Title:	**Instrument Testing on PLM EQM Level**
CI-No:	150 000

Prepared by:	S. Idler	Date:	20.07.04
Checked by:	C. Schlosser		26.7.04
Product Assurance:	R. Stritter		26.07.04
Configuration Control:	W. Wietbrock		28.07.04
Project Management:	W. Rühe		28.7.04

Distribution:	See Distribution List (last page)

Issue	Date	Sheet	Description of Change	Release
Draft	30.04.02	all	Draft for review and comments	
Issue 1	22.05.02	all	Initial issue	
Issue 2	06.06.03	all	Complete revision of issue 1, reflecting the development of the programme and taking into account related comments from the instrument contractors.	
Issue 3	20.07.04	all	Complete revision of issue 2 in the frame of the Herschel CDR, 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.	

List of Content

List of Figures

List of Tables

1 Scope

This plan defines the instrument tests to be performed on PLM level during the Herschel EQM programme. This includes the instrument incoming inspections after delivery to ASED, the activities and interface tests planned for the instrument integration in the PLM EQM and the instrument related tests to be performed during the various PLM EQM test phases. All these activities and tests are described per instrument and per test activity in specific form sheets.

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

The main objective is that the document shall be the central document for the compilation of information concerning the EQM instrument testing. Therefore this document shall be used as reference document for the iteration cycles with the parties involved in the instrument related part of the PLM EQM AIT programme. Furthermore this document serves as reference document for the higher level PLM EQM 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 PLM EQM AIT planning and the information provided by the instrument contractors. In case of changes of the planning this document will be updated accordingly (‘living document’).

The document provides the specification for the instrument related PLM EQM test procedures.

Note:

The current issue 3 reflects the status as per 20.07.2003. All information available by that date has been included. Open items are indicated by TBDs or TBCs. A further consolidation of this document is needed. The next update is planned at begin of October 2004. This requires the comments and inputs (in particular the close outs of the TBDs and TBCs) from the instrument teams by the end of September 2004. Main focus shall be put on the mechanical and electrical integration procedures being the first steps of the spacecraft level instrument activities. Dedicated AIT meetings at the instrument sites will be performed to support this process. Further iteration steps are planned.

2 Documents

2.1 Applicable Documents

AD 1	SCI-PT-IIDA-04624	Herschel/Planck Instrument Interface Document, Part A	Issue 3.1
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 3.1
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	H-EPLM AIV and Herschel Satellite AIT Requirements Specification	Issue 4.2
AD 6	HP-2-ASED-PL-0022	Herschel PLM EQM AIT Plan	Issue 2.1
AD 7	HP-2-ASED-PL-0007	Herschel PA Plan	Issue 2, Rev. 1
AD 8	HP-2-ASED-PL-0023	Herschel Contamination Control Plan	Issue 2

2.2 Reference Documents

RD 1	-	-	
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 TBD
RD 4	HP-2-ASED-TN-0041	HERSCHEL EQM Thermal Model and Analysis	Issue 4
RD 5	HP-2-ASED-TN-0002	Herschel Alignment Concept	Issue TBD
RD 6	SPIRE-RAL-PRC-001923	SPIRE FPU Handling and Integration Procedure	Issue 1, 20.05.04
RD 7	SPIRE-RAL-DOC-001905	SPIRE EQM Test Plan	Issue 1.0, 19.12.03

RD 8	SPIRE-RAL-DOC-000768	Operating the SPIRE Instrument	Issue Draft, 31.05.2003
RD 9	SPIRE-RAL-DOC-001652	SPIRE Functional Test Specification	Issue 1.0, 05.12.2003
RD 10	SPIRE-RAL-DOC-001799	SPIRE DRCU Integration Test Specification	Issue 1.0, 05.09.2003
RD 11	SPIRE-RAL-NOT-000983	Definition of SPIRE CQM Deliverables for System Level Testing	Issue 3.0, 19.12.03
RD 12	SPIRE-RAL-DOC-001132	SPIRE Warm Electronics Integration Plan	Issue 0.1, 10.01.02
RD 13	SPIRE-RAL-DOC-001049	SPIRE CQM Instrument Level Test Plan	Issue 1.0, 15.05.02
RD 14	SPIRE-RAL-NOT-000982	SPIRE EQM Test Program Definition Test Case Forms	Issue 0.2, 19.02.02
RD 15	SPIRE-RAL-DOC-001123	SPIRE CQM Performance Test Specification	Issue 0.4 Draft, 29.05.02
RD 16			
RD 17			

3 Objective of PLM EQM AIT Programme

3.1 PLM EQM Test Programme General Objectives

The main objective of the EQM test program on PLM EQM level is to check the mechanical, electrical, electromagnetic and thermal compatibility of the instruments with the PLM and the PLM environment.

Another important objective is to validate the instrument integration, alignment and test procedures and the PLM test set-up as far as possible and to gain experience in operating the PLM and GSE for the PFM programme.

The EQM AIT programme uses the ISO QM cryostat which has been refurbished and modified in some areas to provide as much as possible the Herschel cryostat environmental 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 EQM 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 PLM level instrument test programme.
Instrument Alignment Check	Check of instrument alignment and validation of alignment procedure (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..

Test	Test Objectives	Conditions	Remarks
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	
EMC Test	Check of functional performance of the integrated instrument under electromagnetic worst case conditions (radiated susceptibility).	Tank temperature: 1.7 K	Instruments to be in the most sensitive mode(s).

