors (if needed) will be provided by HIFI.

Note 2: The warm check of the FPU (step 5 above) includes a continuity check (measurement of noise level) of the IF output signal (a functional test is only possible when the FPU is at operating temperature). This check needs the connection of the SCOE to the ends of the cryoharness coax cables (at the position of the up-converters). The test coax cables will be provided by HIFI. For the EQM only 2 output signals need to be checked.

5.4.2.2 LO Subsystem

TBD by HIFI.

5.4.2.3 Warm Units

TBD by HIFI.

5.4.3 PACS Electrical Integration

TBD by PACS.

5.4.4 SPIRE Electrical Integration

Caution:

- Several subsystems with the SPIRE FPU are ESD sensitive, and especially vulnerable during the integration process. All normal precautions shall be taken when handling the FPU especially when open connectors are present.
- All exposed connectors shall be EMC sealed (details TBD by SPIRE).

Preconditions:

- Cryoharness integrated and a check of the grounding within the cryoharness shall be performed.
- FPU, JFP and JFS mechanically integrated to the OBA and temporarily grounded to OBA chassis.
- Warm electronics integrated on to the SVM.
- Note: During electrical integration the FPU is grounded via the temporary ground strap!

Major Integration steps:

- Grounding verification (check that FPU Faraday shield is isolated from the chassis of the CVV/SVM).
- Connect cryoharness to FPU, JFETS, FCU and DCU following predefined sequence.
- Remove the temporary ground strap from the FPU.
- On the DCU and FCU cryoharness connectors, break all the connections between the FPU Faraday Shield Link and the EMC backshells.
- Measure and record the isolation resistance between the FPU Faraday Shield links and the chassis of the DCU.
- Reconnect all the links between the FPU Faraday Shield Links and the Cryoharness EMC backshells.
- Saving plugs shall be fitted to the connected CVV feed through connectors, when the intermediate cryoharness is not installed.
- Saving plugs shall be fitted to the connected SVM CB connectors, when the SVM cryoharness is not installed.

Note: Grounding verification with connections between FPU Faraday Shield and cryoharness backshells separated TBC by ASED.

For details concerning the electrical integration see RD 6.

6 Instrument Specific Test Activities

6.1 Instrument EGSE Validation

The Instrument EGSE validation will comprise a stand-alone test of the Instrument EGSE (self-test) and its interface to the CCS.

The principle function and operability of the EGSE together with the satellite and the test procedures have already been validated during the EQM programme.

Related test activity descriptions per instrument see section 10.1.

6.2 Alignment Check

The main objectives of the alignment checks are the verification of the alignment of HIFI LOU to the HIFI FPU versus the predictions, in particular with respect to the impact of the CVV pressure change and cool down on the instrument alignment.

The determination of the shift and rotation of the optical bench after cryostat evacuation and cool down will be performed in two steps.

- The first alignment check will be performed on PLM level after the evacuation in order to quantify potential displacements due to evacuation.
- The second alignment check will be performed after the cool down, during the re-adjustment of the tank straps.

Further alignment checks are planned prior and after the environmental tests on satellite level (sine vibration, TB/TV test and acoustic noise test). During the TB/TV test the alignment will also be monitored within the TB/TV chamber in order to verify the predicted displacements due to outer cool down of the CVV and atmospheric pressure release.

The entire alignment check, incl. the alignment of the optical bench, is based on the alignment measurements between the HIFI FPU and LOU using the alignment camera system.

The shift and rotation will be determined by measurements of HIFI FPU alignment versus the HIFI LOU with a dedicated alignment camera system.

The alignment camera system consists of two alignment cameras which will be mounted on the LOU support plate, allowing monitoring simultaneously shift and rotation (two cameras are needed to determine the rotation about the y axis). A distance measurement in y direction is also possible, however, with reduced accuracy (TBC).

The correct alignment of the HIFI LOU versus HIFI FPU is required to allow reasonable instrument functional performance verification.

Details see RD 05.

6.3 Short Functional Test (SFT)

The principle objective of the SFT is the check of the electrical integrity and operability (command and control) of the PLM. As regards the instruments the SFT covers the instrument switch-on and the functional verification of the electrical instrument interfaces.

The SFT does not require any specific PLM configuration/condition (e. g. cryostat orientation) or specific instrument GSE. The test duration is in the range of 1 hour per instrument. The test evaluation is based on housekeeping data, i. e. no need of science data evaluation.

Two different types of SFTs exist, depending on the helium tank temperature conditions:

- SFT warm (tank without helium)
- SFT cold (tank with normal boiling or supra fluid helium)

The related instrument SFT procedures are adapted to these specific thermal environmental conditions for the FPUs.

Related test activity descriptions per instrument see section 10.2.

6.3.1 HIFI SFT

TBD by HIFI.

6.3.2 PACS SFT

TBD by PACS.

6.3.3 SPIRE SFT

6.3.3.1 SPIRE SFT Warm Test

The following functional tests will be carried out to test the system when the FPU is integrated into the cryostat, the cryostat is closed, the complete cryoharness is installed and the SPIRE Warm Units are integrated, but before cool down of the cryostat.

Details TBD by SPIRE.

6.3.3.2 SPIRE SFT Cold Test

A series of functional tests will be carried out to test the system when the FPU is integrated in the cryostat and cold. The cryoharness is completely installed and the SPIRE Warm Units are integrated.

During these tests the instrument will be controlled via the spacecraft and its associated EGSE.

Alternatively, the test could be carried out with the SPIRE CDMS simulator or the spacecraft EGSE (TBD by ASED).

SPIRE SFT Cold Test (He I):

A subset of the full cold functional test will be carried out as specified in RD 9.

The test duration is 1 hour.

SPIRE SFT Cold Test (He II):

Full cold functional test will be carried out as specified in RD 9.

The test will take 4 hours.

6.4 Specific Performance Test (SPT)

6.4.1 General

Objective of the SPT is to verify dedicated aspects of the instruments performance. This may require a specific spacecraft configuration.

I. e. SPTs are a tools to verify the instrument performance on PLM and satellite level. The tests are strongly based on the instrument level tests in order to allow a quick and reliable performance assessment by comparing the PLM and satellite level test results with the instrument level test results (no degradation with respect to instrument level test results, assuming that the environmental conditions are similar).

The thermal conditions inside the cryostat are not fully flight representative since the CVV temperature is at room temperature. The detector back ground can be adjusted by specific cryogenic means (see RD 2). Inside the TB/TB chamber the situation can be improved.

Related test activity descriptions per instrument see section 10.3.

Note: The SFTs will be merged in the IMT/IST.

6.4.2 HIFI SPT

The following SPTs are defined for HIFI (see also section 10.3 of this document):

- IF Properties Test
- Radiometry Test (using the internal calibration source)
- LO Beam Standing Wave Test [1)]

[1)] The test comprises the impact verification of the standing waves on the LO Beam between LOU and FPU.

Test details TBD by HIFI.

6.4.3 PACS SPT

The following SPTs are defined for PACS (see also section 10.3 of this document):

- Cooler Recycle
- Full Functional Test
- Short Performance Test
- Astronomical Observation Template (AOT) Tests
- PACS/SPIRE Parallel Mode Test

Test details TBD by PACS.

6.4.4 SPIRE SPT

The following SPTs are defined for SPIRE (see also section 10.3 of this document):

- Cooler Recycle
- Ambient Background Verification Test
- Photometer Mode Test
- Spectrometer Mode Test
- PACS/SPIRE Parallel Mode Test

Test details TBD by SPIRE.

6.5 Integrated Module Test (IMT)

The superior objective of the IMT is the verification of the correct operation of the fully integrated PLM in a series of representative mission modes. This includes the verification of the functional performance of the integrated instruments and their measurement performance, as far as it is possible on that level.

On PLM PFM level only one IMT is planned. This IMT will comprise the instrument SFTs and specific operational scenarios to determine the related temperature transients.

Figure 6-1 shows the activities to be performed during the IMT.

IMT/IST Flow (PFM/Satellite Level)						
Step	**HIFI**	**PACS**	**SPIRE**	**PFM/Satellite Position**	**Duration**	**Remarks**
1	Off	Off	Off	No requirement	-	
2	Stand-By	Safe Mode	Ready Mode	No requirement	TBD	Temperature stabilization
3	SFT Cold	Safe Mode	Ready Mode	No requirement	1 h	
4	IF Properties Test	Safe Mode	Ready Mode	No requirement	1 h	SPT
5	Radiometry Test	Safe Mode	Ready Mode		1 day	SPT
6	LOBeam Standing Wave Test	Safe Mode	Ready Mode	No requirement	1 day	SPT
7	Stand-By	SFT Cold	Ready Mode	No requirement	1 h	
8	Stand-By	Cooler Recycle	Ready Mode	23° to 30° to +y	2 h	
9	Stand-By	Full Functional Test	Ready Mode	No requirement	TBD	SPT
10	Stand-By	Short Performance Test (incl. cryo cover	Ready Mode	No requirement	TBD	SPT
11	Stand-By	AOT Tests	Ready Mode	No requirement	TBD	SPT
12	Stand-By	Safe Mode	SFT Cold	No requirement	1 h	
13	Stand-By	Safe Mode	Cooler Recycle	23° to 30° to +y	2 h	
14	Stand-By	Safe Mode	Ambient Background Verification Test	No requirement	1 h	SPT
15	Stand-By	Safe Mode	Photometer Mode	No requirement	1 h	SPT
18	Stand-By	Safe Mode	Spectrometer Mode	No requirement	1 h	SPT
16	Stand-By	Cooler Recycle	Ready Mode	23° to 30° to +y	2 h	If required
17	Stand-By	PACS/SPIRE Parallel Mode	PACS/SPIRE Parallel Mode	No requirement	TBD	SPT
19	Off	Off	Off	No requirement	-	

Figure 6-1: IMT/IST Activity Flow (proposal TBC by HIFI/PACS/SPIRE)

During the IMT the constraints of the PLM tilting angle during PACS and SPIRE cooler recycles will be considered.

An in-orbit representative thermal background will be achieved by specific cryogenic means which are described in RD 2.

Further details of the instrument test sequences still TBD by HIFI/PACS/SPIRE.

Related test activity descriptions per instrument see section 10.4.

6.6 Integrated System Test (IST)

The superior objective of the IST is the verification of the correct operation of the fully integrated satellite in a series of representative mission modes. This includes the verification of the functional performance of the integrated instruments and their measurement performance, as far as it is possible on that level:

The individual instrument related test sequence for the IST which is performed on satellite level is practically the same as for the IMT which is performed on PLM PFM level (see Figure 6-1).

However, the IST set-up is different to the IMT set-up: During the IST the instruments are controlled via the satellite bus, whilst during the IMT the instruments are connected to the EGSE (satellite bus not yet integrated).

Two IST runs are planned, the first, called IST1, will be performed directly after the completion of the satellite integration, the second, called IST2, after the sine vibration and TB/TV tests.

Related test activity descriptions per instrument see section 10.4.

