Title: **Satellite AIT Plan**

Part 2: EPLM & S/C-PFM Acceptance Phase

CI-No: HP-2-ASED-PL-0026

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Abbreviations (complete list see RD 02)

ABCL	As Built Configuration List
ACMS	Attitude Control and Monitoring Subsystem
ACR	AIT Change Request
AIT	Assembly, Integration and Test
AIV	Assembly, Integration and Verification
AN	Acoustic Noise
BOLA	Bolometer Amplifier Unit
CB	Cryostat Baffle
CC	Cryostat Cover
CCH	Cryo-Control Harness
CCP	Contamination Control Plan
CCS	Central Checkout System
CCS	Cryo-Control Subsystem
CCU	Cryostat Control Unit
CE	Conducted Emission
CFE	Customer Furnished Equipment
CFRP	Carbon Fibre Reinforced Plastic
CIDL	Configuration Item Data List
COG	Centre of Gravity
CR	Change Request
CR	Cleanroom
CS	Conducted Susceptibility
CVSE	Cryogenic and Vacuum Servicing Equipment
CVV	Cryostat Vacuum Vessel
DDP	Design and Development Plan
DRB	Delivery Review Board
EGSE	Electrical Ground Support Equipment
EMC	Electromagnetic Compatibility
EPLM	Extended Payload Module
EQM	Engineering Qualification Model
ESD	Electrostatic Discharge
FM	Flight Model
FN	Friedrichshafen, Astrium Site in Germany
FPU	Focal Plane Units
GHe	Gaseous Helium
GSE	Ground Support Equipment
HOT	He-I Auxiliary Tank of PLM
HSS	Herschel Sunshield/Sunshade
HTT	He-II Main Tank of PLM
ICD	Interface Control Document/Drawing
IMT	Integrated Module Test
ISO	Infrared Space Observatory
IST	Integrated System Test
KIP	Key Inspection Point
LHe	Liquid Helium
LOU	Local Oscillator Unit
LVA	Launch Vehicle Adapter
MGSE	Mechanical Ground Support Equipment
MIP	Mandatory Inspection Point
MLI	Multi Layer Insulation
MPT	Multi Purpose Trolley
MTD	Mass & Thermal Dummy = STM Equipm.
NA	Not Applicable
NCR	Non Conformance Report
OB	Optical Bench
OGSE	Optical Ground Support Equipment
OSR	Optical Surface Reflectors
OTN	Ottobrunn, Astrium Site in Germany
PA	Product Assurance
PFM	Protoflight Model
PLM	Payload Module
PTR	Post Test Review
QA	Quality Assurance
RE	Radiated Emission
RS	Radiated Susceptibility
S/S	Subsystem
SCOE	Special Checkout Equipment
SFPT	System Functional Performance Test
SFT	Short Functional Test
SFW	Spatial Framework
SIT	Scientific Internal Harness
STM	Structural and Thermal Model
SVM	Service Module
SVT	System Validation Test
TB	Thermal Balance
TGSE	Tanking Ground Support Equipment
TMM	Thermal Mathematical Model
TMU	Transport Monitoring Unit
TRR	Test Readiness Review
TTA	Thermal Test Adapter
TV	Thermal Vacuum
VPP	Verification Program Plan
WU	Warm Unit

1 INTRODUCTION

The Herschel Satellite AIT programme is divided into two main consecutive sections:

- the STM qualification phase where basically the satellite will be thermally and structurally qualified
- the PFM acceptance phase where the satellite functional and EMC qualification will be completed as well as the acceptance for flight

Major elements of the PFM EPLM, i.e. the cryostat, consisting of Cryostat Vacuum Vessel (CVV), thermal radiation shields, He-II main tank, He-I auxiliary tank, and optical bench (OB), will be used for both sections.

This 2nd part of the AIT Plan describes the assembly, integration and qualification test activities to be performed by Astrium GmbH as payload module and satellite AIT contractor on

- the refurbishment and upgrade of the PFM EPLM with FM instruments (FPUs and WUs) and CCU, Sunshield, Sunshade and
- the final integration of the PFM satellite with PFM SVM and Telescope and
- the subsequent satellite level tests for completion of qualification and flight acceptance

The first EPLM integration and subsequent Satellite STM qualification campaign are described in the 1st part of the AIT plan, see RD 05.

The PLM EQM AIT programme is also described in a separate document, RD 04.

Details about the Herschel payload and satellite model philosophy can be found in chapter 3 below.

1.1 OBJECTIVE

The objective of this second part of the AIT plan is to define:

- a PLM and satellite level integration and acceptance test programme in accordance with the system level AIV/AIT requirements per AD 02
- the relevant organisation, necessary to carry out all tasks of the AIT programme
- the definition and utilisation of GSE and facilities dedicated to this programme
- the required integration/test documentation
- the integration and test sequences
- detailed test steps and operations to be performed within the identified sequence
- the general company rules, PA and safety procedures to be followed throughout the AIT activities
- the AIT programme schedule and the major milestones like MIP, KIP, TRR, PTR
- major handling and transportation activities

2 DOCUMENTS

2.1 APPLICABLE DOCUMENTS

The following documents of issue as valid at the issue date of this document, if not otherwise stated below, form a part of this plan and are applicable to the extent specified in the text of this plan.

AD #	Document Title	Document Identifier
AD 01	HERSCHEL/PLANCK Verification Programme Plan (VPP)	HP-1-ASPI-PL-0225
AD 02	HERSCHEL EPLM AIV and HERSCHEL Satellite AIT Requirements Specification	HP-1-ASPI-SP-0008
AD 03	H-EPLM Requirements Specification	HP-2-ASED-SP-0003
AD 04	EMC Requirements Specification	HP-1-ASPI-SP-0037
AD 05	Contamination Control Plan	HP-2-ASED-PL-0023
AD 06	PA Plan	HP-2-ASED-PL-0007
AD 07	Herschel/Plank DDP	HP-1-ASPI-PL-0009
AD 08	Instrument Interface Document IID – part B, HIFI	SCI-PT-IIDB/HIFI-02125
AD 09	Instrument Interface Document IID – part B, PACS	SCI-PT-IIDB/PACS-02126
AD 10	Instrument Interface Document IID – part B, SPIRE	SCI-PT-IIDB/SPIRE-02124
AD 11	HERSCHEL EPLM Verification Programme Plan	HP-2-ASED-PL-0003
AD 12	Herschel/Planck System Requirement Specification	SCI-PT-RS-05991

2.2 REFERENCE DOCUMENTS

RD #	Document Title	Document Identifier
RD 01	Facility and Transportation Plan	HP-2-ASED-PL-0014
RD 02	List of Acronyms	HP-1-ASPI-LI-0077
RD 03	Herschel Alignment Concept	HP-2-ASED-TN-0002
RD 04	Herschel PLM/EQM AIT Plan	HP-2-ASED-PL-0022
RD 05	Herschel Satellite AIT Plan, Part 1: STM Satellite Qualification Phase	HP-2 ASED-PL-0025
RD 06	EGSE General Requirement Specification	HP-1-ASPI-SP-0045
RD 07	HERSCHEL MGSE Requirement Specification	HP-2-ASED-SP-0019
RD 08	HERSCHEL CVSE Requirement Specification	HP-2-ASED-SP-0012
RD 09	Handling and Transportation during Qualification Test Phase Technical Note	HP-2-ASED-TN0024
RD 10	Instrument Testing on PLM and Satellite PFM level	HP-2-ASED-PL-0031

3 MODEL PHILOSOPHY

The Herschel Satellite AIT sequence and planning is based on the following satellite models (refer to AD 02):

- a Structural and Thermal Model (STM) for structural and thermal qualification
- a Proto-flight Model (PFM) for qualification completion and final flight acceptance

These models are completed by the following PLM models:

- an Engineering Qualification Model (EQM) for cryogenic qualification of the PLM based on the ISO QM, of which the AIT programme is defined in RD 04.
- a Proto-Flight Model (PFM) of the EPLM (partly equipped with STM/MTD units) to be used in the Satellite STM test campaign and, after refurbishment and replacement of STM/MTD equipment by PFM units, for the Herschel PFM Satellite

These models are completed by the following SVM models

- a Structural and Thermal Model of the SVM to be used in the Satellite STM qualification test campaign
- a Proto-Flight Model of the SVM to be used for the PFM Satellite acceptance test campaign

The main objectives of each model are given hereafter:

- Satellite and SVM STM:
  - development model for structure lay-out and certification
  - development model for thermal control certification
  - confirmation of mechanical and thermal environment at satellite level before satellite flight model testing.
- Satellite and SVM PFM
  - qualification completion in areas where this qualification has not been completely achieved with the other models
  - acceptance for flight.
- PLM EQM
  - development model for instrument compatibility, functional and EMC tests at cryogenic temperature.
- EPLM PFM
  - Mechanical and thermal qualification at Satellite STM level
  - qualification completion at PLM and satellite level in areas where this qualification has not been completely achieved with the other models
  - acceptance on PLM and satellite level for flight.

For illustration of how the different models come together during AIT sequence a simplified PLM and Satellite STM and PFM AIT flow is shown in the following figure, together with reference to the respective part of the AIT plan. The associated schedule is presented in chapter 10.

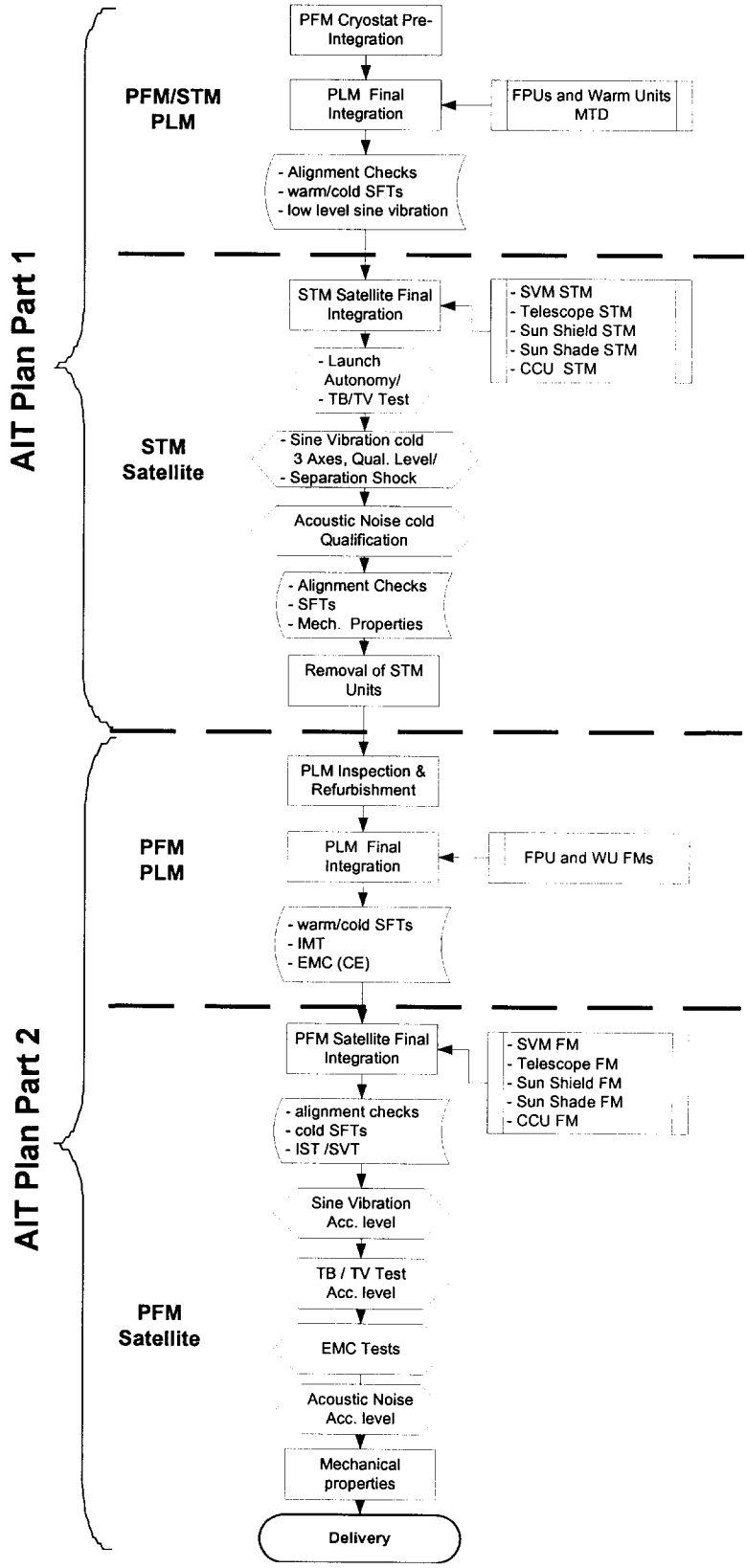


Fig. 3-1: Simplified PLM and Satellite STM/PFM qualification and acceptance AIT Flow

4 CONFIGURATION AND DESIGN DESCRIPTION

4.1 EXTENDED PAYLOAD MODULE

4.1.1 EPLM OVERALL CONFIGURATION

The main parts of the EPLM are the:

- Cryostat with CVV, radiation shields, He-I, He-II tank and OB
- The scientific instruments inside and outside the cryostat and in the SVM
- 3.5 m Telescope with its support structure
- Sunshield with solar array
- Sunshade
- PLM/SVM interface structure

The following figure gives an overview on the EPLM configuration.

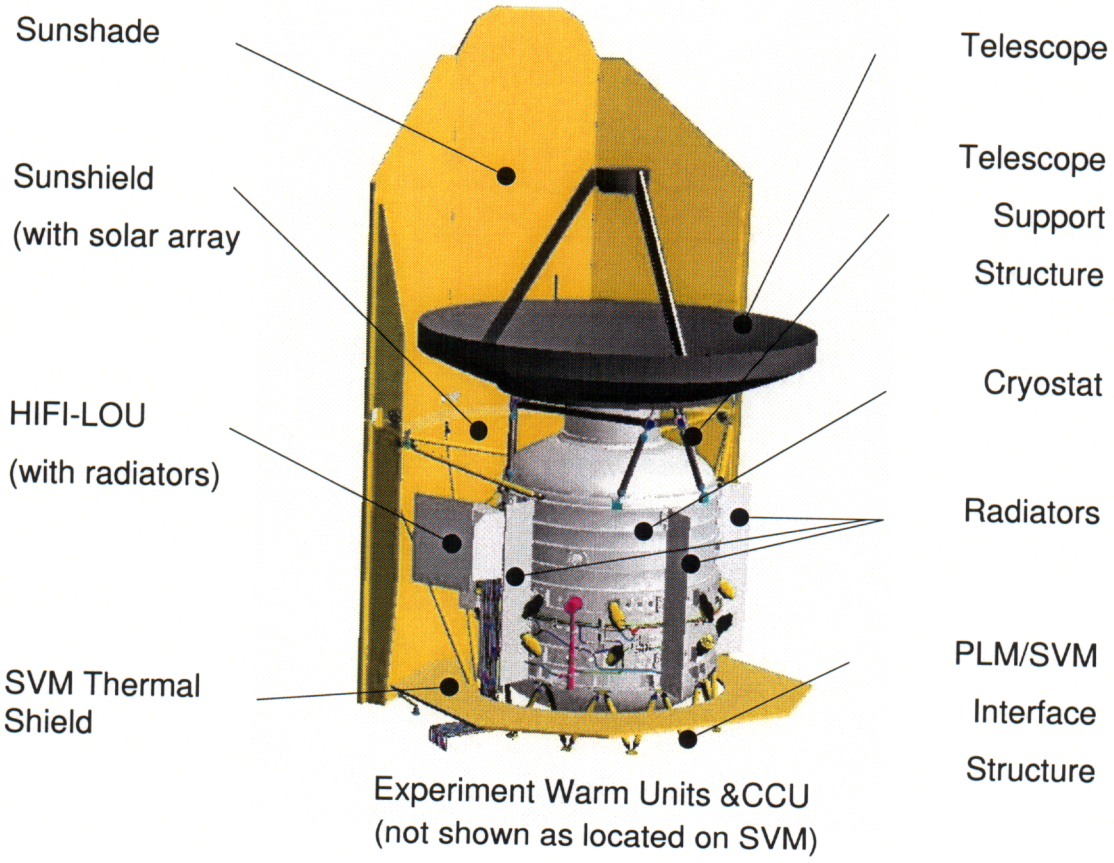


Fig. 4-1: EPLM External View

The EPLM is mounted on top of the SVM via GFRP-struts.

On the outside of the Cryostat Vacuum Vessel (CVV) the Bolometer Amplifier Unit (BOLA) and the Local Oscillator Unit (LOU) of two of the instruments HIFI and PACS are arranged. The rear of the CVV is used as a radiator to space and is therefore equipped with 3 radiators (nose) to improve the radiator performance.

The two individual units Sunshade and Sunshield are bolted together to form one integral unit. This composed unit requires no frame for lateral stability and is supported via a set of lateral and vertical struts to the CVV and the SVM.

The Sunshade unit consists of 3 different sub panels. The individual panel shape is generated by the Ariane 5 Fairing dimensions, and to provide full Telescope shadowing.

The panels are bonded together by the use of additional doublers and are attached to the Sunshield via bolts and brackets to allow separate production and verification. The front of the Sunshade is covered with OSRs.

The Sunshield consists of 3 unique panels of 2.5m x 1.6m each carrying the solar array assembly.

The integrated Sunshield/Sunshade are supported by means of struts made of GFRP and are connected to the cryostat. The lower struts are directly connected to the SVM. The whole rear area of the unit is covered with high-efficient MLI.

The Telescope is mounted upon the CVV on 3 CFRP bipods.

The CVV provides the vacuum for the He S/S and the instruments on ground. A cover closes it during ground operations and launch.

The segmented 2160-l Main He-II tank (HTT) is arranged inside the cryostat. The tank equipment (valves, phase separator, safety devices, sensors, heaters etc.) are similar to the ISO PLM equipment. 16 tank support straps, which are connected to the Upper and Lower Spatial Framework, suspend the tank. The tank support straps consist each of 4 GFRP and 2 CFRP chain loops. Steel bolts, which also act as thermal anchors connect them, and mechanical support of the three GHe cooled thermal radiation shields. The tank support straps are pre-tensioned by 16 tank support strap tensioning devices on the outside of the CVV.

A lens-shaped auxiliary LHe (He-I) tank (HOT) for launch autonomy cooling is mounted to the lower spatial framework.

The Optical Bench, which supports the scientific instruments, is mounted on top of the upper spatial framework. A common instrument protection shield surrounds the instruments on the Optical Bench. To provide the cooling level 0 of the instruments, they are connected via straps directly to the He-II tank. The He vent gas leaving the He-II tank is used for the provision of cooling levels 1 and 2 of the instruments (by connection to the ventline surrounding the instruments) and is then used for cooling of the three cryostat radiation shields. On top of the cryostat a baffle is mounted to suppress stray light incidence.

The thermal requirements for the three different levels are as specified in AD 08, AD 09 and AD 10.

	HIFI	PACS	SPIRE
Level 0	0 K ... 2 K stability: 6 mK/100s	1.6 K ... 1.75 K 1.6 K ... 2.2 K 1.6 K ... 3.5 K	tbd ... 2 K
Level 1	TBD ... 6 K stability: 6 mK/100s	3 K ... 5 K	tbd ... 6 K
Level 2	TBD ... 20 K stability: 15 mK/100s	NA	tbd ... 15 K

Tab. 4-1: Instrument Thermal Level Requirements

An internal view of the cryostat is given in Fig. 4-2. A half section of the cryostat with the important dimensions is given in Fig. 4-3.

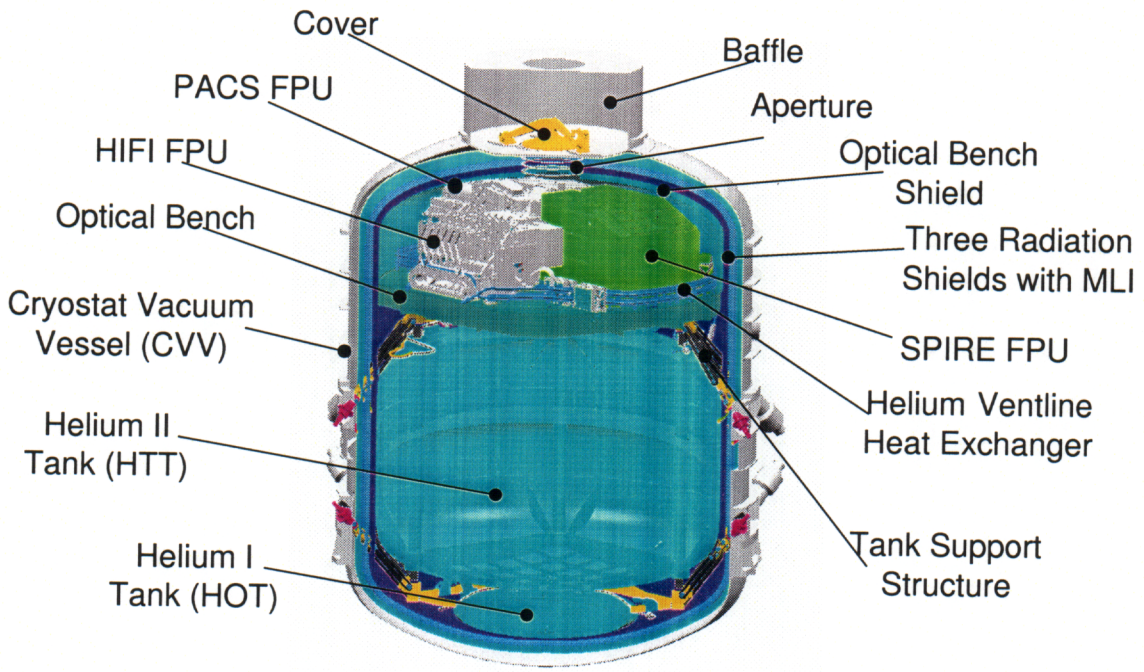


Fig. 4-2: Inner View of Herschel PLM Cryostat

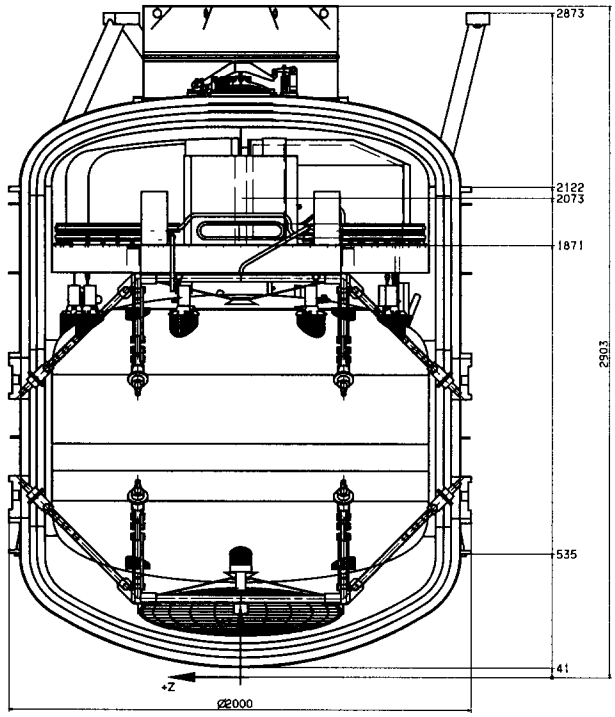


Fig. 4-3: Cross Section of Herschel PLM Cryostat with main dimensions

4.1.2 EPLM SUBSYSTEMS

The **PLM** consists of the following subsystems

- Cryostat Structure Subsystem
- Cryostat Helium Subsystem
- Cryostat Insulation Subsystem
- Cryostat Electrical Subsystem
- Instrument Secondary Structure
- Instrument FPUs and WUs (LOU & BOLA) mounted on CVV

The **EPLM** is completed by

- Sunshield/Sunshade (HSS)
- Telescope
- SVM Thermal Shield
- remaining Instrument WUs mounted on SVM panels

together with their corresponding support structure

The main components of these **EPLM Subsystems** are:

- Cryostat Structure S/S
  - Cryostat Vacuum Vessel (CVV) with three radiators, Cryostat Cover and Cavity, Tank Support and Spatial Framework, Optical Bench for instrument FPUs, Optical Feedthroughs,
- Cryostat Helium S/S:
  - He-II tank, He-I tank, Liquid Helium Valves, Helium System Tubing, other Helium System Equipment
- Cryostat Insulation S/S:
  - Cylinder Thermal Shields, Lower and Upper Thermal Shields, Optical Bench and Beam Pattern Shield, Cryostat MLI
- Cryostat Electrical S/S:
  - Cryostat Control Unit, Cryostat Control Instrumentation, Cryostat Control Harness; scientific instrument harness
- Scientific Instruments (CFE)
  - HIFI, PACS & SPIRE Focal Plane Units, BOLA, LOU, Instrument WUs
- Instrument Secondary Structure:
  - BOLA and LOU Support Structure, Optical Windows and Filters, Support Frame for Windows and Filters, LOU Waveguide Mounting Structure, Instrument Thermal Connectors (cooling straps) and CVV & Optical Bench Alignment References
- HSS
  - Sunshield/Sunshade Structure, Solar Generator, MLI, Sunshade radiator; HSS Support Structure
- Telescope
  - Telescope Structure, Telescope Support Structure, Alignment references
- SVM Thermal Shields
  - Thermal Shields, Support Structure, MLI

4.1.3 EPLM FUNCTIONAL DESCRIPTION

The overall function of the EPLM is to provide a suitable environment for the scientific instruments and the telescope on ground, during launch and in orbit, for the required lifetime.

The cryostat structure S/S comprises mainly the CVV and OB and provides the mounting base for the scientific instruments, the telescope and the sunshield/sunshade. It supports the He S/S (He-II tank, ventline), the Insulation S/S (radiation shields and MLI) and the instrumentation and harness of the Electrical S/S. The CVV provides the insulation vacuum for the He S/S during ground operations and early phase after launch. It is equipped with a cryostat cover which is opened in orbit to provide the instruments with the telescope beam.

The Cryostat Helium S/S provides the cooling of the scientific instruments inside the CVV on ground, during launch and in orbit. The He-II tank is the reservoir that provides the cooling over the lifetime of the H-PLM in orbit and for ground testing. The He-I tank is used as a cooling reservoir during launch preparation for launch autonomy.

The Cryostat Insulation S/S (radiation shields and MLI) enables the cryostat to provide the required temperatures and the lifetime. It protects the CVV from external radiative heat input (e.g. from SVM and Sunshield) and the He-II tank from radiative heat input from the CVV.

The Cryostat Control Unit, Instrumentation and the Cryostat Control Harness of the Cryostat Electrical S/S enable the proper function of the cryostat on ground, during launch and in orbit (housekeeping data). The scientific instrument harness provides the electrical connection between the instrument cold units inside the cryostat and the instrument warm units outside the cryostat and in the SVM.

The Sunshield/Sunshade shadow the Cryostat and the Telescope from sun illumination. The solar generator provides the electrical power for operation of the satellite.

The SVM shield shadows the CVV radiator from the warm SVM and reflects heat to space via the so called v-groove effect.

A flow schematic of the PLM Helium Subsystem is presented in the following figure.

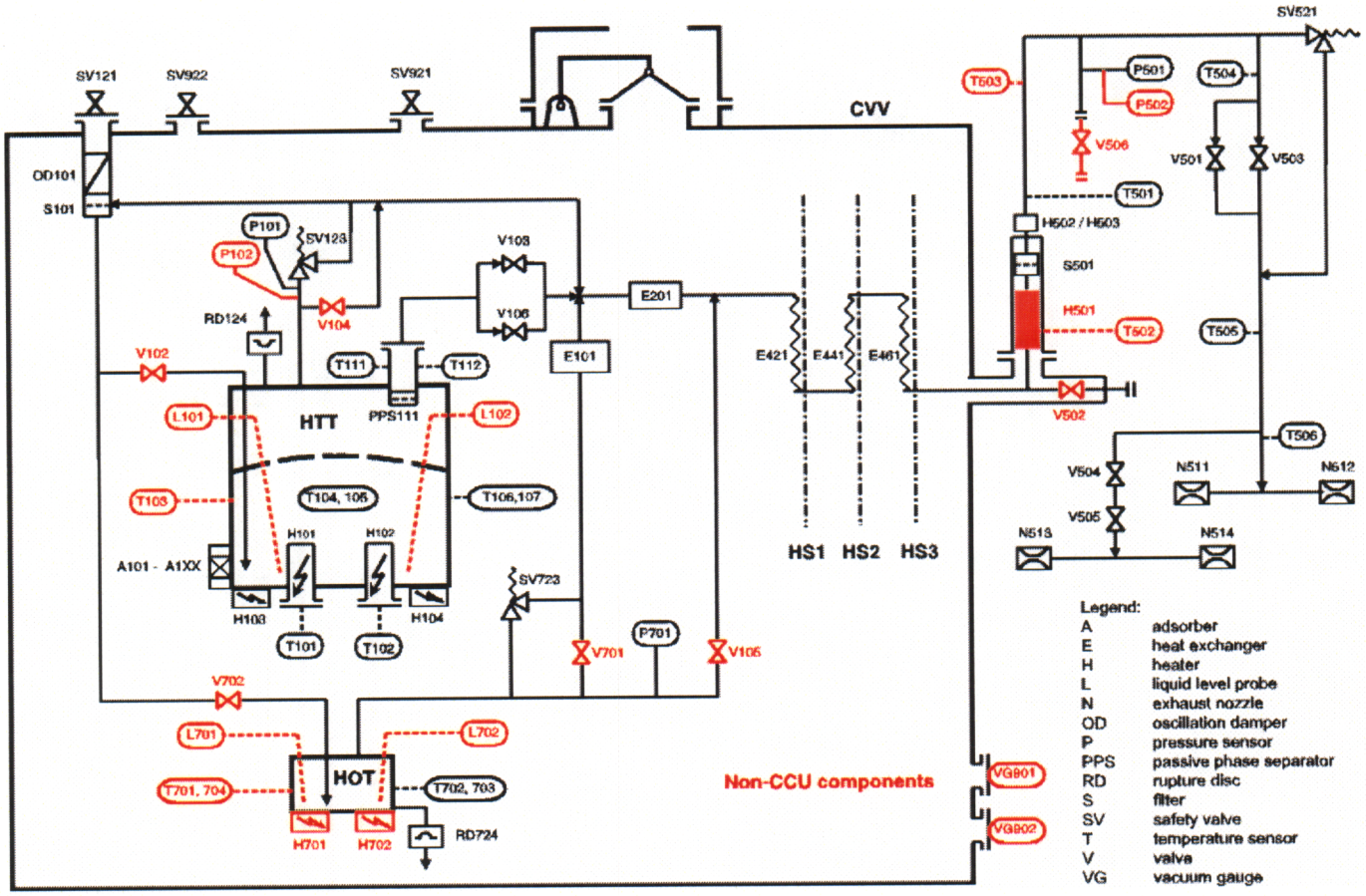


Fig. 4-4: Helium Subsystem Flow Schematic

4.1.4 EPLM FOR STM SATELLITE QUALIFICATION TEST PHASE

For the first PLM test sequence and the subsequent STM satellite qualification test sequence the configuration of the EPLM is as listed below.

- Cryostat	PFM configuration
- Scientific Instruments (FPU & WU) & CCU	STM configuration (=MTDs)
- Sunshade, Sunshield	STM configuration
- Telescope	STM configuration
- SVM Thermal Shields	PFM configuration (tbc)

4.1.5 EPLM FOR PFM SATELLITE ACCEPTANCE TEST PHASE

After completion of the STM qualification test sequence the STM/MTD type units and subsystems are removed and replaced by PFM respectively FM type units.

4.2 SATELLITE

Fig. 4-5 below provides an HERSCHEL satellite overall view. Two different satellite model configurations can be distinguished:

- STM Satellite for Qualification Test Phase
- PFM Satellite for Acceptance Test Phase

4.2.1 STM SATELLITE FOR QUALIFICATION TEST PHASE

The STM satellite model consists of the EPLM in a configuration as described in chapter 4.1.4 above plus the STM SVM.

4.2.2 PFM SATELLITE FOR ACCEPTANCE TEST PHASE

The PFM satellite will basically consist of the EPLM in a configuration as described in chapter 4.1.5 above plus the PFM SVM.

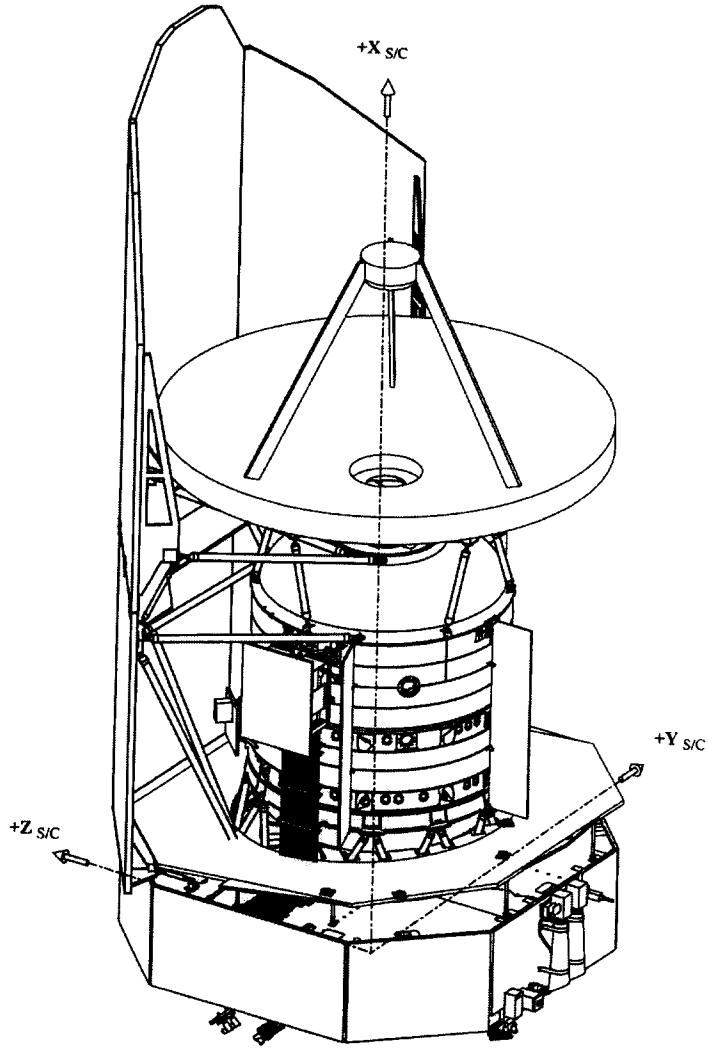


Fig. 4-5: HERSCHEL Satellite Global View and Definition of Satellite Axes

4.2.3 SATELLITE AXIS CONVENTION

The HERSCHEL Satellite reference frame (O, Xs, Ys, Zs), see Fig. 4-5, is a right-handed Cartesian system with:

- its origin O is located at the point of intersection of the longitudinal launcher and the satellite/launcher separation plane; the origin coincides with the centre of the satellite/launcher separation plane
- Xs-axis coincides with the nominal optical axis of HERSCHEL telescope. Positive Xs-axis is oriented towards the target source.; the Xs-axis coincides with the launcher longitudinal axis
- Zs is in the plane normal to Xs-axis, such that nominally the Sun will lie in the (Xs, Zs) plane (zero Roll angle with respect to Sun). Positive Zs-axis is oriented towards the Sun
- Ys completes the right handed orthogonal reference frame.