Table 3-1: Instrument related Tests on PLM EQM Level

4 PLM EQM AIT Flow

4.1 Activities Overview

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

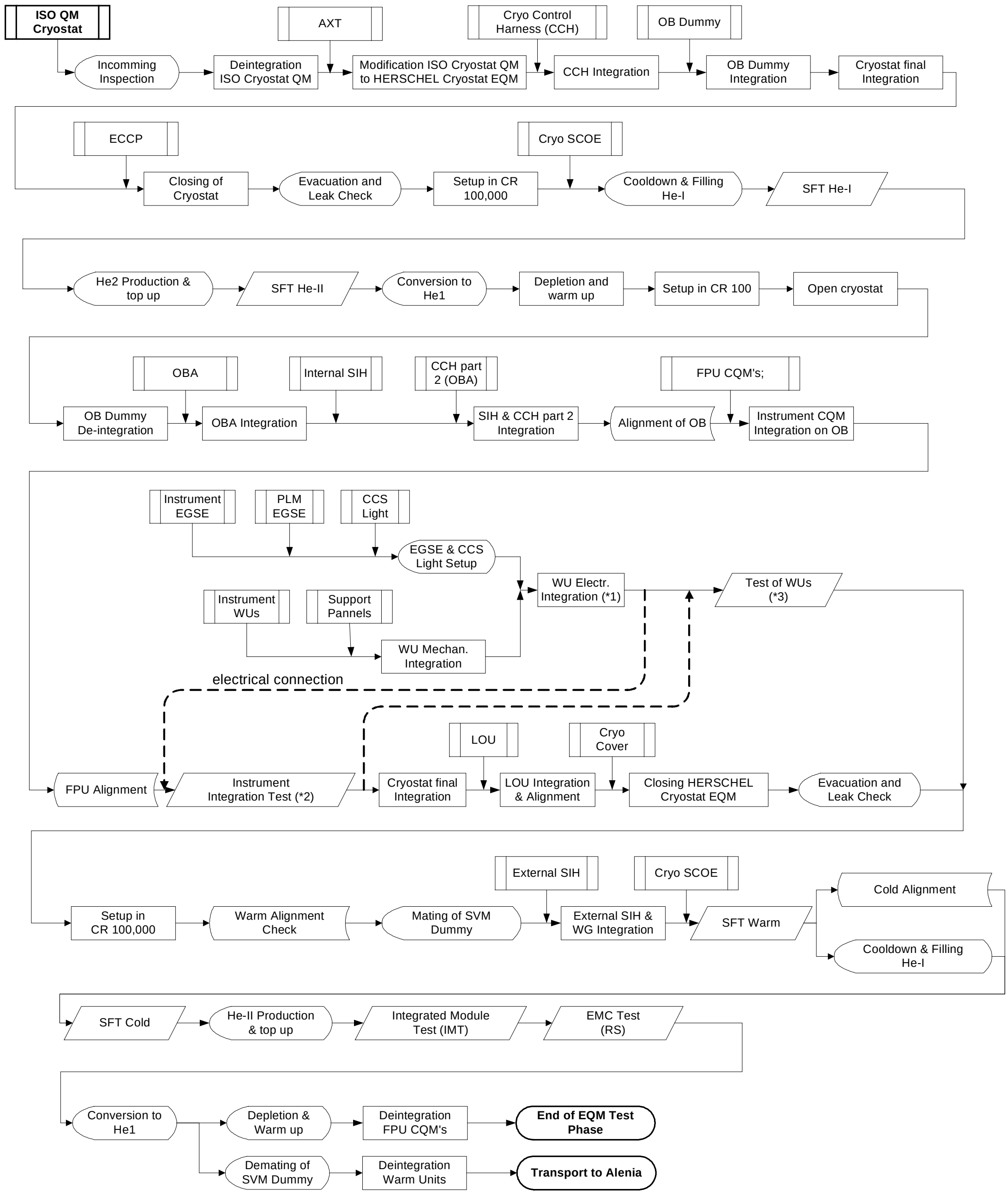

Figure 4-1: EQM AIT Flow

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 desiccant
- 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
- 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 test facility at Astrium (Ottobrunn). The layout of the test facilities is shown in Figure 8-3. For details see AD 06. The spacecraft EGSE is not required with the exception of the SPIRE Warm Units test. The testing on the FPU 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 (supplied by SPIRE):

- FPU and JFETs
- Test leads
- Breakout boxes

Expected duration: 1/2 day.

5.2.4.2 Warm Units Testing

Limited function tests will be carried out on the Warm Units. The following equipment will be required and supplied by SPIRE:

- DPU AVM
- DCU QM1
- FCU QM1
- DRCU separate Power Supply
- IEGSE (already at ASED)
- CDMS simulator
- FPU simulator
- WIH (test harness)
- Test Harness

Warm Units pre-integration test on instrument level:

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

Expected duration: 1/2 day.

Warm Units pre-integration test with Spacecraft EGSE:

- SPIRE Warm Units will be connected to the Spacecraft EGSE
- Repeat Warm Units pre-integration test on instrument level

Expected duration: 1/2 day.

5.3 Mechanical Integration

5.3.1 HIFI Mechanical Integration

Staggered delivery (TBC):

1. FPU, FCU, FCU SCOE to operate FCU, test harness to connect FCU and FPU and FCU SCOE, FPU simulator
2. LOU, LCU, LSU, LCU/LSU SCOE, test harness/waveguides to connect LOU with LCU and LSU and LCU/LSU SCOE
3. Remaining Warm Units

Flow and procedures TBD by HIFI.

5.3.2 PACS Mechanical Integration

Flow and procedures 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 OBP.
- A specific lifting gear (MGSE) is supplied for the integration of SPIRE FPU and JFET assembly on the OBP.
- 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 Optical Bench Plate.
- Fix the Spectrometer JFET studs (2 off) to the Optical Bench Plate.
- Lift the FPU and JFETs using the lifting gear from the SPIRE transportation baseplate onto the Herschel Optical Bench Plate.

- 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 HOB.
- When all units are rested on the HOB fit the attachment screws to the bipod feet as fothe 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 for the EQM consist of the DPU AVM and the DRCU QM1. An engineering model of the warm interconnect harness will be used.

A separate power supply will be installed in dedicated rack connected to the DRCU via a SPIRE provided harness.

The major integration steps for the SPIRE Warm Units are:

- TBD by SPIRE

The SPIRE Warm Units will be integrated on the SMV Simulator according to the Warm Electronics Integration Plan (see RD 12).

5.4 Electrical Integration

5.4.1 General

The instrument electrical integration comprises the check of

- The Warm Units internal interconnections.
- The connection of the Warm Units to the CDMU (FE).
- The connection between the FPU/LOU and the Warm Units.

The Warm Units internal interconnections and the connection of the Warm Units to the CDMU FE will be checked in their entity per instrument after their integration on the dummy SVM, using the instrument provided external FPU simulators (HIFI) or built-in FPU simulators (PACS). The 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 connection with the Warm Units the CDMU FE lines will be electrically checked (voltages).

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.
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

The following steps are proposed (steps 1 to 6 are part of the incoming inspection):

1. Delivery of FPU, FCU SCOE to operate the FCU, test harness to connect FCU SCOE to FCU and to coax cable ends, termination plugs for FCU (if needed) and FPU Simulator (TBC).
2. Unpacking and incoming inspection (check of shipping documents and inspection of hardware).
3. Integration of FCU on SVM mock-up.
4. Installation of FCU SCOE.
5. Connection of FCU SCOE to FCU.
6. Check of FCU with FCU SCOE.
7. Removal of FCU termination plugs (if any) and connection of cryoharness to FCU.
8. Mechanical/thermal integration of FPU.
9. Connection of cryoharness (incl. coax cables) to FPU.
10. Warm Check of FPU plus FCU with FCU SCOE.

11. 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 cryoharness EQM is flight representative with the exception that for the cryoharness between the LOU and LCU the following 2 bundles are provided:

- SIH-IH/SH-07 from LOU P05/P07 to LCU P09/P10 via SVM-CB J03/P03
- SIH-IH/SH-11 from LOU P06/P08 to LCU P16/P17 via SVM-CB J01/P01

The connections for the not available LOU channels 1, 2, 5, 6 and 7 and the heaters to the LCU are not implemented. The LOU and LCU provides dummy connectors (at flight representative position) for the not available LOU channel 4 (P07 and P08 on LOU and P10 and P17 on LCU), with all returns and shields being grounded.

The FCU and FPU EQMs are assumed to be identical to the PFMs as regards form and fit (e. g. identical connector type/position).

Note 3: The warm check of the FPU (step 13 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.

Note 4: The electrical integration test for the LOU is still TBD by HIFI.

5.4.3 PACS Electrical Integration

Flow and procedures 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.

Preconditions:

- Cryoharness integrated and a check of the grounding within the cryoharness shall be performed.
- Note: Only a subset of the spacecraft cryoharness branches is installed in the EQM. The non-used connectors on the FPU and JFETs will be fitted with saving plugs (provided by SPIRE) TBC by SPIRE.

- 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).
- Cryoharness cross talk checkout (TBC by ASED, for details see below).
- 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.

Grounding verification with connections between FPU Faraday Shield and cryoharness backshells separated (TBC by ASED, J. Lang).