6.7 EMC Test

With respect to the instruments the general objective of the PLM PFM and satellite level EMC test programme is to demonstrate that the instruments are compatible with the satellite electro-magnetic environment.

On PLM PFM level the EMC tests comprise measurements of the conducted emission (CE) per instrument. For EMC tests in this configuration a standard integration facility is sufficient. For the tests the SVM with the PCDU is necessary. The test will therefore be conducted in frame of the SVM integration at the PLM PFM.

On satellite level the EMC tests comprise CE (as far as not already done on PLM PFM level), radiated emission (RE) and radiated susceptibility (RS) tests.

The CE tests will be performed in the integration facility. The RE and RS tests will be conducted in an anechoic chamber. The anechoic chamber will be prepared to allow testing under clean room conditions. The satellite level EMC testing is foreseen at ESTEC facilities

During the CE and RE tests each instrument is switched in a mode with maximum generation of electrical distortion on the electrical lines. The other two instruments are switched off during that period (to exclude ambiguities), with the exception of the PACS/SPIRE Parallel Mode. As first step of the CE and RE testing a reference test will be made to detect the environmental noise with the instruments being switched off.

During the RS tests the instruments are switched in a mode with highest sensitivity to electromagnetic distortions. Prior to the RS test a reference test will be made to determine the instrument performance under nominal conditions. If necessary the reference test will be repeated during the EMC test programme to identify potential performance drifts. The instruments will be tested individually with the other instruments being switched off (to exclude distortions).

Note: The electromagnetic autocompatibility between the instruments is verified during the IMT/IST with the instruments being operated as in flight.

An in-orbit representative thermal background will be achieved by specific cryogenic means which are described in RD 2.

During the EMC test the constraints of the PLM tilting angle during PACS and SPIRE cooler recycles will be considered.

Figure 6-1 and Figure 6-2 describe the planned EMC test flow with the instrument modes.

EMC Test Flow (PLM Level)						
Step	**Test Type**	**HIFI**	**PACS**	**SPIRE**	**PLM Position**	**Duration**
1	-	Off	Off	Off	No requirement	-
2	Reference test	Off	Off	Off	No requirement	TBD
3	CE	Stand-By	Off	Off	No requirement	TBD
4	CE	Most noisiest mode	Off	Off	No requirement	TBD
5	CE	Off	Stand-By	Off	No requirement	TBD
6	CE	Off	Most noisiest mode	Off	No requirement	TBD
7	CE	Off	Off	Ready	No requirement	TBD
8	CE	Off	Off	Most noisiest mode	No requirement	TBD
9	CE	Off	Stand-by	Ready	No requirement	TBD
10	CE	Off	PACS/SPIRE Parallel Mode	PACS/SPIRE Parallel Mode	No requirement	TBD
11	-	Off	Off	Off	No requirement	-

Figure 6-1: EMC Test Activities Flow on PLM PFM Level

EMC Test Flow (Satellite Level)						
Step	**Test Type**	**HIFI**	**PACS**	**SPIRE**	**Satellite Position**	**Duration**
1	-	Off	Off	Off	No requirement	-
2	Reference test	Off	Off	Off	No requirement	TBD
3	CE	Most noisiest mode	Off	Off	No requirement	TBD
4	CE	Off	Most noisiest mode	Off	No requirement	TBD
5	CE	Off	Off	Most noisiest mode	No requirement	TBD
6	CE	Off	PACS/SPIRE Parallel Mode	PACS/SPIRE Parallel Mode	No requirement	TBD
7	-	Off	Off	Off	No requirement	-
8	Reference test	Off	Off	Off	No requirement	TBD
9	RE	Most noisiest mode	Off	Off	No requirement	TBD
10	RE	Off	Most noisiest mode	Off	No requirement	TBD
11	RE	Off	Off	Most noisiest mode	No requirement	TBD
12	RE	Off	PACS/SPIRE Parallel Mode	PACS/SPIRE Parallel Mode	No requirement	TBD
13	-	Off	Off	Off	No requirement	-
14	Reference test	Most sensitive mode	Off	Off	No requirement	TBD
15	RS	Most sensitive mode	Off	Off	No requirement	
16	-	Off	Cooler Recycle	Off	23° to 30° to +y	TBD
17	Reference test	Off	Most sensitive mode	Off	No requirement	
18	RS	Off	Most sensitive mode	Off	No requirement	
19	-	Off	Off	Cooler Recycle	23° to 30° to +y	TBD
20	Reference test	Off	Off	Most sensitive mode	No requirement	
21	RS	Off	Off	Most sensitive mode	No requirement	
22	-	Off	Off	Off	No requirement	-

Figure 6-2: EMC Test Activities Flow on Satellite Level

The following principle test flow is applied for the CE and RE test:

- Powering of instrument
- Commanding of instrument into most noisiest mode
- HK data monitoring

The following principle test flow is applied for the RS test:

- Powering of instrument
- Commanding of instrument into most sensitive mode
- HK data monitoring (reference measurements)
- Application of EMI
- HK data monitoring
- Analysis of the scientific data (quick look).

The most noisiest/sensitive modes of the instruments are defined hereafter:

HIFI

TBD by HIFI.

PACS

TBD by PACS.

SPIRE

TBD by SPIRE.

The following primary and secondary power lines will be considered during the CE and RE tests:

HIFI

- ICU main
- LCU main
- WEH main
- HRH main

PACS

TBD by PACS

SPIRE

TBD by SPIRE

The following parameters will be monitored during the RS tests:

HIFI

- TBD by HIFI

PACS

- TBD by PACS

SPIRE

- TBD by SPIRE

Related test activity descriptions per instrument see section 10.5.

Note:

The satellite housekeeping data is sampled on-board every 1 second but transmitted only every 4 seconds. Therefore, instead of continuous sweeping a step-wise frequency adjustment will be applied for susceptibility testing. A minimum exposure time of 8 seconds is recommended for each frequency step. The data transmission sampling rate could be increased to 1 Hz for single parameters, on the expense of the number of parameters which can be monitored. Therefore, an increase of the sampling rate will be considered only for those parameters, which already showed susceptibility during unit level test. Such specific parameters together with the frequency bands where susceptibility exists are TBD by HIFI/PACS/SPIRE.

6.8 Sine Vibration and Acoustic Noise Test

Both tests are performed on satellite level. The main objectives as regards the instruments are to check the workmanship and the stability of the alignment.

During both tests the instruments are switched off.

6.9 TB/TV Test

The main objective of this satellite level test as regards the instruments is the instrument is the verification of functional performance of the instruments in nearly flight conditions (details TBD).

During the TB/TV test all relevant instrument temperatures are continuously monitored.

A reduced IST sequence will be performed for the verification of the instruments functional performance (see

Figure 6-1). Details TBD by HIFI/PACS/SPIRE. These tests will be carried out after the temperature stabilisation in cold.

During the TB/TV test the constraints of the PLM tilting angle during PACS and SPIRE cooler recycles will be considered. The tilting angle of the satellite is limited by the test chamber to 25° (TBC).

Cover flushing not foreseen (TBC).

The test is carried out at ESTEC (LSS).

TB/TV Test Flow (Satellite Level)

Step	HIFI	PACS	SPIRE	Satellite Position	Duration	Remarks
1	Off	Off	Off	No requirement	-	
2	SFT cold	Safe Mode	Ready Mode	No requirement	1 h	prior to closure of TV chamber
3	Stand-By	SFT cold	Ready Mode	No requirement	1 h	
4	Stand-By	Safe Mode	SFT cold	No requirement	1 h	
5	SFT cold	Safe Mode	Ready Mode	No requirement	1 h	after closure of TV chamber, prior to evacuation
6	Stand-By	SFT cold	Ready Mode	No requirement	1 h	
7	Stand-By	Safe Mode	SFT cold	No requirement	1 h	
8	Off	Off	Off	No requirement	-	after evacuation of TV chamber
9	SFT Cold	Safe Mode	Ready Mode	No requirement	1 h	
10	IF Properties Test	Safe Mode	Ready Mode	No requirement	1 h	
11	Radiometry Test	Safe Mode	Ready Mode		1 day	
12	LOBeam Standing Wave Test	Safe Mode	Ready Mode	No requirement	1 day	
13	Stand-By	SFT Cold	Ready Mode	No requirement	1 h	
14	Stand-By	Cooler Recycle	Ready Mode	23° to 30° to +y	2 h	
15	Stand-By	Full Functional Test	Ready Mode	No requirement	TBD	
16	Stand-By	Short Performance Test	Ready Mode	No requirement	TBD	
17	Stand-By	AOT Tests	Ready Mode	No requirement	TBD	
18	Stand-By	Safe Mode	SFT Cold	No requirement	1 h	
19	Stand-By	Safe Mode	Cooler Recycle	23° to 30° to +y	2 h	
20	Stand-By	Safe Mode	Ambient Background Verification Test	No requirement	1 h	
21	Stand-By	Safe Mode	Photometer Mode	No requirement	1 h	
22	Stand-By	Safe Mode	Spectrometer Mode	No requirement	1 h	
23	Stand-By	Cooler Recycle	Ready Mode	23° to 30° to +y	2 h	
24	Stand-By	PACS/SPIRE Parallel Mode	PACS/SPIRE Parallel Mode	No requirement	TBD	
25	Off	Off	Off	No requirement	-	

Figure 6-1: TB/TV Test Activities Flow

6.10 System Validation Test (SVT)

The SVT is performed on satellite level with the satellite directly linked to the control centre.

As regards the instruments the objective of this test is the verification of the instrument commanding and monotoring by the control centre (validation of compatibility between the control centre data base and the data base used during the AIT programme).

Figure 6-1 provides the proposed test activities flow.

SVT Flow (Satellite Level)						
Step	**HIFI**	**PACS**	**SPIRE**	**Satellite Position**	**Duration**	**Remarks**
1	Off	Off	Off	No requirement	-	
2	Stand-By	Safe Mode	Ready Mode	No requirement	TBD	
3	SFT Cold	Safe Mode	Ready Mode	No requirement	1 h	
4	Functional Test (TBD)	Safe Mode	Ready Mode	No requirement	1 h	
7	Stand-By	SFT Cold	Ready Mode	No requirement	1 h	
8	Stand-By	Functional Test (TBD)	Ready Mode	No requirement	2 h	
12	Stand-By	Safe Mode	SFT Cold	No requirement	1 h	
13	Stand-By	Safe Mode	Functional Test (TBD)	No requirement	2 h	
16	Stand-By	Safe Mode	Ready Mode	No requirement	2 h	
17	Stand-By	PACS/SPIRE Parallel Mode	PACS/SPIRE Parallel Mode	No requirement	TBD	
19	Off	Off	Off	No requirement	-	

Figure 6-1: SVT Activities Flow (TBC)

7 Test Configuration

7.1 PLM PFM / Satellite Hardware Configuration

During the PLM PFM level testing the cryostat hardware is the flight hardware. The SVM hardware uses the STM structure with the Warm Unit mounted on the flight panels. During the satellite level testing also for the SVM the flight hardware is used. For details see AD 6, chapter 4.