4.3 EPLM AND SATELLITE PRODUCT TREE

The following tables provide an overview of the elements of the Herschel EPLM and Satellite and their logical order. Both, flight hardware and GSE are listed.

ID	Level	CI-Number	Hardware
1	1	100 000 000	**Herschel Satellite**
2	2	110 000 000	Herschel CFE Items
3	3	111 000 000	HIFI
21	3	112 000 000	SPIRE
35	3	113 000 000	PACS
42	3	114 000 000	Herschel Telescope
44	2	120 000 000	Herschel Extended Payload Module PFM
45	3	121 000 000	Payload Module PFM
188	3	122 000 000	Telescope Mounting Structure
191	3	123 000 000	Herschel Sunshield and Sunshade
211	3	124 000 000	PLM / SVM Interface Struts
214	2	130 000 000	Herschel SVM
215	3	131 000 000	SVM Connector Brackets
216	3	132 000 000	SVM Thermal Shield
221	2	140 000 000	GSEs
222	3	141 000 000	Herschel Spacecraft GSE
241	3	142 000 000	EPLM GSE
328	2	150 000 000	Herschel Payload Module EQM
329	3	151 000 000	Cryostat Structure Subsystem
401	3	152 000 000	Cryostat Helium Subsystem
435	3	153 000 000	Cryostat Insulation
459	3	154 000 000	Cryostat Electrical Subsystem
465	3	155 000 000	Instrument Secondary Structure
472	3	156 000 000	EQM GSE

Tab. 4-2: HERSCHEL Product Tree (Level 1-3)

ID	Level	CI-Number	Hardware
2	2	110 000 000	Herschel CFE Items
3	3	111 000 000	HIFI
4	4	111 100 000	HIFI Cryostat Units
5	5	111 110 000	HIFI Focal Plane Unit
6	5	111 120 000	LOU (outside cryostat)
7	5	111 130 000	LOU Radiator (outside cryostat)
8	5	111 140 000	LOU Waveguides (outside cryostat)
9	4	111 200 000	HIFI Warm Units
10	5	111 210 000	Local Oscillator Control Unit
11	5	111 220 000	Local Oscillator Synthesizer Unit
12	5	111 230 000	Focal Plane Control Unit
13	5	111 240 000	High resolution Spectrometer Unit
14	5	111 250 000	Wide-Band Spectrometer Unit
15	5	111 260 000	Interface Control Unit
16	4	111 300 000	HIFI Flight Spares
17	4	111 500 000	Instrument GSE
18	5	111 510 000	MGSE
20	5	111 520 000	EGSE
21	3	112 000 000	SPIRE
22	4	112 100 000	SPIRE Cryostat Units
23	5	112 110 000	SPIRE Focal Plane Unit
24	5	112 120 000	SPIRE JFETs
27	5	112 130 000	SPIRE Instrument Cryo Harness
30	4	112 200 000	SPIRE Warm Units
31	5	112 210 000	Digital Processing Unit
32	5	112 220 000	FPU Control Unit
33	5	112 230 000	Detector Control Unit
34	4	112 500 000	Instrument GSE
35	3	113 000 000	PACS
36	4	113 100 000	PACS Cryostat Units
37	5	113 110 000	PACS Focal Plane Unit
38	5	113 120 000	BOLA
39	5	113 130 000	BOLA Radiator
40	4	113 200 000	PACS Warm Units
41	4	113 500 000	Instrument GSE
42	3	114 000 000	Herschel Telescope
43	4	114 500 000	Herschel Telescope GSE

Tab. 4-3: HERSCHEL Product Tree (Instruments and Telescope CFE)

ID	Level	CI-Number	Hardware
44	2	120 000 000	Herschel Extended Payload Module PFM
45	3	121 000 000	Payload Module PFM
46	4	121 100 000	Cryostat Structure Subsystem
47	5	121 110 000	Cryostat Vacuum Vessel (CVV)
54	5	121 120 000	Tank Support and Spatial Framework
63	5	121 130 000	Cryostat Cover and Baffle
66	5	121 140 000	Instrument Optical Bench
70	5	121 150 000	Cooling Straps ? > see 121 570!
71	4	121 200 000	Cryostat Helium Subsystem
72	5	121 210 000	Helium II Tank
73	5	121 220 000	Helium System Components
93	5	121 230 000	Liquid Helium Valves
96	5	121 240 000	Helium System Tubing
103	5	121 250 000	Helium I Tank
104	5	121 260 000	Helium System Equipments
112	4	121 300 000	Cryostat Insulation Subsystem
113	5	121 310 000	Lower Cylinder Thermal Shields
117	5	121 320 000	Upper Cylinder Thermal Shields
121	5	121 330 000	Lower Bulkhead Thermal Shields
125	5	121 340 000	Upper Bulkhead Thermal Shields
130	5	121 350 000	Optical Bench and Beam Pattern Shield
133	5	121 360 000	Cryostat Internal MLI
153	5	121 370 000	Cryostat External MLI
163	4	121 400 000	Cryostat Electrical Subsystem
164	5	121 410 000	Cryostat Control Unit
165	5	121 420 000	Cryostat Control Instrumentation
166	5	121 430 000	PLM Cryo Harness
177	4	121 500 000	Instrument Secondary Structures
178	5	121 510 000	BOLA Support Structure
179	5	121 520 000	LOU Support Structure
182	5	121 530 000	Optical Windows and Filters
183	5	121 540 000	Support Frame for Windows and Filters
184	5	121 550 000	Optical Bench Harness Connector Brackets (tbc)
185	5	121 560 000	LOU Waveguides Mounting Structure
186	5	121 570 000	Instrument Thermal Connectors (cooling straps)
187	5	121 580 000	PLM and Optical Bench Alignment References
188	3	122 000 000	Telescope Mounting Structure
189	4	122 100 000	Telescope Mounting Structure
190	4	122 200 000	Telescope Mounting Structure MLI
191	3	123 000 000	Herschel Sunshield and Sunshade
192	4	123 100 000	Sunshield / Sunshade Structure
193	5	123 110 000	Sunshield
196	5	123 120 000	Sunshade
199	4	123 200 000	Solar Power Generator
200	5	123 210 000	Electrical Wiring and Solar Cells
201	4	123 300 000	Thermal Control
202	5	123 310 000	Sunshield
206	5	123 320 000	Sunshade
211	3	124 000 000	PLM / SVM Interface Struts
212	4	124 100 000	PLM / SVM Interface Struts

Tab. 4-4: HERSCHEL Product Tree (EPLM)

ID	Level	CI-Number	Hardware
214	2	130 000 000	Herschel SVM
215	3	131 000 000	SVM Connector Brackets
216	3	132 000 000	SVM Thermal Shield
217	4	132 100 000	SVM Thermal Shield
218	4	132 200 000	SVM Thermal Shield MLI
219	4	132 300 000	SVM Thermal Shield Fixation
220	4	132 400 000	SVM Thermal Shield Fixation MLI
221	2	140 000 000	GSEs
222	3	141 000 000	Herschel Spacecraft GSE
223	4	141 100 000	Herschel S/C MGSE
224	5	141 110 000	Transport Container H-TSC
225	5	141 120 000	Mass Property Adapter
226	5	141 130 000	Vibration Test Adapter (S/C I/F)
227	5	141 140 000	Thermal Test Adapter (S/C I/F)
228	5	141 150 000	Alignment Adapter for Rotary Table (S/C I/F)
229	5	141 160 000	Thermal Test Adapter (TTAS) (S/C I/F)
230	5	141 170 000	Acoustic Noise Test Adapter (MTA-B)
231	5	141 180 000	Interface Adapter to LEAF
232	4	141 200 000	Herschel S/C EGSE
233	5	141 210 000	Central Checkout System
234	5	141 220 000	CDMU SCOE
235	5	141 230 000	Power SCOE
236	5	141 240 000	ACMS SCOE
237	5	141 250 000	TT & C SCOE
238	5	141 260 000	TM / TC Front End
241	3	142 000 000	EPLM GSE
242	4	142 100 000	EPLM MGSE
243	5	142 110 000	Test and Integration Device
257	5	142 120 000	Handling Device
265	5	142 130 000	Transport Device
267	5	142 140 000	Test Adapter
278	5	142 150 000	Trolleys and Stands
280	5	142 160 000	Miscellaneous
283	4	142 200 000	EPLM EGSE
284	5	142 210 000	Central Checkout System (light)
285	5	142 220 000	Cryo SCOE
286	5	142 230 000	Transport Stimuli & Monitoring Unit
287	5	142 240 000	CDMU Frontend
288	5	142 250 000	PLM SCOE
289	5	142 260 000	Cables for TV Test
290	4	142 300 000	EPLM CVSE
291	5	142 310 000	EPLM CVSE
304	4	142 400 000	EPLM OGSE
305	5	142 410 000	LOU Alignment Camera
306	5	142 420 000	Alignment Reference Cubes
307	5	142 430 000	Tripod
308	4	142 500 000	Mass and Thermal Dummies
309	5	142 510 000	Instrument Dummies
322	5	142 520 000	Telescope Dummy
323	4	142 600 000	Mockups
324	4	142 700 000	Cryo Test Adapter (CTA) for PFM
325	5	142 710 000	CVV Interface Plate (CVVIP)
326	5	142 720 000	Cryo Test Cavity for PFM (CTCP)
327	4	142 800 000	Miscellaneous

Tab. 4-5: HERSCHLE Product Tree (SVM & GSE)

5 INTEGRATION & TEST RULES AND LOGIC

5.1 BASIC INTEGRATION RULES

5.1.1 PRE-INTEGRATION INSPECTION AND H/W RELEASE

Before starting any integration activity an incoming inspection will be performed on each delivered item to control the quality of the hardware to be integrated.

As a minimum, the following controls/measurements will be performed:

- control of data package according to the shipping list
- completeness of H/W according to shipment documentation
- visual inspection (no obvious damage or degradation)
- cleanliness inspection
- conformity of identification markings and serial numbers to the configuration status
- fit check (if possible)
- functional health checks (where appropriate)

Release of hardware for integration will be controlled. Parts required for a particular integration activity will be kited to reflect the requirements of the governing integration procedure and the parts lists prior to the need date.

5.1.2 HARDWARE AS BUILT CONFIGURATION STATUS LIST

Through an official record (ABCL) the hardware "as built status" will be traced during the AIT activities.

The list will include:

- name of hardware
- identity tag number
- drawing references
- integrated hardware part identification and serial number
- integration date

5.1.3 HANDLING

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

In particular, overhead cranes will be operated by authorised crane operators.

5.1.4 HARNESS AND WAVEGUIDES INTEGRATION

Harness and waveguides will be handled and installed only by experienced and authorised personnel.

All electrical interfaces will be protected by connector savers during integration, so mating/demating will be made by breaking non flight hardware interfaces. Through an official record, all flight connector mating/demating steps will be traced during the AIT activities. This record shall state:

- unit and harness connectors identification: reference and type
- mating/demating date for:
  - harness connector to saver
  - unit connector to saver
  - harness connector to unit connector (tightening of fixing screws)

Electrical integration of harness will be completed by execution of detailed functional checks/tests. Open ends of the waveguides will be protected by adequate caps.

5.1.5 ELECTRONIC UNITS INTEGRATION

The general approach is a sequential assembling and testing. Each unit shall be reasonable functionally tested within existing constraints as far as possible before further units are added. The philosophy shall allow the identification of problems as clear and early as possible.

After unit mechanical integration and fixing bolt torque, a bonding measurement (or isolation as required) between unit housing and structure reference grounding point will be performed.

Electrical integration of units and subsystems will be completed by execution of detailed functional checks and tests, see below.

In particular, prior to cryostat final closure and evacuation a health check of the FPUs and associated inner harness will be performed with corresponding unit testers.

Precautions and limitations as prescribed by the instrument suppliers will be strictly observed.

The system integration (electrical connection of SVM to PLM) will be performed according to the same principles: electrical interface verification completed by functional checks during and after final connection as explained hereafter.

5.1.6 ELECTRICAL INTERFACE CHECKS

Electrical checks will be automated as far as practicable. This will ensure systematic control of all interfaces of a unit to be integrated. Before and after connection of a harness to its dedicated unit connector, all electrical interfaces will be tested using an Integration Data Acquisition System. The following checks will be performed to verify the electrical interface compatibility, to avoid any degradation of flight units:

- grounding plan verification through grounding measurements at unit and harness connector level
- safety verification of output signals by measurement at emitter unit level in unloaded configuration before harness connection. Such a verification will be restricted to high level signals (power supply – high level commands) and to signals for which a specific measurement is required due to the risk encountered by receiver units
- harness verification by performing the same kind of measurements at harness connector level before connection to the receiver unit
- signal characteristics measurement in loaded configuration (harness connected at emitter and receiver unit level) through break-out boxes and T-adapters

After removal of break-out boxes and T-adapters, final connection of each harness connector and tightening of fixation screws (plus marking where required) will be performed.

5.1.7 FUNCTIONAL CHECKS

Electrical integration of units, instruments and subsystems will be completed by execution of detailed functional tests. Test equipment and procedures will be reused as elements of subsequent SFT, IMT or IST. The environmental test will be accomplished by short functional test at ambient, He-I, or He-II conditions.

Functional checks of integrated units before continuing the next unit integration operations. These kind of functional checks are restricted to the minimum and allow to only verify that the unit can be powered, commanded, and monitored.

5.1.8 ALIGNMENTS

5.1.8.1 ALIGNMENT PLAN

This chapter defines the alignment philosophy and the measurements which will be performed during the various steps of integration and testing with the PFM PLM and Satellite. During the on-ground alignment two constraints must be taken into account:

1. The alignment requirements are valid for in-orbit conditions
2. The alignment requirements are specified for operational conditions, whereas the alignment can only be performed at ambient conditions.

The following environmental conditions will change between on-ground alignment and in-orbit operation:

- Gravity from 1g to zero g
- Atmospheric pressure from 1bar to 0 bar
- Outer CVV temperature

These effects must be determined and have to be pre-compensated by a corresponding offset on-ground. The experience gained with theoretical determination of this offset and its confirmation during testing with EQM PLM will be applied for PFM PLM activities.

Also the effects due to internal temperature and pressure changes being confirmed during on-ground testing of EQM shall be considered, however, the effect on alignment of outer CVV temperature change can only accurately be verified during TB/TV testing, and the gravity release effect can only be determined theoretically. Restrictions must also be made for the testing of the temperature change.

Alignment of the Herschel elements has to be performed in multiple steps and can be divided in three main areas.

5.1.8.2 PLM ALIGNMENT

The instrument alignments are achieved by multiple measurements during PLM re-integration integration and test

- alignment of optical bench (OB) versus CVV before FPU integration
- alignment of FPUs versus OB after FPU integration
- alignment of LOU versus OB (HIFI) after LOU integration through open cover and/or optical window using alignment camera (tbc)
- alignment check HIFI vs. LOU after CVV evacuation (warm)
- alignment check HIFI vs. LOU during/after cool down, filling and final adjustment of strap pretension

5.1.8.3 SVM ALIGNMENT

The SVM alignments i.e. ACMS and RCS sensors, actuators, and thrusters are performed by ALENIA during module integration versus a SVM master reference cube.

5.1.8.4 SATELLITE SYSTEM ALIGNMENT

During satellite final integration, the system alignment consists of two main steps:

- alignment of telescope versus CVV
- measurement of the PLM axis versus SVM axis

During the various steps of PLM refurbishment and reintegration after STM test completion, PFM satellite integration and testing, these measurements are repeated at appropriate steps, as indicated in chapter 5.2 below.

5.1.9 CRYO OPERATIONS

In order to allow instrument testing in the required thermal environment, the cryostat will be cooled down and the tanks filled with LHe. Instrument cool down requirements will be respected.

5.1.9.1 COOLDOWN & FILLING

The cooldown and filling will be performed according dedicated procedures, based on existing and verified ISO documents and Herschel EQM PLM documents and using the refurbished ISO CVSE.

Cooldown and filling will start after successfully performed leak test of the internal Helium S/S to the cryostat isolation vacuum and isolation vacuum to ambient. After filling of the main tank with LHe-I, a cold leak test will be performed.

Similar procedures will be used for filling the auxiliary tank with He-I. Cooldown and filling will be performed with x-axis in vertical direction only. The principal set-up for cooldown and filling operations is shown in the following figure.

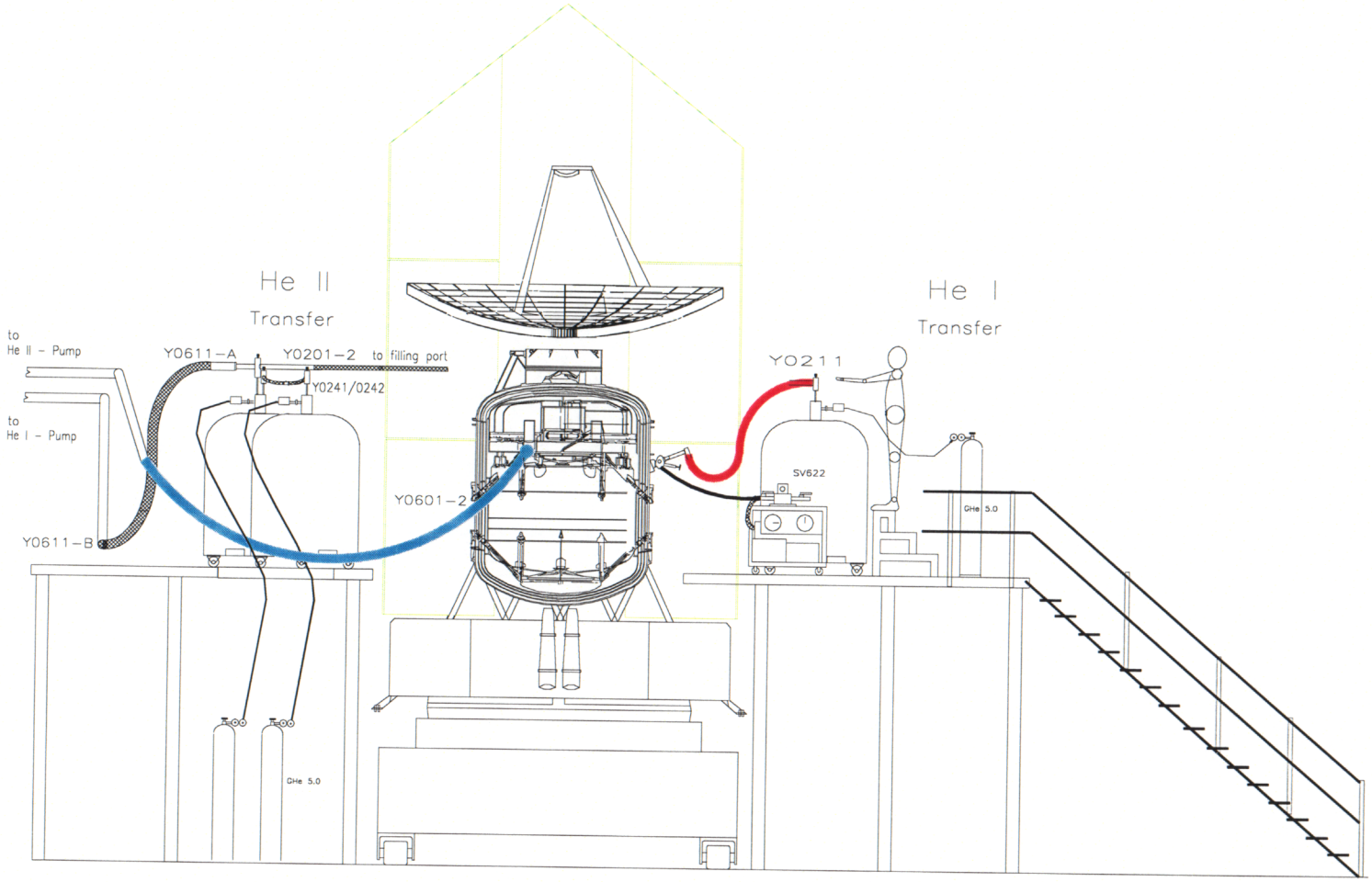


Fig. 5-1: Set-up for cooldown, helium filling (He-I) and He-II production operations

5.1.9.2 HELIUM II PRODUCTION AND TOP-UP

The Helium II production and top up will be performed according dedicated procedures also based on verified ISO and Herschel EQM PLM documents and using the refurbished ISO CVSE.

He-II production and top up will be performed with x-axis in vertical direction only.

Specific constraints (to be defined) , e.g. thermal gradients limited for instruments, will be strictly observed.

Principal test set-up is shown in Fig. 5-1 above.

5.1.9.3 DEPLETION AND WARM UP

Depletion and warm-up activities, if necessary, will be performed according dedicated procedures also based on verified ISO and Herschel EQM PLM documents and using the Herschel (refurbished ISO) CVSE.

During the nominal PFM integration and test sequence no depletion and warm up is foreseen.

5.1.10 HANDLING AND TRANSPORTATION

Detailed requirements regarding handling and transportation activities of the PLM and the satellite shall be covered in dedicated handling and transportation procedures.

An overview of the necessary handling and transportation activities is given in RD 09.

A description of the major facilities and GSE needed and the major transportation steps are shown in chapters 8 and 9 below.

If the PLM or satellite in cold conditions needs be transported with x axis horizontally, e.g. between facilities see Fig. 5-2, then the He-II tank will be filled to no more than about 50% for that purpose.

The Transportation Monitoring Unit (TMU) will be attached to the transportation container and activated during transportation.

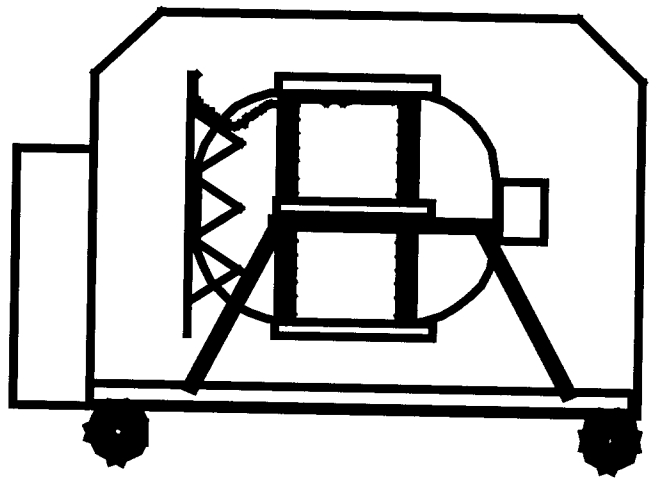


Fig. 5-2: PLM Transportation

5.2 AIT LOGIC FLOW

The PFM PLM and Satellite integration flows are given in Fig. 5-3 and Fig. 5-4.

The PFM Satellite qualification and acceptance test flow is presented in Fig. 5-5.

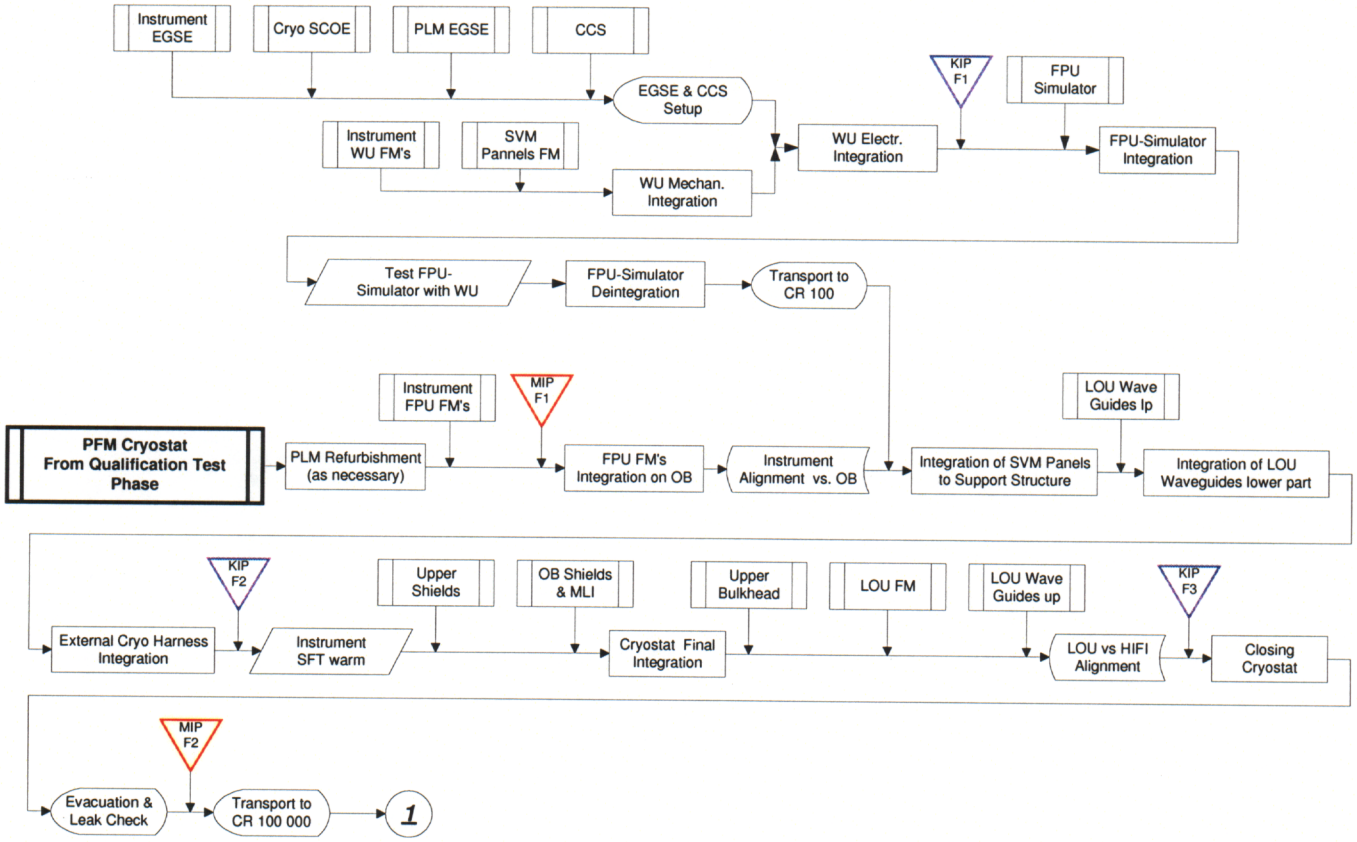


Fig. 5-3: PFM PLM integration logic flow in CR 100

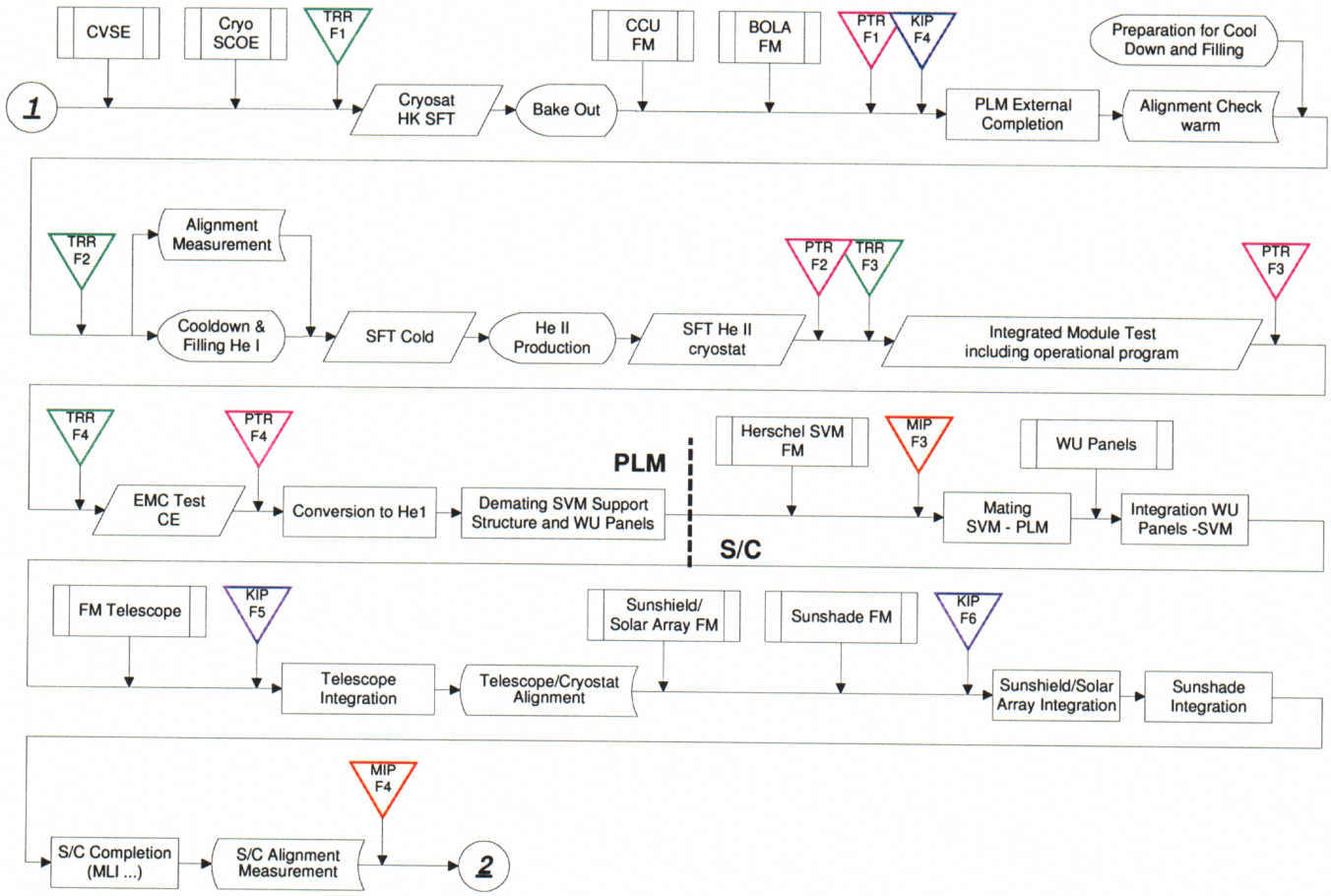


Fig. 5-4: PFM PLM and Satellite Integration logic flow in CR 100,000

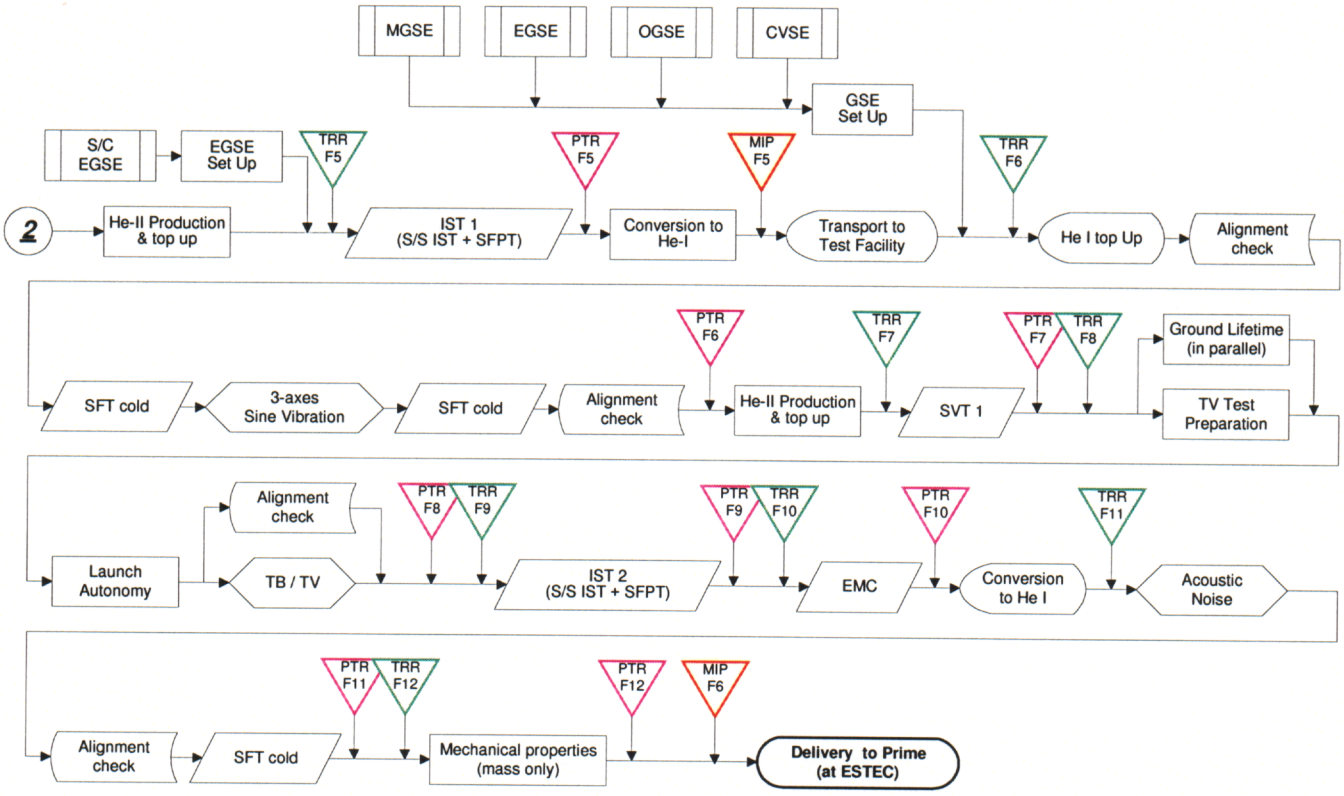


Fig. 5-5: PFM Satellite qualification and acceptance test logic flow

5.3 PLM LEVEL INTEGRATION AND TESTING

5.3.1 PLM REFURBISHMENT AND INTEGRATION

Based upon final inspection results after completion of STM satellite qualification test campaign and subsequent partial de-integration of the PLM, necessary and agreed refurbishment activities will be completed.

Thereafter the PFM PLM will be re-integrated. In this frame the following items that had been Mass and Thermal Dummies for the STM satellite will be replaced by PFM/FM units:

- Instrument FPUs for PACS, HIFI, and SPIRE
- LOU incl. radiator
- BOLA incl. radiator
- CCU (installed during satellite integration)

Mechanical and electrical assembly and integration will be performed according to formal step-by-step procedures only. All activities will be given there in correct timely order.

All integration activities on the PFM cryostat will performed in cleanroom class 100 environment up to and including final closure of the cryostat and evacuation.

The handling and integration activities of PFM hardware will be carried out using dedicated MGSE as described in chapter 9 below. It will be done by trained authorised personnel only with the necessary experience (e.g. ISO heritage).