Cryoharness cross talk checkout (TBC by ASED):

The cryoharness can be connected between the SPIRE DCU and a SPIRE provided GSE that simulates the JFET units with resistor networks. The unit provides a 1Hz oscillating signal on 4 out of 24 signal channels and allows the cross talk between channels to be assessed. It also allows the function of the harness to be checked safely before integration onto the FPU. Details are available in RD 7.

Note: Due to the EQM cryoharness integration sequence, i.e. closure of the CVV before installation of external harness) a cross talk check with the complete cryoharness (CVV internal, intermediate and SVM harness) will not be possible.

For details concerning the electrical integration see RD 6.

5.5 Instrument De-Integration

5.5.1 HIFI De-Integration

TBD by HIFI.

5.5.2 PACS De-Integration

TBD by PACS.

5.5.3 SPIRE De-Integration

5.5.3.1 Electrical Disconnection

Disconnection is the reverse of connection.

For details see RD 6.

5.5.3.2 Removal from spacecraft

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.

For details 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).

Secondly, after connection to the CCS lite, an interface check will be performed (PIPE protocol).

Its objective is to check the proper electrical EGSE – CCS connections and the correct functioning of the EGSE – CCS interface drivers.

Note: This test does not substitute the principle verification of the Instrument EGSE – CCS interface which is part of the Instrument EGSE and CCS AIT programme.

For specific check-out equipment (e. g. HIFI test signal source) dedicated validation tests will be performed, as required.

Related test activity descriptions per instrument section 10.1.

6.2 Alignment Check

The main objectives of the alignment checks are:

- Validation of the instrument alignment procedure.
- Determination of the impact of the CVV pressure change and cool down on the instrument alignment.
- Alignment of HIFI LOU versus HIFI FPU.

The determination of the shift and rotation of the OB after cryostat evacuation and cool down will be performed in two steps. The first alignment check will be performed 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.

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.

Note: To support these measurements the instruments FPU CQM is equipped with alignment references equal to the FPU PFM.

Related test activity descriptions see section 10.2.

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 (Note: 1 day for SPIRE). 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 10.3.

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

A series of 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.

No spacecraft EGSE is required for these tests.

A full warm functional test according to RD 9 will be performed.

These tests will take approximately 1 day.

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 (see 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)

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 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 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 SPTs will be conducted with in-orbit representative thermal conditions inside the cryostat and as regards the detector back ground. This will be achieved by specific cryogenic means (e. g. cryo cover as described in RD 2). The SPTs of the PACS and SPIRE instrument include the verification of the hold time of the 300 mK cooler.

Related test activity descriptions per instrument see section 10.4.

Note: The SPTs will be conducted as subsets of the IMT.

6.4.1 HIFI SPT

The following SPTs are defined for HIFI (see also section 10.4 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.

6.4.2 PACS SPT

The following SPTs are defined for PACS (see also section 10.4 of this document):

- Cooler Recycle / Hold Time
- Full Functional Test
- Short Performance Test [1)]
- Astronomical Observation Template (AOT) Tests
- PACS/SPIRE Parallel Mode Test

[1)] It would be preferred to break down the Short Performance Test into its different subsets (e. g. with the cooler recycle one of them) (break down TBD by PACS).

Test details TBD by PACS.

6.4.3 SPIRE SPT

The SPIRE SPTs will include the following Flight Operations Thermal Balance Tests:

- Cooler Recycle / Hold Time
- Ambient Background Verification Test
- Photometer Chop Mode Test

Test details TBD by SPIRE.

The case forms are contained in Section 10.4 of this document

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 EQM level only one IMT is planned. This IMT will comprise 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 Flow (EQM)						
Step	**HIFI**	**PACS**	**SPIRE**	**EPLM Position**	**Duration**	**Remarks**
1	Off	Off	Off	No requirement	-	
2	SFT Cold He2	Stand-By	Stand-By	No requirement	1 h	SFT
3	IF Properties Test	Stand-By	Stand-By	No requirement	1 h	
4	Radiometry Test				1 day	SPT
5	Reduced Standing Wave Test	Stand-By	Stand-By	No requirement	1 day	SPT
6	Stand-By	Stand-By	SFT Cold He2	No requirement	1 h	SFT
7	Stand-By	Stand-By	Instrument Cold Functional Test	No requirement	6 h	
8	Stand-By	Stand-By	Cooler Recycle	23° to 30° to +y	3 h	
9	Stand-By	Stand-By	Ambient Background Verification Test	No requirement	1 h	SPT
10	Stand-By	Stand-By	Photometer Mode Thermal Balance Test	No requirement	2 - 3 h	SPT
11	Stand-By	SFT Cold He2	Stand-By	No requirement	TBD	SFT
12	Stand-By	PACS Cooler Recycle	Stand-By	23° to 30° to +y	3 h	
13	Stand-By	PACS/SPIRE Parallel Mode	PACS/SPIRE Parallel Mode	No requirement	TBD	
14	Stand-By	Short Functional Test	Wait for Cooler Exhaustion	No requirement	TBD	SPT
15	Stand-By	AOT Tests	Wait for Cooler Exhaustion	No requirement	TBD	SPT
16	Stand-By	Wait for Cooler Exhaustion	Wait for Cooler Exhaustion	No requirement	TBD	SPT
17	Off	Off	Off	No requirement	-	

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

The IMT includes the verification of the hold time of the 300 mK cooler, i. e. in the IMT a full cooler recycle period is foreseen for PACS and 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 10.5.

6.6 EMC Test

The general objective of the instrument PLM EQM level EMC test programme is to demonstrate that the instruments are compatible with the Herschel PLM electro-magnetic environment.

The EMC tests comprise a radiated susceptibility (RS) test.

Conducted emission (CE) and conducted susceptibility (CS) tests on primary power side are not planned because of the limited representativity of the AVM primary power interfaces and the unavailability of the PCDU. Instead, for the CE and CS performance it shall be referred to the instruments level test results.

Also CE and CS tests on secondary power and on cryoharness are not planned. The CS test objectives on the cryoharness are in principle covered by the RS test.

During the RS test the instruments are switched in a mode with highest sensitivity to electromagnetic distortions.

The instruments will be tested individually, i. e. the EMC test configurations and sweeps will be repeated for each instrument.

Prior to the EMC tests a reference test will be made to determine the performance under nominal conditions.

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

The EQM EMC tests will be performed in a standard integration facility at Astrium (i. e. no anechoic chamber). In order to be allowed to perform the RS test outside the anechoic chamber the radio regulation community have formally to be requested for permission at least 6 months prior to test.

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

Figure 6-2 describes the instrument tests and modes to be performed within the EMC test.

EMC Test Flow (EQM)						
Step	Test Type	HIFI	PACS	SPIRE	EPLM Position	Duration
1	-	Off	Off	Off	No requirement	-
2	Reference test	Measurement Mode (Band 3 H)	Stand-By	Stand-By	No requirement	1 day (TBC)
3	Reference test	Measurement Mode (Band 3 V)	Stand-By	Stand-By	No requirement	
4	RS	Measurement Mode (Band 3 H)	Stand-By	Stand-By	No requirement	
5	RS	Measurement Mode (Band 3 V)	Stand-By	Stand-By	No requirement	
6	-	Stand-By	Cooler Recycle	Stand-By	23° to 30° to +y	1 day (TBC)
7	Reference test	Stand-By	TBD (most sensitive mode)	Stand-By	No requirement	
8	RS	Stand-By	TBD (most sensitive mode)	Stand-By	No requirement	
9	-	Stand-By	Stand-By	Cooler Recycle	23° to 30° to +y	1 day (TBC)
10	Reference test	Stand-By	Stand-By	TBD (most sensitive mode)	No requirement	
11	RS	Stand-By	Stand-By	TBD (most sensitive mode)	No requirement	
12	-	Off	Off	Off	No requirement	-

Note: Most sensitive/noisiest modes during EMC tests TBD by HIFI/PACS/SPIRE.