The cryostat provides an actively cooled cover with specific mirrors on the inside to simulate the in flight background conditions. The cover can be actively cooled.

The cryostat provides the following major limitations which are relevant for the instrument testing

- During ground testing (with the exception of the TB/TV test) the line of sight of LO beam between HIFI LOU and HIFI FPU is obstructed by the CVV window borders, since at ambient it is not possible to move the optical bench such that the FPU LOS matches the window axes.

7.2 Instrument Hardware Configuration

7.2.1 HIFI PFM Deliverables

The HIFI instrument delivery configuration for the PLM PFM programme is as per Table 7-1.

Unit	Model	Remarks
FPU	PFM	1 box
LOU	PFM	1 box
FCU	PFM	1 box
LSU	PFM	1 box
LCU	PFM	1 box
HRI	PFM	1 box
HRH	PFM	1 box
HRV	PFM	1 box
WEH	PFM	1 box
WEV	PFM	1 box
WOH	PFM	1 box
WOV	PFM	1 box
ICU	PFM	1 box
WIH	PFM	Warm Units interconnection harness

Note: Cryo harness and HIFI Waveguide Assembly will be provided by ASED.

Table 7-1: HIFI Instrument Hardware Items

7.2.2 PACS PFM Deliverables

The PACS instrument delivery configuration for the PLM PFM programme is as per Table 7-1.

Unit	Model	Remarks
FPU	PFM	1 box
DPU	PFM	1 box
SPU	PFM	2 boxes (one prime and one redundant)
DECMEC	PFM	2 boxes (one prime and one redundant)
BOLC	PFM	1 box with prime and redundant sections
WIH	PFM	Warm Units interconnection harness

Note: Cryo harness will be provided by ASED.

Table 7-1: PACS Instrument Hardware Items

7.2.3 SPIRE PFM Deliverables

The SPIRE instrument delivery configuration for the PLM PFM programme is as per Table 7-1.

Unit	Model	Remarks
FPU	PFM	
JFS	PFM	
JFP	PFM	
DCU	PFM	
FCU	PFM	
DPU	PFM	1 box with prime and redundant sections
DMU	PFM	2 boxes (one prime and one redundant)
WIH	PFM	Warm Units interconnection harness

Note: Cryo harness will be provided by ASED.

Table 7-1: SPIRE Instrument Hardware Items

7.3 Instrument GSE Configuration

7.3.1 Instrument EGSE Configuration

The delivered Instrument EGSE for the PLM PFM level instrument test programme is as per Table 7-1.

Instrument	GSE	Remarks
HIFI/PACS/SPIRE	2 Instrument EGSE Stations for all 3 instruments	One EGSE Station operated in real time, the other one used as backup or for post processing tasks
HIFI	FPU simulator	For stand-alone tests after incoming inspection
PACS	TBD by PACS	For stand-alone tests after incoming inspection
SPIRE	TBD by SPIRE	For stand-alone tests after incoming inspection

Table 7-1: Instrument EGSE Items

The Instrument EGSE Station is composed by the following items:

- SCOS workstation – used primarily to run the SCOS-2000 software. This will be a PC running Linux with a dual display card driving two displays.
- Analysis workstation – used to run the instrument analysis software (QLA/IA/PCSS). This will be a PC running Linux with a dual display card driving two displays.
- Data Server – used primarily to run the HCSS software. This will be a PC running Linux with a single display and large disk drives with backup facility (to tape/CD TBD).
- Colour laser printer.
- LAN switch - protects the Operational System from the Analysis System allowing access to the external internet from the Analysis System.
- Laptops – used to run instrument specific analysis tools. These are not provided as part of the EGSE but may be used by instrument experts as necessary during testing.

7.3.2 Instrument MGSE Configuration

All instrument hardware will be delivered in appropriate containers including shock indicators, temperature monitoring as well as cleanliness provisions. For each FPU and the HIFI LOU appropriate lifting devices will be delivered with the units. Details TBD by HIFI, PACS and SPIRE.

7.3.2.1 Delivered MGSE

HIFI

TBD by HIFI

PACS

TBD by PACS

SPIRE

SPIRE will provide a MGSE and lifting equipment according to RD 6, Annex A, which includes as least the following:

- FPU/JFET base plate lifting gear (for lifting out of and in the transport container).
- FPU and JFET handling frame (for installation on OBA)
- Temporary FPU Grounding Strap including M4 x 6mm fastener (to connect to OBA).

7.3.2.2 Customer Furnished MGSE

HIFI

TBD by HIFI

PACS

TBD by PACS

SPIRE

ASED will supply the following MGSE and tools:

- Crane, with 'Hyroset'
- Torque wrench
- Allan key, spanners, etc.
- DVM for electrical isolation testing.

7.4 Instrument Documentation

7.4.1 EIDP

For each instrument an EIDP will be provided.

7.4.2 Integration and Test Procedures

The following instrument spacecraft level integration and test procedures will be provided by HIFI/PACS/SPIRE:

Procedures	Instrument inputs (procedures) required by	First Issue
Instrument Incoming Inspection Procedures	Instrument delivery - 2 months	Instrument delivery - 1 month
Instrument Hoisting and Handling Procedures	"	"
Instrument FPU/LOU Integration Procedures	"	"
Instrument Warm Units Integration Procedures	"	"
Instrument EGSE Setup and Verification Procedures	"	"
Instrument Electrical Integration Procedures	"	"
Instrument SFT Procedures	Instrument delivery	Instrument delivery + 1 month
Instrument IMT/IST Procedures	"	"
Instrument SPT Procedures (if any)	"	"
Instrument TV Test Procedure	"	"
Instrument EMC Test Procedures	"	"

Table 7-1: List of Instrument Spacecraft Level Integration and Test Procedures

7.4.3 Test Sequences

The instrument test sequences to be applied on PLM level is a subset of the instrument level test sequences. They will be delivered by the instruments in CCS TOPE compatible format and include all telecommands to control and monitor the instruments during testing.

For PLM level purposes these sequences will be appropriately embedded in the PLM test sequences. A specific validation of the instrument provided test sequences is not planned.

The following test sequences will be delivered:

HIFI:

TBD by HIFI

PACS

TBD by PACS

SPIRE

TBD by SPIRE

8 Test Configuration

8.1 Principle PLM Test Configuration

The principle EGSE configuration for PLM PFM and satellite level testing is shown in Figure 8-1 and Figure 8-2.

PLM EQM is equipped with the 3 instrument FPU CQMs and an SVM dummy structure with the integrated instrument Warm Unit AVMs. The CCS "light" serves as core and controls the PLM EGSE with the data- and power front ends, the Cryo SCOE and the Instrument EGSE. The PLM EGSE provides flight representative interfaces to the instruments. The Instrument EGSE is common for all instruments. For details see AD 06.