The major activities during the PFM PLM re-integration are summarised as follows:

- **Instrument Warm Units and SVM panel preparation**
  - EGSE/CCS preparation and set-up
  - Mechanical integration of WUs on SVM Panels
  - Electrical Integration of WUs
  - Interface verification (SVM I/F's provided by PLM EGSE)
  - EGSE harness connection
  - FPU Simulator Integration
  - Test Instrument Warm Units with FPU Simulator
    - HIFI test sequence debugging
    - PACS test sequence debugging
    - SPIRE test sequence debugging
    - PACS/SPIRE test sequence debugging (parallel mode)
  - FPU Simulator De-integration
  - Cleaning & Transport of WUs on SVM panels to CR 100

- **Integration and alignment of FM Instrument FPUs**
  - Mechanical/thermal Integration FPUs onto OB
  - Integration SIH (connection SIH to FPU)
  - FPU electrical interface check
  - FPU Alignment vs. OB/CVV

- **Integration WUs and SVM support Structure**
  - Integration of SVM Support Structure
  - Integration of pre-integrated SVM Panels to Support Structure
  - Integration LOU Waveguides lower part (SVM)
  - External Cryo Harness Integration
  - Integration external harness (CCH & SIH)
  - WU electrical interface check
  - Connection external SIH to WUs
  - Instrument SFT 1 Warm

- **PFM Cryostat Final Integration**
  - Integration of OB shield (straylight tight)
  - Integration of OB MLI (straylight tight)
  - Assembly upper shields (MLI pre-integrated)
  - Assembly upper bulkhead
  - Connection of filling port SV121 & leak test
  - Integration and alignment of LOU & waveguides upper part
  - Integration of Cryostat Cover (CC) and Cryostat Baffle (CB)
  - Evacuation & leak check

- **Transport to clean room 100,000**
- **Bake-out and PLM external integration**
  - Short Functional Test (Cryo HK only)
  - Bake out
  - integration and connection of BOLA and CCU
  - Alignment Check warm

The PLM integration sequence is completed with the alignment check after evacuation of CVV and final external integration.

Details about the flow and the actual schedule are given in chapter 5.2 and chapter 10 respectively.

5.3.2 PLM TESTING

Before the PLM is finally mated with the SVM and other elements to become the PFM satellite it is submitted to the following test and further preparation steps:

- Cooldown & filling with He-I
- Alignment measurement during cooldown & adjustment as necessary
- Short functional test of Cryo Control and Instruments at He-I
- He-II production & top-up
- Short Functional Test cold (He-II condition)
- Integrated Module Tests (IMT) incl. operational programme
  - Cryostat Tests (CCU & Instrumentation)
  - HIFI Tests
  - PACS Tests
  - SPIRE Tests
  - PACS/SPIRE Tests (parallel mode)
- EMC tests (CE only)
- Conversion to He-I

Detail s about the flow and the actual schedule are given in chapter 5.2and chapter 10 respectively.

The SFT, the IMT and the EMC tests are briefly described in the following chapters.

5.3.2.1 SHORT FUNCTIONAL TEST (SFT)

The SFT is foreseen to verify mainly through umbilical links the correct functioning of units or the complete module, in order to validate a specific installation or to check the system health after dedicated integration or test steps (e.g. cooldown, He-II production).

This test is performed by setting the system in defined operational configurations and checking that all elements under test are working properly.

During the PLM integration and test phase the Cryo-Control Subsystem (CCS) and the instruments are concerned. Evaluation should preferably be based on housekeeping (HK) data rather than scientific data.

Further details for instrument related SFT can be found in RD 10.

5.3.2.2 INTEGRATED MODULE TEST (IMT)

The IMT shall be a sequence of tests which allow a full assessment of the functional and measurement performance of the integrated instrument in conjunction with the spacecraft, as far as it is possible on this level.

The IMT sequence for HIFI shall cover the following two objectives

- Ensure that the instrument is working properly and that the performance is within the predicted limits derived from the instrument level test results.
- Determine the impact of standing waves in the local optical path (LOU to FPU) by a dedicated reduced standing wave test.

For PACS the IMT sequence comprises the check of the instrument function and the verification of the performance at representative background conditions (dark background test).

The SPIRE IMT sequence is based on need to look at the following aspects:

- Recovery from cooler recycle.
- Settling time for photometer mode switch on.
- Switching from photometer to spectrometer mode.
- Switching from SPIRE prime to PACS/SPIRE parallel.
- Total cooler hold time during nominal operations.

The testing of the SPIRE instrument has to be based around the recycling of the 300 mK cooler. At least one full operational cycle of the cooler (nominal 48 hours) is required in order to evaluate the hold time of the cooler under nominal in flight operating conditions. Two cooler cycles which need not be contiguous would be preferred. In the IMT two full cooler recycle periods are foreseen (tbc). During the IMT the constraints of the PLM tilting angle during PACS and SPIRE cooler recycles has to be considered.

Further details for instrument related IMT can be found in RD 10.

5.3.2.3 EMC TEST

During PFM PLM integration and test, the EMC test comprises measurements of the conducted emission per instrument (CE test) only. During these measurements the instruments are switched in a mode with maximum generation of electrical distortion on the electrical lines.

The instruments are tested individually, i. e. the EMC test configurations and sweeps have to be repeated for each instrument (TBC). During the EMC test the constraints of the PLM tilting angle during PACS and SPIRE cooler recycles have to be considered.

Details for instrument related EMC tests can be found in RD 10.

5.4 PFM SATELLITE INTEGRATION AND TESTING

5.4.1 PFM SATELLITE FINAL INTEGRATION

To complete the EPLM and finally the PFM satellite, the steps listed below will be undertaken to assemble the remaining elements and modules to the PLM. The PLM remains in He-I condition during this period.

- De-integration of SVM support structure and WU panels
- Integration and alignment of SVM
- Integration and electrical connection of WU panels
- Integration of SVM shields
- Integration and alignment of Telescope incl. support structure
- Mech./thermal integration and electrical connection of Sun Shield/Solar Array including support structure
- Mechanical and thermal integration of Sun Shade including support structure
- Integration of remaining external MLI
- Final satellite alignment measurements

5.4.2 PFM SATELLITE QUALIFICATION AND ACCEPTANCE TESTS

To complete the qualification and to accomplish acceptance for flight the following main test and inspection steps are foreseen on the integrated PFM satellite.

- He-II production & top-up
- Integrated System Test (IST1) (S/S IST and SFPT)
- Conversion to He-I
- Transport to Test Facility (ESTEC)
- Alignment Check and SFT, He-I
- Sine vibration acceptance level, 3 axis, He-I
- Alignment Check and SFT, He-I
- He-II production and top-up
- System Validation Test (SVT)
- Ground lifetime and launch autonomy verification (in parallel to TB/TV preparation)
- Thermal balance and thermal vacuum test including alignment checks (tbc), He-II
- IST2 (S/S IST and SFPT)
- EMC Tests
- Conversion to He-I
- Acoustic Noise Test (acceptance level)
- SFT and alignment check, He-I
- Mechanical properties measurement (mass, only)

- Delivery to Prime

The main test activities are briefly described in the following chapters.

5.4.2.1 INTEGRATED SYSTEM TEST (IST)

The full IST is the reference system performance test. It will be run twice:

- after system integration phase, i.e. after PLM and SVM mating to verify the performance of the overall satellite system at start of its ground life
- after the environmental test sequence (i.e. after TB/TV / before Acoustic Noise) to verify that no intolerable performance drift or degradation happened during the mechanical and thermal tests.

The IST is a combination of tests developed from unit, subsystem, or module level test sequences.

It consists of

- subsystem performance measurements at system level, i.e. the most complete possible verification of performance and characteristics of each PLM and SVM subsystem with regard to its specifications, when integrated in the actual system environment instead of a simulated one.
- system functional performance measurements incl. scientific instruments for verifying where possible the system specification.

Measurements to be performed are identified in the test matrices provided in AD 01, AD 11, and RD 10.

5.4.2.2 SHORT FUNCTIONAL TEST (SFT)

The SFT consists of a subset of the IST sequence and is foreseen to verify system electrical integrity following transportation of the satellite or in-between /during environmental test steps. The instrument part of this test is basically limited to a switch on and a functional verification of the interfaces.

Measurements to be performed during a SFT are identified in the test matrices provided in AD 01, AD 11, and RD 10.

5.4.2.3 SINE VIBRATION TEST

The PFM sine vibration test consists of the following steps in the three orthogonal main satellite axes:

- low level sine vibration run to verify the structural and coupled load analysis and to identify/confirm the major Eigenfrequencies and to agree upon necessary notching for the acceptance level test
- intermediate level run for determination of final notching levels (tbc)
- acceptance level sine vibration for verification of the workmanship of the mechanical system, the verification of the alignment requirements, and the demonstration that the thermal insulation and its support elements can withstand the environmental loads.
- low level run for comparison of previous satellite signature

Notching of levels applied to the satellite will be made at the resonance frequencies of the main structural elements in order not to over-stress the satellite. These notching criteria will be determined in accordance with launcher regulations.

5.4.2.3.1 TEST SET-UP AND CONDITIONS

The sine vibration test will be performed with the PLM in cold (He-I) condition.

As for launch the HTT will be filled (≥ 95%) with He-I. This condition will be verified/achieved before each test run. The PLM auxiliary helium tank will be empty.

The SVM propellant tank will be filled with simulation fluid (de-ionised water) and pressurised (tbc by SVM contractor).

The satellite will be installed on the shaker with the vibration test adapter representative of the launcher interface. The clamp band will be mechanically identical to a flight one.

Protective covers for e.g. telescope, Sun shield, OSRs, thrusters, sensors etc., will be removed before and reinstalled immediately after test to minimise exposure of sensitive surfaces to potential contamination.

The figure below shows the principal vibration set-up.

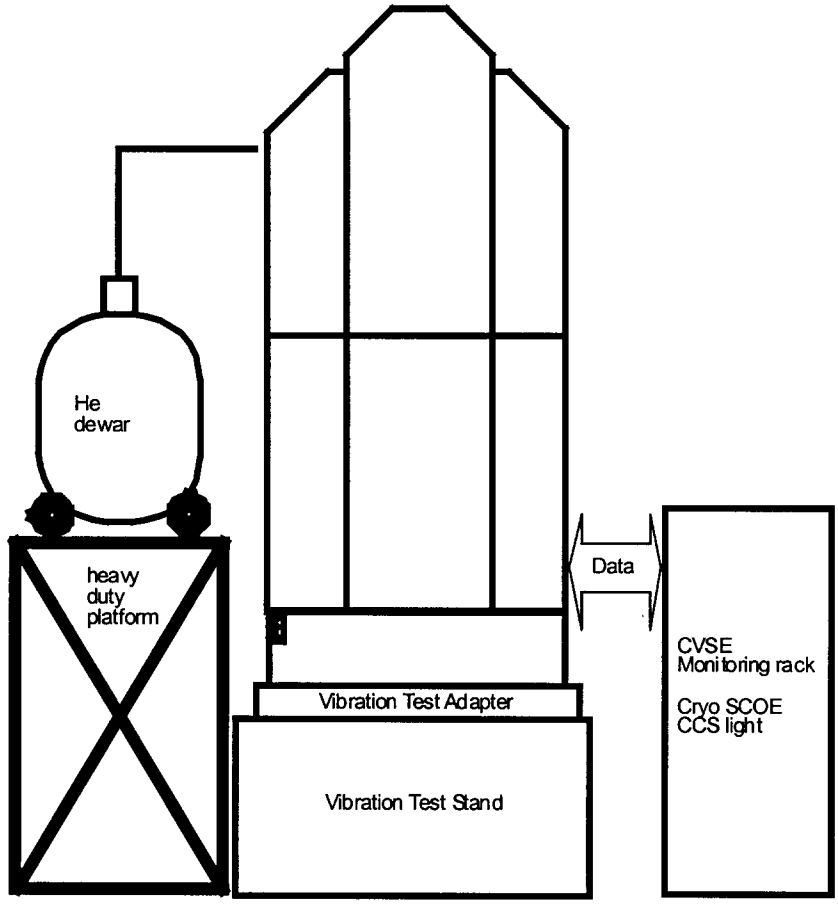


Fig. 5-6: PFM Satellite sine vibration test set-up

Test accelerometers will be installed on the satellite at pre-defined locations, in order to be able to compare test results with previous structural mathematical models and to monitor the vibration levels applied to particular equipment and interfaces.

5.4.2.4 SYSTEM VALIDATION TEST (SVT)

The System Validation Test (SVT) consists of a system level compatibility test with the ground segment. For this purpose the PLM cryostat will be at He-II conditions.

The test objectives are

- to verify the compatibility between the control centre data base and the command and telemetry data base used during the AIT sequence
- to validate the control centre mission operation software

Currently there is one SVT foreseen in the PFM acceptance test sequence.

The SVT will include ACMS closed loop test (tbc) amongst those already performed at subsystem level. The validation of these test will be done during the SVM integration phase (tbc by SVM supplier). A special test harness may need to be installed.

The system level compatibility will be proven by command and data flow tests involving the satellite, the system EGSE, and the control centre (this includes the satellite control centre and the scientific operation centre). The SVT procedure will be written taking into account ESTEC/ESOC requirements.

To assist ESOC in development of the mission operation software it may be required to supply ESOC with real time satellite telemetry data during certain testing phases (e.g. TB/TV tests) on a non-interference basis.

5.4.2.5 GROUND LIFETIME AND LAUNCH AUTONOMY VERIFICATION

The ground lifetime and launch autonomy verification test will be combined with the preparation of the subsequent TB/TV tests. The objectives are

- to obtain a set of temperature parameters and He mass flow for near ground equilibrium conditions for comparison with the model prediction
- to verify the Cryostat Helium Subsystem correct behaviour during launch preparation and start phase.

The test sequence will be as follows

- He-II production and top up,
- wait for near equilibrium and record temperature distribution and He mass flow
- closing of HTT
- Disconnect of He Pumping Unit I and II
- Filling of HOT with He-I
- Refilling of HOT with He-I each two days (tbc) according preliminary launch time line and recording of HTT temperature profile

5.4.2.6 TB/TV TEST

The PFM satellite will be submitted to the following thermal vacuum tests:

- Thermal Vacuum (step 1)
- Thermal Balance (step 2)
- Thermal Vacuum Cycles

Step 1 will be performed for verification of the He S/S, MLI workmanship and alignment measurement. During this phase the CVV outer surface will be actively cooled with LN2.

For step 2 and the subsequent thermal vacuum cycles the active cooling will be terminated and the cryostat will be thermally free floating. Then I/F heat transfer and identification of proper system functional aspects will be verified during thermal balance test. It serves also for correlation of the Thermal Mathematical Model (TMM) predictions with the measured data with regard to mainly lifetime and temperature distributions.

5.4.2.6.1 THERMAL VACUUM TEST (STEP 1)

The first part of the TB/TV test covers the test of cryogenic equipment and subsystem, including the stabilisation period (from pre-launch autonomy to cryo cover opening in orbit) in order to verify

- PLM thermal mathematical model correlation
- launch transient temperatures
- internal temperature distribution
- External vent line performances (delta p, nozzle)

5.4.2.6.2 THERMAL BALANCE TEST (STEP 2)

The TB test covers two basic objectives

1. the test of cryogenic units in order to verify:
   - PLM mathematical thermal model correlation
   - internal temperature distribution
   - CVV temperature (influence from SVM and Sun Shield, Sun Shade, Telescope)
2. the test of the warm units to be tested together in flight conditions in order to mainly verify
   - SVM mathematical thermal model correlation
   - SVM global thermal performances
   - Telescope temperature (influence form Sun Shield, Sun Shade)
   - Sun Shade, Sun Shield temperatures
   - performance verification of active and passive thermal control subsystem in flight representative conditions
   - performance verification of the satellite system in flight representative conditions

5.4.2.6.3 THERMAL VACUUM CYCLING TEST

Thermal vacuum cycling is foreseen to complete acceptance of FM electronic equipment. Due to the absence of a system Qualification Model, it will also serve to qualify the complete system in thermal vacuum environment.

This thermal cycling test will allow to accept the FM electrical performances of the following equipment at extreme temperature with hot and cold soaks:

- all electronic units of the PLM including instrument WUs
- all SVM subsystems
  - the data handling subsystem
  - the RF subsystem
  - the power conditioning subsystem
  - the Attitude Control and Monitoring Subsystem
  - the Reaction Control Subsystem

Test Conditions and Sequence:

Hot soak conditions:

- the temperature of equipment to be accepted will be obtained by solar attitude or heater power adjustments

- the criteria for starting of system testing is reached when the unit temperatures are equal to (or near to) hot soak predicted temperature
- unit temperatures have to remain below upper acceptance limit

Cold soak conditions:

- the temperature of equipment to be accepted will be obtained by solar attitude or heater power adjustments
- if necessary some units will be turned off to cool down the whole satellite
- criteria for staring of system testing is reached when main unit temperatures are equal or below cold soak predicted temperature
- unit temperatures have to remain above lower acceptance limit
- during system testing unit temperatures are stabilised by turning on/off internal units and external heat fluxes of solar simulator

Transition phase

- hot soak -> cold soak
- the change will be done by switching off of dissipating units, by solar attitude or solar power adjustments until cold soak criteria are obtained
- cold soak -> hot soak
- the change will be done by switching on of dissipating units, by solar attitude or solar power adjustments until hot soak criteria are obtained

5.4.2.6.4 TB/TV TEST SET-UP

The test set-up is principally shown in the figure below. Objective is to test the satellite in completely integrated configuration, i.e. with Telescope, Sun Shield and Sun Shade, and SVM Thermal Shields.

Before actual test the GSE/CVSE (i.e. He dewar and platform) will be removed from the TV chamber.

The protective covers of telescope, sunshield, OSRs, thrusters, sensors etc. will also be removed before and reinstalled immediately after test to minimise exposure of sensitive surfaces to potential contamination.

The HTT will be filled with He-II completely (≥98%); the auxiliary tank will be empty, after completion of launch autonomy test.

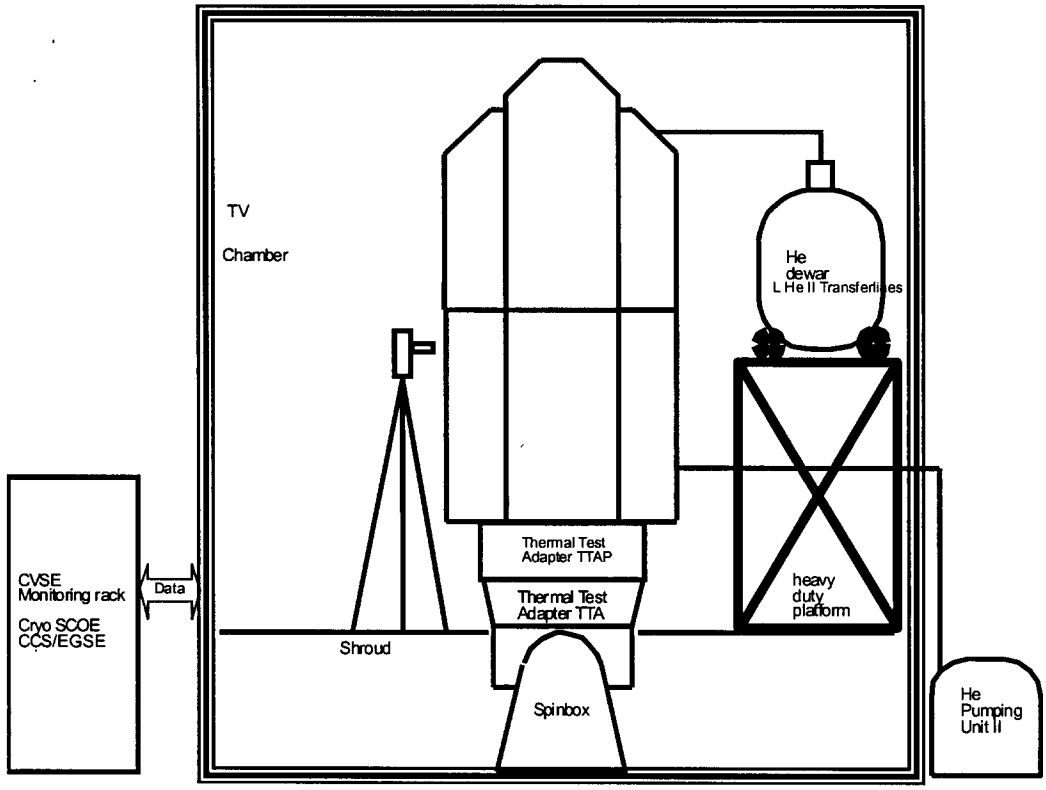


Fig. 5-7: TB/TV test set-up

5.4.2.7 EMC TEST

The EMC test shall demonstrate the ability of the satellite system to operate during any phase without suffering or causing unacceptable performance degradation du to electromagnetic interferences (EMI). This definition includes interferences with its own system (auto-compatibility) as well as interferences with other systems (e.g. launcher – EGSE...).

The satellite will be placed in a clean room with anechoic walls, where the ambient noise is at least 6dB below the test level in all required frequency ranges.

For tested operational configurations, refer to EMC test specification to be established. For instrument related tests refer to RD 10.

It is assumed that all monitoring of the satellite , particularly concerning the instruments, is performed via telemetry and practically in real time.

The constraints of the PLM tilting angle during PACS and SPIRE cooler recycles will be considered during EMC testing

Following measurements will be performed:

a) Conducted Emission

The conducted EMI will be measured through current probes set around critical harness bundles. In certain cases (based on case by case analysis) the measurements my be carried out by using current probes around only one wire or by direct voltage measurements at connector level, provided that the test harness does not affect the measurement.

This test can be considered as complementary verification of corresponding results of SVM and PLM (EQM and PFM) measurements. CE measurements will be confined to those areas not already tested at lower levels (module/subsystem) or for which the test configurations were not fully representative.

b) **Conducted Susceptibility**

The required margin between emission and susceptibility will be verified by sending EMI at calibrated level and defined frequencies from power lines to the PLM equipment. These signals will superpose to the conducted EMI normally generated by the SVM. Current probes or other standard devices will be used to inject the EMI into the harness bundles.

c) **Radiated Emission**

to demonstrate the compliance with the launch vehicle requirements, narrow band E-filed emissions will be measured at LVA plane, using standard calibrated antennas in the required frequency range.

For this test the satellite will be set in pre-launch and launch configuration externally powered or powered by internal batteries.

To determine the compatibility of the overall platform with the scientific instruments, the narrow band E-field emissions will be measured at three different locations around the cryostat with calibrated antennas set at predefined distance toward the PLM.

d) **Radiated Susceptibility**

The satellite shall not exhibit any malfunction or degradation of performance when subject to E-field and H-field with levels and characteristics as defined in AD 04.

This will be verified by emitting radiated EMI toward the satellite and scientific instruments. Radiating antennas will be set at predefined location around the PLM.

5.4.2.8 ACOUSTIC NOISE TEST

Main objectives of this acoustic noise test are

- final demonstration of the satellite structure characteristics and workmanship
- verification of compliance with the relevant analytical model parameters
- verification of the system integrity and alignment stability after acoustic noise

The satellite will be submitted to acceptance level noise spectrum.

The sequence of tests will be as follows:

- low level run (for preliminary adjusting of individual sound pressure levels)
- intermediate level run (tbc), duration as short as possible (for final adjustment of individual sound pressure levels)
- acceptance level run

5.4.2.8.1 TEST SET-UP AND CONDITIONS

The acoustic noise test will be performed with the PLM in cold (He-I) condition.

The HTT will be filled (>95%) with He-I. The HOT will be empty.

The SVM propellant tanks will be filled with simulation fluid (de-ionised water) and pressurised (tbc by SVM contractor).

The satellite will be installed in the chamber on a dedicated acoustic noise test stand. The clamp band interface will be mechanically identical to a flight one.

The CVSE and GSE will be removed from the acoustic noise chamber before the actual tests.

All protective covers will be removed before and reinstalled immediately after test to minimise exposure of sensitive surfaces to potential contamination.

Measurement of sound pressure levels will be done by microphones. Power spectral density response will be given by accelerometers and strain gauges (if necessary).

The figure below shows the principal acoustic noise test set-up.

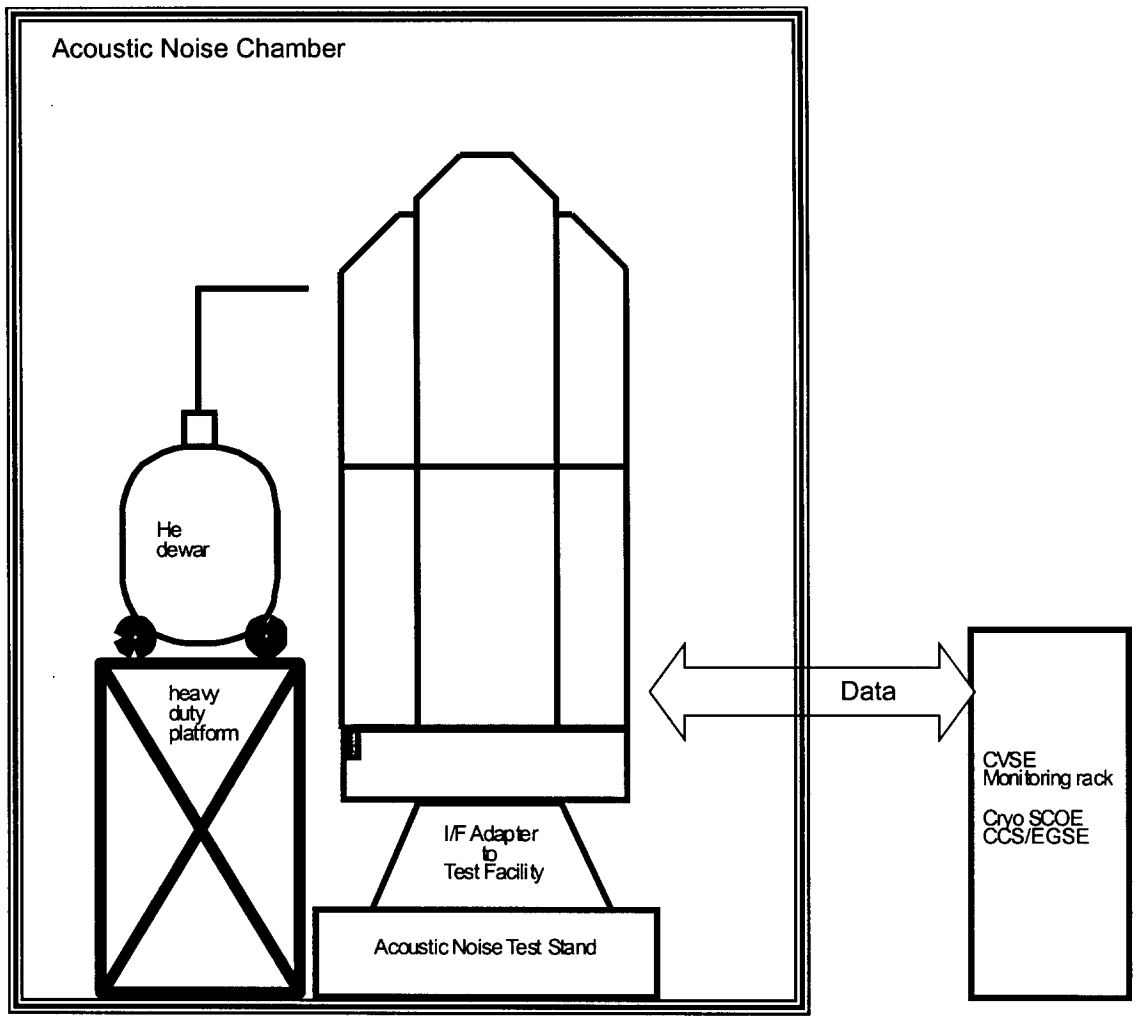


Fig. 5-8: Acoustic noise test set-up

6 ORGANISATION AND MANAGEMENT

6.1 AIT TASKS

Astrium GmbH is in charge of system level AIT which includes the operations on the following models: PFM PLM, satellite STM, Satellite PFM.

The main tasks to be performed under the AIT organisation are the following:

- detailed planning of AIT activities
- definition and sequencing of tests and operations
- preparation of integration and test
- co-ordination and preparation of test facilities
- preparation of test set-up
- organisation of test reviews
- execution of AIT operations
- reporting of AIT operations
- determination and on site management of AIT team and technical support.

In order to fulfil these tasks, the following general rules will need to be respected:

- Prior to the start of any integration or test activity:
  - KIP/MIP or TRR has to be held as agreed in the AIT flow
  - relevant procedures are available, reviewed and approved
  - test configuration is defined, established and verified by Product Assurance
  - necessary GSE, test instrumentation and facility is available and accepted for use
  - safe working conditions for personnel and hardware have been established and verified by safety
  - designated personnel is specially distinguished in the integration and test area

- During any integration and test activity:
  - all activities proceed according to approved procedures only
  - anomalies or discrepancies with the procedure shall be reflected in a non-conformance report immediately raised

- Conclusion of integration or test activity:
  - all activities are successfully completed
  - declaration sheets to verify completion are signed by the responsible engineers
  - appropriate action is taken on all non-conformance reports raised during the activity
  - an integration or test report is issued within an adequate time interval

6.2 AIT ORGANISATION AND PERSONNEL

The AIT team will be recruited of a number of people from different disciplines. The team will be sized according to the manpower required during the various integration and test steps.

An AIT manager will be responsible for the overall co-ordination of the team.

Only trained personnel, familiar with special requirements of class 100,000/100 clean-rooms will work with the various H/W.

The AIT team will be supported as appropriate by optical engineering, mechanical engineering, thermal engineering and various support from manufacturing departments. The necessary engineering support from the different disciplines will be provided according to the AIT program requirements.

For instrument and SVM related tests, adequate engineering and AIT support from respective suppliers is anticipated.

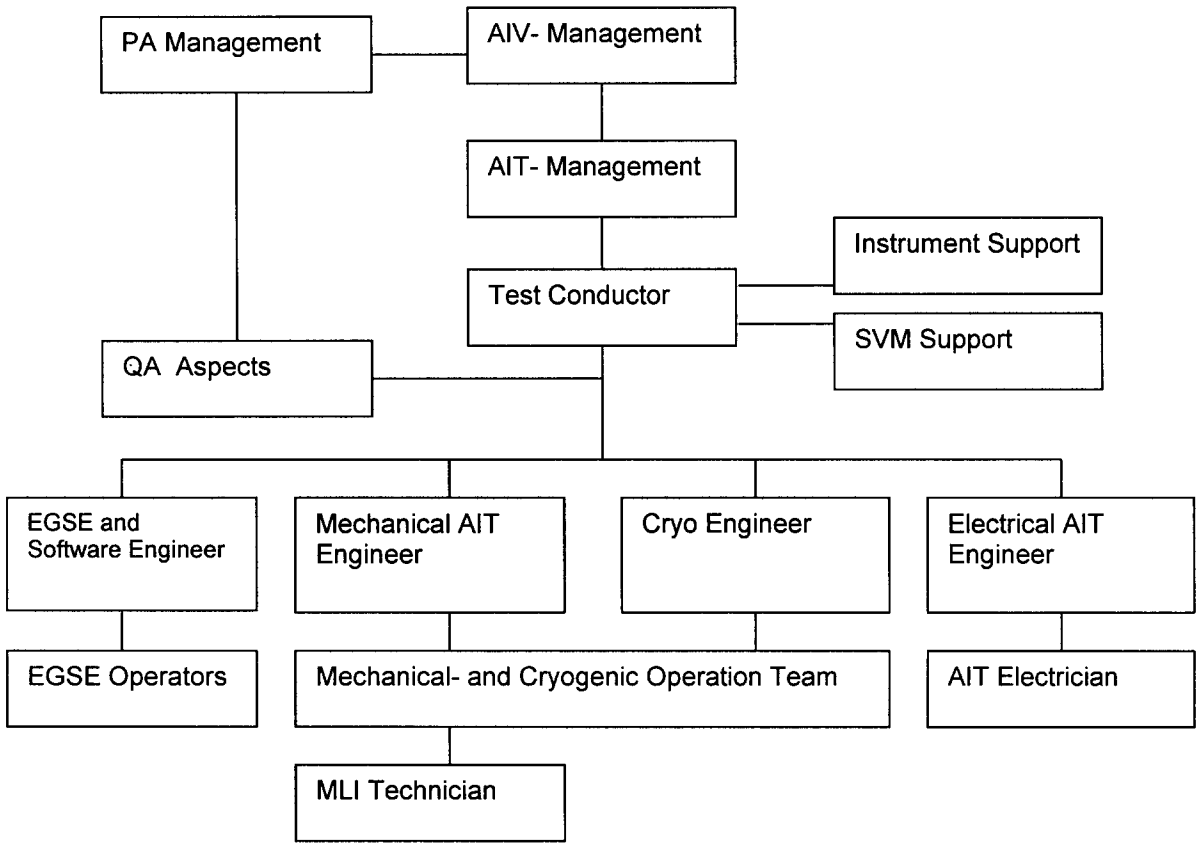


Fig. 6-1: AIT Team Organisation

6.3 AIT MEETINGS AND REVIEWS

In the following a short overview of meetings and reviews including their objectives is provided.

Further reviews, as the Qualification Review and Delivery Review Board (DRB) are no AIT specific reviews, however corresponding inputs will be delivered from AIT.

6.3.1 AIT INTERNAL MEETINGS

Regular internal meetings (daily, weekly,.. as necessary) will accompany the AIT process. The meetings are used to discuss the status of AIT, further AIT activities with the corresponding members of the engineering team and PA.

6.3.2 TEST READINESS REVIEW (TRR)

A test readiness review is associated with major operations and test (e.g. PLM tests, satellite environmental tests). The TRR will be called by Astrium and chaired by the respective test conductor. The customer and ESA will be invited.

The objective of a TRR is to determine if the test or test sequence under review may start. To achieve this, the following must be declared/ certified:

- that the hardware status is known, compliant and properly documented (CIDL/ABCL)
- that it is in a fit state to be tested (open works and NCR's closed or not affecting the tests)
- that the test facilities to be used are available and validated
- that all appropriate test objectives and the associated test procedures are agreed and approved
- the supporting documentation is available
- that all supporting equipment (hardware and software) is available and validated
- that the team exists and is sufficiently briefed, also in term of responsibility
- that the test schedule is available and agreed
- that all safety aspects have been properly addressed

The TRR shall ensure a successful performance of the envisaged test. Test readiness reviews are announced at a suitable period prior to begin of corresponding tests.

6.3.3 POST TEST REVIEW (PTR)

This review is to confirm that the corresponding test was carried out according to the applicable test procedure, to review the result and to release the hardware configuration for the next step or to decide on the course of action where non-conformances occurred.

6.3.4 NON CONFORMANCE REVIEW BOARD (NRB)

A review board will be established if non-conformances within integration or test program are encountered. This board has to decide upon corrective actions to be taken and therefore defines how to proceed in the program. The rules to be followed are described in the PA Plan, AD 06.

6.3.5 KIP/MIP

Key Inspection Points and Mandatory Inspection Points (KIP/MIP) will be implemented in the integration and test flow to be performed in accordance with the PA plan (AD 06). The following KIP's and MIP's are planned:

Key Inspection Points:

- KIP F1: after WU mechanical and electrical integration on SVM panels before test with FPU simulators
- KIP F2: after External Cryo Harness integration and before first FPUs functional checks

- KIP F3: after LOU alignment and before closing of cryostat
- KIP F4: after Cryostat bake out and before PLM external completion and alignment
- KIP F5: after mating of PLM with SVM and before Telescope and SSH/SSD integration
- KIP F6: after sunshield and sunshade integration

Mandatory Inspection Points:

- MIP F1: after PLM refurbishment and before FPU integration and alignment
- MIP F2: after PLM evacuation and leak check and before transport to CR 100,000
- MIP F3: after completion of PLM tests and demating of SVM support structure and before mating of PLM with PFM SVM
- MIP F4: after completion of PFM satellite integration and alignment and before IST at He-II
- MIP F5: After first IST and conversion to He-I and before transportation of Satellite to Test Facility
- MIP F6: After completion of satellite acceptance sequence and before delivery to Prime at ESTEC

6.4 AIT DOCUMENTATION

The integration and test documentation comprises different types of documents:

- documents used for definition of AIT activities:
  AIT plans and other applicable documents called therein
- documents used for performing the AIT activities defined above:
  integration and test procedures
- documents used for reporting AIT activities:
  integration and test reports
- documents for controlling the AIT:
  log books and AIT forms like ACR

The logical relationship of this documentation with the overall design and verification is shown in the following figure.