Figure 6-2: EMC Test Activities Flow

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

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

The following parameters are monitored during the susceptibility tests:

<u>HIFI:</u>

- TBD by HIFI

<u>PACS</u>

- TBD by PACS

SPIRE

The SPIRE instrument will be set in the most sensitive mode to allow the effects of EMI to be verified.

The EQM cryostat will be placed in a condition as close as possible to the expected flight conditions. The cryostat cover will be cooled and the background will be verified by a dedicated test.

Noise traces are taken from the detectors at the highest data sampling frequency allowed by the electronics before and after the radiated susceptibility test.

The results will be compared to the ILT and the SPIRE EMC model.

Related test activity descriptions per instrument see section 10.6.

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.

Warning:

The instrument interconnection harness shall not have any open lines, i. e. lines which are specified in the IID-B but which not used for the instrument EQM (e. g. due to missing redundancies, etc.) are assumed to be properly terminated inside the affected instrument units.

7 Test Configuration

7.1 PLM EQM Hardware Configuration

The PLM hardware comprises the refurbished and modified ISO cryostat QM plus a newly developed SVM simulator.

The ISO cryostat is identical to the Herschel cryostat PFM as regards the

- optical bench with its mechanical and thermal interfaces to the FPUs
- instrument shield with LO beam baffles
- cryoharness with its electrical interfaces to the FPUs, LOU and Warm Units
- LOU support structure with its mechanical interfaces to the LOU

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

- Line of sight of LO beam between HIFI LOU and HIFI FPU is obstructed by the CVV window borders since it is not possible to move the optical bench such that the FPU LOS matches the window axes. Note: the EQM upper bulkhead design is identical to the PFM, i. e. designed to match the window axes at in flight conditions.

The SVM simulator consists of a platform with a support frame and provides all mechanical interfaces to support the warm unit EQMs/AVMs. The arrangement of the Warm Units on the SVM simulator is identical to the SVM PFM as far as the Warm Units are flight representative with respect to their interfaces.

For instrument testing the cryostat together with SVM simulator can be tilted around z-axis.

For details of the PLM EQM hardware configuration see AD 6, section 4.

7.2 Instrument Hardware Configuration

7.2.1 HIFI EQM Configuration

The delivered HIFI instrument hardware for the PLM EQM programme is configured as per Table 7-1. In addition this table indicates the unit test histories prior to shipment to ESA.

Unit	Built Standard	Unit ID	Form	Fit	Function	EMC	TC/TV	Vibration
FPU	QM	FH-FPU-QM	FM	FM	Only band 3 active [2)]	Yes	Yes	Yes
FCU	DM	FH-FCU-DM-2	FM	FM	No redundancy	Yes	No	No
LOU	QM	FH-LOU-QM	[1)]	FM	Only band 3	Yes	Yes	Yes
LCU	DM	FH-LCU-DM	FM	FM	No redundancy	Yes	No	No
LSU	DM	FH-LSU-DM	FM	FM	No redundancy	Yes	No	No
WEH	QM	FH-WEH-QM	FM	FM	FM	Yes	Yes	Yes
WEV	Not delivered							
WOH	QM	FH-WHO-QM	FM	FM	FM	Yes	Yes	Yes
WOV	Not delivered							
HRH	QM	FH-HRH-QM	FM	FM	FM	Yes	Yes	Yes
HRV	Not delivered							
ICU	QM	FH-ICU-QM	FM	FM	No redundancy	Yes	Yes	Yes

[1)] LOU consists of the LOA for band 3a/3b plus a connector bracket with connectors to simulate the electrical interfaces of LOA for band 4a/4b plus two penta prisms, all mounted on the LOU dummy base plate with flight representative interface to the CVV side support plate.

[2)] The FPU QM contains heaters to simulate the FPU thermal load.

Table 7-1: HIFI EQM Hardware Built Standards

7.2.2 PACS EQM Configuration

The delivered PACS instrument hardware for the PLM EQM programme is configured as per Table 7-2.

Unit	Form	Fit	Function	Redundance	Remark
DPU	FM	FM	FM	No redundancy foreseen for AVM	PFM fully redundant
SPU	Delivered as rack, mountable on SVM TBC	FM	FM	No redundancy foreseen for AVM	PFM fully redundant
DECMEC	Delivered as rack, mountable on SVM TBC	FM	FM	No redundancy foreseen for AVM	PFM partially redundant
BOLC	Delivered as rack, mountable on SVM TBC	FM	Delivered without power supply	No redundancy foreseen for AVM	PFM partially redundant
WIH	FM	FM	FM	N.A.	Identical with PFM harness; back shells to be discussed
FPU	FM	FM	Full optics. All mechanisms complete. Both photo-conductor arrays working, but only 2x12 modules integrated instead of 2x25. Both bolometer arrays completely equipped, but only 50% in each array with full IR performance.	Same redundancy as PFM	PFM subunits partially redundant

Table 7-2: PACS EQM Hardware Built Standards

7.2.3 SPIRE EQM Configuration

The delivered SPIRE instrument hardware for the PLM EQM programme is configured as per Table 7-3 (extracted from RD 11).

Unit: HSFPU and JFETs

Subsystem /component	**Delivered CQM Form/Capability**
Structure/baffles/wiring standoffs etc	Flight Representative
Mirrors	Flight Representative
Filters	Flight representative
Beam steering mirror	The STM is fitted this has the following capabilities: Form and fit compliant Non- moving No redundancy Simulated motor coils fitted only – no sensors Thermal conduction flight representative Thermal dissipation close to flight representative
3He Fridge/thermal straps	The CQM is fitted this has the following capabilities: Form and fit compliant Functionally fully flight representative All parts flight build standard except thermometers and heaters will be commercial/industrial grade
300 mK Thermal control system	None
Photometer LW array	Flight representative
Photometer MW array	Form and fit compliant Resistors used to represent detectors. Temperature monitors functionally representative (TBC)
Photometer SW array	Ditto
SMEC	STM is fitted this has the following capabilities: Non- moving No redundancy Simulated motor coils fitted only – no sensors Thermal conduction flight representative Thermal dissipation close to flight representative
Spectrometer SW array	As P/MW and P/SW arrays
Spectrometer LW array	As S/SW array
Photometer Calibrator	Form and fit compliant Functionally representative Electrical interfaces compliant Thermal interfaces compliant No redundancy (TBC)
Spectrometer Calibrator	Form and fit compliant

Subsystem /component	Delivered CQM Form/Capability
	Functionally representative Electrical interfaces compliant Thermal interfaces compliant No redundancy
JFET Racks	Flight Representative
P/LW JFET Modules	CQM is fitted Fully flight representative
All other JFET Modules	STMs are fitted with the following capabilities: Form and fit compliant Electrical interfaces compliant Thermal interfaces compliant Resistors for thermal dissipation are provided
FPU RF Filters	Flight representative
JFET Back harnesses	Flight representative
Thermometry	Flight representative
FPU internal harnesses	Flight representative