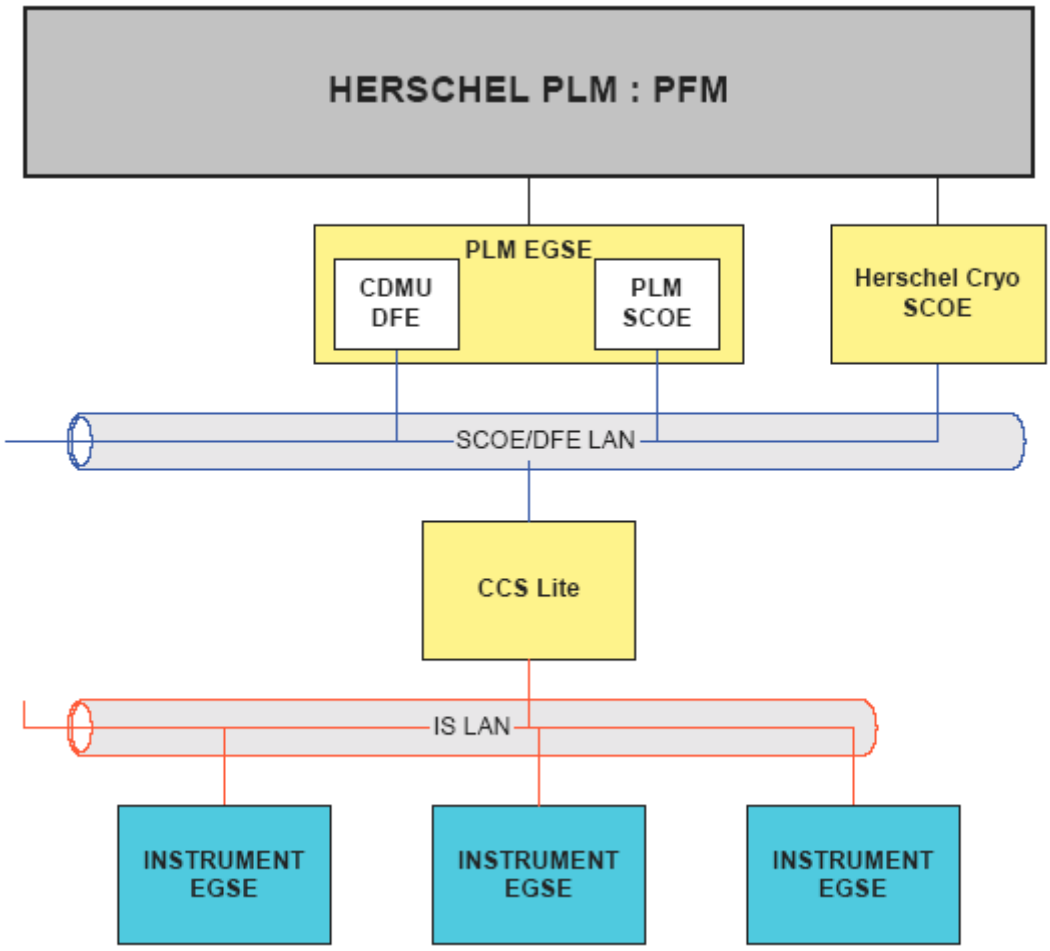

Figure 8-1: Principle EGSE Configuration for PLM PFM Level Testing

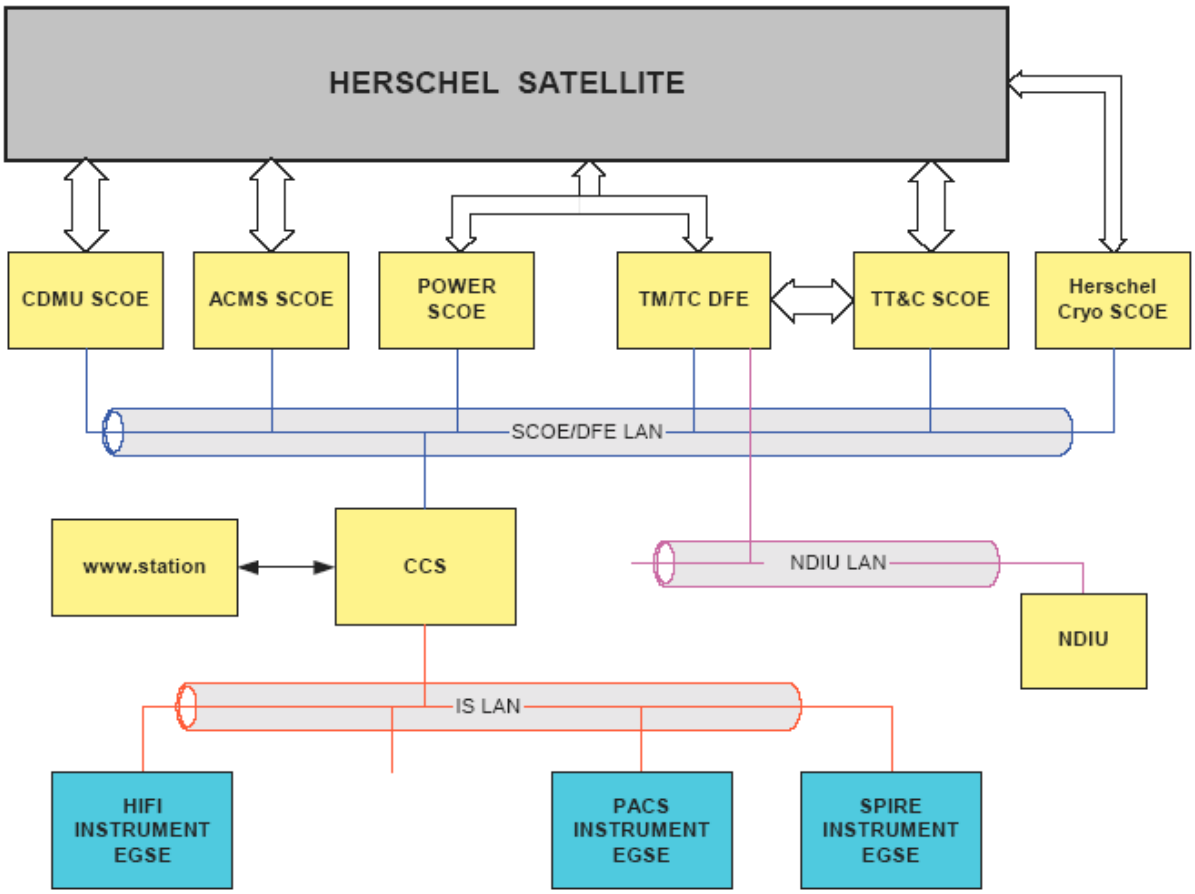

Figure 8-2: Principle EGSE Configuration for Satellite Level Testing

Figure 8-3 shows the Instrument EGSE block diagram and provides an overview of the interface to the CCS.

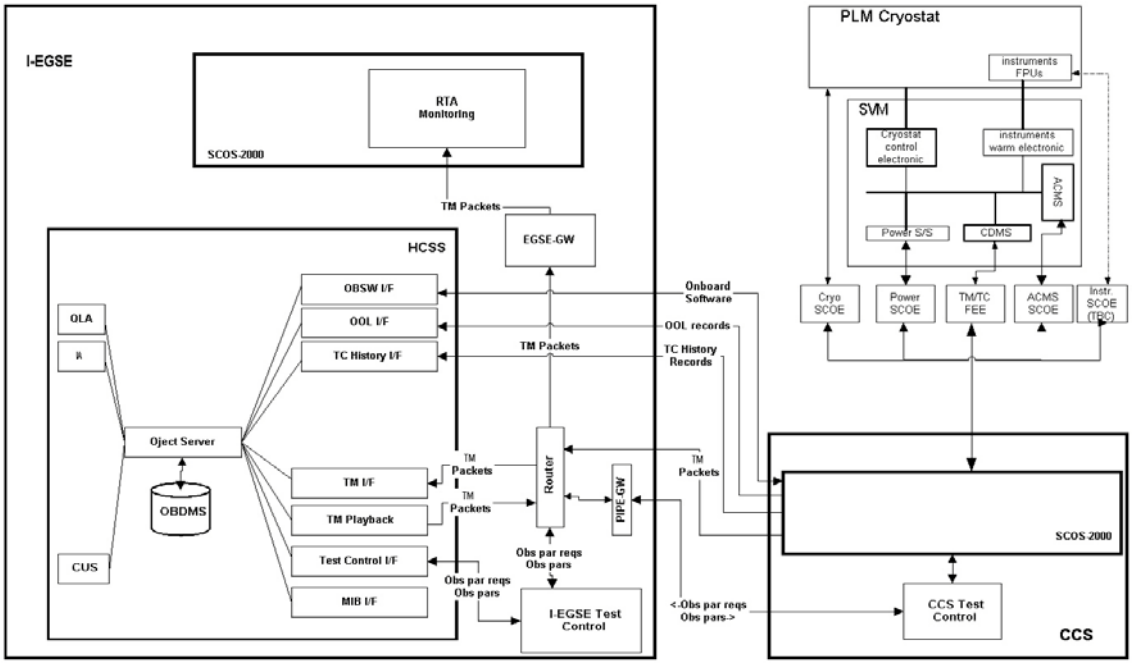

Figure 8-3: Data Exchange during Satellite Level Testing

All PLM and satellite level instrument tests will be executed from the CCS re-using a subset of instrument level test procedures.

The CCS interfaces to the Instrument EGSE uses the PIPE protocol (for details see RD 3). The database is physically located in the IEGSE (HCSS).

Access to the Instrument EGSE via internet is only foreseen for monitoring (no commanding) and will be provided by the Instrument EGSE itself. Online transfer of recorded data is possible e. g. by FTP.

8.2 Test Facility

The integration will take place in a clean room class 100 (cryostat) or 100000 at EADS Astrium GmbH FN. The layout of the integration facilities is shown in Figure 8-1. The acceptance tests will be performed at ESTEC. For details see AD 6.

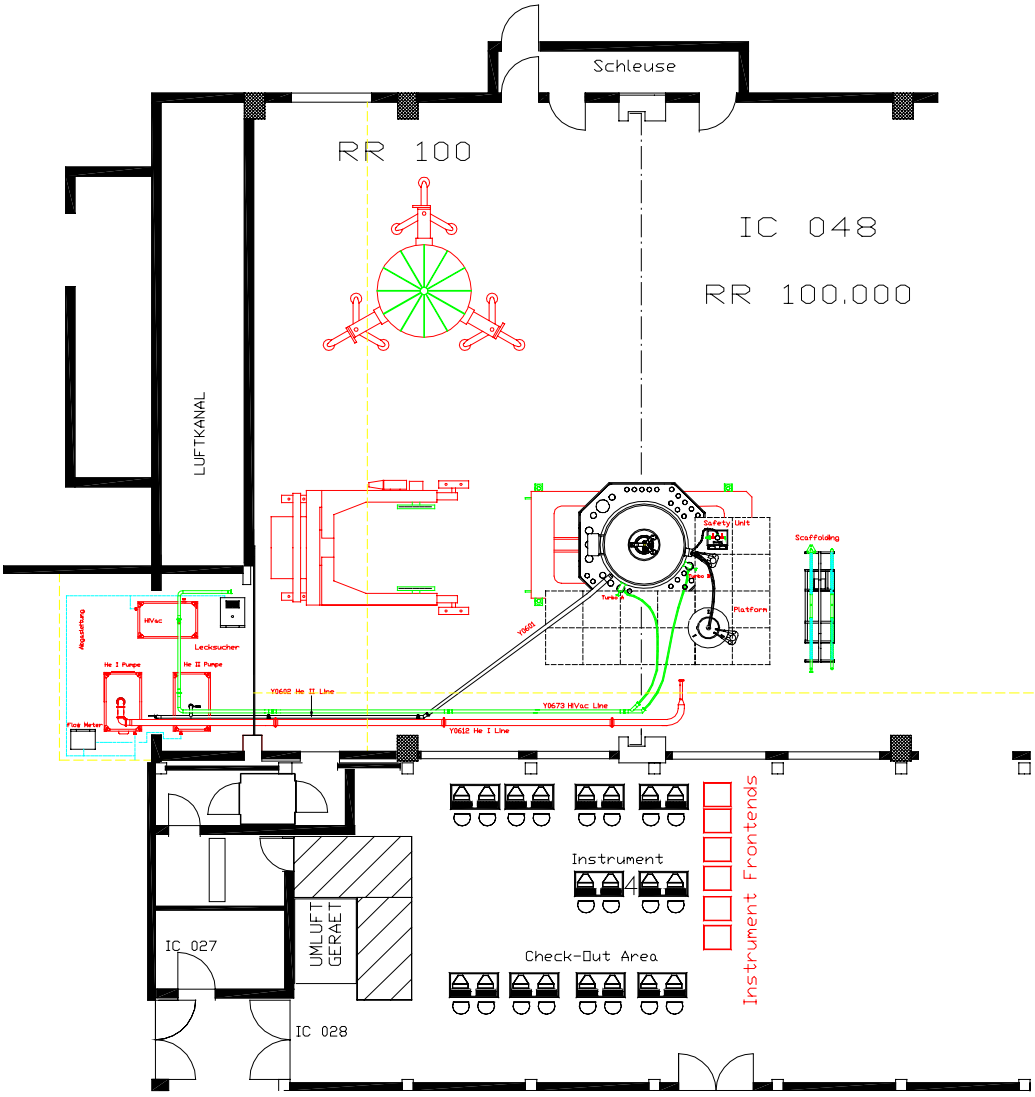

Figure 8-1: Layout of Integration Facility at EADS Astrium GmbH FN

9 Instrument Specific Test Conditions and Constraints

9.1 Instrument Test Durations

In the following tables the nominal duration of the instrument test sequences are listed.

HIFI

Test	Duration	Remark
HIFI Incoming inspection	1 day	
HIFI Mechanical Integration FPU	1 day	
HIFI Mechanical Integration Warm Units	4 days	
HIFI EGSE Check Out	1 h	Common EGSE
HIFI Electrical Integration	2 days	
HIFI Alignment Test	2 days	
HIFI SFT Warm	1 h	
HIFI SFT Cold	1 h	
HIFI IF properties	1 h	Part of IMT/IST
HIFI Radiometry	1 day	Part of IMT/IST
HIFI LO Beam Standing Wave Test	1 day	Part of IMT/IST
HIFI IMT/IST	5 days (TBC)	
HIFI EMC Test	5 days (TBC)	
HIFI TV Test	2 days (TBC)	

Note: In all cases the related test sequences have not been produced and tested.