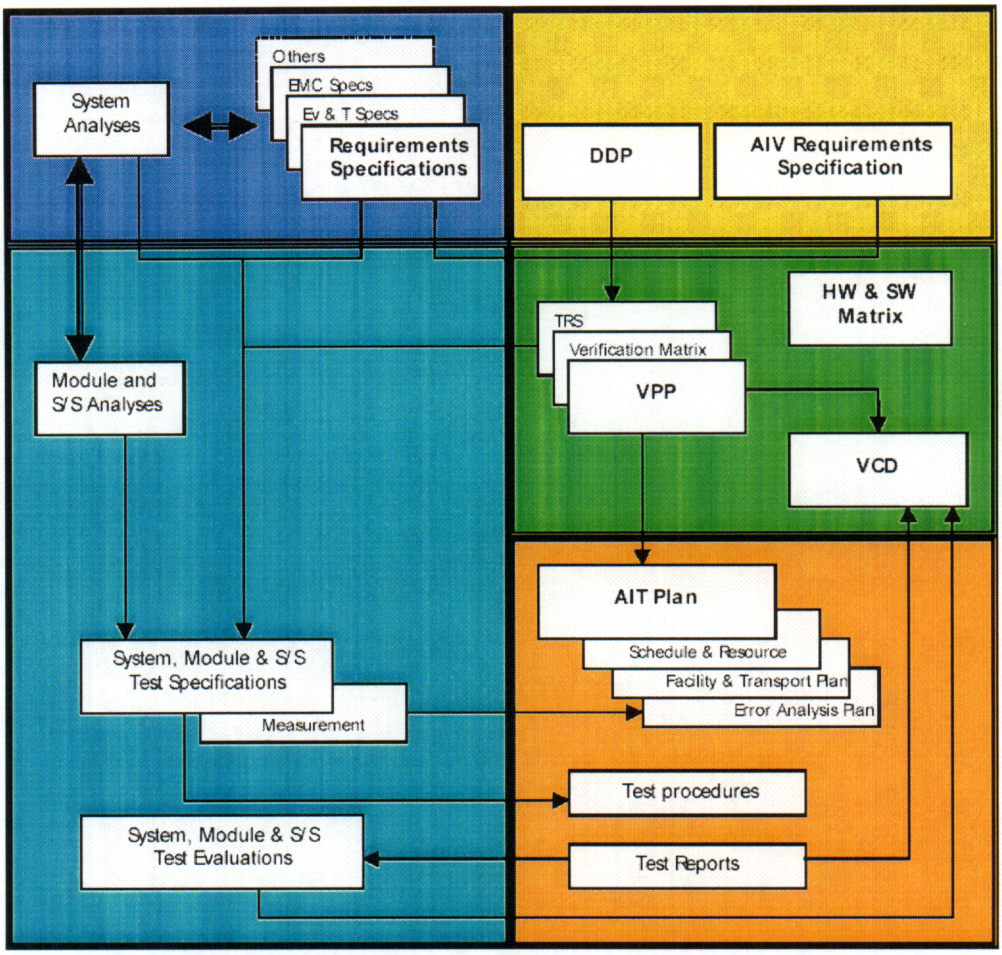


Fig. 6-2: Verification logic and links

6.4.1 INTEGRATION AND TEST PROCEDURES

Integration and Test Procedures will be written for all major AIT activities. This documentation will provide detailed step-by-step instructions to the dedicated teams conducting these activities.

Each procedure corresponds to a dedicated phase (CVV integration, vibration test , SFT etc) defined between two milestones, so running an Integration or Test procedure will typically have a duration of several days to several weeks.

The procedures take into account the mechanical and electrical setting of the satellite, define how integration steps and tests hang together in sequence, describe the elementary operations and tests which have to be carried out to complete the described integration or test phase. The sequencing shall be followed up when logical criteria lay down their order, nevertheless the AIT manager can modify the sequence in certain cases when circumstances require according to availability of material, personnel or facilities. So the actual planning of AIT activities is done on a daily/weekly basis by the AIT manager by reference to the different procedure paragraphs.

The integration and test procedures can integrate in their step by step operation section all operations to be performed from beginning to end of the related phase, but they can also call up specific test procedures for precisely defined operations and tests. These specific procedures are usually issued at each time that a test or operation can be run identically in different contexts, or when it is more convenient to isolate a coherent

activity that my require specific support equipment or a specialised team. For automatic test sequences test procedures will be written in a specific test language.

Integration and test procedures shall contain the following information:

- General view:
  - Describing the activity objective, item to be integrated or tested, references, methods and success criteria
  - List of applicable and reference documents
  - Facilities description, listing of GSE items, tooling required, personnel functions and other equipment
- Instructions:
  - Provision of general set-up instructions including cleanliness and safety, environmental conditions, hazards and precautions
  - Step-by-step operation sequences, including an operational flow diagram where required

    In this section all measurements will be recorded against the required schedule, including check out sequences to be executed in case of test configurations (description of activity set-up) and pass/fail criteria
- Necessary documentation and data sheets:
  - Identification of test result data to be delivered by the corresponding GSE
  - Data sheets to be prepared by the operator
  - declaration sheet to verify completion is signed by the responsible engineers.

6.4.2 INTEGRATION AND TEST REPORTS

Integration reports shall be established during the actual integration process. They shall consist of the filled-out working copies of the respective integration procedure.

For each test, a test report containing the actually performed operations and the detailed test results shall be generated.

Parts of the test report start as soon as the test itself is running. As the test proceeds the information, documents, lists, data sheets, records etc. are incorporated in the corresponding sections up to the test completion. Finalising the test report require to analyse the results with respect to success criteria and to draw the test conclusion.

The major sections of the test report are as follows:

- Scope and the test report digest (one page for major test data including summary)
- Relevant pages of the filled-in/ as-run procedure including performed operations, test period
- Detailed test results and analysis where applicable
- Pass / fail information for success criteria
- Configuration status w.r.t. specimen configuration during operation, GSE configuration, test set-up
- NCR status including a list of non-conformances issued during operations
- Time record, which lists the actual operation sequence. Raw data sheets if applicable like log sheets, minutes, data recording
- Procedure Variation Sheet

6.4.3 LOG BOOKS AND AIT FORMS

Log documentation:

A logbook will be established at the beginning of AIT activities and will be maintained up to date until delivery. It will contain log sheets that will be used to document all planned and unplanned events, supporting documentation will be added as necessary. In addition, a configuration list will be kept current to reflect the as-built status (ABCL) at any point of time.

The logbook will provide a complete traceability for all items being integrated or under test.

AIT change request (ACR)

The ACR is the only authorised way to improve or modify an integration/test procedure when competent authority has already approved this one and there is not enough time to prepare a new issue. All changes will be justified and agreed prior to the event. ACRs will be approved at the same authority level in the organisation as it is the case for the integration/test procedure.

The ACR has to identify following issues:

- adding a new task
  The corresponding test sequence (step-by-step section) shall be included into the ACR file with clear definition sequencing
- suppressing a planned task
  The ACR shall clearly identify the test sequence of the current procedure to be cancelled.
- modifying a task already clearly defined

The ACR shall include the new issue of the test sequence to be updated.

The ACR can be the consequence of:

- change in test plan
- calculation, prediction analysis, thermal or mechanical models processing etc.
- analysis of preliminary result (coming form another test or processed during the test itself)
- unavailability of unit, test equipment, facility etc.
- unexpected limitation in capability of test equipment or test facilities
- non conformance and failure.

The ACR modifies an integration/test procedure and after agreement it becomes a part of this one, so the ACR does not justify to issue a specific test report, but it will be automatically included in the test report of the corresponding procedure.

Non-conformance reporting and control will be performed on any article or material which fails to meet the requirements of the contract as interpreted through drawings, technical specifications and integration/test procedures.

6.5 PRODUCT ASSURANCE AND SAFETY

6.5.1 PRODUCT ASSURANCE

The product assurance requirements and responsibilities to be accomplished in order to build and ascertain an adequate quality level during all AIT operations performed on Herschel hardware are defined in AD 06.

6.5.2 QUALITY ASSURANCE GENERAL ACTIVITIES

In accordance with AD 06 a QA engineer shall be in charge or AIT activities supervision from quality control point of view. His responsibilities include

- consideration of PA requirements in AIT documentation
- approval of integration and test procedures and test reports
- control of cleanliness and environmental conditions within AIT facilities
- inspection of qualification and flight hardware before integration
- verification of GSE status and test set-up
- verification of calibration validity of measurement equipment
- supervision of assembly and integration processes
- control of electrical mating and demating steps during the integration process
- visual inspections and reporting during all AIT activities including test phases and transportation including MIPs and KIPs
- control and management of module and system configuration and as-built status through the AIT sequence
- issuing of module and system logbooks
- participation in test meetings and reviews as defined in chapter 6.3
- approval of changes to the existing procedures
- initiation and processing of non-conformance reports
- organisation of Non-conformance Review Boards (NRB)

6.5.3 INSPECTION PROCEDURES AND REPORTS

Visual inspections are necessary to verify the satellite hardware status e.g. before and after each main integration and test phase. These inspections are to be considered as part of the general verification plan and shall be performed all along the AIT sequence. In order to systematically accomplish this tasks inspections shall be performed based on written procedures. These can be self-standing documents or integral parts of the integration and test procedures.

Each detailed inspection shall be reported in a specific inspection report. This report can be issued separately or incorporated in the corresponding integration or test report.

6.5.4 SAFETY

Safety requirements as defined in chapters 5 and 10 of AD 06 shall be followed as general rule.

The implementation of safety rules is made through dedicated emergency procedures (to be issued). These procedures shall define the emergency cases and the corresponding instructions to protect the satellite and the personnel at any time.

The implemented safety systems are mainly related to the following hazards:

- cryogenic temperatures, pressure and temperature within
  - He-II Main Tank (HTT)
  - He-I Auxiliary Tank (HOT)
  - CVV

  The HTT and HOT are protected with a staged safety system enabling to release pressure at different thresholds. The CVV is equipped with safety valves.
- toxicity of propellants, pressure in RCS

7 CLEANLINESS AND CONTAMINATION CONTROL

The detailed requirements on cleanliness and contamination control for Herschel EPLM and satellite AIT are comprised in the Contamination Control Plan , AD 05.

This chapter outlines only the major relevant requirements to be respected during Herschel AIT.

7.1 CLEANLINESS REQUIREMENTS

Cleaning and Cleanliness inspection for any Hardware entering the clean room class 100 is mandatory following approved procedures.

7.2 CLEANLINESS MONITORING ACTIVITIES

The following paragraphs list some of the cleanliness control measurements which are suitable and which shall be implemented in an appropriate manner.

- Standard-Cleanliness Monitoring

  Particulate and molecular cleanliness monitoring shall be performed during all phases of AIT, starting from the point of arrival of the hardware at the AIT site until launch.

- Witness Samples

  Witness samples have to accompany cleanliness sensitive surfaces and components. Samples have to be located close to critical surfaces or surfaces which are representative with respect to overall contamination.

  The witness samples have to be exchanged periodically in certain time intervals according to the contamination control plan. The samples will be tested by special laboratories with regard to particle fall-out and molecular contamination.

7.3 SPECIAL PROTECTIONS TO PREVENT CONTAMINATION

If special protections are necessary to prevent or limit contamination on sensitive optical surfaces and other equipment the associated requirements shall be respected and implemented for the detailed planning of AIT procedures with high priority.

Sensitive items include:

- Solar Array surface on Sunshield
- Optical Surface Reflectors on SVM and Sunshade
- RCS Thrusters and fill/drain ports
- ACMS sensors
- FPUs
- Optical Windows
- Telescope Reflector
- all inner surfaces of the Cryostat and the Helium Subsystem

8 FACILITIES AND TRANSPORTATION

8.1 INTEGRATION FACILITIES

The main integration facilities at Astrium GmbH sites used within the Herschel PLM and Satellite AIT program are:

- Clean room class 100 used for
  - PLM refurbishment after completion of STM test campaign
  - mechanical and electrical integration and alignment of the PLM up to closure and evacuation of the CVV
  - first functional tests of FPUs with WUs mounted on SVM support structure
- Clean room class 100,000 used for
  - incoming inspection of components
  - pre-integration of Hardware incl. functional testing
  - provision and cleanliness inspection of all PLM and SVM H/W before entering the class 100 area
  - final integration of EPLM and satellite
  - He-I filling and He-II production
  - functional testing on EPLM and satellite before transportation to test facility

These integration facilities are standard for AIT of optical space payloads and satellites.

The main dimensions and capabilities for the integration facility at Astrium GmbH in OTN are as follows:

- **Clean Room Class 100,000** (according to US-Fed. Std. 209)
  - length 14 m
  - width 20 m
  - height 12 m
  - door width 6 m/height 7.2 m
  - max. crane load 4000 kg
  - max. hook height 9.4 m
  - max. floor load 1000 kg/m^2
  - clean air supply turbulent vertical airstream with about 10% fresh air ; particle and active carbon filters

- **Clean Room Class 100** (according to US-Fed. Std. 209)
  - length 10 m
  - width 8 m
  - height 7 m
  - max. crane load 4000 kg
  - max. hook height 6 m
  - max. floor load ca. 10000 kg/m^2 (within the concrete foundation)

- air supply — from CR100.000 with additional particle filters, horizontal adjustable laminar air flow (~0.45m/s)

- **Checkout Room** (lab conditions)
  - min. useable area 25 m^2

The cable length between the checkout-room and PLM Electronics in the class 100,000 is $\leq$ 30 m.

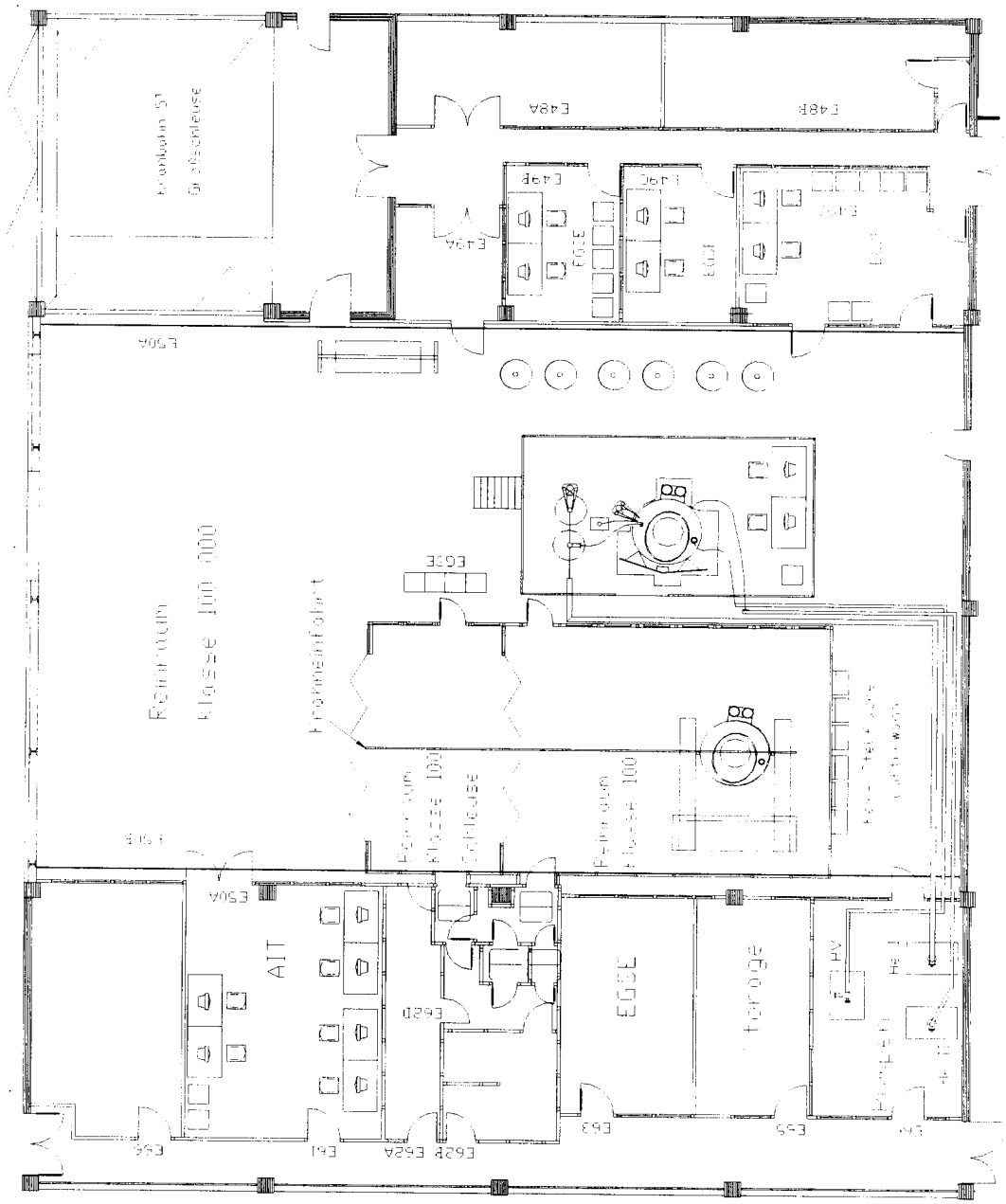


Fig. 8-1: Integration facility at Astrium OTN

The main dimensions and capabilities for the integration facility at Astrium GmbH in FN are as follows:

Facility FN	Data	Remarks
Cleanroom Class 100	17.5 x 10 x 12 m (LxWxH)	
Cleanroom Class 100,000	36.5x17.5x12 m (LxWxH)	
Crane capacity	Two cranes : 50 000 N 100,000 N	Enables the handling with two cranes
Crane height (under hook)	10 m	In class 100 and In class 100,000
Seismic mass	5 000 kg Size 2.6 x 3.6 m	For optical alignment
Illumination	Additional halogen floodlight	Prevents electro magnetic disturbances and ionisation of dust particles
Air supply	particle and active carbon filters	

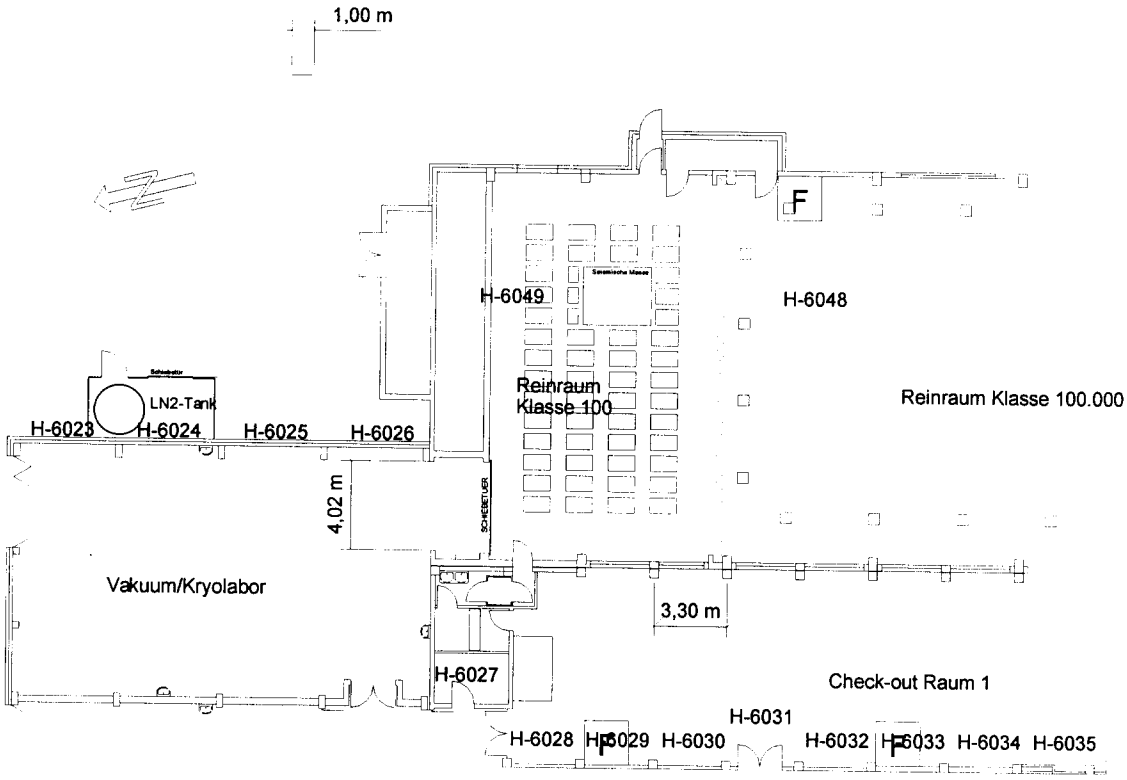


Fig. 8-2: Integration facility at Astrium FN

8.2 TEST FACILITIES

In addition to the integration facilities the following test facilities at ESTEC are chosen as baseline. Potential back-up facilities are also listed.

• Shaker for PFM Satellite Acceptance Level Sine Vibration Tests	ESTEC HYDRA Shaker or IABG Multishaker System
• Acoustic Noise Chamber for PFM Satellite Acceptance Level Test	ESTEC or IABG
• Anechoic Chamber for PFM Satellite EMC tests	ESTEC or IABG
• Thermal Vacuum Chamber for PFM Satellite TB/TV test	ESTEC or IABG
• Weighing Machine for Mass Determination	ESTEC or IABG

8.3 TRANSPORTATION

The following major transport and movement activities are foreseen in the PFM PLM and Satellite AIT sequence prior to shipment of the qualified and accepted satellite to the launch site.

- The PFM SVM will be transported from ALENIA to the ASTRIUM Satellite AIT facility for mating with the PLM
- After PFM PLM and SVM mating and subsequent functional tests the satellite will be transported from the ASTRIUM AIT facility to the Environmental Test Site for completion of qualification and acceptance environmental testing
- Within the Environmental Test Site the satellite will be moved between different environmental test facilities and the corresponding preparation areas.

All Transportation and movement will be under AIT and QA supervision.

9 GROUND SUPPORT EQUIPMENT (GSE)

The purpose of GSE is to support the Herschel PLM and Satellite AIT activities as non flight equipment's. The GSE ensures that the function of

- integration and handling
- transportation
- optical alignment
- testing and verification

of the Hardware and Software in their intended environment are fully supported and carried out easily and safely (refer also to chapter 13 of the PA Plan AD 06).

All measurement equipment foreseen to be used for qualification, acceptance or performance verification tests will be subject to agreed calibration process. It will be ensured that these items are within the normal calibration periods at the time of tests.

Utilisation of GSE elements during the various integration and test steps are described in the detailed activity sheets in annex 1.

9.1 MECHANICAL GROUND SUPPORT EQUIPMENT (MGSE)

The following MGSE will be used during the various phases of PLM and satellite AIT:

MGSE reused from ISO		
Item	**No.**	**Reference**
ISO PLM Integration dolly	1	ISO-VV-ZYYR-SP-0043
ISO Hoisting equipment SN02	1	ISO-VV-ZYYY-SP-0048
ISO Test dolly SN02	1	ISO-VV-ZYYX-SP-0473
ISO Transport container	1	
ISO Transport Monitoring Unit (TMU)	1	
ISO Test dolly (enlarged) SN03	1	-
Heavy duty working platform	1	-
Load cells with strap pretension gauge	16	-

Tab. 9-1: MGSE Equipment reused from ISO

HERSCHEL PLM and Spacecraft MGSE		
Item	**No.**	**Reference**
Transport Container H-TSC	1	
Vertical Lifting Device VLD	1	
Horizontal Lifting Device (beams) HLDB	1	
Vertical Lifting Device for HSS VLDS	1	
Hoisting Device for Optical Bench HDOB	1	
General Purpose hoisting Device GPHD	1	
Hoisting sling set HSL	tbd	
Support Trolley for Rotary Table STR	1	
Mobile Access Platform MAP	1	
Handling and Transport Adapter for PLM I/F ADA	1	
Handling and Transport Adapter for EQM I/F ADB	1	
Vibration Adapter for PLM I/F VAP	1	
Vibration Adapter for S/C I/F VAS	1	
Thermal test Adapter for PLM I/F TTAP	1	
Thermal test Adapter for S/C I/F TTAS	1	
Alignment Adapter PLM I/F for Rotary Table AAP	1	
Alignment Adapter EQM I/F for Rotary Table AAQ	1	
Alignment Adapter S/C I/F for Rotary Table AAS	1	
Movable Cabinets/Handcarts for: • MGSE items • Flight H/W items • Break Out Boxes and adapter cables • MLI parts • Vacuum circuit items	tbd	
Mass Dummy for MGSE purpose	tbd	
Rotary Table RT	1	

Tab. 9-2: HERSCHEL PLM and S/C MGSE items

HERSCHEL SVM MGSE		
Item	**No.**	**Reference**
Equipment Panel Trolley EPT	1	
Panel Tilting Trolley PTT	1	
Equipment Panel Lifting Device ELD	1	
SVM Stiffener Set SSS	1	
Multi Purpose Trolley MPT	1	
Vertical Integration Stand VIS	1	
SVM Lifting Device SLD	1	
Transport and Handling Adapter THA	1	
Handling Clamp Band CB	1	
Test Clamp Band TCB	1	
RCS Loading Equipment PPLE	1	
Ground Half Coupling GHC	1	
Simulate Loading Equipment	1	
Leak Test Equipment	1	
Pump purge Equipment PPE	1	
ACMS Sensor protective covers	tbd	
Thruster protective covers	tbd	
OSR protective covers	tbd	
SVM Container TSCS	1	
Equipment Drive Unit EDU	1	

Tab. 9-3: HERSCHEL SVM MGSE items

HERSCHEL EPLM Subsystem and Equipment MGSE		
Item	**No.**	**Reference**
SSH/SSD Container	**1**	
SSD Protective Devices		
HERSCHEL Telescope Container	1	
HERSCHEL Telescope Protective Cover	1	
Optical Bench Transport Container	1	
Instruments Transport Container (HIFI, PACS and SPIRE)		

Tab. 9-4: HERSCHEL EPLM Subsystem and Equipment MGSE

MGSE Items from XMM project		
Item	**No.**	**Reference**
Multi Purpose Trolley MPT (already at APCO for refurbishment)	1	
Levelling Jacks for MPT (already at APCO for refurbishment)	1	
Equipment Drive Unit EDU (already at APCO for refurbishment)	1	
I/F support to LEAF ISL	1	
Mech. Test Adapter for acoustic noise test MTA-B	1	
Pump Purge Equipment for ISL pressurisation PPE-C	1	
Vertical Support Stand VSS	1	
Handling and Transport Adapter HTA.D (must be shipped to APCO for MPT test)	1	
Clamping Band CB-A (must be shipped to APCO for MPT test)	1	
Clamping Band CB-B (for test)	1	
Scaffolding AP-D	1	
Thermal Test Adapter TTA	1	
Horizontal Lifting Device HLD	1	
Weight plates for HLD		
Mass Property Adapter MPA-B	1	

Tab. 9-5: MGSE Items reused from XMM (provided by ESTEC)

9.2 ELECTRICAL GROUND SUPPORT EQUIPMENT (EGSE)

The following EPLM (Tab. 9-6) and Satellite (Tab. 9-7) specific electrical ground support equipment is required for the PFM EPLM and PFM satellite integration and test sequence.

A schematic of the PFM PLM and PFM Satellite EGSE is shown in Fig. 9-1 and Fig. 9-2.

Equipment		No.	Reference
HIFI Instrument EGSE	from EQM	1	PTI No. 111520
SPIRE Instrument EGSE	from EQM	1	PTI No. 1125...
PACS Instrument EGSE	from EQM	1	PTI No. 1135...
Central Checkout System (CCS) light	from EQM	1	PTI No. 142210 (EPLM)
Cryo SCOE	new	1	PTI No. 142220 (EPLM)
CDMU Front End	from EQM	1	PTI No. 142230 (EPLM)
PLM SCOE	from EQM	1	PTI No. 142240 (EPLM)
Test cabling	from EQM (?)	1	PTI No. 142250 (EPLM)
Brake out Boxes (BOB) and savers set	from EQM (?)	1	

Tab. 9-6: EPLM PFM EGSE Items

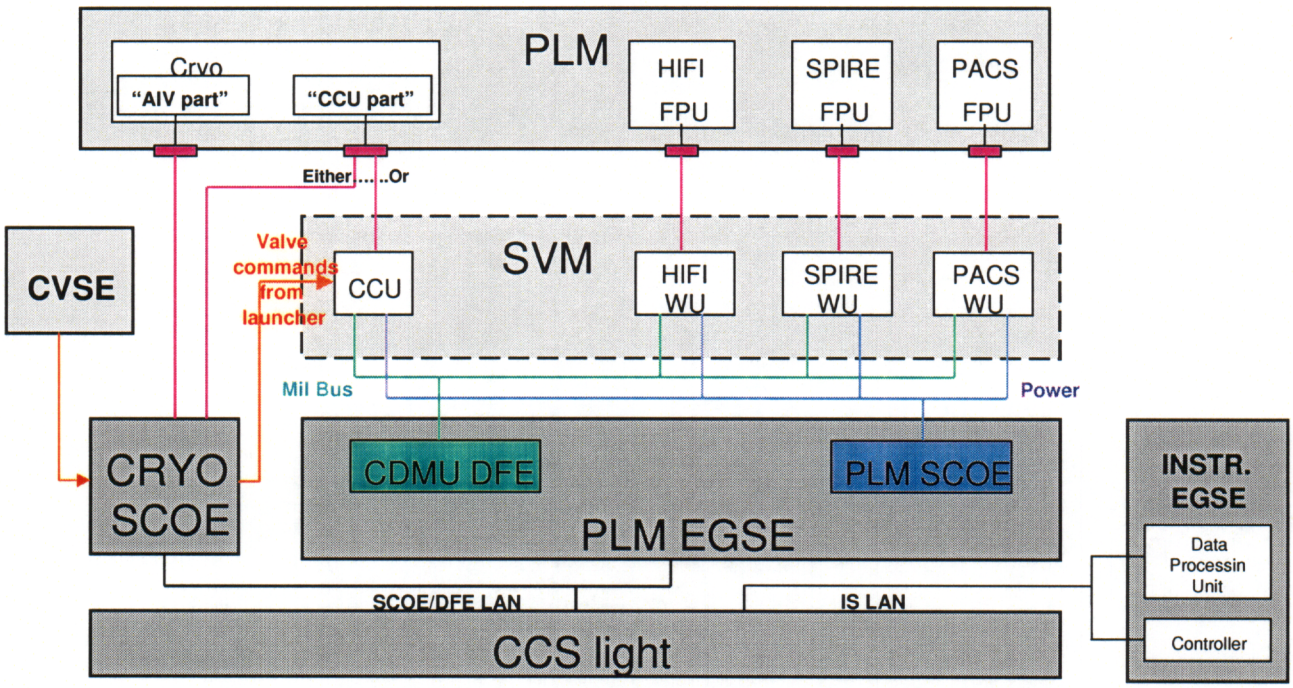


Fig. 9-1: PFM PLM EGSE Configuration

Equipment		No.	Reference
HIFI Instrument EGSE	from PLM PFM	1	PTI No. 111520
SPIRE Instrument EGSE	from PLM PFM	1	PTI No. 1125...
PACS Instrument EGSE	from PLM PFM	1	PTI No. 1135...
Cryo SCOE	from PLM PFM or EQM	1	PTI No. 142220 (EPLM)
Central Checkout System (CCS)	from Alenia	1	PTI No. 141210
CDMU SCOE	from Alenia	1	PTI No. 141220
Power SCOE	from Alenia	1	PTI No. 141230
ACMS SCOE	from Alenia	1	PTI No. 141240
TT&C SCOE	from Alenia	1	PTI No. 141250
TM/TC FEE	from Alenia	1	PTI No. 141260
Cables (set)	from Alenia	1	ASPI PTI No. 3A218
BOB and savers (set)	from Alenia	1	ASPI PTI No. 3A219

Tab. 9-7: PFM Satellite EGSE Items

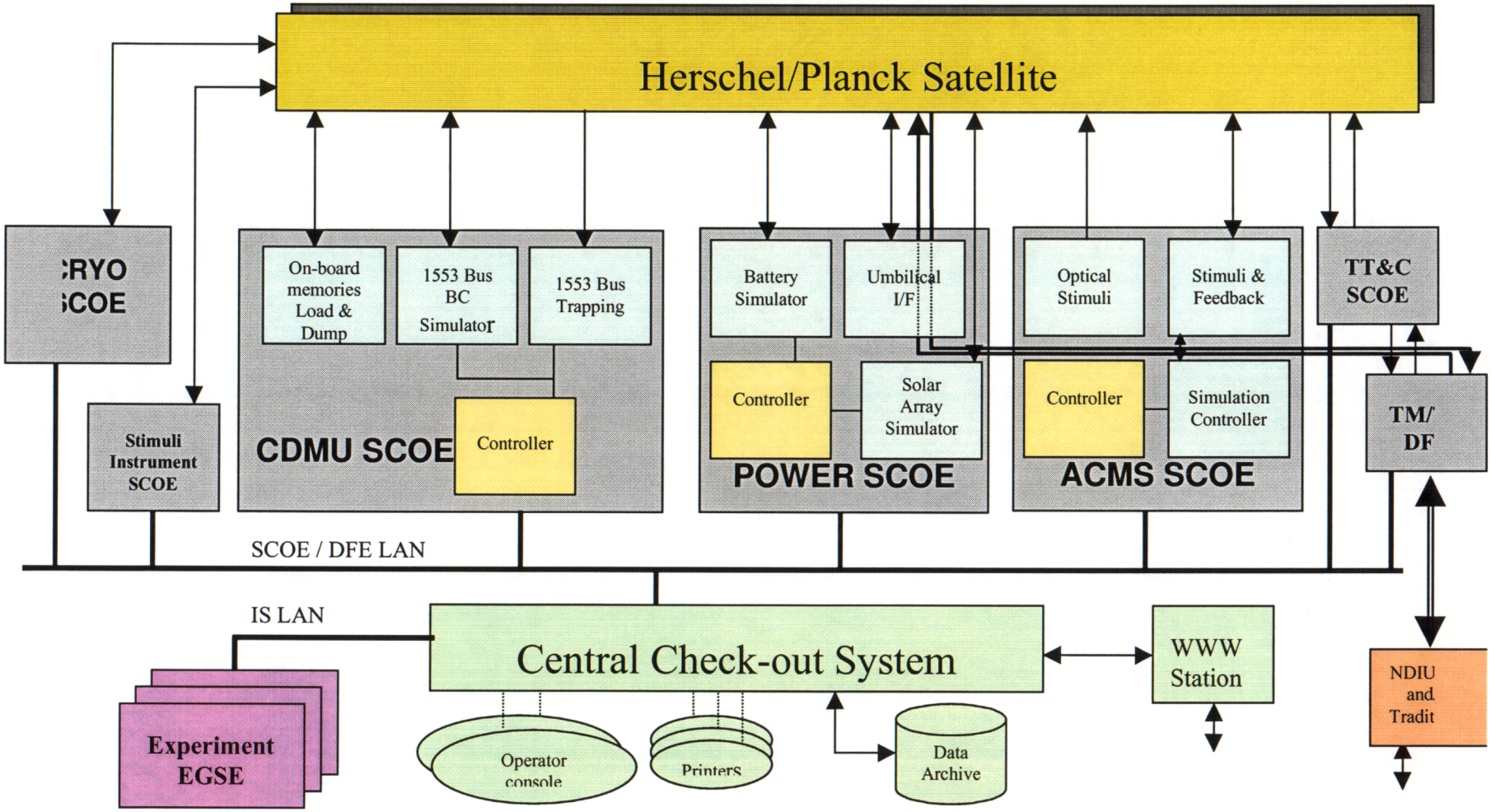


Fig. 9-2: PFM Spacecraft EGSE Configuration

9.3 CRYO VACUUM SERVICE EQUIPMENT (CVSE)

The CVSE equipment and components were developed and used for the Infrared Space Observatory (ISO). After refurbishment the CVSE components will include all cryogenic equipment which are necessary to support all Herschel Integration and test activities.