Unit: HSDCU

Subsystem /component	Delivered CQM Form/Capability
External structure/mechanical interfaces	QM1 is supplied – this has flight representative envelope
Electrical Interfaces	One photometer LIA card Two spectrometer LIA cards Prime interfaces flight representative No redundant interfaces implemented
Functionality	Near flight performance on prime side No redundant side implemented
Electrical Component Level	Commercial/industrial level parts with near flight performance

Unit: HSFCU

Subsystem /component	Delivered CQM Form/Capability
External structure/mechanical interfaces	Not form and fit compliant – power supply is not housed within the FCU flight envelope
Electrical Interfaces	Interfaces to S/C not flight representative – EGSE replaces power supply unit Prime instrument interfaces flight representative No redundant interfaces implemented
Functionality	Near flight performance on prime side except for MCU MCU is QM0 with non-flight performance – can drive motor

Subsystem /component	Delivered CQM Form/Capability
	coils in backup mode (only) No redundant side implemented
Electrical Component Level	Commercial/industrial level parts with near flight performance

Unit: HSDPU (this unit will also be used for the AVM)

Subsystem/Component	Delivered CQM Form/Capability
External structure/mechanical interfaces	Flight representative
Electrical Interfaces	Prime interfaces flight representative No redundant interfaces implemented
Functionality	Near flight performance on prime side No redundant side implemented
Electrical component level	Commercial/industrial level parts with near flight performance

Unit: HSWIH (warm interconnect harness)

Subsystem/Component	Delivered CQM Form/Capability
External structure/mechanical interfaces	Flight representative
Electrical Interfaces	Flight representative
Functionality	Near flight performance
Electrical component level	Commercial/industrial level parts with near flight performance

Table 7-3: SPIRE EQM Hardware Built Standards (extracted from RD 11)

7.3 Instrument GSE Configuration

7.3.1 Instrument EGSE Configuration

The delivered Instrument EGSE for the PLM EQM level instrument test programme is as per Table 7-4.

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
HIFI	CW test signal source with LO beam splitter	For EMC tests Equipment will be located between LOU and CVV windows (LOU chain 3 beam)
PACS	TBD by PACS	For stand-alone tests after incoming inspection
SPIRE	CDMS simulator	Loan for stand alone integration checks only
SPIRE	Test harness	
SPIRE	FPU simulator	Loan for stand alone warm electronics checkout only. This unit does NOT interface to the cryoharness
SPIRE	Cross talk unit	Stand alone cross talk unit for checkout of Astrium detector side harness

Table 7-4: 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 and PACS.

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 baseplate lifting gear (for lifting out of and in the transport container).
- FPU and JFET handling frame (for installation on Herschel Optical Bench Plate)
- 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 'Hydroset'
- 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 7-5: 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

<u>PACS</u>

TBD by PACS

<u>SPIRE</u>

TBD by SPIRE

8 Test Set-up

8.1 Principle PLM Test Set-up

The principle PLM EQM test set-up is shown in Figure 8-1.

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.

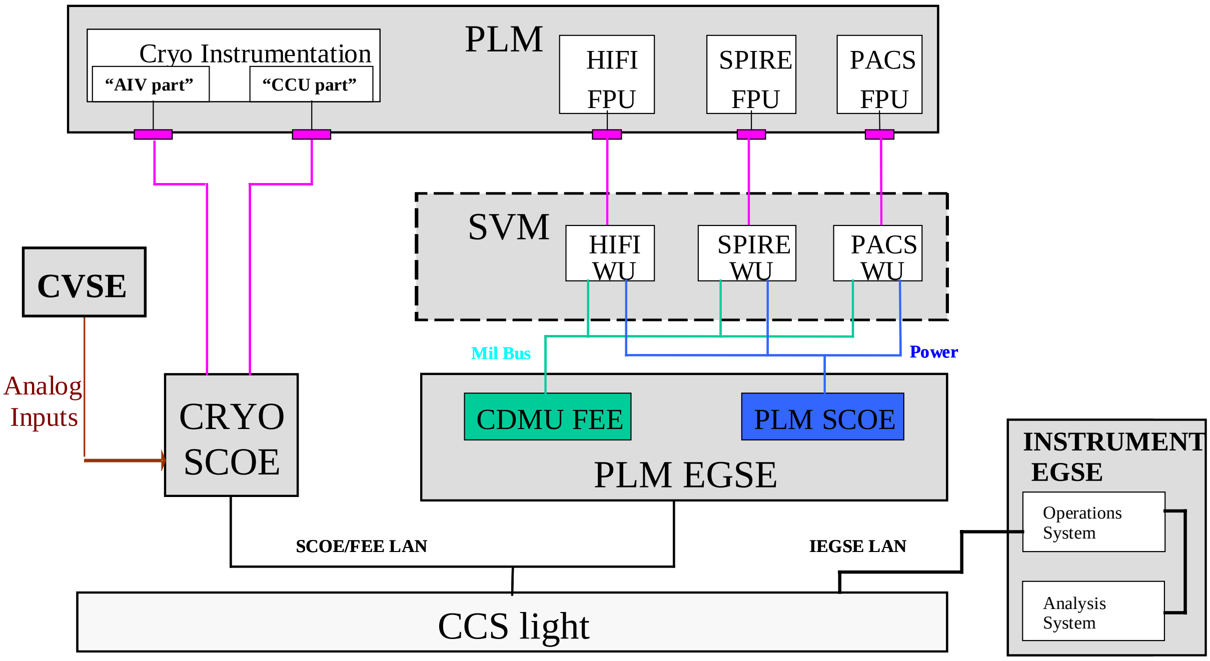

Figure 8-1: Principle Test Set-up for EQM Tests

Figure 8-2 shows the Instrument EGSE block diagram and provides an overview of the interface to the CCS.

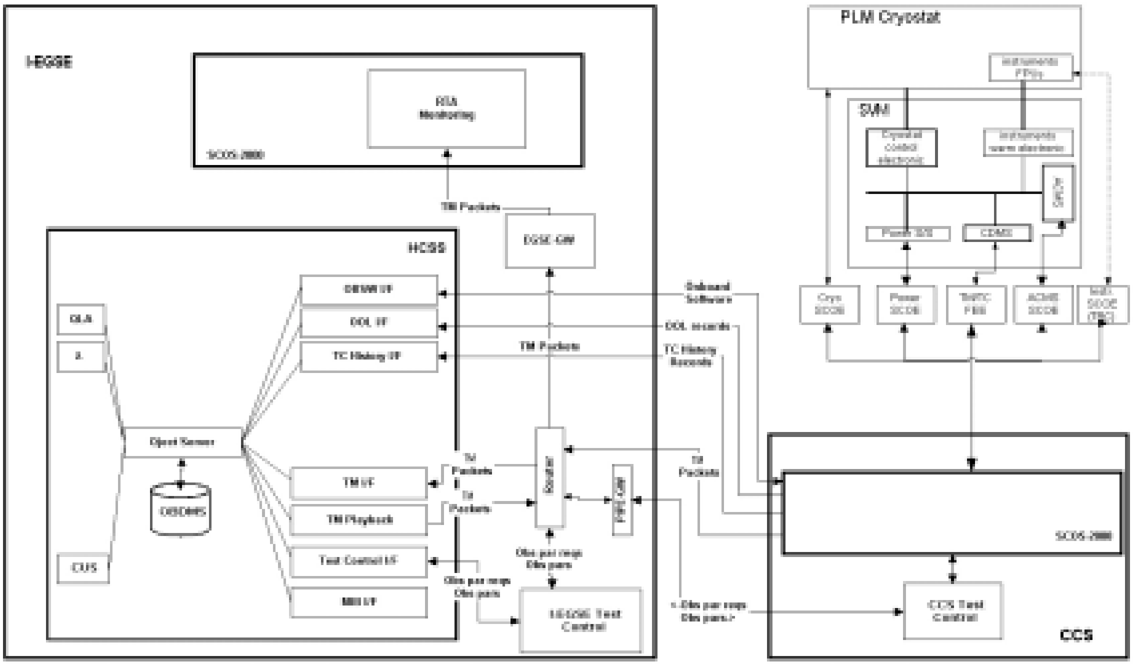

Figure 8-2: Data Exchange during PLM EQM Test

All PLM level instrument tests will be executed from the CCS light 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.