Table 9-1: HIFI Test Duration

PACS

TBD by PACS

Table 9-2: PACS Test Duration

SPIRE

Test	Duration	Remark
SPIRE Incoming inspection	1 day	
SPIRE Mechanical Integration FPU	1 day	
SPIRE Mechanical Integration Warm Units	2 days	
SPIRE EGSE Check out	-	Common EGSE
SPIRE Electrical Integration	1 day	
SPIRE SFT Warm	1 h	
SPIRE Short Functional Test Cold	1 h	
SPIRE Cold Functional Test	6 h	
SPIRE Cooler Recycle	1 h	Part of IMT/IST
SPIRE Ambient Background Verification Test	1 h	Part of IMT/IST
Photometer Mode	1 h	Part of IMT/IST
Spektrometer Mode	1 h	Part of IMT/IST
SPIRE IMT/IST	5 days (TBC)	
SPIRE EMC Test	5 days (TBC)	
SPIRE TV Test	2 days (TBC)	

Table 9-3: SPIRE Test Duration

9.2 FPU/LOU Operational Constraints

This chapter defines the restrictions, constraints and limitations as regards the operation of the FPUs /LOU during the PLM PFM and satellite level testing.

HIFI

TBD by HIFI.

PACS

The following operational limitations exist pending the FPU L0/L1/L2 temperature:

IID-B specified operating temperatures are required for the following tests

- Achieve data as regards EMC sensitivity.
- Performance evaluation of bolometers and photometers.
- Calibration purposes using the buitlt in calibration sources.
- Cooler recycling.

For small exceedings (< 1 K) the following tests are possible

- Operation of blue detectors (photometers).
- Verification of mechanisms.

Impacts: reduction of He3-cooler hold-time.

For considerable exceedings (2K-5K) the possible tests are limited to

- Verification of mechanisms.
- Verification of read out electronic.

Impacts: Detector signals are in overload.

For exceedings > 5K only continuity checks are possible.

For the recording of one set of bolometer parameters the minimum required hold time of the sorption cooler is 6 h.

SPIRE

During cool-down, after SFT warm, the instrument is to be left in the Ready Mode "DPU + DRCU - ON Thermometers ON" to allow to monitor the instrument temperatures.

9.3 Spacecraft Orientation

The following spacecraft orientations will be adjusted:

- 0 deg for all tests excluding PACS and SPIRE cooler recycling.
- 23 deg to 30 deg in +y-direction during PACS and SPIRE cooler recycling (duration about 2 h).
- All orientations between +/- 90 deg during integration activities (TBC).

9.4 Sensor Background

The PFM cryostat will provide far infrared background radiation levels for PACS and SPIRE comparable to those induced by the telescope. For HIFI no specific measures for that aspect have been implemented.

This will be accomplished by a specific design of cold plates (mirrors) which perform self-imaging of the PACS and SPIRE FPU entrance holes. Other contributions of thermal radiation are highly suppressed. The cold plate temperature is 80 K (adjustable to in-orbit telescope temperature by control of LHe flow). The goal for the cold plate emissivity is 0.015 (corresponding to the total telescope emissivity). For details see RD 2.

Note: Due to the limited accuracy in emissivity measurements the background radiation of the cover mirror can be fine tuned using the on-line signals of PACS and SPIRE which are assumed to be absolutely calibrated. The fine tuning will be performed prior to the instrument performance tests by appropriate adjustment of the cryo cover temperature (flow rate). When calculating the temperature it should be considered that a constant underlying stray light signal and/or constant instrument offset may be present.

9.5 Thermal Environment

The PLM PFM provides the following thermal environment:

HIFI

On-ground thermal I/F temperature analysis results for HIFI instrument testing (based on thermal analysis, RD-01)			
	HIFI FPU thermal I/F	**I/F node**	**I/F Temperature**
L0	L0 boundary	949	2.15 K
L1	L1 boundary	939	5 K
L2	FPU structure	910	12 K

Notes:

- The L0 interface temperature (node 949) is calculated for Helium filling of 80% and upright cryostat position.

Table 9-1: On-ground Thermal Interface Temperatures for Instrument Testing – HIFI

PACS

On-ground thermal I/F temperature analysis results for PACS instrument testing (based on thermal analysis, RD-01)				
	PACS FPU thermal I/F	**I/F node**	**I/F Temperature**	**Cooler State**
L0	Red Detector	721	1.8 K	Operating
	Blue Detector	723	2 K	Operating
	Cooler Pump	761	2 K	Operating
			15 K peak	Recycling
	Cooler Evaporator	762	2 K	Recycling
L1	FPU structure	783	5.3 K	Operating
L2	Optical bench / FPU legs		12 K	Operating

Notes:

- The L1 interface temperature (node 783) is calculated for the Spectrometer Mode. The L1 Node 712 (spectrometer housing) has a temperature of 7.3 K based on the analysis results. The L1 temperature is directly related to the absorptivity/emissivity of the FPU instrument surface, which is outside the responsibility of the ASED. The basis for PACS is an ASED made GMM of the FPU with an emissivity of 0.26.
- The evaporator interface temperature can be only achieved when the “open pod” is filled with superfluid Helium.

Table 9-2: On-ground Thermal Interface Temperatures for Instrument Testing – PACS

SPIRE

On-ground thermal I/F temperature analysis results for SPIRE instrument testing (based on thermal analysis, RD-01)				
SPIRE FPU thermal I/F		I/F node	I/F Temp.	Cooler State
L0	Detector Box	814	2 K	Operating
	Cooler Pump	815	2 K	Operating
			25 K peak	Recycling
	Cooler Evaporator	816	2 K	Recycling
L1	L1 strap I/F	800	6.2 K	Operating
L2	Optical bench / FPU legs		12 K	Operating
L3	HSJFP (JFET Photometer)		15 K	-
	HSJFS (JFET Spectrometer)		15 K	-
-	Instrument shield (equivalent radiative temperature)		16 K	-

Notes:

- The interface temperatures are calculated for spectrometer mode. The temperature of the FPU housing itself is calculated to 7.3 K. The L1 temperature is directly related to the absorptivity/ emissivity of the FPU instrument surface, which is outside the responsibility of ASED. The basis for SPIRE is the ITMM, Issue 2.5 and the associated geometry model assuming an FPU emissivity of 0.2.
- The sorption cooler recycling phase is composed of 2 phases in sequence, as described in the SPIRE IID-B.
- Level 0 interfaces to the He-II tank are dipped into the fluid. During recycling of the SPIRE cooler it is assumed that the cryostat is tilted such that the top of the open pod is in contact with superfluid Helium.

Table 9-3: On-ground Thermal Interface Temperatures for Instrument Testing - SPIRE

Important notes and assumptions to the above tables:

- The temperatures are based on analysis results obtained with H-EPLM TMM, Issue 4.0 (see RD 4) and are provided without uncertainties. The predicted IMT interface temperatures will be verified during STM testing and may require to be updated.
- Heat flows are dominated by radiation due to ambient temperature of the cryostat vacuum vessel at 293K.
- The He-II tank is in closed condition assuming a starting temperature of 1.7 K, increasing with a small gradient.
- The helium flow for optical bench cooling comes out of the HOT with 4.3 K. Variation of the He flow could be possible. Current assumption is 100mg/sec for about 10 h maximum. Then a refill is necessary.
- The cryo cover is cooled to approximately 80 K.

- Special operations of the Herschel cryostat are foreseen to achieve the above values for instrument testing. The radiative environment may still vary, since the temperatures will not be in stable conditions (e.g. thermal shields, harness).

For details see RD 4.

9.6 Cleanliness

The following specific cleanliness provisions will be applied:

HIFI LOU

The LOU opening will be protected against particles by covering the openings with TBD tape during the entire PLM EQM AIT programme with the exception for the IMT and the EMC susceptibility tests.

9.7 Purging

Throughout the PLM PFM and satellite AIT until the closure of the fairing the HIFI LOU will be purged. The following conditions will be applied:

- Gas: Nitrogen of quality 5.0 (> 99.999%)
- Flow rate: 12 l/h
- Exposure time (without purging): 60 days maximum after delivery to ESA

9.8 ESD Procedures

Instruments will be electrically integrated following the relevant ESA standards.

Specific precautions are necessary during the electrical integration of the HIFI FPU and LOU (details TBD by HIFI).

Specific constraints TBD by PACS/SPIRE.

9.9 Microvibration

This chapter defines restrictions as regards microvibrations during instrument performance tests at PLM EQM level.

Specific constraints TBD by HIFI/PACS/SPIRE.

9.10 Red/Green Tag Items

HIFI

TBD by HIFI.

PACS

TBD by PACS.

SPIRE

The following red tag items are fitted to the FPU when delivered:

- Aperture cover
- Alignment cube
- Temporary grounding strap
- Shorting plugs

The aperture cover is removed by unscrewing the four 2-56 UNC (imperial) cap head screws and the lifting the cover clear (TBC by ASED).

The alignment cube is removed by unscrewing the three fixing screws and lifting clear.

No green tagged items.

10 Instrument Test Activity Descriptions

This section describes the individual test activities per instrument which will be performed on PLM PFM and satellite level. Each test activity is self-contained.

The objectives of the tests are as per section 3.2.

For each single test activity a dedicated test procedure will be established per unit and/or subsystem to be tested, as far as applicable.

For the PLM PFM and satellite level tests the test procedures developed for and validated at the instrument level tests will be re-used with no or minimal modifications.

10.1 Instrument EGSE Validation

10.1.1 HIFI EGSE Check Out

Title:	*Experiment:*
EGSE Check Out	**HIFI**

Objectives:
Check of Instrument EGSE function (self-test). Check of Instrument EGSE interfaces to CCS.

Test Description:
Perform self-test on instrument workstation.
Connect instrument work station to CCS via LAN.
Check connect/disconnect commands to instrument workstation.
Send TM and TC history packets to instrument workstation.
Export instrument command sequences and data base to CCS.
Load/dump OBSW files.

Instrument Configuration:	*Specific Requirements on PLM:*
EGSE stand-alone, Instrument EGSE connected to CCS	None.

Particular Environmental Constraints:
None.

Success Criteria:
TBD

Duration:	*Applicable:*
1 day	PLM PFM and satellite

10.1.2 PACS EGSE Check Out

Title:	*Experiment:*
EGSE Check Out	**PACS**

Objectives:
Check of Instrument EGSE function (self-test). Check of Instrument EGSE interfaces to CCS.

Test Description:
Perform self-test on instrument workstation.
Connect instrument work station to CCS via LAN.
Check connect/disconnect commands to instrument workstation.
Send TM and TC history packets to instrument workstation.
Export instrument command sequences and data base to CCS.
Load/dump OBSW files.

Instrument Configuration:	*Specific Requirements on PLM:*
EGSE stand-alone, Instrument EGSE connected to CCS	None.

Particular Environmental Constraints:
None.

Success Criteria:
TBD

Duration:	*Applicable:*
1 day	PLM PFM and satellite

10.1.3 SPIRE EGSE Check Out

Title:	*Experiment:*
EGSE Check Out	**SPIRE**

Objectives:
Check of Instrument EGSE function (self-test). Check of Instrument EGSE interfaces to CCS.

Test Description:
Perform self-test on instrument workstation.
Connect instrument work station to CCS via LAN.
Check connect/disconnect commands to instrument workstation.
Send TM and TC history packets to instrument workstation.
Export instrument command sequences and data base to CCS.
Load/dump OBSW files.