The CVSE is defined as mechanical non-flight equipment to support all vacuum and cryogenic ground activities for both, the Herschel EPLM and Satellite.

The CVSE shall ensure that the function of the Herschel Cryo/vacuum system in its intended environment is fully supported and carried out easily and safely. The CVSE must be able to cover the Herschel EPLM-He S/S requirements starting with the EPLM integration and ending with the launch campaign of the Herschel flight model.

A list of CVSE equipment and installations is given in the following Tab. 9-8.

The CVSE will allow the following basic operations with the Herschel EPLM and Satellite :

- Leak check of cryogenic system
- Evacuation and leak check of the cryostat isolation system
- Cool-down of the auxiliary He-I tank (HOT) and the He-II tank (HTT) from ambient to LHe temperatures
- Filling of the HOT and HTT with He-I in vertical position
- Production and top up of He-II in HTT
- conversion to He-I
- Warm up of the HTT and HOT from He-I temperatures to ambient temperature
- Cooling of the cryostat test cover by flushing to LHe at T = 80 K (TBC)
- Bake-out of the cryostat by flushing of the He subsystem with gaseous, warm (350 K) nitrogen

Equipment	No.	Reference
LHe service vacuum pump unit I	1	
LHe service vacuum pump unit II	1	
LHe transfer lines (He-I service)	2	
LHe transfer lines (He-II service)	1	
LHe flushing lines for cover cooling (TBC)	1	
High vacuum pumping unit	1	
Turbo pump	2	
General purpose vacuum pumps		
GHe and vacuum piping in order to connect the Herschel EQM with the pumping units		
CVSE equipment rack	1	
Helium supply dewars 450 l	8	
Nitrogen supply dewars	2	
He leak detector	1	

Equipment	No.	Reference
Cryogenic test adapter (tbc)	1	
Pirani/Penning gauge, Manometer.	1	
Safety unit	1	
Scaffolding	1	
Flow meter units	1	
Bake out unit	1	
Standard vacuum parts	1 set	
GN_2 quality 5.6		
GHe quality 5.0		

Tab. 9-8: CVSE Equipment List

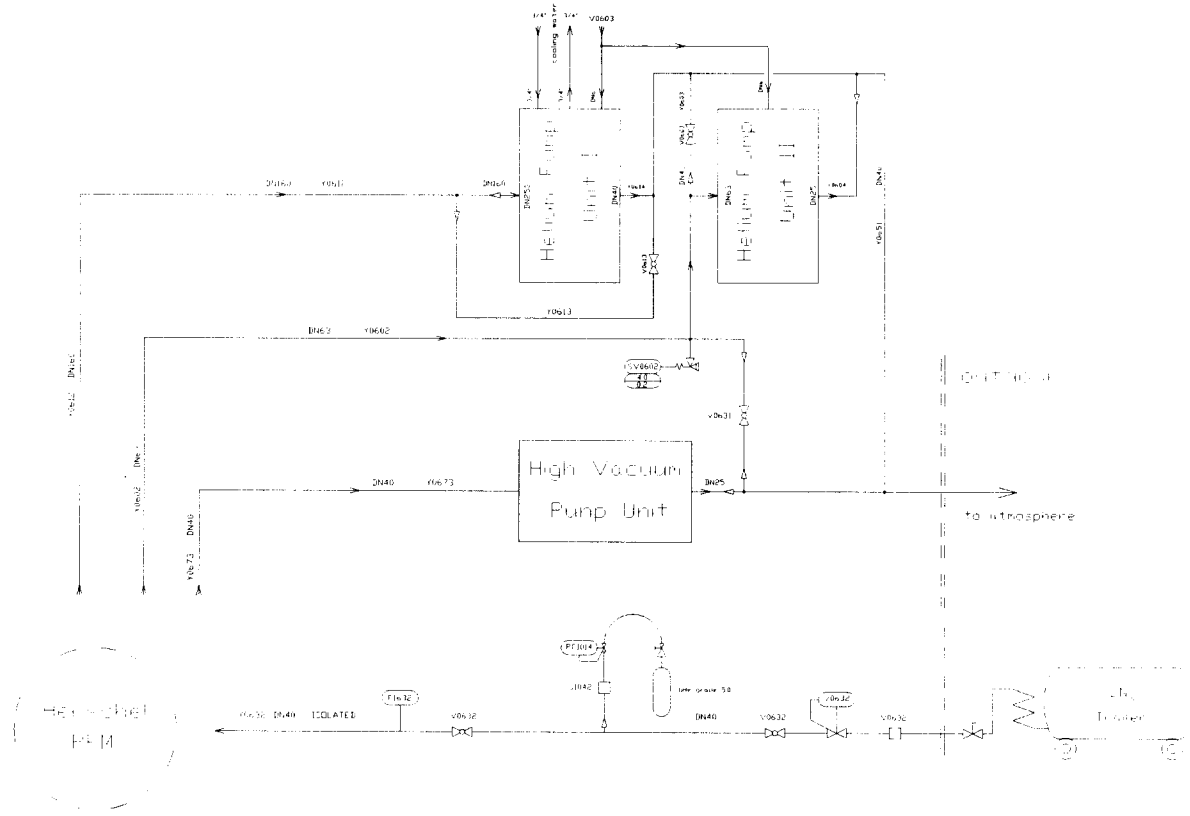


Fig. 9-3: CVSE Flow Schematic

The test set-up for helium filling and He production activities is shown in Fig. 5-1 of chapter 5.1.9.1. CVSE set-up for instrument tests is shown in the figure below.

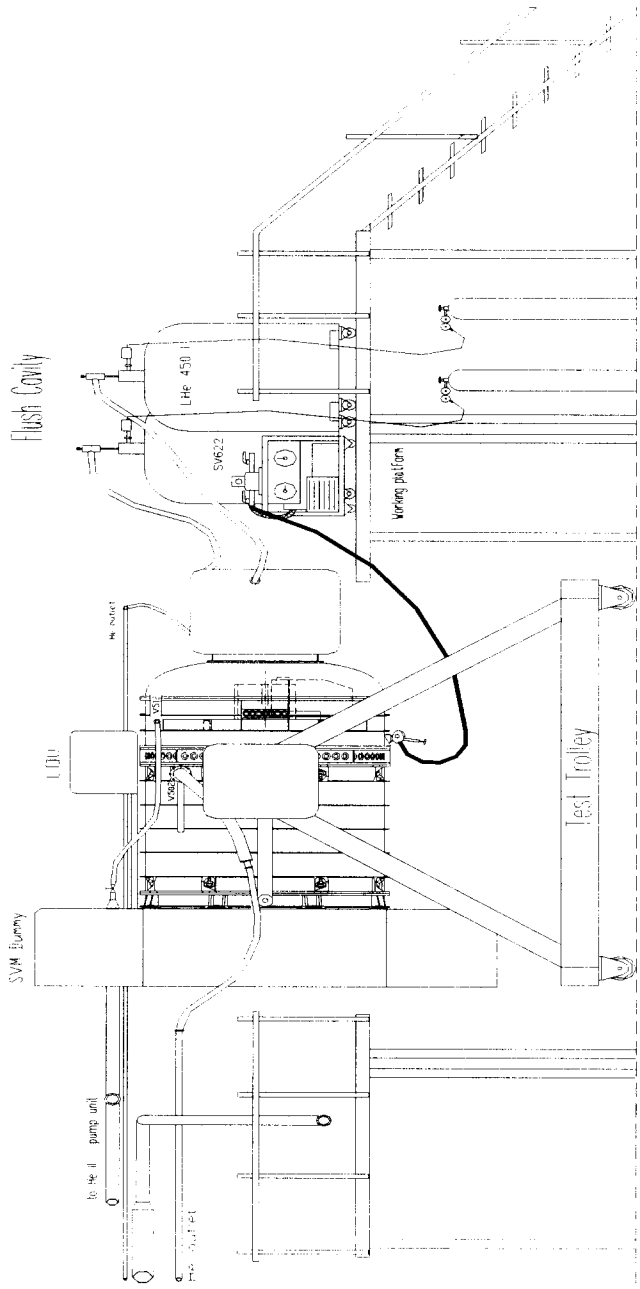


Fig. 9-4: Test Set-up for Instrument and Integrated Module Tests (IMT)

9.4 OPTICAL GROUND SUPPORT EQUIPMENT (OGSE)

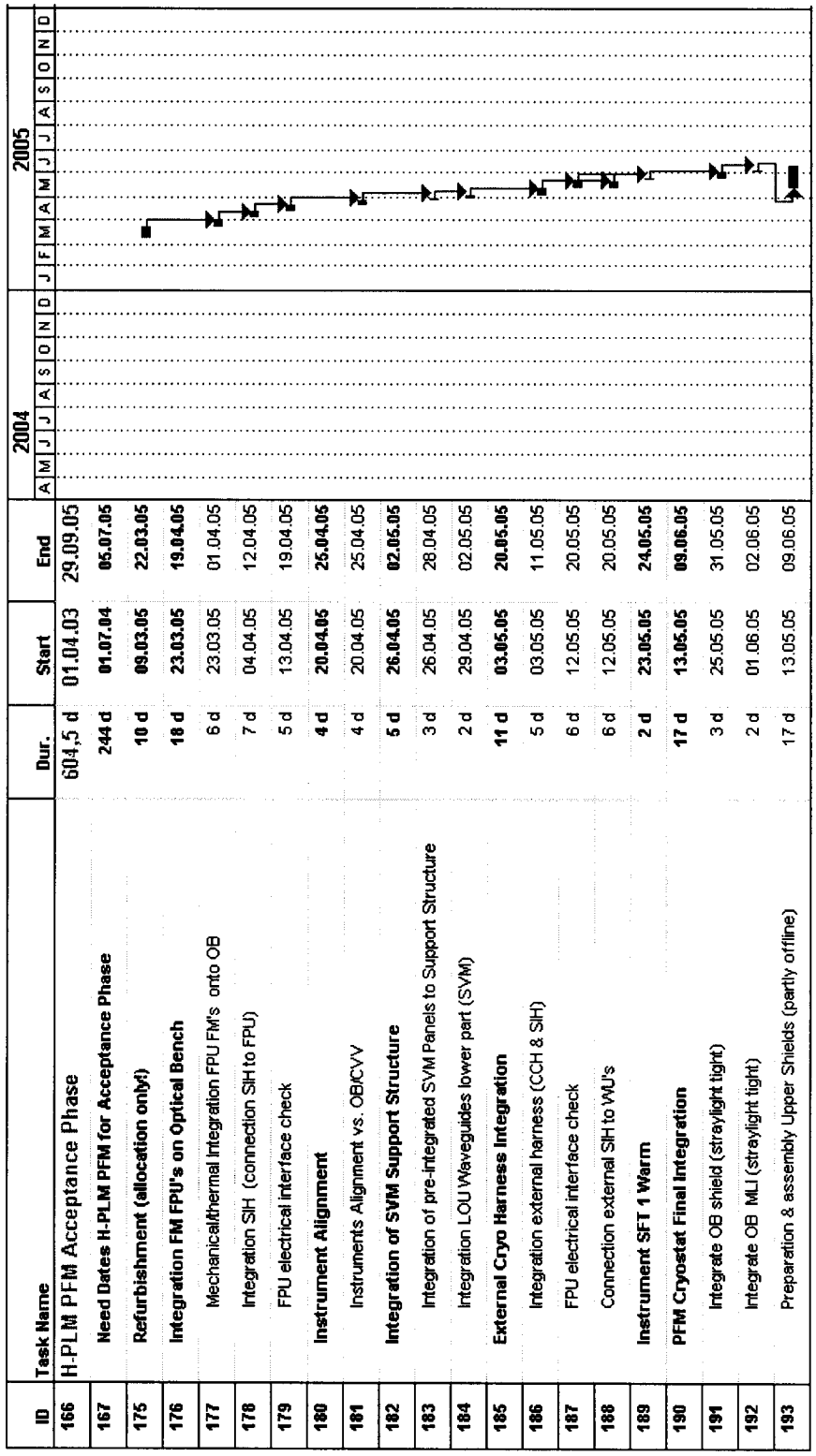
The alignment concept proposed for Herschel is chosen such that standard laboratory products can be used to a large extend for the OGSE. Most of the equipment is already available at Astrium, but some may need to be adapted for Herschel. In the following table the main equipment needed for Herschel system level alignment activities is shown.

No.	Qty	Equipment	Description/Reference
1	2	Theodolite	Wild T2000 S or equivalent
2	1	Linear Measurement Device	For axial and lateral distance measurements
3	2	Angular Transfer Prism	As reference for azimuth
4	2	LOU Alignment Camera	LOU alignment and alignment monitoring
5	Appr.20	Alignment reference cubes	For OB, CVV.....
6	1	Support Structure for LMD	For vertical and horizontal measurements
7	1	Tripod	For Theodolite Height appr. 7m
8	1	Adjustable support for PLM or use of a rotary table	For precise levelling of the PLM
9	1	Adapter	For SVM I/F
10	1	Adapter	For PLM I/F
11	1	Cherry Picker	

Tab. 9-9: OGSE / Alignment Equipment List

10 AIT SCHEDULE

Fig. 10-1 and Fig. 10-2 show the actual planning status of the EPLM PFM and satellite PFM AIT activities, as described in this plan. Please note that these bar charts are given for information only. They will not necessarily be kept up to date for each programme planning evolution. Valid schedule information can be found in the official programme master schedule at mutually any time.



ID	Task Name	Dur.	Start	End
166	H-PLM PFM Acceptance Phase	604,5 d	01.04.03	29.09.05
167	Need Dates H-PLM PFM for Acceptance Phase	244 d	01.07.04	05.07.05
175	Refurbishment (allocation only!)	10 d	09.03.05	22.03.05
176	Integration FM FPU's on Optical Bench	18 d	23.03.05	19.04.05
177	Mechanical/thermal integration FPU FM's onto OB	6 d	23.03.05	01.04.05
178	Integration SIH (connection SIH to FPU)	7 d	04.04.05	12.04.05
179	FPU electrical interface check	5 d	13.04.05	19.04.05
180	Instrument Alignment	4 d	20.04.05	25.04.05
181	Instruments Alignment vs. OB/CVV	4 d	20.04.05	25.04.05
182	Integration of SVM Support Structure	5 d	26.04.05	02.05.05
183	Integration of pre-integrated SVM Panels to Support Structure	3 d	26.04.05	28.04.05
184	Integration LOU Waveguides lower part (SVM)	2 d	29.04.05	02.05.05
185	External Cryo Harness Integration	11 d	03.05.05	20.05.05
186	Integration external harness (CCH & SIH)	5 d	03.05.05	11.05.05
187	FPU electrical interface check	6 d	12.05.05	20.05.05
188	Connection external SIH to WU's	6 d	12.05.05	20.05.05
189	Instrument SFT 1 Warm	2 d	23.05.05	24.05.05
190	PFM Cryostat Final Integration	17 d	13.05.05	09.06.05
191	Integrate OB shield (straylight tight)	3 d	25.05.05	31.05.05
192	Integrate OB MLI (straylight tight)	2 d	01.06.05	02.06.05
193	Preparation & assembly Upper Shields (partly offline)	17 d	13.05.05	09.06.05

Fig. 10-1: PFM PLM integration and test schedule

ID	Task Name	Dur.	Start	End
194	**Closing PFM**	**12 d**	**10.06.05**	**27.06.05**
195	Assembly upper bulkhead, connect filling port, leak test	5 d	10.06.05	16.06.05
196	Integrate LOU & waveguides upper part (CVV)	5 d	17.06.05	23.06.05
197	Alignment LOU/OB (HIFI)	2 d	24.06.05	27.06.05
198	**MIP**	**1 d**	**28.06.05**	**28.06.05**
199	**Integration Cryostat Cover (CC) and Cryostat Baffle (CB)**	**2 d**	**29.06.05**	**30.06.05**
200	**Install Vacuum Pump / Evacuation & Leak Check**	**5 d**	**01.07.05**	**07.07.05**
201	**Transport to cleanroom 100.000**	**2 d**	**08.07.05**	**11.07.05**
202	**Connection CVSE & Bakeout Unit**	**2 d**	**12.07.05**	**13.07.05**
203	**Connect Cryo SCOE & functional test (cryostat HK)**	**2 d**	**12.07.05**	**13.07.05**
204	**Bake-out**	**10 d**	**14.07.05**	**27.07.05**
205	**PLM PFM External Completion**	**2 d**	**12.07.05**	**13.07.05**
206	Integrate BOLA	1 d	12.07.05	12.07.05
207	Alignment Check Warm	1 d	13.07.05	13.07.05
208	**EGSE & Warm Units Integration (parallel activities)**	**354 d**	**01.04.03**	**15.09.04**
209	**EGSE & CCS Setup**	**307 d**	**01.04.03**	**12.07.04**
210	CCS available	0 d	01.04.03	01.04.03
211	CCS set-up	3 d	08.04.03	10.04.03
212	Cryo SCOE available	0 d	01.04.03	01.04.03
213	Cryo SCOE set-up	3 d	11.04.03	15.04.03
214	PLM EGSE available	0 d	01.04.03	01.04.03
215	PLM EGSE set-up	3 d	16.04.03	22.04.03
216	Scientific Instruments EGSE available	0 d	01.07.04	01.07.04
217	Instrument EGSE connection	3 d	08.07.04	12.07.04
218	**Mech. integration FM Instrument WU's on SVM Panels**	**10 d**	**13.07.04**	**26.07.04**

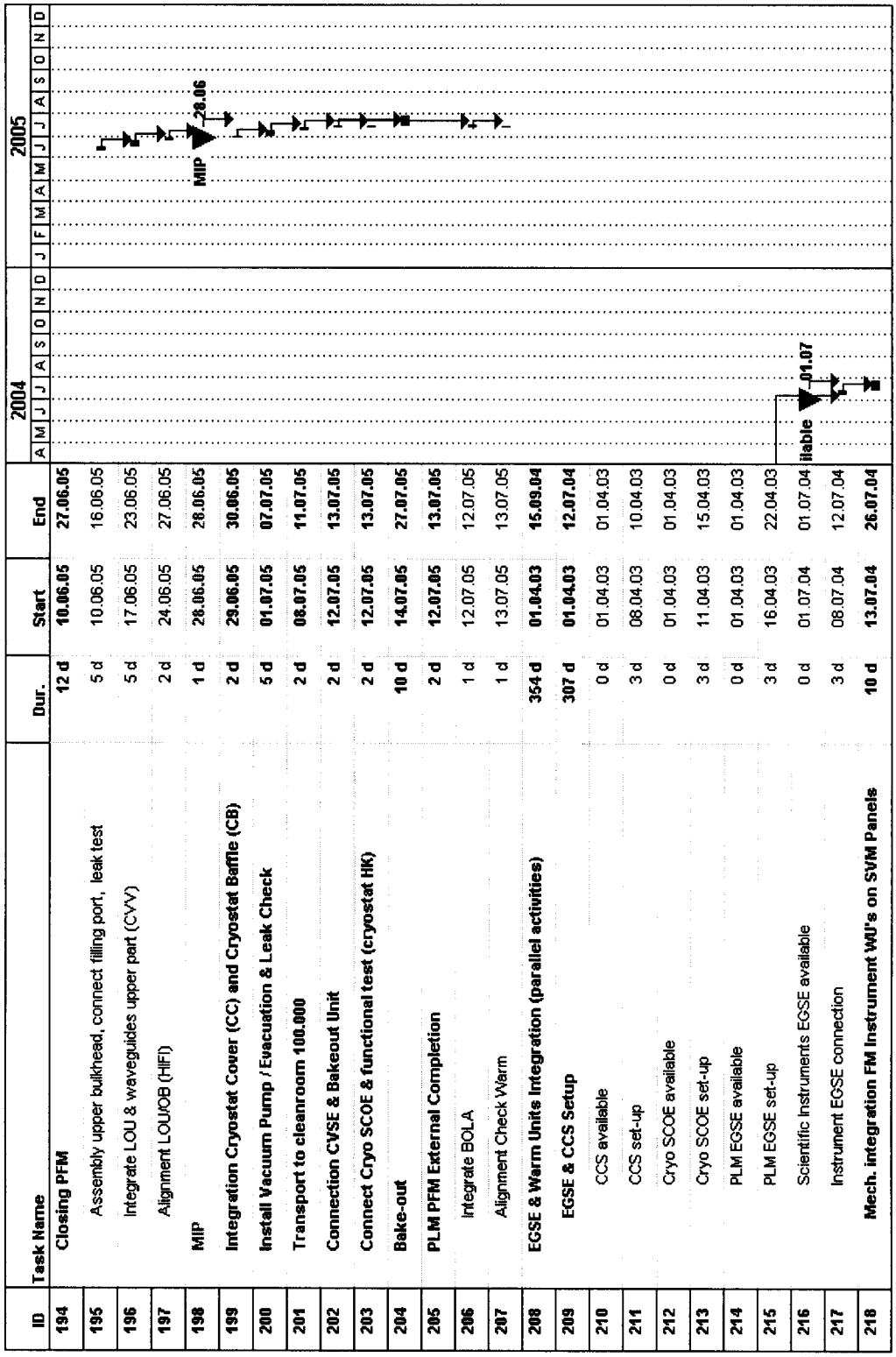
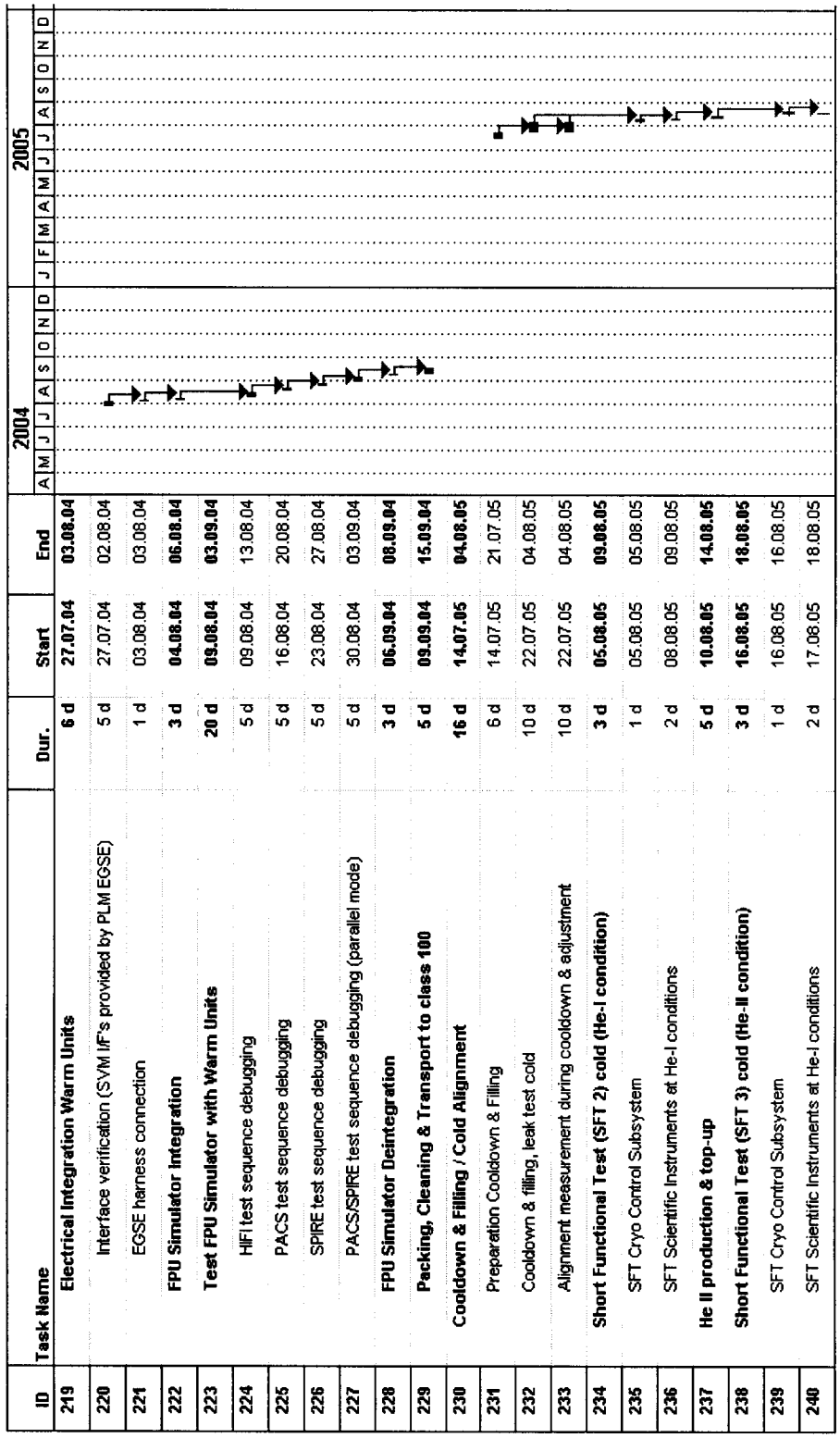
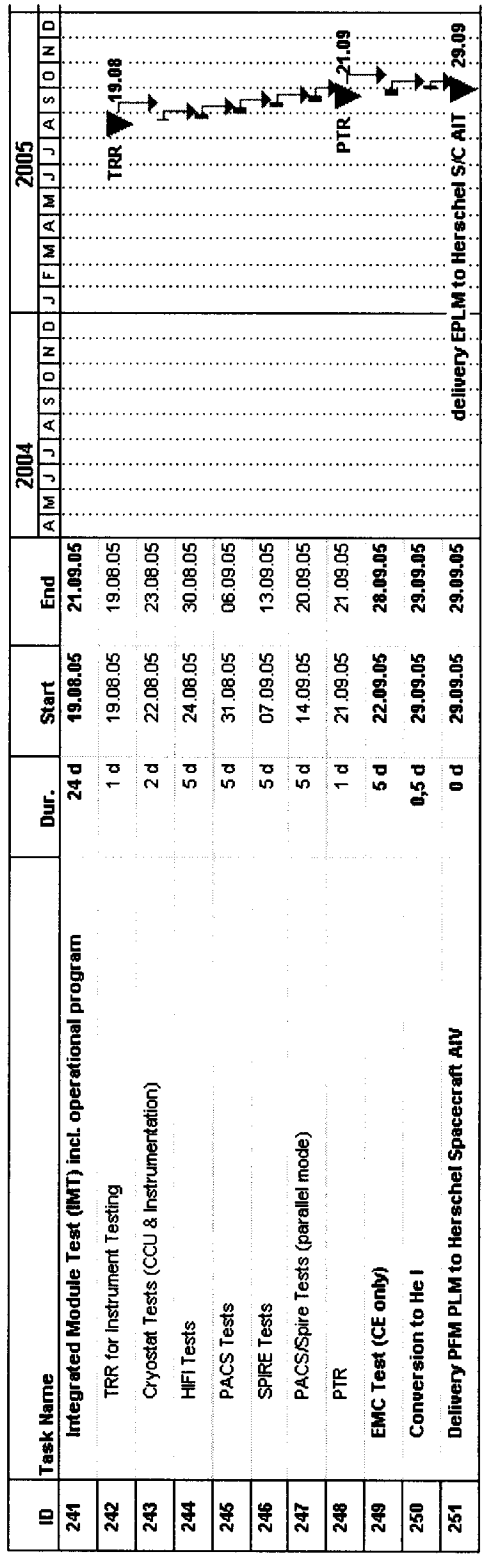


Fig. 10-1: PFM PLM integration and test schedule



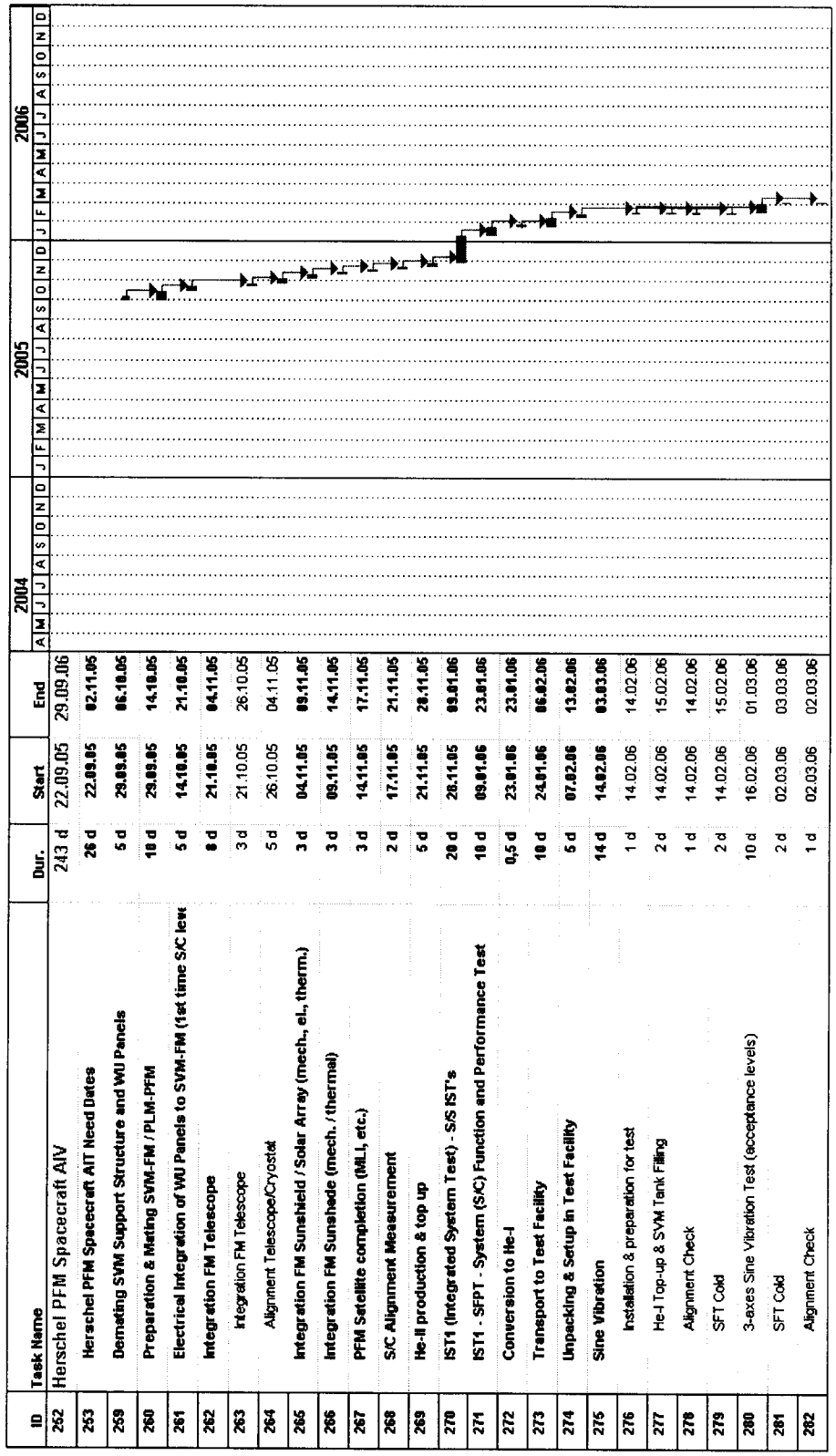
ID	Task Name	Dur.	Start	End
219	**Electrical integration Warm Units**	**6 d**	**27.07.04**	**03.08.04**
220	Interface verification (SVM IF's provided by PLM EGSE)	5 d	27.07.04	02.08.04
221	EGSE harness connection	1 d	03.08.04	03.08.04
222	**FPU Simulator integration**	**3 d**	**04.08.04**	**06.08.04**
223	**Test FPU Simulator with Warm Units**	**20 d**	**09.08.04**	**03.09.04**
224	HIFI test sequence debugging	5 d	09.08.04	13.08.04
225	PACS test sequence debugging	5 d	16.08.04	20.08.04
226	SPIRE test sequence debugging	5 d	23.08.04	27.08.04
227	PACS/SPIRE test sequence debugging (parallel mode)	5 d	30.08.04	03.09.04
228	**FPU Simulator Deintegration**	**3 d**	**06.09.04**	**08.09.04**
229	**Packing, Cleaning & Transport to class 100**	**5 d**	**09.09.04**	**15.09.04**
230	**Cooldown & Filling / Cold Alignment**	**16 d**	**14.07.05**	**04.08.05**
231	Preparation Cooldown & Filling	6 d	14.07.05	21.07.05
232	Cooldown & filling, leak test cold	10 d	22.07.05	04.08.05
233	Alignment measurement during cooldown & adjustment	10 d	22.07.05	04.08.05
234	**Short Functional Test (SFT 2) cold (He-I condition)**	**3 d**	**05.08.05**	**09.08.05**
235	SFT Cryo Control Subsystem	1 d	05.08.05	05.08.05
236	SFT Scientific Instruments at He-I conditions	2 d	08.08.05	09.08.05
237	**He II production & top-up**	**5 d**	**10.08.05**	**14.08.05**
238	**Short Functional Test (SFT 3) cold (He-II condition)**	**3 d**	**16.08.05**	**18.08.05**
239	SFT Cryo Control Subsystem	1 d	16.08.05	16.08.05
240	SFT Scientific Instruments at He-I conditions	2 d	17.08.05	18.08.05