FPU simulators and other instrument specific test equipment (e.g. HIFI stimuli equipment) have no interface to the CCS. I. e. such equipment will be controlled off-line.

The control of the FPU heaters and the HIFI CW test signal source during the EMC test is done manually (TBC by HIFI).

8.2 Test Facility

The tests (incl. EMC test) will take place in a clean room class 100 000 in a test facility at Astrium (Ottobrunn). The layout of the test facilities is shown in Figure 8-3. For details see AD 06.

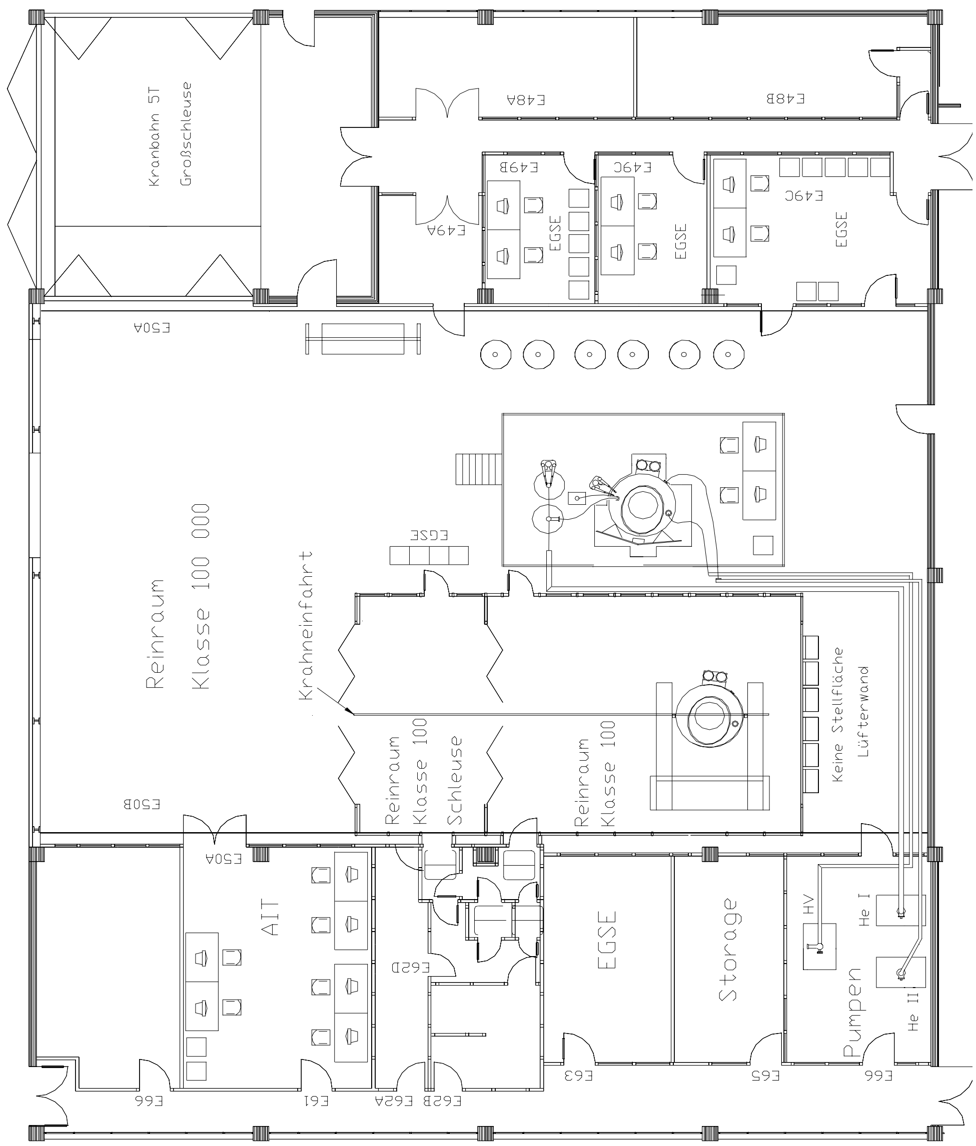

Figure 8-3: Layout of Test Facility

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	1 day	
HIFI EGSE Check out	1 h	
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	
HIFI Radiometry	1 day	
HIFI LO Beam Standing Wave Test	1 day	
HIFI Integrated Module Test	3 days (TBC)	
HIFI EMC Test	2 day (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 Pre-Integration Tests	1.5 day	
SPIRE Mechanical Integration (FPU)	1 day	
SPIRE Mechanical Integration (Warm Units)	4 h	
SPIRE EGSE Check out	1/2 day	Common EGSE
SPIRE Electrical Integration	5 days (TBC)	
SPIRE SFT Warm	1 day	
SPIRE SFT Cold (He I)	1 h	
SPIRE SFT Test (He II)	6 h	
SPIRE SPT - Cooler Recycle Stand Alone Test	3 days	
SPIRE SPT - Ambient Background Verification Test	1 h (TBC)	
SPIRE SPT - Photometer Mode Thermal Balance Test	2 – 3 h	
SPIRE Integrated Module Test	2 days (TBC)	Full cooler cycle

Test	Duration	Remark
SPIRE EMC 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 FPU /LOU during the PLM EQM level testing.

HIFI

The FPU QM contains heaters to simulate the FPU thermal load. These heaters will be powered from a separate power supply (not part of the FCU) via the cryoharness using a break-out box. The break-out box and the power-supply will be delivered by HIFI. Details (location of break-out, operational aspects, EMC aspects, etc.) are TBD by HIFI and to be agreed with ASED.

Other operational constraints, if any, 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

TBD by SPIRE.

9.3 Spacecraft Orientation

The following spacecraft orientations will be adjusted:

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

9.4 Sensor Background

The PLM EQM 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 EQM will provide the thermal environment to allow performance testing of the instruments. The L0 temperature levels provided by the EQM cryostat (ISO) at the FPU thermal links are listed in Table 9-4.