Instrument Configuration:	*Specific Requirements on PLM:*
EGSE stand-alone, Instrument EGSE connected to CCS	None.

Particular Environmental Constraints:
None.

Success Criteria:
TBD

Duration:	*Applicable:*
1 day	PLM PFM and satellite

10.2 Short Functional Test

10.2.1 HIFI Short Functional Test Warm

Title:	*Experiment:*
Short Functional Test Warm	**HIFI**

Objectives:
Confidence test to check electrical integrity and operability of instrument under ambient conditions for both, the FPU and the Warm Units prior to the evacuation of the CVV. The operability of the FPU under ambient conditions is limited; therefore the test cannot fully verify the instrument function. Evaluation will be based on housekeeping data; evaluation of science data is not foreseen.

Test Description:
Send the following commands: Power On (PLM command), Stand-By, TBD, TBD ... Monitor in parallel instrument power consumption (PLM HK parameters) and instrument HK parameters.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	None.

Particular Environmental Constraints:
Clean room, class 100 for FPU, class 100.000 or better for other units. ESD certified area. Relative humidity > 40% and < 55 %.

Success Criteria:
Housekeeping values within pre-defined limits. Correct execution of commands.

Duration:	*Applicable:*
1 h	PLM PFM and satellite

10.2.2 HIFI Short Functional Test Cold

Title:	*Experiment:*
Short Functional Test Cold	**HIFI**

Objectives:
Confidence test to check electrical integrity and operability of instrument at cold conditions for the FPU (cryostat cooled down to He1 or He2 conditions). Evaluation will be based on housekeeping data; evaluation of science data is not foreseen. The tests at He1 and He 2 conditions may differ.

Test Description:
Send the following commands: Power On (PLM command), Stand-By, TBD, TBD ... Monitor in parallel instrument power consumption (PLM HK parameters) and instrument HK parameters. Measure power of mixer for minimum and maximum LO power settings.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	None.

Particular Environmental Constraints:
He1: L0: TBD, L1: TBD and L2: TBD.
He2: L0, L1 and L2 as per Table 9-1.

Success Criteria:
Housekeeping values within pre-defined limits. Correct execution of commands.

Duration:	*Applicable:*
1 h	PLM PFM and satellite

10.2.3 PACS Short Functional Test Warm

Title:	*Experiment:*
Short Functional Test Warm	**PACS**

Objectives:
Confidence test to check electrical integrity and operability of instrument under ambient conditions for both, the FPU and the Warm Units prior to the evacuation of the CVV. The operability of the FPU under ambient conditions is limited; therefore the test cannot fully verify the instrument function. Evaluation will be based on housekeeping data; evaluation of science data is not foreseen.

Test Description:
Send the following commands: Power On (PLM command), Stand-By, TBD, TBD ... Monitor in parallel instrument power consumption (PLM HK parameters) and instrument HK parameters.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	None.

Particular Environmental Constraints:
Clean room, class 100 for FPU, class 100.000 or better for other units. ESD certified area. Relative humidity > 40% and < 55 %.

Success Criteria:
Housekeeping values within pre-defined limits. Correct execution of commands.

Duration:	*Applicable:*
1 h	PLM PFM and satellite

10.2.4 PACS Short Functional Test Cold

Title:	*Experiment:*
Short Functional Test Cold	**PACS**

Objectives:
Confidence test to check electrical integrity and operability of instrument at cold conditions for the FPU (cryostat cooled down to He1 or He2 conditions). Evaluation will be based on housekeeping data; evaluation of science data is not foreseen. The tests at He1 and He 2 conditions may differ.

Test Description:
Send the following commands: Power On (PLM command), Stand-By, TBD, TBD ... Monitor in parallel instrument power consumption (PLM HK parameters) and instrument HK parameters.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	None.

Particular Environmental Constraints:
He1: L0: TBD, L1: TBD and L2: TBD.
He2: L0, L1 and L2 as per Table 9-2.

Success Criteria:
Housekeeping values within pre-defined limits. Correct execution of commands.

Duration:	*Applicable:*
1 h	PLM PFM and satellite

10.2.5 SPIRE Short Functional Test Warm

Title:	*Experiment:*
Short Functional Test Warm	**SPIRE**

Objectives:
Confidence test to check electrical integrity and operability of instrument under ambient conditions for both, the FPU and the Warm Units prior to the evacuation of the CVV. The operability of the FPU under ambient conditions is limited; therefore the test cannot fully verify the instrument function. Evaluation will be based on housekeeping data; evaluation of science data is not foreseen.

Test Description:
Perform switch on procedure.
Switch instrument to Ready Mode.
Commanded each sub-system as appropriate to verify its function (TBD).
Switched instrument back to READY.
The instrument may then be switched OFF or to another mode if further tests are planned.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	None.

Particular Environmental Constraints:
Clean room, class 100 for FPU, class 100.000 or better for other units. ESD certified area. Relative humidity > 40% and < 55 %.

Success Criteria:
Housekeeping values within pre-defined limits. Correct execution of commands.

Duration:	*Applicable:*
about 1 h	PLM PFM and satellite

10.2.6 SPIRE Short Functional Test Cold

Title:	*Experiment:*
Short Functional Test Cold	**SPIRE**

Objectives:
Confidence test to check electrical integrity and operability of instrument at cold conditions for the FPU (cryostat cooled down to He1 or He2 conditions). Evaluation will be based on housekeeping data; evaluation of science data is not foreseen. The tests at He1 and He 2 conditions may differ.

Test Description:
Perform switch on procedure.
Switch instrument to Ready Mode.
Commanded each sub-system as appropriate to verify its function (TBD, different for He1 and He2 conditions).
Switched instrument back to READY.
The instrument may then be switched OFF or to another mode if further tests are planned.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	None.

Particular Environmental Constraints:
He1: L0: TBD, L1: TBD and L2: TBD.
He2: L0, L1 and L2 as per Table 9-3.

Success Criteria:
Housekeeping values within pre-defined limits. Correct execution of commands.

Duration:	*Applicable:*
1 h	PLM PFM and satellite

10.3 Special Performance Tests

10.3.1 HIFI IF Properties

Title:	*Experiment:*
IF Properties	**HIFI**

Objectives:
Check IF standing waves due to representative coax cables between IF box and spectrometers as well as spectral features due to leakage / finite shielding / isolation.

Test Description:
In this test the IF chain of HIFI will be checked in a representative environment. Important changes with respect to HIFI ILT are the change in harness (coax cables) and the environment (different locations / geometry / configuration and other systems involved). It is therefore needed to check the IF properties of the HIFI IF chain in terms of gain, noise, spectral ripple and spectral artefacts (spurs). The measurements will be performed with 3 bias settings per mixer.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	None

Particular Environmental Constraints:
L0, L1 and L2 as per Table 9-1.

Success Criteria:
IF gain / noise, ripple and spectrum within values applicable to IF chain.

Duration:	*Applicable:*
1 h	PLM PFM and satellite

10.3.2 HIFI Radiometry

Title:	*Experiment:*
Radiometry	**HIFI**

Objectives:
Determination of (conversion) gain and noise temperature over the RF band.

Test Description:
The noise temperature and gain will be determined at a limited number of points within the mixer bands that are present. This test is needed to verify proper heterodyne functioning before entering the detailed performance assessment during EMC test. In addition an LO power scan will be performed at each frequency setting as input for the calibration table for the receiver tuning.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	None

Particular Environmental Constraints:
L0, L1 and L2 as per Table 9-1.

Success Criteria:
Deviations determined by comparing to measurement results obtained during HIFI instrument level test are within TBD % or understood.

Duration:	*Applicable:*
1 day	PLM PFM and satellite

10.3.3 HIFI LO Beam Standing Wave Test

Title:	*Experiment:*
LO Beam Standing Wave Test	**HIFI**

Objectives:
Assessment of the level of reflections in the LO path (LOU to FPU).

Test Description:
During this test the level of reflections in the local optical paths (LOU to FPU) will be measured. Such reflections will cause artefacts in the instrument scientific data and it is important to verify that they are effectively suppressed. For reflections in the LO path, the LOU to FPU mixer coupling as a function of LO frequency will be measured.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	None

Particular Environmental Constraints:
L0, L1 and L2 as per Table 9-1.

Success Criteria:
Verification that the variation in LO path coupling due to standing waves is less than 20% peak-to-peak as a function of frequency. Comparison with measurement results obtained during HIFI DM ILT shall confirm LO path losses are within 20 % or understood.

Duration:	*Applicable:*
1 day	PLM PFM and satellite

10.3.4 PACS Cooler Recycle

Title:	*Experiment:*
Cooler Recycle	**PACS**

Objectives:
To verify the temperature stability and balance of the PACS instrument during and after cooler recycle mode operations.
To prepare the instrument for operation with the detectors.

Test Description:
TBD

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	PLM tilted at least 23 deg around z-axis to +y. This operation can be carried out with the PLM rotated up to 90° in the same direction.

Particular Environmental Constraints:
L0, L1 and L2 as per Table 9-2.

Success Criteria:
Cooler is successfully recycled and temperatures settle to within operational limits as predicted by the PACS TMM.

Duration:	*Applicable:*
about 2 h	PLM PFM and satellite

10.3.5 PACS Full Functional Test

Title:	*Experiment:*
Full Functional Test	**PACS**

Objectives:
Validation of PACS switch-on procedure, including validation of connection between EGSE and instrument, memory load and dump. Validate function of DPU, function of SPU and data reduction/compression SW, validate function of DEC/MEC, validate function of BOLC/A, verify function of detectors, detector readouts, detector heaters and temperature sensors, verify function of mechanisms (grating, chopper and filter wheels), verify function of calibration sources, validate function of redundancy chains: not available at EQM Test, verify PACS autonomy functions (limit checks), verify PACS telemetry rates, verify time synchronisation procedure between CDMU and PACS, validate PACS deactivation (shut-down) procedure.

Test Description:
All available detector channels will be exercised by stimulation of internal sources and use of an external source (simulation of expected telescope background).

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	None

Particular Environmental Constraints:
L0, L1 and L2 as per Table 9-2.

Success Criteria:
Deviations determined by comparing to measurement results obtained during PACS DM ILT are within TBD % or understood.

Duration:	*Applicable:*
TBD	PLM PFM and satellite

10.3.6 PACS Short Performance Test

Title:	*Experiment:*
Short Performance Test	**PACS**

Objectives:
Validation of PACS activation sequence, test PACS FPU thermal behaviour, performance test of PACS mechanisms, synchronous operation and grating offset accuracy, detector electronics signal quality photoconductor part, detector electronics signal quality bolometer part, detector signal quality photoconductor part, detector signal quality bolometer part, performance of internal blackbody sources, check of spectrometer, cryostat background measurements (representative telescope flux simulation).

Test Description:
Prior to test the cooler has to be recycled / sufficient hold time has to be available.
All available detector channels will be exercised by stimulation of internal sources and use of an external source (simulation of expected telescope background).

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	None.