Fig. 10-1: PFM PLM integration and test schedule



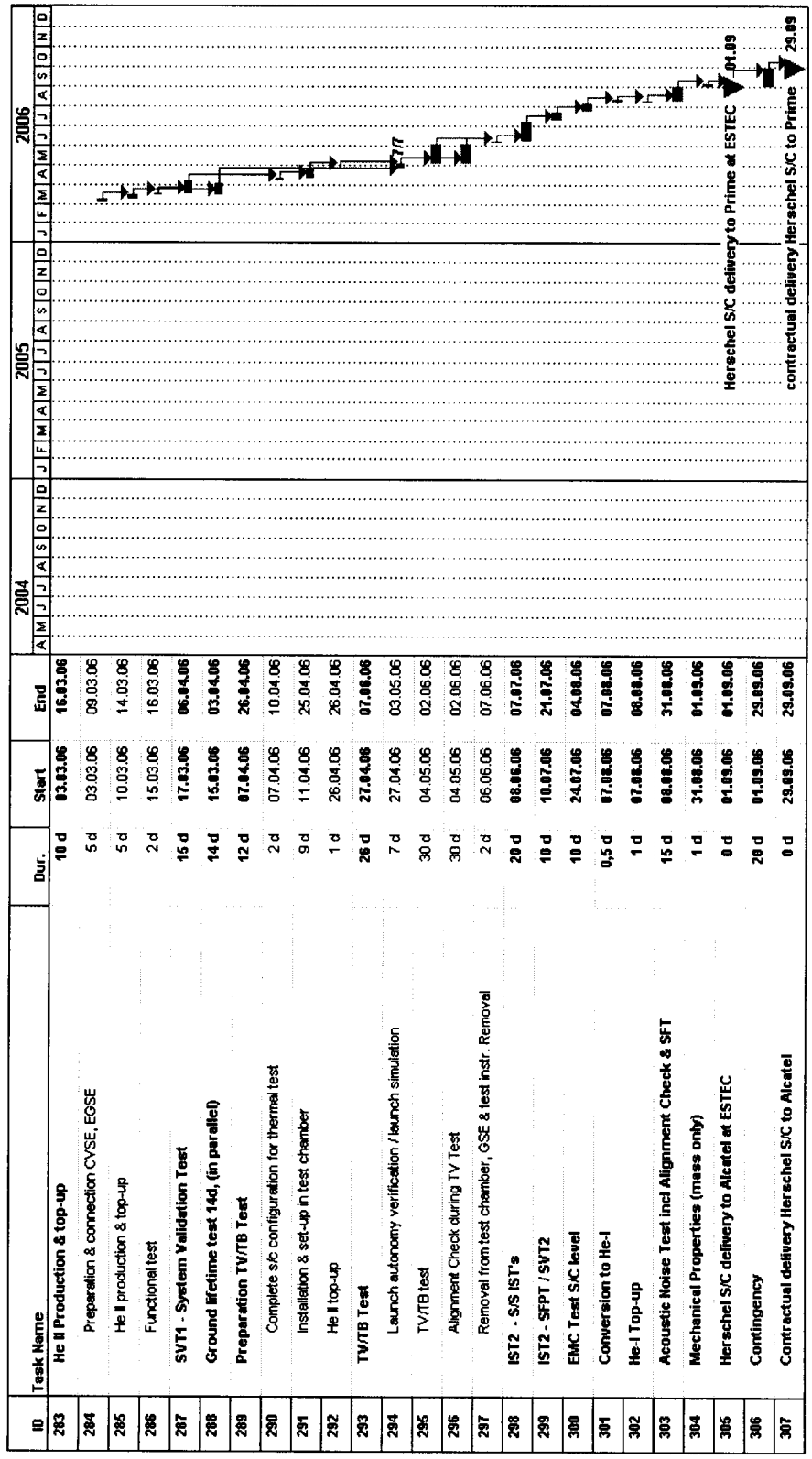
ID	Task Name	Dur.	Start	End
241	**Integrated Module Test (IMT) incl. operational program**	**24 d**	**19.08.05**	**21.09.05**
242	TRR for Instrument Testing	1 d	19.08.05	19.08.05
243	Cryostat Tests (CCU & Instrumentation)	2 d	22.08.05	23.08.05
244	HIFI Tests	5 d	24.08.05	30.08.05
245	PACS Tests	5 d	31.08.05	06.09.05
246	SPIRE Tests	5 d	07.09.05	13.09.05
247	PACS/Spire Tests (parallel mode)	5 d	14.09.05	20.09.05
248	PTR	1 d	21.09.05	21.09.05
249	**EMC Test (CE only)**	**5 d**	**22.09.05**	**28.09.05**
250	**Conversion to He I**	**0,5 d**	**29.09.05**	**29.09.05**
251	**Delivery PFM PLM to Herschel Spacecraft AIV**	**0 d**	**29.09.05**	**29.09.05**

Fig. 10-1: PFM PLM integration and test schedule



ID	Task Name	Dur.	Start	End
252	Herschel PFM Spacecraft AIV	243 d	22.09.05	29.09.06
253	Herschel PFM Spacecraft AIT Need Dates	26 d	22.09.05	02.11.05
259	Demating SVM Support Structure and WU Panels	5 d	29.09.05	06.10.05
260	Preparation & Mating SVM-FM / PLM-PFM	10 d	29.09.05	14.10.05
261	Electrical Integration of WU Panels to SVM-FM (1st time S/C level	5 d	14.10.05	21.10.05
262	Integration FM Telescope	8 d	21.10.05	04.11.05
263	Integration FM Telescope	3 d	21.10.05	26.10.05
264	Alignment Telescope/Cryostat	5 d	26.10.05	04.11.05
265	Integration FM Sunshield / Solar Array (mech., el., therm.)	3 d	04.11.05	09.11.05
266	Integration FM Sunshade (mech. / thermal)	3 d	09.11.05	14.11.05
267	PFM Satellite completion (MLI, etc.)	3 d	14.11.05	17.11.05
268	S/C Alignment Measurement	2 d	17.11.05	21.11.05
269	He-II production & top up	5 d	21.11.05	28.11.05
270	IST1 (Integrated System Test) - S/S IST's	20 d	28.11.05	09.01.06
271	IST1 - SFPT - System (S/C) Function and Performance Test	10 d	09.01.06	23.01.06
272	Conversion to He-I	0,5 d	23.01.06	23.01.06
273	Transport to Test Facility	10 d	24.01.06	06.02.06
274	Unpacking & Setup in Test Facility	5 d	07.02.06	13.02.06
275	Sine Vibration	14 d	14.02.06	03.03.06
276	Installation & preparation for test	1 d	14.02.06	14.02.06
277	He-I Top-up & SVM Tank Filling	2 d	14.02.06	15.02.06
278	Alignment Check	1 d	14.02.06	14.02.06
279	SFT Cold	2 d	14.02.06	15.02.06
280	3-axes Sine Vibration Test (acceptance levels)	10 d	16.02.06	01.03.06
281	SFT Cold	2 d	02.03.06	03.03.06
282	Alignment Check	1 d	02.03.06	02.03.06

Fig. 10-2: PFM Satellite Integration and qualification/acceptance test schedule



ID	Task Name	Dur.	Start	End
283	**He II Production & top-up**	**10 d**	**03.03.06**	**16.03.06**
284	Preparation & connection CVSE, EGSE	5 d	03.03.06	09.03.06
285	He II production & top-up	5 d	10.03.06	14.03.06
286	Functional test	2 d	15.03.06	16.03.06
287	**SVT1 - System Validation Test**	**15 d**	**17.03.06**	**06.04.06**
288	**Ground lifetime test 14d, (in parallel)**	**14 d**	**15.03.06**	**03.04.06**
289	**Preparation TV/TB Test**	**12 d**	**07.04.06**	**26.04.06**
290	Complete s/c configuration for thermal test	2 d	07.04.06	10.04.06
291	Installation & set-up in test chamber	9 d	11.04.06	25.04.06
292	He II top-up	1 d	26.04.06	26.04.06
293	**TV/TB Test**	**26 d**	**27.04.06**	**07.06.06**
294	Launch autonomy verification / launch simulation	7 d	27.04.06	03.05.06
295	TV/TB test	30 d	04.05.06	02.06.06
296	Alignment Check during TV Test	30 d	04.05.06	02.06.06
297	Removal from test chamber, GSE & test instr. Removal	2 d	06.06.06	07.06.06
298	**IST2 - S/S IST's**	**20 d**	**08.06.06**	**07.07.06**
299	**IST2 - SFPT / SVT2**	**10 d**	**10.07.06**	**21.07.06**
300	**EMC Test S/C level**	**10 d**	**24.07.06**	**04.08.06**
301	**Conversion to He-I**	**0,5 d**	**07.08.06**	**07.08.06**
302	**He-I Top-up**	**1 d**	**07.08.06**	**08.08.06**
303	**Acoustic Noise Test incl Alignment Check & SFT**	**15 d**	**08.08.06**	**31.08.06**
304	**Mechanical Properties (mass only)**	**1 d**	**31.08.06**	**01.09.06**
305	**Herschel S/C delivery to Alcatel at ESTEC**	**0 d**	**01.09.06**	**01.09.06**
306	**Contingency**	**20 d**	**01.09.06**	**29.09.06**
307	**Contractual delivery Herschel S/C to Alcatel**	**0 d**	**29.09.06**	**29.09.06**

Fig. 10-2: PFM Satellite Integration and qualification/acceptance test schedule

ANNEX 1 ACTIVITY SHEETS

A1.1 CONTENTS OF ACTIVITY SHEETS

The individual activities presented in the detailed AIT flow, see chapter 5.2, are described in the AIT activity sheets. These sheets present the following information:

- Activity identification (ID)
- Duration (in working days)
- Activity Name (accordance to AIT sequence)
- Objective
- Requirements to be verified
- Environment
- Specimen configuration (at the beginning of the task)
- Activity breakdown
- Applicable documents
- GSE required
- Facility / Instrumentation
- Personnel (AIT and QA)
- Safety Precautions Special Notes
- Special Notes

A1.2 LIST OF ACTIVITY SHEETS

Number	Activity/Definition	No. according schedule
	Start of PFM- Acceptance Test Phase	
F.010.000	**Instrument WU and SVM panel preparation (parallel to F.020.000)**	
F.010.010	Preparation of EGSE and CCS set- up	
F.010.020	Mechanical Integration of WUs on SVM panel	
F.010.030	Electrical Integration of WUs on SVM panel	
F.010.040	FPU Simulator integration	
F.010.050	HIFI test sequence debugging (with FPU sim. and WUs)	
F.010.060	PACS test sequence debugging (with FPU sim. and WUs)	
F.010.070	SPIRE test sequence debugging (with FPU sim. and WUs)	
F.010.080	SPACS/ SPIRE debugging – parallel mode	
F.010.090	FPU simulator de-integration	
F.010.100	Transport SVM panels to CR100	
F.020.000	**PFM Cryostat Final Integration in CR 100**	
F.020.010	PLM Refurbishment activities	
F.020.020	Mechanical/ thermal integration of FM FPUs on OB	
F.020.030	Integration of SIH and connection to FPUs	
F.020.040	Electrical I/F check of FPUs	
F.020.050	Alignment of instruments versus OB/CVV	
F.020.060	Integration of support structure (SVM/ PLM – I/F)	
F.020.070	Integration of SVM panels to support structure	
F.020.080	Integration of LOU wave guides lower part	
F.020.090	Integration external harness (CCH & SIH)	
F.020.100	SFT 0 warm for instruments	
F.020.110	Integration of OB shield incl. MLI (stray light tight)	
F.020.120	Assembly of pre-integrated upper shields	
F.020.130	Assembly of upper bulkhead, connect filling port, leak test	
F.020.140	Integration of LOU and wave guides upper parts	
F.020.150	Alignment of LOU versus OB (HIFI)	
F.020.160	Integrate FM cryostat cover and cryostat baffle	

Number	Activity/Definition	No. according schedule
F.020.170	Install vacuum pumps, evacuation and leak check	
F.020.180	Transport to CR 100,000	
F.030.000	**Bake Out and PLM external Completion**	
F.030.010	Preparation of CVSE including bake out equipment	
F.030.020	Connect Cryo SCOE and perform SFT 1	
F.030.030	Bake out	
F.030.040	Integration of BOLA and CCU	
F.030.050	Alignment check warm	
F.040.000	**He-I and He-II Activities**	
F.040.010	Preparation for cool down and filling	
F.040.020	Cooling and filling LHe including leak test	
F.040.030	alignment verification and adjustments during cool down	
F.040.040	SFT 2 at He-I (cryostat & instruments)	
F.040.050	Production of He-II and top up	
F.040.060	SFT 3 at He-II (cryostat)	
F.050.000	**Integrated Module Test (IMT)**	
F.050.010	Cryostat tests (CCU and instrumentation)	
F.050.020	HIFI tests	
F.050.030	PACS tests	
F.050.040	SPIRE tests	
F.050.050	PACS / SPIRE tests (parallel mode)	
F.060.000	**EMC- Test**	
F.060.010	EMC- test CE at He-II	
F.060.020	Conversion to He-I	
F.070.000	**PFM Satellite Integration**	
F.070.010	De-mating of SVM support structure and WU	
F.070.020	Preparation & Mating of FM SVM and PFM PLM	
F.070.030	Electrical integration of WU – panels to FM SVM	
F.070.040	Integration of telescope	

Number	Activity/Definition	No. according schedule
F.070.050	Alignment telescope to CVV	
F.070.060	Integration of sunshield and S/A (mech., electr. and thermal)	
F.070.070	Integration of sunshade (mech. and thermal)	
F.070.080	S/C completion (MLI etc.)	
F.070.090	S/C alignment measurements	
F.080.000	**Integrated System Test 1 (IST)**	
F.080.010	Preparation and connection of CVSE and GSE	
F.080.020	He-II production and top up	
F.080.030	Integrated system test 1 (S/S- IST & SFPT)	
F.080.040	Conversion to He-I	
F.090.000	**PFM Satellite Sine Vibration Test**	
F.090.010	Transport to environmental test facility	
F.090.020	He-I top up	
F.090.030	SVM activities (RCS tank filling etc.)	
F.090.040	Alignment check	
F.090.050	SFT 4 at He-I	
F.090.060	Sine vibration test (3 axes, acceptance level)	
F.090.070	SFT 5 at He-I	
F.090.080	Alignment check	
F.100.000	**TB / TV Test including System Validation Tests**	
F.100.010	Transport to TV test facility	
F.100.020	Preparation and connection of CVSE and EGSE	
F.100.030	He-II production and top up	
F.100.040	System validation test 1 (SVT)	
F.100.050	Installation and set-up in LSS	
F.100.060	Ground Lifetime and launch autonomy verification	
F.100.070	TB / TV test	
F.100.080	Alignment check during TB/TV test	
F.100.090	Removal from test chamber	

Number	Activity/Definition	No. according schedule
F.110.000	**Integrated System Test 2 (IST)**	
F.110.010	Preparation of S/C and GSE set-up	
F.110.020	IST 2 (S/S- IST & SFPT)	
F.120.000	**EMC test**	
F.120.010	EMC test S/C level	
F.120.020	Conversion to He-I	
F.130.000	**Acoustic Noise Test**	
F.130.010	Transport to acoustic noise test facility	
F.130.020	He-I top up	
F.130.030	Acoustic noise test	
F.130.040	Alignment check	
F.130.050	SFT 6 at He-I	
F.140.000	**Mechanical Properties**	
F.140.010	Determination of mass	
	End of Herschel PFM Acceptance Test Phase	

A1.3 DETAILED ACTIVITY SHEETS

A1.3.1 Instrument WU and SVM Panel Preparation (F010.000)

Activity Number: F010.010 **Duration:** tbd

Activity Name: **Preparation of EGSE and CCS set-up** **Model:** WU/SVM

Objective:

- Preparation of the GSE and CCS set-up for integration and test of WUs with the FPU simulator

Requirements to be verified:

- According to EGSE general requirement specification

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100 000

Configuration:

- released GSE for integration activities

Activity Breakdown:

- prepare the instrument EGSE, Cryo SCOE, PLM EGSE and CCS for test of Warm Units
- provide the EGSE parts at the defined test area

Applicable Documents:

- EGSE general requirement specification
- PFM integration procedure
- Contamination control plan

GSE required:

- Instrument EGSE
- Cryo special check out equipment (SCOE)
- PLM EGSE
- Control check out system (CCS)

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100 000
- check out area

Personnel:

EGSE operators

electrical engineer

AIT engineer

AIT technician

QA engineer

Safety Precautions:

- ESD requirements for integration of WUs

Special Notes:

- cleanliness requirements have to be applied

Activity Number: F.010.020 **Duration:** tbd

Activity Name: **Mechanical Integration of WUs on SVM Panels** **Model:** WU/SVM

Objective:

- Mechanical integration of FM Warm Units on SVM panel

Requirements to be verified:

- According to WUs integration procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100 000

Configuration:

- SVM panels fixed on tables (or support structure)
- WUs released for integration

Activity Breakdown:

- clean the I/F area of WUs
- provide thermal filler, bonding straps, bonding washers etc.
- integrate WUs
- integrate bonding straps
- check screw torque and screw locking
- measure bonding resistance

Applicable Documents:

- WUs integration procedure
- SVM integration procedure

GSE required:

- panel support structure
- Bonding measurement device
- Standard integration tools

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100 000
- Cleaning equipment

Personnel:

AIT engineer

AIT mech. technician

AIT electr. technician

QA engineer

Safety Precautions:

- ESD requirements

Special Notes:

- the cleanliness requirements have to be applied

Activity Number: F.010.030 **Duration:** tbd

Activity Name: **Electrical Integration of WUs on SVM panel** **Model:** WU/SVM

Objective:

Electrical integration of WUs on SVM panel

Requirements to be verified:

According to integration procedure of WUs

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100 000

Configuration:

- Instrument WUs mechanically integrated on SVM panels

Activity Breakdown:

- prepare EGSE and CCS
- Electrical integration of WUs
- Perform KIP F1

Applicable Documents:

- WUs integration procedure

GSE required:

- EGSE and CCS
- IDAS

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100 000

Personnel:

AIT engineer

EGSE operators

AIT electr. technician

QA engineer

Safety Precautions:

- ESD requirements

Special Notes:

- NA

Activity Number: F.010.040 **Duration:** tbd

Activity Name: **FPU Simulator integration** **Model:** WU/SVM

Objective:

- Integration of FPU simulator

Requirements to be verified:

- According to FPU simulator requirement specification

Environment:

temperature:	22 ± 3 ° C
humidity:	45% < RH < 70%
cleanliness:	clean class 100,000

Configuration:

- SVM support structure and panels provided
- WUs mechanically and electrically integrated on SVM panels

Activity Breakdown:

- prepare FPU simulator
- attach FPU simulator to instrument WUs

Applicable Documents:

- integration procedure for WUs
- WUs pre- test procedure (with FPU simulator)

GSE required:

- panel support structure (tables)
- Bonding measurement device
- Standard integration tool
- EGSE and CCS

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100,000

Personnel:

AIT engineer

EGSE operators

AIT electr. technician

QA engineer

Safety Precautions:

- NA

Special Notes:

- the cleanliness requirements have to be applied

Activity Number: F.010.050 **Duration:** tbd

Activity Name: **HIFI test sequence debugging (WUs with FPU simulator)** **Model:** WU/SVM

Objective:

- Debugging of HIFI WU with FPU simulator

Requirements to be verified:

- According to HIFI WU test procedure with FPU simulator

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100,000

Configuration:

- WUs and FPU simulator connected

Activity Breakdown:

- Perform debugging of HIFI WUs including FPU simulator

Applicable Documents:

- Procedure for debugging of HIFI WU
- Manual of FPU simulator

GSE required:

- SVM panel support structure (tables)
- EGSE and CCS
- FPU simulator

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100,000

Personnel:

AIT engineer

EGSE operators

AIT electr. technician

QA engineer

Safety Precautions:

- ESD requirements have to be applied

Special Notes:

- NA

Activity Number: F.010.060 **Duration:** 3 tbd

Activity Name: **PACS test sequence debugging (WUs with FPU simulator)** **Model:** WU/SVM

Objective:

- Debugging of PACS WU with FPU simulator

Requirements to be verified:

- According to PACS WU test procedure with FPU simulator

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100,000

Configuration:

- WUs and FPU simulator connected

Activity Breakdown:

- Perform debugging of PACS WU including FPU simulator
-

Applicable Documents:

- Procedure for debugging of PACS WU
- Manual of FPU simulator

GSE required:

- panel support structure (tables)
- EGSE and CCS
- FPU simulator

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100 000

Personnel:

AIT engineer

EGSE operators

AIT electr. technician

QA engineer

Safety Precautions:

- ESD requirements have to be applied

Special Notes:

- NA

Activity Number: F.010.070 **Duration:** tbd

Activity Name: **SPIRE test sequence debugging (with FPU simulator and WUs)** **Model:** WU/SVM

Objective:

- Debugging of SPIRE WU with FPU simulator

Requirements to be verified:

- According to SPIRE WU test procedure with FPU simulator

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100

Configuration:

- WUs and FPU simulator connected

Activity Breakdown:

- Perform debugging of SPIRE WUs with FPU simulator

Applicable Documents:

- Procedure for debugging of SPIRE WUs
- Manual of FPU simulator

GSE required:

- panel support structure (tables)
- EGSE and CCS
- FPU simulator

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100 000
-

Personnel:

AIT engineer

EGSE operators

AIT electr. technician

QA engineer

Safety Precautions:

- ESD requirements

Special Notes:

- NA

Activity Number: F.010.080 **Duration:** tbd

Activity Name: **SPACS/ SPIRE debugging – parallel mode (WUs with FPU simulator)** **Model:** WU/SVM

Objective:

- Debugging (parallel mode) of PACS / SPIRE WUs with FPU simulator

Requirements to be verified:

- According to PACS / SPIRE WU test procedure with FPU simulator (parallel mode)

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100,000

Configuration:

- WUs and FPU simulator connected

Activity Breakdown:

- Perform debugging of PACS / SPIRE WUs including FPU simulator – parallel mode

Applicable Documents:

- Procedure for debugging (parallel mode) of PACS / SPIRE WUs
- Manual of FPU simulator

GSE required:

- panel support structure (tables)
- EGSE and CCS
- FPU simulator

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100,000

Personnel:

AIT engineer

EGSE operators

AIT electr. technician

QA engineer

Safety Precautions:

- ESD requirements

Special Notes:

- NA

Activity Number: F.010.090 **Duration:** tbd

Activity Name: **FPU simulator de-integration** **Model:** WU/SVM

Objective:

De-integration of the FPU simulator

Requirements to be verified:

- According to user manual of FPU simulator

Environment:

- temperature: 22 ± 3 ° C
- humidity: 40% < RH < 60%
- cleanliness: clean class 100

Configuration:

- FPU simulator connected to WUs mounted on SVM panels for debugging of WU
- EGSE connected

Activity Breakdown:

- Demating of EGSE
- Demating of FPU simulator

Applicable Documents:

- FPU simulator integration procedure
- Manual for FPU simulator

GSE required:

- panel support structure (tables)
- Standard integration tool
- EGSE/CCS
- FPU simulator

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100 000

Personnel:

AIT engineer

EGSE operator

AIT electrician

QA engineer

Safety Precautions:

- ESD requirements

Special Notes:

- NA

Activity Number: F.010.100 **Duration:** tbd

Activity Name: **Transport SVM panels to CR100** **Model:** WU/SVM

Objective:

- Cleaning, Cleanliness Verification and Transport of SVM panels including WUs to CR100

Requirements to be verified:

- According to Contamination Control Plan (AD05)

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100,000/ 100

Configuration:

- WUs integrated on SVM panels

Activity Breakdown:

- Transport of SVM panel and support structure in the airlock of Clean Room 100
- Clean SVM panels including WUs and support structure for clean class 100
- Locate the support structure and panels including WUs inside of cleanroom class 100 for SFT with PLM

Applicable Documents:

- PFM PLM integration procedure
- Contamination Control Plan
- cleaning and cleanliness verification procedure

GSE required:

- Support structure for SVM panel
- Cleaning equipment
- Cleanliness verification equipment
- standard hoisting device

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100,000 & 100 and airlock
- overhead crane

Personnel:

AIT engineer

AIT technician

QA engineer

Safety Precautions:

- ESD requirements

Special Notes:

the cleanliness requirements have to be applied

A1.3.2 PFM Cryostat Final Integration in CR 100 (F.020.000)

Activity Number: F.020.010 **Duration:** tbd

Activity Name: **PLM Refurbishment activities** **Model:** PLM

Objective:

- complete the defined (at the end of qualification phase) refurbishment activities on PLM

Requirements to be verified:

- According to PLM integration procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100

Configuration:

- PLM mounted in the integration dolly in CR 100
- OB integrated including connected tubing
- Cryostat at ambient temperature
- STM units removed
- Inspection and definition of refurbishment completed

Activity Breakdown:

- remove items that need to be replaced
- install replacement items
- repair damaged items as agreed

Applicable Documents:

- PFM PLM integration procedure
- PLM refurbishment procedure
- Contamination Control Plan (AD05)

GSE required:

- PLM Integration dolly
- Working platform

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100
- overhead crane

Personnel:

- tbd

Safety Precautions:

- Standard safety precautions for crane operations
- tbd

Special Notes:

- the cleanliness requirements have to be applied

Activity Number: F.020.020 **Duration:** tbd

Activity Name: **Mechanical/ thermal integration of FM FPUs on OB** **Model:** PLM

Objective:

- Mechanical and thermal integration of FM Focal Plane Units on Optical Bench

Requirements to be verified:

- Integration according to drawings and integration procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100

Configuration:

- PLM mounted in the integration dolly
- integrated and aligned OB

Activity Breakdown:

- perform MIP F1 before FPU integration
- final cleaning and inspection of FM FPUs
- mechanical integration of FM FPUs
- install cooling straps to FPUs
- install grounding straps
- check of screw torque and marking
- measure bonding values

Applicable Documents:

- PFM PLM integration procedure (AD..
- Contamination Control Plan (AD..
- FPU integration procedure (AD..

GSE required:

- PLM Integration dolly
- working platform
- instrument lifting device
- bonding meter

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100
- Facility crane, standard hoisting slings

Personnel:

crane operator / technician

AIT engineer

QA engineer

Safety Precautions:

- Standard safety precautions for crane operations
- ESD precautions

Special Notes:

- the cleanliness requirements have to be applied

Activity Number: F.020.030 **Duration:** tbd

Activity Name: **Integration of SIH and connection to FPUs** **Model:** PLM

Objective:

- integration/connection of the Scientific Signal Harness to complete the cryogenic harness

Requirements to be verified:

- resistance values, pin allocation etc.

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100

Configuration:

- PLM mounted in the integration dolly
- FPUs mechanically and thermally mounted on OB

Activity Breakdown:

- If harness was affected by refurbishment:
  - Integration of SIH connectors to CVV
  - Perform leak test of feedthrough connectors
  - Routing of harness from CVV inner side to OB via straps
  - Fixate SIH to the 1st shield (thermal connection)
- Else
  - Connect the SIH to the FPUs
  - finalise SIH routing
  - check of screw locking
  - perform electrical check from vacuum feedthrough to FPUs with integration data acquisition system

Applicable Documents:

- PFM integration procedure
- SIH integration and test procedure
- Contamination Control Plan

GSE required:

- PLM Integration dolly
- scaffolding
- integration data acquisition system

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100

Personnel:

AIT engineer

electrical engineer

electrical technician

QA engineer

Safety Precautions:

- ESD requirements have to be applied

Special Notes:

- the cleanliness requirements have to be applied

Activity Number: F.020.040 **Duration:** tbd

Activity Name: **Electrical I/F check of FPUs** **Model:** PLM

Objective:

- Electrical check of instrument I/F after final electrical integration

Requirements to be verified:

- Functionality of the three instruments according to instruments specification
- According to SIH integration and test procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100

Configuration:

- PLM installed in the integration dolly
- integrated but not aligned FPUs onto OB

Activity Breakdown:

- connect instrument test equipment to vacuum feedthrough connectors
- electrical check out of instruments and internal SIH

Applicable Documents:

- electrical test procedure for PACS
- electrical test procedure for SPIRE
- electrical test procedure for HIFI

GSE required:

- PLM Integration dolly
- Working platform
- Electrical checkout equipment

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100

Personnel:

scientific representative

electrical operators

electrical technician

QA engineer

Safety Precautions:

- NA

Special Notes:

- ESD requirements have to be applied

Activity Number: F.020.050 **Duration:** tbd

Activity Name: **Alignment of instruments versus OB/CVV** **Model:** PLM

Objective:

- alignment verification/adjustments of instrument FPUs versus OB
- Alignment measurements OB versus CVV

Requirements to be verified:

- Alignments requirements of instruments

Environment:

- temperature: 22 ± 3 ° C
- humidity: 40% < RH < 60%
- cleanliness: clean class 100

Configuration:

- PLM mounted in the integration dolly
- integrated OB including FPUs
- SIH completely integrated

Activity Breakdown:

- install alignment equipment
- shimming and / or adjustment of instruments to fulfil the alignment requirements
- final torque of screws and check of screw locking
- measure and record the final alignment values FPUs versus OB and from OB to CVV reference cube

Applicable Documents:

- PLM integration procedure
- instrument alignment procedure
- Contamination Control Plan

GSE required:

- PLM Integration dolly
- scaffolding
- PLM alignment equipment/ OGSE

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100

Personnel:

AIT engineer

AIT technician

optical engineer

QA Engineer

Safety Precautions:

- NA

Special Notes:

- the cleanliness requirements have to be applied

Activity Number: F.020.060 **Duration:** tbd

Activity Name: **Integration of support structure (SVM/ PLM - I/F)** **Model:** PLM

Objective:

- mechanical integration of SVM support structure

Requirements to be verified:

- according to PLM integration procedure

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100

Configuration:

- integrated and aligned FPUs onto OB
- cryostat topside closed by foil

Activity Breakdown:

- final cleaning and inspection of SVM support structure
- integration of SVM support structure
- alignment of SVM I/F
- check of screw torque and marking

Applicable Documents:

- PLM integration procedure
- Contamination Control Plan

GSE required:

- PLM Integration dolly
- Working platform

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100
- overhead crane

Personnel:

1 AIT engineer

2 AIT technician

1 crane operator

1 QA engineer

Safety Precautions:

- NA

Special Notes:

- the cleanliness requirements have to be applied

Activity Number: F.020.070 **Duration:** tbd

Activity Name: **Integration of SVM panels to support structure** **Model:** PLM

Objective:

- Mechanical integration of SVM panel to the SVM support structure

Requirements to be verified:

- According to PFM PLM integration procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100

Configuration:

- PLM mounted in the integration dolly
- PFM support structure is attached to PLM

Activity Breakdown:

- final cleaning and inspection of SVM panels
- connect SVM panel including instrument WUs to SVM support structure
- final torque of screws and check of screw locking

Applicable Documents:

- PFM PLM integration procedure
- Contamination Control Plan

GSE required:

- PLM Integration dolly
- Working platform

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100
- overhead crane

Personnel:

AIT engineer

AIT technician

crane operator

QA engineer

Safety Precautions:

- NA

Special Notes:

- the cleanliness requirements have to be applied

Activity Number: F.020.080 **Duration:** tbd

Activity Name: **Integration of LOU wave guides lower part** **Model:** PLM

Objective:

- Integration of lower part of wave guides routed outside of the SVM panel

Requirements to be verified:

- According to wave guide integration procedure (AD .

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100

Configuration:

- PLM mounted in the integration dolly
- PLM internally fully integrated and CVV aperture closed by foil
- SVM support structure and panels with instrument WUs installed

Activity Breakdown:

- preparation of fixation area
- integrate wave guides on SVM to SVM I/F
- final torque of screws and check of screw locking
- check grounding

Applicable Documents:

- Integration Procedure for LOU including wave guides
- Contamination Control Plan

GSE required:

- PLM Integration dolly
- digital multimeter

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100

Personnel:

AIT engineer

AIT technician

high frequency specialist

QA engineer

Safety Precautions:

- Standard safety precautions for crane operations

Special Notes:

- the cleanliness requirements have to be applied

Activity Number: F.020.090 **Duration:** tbd

Activity Name: **Integration external harness (CCH & SIH)** **Model:** PLM

Objective:

- Installation/connection of external harness for Science Instruments and Cryostat Control to CVV

Requirements to be verified:

- According to PFM PLM integration procedure
- According to PFM PLM harness specification

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100

Configuration:

- PLM mounted in the integration dolly
- external CCH and SIH pre-integrated (from STM campaign)
- SVM support structure incl. instrument WUs installed

Activity Breakdown:

- prepare of harness fixation area
- complete external CCH and SIH at PLM and SVM support structure as necessary
- connect harness to corresponding WUs
- electrical check out of SIH and CCH including instrumentation
- perform KIP F2 before SFT warm

Applicable Documents:

- PLM integration procedure
- external CCH integration and test procedure
- external SIH integration procedure

GSE required:

- PLM Integration dolly
- scaffolding
- IDAS

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100

Personnel:

AIT engineer

AIT/ electrical engineer

electrical technician

QA engineer

Safety Precautions:

- NA

Special Notes:

- the cleanliness requirements have to be applied

Activity Number: F.020.100 **Duration:** tbd

Activity Name: **SFT 0 warm for instruments** **Model:** PLM

Objective:

- Short functional test for instruments

Requirements to be verified:

- According to instrument requirement specification

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100

Configuration:

- PLM mounted in the integration dolly
- External harness integrated (CCH & SIH)

Activity Breakdown:

- Perform KIP F2
- prepare check out equipment (CCS and Cryo SCOE)
- Perform SFT 0 for instruments

Applicable Documents:

- PFM PLM integration procedure
- Short functional test procedure for instruments

GSE required:

- PLM Integration dolly
- Working platform
- CCS and Cryo SCOE

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100 and 100 000

Personnel:

AIT engineer

check out operators

QA engineer

Safety Precautions:

- NA

Special Notes:

- NA

Activity Number: F.020.110 **Duration:** tbd

Activity Name: **Integration of OB shield incl. MLI (stray light tight)** **Model:** PLM

Objective:

- Integration of OB shield

Requirements to be verified:

- straylight requirements

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100

Configuration:

- PLM with SVM support structure mounted in the integration dolly
- Integrated OB including FPUs

Activity Breakdown:

- final cleaning and inspection of OB
- record mass of OB shield
- final cleaning and inspection of OB shield
- Installation of instrument baffle
- mechanical installation of shield, connect sensor harness and electrical check
- straylight tightening
- check of screw torque and locking

Applicable Documents:

- PLM integration procedure
- Contamination Control Plan

GSE required:

- PLM Integration dolly
- scaffolding
- OB lifting device
- multimeter for grounding resistance measurement

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100

Personnel:

crane operator / technician

AIT engineer

AIT electrical technician

MLI technician

QA engineer

Safety Precautions:

- Standard safety precautions for crane operations
-

Special Notes:

- the cleanliness requirements have to be applied

Activity Number: F.020.120 **Duration:** tbd

Activity Name: **Assembly of pre-integrated upper shields** **Model:** PLM

Objective:

- Integration of upper conical shields

Requirements to be verified:

- According to integration procedure (AD .

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100

Configuration:

- PLM fixate in the integration dolly in vertical direction
- previously defined activities finally integrated (OB, FPUs, accelerometers, OB shield including MLI)

Activity Breakdown:

- final cleaning and inspection of upper shields
- Pre-integrate upper shields. sensors, harness, MLI, MLI-grounding and electrical check
- final inspection of the joining areas (e.g. cylindrical shields, CVV upper part)
- successive mechanical integration of upper conical shields 1,2 and 3
- connect electrical sensors to the cryo harness
- perform functional check after sensor connection
- complete MLI of every shield: connection of each cylindrical shield MLI to each conical shield MLI by sewing
- check the grounding of MLI
- final check of screw torque and locking

Applicable Documents:

- PFM PLM integration procedure
- Contamination Control Plan
- PLM instrumentation list

GSE required:

- PLM Integration dolly
- scaffolding
- shield lifting device
- temperature sensor measurement equipment

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100

Personnel:

crane operator

AIT engineer

AIT technician

harness technician

MLI specialists

QA engineer

Safety Precautions:

- Standard safety precautions for crane operations are applicable.