L0 Interface	Instrument In-Orbit Requirements		Node	Assumed Conductance to AXT	Analysis Results
	Heat Load	Temperature			
PACS Red Detector	0.8 mW	1.6 K … 1.75 K	721	0.107 W/K	1.71 K
PACS Blue Detector	2.0 mW		723	0.054 W/K	1.74 K
PACS Cooler Pump	2.0 mW	1.6 K … 2 K	761	0.100 W/K	1.72 K
	500 (peak) mW	1.6 K … 5 K			6.7 K
PACS Cooler Evaporator	15 mW	1.6 K … 10 K 1.6 K … 1.85 K	762	0.098 W/K	1.85 K
SPIRE Detector	4 mW	< 2 K	814	0.251 W/K	1.72 K
	1 mW (goal)	< 1.71 K (goal)			1.71 K
SPIRE Cooler Pump	2 mW	< 2 K	815	0.244 W/K	1.71 K
	500 mW (peak)	< 10 K (peak)			3.1 K
SPIRE Cooler Evaporator	15 mW	< 1.85 K	816	0.251 W/K	1.76 K
	15 mW (goal)	< 1.75 K (goal)			1.76 K
HIFI Detector	6.8 mW	< 2 K	949	0.058 W/K	1.82 K

Note: The L0 interface temperatures are based on analysis results as reported in HP-2-AIRL-AN-0004, issue 6, dated 19.04.04 (section 4.9). The analysis takes also into account an assumed thermal conductance of the AXT wall of 0.5 W/K. The AXT He temperature is assumed to be 1.7 K. All analyses are related to material properties at 1.7 K and are provided without uncertainties. The PLM EQM temperatures will be verified during the EQM training phase.

Table 9-4: Interface Temperatures provided by the EQM Cryostat

For the L1/L2/L3 interfaces suitable temperatures will be achieved by appropriate adjustment of the mass flow from the AXT (L1/L2/L3 ventline) and from the main tank (separate ventline for thermal shield cooling to minimize parasitic heat load to OBA).

For details see RD 4.

9.6 Cleanliness

The following specific cleanliness provisions will be applied:

<u>HIFI LOU</u>

The LOU opening (Channel 3a/3b) 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

During the PLM EQM AIT no purging will be provided.

Note: SPIRE may require purging (TBC by SPIRE).

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

FPU - Red Tag Items

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 EQM 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 EQM 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: **EGSE Check Out**	*Experiment:* **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: As per Table 7-4.	*Specific Requirements on PLM:* None.

Particular Environmental Constraints:
None.

Success Criteria:
TBD

Duration: 1 day	*Applicable:* PLM EQM

10.1.2 PACS EGSE Check Out

Title: **EGSE Check Out**	*Experiment:* **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: As per Table 7-4.	*Specific Requirements on PLM:* None.

Particular Environmental Constraints:
None.

Success Criteria:
TBD

Duration: 1 h	*Applicable:* PLM EQM

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:*
As per Table 7-4.	None.

Particular Environmental Constraints:
None.

Success Criteria:
TBD

Duration:	*Applicable:*
1 h	PLM EQM

10.2 Alignment Check

10.2.1 HIFI Alignment Test

Title:
Alignment Test

Experiment:
HIFI

Objectives:
Check change in alignment of FPU and LOU after evacuation and cool down. With this check also the alignment of the optical bench with respect to the CVV is covered. Another objective is the validation of the alignment procedure (as far as possible).

Test Description:
During this test the relative alignment between the LOU and FPU will be monitored. The alignment devices located on the FPU and alignment devices installed on the LOU will be used. The alignment will be checked by an alignment camera. The alignment will be recorded prior to evacuation, after evacuation / prior to cool down and after cool down.

Instrument Configuration:
As per Table 7-1 plus dedicated (non-flight) alignment devices on LOU plus alignment camera.

Specific Requirements on PLM:
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:
Alignment stays within the predicted error budget.

Duration:
2 days per alignment check

Applicable:
PLM EQM

10.3 Short Functional Test

10.3.1 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 Table 7-1 and Table 7-4.	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 EQM

10.3.2 HIFI Short Functional Test Cold

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

Objectives:
Confidence test to check electrical integrity and operability of instrument. 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. Measure power of mixer for minimum and maximum LO power settings.

Instrument Configuration: As per Table 7-1 and Table 7-4.	*Specific Requirements on PLM:* None.

Particular Environmental Constraints:
CVV evacuated.
L0: TBD, L1: TBD and L2: TBD.

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

Duration: 1 h	*Applicable:* PLM EQM

10.3.3 PACS Short Functional Test Warm

Title: **Short Functional Test Warm**	*Experiment:* **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: As per Table 7-2 and Table 7-4.	*Specific Requirements on PLM:* 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: TBD h	*Applicable:* PLM EQM

10.3.4 PACS Short Functional Test Cold

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

Objectives:
Confidence test to check electrical integrity and operability of instrument. 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: As per Table 7-2 and Table 7-4.	*Specific Requirements on PLM:* None.

Particular Environmental Constraints:
CVV evacuated.
L0: TBD, L1: TBD and L2: TBD.

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

Duration: TBD h	*Applicable:* PLM EQM

10.3.5 SPIRE Short Functional Test Warm

Title: **Short Functional Test Warm**	*Experiment:* **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:
The S/C-instrument interfaces are checked by switch on procedure (TBD).
The instrument is placed into a state ready to receive and execute commands (READY – TBC).
Each sub-system is commanded as appropriate to verify its function (TBD).
The instrument is switched back to READY.
The instrument may be switched OFF or to another mode if further tests are planned.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Table 7-3 and Table 7-4.	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 monitored via CCS and QLA within pre-defined limits derived from instrument level test results. Correct execution of commands.

Duration:	*Applicable:*
about 6 h	PLM EQM

10.3.6 SPIRE Short Functional Test Cold

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

Objectives:
Confidence test to check electrical integrity and operability of instrument. Evaluation will be based on housekeeping data, evaluation of science data is not foreseen.

Test Description:
The S/C-instrument interfaces are checked by switch on procedure (TBD).
The instrument is placed into a state ready to receive and execute commands (READY – TBC).
Each sub-system is commanded as appropriate to verify its function (TBD).
The instrument is switched back to READY.
The instrument may be switched OFF or to another mode if further tests are planned.

Instrument Configuration: As per Table 7-3 and Table 7-4.	*Specific Requirements on PLM:* None.

Particular Environmental Constraints:
CVV evacuated.
L0: TBD, L1: TBD and L2: TBD.
(Target: Flight interface temperatures, see Table 9-4.

Success Criteria:
Housekeeping values monitored via CCS and QLA within pre-defined limits derived from instrument level test results. Correct execution of commands.

Duration: about 6 h	*Applicable:* PLM EQM

10.4 Special Performance Tests

10.4.1 HIFI IF Properties

Title: **IF Properties**	*Experiment:* **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 DM tests 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: As per Table 7-1 and Table 7-4.	*Specific Requirements on PLM:* None

Particular Environmental Constraints:
Mass flow rate: 2.2 mg/s.
L0: TBD, L1: TBD and L2: TBD.
Sensor background TBD.

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

Duration: 1 h	*Applicable:* PLM EQM

10.4.2 HIFI Radiometry

Title: **Radiometry**	*Experiment:* **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: As per Table 7-1 and Table 7-4.	*Specific Requirements on PLM:* None

Particular Environmental Constraints:
Mass flow rate: 2.2 mg/s.
L0: TBD, L1: TBD and L2: TBD.
Sensor background TBD.

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

Duration: 1 day (TBC)	*Applicable:* PLM EQM

10.4.3 HIFI LO Beam Standing Wave Test

Title: **LO Beam Standing Wave Test**	*Experiment:* **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: As per Table 7-1 and Table 7-4.	*Specific Requirements on PLM:* Flight representative spacecraft configuration. For the LO path the test configuration will include representative baffles, shields and LO windows along the LO beam path.

Particular Environmental Constraints:
Mass flow rate: 2.2 mg/s.
L0: TBD, L1: TBD and L2: TBD.
Sensor background TBD.