Particular Environmental Constraints:
L0, L1 and L2 as per Table 9-2.
Sensor background TBD.

Success Criteria:
Deviations determined by comparing to measurement results obtained during PACS DM ILT are within TBD % or understood.

Duration:	*Applicable:*
TBD	PLM PFM and satellite

10.3.7 PACS Astronomical Observation Template (AOT) Tests

Title:	*Experiment:*
Astronomical Observation Template (AOT) Tests	**PACS**

Objectives:
To verify in a short and representative way that the planned observation strategies (command sequences and data acquisition) are compatible with the system, pointing issues cannot be proven.

Test Description:
Prior to test the cooler has to be recycled / sufficient hold time has to be available.
Test of PACS Single Band Photometry Mode,
Test of PACS Dual Band Photometry Mode,
Test of PACS Line Spectroscopy Mode,
Test of PACS Range Spectroscopy Mode
Test of PACS Calibration Measurement using FPU internal blackbodies.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	None.

Particular Environmental Constraints:
L0, L1 and L2 as per Table 9-2.
Sensor background TBD.

Success Criteria:
TBD.

Duration:	*Applicable:*
TBD day	PLM PFM and satellite

10.3.8 PACS PACS/SPIRE Parallel Mode

Title:	*Experiment:*
PACS/SPIRE Parallel Mode	**PACS**

Objectives:
Verification of operability of PACS/SPIRE in parallel. Monitoring of PACS thermal behaviour with SPIRE being switched on.

Test Description:
Prior to test the cooler has to be recycled / sufficient hold time has to be available.
PACS activation.
PACS thermal behaviour, with SPIRE being switched on,
Test of PACS/SPIRE parallel mode AOT with PACS in single band Photometry mode,
Test of PACS/SPIRE parallel mode AOT with PACS in dual band Photometry mode,
PACS deactivation.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	None.

Particular Environmental Constraints:
L0, L1 and L2 as per Table 9-2.
Sensor background TBD.

Success Criteria:
Deviations determined by comparing to measurement results obtained during PACS DM ILT are within TBD % or understood.

Duration:	*Applicable:*
TBD	PLM PFM and satellite

10.3.9 SPIRE Cooler Recycle

Title:	*Experiment:*
Cooler Recycle	**SPIRE**

Objectives:
To verify the temperature stability and balance of the SPIRE instrument during and after cooler recycle mode operations.
To prepare the instrument for operation with the photometer or spectrometer detectors.

Test Description:
The cryostat will be placed in a condition that as nearly as possible replicates the expected flight conditions (limitations due to ambient temperature of CVV). The SPIRE cooler recycle sequence will be carried out and the temperatures of the various stages monitored. The results will be compared to those from the SPIRE Instrument Thermal Model (ITMM)

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	PLM tilted at least 23 deg around z-axis to +y. This operation can be carried out with the PLM rotated up to 90° in the same direction.

Particular Environmental Constraints:
Mass flow rate: as close as possible to that expected in flight (limitations due to ambient temperature of CVV).
L0, L1 and L2 as per Table 9-3.

Success Criteria:
Cooler is successfully recycled and temperatures settle to within operational limits as predicted by the SPIRE ITMM.

Duration:	*Applicable:*
about 2 h	PLM PFM and satellite

10.3.10 SPIRE Ambient Background Verification

Title:	*Experiment:*
Ambient Background Verification	**SPIRE**

Objectives:
To check the photon background on the photometer detectors after cooler recycle and before all other tests.

Test Description:
The EQM cryostat will be placed in a condition that as nearly as possible replicates the expected flight conditions (limitations due to ambient temperature of CVV).
The SPIRE cooler has been recycled and the instrument is at nominal temperature.
The photometer JFETs are switched on and the instrument temperatures allowed settling.
The SPIRE shutter may be closed (TBD).
Load curves are taken on the photometer detectors by varying the bias voltage.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	None

Particular Environmental Constraints:
Mass flow rate: as close as possible to that expected in flight (limitations due to ambient temperature of CVV).
L0, L1 and L2 as per Table 9-3.

Success Criteria:
Data analysed in real time to calculate the background flux on the detectors. Background should be within limits defined for the follow on test.

Duration:	*Applicable:*
about 1 h	PLM PFM and satellite

10.3.11 SPIRE Photometer Mode

Title:	*Experiment:*
Photometer Mode	**SPIRE**

Objectives:
To verify the temperature stability and balance of the SPIRE instrument during photometer chopped mode operations.

Test Description:
The cryostat will be placed in a condition that as nearly as possible replicates the expected flight conditions (limitations due to ambient temperature of CVV).
The ambient background in the instrument is such as to allow meaningful signals from the detectors to be seen. This will be verified by a dedicated measurement.
The SPIRE cooler has been recycled and the instrument is at nominal temperature.
The photometer JFETs are switched on and the instrument temperatures allowed settling.
A simulated photometer chop observation is carried out – this will include operation of the photometer calibrator and beam steering mirror.
The results will be compared to the ILT and the SPIRE ITMM.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	None.

Particular Environmental Constraints:
Mass flow rate: as close as possible to that expected in flight (limitations due to ambient temperature of CVV).
L0, L1 and L2 as per Table 9-3.
Photon background on the detector in the 420-580 μm band within x5 (TBC) of that expected in flight – this equivalent to a blackbody of <~ 20 K in the beam of SPIRE.

Success Criteria:
The instrument temperatures stay within pre-defined limits as predicted by the SPIRE ITMM.
No excess background is seen on the detectors during operations.

Duration:	*Applicable:*
about 1 h	PLM PFM and satellite

10.3.12 SPIRE Spectrometer Mode

Title:	*Experiment:*
Spectrometer Mode	**SPIRE**

Objectives:
To verify the temperature stability and balance of the SPIRE instrument during spectrometer mode operations.

Test Description:
The cryostat will be placed in a condition that as nearly as possible replicates the expected flight conditions (limitations due to ambient temperature of CVV).
The ambient background in the instrument is such as to allow meaningful signals from the detectors to be seen. This will be verified by a dedicated test.
The SPIRE cooler has been recycled and the instrument is at nominal temperature.
The spectrometer JFETs are switched on and the instrument temperatures allowed settling.
The spectrometer calibrator is switched on.
A simulated spectrometer chop observation is carried out – this will include operation of the photometer calibrator and beam steering mirror.
The results will be compared to the ILT and the SPIRE ITMM.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	PLM tilted at least 85° around z-axis to either +y or -y direction.

Particular Environmental Constraints:
Mass flow rate: as close as possible to that expected in flight (limitations due to ambient temperature of CVV).
L0, L1 and L2 as per Table 9-3.
Sensor background TBD.

Success Criteria:
The instrument temperatures stay within pre-defined limits as predicted by the SPIRE ITMM.
No excess background is seen on the detectors during operations.

Duration:	*Applicable:*
about 1 h	PLM PFM and satellite

10.3.13 SPIRE PACS/SPIRE Parallel Mode

Title:	*Experiment:* **SPIRE**

Objectives:
TBD

Test Description:
The SPIRE cooler has been recycled and the instrument is at nominal temperature.
TBD.

Instrument Configuration: As per Figure 8-1 or Figure 8-2.	*Specific Requirements on PLM:* None.

Particular Environmental Constraints:
Mass flow rate: as close as possible to that expected in flight (limitations due to ambient temperature of CVV).
L0, L1 and L2 as per Table 9-3.
Sensor background TBD.

Success Criteria:
TBD

Duration: TBD	*Applicable:* PLM PFM and satellite

10.4 Integrated Module Tests / Integrated System Tests

10.4.1 HIFI Integrated Module Test / Integrated System Test

Title:	*Experiment:*
Integrated Module Test / Integrated System Test	**HIFI**

Objectives:

Verification of the functional performance of the integrated instrument in all modes. Check of the instrument performance as far as possible with PLM configuration.

Test Description:

The Integrated Module Test is composed by the following test steps: 1) Short Functional Test, 2) IF Properties, 3) Radiometry (for TBD receiver settings), 4) LO Beam Standing Wave Test, 5) Stability Test (TBC). For details to the single test steps see the related Test Activity Descriptions. The Stability Test is TBD.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	None.

Particular Environmental Constraints:

L0, L1 and L2 as per Table 9-1.

Success Criteria:

Housekeeping values within pre-defined limits. Correct execution of commands. No performance degradation with respect to instrument level test results.

Duration:	*Applicable:*
3 days (TBC)	PLM PFM and satellite

10.4.2 PACS Integrated Module Test / Integrated System Test

Title:	*Experiment:*
Integrated Module Test / Integrated System Test	**PACS**

Objectives:

Verification of the functional performance of the integrated instrument in all modes. Check of the instrument performance as far as possible with PLM configuration.

Test Description:

The Integrated Module Test is composed by the following test steps: TBD. For details to the single test steps see the related Test Activity Descriptions.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	PLM tilted > 23 deg to +y during cooler recycle.

Particular Environmental Constraints:

L0, L1 and L2 as per Table 9-2.
Sensor background TBD.

Success Criteria:

Housekeeping values within pre-defined limits. Correct execution of commands. No performance degradation with respect to instrument level test results.

Duration:	*Applicable:*
TBD	PLM PFM and satellite

10.4.3 SPIRE Integrated Module Test / Integrated System Test

Title:	*Experiment:*
Integrated Module Test / Integrated System Test	**SPIRE**

Objectives:

Verification of the functional performance of the integrated instrument in all modes. Check of the instrument performance as far as possible with PLM configuration.

Test Description:

The Integrated Module Test is composed by the following test steps: (TBD). For details to the single test steps see the related Test Activity Descriptions.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	PLM tilted > 23 deg to +y during cooler recycle.

Particular Environmental Constraints:

Mass flow rate: as close as possible to that expected in flight (limitations due to ambient temperature of CVV).
Photon background on the detector in the 420-580 μm band within x5 (TBC) of that expected in flight – this equivalent to a blackbody of <~ 20 K in the beam of SPIRE.
This may be achieved using the SPIRE shutter (TBD).

Success Criteria:

Housekeeping values within pre-defined limits. Correct execution of commands. No performance degradation with respect to instrument level test results.

Duration:	*Applicable:*
TBD	PLM PFM and satellite

10.5 EMC Tests

10.5.1 HIFI EMC Test

Title:	*Experiment:*
EMC Test	**HIFI**

Objectives:
Check of instrument functional performance in its most sensitive mode under electromagnetic worst case conditions (conducted and radiated EMC).

Test Description:
During this test the EMC susceptibility of HIFI in a representative environment will be assessed. Susceptibility will be measured in terms of changes in performance parameters like noise temperature, but also in terms of spectral information (spurious responses). The RF bands will be fully tested on performance for a TBD number of receiver settings. The internal calibration source will be used as the stimuli for the performance test and to search for EMI of the IF chain. For verification of the absence of EMI of the LO an external line test source, comprising a harmonic generator driven by a microwave synthesiser, will be required. This test signal will be injected with a beamsplitter between the LOU and the CVV window. IF properties might be separately tested under simulated EMC environment again as part of this EMC test.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	Satellite in EMC chamber.