Special Notes:

- the cleanliness requirements have to be applied

Activity Number:	F.020.130	**Duration:**	tbd
Activity Name:	**Assembly of upper bulkhead, connect filling port, leak test**	**Model:**	PLM

Objective:

- Assembly of cryostat upper bulkhead
- Connect filling port including airlock and SV121
- Perform leak tests

Requirements to be verified:

- According to PLM integration procedure
- tightness of interfaces

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100

Configuration:

- PLM fixate in the integration dolly in vertical direction
- integrated upper shield group including MLI and sensors

Activity Breakdown:

- measure and record mass of upper bulked
- final cleaning and inspection of upper bulked
- install sealing of cylindrical CVV I/F
- install cold seal for filling port I/F
- connect upper bulkhead to cyl. CVV
- Position upper bulkhead such that filling port fits to the bulkhead opening
- mount filling port tube to upper bulkhead, check dimensions, final screw torque and locking
- perform leak test of filling port tube I/F to CVV
- mount Airlock tubing to CVV
- install internal part (special tube plug) and external parts for leak testing
- final torque of screws and check of screw locking
- perform leak test of airlock tubing I/F to CVV
- install the safety valve SV121
- install airlock for SV121
- perform leak test of SV121
- protect upper cone aperture with foil

Applicable Documents:

- PLM integration procedure
- Contamination Control Plan

GSE required:

- PLM Integration dolly
- scaffolding
- upper cone lifting device
- leak test equipment

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100

Personnel:

crane operator

AIT engineer

AIT / CVSE technician

QA engineer

Safety Precautions:

- Standard safety precautions for crane operations

Special Notes:

- the cleanliness requirements have to be applied
- prevent any contamination through the open CVV aperture

Activity Number: F.020.140 **Duration:** tbd

Activity Name: **Integration of LOU and wave guides upper parts** **Model:** PLM

Objective:

- Integration of LOU connect to wave guides upper part routed outside of the CVV

Requirements to be verified:

- According to wave guide integration procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100

Configuration:

- PLM mounted in the integration dolly
- PLM internally fully integrated and CVV aperture closed by foil

Activity Breakdown:

- final cleaning and inspection of LOU
- preparation of fixation area
- integrate FM LOU
- attach wave guides to LOU
- final torque of screws and check of screw locking
- check grounding

Applicable Documents:

- Integration Procedure for LOU including wave guides
- Contamination Control Plan
- LOU handling manual

GSE required:

- PLM Integration dolly
- scaffolding
- LOU lifting device

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100
- overhead crane

Personnel:

AIT engineer

AIT technician

crane operator

high frequency specialist

QA engineer

Safety Precautions:

- Standard safety precautions for crane operations

Special Notes:

- the cleanliness requirements have to be applied

Activity Number: F.020.150 **Duration:** tbd

Activity Name: **Alignment of LOU versus OB (HIFI)** **Model:** PLM

Objective:

- Alignment adjustments of LOU (mirror cubes) versus OB (HIFI FPU)

Requirements to be verified:

- according to PLM requirement specification

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100

Configuration:

- PLM mounted in the integration dolly
- two reference cubes on HIFI FPU are installed
- one reference cube on LOU is installed
- two windows in the CVV are installed for LOU alignment
- the cover is not installed

Activity Breakdown:

- install alignment equipment
- perform alignment measurements through aperture (cover) and HIFI windows
- perform KIP F3 before closing of cryostat

Applicable Documents:

- PLM integration procedure
- instrument alignment procedure
- Contamination Control Plan

GSE required:

- PLM Integration dolly
- scaffolding
- PLM alignment equipment/ OGSE

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100

Personnel:

crane operator

AIT engineer

alignment technicians

QA engineer

Safety Precautions:

- NA

Special Notes:

- the cleanliness requirements have to be applied

Activity Number: F.020.160 **Duration:** tbd

Activity Name: **Integrate FM cryostat cover and cryostat baffle** **Model:** PLM

Objective:

- Integrate FM cryostat cover and cryostat baffle to close the cryostat

Requirements to be verified:

- according to PLM integration procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100

Configuration:

- PLM mounted in the integration dolly
- CVV aperture closed with foil

Activity Breakdown:

- release of cover and all components (e.g. hold-down and release mechanism, hinges including springs) for integration
- record actual mass of cover complete and baffle
- final cleaning and inspection of cover components and baffle
- remove foil from CVV aperture
- install O-ring seal to cover I/F without vacuum grease tbc
- integrate cover components
- mechanical installation of baffle
- installation of hold down release harness including I/F bracket (on upper bulked)
- electrical check of integrated harness

Applicable Documents:

- PLM integration procedure
- Contamination Control Plan

GSE required:

- PLM Integration dolly in vertical direction
- scaffolding
- electrical checkout system (IDAS)
- lifting device for cover and baffle

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100

Personnel:

crane operator / technician

AIT engineer

QA engineer

Safety Precautions:

- Standard safety precautions for crane operations

Special Notes:

- the cleanliness requirements have to be applied
- prevent any contamination through the open CVV aperture

Activity Number: F.020.170 **Duration:** tbd

Activity Name: **Install vacuum pumps, evacuation and leak check** **Model:** PLM

Objective:

- check of pumping units, provide the evacuation line to CVV and installation of vacuum gauges
- evacuate CVV and perform leak checks

Requirements to be verified:

- according to CVSE Specification
- cleanliness of evacuation line

Environment:

temperature: 22 ± 3 ° C

humidity: 45% < RH < 70%

cleanliness: clean class 100 /100.000

Configuration:

- PLM fixate in the integration dolly in vertical position
- all PLM apertures (e.g. cover, windows) closed

Activity Breakdown:

- check the proper working of the pumping systems
- check the cleanliness status of all evaluation tubes and parts
- install the evacuation line to CVV
- perform leak check of evacuation line
- start evacuation of the vacuum vessel (controlled Δ P/ min to avoid MLI damages) by the high vacuum pumping unit – low stage
- after having reached specified vacuum value ($p<1x10^{-2}$ mbar) start turbo-pumps and continue evacuation
- perform integral leak check of Cryostat Helium S/S
- perform local leak checks of CVV O-rings
  - lower bulkhead
  - upper bulkhead
- perform local leak checks of:
  - filling port I/F to upper cone
  - safety valves SV 921 and SV 922 to upper cone
  - all tubing I/F to CVV
  - all strap pretension device I/F to CVV
  - all electrical feedthroughs
- perform MIP F2 before movement to CR 100 000

Applicable Documents:

- PLM integration procedure
- Leak test procedure
- Contamination Control Plan

GSE required:

- PLM Integration dolly in vertical direction
- Scaffolding
- CVSE – High vacuum pumping unit with 2 turbo pumps
- Leak test equipment

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100

Personnel:

Test conductor (AIT engineer)

CVSE / AIT technician

QA Engineer

Safety Precautions:

- NA

Special Notes:

- the cleanliness requirements have to be applied
- max. pressure gradient to be observed

Activity Number: F.020.180 **Duration:** tbd

Activity Name: **Transport to CR 100,000** **Model:** PLM

Objective:

- PLM dismounting from integration dolly and movement to cleanroom class 100 000 by hoisting equipment and crane as well as installation of PLM in test dolly

Requirements to be verified:

- According to general MGSE requirement specification (RD07)

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100 / 100.000

Configuration:

- PLM final integrated except external components
- CVV evacuated and leak tested
- PLM mounted in Integration dolly and tilt to x-axis in horizontal position

Activity Breakdown:

- release for transport
- disconnect evacuation lines from PLM
- connect PLM hoisting equipment
- dismount PLM from integration dolly
- move PLM by crane to cleanroom clean class 100 000
- install PLM in test dolly – PLM in x-axis in horizontal position mounted into test dolly

Applicable Documents:

- PLM integration procedure
- Manual for PLM integration dolly and test dolly

GSE required:

- PLM Integration dolly
- Working platform
- PLM test dolly
- PLM hoisting equipment

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100 and class 100.000

Personnel:

crane operator

AIT engineer

AIT technician

QA engineer

Safety Precautions:

- Standard safety precautions for crane operations

Special Notes:

- NA

A1.3.3 Bake Out and PLM External Completion (F.030.000)

Activity Number: F.030.010 **Duration:** tbd

Activity Name: **Preparation of CVSE including bake out equipment** **Model:** PLM

Objective:

- re-connect the CVSE to continue the evacuation until required vacuum pressure
- preparation of CVSE for cool down and filling
- installation of bake out equipment

Requirements to be verified:

- according to PLM requirement specification
- according to cool down and test procedure
- according to bake out procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM vertically mounted in the test dolly
- evacuation port already installed and leak tested
- evacuation lines installed and leak tested
- CVV is evacuated until required vacuum pressure (VG901 and VG902)

Activity Breakdown:

- Re-install turbo pumps and connect the evacuation lines to the high vacuum pumping unit
- Continue evacuation of the CVV
- Connect ventline
- Installation and leak test of filling port
- install the flexible heatable tubing for bake out
- connect bake out equipment to GN2 supply
- perform TRR F1 before SFT and bake out

Applicable Documents:

- PLM integration procedure
- Bake out test procedure

GSE required:

- PLM test dolly
- scaffolding
- leak test equipment

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100.000
- overhead crane , standard hoisting slings

Personnel:

AIT engineer / test conductor

CVSE technician

QA engineer

Safety Precautions:

- NA

Special Notes:

- the cleanliness requirements have to be strongly applied for the bake out equipment (GN2 flow through the He S/S)

Activity Number: F.030.020 **Duration:** tbd

Activity Name: **Connect Cryo SCOE and perform SFT 1** **Model:** PLM

Objective:

- Connect the Cryo SCOE for SFT1 before bake out
- perform SFT1

Requirements to be verified:

- proper functional and required values of the cryostat instrumentation according to PLM requirement specification (AD ..)

Environment:

temperature: 22 ± 3 ° C

humidity: 40% < RH < 60%

cleanliness: clean class 100.000

Configuration:

- PLM mounted in the test dolly
- external harness integrated

Activity Breakdown:

- perform TRR 1 (for SFT and bake out)
- prepare check out equipment (CCS and Cryo SCOE)
- perform SFT 1

Applicable Documents:

- PLM integration procedure
- short functional test procedure

GSE required:

- PLM test dolly
- Working platform
- CCS light and Cryo SCOE

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100.000
- Check out area

Personnel:

AIT engineer

check out operators

QA engineer

Safety Precautions:

- NA

Special Notes:

- NA

Activity Number: F.030.030 **Duration:** tbd

Activity Name: **Bake out** **Model:** PLM

Objective:

- Bake out of the cryostat Helium S/S to improve the isolation vacuum and support the outgassing process

Requirements to be verified:

- According to H-EPLM Requirement Specification

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM fixate in the test dolly
- CVSE and bake out equipment is installed
- Cryo SCOE is connected
- TRR has been performed

Activity Breakdown:

- Check of the complete set up
- Perform bake out according procedure
- Perform PTR F1

Applicable Documents:

- bake out test procedure
- Contamination Control Plan

GSE required:

- PLM test dolly
- scaffolding
- measurement device for bake out equipment
- CVSE
- Bake out equipment

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100.000

Personnel:

AIT engineer / test conductor

SCOE operators

AIT / CVSE technician

QA engineer

Safety Precautions:

- the GN2 for bake out will be heated above 80°C

Special Notes:

- the cleanliness requirements have to be strongly applied for the bake out equipment (GN2 flow through the cryostat Helium S/S)

Activity Number: F.030.040 **Duration:** tbd

Activity Name: **Integration of BOLA and CCU** **Model:** PLM

Objective:

- Integration of Bolometer Amplifier (used for PACS)

Requirements to be verified:

- According to BOLA integration procedure

Environment:

temperature:	2 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM mounted in the test dolly
- FM BOLA and CCU released for integration

Activity Breakdown:

- Record the mass of BOLA
- preparation of fixation areas
- install BOLA to CVV support structure
- install and connect CCU onto SVM support structure
- check screw torque and locking etc.
- perform electrical checks
- perform KIP F4 after external completion

Applicable Documents:

- PLM integration procedure
- Contamination Control Plan

GSE required:

- PLM test dolly
- scaffolding
- standard hoisting devices

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100.000
- overhead crane

Personnel:

AIT engineer

AIT technician

crane operator

QA engineer

Safety Precautions:

- NA

Special Notes:

- the cleanliness requirements have to be applied

Activity Number: F.030.050 **Duration:** tbd

Activity Name: **Alignment check warm** **Model:** PLM

Objective:

- measure the alignment status after bake out

Requirements to be verified:

- according to PLM requirement specification
- according to PLM integration procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM mounted in test dolly
- bake out has been performed

Activity Breakdown:

- install alignment equipment
- perform alignment measurements LOU versus OB (HIFI) with alignment camera
- compare the alignment measurements prior and after bake out

Applicable Documents:

- instrument alignment procedure
- Contamination Control Plan

GSE required:

- PLM Integration dolly in vertical direction
- Working platform
- PLM alignment equipment

Facility / Instrumentation:

- Astrium AIT facility; clean room class 100.000

Personnel:

crane operator / technician

AIT engineer

optical engineer

QA engineer

Safety Precautions:

- NA

Special Notes:

the cleanliness requirements have to be applied

A1.3.4 He-I and He-II Activities (F.040.000)

Activity Number: F.040.010 **Duration:** tbd

Activity Name: **Preparation for cool down and filling** **Model:** PLM

Objective:

- preparation of CVSE for cool down and filling activities

Requirements to be verified:

- according to cool down and test procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM vertically mounted in the test dolly
- evacuation port already installed and leak tested
- evacuation lines installed and leak tested
- CVV evacuated until required vacuum pressure (VG901 and VG902)

Activity Breakdown:

- Re-install turbo pumps and connect the evacuation lines to the high vacuum pumping unit
- Continue evacuation of the CVV
- Requirement for start of cooldown: $P< 1x10^{-5}$ mbar install working platform (also used for filled LHe dewar)
- Connect ventline
- Installation and leak test of filling port
- Prepare LHe transfer line
- Provide LHe supply dewars

Applicable Documents:

- cool down and filling test procedure

GSE required:

- PLM test dolly
- working platform for additional load (LHe dewar etc.)
- leak test equipment
- strap pretension measurement equipment

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100 000;
- overhead crane , standard hoisting slings

Personnel:

AIT engineer / test conductor

CVSE technician

QA engineer

Safety Precautions:

- Standard safety precautions for crane operations
- Standard safety precautions for cryo operations

Special Notes:

- cleanliness requirements for LHe transfer lines shall be applied

Activity Number: F.040.020 **Duration:** tbd

Activity Name: **Cooling and filling LHe including leak test** **Model:** PLM

Objective;

- cool down and filling of Helium II tank

Requirements to be verified:

- according to cool down test procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM mounted in the test dolly
- CVV is evacuated down to required values and turbo pumps in operation
- EGSE is connected and in operational condition
- filling port is installed and leak tested
- strap pretension measurement device is installed

Activity Breakdown:

- perform TRR F2 (release for cool down and filling)
- install transfer line in supply dewar and PLM filling port
- Start cool down of HTT w.r.t. temperature gradients
- During cool down increase the pretension to the required values w.r.t. OB alignment too
- Start filling of HTT if temperatures T101 /102 ≤ 4.2 K
- Continue filling until liquid level ≥ 98 %
- Prepare final configuration after filling (e.g. CVV evacuation, oscillation damper, valve status, filling port, transfer lines etc.)

Remark:

- alignment measurements shall be performed in parallel to cool down and filling activities

Applicable Documents:

- cool down and filling test procedure
- procedure for preparation of transfer lines
- procedure for mounting and dismounting of oscillation damper

GSE required:

- PLM test dolly
- heavy platform
- evacuation equipment
- strap pretension measurement equipment
- CVSE for filling operations
- checkout equipment (CCS and Cryo SCOE)

Facility / Instrumentation:

- Astrium GmbH, cleanroom class 100 000;
- overhead crane, standard hoisting slings

Personnel: (double shift)

AIT engineer / test conductor

cryo operation manager

check out operator

CVSE technician

QA engineer

Safety Precautions:

- Standard safety precautions for crane and cryo operations

Special Notes:

- cleanliness requirements for LHe transfer lines shall be applied

Activity Number: F.040.030 **Duration:** tbd

Activity Name: **alignment verification and adjustments during cool down** **Model:** PLM

Objective:

- alignment measurements through the " LOU windows" during cool down

Requirements to be verified:

- according PLM requirement specification

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM mounted in the test dolly
- cool down activities are running

Activity Breakdown:

- install alignment equipment
- Cool down and filling activities in parallel
- Adjust strap pretension in parallel
- perform alignment measurement LOU vs. HIFI FPU with alignment camera

Applicable Documents:

- Herschel alignment concept
- Alignment procedure

GSE required:

- PLM test dolly
- scaffolding
- strap pretension measurement equipment
- alignment equipment

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100 000;

Personnel:

AIT engineer / test conductor

alignment technicians / engineers

QA engineer

Safety Precautions:

- safety precautions for crane and cryo operations

Special Notes:

- cleanliness requirements for LHe transfer lines shall be applied

Activity Number: F.040.040 **Duration:** tbd

Activity Name: **SFT 2 at He-I (cryostat & instruments)** **Model:** PLM

Objective:

- perform a short functional test of the cryostat and scientific instruments after cool down activities and before He-II production

Requirements to be verified:

- proper functional and required values of the cryostat instrumentation according to H-EPLM requirement specification (AD 03)

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM mounted in the test dolly
- PLM at He-I conditions

Activity Breakdown:

- prepare check out equipment (CCS and Cryo SCOE)
- perform SFT

Applicable Documents:

- short functional test procedure

GSE required:

- PLM test dolly
- scaffolding
- checkout equipment (CCS and Cryo SCOE)

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100 000; check out area

Personnel:

test conductor

AIT engineer

checkout operators

QA engineer

Safety Precautions:

- standard precautions for cryo operations

Special Notes:

- NA

Activity Number: F.040.050 **Duration:** tbd

Activity Name: **Production of He-II and top up** **Model:** PLM

Objective:

- execute the transfer activities from He-I to He-II

Requirements to be verified:

- according to H-EPLM requirement specification (AD 03)
- according to He-II production and top up procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM mounted in the test dolly
- PLM Cryostat in He-I conditions, any HTT filling level
- vent line is connected
- filling port is mounted

Activity Breakdown:

- Check PLM status (liquid level of HTT, valve status, CVSE; Cryo SCOE)
- Preparation activities (if mounted remove oscillation damper; prepare MGSE, install aux. lines, prepare and install transfer lines, install supply and transport dewar)
- refilling of HTT with He-I if needed
- Prepare He-I and He-II pumping units
- Filling of HOT with He-I
- Prepare and connect He-I and He-II pumping units to SV 121 respectively to V502
- Start He-II production (valve status according to He-II production and top procedure)
- After completion of He-II production prepare final configuration (check valve status, retract transfer line and close filling port, stop He pumping unit I, remove supply and transport dewar, continue pumping with He pumping unit II)

Applicable Documents:

- He-II production and top up procedure
- procedure for preparation o f transfer lines
- procedure for mounting and dismounting of oscillation damper

GSE required:

- PLM test dolly
- heavy duty working platform
- checkout equipment (CCS light and Cryo SCOE)
- CVSE for filling operations (He vacuum pumping unit I and II, Transfer lines, LHe supply dewars)
- safety line to filling port

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100 000;
- overhead crane , standard hoisting slings

Personnel:

AIT engineer / test conductor

cryo operation manager

check out operator

CVSE technician

Safety Precautions:

- Standard safety precautions for crane and cryo operations

Special Notes:

cleanliness requirements for LHe transfer lines shall be applied

Activity Number: F.040.060 **Duration:** tbd

Activity Name: SFT 3 at He-II (cryostat) **Model:** PLM

Objective:

- perform a short functional test after He-II production

Requirements to be verified:

- proper functional and required values of the cryostat instrumentation according to H-EPLM requirement specification (AD 03)

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM mounted in the test dolly
- HTT in He-II conditions

Activity Breakdown:

- prepare check out equipment (CCS and Cryo SCOE)
- perform SFT
- perform PTR F2

Applicable Documents:

- short functional test procedure

GSE required:

- PLM test dolly
- scaffolding
- checkout equipment (CCS and Cryo SCOE)
- CVSE

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100 000; check out area

Personnel:

test conductor

AIT engineer

check out operators

QA engineer

Safety Precautions:

- NA

Special Notes:

- NA

A1.3.5 Integrated Module Tests (IMT) (F.050.000)

Activity Number: F.050.010 **Duration:** tbd

Activity Name: **Cryostat tests (CCU and instrumentation)** **Model:** PLM

Objective:

- preparation of integrated module tests (IMT)
- preparation of instrument test set-up for functional and performance testing of the instruments (HIFI,PACS and SPIRE)
- check of instrument EGSE (self test) and instrument EGSE interfaces to System EGSE

Requirements to be verified:

- according to H-EPLM requirement specification (AD03)
- according to Instrument Test Procedure on PLM PFM level

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM mounted in the test dolly
- SFT at He-II has been performed

Activity Breakdown:

- Provide the EGSE set-up for instrument testing
- Perform self-test of instrument EGSE
- Check instrument EGSE interfaces to System EGSE
- perform TRR F3 including release for instrument testing

Applicable Documents:

- Dedicated Instrument Test Procedures

GSE required:

- PLM test dolly
- PLM EGSE, Cryo SCOE, CCS light, data and power front ends

Facility / Instrumentation:

- Astrium GmbH , cleanroom class 100 000;
- Check out area

Personnel:

AIT engineer / test conductor

Cryo manager

representatives of instruments

EGSE operators

instrument operators

QA engineer

Safety Precautions:

- Standard safety precautions for cryo operations

Special Notes:

- NA

Activity Number: F.050.020 **Duration:** tbd

Activity Name: HIFI Tests **Model:** PLM

Objective:

- Functional and performance test of HIFI

Requirements to be verified:

- According to functional and performance test procedure for HIFI

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM mounted in the test dolly
- PLM in He-II conditions
- EGSE set-up completely tested

Activity Breakdown:

- Perform functional performance test
- Evaluate results, release for next instrument test

Applicable Documents:

- functional and performance test procedure for HIFI

GSE required:

- PLM test dolly
- scaffolding
- checkout equipment (CCS light and Cryo SCOE)

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100 000; check out area

Personnel:

AIT engineer / test conductor

Cryo manager

representatives of instruments

EGSE operators

instrument operators

QA engineer

Safety Precautions:

- Standard safety precautions for cryo operations

Special Notes:

- NA

Activity Number: F.050.030 **Duration:** tbd

Activity Name: **PACS Tests** **Model:** PLM

Objective:

- Functional and performance test of PACS

Requirements to be verified:

- According to functional and performance test procedure for PACS

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM mounted in the test dolly
- PLM in He-II conditions
- EGSE set-up completely tested

Activity Breakdown:

- Perform functional performance test
- Evaluate results, release for next instrument test

Applicable Documents:

- functional and performance test procedure for PACS

GSE required:

- PLM test dolly
- scaffolding
- checkout equipment (CCS light and Cryo SCOE)

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100 000; check out area

Personnel:

AIT engineer / test conductor

Cryo manager

representatives of instruments

EGSE operators

instrument operators

QA engineer

Safety Precautions:

- Standard safety precautions for cryo operations

Special Notes:

- NA

Activity Number: F.050.040 **Duration:** tbd

Activity Name: **SPIRE Tests** **Model:** PLM

Objective:

- Functional and performance test of SPIRE

Requirements to be verified:

- According to functional and performance test procedure for SPIRE

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM mounted in the test dolly
- PLM in He-II conditions
- EGSE set-up completely tested

Activity Breakdown:

- Perform functional performance test
- Evaluate results, release for next instrument test

Applicable Documents:

- functional and performance test procedure for SPIRE

GSE required:

- PLM test dolly
- scaffolding
- checkout equipment (CCS light and Cryo SCOE)

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100 000; check out area

Personnel:

AIT engineer / test conductor

Cryo manager

representatives of instruments

EGSE operators

instrument operators

QA engineer

Safety Precautions:

- Standard safety precautions for cryo operations

Special Notes:

NA

Activity Number: F.050.050 **Duration:** tbd

Activity Name: **PACS / SPIRE tests (parallel mode)** **Model:** PLM

Objective:

- Test of parallel mode for PACS / SPIRE

Requirements to be verified:

- According to test procedure for PACS / SPIRE in parallel mode

Environment:

temperature: 22 ± 3 ° C

humidity: 40% < RH < 60%

cleanliness: clean class 100.000

Configuration:

- PLM mounted in the test dolly
- PLM in He-II conditions
- EGSE set-up completely tested

Activity Breakdown:

- Execute the parallel mode of PACS / SPIRE
- Evaluate results
- Perform PTR F3

Applicable Documents:

- functional and performance test procedure for PACS and SPIRE

GSE required:

- PLM test dolly
- scaffolding
- checkout equipment (CCS and Cryo SCOE)

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100 000; check out area

Personnel:

AIT engineer / test conductor

Cryo manager

representatives of instruments

EGSE operators

instrument operators

QA engineer

Safety Precautions:

- Standard safety precautions for cryo operations

Special Notes:

- NA

A1.3.6 EMC Tests (F.060.000)

Activity Number: F.060.010 **Duration:** tbd

Activity Name: **EMC test CE at He-II** **Model:** PLM

Objective:

- EMC test on PLM level

Requirements to be verified:

- EMC requirement specification AD 04
- EMC test specification

Environment:

temperature: 22 ± 3 ° C

humidity: 40% < RH < 60%

cleanliness: clean class 100.000

Configuration:

- PLM mounted on test dolly
- HTT at He-II temperature

Activity Breakdown:

- verify EGSE/CCS set-up for EMC testing
- install and calibrate EMC test set-up
- perform TRR F4
- Perform EMC test (CE only)
- Perform PTR F4

Applicable Documents:

- EMC test specification
- EMC test procedure

GSE required:

- PLM Test dolly
- working platform
- checkout equipment (CCS- and Cryo SCOE)
- CVSE
- EMC (CE) test equipment

Facility / Instrumentation:

- Astrium AIT facility, cleanroom class 100 000
- Check out area

Personnel:

AIT Test conductor

EMC measurement team

Cryo manager

EGSE / CCS operators

AIT / CVSE technician

QA engineer

Safety Precautions:

- standard safety precautions for cryo operations
- standard precautions for EMI

Special Notes:

NA

Activity Number: F.060.020 **Duration:** tbd

Activity Name: **Conversion to He-I** **Model:** PLM

Objective:

- Conversion of HTT from He-II to He-I condition

Requirements to be verified:

- none

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM mounted in the test dolly
- HTT in He-II conditions
- ventline attached to V502
- CVSE and CCS connected
- He pumping unit II connected and running

Activity Breakdown:

- Shut- off helium ventline by closing V501/503 and 502
- Stop He pumping unit II and disconnect
- shut-off HTT by closing V104/103/106
- activate heaters H103/104 to heat up HTT to 4.2K and 1050mbar
- monitor HTT pressure and temperature
- When He-I conditions are achieved, open V104 and subsequently V502 or 501/503 to allow helium vent flow through either ventline or exhaust nozzles

Applicable Documents:

- PLM Depletion and warm up procedure

GSE required:

- PLM test dolly
- scaffolding
- checkout equipment (CCS light and Cryo SCOE)
- CVSE

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100 000; check out area

Personnel:

AIT engineer

CVSE operator

EGSE operator

CVSE technicians

QA engineer

Safety Precautions:

- standard safety precautions for cryo operations

Special Notes:

- ensure positive pressure gradient to ambient at any time in ventline to prevent backflow of air into He-Subsystem

A1.3.7 PFM Satellite Integration (F.070.000)

Activity Number: F.070.010 **Duration:** tbd

Activity Name: **De-mating of SVM support structure and WU** **Model:** PFM SAT

Objective:

De-integration of SVM support structure

Requirements to be verified:

- according to HERSCHEL EPLM AIV and HERSCHEL Satellite AIT Requirements Specification (AD02)
- according to PLM integration procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100 000

Configuration:

- PLM mounted in the test dolly
- PLM main tank in He-I conditions

Activity Breakdown:

- disconnect harness between SVM structure and PLM
- dismount SVM support structure including WUs from
- perform visual inspection
- store SVM support structure and de-integrate the SVM panels including FM WUs

Applicable Documents:

- PLM integration procedure

GSE required:

- miscellaneous integration tools

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100 000;
- overhead crane

Personnel:

AIT engineer

AIT technician for SVM - activities

QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations

Special Notes:

- NA

Activity Number: F.070.020 **Duration:** tbd

Activity Name: **Preparation & Mating of FM SVM and PFM PLM** **Model:** PFM SAT

Objective:

- Preparation & Mating of PLM with FM SVM

Requirements to be verified:

- according to HERSCHEL EPLM AIV and Satellite AIT Requirements Specification (AD02)
- according to PFM satellite integration procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM mounted in test dolly
- PLM HTT in He-I conditions
- SVM mounted in the MPT

Activity Breakdown:

- perform SVM incoming inspection
- prepare SVM MGSE
- mechanical check of the SVM / PLM I/F
- prepare required status of SVM component [reaction control system (RCS), power control system (PCS), Attitude and orbit control systems (ACMS) etc.]
- check the electrical harness integration and I/F to PLM
- perform MIP F3
- SVM released for mating
- lifting of PLM with vertical lifting device
- mechanical and electrical mating of SVM to PLM
- shimming and alignment of I/F in axial and lateral direction
- check the final screw torque an locking

Applicable Documents:

- SVM integration procedure
- PFM satellite integration procedure

GSE required:

- satellite Multi Purpose Trolley
- PLM test dolly
- PLM vertical lifting device
- SVM hoisting equipment
- Hydraset
- working platform
- checkout equipment (CCS- and Cryo SCOE)

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100 000
- check out area
- overhead crane

Personnel:

SVM integration/ test manager

AIT PLM engineer

AIT technician for SVM - activities

SVM check out operators

SVM QA engineer

EPLM QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations

Special Notes:

NA

Activity Number: F.070.030 **Duration:** tbd

Activity Name: **Electrical integration of WU panels to FM SVM** **Model:** PFM SAT

Objective:

- Integration of WU panels to FM SVM

Requirements to be verified:

- according to FM S/C integration procedure
- according contamination control plan (AD 05)

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100 000

Configuration:

- PLM main tank in He-I conditions
- PFM PLM and FM SVM mated and mounted on MPT
- FM panel including WUs prepared for integration to FM SVM

Activity Breakdown:

- Mechanical integration of FM panel including WUs
- Electrical integration of FM panel including WUs

Applicable Documents:

- PFM satellite integration procedure
- FM SVM integration procedure

GSE required:

- SVM Multi Purpose Trolley (MPT)
- working platform
- checkout equipment (CCS/EGSE incl. Cryo SCOE)
-

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class
- 100 000; check out area
- overhead crane

Personnel:

AIT PLM engineer

AIT technicians

check out operators

AIT electrical technicians

QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations

Special Notes:

ESD requirements have to be applied

Activity Number: F.070.040 **Duration:** tbd

Activity Name: **Integration of telescope** **Model:** PFM SAT

Objective:

- Integration of FM Telescope

Requirements to be verified:

- according to FM S/C integration procedure
- according contamination control plan (AD 05)

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100 000

Configuration:

- PLM and SVM mated and aligned onto MPT
- PLM main tank in He-I conditions

Activity Breakdown:

- Telescope released for mating
- verify the cleanliness status (obscuration values)
- install working platform
- provide telescope lifting device
- integrate telescope struts
- pre-shimming and pre-alignment of telescope
- check the final screw torque and locking
- document the obscuration status after integration
- protect the telescope critical surface
- perform KIP F5

Applicable Documents:

- PFM satellite integration procedure
- FM telescope handling procedure
-

GSE required:

- SVM Multi Purpose Trolley (MPT)
- telescope lifting device
- Hydra-set
- working platform

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100.000; check out area
- overhead crane

Personnel:

AIT PLM engineer

AIT technician

check out operators

QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations

Special Notes:

- apply precautions for telescope handling due to the critical surfaces

Activity Number: F.070.050 **Duration:** tbd

Activity Name: **Alignment telescope to CVV** **Model:** PFM SAT

Objective:

- Final alignment of telescope to CVV

Requirements to be verified:

- according to PFM S/C integration procedure
- according to telescope alignment procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM and SVM mated and aligned onto MPT
- PLM main tank in He-I conditions
- telescope integrated onto EPLM

Activity Breakdown:

- preparation of alignment equipment
- install working platform
- install / check the mirror cubes for alignment measurements
- final shimming and alignment of telescope
- check the final screw torque an locking
- document the obscuration status
- protect the telescope critical surface

Applicable Documents:

- telescope alignment procedure
- according to PFM S/C integration procedure

GSE required:

- SVM Multi Purpose Trolley (MPT)
- working platform
- alignment equipment
- special integration tools for shimming

Facility / Instrumentation:

- Astrium AIT facility, cleanroom class 100.000
- Check out area
- overhead crane

Personnel:

AIT S/C integration engineer

AIT technician

alignment technician / engineers

QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations

Special Notes:

- apply precautions for telescope handling due to the critical surfaces

Activity Number: F.070.060 **Duration:** tbd

Activity Name: **Integration of sunshield and S/A (mechanical, electrical and thermal)** **Model:** PFM SAT

Objective:

- Mechanical, electrical and thermal integration of FM sunshield & solar array

Requirements to be verified:

- according to PFM S/C integration procedure
- according to Sunshield & S/A integration procedure

Environment:

- temperature: 22 ± 3 ° C
- humidity: 40% < RH < 60%
- cleanliness: clean class 100.000

Configuration:

- PLM and SVM mated and aligned onto MPT
- PLM HTT in He-I conditions
- telescope integrated onto EPLM and aligned to CVV
- sunshield released for integration

Activity Breakdown:

- release of sunshield for integration
- preparation of sunshield for integration
- provide working platform
- provide struts for sunshield integration
- integrate the struts to SVM and PLM
- mechanical integration of the sunshield
- check the final screw torque and locking
- electrical integration and check of the S/A harness
- integrate/complete the sunshield MLI
- protect the sunshield outer surface (S/A)

Applicable Documents:

- PFM S/C integration procedure
- Sunshield integration procedure including electrical checkout of S/A
- sunshield handling procedure

GSE required:

- SVM Multi Purpose Trolley (MPT)
- working platform
- sunshield surface protection parts
- sunshade hoisting equipment
- Hydra- set
- digital multimeter

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100 000
- Check out area
- overhead crane

Personnel:

AIT S/C integration engineer

AIT technician

S/A electrician technicians

MLI technician

QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations

Special Notes:

- observe special precaution for sunshield handling

Activity Number: F.070.070 **Duration:** tbd

Activity Name: **Integration of sunshade (mech. and thermal)** **Model:** PFM SAT

Objective:

- Mechanical and thermal integration of sunshade

Requirements to be verified:

- according to PFM S/C integration procedure

Environment:

- temperature: 22 ± 3 ° C
- humidity: 40% < RH < 60%
- cleanliness: clean class 100.000

Configuration:

- PLM and SVM mated and aligned onto MPT
- PLM HTT in He-I conditions
- telescope integrated onto EPLM and aligned to CVV
- sunshield integrated
- sunshade released for integration

Activity Breakdown:

- preparation of sunshade elements for integration
- provide working platform
- provide I/F brackets for sunshade integration
- integrate the I/F brackets to sunshields
- mechanical integration of the sunshade
- check the final screw torque and locking
- integrate the sunshade MLI

Applicable Documents:

- PFM S/C integration procedure
- Sunshade integration procedure
- Sunshade handling procedure

GSE required:

- SVM Multi Purpose Trolley (MPT)
- working platform
- sunshield surface protection parts
- sunshade hoisting equipment
- Hydraset

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100 000
- Check out area
- overhead crane

Personnel:

AIT S/C integration engineer

AIT technician

MLI technician

QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations

Special Notes:

- observe special precaution for sunshade handling

Activity Number: F.070.080 **Duration:** tbd

Activity Name: **S/C completion (MLI etc.)** **Model:** PFM SAT

Objective:

- Completion of satellite configuration before transport to environmental test facility

Requirements to be verified:

- according to PFM S/C integration procedure

Environment:

- temperature: 22 ± 3 ° C
- humidity: 40% < RH < 60%
- cleanliness: clean class 100.000

Configuration:

- PLM and SVM mated and aligned onto MPT
- PLM HTT in He-I conditions
- telescope integrated onto PLM and aligned to PLM
- sunshield integrated
- sunshade integrated

Activity Breakdown:

- provide working platform
- integrated the rest of MLI blankets in sunshield / sunshade I/F areas
- complete the S/C configuration for the following tests
- perform MIP