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: 1 days	*Applicable:* PLM EQM

10.4.4 PACS Full Functional Test

Title:
Full Functional Test

Experiment:
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:

As per Table 7-2 and
Table 7-4.

Specific Requirements on PLM:
PLM tilted about 20° to +y during cooler recycle.

Particular Environmental Constraints:
Mass flow rate: 2.2 mg/s.
L0: TBD, L1: TBD and L2: TBD.
Sensor background TBD.

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

Duration:
3 days (TBC)

Applicable:
PLM EQM

10.4.5 PACS Short Performance Test

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

Objectives:
Validation of PACS activation sequence, test PACS FPU thermal behaviour, performance test of PACS mechanisms, synchronous operation and grating offset accuracy, cooler recycling, 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:
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: As per Table 7-2 and Table 7-4.	*Specific Requirements on PLM:* PLM tilted about 20° to +y during cooler recycle.

Particular Environmental Constraints:
Mass flow rate: 2.2 mg/s.
L0: TBD, L1: TBD and L2: TBD.
Sensor background TBD.

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

Duration: 3 days (TBC)	*Applicable:* PLM EQM

10.4.6 PACS Astronomical Observation Template (AOT) Tests

Title: **Astronomical Observation Template (AOT) Tests**	*Experiment:* **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:
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 Table 7-2 and Table 7-4.	PLM tilted about 20° to +y during cooler recycle.

Particular Environmental Constraints:
Mass flow rate: 2.2 mg/s.
L0: TBD, L1: TBD and L2: TBD.
Sensor background TBD.

Success Criteria:
TBD.

Duration:	*Applicable:*
TBD day	PLM EQM

10.4.7 PACS PACS/SPIRE Parallel Mode

Title:
PACS/SPIRE Parallel Mode

Experiment:
PACS

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

Test Description:
PACS activation including cooler recycling,
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:
As per Table 7-2 and
Table 7-4.

Specific Requirements on PLM:
PLM tilted about 20° to +y during cooler recycle.

Particular Environmental Constraints:
Mass flow rate: 2.2 mg/s.
L0: TBD, L1: TBD and L2: TBD.
Sensor background TBD.

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

Duration:
1 day

Applicable:
PLM EQM

10.4.8 SPIRE Cooler Recycle

Title:
Cooler Recycle

Experiment:
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 i.e. the mass flow rate and shield temperatures must be those expected in flight. 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:
As per Table 7-3 and
Table 7-4.

Specific Requirements on PLM:
PLM tilted at least 17° around z-axis to +y. This operation can be carried out with the PLM rotated to 90° in the same direction.

Particular Environmental Constraints:
Mass flow rate: 2.2 mg/s.
L0: TBD, L1: TBD and L2: TBD.
Sensor background TBD.

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

Duration:
about 3 h

Applicable:
PLM EQM

10.4.9 SPIRE Photometer Chop Mode

Title: **Photometer Chop Mode**	*Experiment:* **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 i.e. the mass flow rate and shield temperatures must be those expected in flight.
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 to settle.
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: As per Table 7-3 and Table 7-4.	*Specific Requirements on PLM:* None

Particular Environmental Constraints:
Mass flow rate: 2.2 mg/s.
L0: TBD, L1: TBD and L2: TBD.
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: about 1 h	*Applicable:* PLM EQM

10.4.10 SPIRE Ambient Background Verification

Title: **Ambient Background Verification**	*Experiment:* **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, i.e. the mass flow rate and shield temperatures must be those expected in flight.
The SPIRE cooler has been recycled and the instrument is at nominal temperature.
The photometer JFETs are switched on and the instrument temperatures allowed to settle.
Load curves are taken on the photometer detectors by varying the bias voltage.

Instrument Configuration:	*Specific Requirements on PLM:*
As per Table 7-3 and Table 7-4.	None

Particular Environmental Constraints:
Mass flow rate: 2.2 mg/s.
L0: TBD, L1: TBD and L2: TBD.
Sensor background TBD.

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 EQM

10.4.11 SPIRE PACS/SPIRE Parallel Mode

Title:	*Experiment:* **SPIRE**

Objectives:
TBD

Test Description:
TBD.

Instrument Configuration: As per Table 7-3 and Table 7-4.	*Specific Requirements on PLM:* PLM tilted about 20° to +y during PACS cooler recycling. PLM tilted at least 17° around z-axis to +y during SPIRE cooler recycle.

Particular Environmental Constraints:
Mass flow rate: 2.2 mg/s.
L0: TBD, L1: TBD and L2: TBD.
Sensor background TBD.

Success Criteria:
TBD

Duration: TBD day	*Applicable:* PLM EQM

10.5 Integrated Module Tests

10.5.1 HIFI Integrated Module Test

Title:	*Experiment:*
Integrated Module 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 Table 7-1 and Table 7-4.	None.

Particular Environmental Constraints:

Mass flow rate: 2.2 mg/s.
L0: TBD, L1: TBD and L2: TBD.
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:*
3 days (TBC)	PLM EQM

10.5.2 PACS Integrated Module Test

Title:
Integrated Module Test

Experiment:
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:

As per Table 7-2 and
Table 7-4.

Specific Requirements on PLM:
PLM tilted about 20° to +y during cooler recycle.

Particular Environmental Constraints:
Mass flow rate: 2.2 mg/s.
L0: TBD, L1: TBD and L2: TBD.
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:
TBD

Applicable:
PLM EQM

10.5.3 SPIRE Integrated Module Test

Title:
Integrated Module Test

Experiment:
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:

As per Table 7-3 and Table 7-4.

Specific Requirements on PLM:
PLM tilted at least 17° around z-axis to +y during cooler recycle.

Particular Environmental Constraints:
Mass flow rate: 2.2 mg/s.
L0: TBD, L1: TBD and L2: TBD.
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:
Housekeeping values within pre-defined limits. Correct execution of commands. No performance degradation with respect to instrument level test results.

Duration:
TBD

Applicable:
PLM EQM

10.6 EMC Tests

10.6.1 HIFI EMC Test

Title: **EMC Test**	*Experiment:* **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 Table 7-1 and Table 7-4 including a harmonic generator with beam splitter mounted between the LOU and CVV window.	Representative spacecraft configuration, representative configuration of LO windows and beam path, representative cryoharness, representative ground impedance between SVM and PLM.

Particular Environmental Constraints:
Mass flow rate: 2.2 mg/s.
L0: TBD, L1: TBD and L2: TBD.
Sensor background TBD.

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

Duration: 2 days	*Applicable:* PLM EQM

10.6.2 PACS EMC Test

Title: **EMC Test**	*Experiment:* **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 Table 7-2 and Table 7-4.	PLM tilted about 20° to +y during cooler recycle.

Particular Environmental Constraints:
Mass flow rate: 2.2 mg/s.
L0: TBD, L1: TBD and L2: TBD.
Sensor background TBD.

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

Duration: 2 days	*Applicable:* PLM EQM

10.6.3 SPIRE EMC Test

Title: **EMC Test**	*Experiment:* **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 to settle.
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 Table 7-3 and Table 7-4.	

Particular Environmental Constraints:
Mass flow rate: 2.2 mg/s. (note: not achievable, check with Michel L.)
L0: TBD, L1: TBD and L2: TBD.
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:
No excess noise on the detectors. Deviations from measurement results obtained during HIFI DM ILT are within TBD % or understood.

Duration: TBD	*Applicable:* PLM EQM

	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
	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			
	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
	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			