Particular Environmental Constraints:
L0, L1 and L2 as per Table 9-1.

Success Criteria:
Deviations from measurement results obtained during HIFI DM ILT are within TBD % or understood.

Duration:	*Applicable:*
5 days	PLM PFM and satellite

10.5.2 PACS EMC Test

Title:	*Experiment:*
EMC Test	**PACS**

Objectives:
Check of instrument functional performance in its most sensitive mode under electromagnetic worst case conditions (conducted and radiated EMC).

Test Description:
During ILT, two specific EMC test sequences will be developed. During EQM, performance of these sequences will allow verification of certain EMC requirements in addition to the results from specified test set-ups. Note: EQM EMC testing might very likely require conducted and radiated emission and conducted and radiated susceptibility measurements (details still TBD).
PACS activation including cooler recycling,
PACS in "most noisy" mode(s) (all actuators ON, etc.),
PACS in "most sensitive" mode(s) (all mechanisms quiet except chopper, all detector read-outs in most sensitive status, etc.),
PACS deactivation.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	Satellite in EMC chamber. PLM tilted > 23 deg to +y during cooler recycle.

Particular Environmental Constraints:
L0, L1 and L2 as per Table 9-2.
Sensor background TBD.

Success Criteria:
Deviations from measurement results obtained during HIFI DM ILT are within TBD % or understood.

Duration:	*Applicable:*
5 days	PLM EQM

10.5.3 SPIRE EMC Test

Title:	*Experiment:*
EMC Test	**SPIRE**

Objectives:
Check of instrument functional performance in its most sensitive mode (Photometer Standby) under electromagnetic worst case conditions (conducted and radiated EMC).

Test Description:
The EQM cryostat will be placed in a condition that as nearly as possible replicates the expected flight conditions i.e. the mass flow rate and shield temperatures must be those expected in flight.
The ambient photon background in the instrument is low enough such that meaningful noise measurements can be made on the detectors. The background will be verified by a dedicated test.
The SPIRE cooler has been recycled and the instrument is at nominal temperature.
The photometer JFETs are switched on and the instrument temperatures allowed settling.
Noise traces are taken from the detectors at the highest data sampling frequency allowed by the electronics before and during conducted and radiated EM testing.
The results will be compared to the ILT and the SPIRE EMC model.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Figure 8-1 or Figure 8-2.	Satellite in EMC chamber. PLM tilted > 23 deg to +y during cooler recycle.

Particular Environmental Constraints:
Mass flow rate: as close as possible to that expected in flight (limitations due to ambient temperature of CVV).
L0, L1 and L2 as per Table 9-3.
Photon background on the detector in the 420-580 μm band within x5 (TBC) of that expected in flight – this equivalent to a blackbody of <~ 20 K in the beam of SPIRE.
This may be achieved using the SPIRE shutter (TBD).

Success Criteria:
No excess noise on the detectors. Deviations from measurement results obtained during HIFI DM ILT are within TBD % or understood.

Duration:	*Applicable:*
5 days	PLM PFM and satellite

10.6 TB/TV Tests

10.6.1 HIFI TB/TV Test

Title:	*Experiment:*
TB/TV Test	**HIFI**

Objectives:

Check of temperatures and temperature transient of performance critical HIFI elements under nearly flight conditions.
Verification of instrument performance in nearly flight conditions.

Test Description:

Monitoring of temperature levels on the following HIFI FPU elements: IF box, mixers and IF amplifiers, diplexer mechanisms, chopper and calibration source and on the LOU power amplifiers and multiplier stages.
Performance measurements.

Instrument Configuration:	*Specific Requirements on PLM and/or satellite:*
As per Figure 8-1 or Figure 8-2.	Satellite in TV chamber.

Particular Environmental Constraints:

L0, L1 and L2 as per Table 9-1.

Success Criteria:

Deviations from measurement results obtained during HIFI DM ILT are within TBD % or understood.

Duration:	*Applicable:*
TBD	Satellite

10.6.2 PACS TB/TV Test

Title:	*Experiment:*
TB/TV Test	**PACS**

Objectives:

Check of temperatures and temperature transient of performance critical PACS elements under nearly flight conditions.

Verification of instrument performance in nearly flight conditions.

Test Description:
TBD

Instrument Configuration:	*Specific Requirements on PLM and/or satellite:*
As per Figure 8-1 or Figure 8-2.	Satellite in TV chamber. PLM tilted > 23 deg to +y during cooler recycle.

Particular Environmental Constraints:
L0, L1 and L2 as per Table 9-2.
Sensor background TBD.

Success Criteria:
Deviations from measurement results obtained during HIFI DM ILT are within TBD % or understood.

Duration:	*Applicable:*
TBD	Satellite

10.6.3 SPIRE TB/TV Test

Title:	*Experiment:*
TB/TV Test	**SPIRE**

Objectives:

Check of temperatures and temperature transient of performance critical SPIRE elements under nearly flight conditions.
Verification of instrument performance in nearly flight conditions.

Test Description:
TBD

Instrument Configuration:	*Specific Requirements on PLM and/or satellite:*
As per Figure 8-1 or Figure 8-2.	Satellite in TV chamber. PLM tilted > 23 deg to +y during cooler recycle.

Particular Environmental Constraints:
Mass flow rate: as close as possible to that expected in flight.
L0, L1 and L2 as per Table 9-3.
Sensor background TBD.

Success Criteria:
No excess noise on the detectors. Deviations from measurement results obtained during HIFI DM ILT are within TBD % or understood.

Duration:	*Applicable:*
TBD	Satellite

10.7 SVT Tests

10.7.1 HIFI SVT Test

Title:	*Experiment:*
SVT Test	**HIFI**

Objectives:
Verification of instrument commanding, telemetry and science data from/to the control centre.

Test Description:
TBD

Instrument Configuration:	*Specific Requirements on PLM and/or satellite:*
	None.

Particular Environmental Constraints:
L0, L1 and L2 as per Table 9-1.

Success Criteria:
Deviations from measurement results obtained during HIFI DM ILT are within TBD % or understood.

Duration:	*Applicable:*
TBD	Satellite

10.7.2 PACS SVT Test

Title:	*Experiment:*
SVT Test	**PACS**

Objectives:
Verification of instrument commanding, telemetry and science data from/to the control centre.

Test Description:
TBD

Instrument Configuration:	*Specific Requirements on PLM and/or satellite:*
	Satellite in flight configuration. PLM tilted > 23 deg to +y during cooler recycle.

Particular Environmental Constraints:
L0, L1 and L2 as per Table 9-2.
Sensor background TBD.

Success Criteria:
Deviations from measurement results obtained during HIFI DM ILT are within TBD % or understood.

Duration:	*Applicable:*
TBD	Satellite

10.7.3 SPIRE SVT Test

Title:	*Experiment:*
SVT Test	**SPIRE**

Objectives:
Verification of instrument commanding, telemetry and science data from/to the control centre.

Test Description:
TBD

Instrument Configuration:	*Specific Requirements on PLM and/or satellite:*
	Satellite in flight configuration. PLM tilted >23 deg to +y during cooler recycle.

Particular Environmental Constraints:
Mass flow rate: as close as possible to that expected in flight (limitations due to ambient temperature of CVV).
L0, L1 and L2 as per Table 9-3.
Sensor background TBD.

Success Criteria:
No excess noise on the detectors. Deviations from measurement results obtained during HIFI DM ILT are within TBD % or understood.

Duration:	*Applicable:*
TBD	Satellite

	Name	Dep./Comp.		Name	Dep./Comp.
	Alberti von Mathias Dr.	AOE22		Tenhaeff Dieter	AOE22
	Alo Hakan	OTN/TP 45		Thörmer Klaus-Horst Dr.	OTN/AED65
x	Barlage Bernhard	AED11		Wagner Klaus	AOE23
x	Bayer Thomas	AET52	x	Wietbrock, Walter	AET12
x	Faas Horst	AEA65		Wöhler Hans	AOE22
	Fehringer Alexander	AOE13			
	Frey Albrecht	AED422			
x	Gerner Willi	AED11			
	Grasl Andreas	OTN/AET52			
	Grasshoff Brigitte	AET12	x	Alcatel	ASP
x	Hauser Armin	AOE23	x	ESA/ESTEC	ESA
	Hinger Jürgen	AOE23			
x	Hohn Rüdiger	AET52		**Instruments:**	
	Huber Johann	AOA4	x	MPE (PACS)	MPE
	Hund Walter	ASE4A	x	RAL (SPIRE)	RAL
x	Idler Siegmund	AED432	x	SRON (HIFI)	SRON
	Ivády von András	FAE22			
	Jahn Gerd Dr.	AOE23		**Subcontractors:**	
x	Kalde Clemens	APE3		Air Liquide, Space Department	AIR
	Kameter Rudolf	OTN/AET52		Air Liquide, Space Department	AIRS
	Kettner Bernhard	AOE22		Air Liquide, Orbital System	AIRT
x	Knoblauch August	AET32		Alcatel Bell Space	ABSP
x	Koelle Markus	AET22		Astrium Sub-Subsyst. & Equipment	ASSE
x	Kroeker Jürgen	AED65		Austrian Aerospace	AAE
	Kunz Oliver Dr.	AOE23		Austrian Aerospace	AAEM
x	Lamprecht Ernst	OTN/ASI21		APCO Technologies S. A.	APCO
x	Lang Jürgen	ASE4A		Bieri Engineering B. V.	BIER
	Langfermann Michael	AET52		BOC Edwards	BOCE
x	Mack Paul	OTN/AET52		Dutch Space Solar Arrays	DSSA
x	Muhl Eckhard	OTN/AET52		EADS CASA Espacio	CASA
x	Pastorino Michel	ASPI Resid.		EADS CASA Espacio	ECAS
	Peltz Heinz-Willi	AET42		EADS Space Transportation	ASIP
	Pietroboni Karin	AED65		Eurocopter	ECD
	Platzer Wilhelm	AED22		HTS AG Zürich	HTSZ
	Puttlitz Joachim	OTN/AET52		Linde	LIND
	Rebholz Reinhold	AET52		Patria New Technologies Oy	PANT
	Reuß Friedhelm	AED62		Phoenix, Volkmarsen	PHOE
x	Rühe Wolfgang	AED65		Prototech AS	PROT
	Runge Axel	OTN/AET52		QMC Instruments Ltd.	QMC
	Sachsse Bernt	AED21		Rembe, Brilon	REMB
x	Schink Dietmar	AED422		Rosemount Aerospace GmbH	ROSE
x	Schlosser Christian	OTN/AET52		RYMSA, Radiación y Microondas S.A.	RYM
	Schmidt Rudolf	FAE22		SENER Ingenieria SA	SEN
	Schweickert Gunn	AOE22		Stöhr, Königsbrunn	STOE
	Stauss Oliver	AOE13		Terma A/S, Herlev	TER
	Steininger Eric	AED422			
x	Stritter Rene	AED11			