Applicable Documents:

- PFM S/C integration procedure

GSE required:

- Satellite Multi Purpose Trolley (MPT)
- working platform
- digital multimeter (grounding measurements)

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100 000
- Check out area
- overhead crane

Personnel:

AIT S/C integration engineer

AIT technician

MLI technician

QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations

Special Notes:

- NA

Activity Number: F.070.090 **Duration:** tbd

Activity Name: **S/C alignment measurements** **Model:** PFM SAT

Objective:

- Final alignment measurements status after satellite integration and before environmental tests

Requirements to be verified:

- according to PFM satellite alignment procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PLM and SVM mated and aligned
- PLM main tank in He-I conditions
- telescope integrated and aligned
- **sunshade integrated**

Activity Breakdown:

- preparation of alignment equipment
- install working platform
- check the mirror cubes for alignment measurements
- perform alignment measurements (status before vibration)
- perform MIP F4

Applicable Documents:

- PFM satellite alignment procedure

GSE required:

- SVM Multi Purpose Trolley (MPT)
- working platform
- alignment equipment
- checkout equipment (CCS- and Cryo SCOE)

Facility / Instrumentation:

- Astrium AIT Facility , cleanroom class 100.000
- Check out area
- overhead crane

Personnel:

AIT S/C integration engineer

AIT technician

alignment technician / engineers

QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations

Special Notes:

NA

A1.3.8 Integrated System Test 1 (IST) (F.080.000)

Activity Number: F.080.010 **Duration:** tbd

Activity Name: **Preparation and connection of CVSE and GSE** **Model:** PFM SAT

Objective:

Preparation and connection of GSE/CCS and CVSE after satellite integration and before He-II production

Requirements to be verified:

- according to GSE and CVSE requirement specifications

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM Satellite mounted on MPT
- HTT at He-I temperature, any filling level
- HOT empty
- complete EGSE/CCS available and validated
- CVSE available

Activity Breakdown:

- install working platform
- connect checkout equipment (CCS/EGSE incl. Cryo SCOE) to the satellite
- install CVSE incl. filling port

Applicable Documents:

- He-I filling and top up procedure
- He-II production and top up procedure

GSE required:

- Multi Purpose Trolley (MPT)
- working platform
- checkout equipment (CCS/EGSE incl. Cryo SCOE)
- CVSE for He-I top up and He-II production

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100,000
- overhead crane

Personnel:

Test Manager

AIT Test conductor

Cryo manager

EGSE operators

AIT / CVSE technician

QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations

Special Notes:

- NA

Activity Number: F.080.020 **Duration:** tbd

Activity Name: **He-II production and top up** **Model:** PFM SAT

Objective:

perform the He-II production and top up before IST

Requirements to be verified:

- according to He-II production and top up procedure

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM Satellite mounted on MPT
- HTT at He-I temperature, any filling level
- HOT empty
- filling port mounted

Activity Breakdown:

- Check PLM status (liquid level of HTT, valve status Cryo EGSE etc.)
- Remove oscillation damper (if installed), prepare MGSE, install auxiliary lines, install transfer lines, install supply- and transport dewar.
- Prepare He-I and He-II pump units
- Top up of HTT with He-I
- Connect He-I and He-II pump units
- Start He-II production in HTT
- Continue with He-II top up
- Prepare final configuration after top up (check valve status, retract transfer line and close filling port, stop He pump unit I , remove supply- and transport dewar, continue pumping with He pump unit II)

Applicable Documents:

- He-II production and top up procedure

GSE required:

- Multi Purpose Trolley (MPT)
- heavy duty access working platform
- checkout equipment (CCS/EGSE and Cryo SCOE)
- CVSE for He-I and He-II top up
- He-I supply and transfer equipment

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100,000
- overhead crane

Personnel: (2-shift)

Test Manager

AIT Test conductor

Cryo manager

EGSE operators

AIT / CVSE technician

QA engineer

Safety Precautions:

- standard safety precautions for cryo and crane operations

Special Notes:

- NA

Activity Number: F.080.030 **Duration:** tbd

Activity Name: **IST 1 (S/S IST & SFPT)** **Model:** PFM SAT

Objective:

Verify overall satellite performance after integration by:

- Subsystem performance measurements
- Scientific Instruments performance at He-II temp.
- Overall system performance measurement

Requirements to be verified:

- according to Satellite requirement specification
- according to H-EPLM requirement specification

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100,000

Configuration:

- Satellite mounted on MPT
- HTT at He-II temperature
- CVSE and CCS/EGSE available and connected

Activity Breakdown:

- perform TRR F5
- conduct subsystem performance tests (SVM and PLM S/S)
- conduct instrument performance tests
- conduct end-to-end system performance test
- perform PTR F5

Applicable Documents:

- Integrated System Test procedure

GSE required:

- Satellite Multi Purpose Trolley
- scaffolding
- CVSE
- CCS/EGSE incl. Cryo SCOE

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100,000

Personnel:

Test Conductor

electrical AIT engineers

CVSE operator

EGSE/CCS Operators

SVM test support team

QA engineer

Safety Precautions:

- standard safety precautions for cryo operations

Special Notes:

- NA

Activity Number: F.080.040 **Duration:** tbd

Activity Name: **Conversion to He-I** **Model:** PFM SAT

Objective:

- Conversion of HTT from He-II to He-I condition before transportation to environmental test site

Requirements to be verified:

- none

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM Satellite mounted on MPT in AIT facility
- HTT at He-II temperature
- ventline attached to V502
- CVSE and CCS connected
- He pumping unit II connected and running

Activity Breakdown:

- Shut- off helium ventline by closing V501/503 and 502
- Stop He pumping unit II and disconnect
- shut-off HTT by closing V104/103/106
- activate heaters H103/104 to heat up HTT to 4.2K and 1050mbar
- monitor HTT pressure and temperature
- When He-I conditions are achieved, open V104 and subsequently V502 or 501/503 to allow helium vent flow through either ventline or exhaust nozzles
- perform MIP F5

Applicable Documents:

- Helium depletion and warm-up procedure

GSE required:

- Satellite Multi Purpose Trolley
- Scaffolding
- Cryo SCOE; CCS
- CVSE

Facility / Instrumentation:

- Astrium AIT facility , cleanroom class 100,000

Personnel:

AIT engineer

Cryo Engineer

EGSE operator

CVSE technicians

QA engineer

Safety Precautions:

- standard safety precautions for cryo operations

Special Notes:

- ensure positive pressure gradient to ambient at any time in ventline to prevent backflow of air into He-Subsystem

A1.3.9 Sine Vibration Test (F.090.000)

Activity Number: F.090.010 **Duration:** tbd

Activity Name: **Transport to environmental test facility** **Model:** PFM SAT

Objective:

Transport of PFM satellite and associated GSE from Astrium GmbH AIT site to environmental test site at ESTEC

Requirements to be verified:

- according to PFM satellite handling and transportation procedure

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM satellite mounted on MPT
- Cryostat in He-I conditions; any HTT filling level
- HOT empty

Activity Breakdown:

- remove working platform
- disconnect checkout equipment and CVSE
- prepare the transport container
- move the satellite with lifting device to the prepared container
- install and check the transport data recording equipment (TMU)
- transport of satellite to environmental test site
- transport of GSE to test site
- open satellite container and lift satellite with lifting device onto MPT
- perform incoming inspection

Applicable Documents:

- PFM satellite handling and transportation procedure

GSE required:

- Satellite Multi Purpose Trolley (MPT)
- working platform
- satellite lifting device
- checkout equipment during transport
- Satellite transport container incl. TMU

Facility / Instrumentation:

- Astrium GmbH AIT Facility , cleanroom class 100.000
- ESTEC test facility; preparation area
- overhead crane

Personnel:

AIT Test conductor

AIT technician

EGSE operator

transport team

QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations

Special Notes:

- NA

Activity Number: F.090.020 **Duration:** tbd

Activity Name: **He-I top up** **Model:** PFM SAT

Objective:

Perform top up of He-I in HTT before Satellite Sine Vibration Test to achieve launch representative conditions

Requirements to be verified:

according He-I filling and top up procedure

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM Satellite mounted on MPT
- Cryostat at He-I temperature; any HTT filling level
- HOT empty

Activity Breakdown:

- prepare He-I supply and transfer equipment
- install He-I supply and transfer equipment
- install the exhaust line
- perform TRR F6
- fill up HTT until filling level of >95% achieved

Applicable Documents:

- He-I filling and top up procedure

GSE required:

- Multi Purpose Trolley
- working platform
- checkout equipment (CCS and Cryo SCOE)
- CVSE for He-I top up
- He-I supply and transfer equipment

Facility / Instrumentation:

- ESTEC test facility; preparation area

Personnel:

Test Manager

AIT Test conductor

Cryo engineer

EGSE operators

AIT / CVSE technician

QA engineer

Safety Precautions:

- standard safety precautions for cryo operations

Special Notes:

- NA

Activity Number: F.090.030 **Duration:** tbd

Activity Name: **SVM activities (RC tank filling etc.)** **Model:** PFM SAT

Objective:

Prepare SVM for sine vibration tests and subsequent environmental tests

Requirements to be verified:

- NA

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100,000

Configuration:

- PFM Satellite mounted in MPT
- HHT at He-I temperature; any filling level
- RCS empty and at ambient (tbc) pressure

Activity Breakdown:

- perform internal and external leak check on RCS
- perform functional check of RCS units (valves, sensors)
- fill propellant tank with simulation fluid
- pressurise RCS to tbd bar

Applicable Documents:

- RCS filling and pressurisation procedure
- RCS leak test procedure

GSE required:

- Satellite Multi Purpose Trolley
- CVSE
- EGSE/CCS
- RCS Loading Equipment PPLE
- RCS Ground Half Coupling GHC
- SVM Simulate Loading Equipment
- SVM Leak Test Equipment
- SVM Pump purge Equipment PPE

Facility / Instrumentation:

- IABG/ESTEC test facility; preparation area

Personnel:

AIT engineer

EGSE operator

CVSE technician

AIT technicians

SVM support team

QA engineer

Safety Precautions:

- standard safety precautions for cryo operations are applicable
- precautions against explosion due to pressure in RCS

Special Notes:

- NA

Activity Number: F.090.040 **Duration:** tbd

Activity Name: **Alignment check before Sine Vibration test** **Model:** PFM SAT

Objective:

- check satellite mechanical axes stability
- verify ACMS/RCS sensor/actuator alignment stability
- verify telescope alignment stability
- verify LOU vs. HIFI alignment

after transportation to test facility and before Sine Vibration test

Requirements to be verified:

- alignment requirements for telescope, HIFI/LOU, ACMS/RCS sensors and actuators and satellite main axes

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM Satellite mounted on MPT
- HTT in He-I condition; any filling level
- HOT empty
- RCS filled with simulation fluid and pressurised to tbd bar
- OGSE available and set-up

Activity Breakdown:

- lift satellite and install on rotary table (tbc)
- verify alignment of LOU vs. HIFI FPU with alignment camera
- verify alignment of telescope versus CVV
- verify alignment of SVM axes versus CVV
- verify alignment of ACMS/RCS units vs. SVM
- reinstall satellite on MPT

Applicable Documents:

- PFM satellite alignment verification procedure

GSE required:

- Satellite Multi Purpose Trolley or Rotary Table (tbc)
- Satellite lifting device
- Hydraset
- OGSE

Facility / Instrumentation:

- ESTEC test facility; preparation area
- overhead crane

Personnel:

Test conductor

AIT engineer

AIT technician

crane operator

alignment technician / engineers

QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations
- precautions against explosion due to pressure in RCS

Special Notes:

- NA

Activity Number: F.090.050 **Duration:** tbd

Activity Name: **SFT 4 at He-I** **Model:** PFM SAT

Objective:

- perform Satellite Short Functional Test before Sine Vibration Test to verify good functioning of the complete satellite system

Requirements to be verified:

- as per SFT procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- Satellite mounted on MPT
- HTT at He-I temperature, any filling level
- RCS filled with simulation fluid and pressurised to tbd bar

Activity Breakdown:

- prepare and connect check out system (CCS/EGSE and Cryo SCOE)
- perform SFT

Applicable Documents:

- Satellite short functional test procedure

GSE required:

- Multi Purpose Trolley (MPT)
- Working platform
- Check-out System (CCS/EGSE incl. Cryo SCOE)
- CVSE

Facility / Instrumentation:

- ESTEC test facility; preparation area

Personnel:

Test Manager

AIT Test conductor

Cryo manager

EGSE operators

AIT / CVSE technician

QA engineer

Safety Precautions:

- standard safety precautions for cryo operations
- precautions against explosion due to pressure in RCS

Special Notes:

- NA

Activity Number: F.090.060 (1/2) **Duration:** tbd

Activity Name: **Sine vibration test (3 axes, acceptance level)** **Model:** PFM SAT

Objective:

Perform acceptance level (and duration) sine vibration test in three axis to verify structural and functional integrity of complete PFM satellite

Requirements to be verified:

- according to Environmental Requirement Specification

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- STM Satellite mounted on MPT
- HTT at He-I temperature; any filling level
- HOT empty
- RCS filled with simulation fluid and pressurised to tbd bar

Activity Breakdown:

- Move satellite on MPT from preparation area to shaker facility
- Install sine vibration test adapter
- Lift satellite and mount on shaker
- install / connect all vibration sensors
- install and connect CVSE for He-I Top Up
- install CCS/EGSE
- perform TRR
- perform He-I top up as necessary before each vibration run; minimum He-level >95%
- remove protective covers from all items
- perform vibration test
  - low level (resonance search)
  - intermediate level
  - low level
  - acceptance level (and duration)
  - low level

  for all three (X, Y, Z) satellite axes
- perform PTR
- reinstall protective covers
- dismount satellite from shaker and remount on MPT

Applicable Documents:

- PFM satellite sine vibration test procedure

GSE required:

- Satellite Multi Purpose Trolley
- Satellite Lifting Device
- Hydraset
- vibration test adapter
- Scaffolding
- Mobile Access Platform
- Protective Covers
- CVSE
- Cryo SCOE, CCS /EGSE

Activity Number: F.090.060 (2/2) **Duration:** tbd

Activity Name: **Sine vibration test (3 axes, acceptance level)** **Model:** PFM SAT

Facility / Instrumentation:

- ESTEC test facility; shaker
- overhead crane

Personnel:

AIT engineer

AIT technicians

shaker facility operation team

EGSE operators

Cryo Engineer

CVSE technicians

QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations
- precautions against explosion due to pressure in RCS

Special Notes:

- NA

Activity Number: F.090.070 **Duration:** tbd

Activity Name: **SFT 5 at He-I** **Model:** PFM SAT

Objective:

- perform Satellite Short Functional Test after Sine Vibration Test to verify good functioning of the complete satellite system

Requirements to be verified:

- as per SFT procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- Satellite mounted on MPT
- HTT at He-I temperature, any filling level
- RCS filled with simulation fluid and pressurised to tbd bar

Activity Breakdown:

- prepare and connect check out system (CCS/EGSE and Cryo SCOE)
- perform SFT

Applicable Documents:

- Satellite short functional test procedure

GSE required:

- Multi Purpose Trolley (MPT)
- Working platform
- Check-out System (CCS/EGSE incl. Cryo SCOE)
- CVSE

Facility / Instrumentation:

- ESTEC test facility; preparation area

Personnel:

Test Manager

AIT Test conductor

Cryo manager

EGSE operators

AIT / CVSE technician

QA engineer

Safety Precautions:

- standard safety precautions for cryo operations
- precautions against explosion due to pressure in RCS

Special Notes:

- NA

Activity Number: F.090.080 **Duration:** tbd

Activity Name: **Alignment check after sine vibration test** **Model:** PFM SAT

Objective:

- check satellite mechanical axes stability
- verify ACMS/RCS sensor/actuator alignment stability
- verify telescope alignment stability
- verify LOU vs. HIFI alignment

after Sine Vibration test

Requirements to be verified:

- alignment requirements for telescope, HIFI/LOU, ACMS/RCS sensors and actuators and satellite main axes

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM Satellite mounted on MPT
- HTT in He-I condition; any filling level
- RCS filled with simulation fluid and pressurised to tbd bar
- OGSE available and set-up

Activity Breakdown:

- lift satellite and install on rotary table (tbc)
- verify alignment of LOU vs. HIFI FPU with alignment camera
- verify alignment of telescope versus CVV
- verify alignment of SVM axes versus CVV
- verify alignment of ACMS/RCS units vs. SVM
- reinstall satellite on MPT
- perform PTR F6 after vibration and alignment check

Applicable Documents:

- PFM satellite alignment verification procedure

GSE required:

- Satellite Multi Purpose Trolley or Rotary Table (tbc)
- Satellite lifting device
- Hydraset
- OGSE

Facility / Instrumentation:

- ESTEC test facility; preparation area
- overhead crane

Personnel:

Test conductor

AIT engineer

AIT technician

crane operator

alignment technician / engineers

QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations
- precautions against explosion due to pressure in RCS

Special Notes:

- NA

A1.3.10 TB/TV Test including System Validation Tests (F.100.000)

Activity Number: F.100.010 **Duration:** tbd

Activity Name: **Transport to TV test facility** **Model:** PFM SAT

Objective:

Transport of PFM satellite from sine vibration facility to TV/TB chamber

Requirements to be verified:

- none

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM satellite mounted on MPT
- HTT at He-I temperature, any filling level
- HOT empty
- RCS filled and pressurised to tbd bar

Activity Breakdown:

- disconnect CVSE and CCS from satellite
- move the PFM satellite mounted on MPT to the TB/TV test facility

Applicable Documents:

- PFM satellite handling and transportation procedure

GSE required:

- Satellite Multi Purpose Trolley

Facility / Instrumentation:

- ESTEC test facility

Personnel:

AIT engineer

AIT technician

QA engineer

Safety Precautions:

- standard safety precautions for cryo operations
- precautions against explosion due to pressure in RCS

Special Notes:

NA

Activity Number: F.100.020 **Duration:** tbd

Activity Name: **Preparation and connection of CVSE and GSE** **Model:** PFM SAT

Objective:

Preparation of MGSE, EGSE/CCS and CVSE at TB/TV facility

Requirements to be verified:

- according to EGSE, MGSE and CVSE requirement specifications

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM Satellite mounted on MPT
- HTT at He-I temperature, any filling level
- HOT empty
- RCS filled and pressurised to tbd bar
- complete GSE finally prepared and available

Activity Breakdown:

- install working platform
- connect checkout equipment (CCS/EGSE incl. Cryo SCOE) to the satellite
- install CVSE incl. filling port

Applicable Documents:

- He-I filling and top up procedure
- He-II production and top up procedure
- TB/TV test procedure

GSE required:

- Multi Purpose Trolley (MPT)
- working platform
- S/C hoisting device
- checkout equipment (CCS/EGSE incl. Cryo SCOE)
- CVSE for He-I top up, He-II production and TB/TV testing

Facility / Instrumentation:

- ESTEC test facility; preparation area
- overhead crane
- EGSE area

Personnel:

Test Manager

AIT Test conductor

Cryo manager

EGSE operators

AIT / CVSE technician

QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations
- precautions against explosion due to pressure in RCS

Special Notes:

- NA

Activity Number: F.100.030 **Duration:** tbd

Activity Name: **He-II production and top up** **Model:** PFM SAT

Objective:

perform the He-II production and top up before SVT and TB/TV tests

Requirements to be verified:

- according to He-II production and top up procedure

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM Satellite mounted on MPT
- HTT at He-I temperature, any filling level
- HOT empty
- filling port mounted
- RCS filled and pressurised to tbd bar

Activity Breakdown:

- Check PLM status (liquid level of HTT, valve status Cryo EGSE etc.)
- Remove oscillation damper (if installed), prepare MGSE, install auxiliary lines, install transfer lines, install supply- and transport dewar.
- Prepare He-I and He-II pump units
- Top up of HTT with He-I
- Connect He-I and He-II pump units
- Start He-II production in HTT
- Continue with He-II top up
- Prepare final configuration after top up (check valve status, retract transfer line and close filling port, stop He pump unit I , remove supply- and transport dewar, continue pumping with He pump unit II)

Applicable Documents:

- He-II production and top up procedure

GSE required:

- Multi Purpose Trolley (MPT)
- heavy duty access working platform
- checkout equipment (CCS/EGSE and Cryo SCOE)
- CVSE for He-I and He-II top up
- He-I supply and transfer equipment

Facility / Instrumentation:

- ESTEC test facility
- preparation area in front of TB/ TV chamber
- overhead crane
- EGSE area

Personnel: (2-shift)

Test Manager

AIT Test conductor

Cryo manager

EGSE operators

AIT / CVSE technician

QA engineer

Safety Precautions:

- standard safety precautions for cryo and crane operations
- precautions against explosion due to pressure in RCS

Special Notes:

- NA

Activity Number: F.100.040 **Duration:** tbd

Activity Name: **System validation test 1 (SVT)** **Model:** PFM SAT

Objective:

to demonstrate compatibility between the Herschel satellite and the satellite control centre at ESOC

Requirements to be verified:

- according to satellite performance requirement specification

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100,000

Configuration:

- PFM SAT mounted in MPT
- HTT at He-II conditions; any filling level
- HOT empty
- RCS filled and pressurised to tbd bar
- CVSE and CCS/EGSE connected

Activity Breakdown:

- perform TRR F7
- setting of CCS/EGSE in SVT configuration
- connect ESOC interface equipment and modems
- perform SVT (details to be defined with ESOC support)
- perform PTR F7

Applicable Documents:

- SVT procedure

GSE required:

- satellite Multi Purpose Trolley
- checkout equipment (CCS/EGSE and Cryo SCOE)
- He pump units I and II

Facility / Instrumentation:

- ESTEC test facility
- preparation area in front of TV chamber
- EGSE area

Personnel:

Test manager

Test conductor

Cryo engineer

EGSE operators

AIT / CVSE technician

SVM support team

ESOC operations team

QA engineer

Safety Precautions:

- standard safety precautions for cryo operations
- precautions against explosion due to pressure in RCS

Special Notes:

- It may be required to perform some ACMS closed loop test cases. It may be necessary therefore to install special ACMS test cabling at an earlier stage during AIT

Activity Number: F.100.050 **Duration:** tbd

Activity Name: **Installation and set-up in LSS** **Model:** PFM SAT

Objective:

Installation of the satellite including GSE/CVSE in TV chamber

Requirements to be verified:

- according to satellite AIT requirement specification
- according to PFM satellite TB/TV test procedure
- according to contamination control plan

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM Satellite mounted on MPT
- HTT at He-II conditions
- HOT empty
- RCS filled and pressurised to tbd bar

Activity Breakdown:

- check the cleanliness status of TV chamber
- preparation of TV chamber and bake out
- preparation of active cooling of CVV
- Install S/C in the TV chamber including thermal adapter and thermal shields
- install internal and external CVSE
- install test harnesses and connect to CCS
- perform leak tests of installed tubing
- complete the MLI installation at S/C and thermal adapter
- remove protective covers from contamination sensitive surfaces
- install samples for contamination control

Applicable Documents:

- PFM Satellite TB/TV Test Procedure

GSE required:

- Satellite vertical lifting device
- cleaning equipment
- samples for particle and molecular contamination verification
- thermal test adapters (TTAP and TTA)
- checkout equipment (CCS/EGSE and Cryo SCOE)
- He pump units I and II
- TV chamber data acquisition
- TV chamber pump units
- safety equipment

Facility / Instrumentation:

- ESTEC test facility
- TV chamber
- overhead crane
- EGSE area

Personnel:

Test Manager
AIT Test conductor
Cryo engineer
EGSE operators
AIT / CVSE technician
TV chamber operation team
technical support for SVM activities
QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations
- precautions against explosion due to pressure in RCS
- safety equipment during TB/TV test shall be provided

Special Notes:

- the cleanliness requirements shall be strongly applied

Activity Number: F.100.060 **Duration:** tbd

Activity Name: **Ground Lifetime and Launch autonomy verification** **Model:** PFM SAT

Objective:

perform the ground life time and launch autonomy test during/after installation into the TV chamber to

- obtain a set of temperature parameters and the mass flow for near ground equilibrium conditions for comparison with model predictions (ground lifetime)
- to simulate the conditions on the launcher during final launch preparations and launch and to verify acceptable temperatures and filling level in HTT at begin of mission

Requirements to be verified:

- according to satellite AIT requirement specification
- according to Satellite performance requirement specification

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- satellite installed in vertical direction on thermal test adapter inside the open TV chamber
- HTT at He-II temperature
- HOT empty
- CVSE and CCS attached to satellite
- RCS filled and pressurised to tbd bar

Activity Breakdown:

- ground lifetime:
  - record cryostat control instrument data (temperatures , mass flow etc.)
  - wait for temperature equilibrium and compare with prediction
- He-II top up
- Launch autonomy
  - closing of HTT
  - Disconnect of He Pumping Unit I and II
  - Filling of HOT with He-I
  - Refilling of HOT with He-I every other day (tbc) and recording of the He-II tank temperature profile
- depletion of HOT at end of launch autonomy test
- connect He pumping units I and II
- opening of HTT

Applicable Documents:

- PFM launch autonomy / ground life time test procedure

GSE required:

- working platform
- checkout equipment (CCS/EGSE and Cryo SCOE)
- CVSE for launch autonomy and ground lifetime test

Facility / Instrumentation:

- IABG/ESTEC test facility; TV chamber
- EGSE area
- test team offices

Personnel:

Test conductor
Cryo manager
EGSE operators
AIT / CVSE technician
QA engineer

Safety Precautions:

- standard safety precautions for cryo and crane operations
- precautions against explosion due to pressure in RCS

Special Notes:

- NA

Activity Number: F.100.070 (1/2) **Duration:** tbd

Activity Name: **TB / TV test** **Model:** PFM SAT

Objective:

- perform TB/ TV test as defined
- qualification of thermal design
- validation of mathematical model to predict temperatures on flight and life time
- verification of alignment (HIFI vs. LOU)
- verification of I/F heat transfer
- identification of proper system functional aspects
- verification of MLI workmanship

Requirements to be verified:

- according to satellite AIT requirement specification
- according to TB/TV test procedure

Environment:

as per TB/TV test procedure

Configuration:

- satellite installed in vertical direction on thermal test adapter inside the open TV chamber
- HTT at He-II temperature
- HOT empty after launch autonomy tests
- CVV active cooling attached
- RCS filled and pressurised to tbd bar

Activity Breakdown:

- perform He-II top up
- visual inspection of installed H/W
- release for TB/ TV test
- close TV chamber
- pumping and cool down of TV chamber
- simulation of launch phase pressure gradients
- the shroud temperature shall be below 100k, the vacuum pressure inside the chamber shall be below 1x10 –5 mbar tbc.

- Step 1
  - Actively cool down of CVV until 90 K tbc
  - tilting of satellite according PPS needs (maximal 30 degrees)
  - check of cryostat internal balance
  - alignment measurements (see F.100.080)
- Step 2
  - switch off active cooling of CVV
  - perform thermal balance test
  - perform thermal cycling test incl. hot and cold soak and transition phase

Applicable Documents:

- PFM Satellite TB/TV Test Procedure

GSE required:

- checkout equipment (CCS/EGSE, Cryo SCOE, Brake-out boxes, power supplies)
- He pump units I and II
- thermal test adapter
- diverse protective covers
- Special cooling equipment for CVV
- TV chamber data acquisition
- TV chamber pump units
- safety equipment

Activity Number: F.100.070 (2/2) **Duration:** tbd

Activity Name: **TB / TV test** **Model:** PFM SAT

Facility / Instrumentation:

- ESTEC test facility; TV chamber
- EGSE area
- test team offices

Personnel: (3-shift during test)

Test Manager

AIT Test conductor

Cryo manager

EGSE operators

AIT / CVSE technician

chamber operation team

SVM support team

QA engineer

Safety Precautions:

- standard safety precautions for cryo operations
- precautions against explosion due to pressure in RCS

Special Notes:

- the cleanliness requirements shall be strongly applied

Activity Number: F.100.080 **Duration:** tbd

Activity Name: **Alignment check during TB/TV test** **Model:** PFM SAT

Objective:

Check alignment stability of HIFI FPU versus LOU during TB/TV test

Requirements to be verified:

- alignment requirements for LOU/HIFI

Environment:

- as per TB/TV test procedure

Configuration:

- PFM Satellite mounted on Thermal Test Adapter in TV chamber
- TB/TV test running
- HTT at He-II temperature

Activity Breakdown:

- Continuous alignment measurement of HIFI FPU reference to outer CVV (LOU) through LOU optical window with alignment camera (tbc)

Applicable Documents:

- PFM satellite TB/TV test procedure
- PFM satellite alignment verification procedure

GSE required:

- as for TV/TB test (F.100.080)
- OGSE tbd

Facility / Instrumentation:

- ESTEC test facility;
- TV chamber

Personnel:

AIT engineer

alignment engineer

QA engineer

Safety Precautions:

- standard safety precautions for cryo operations

Special Notes:

- alignment check during TV test possible only via LOU alignment camera. Availability/feasibility to be confirmed

Activity Number: F.100.090 **Duration:** tbd

Activity Name: **Removal of Satellite from test chamber** **Model:** PFM SAT

Objective:

Remove PFM satellite and associated GSE from Thermal Vacuum Test Chamber

Requirements to be verified:

- none

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM Satellite mounted on Thermal Test Adapter installed in TV test chamber
- HTT at He-II temperature

Activity Breakdown:

- Open TV chamber
- disconnect vent line and all electrical connections
- disconnect active CVV cooling straps
- reinstall protective covers to contamination sensitive items
- lift satellite out of TV test chamber
- remove thermal test adapter
- install satellite on MPT
- reconnect CVSE and CCS
- perform PTR F8

Applicable Documents:

- TB/TV test procedure
- PFM satellite handling and transportation procedure

GSE required:

- Satellite vertical lifting device
- Hydraset
- Satellite Multi Purpose Trolley
- Thermal Test Adapter
- CVSE
- Cryo SCOE, CCS/EGSE

Facility / Instrumentation:

- ESTEC test facility; TV test chamber; preparation area
- overhead crane

Personnel:

Test conductor

AIT engineer

AIT technicians

CVSE operator

EGSE/CCS Operators

QA engineer

Safety Precautions:

- standard safety precautions for cryo and crane operations
- precautions against explosion due to pressure in RCS

Special Notes:

- NA

A1.3.11 Integrated System Test 2 (F.110.000)

Activity Number: F.110.010 **Duration:** tbd

Activity Name: **Preparation of S/C and GSE set-up** **Model:** PFM SAT

Objective:

- Preparation of satellite and GSE set up for Integrated System Test after TV tests

Requirements to be verified:

- none

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100,000

Configuration:

- Satellite mounted on MPT in front of TV chamber
- cryostat at He-II temperature
- RCS filled and pressurised to tbd bar
- CVSE and CCS/EGSE available
-

Activity Breakdown:

- install working platform
- connect checkout equipment (CCS/EGSE and Cryo SCOE) to the satellite
- connect CVSE

Applicable Documents:

- Integrated System Test procedure

GSE required:

- Satellite Multi Purpose Trolley
- scaffolding
- working platform
- CVSE
- CCS/EGSE incl. Cryo SCOE

Facility / Instrumentation:

- ESTEC Test facility, preparation area
- overhead crane
- EGSE area

Personnel:

Test Conductor

electrical AIT engineers

CVSE operator

EGSE/CCS Operators

AIT/CVSE technicians

QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations
- precautions against explosion due to pressure in RCS

Special Notes:

- NA

Activity Number: F.110.020 **Duration:** tbd

Activity Name: **IST 2 (S/S IST & SFPT)** **Model:** PFM SAT

Objective:

Verify overall satellite performance after TB/TV tests by:

- Subsystem performance measurements
- Scientific Instruments performance at He-II temp.
- Overall system performance measurement

Requirements to be verified:

- according to Satellite requirement specification
- according to H-EPLM requirement specification

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100,000

Configuration:

- Satellite mounted on MPT in front of TV chamber
- cryostat at He-II temperature
- RCS filled and pressurised to tbd bar
- CVSE and CCS/EGSE available and connected

Activity Breakdown:

- perform TRR F9
- conduct subsystem performance tests (SVM and PLM S/S)
- conduct instrument performance tests
- conduct end-to-end system performance test
- perform PTR F9

Applicable Documents:

- Integrated System Test procedure

GSE required:

- Satellite Multi Purpose Trolley
- scaffolding
- CVSE
- CCS/EGSE incl. Cryo SCOE

Facility / Instrumentation:

- ESTEC Test facility, preparation area
- EGSE area

Personnel:

Test Conductor

electrical AIT engineers

CVSE operator

EGSE/CCS Operators

SVM test support team

QA engineer

Safety Precautions:

- standard safety precautions for cryo operations
- precautions against explosion due to pressure in RCS

Special Notes:

- NA

A1.3.12 EMC Test (F.120.000)

Activity Number: F.120.010 **Duration:** tbd

Activity Name: **EMC test Satellite level** **Model:** PFM SAT

Objective:

- Demonstration of compliance with launch vehicle EMC requirements
- demonstration of margin on power lines at interfaces between SVM and PLM
- demonstration of compatibility of scientific instruments in specified environment in flight configuration

Requirements to be verified:

- EMC requirement specification AD 04
- EMC test specification

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- Satellite mounted on MPT in EMC chamber
- HTT at He-II temperature
- RCS filled and pressurised
- CVSE and CCS connected

Activity Breakdown:

- Perform TRR F10
- verify EGSE/CCS set-up for EMC testing
- install and calibrate EMC test set-up
- Perform EMC test (CE, CS, RE, RS)
- Perform PTR F10

Applicable Documents:

- EMC test specification
- EMC test procedure

GSE required:

- satellite multi purpose trolley
- working platform
- CVSE
- EGSE/CCS

Facility / Instrumentation:

- ESTEC test facility; EMC Test chamber
- EMC probes and measurement equipment
- Anechoic walls

Personnel:

Test conductor

AIT engineer

CVSE operator

EGSE/CCS Operators

SVM test engineers

EMC facility and measurement team (ESTEC)

crane operator

QA engineer

Safety Precautions:

- standard safety precautions for crane operations are applicable
- precautions against explosion due to pressure in RCS
- standard precautions for EMI

Special Notes:

- NA

Activity Number: F.120.020 **Duration:** tbd

Activity Name: **Conversion to He-I** **Model:** PFM SAT

Objective:

- Conversion of HTT from He-II to He-I condition

Requirements to be verified:

- none

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM Satellite mounted on MPT in EMC chamber
- HTT at He-II temperature
- ventline attached to V502
- CVSE and CCS connected
- He pumping unit II connected and running
- RCS filled and pressurised to tbd bar

Activity Breakdown:

- Shut- off helium ventline by closing V501/503 and 502
- Stop He pumping unit II and disconnect
- shut-off HTT by closing V104/103/106
- activate heaters H103/104 to heat up HTT to 4.2K and 1050mbar
- monitor HTT pressure and temperature
- When He-I conditions are achieved, open V104 and subsequently V502 or 501/503 to allow helium vent flow through either ventline or exhaust nozzles

Applicable Documents:

- Helium depletion and warm-up procedure

GSE required:

- Multi Purpose Trolley
- Scaffolding
- Cryo SCOE; CCS
- CVSE

Facility / Instrumentation:

- ESTEC test facility; EMC Test chamber; preparation area

Personnel:

AIT engineer

CVSE operator

EGSE operator

CVSE technicians

QA engineer

Safety Precautions:

- standard safety precautions for cryo operations
- precautions against explosion due to pressure in RCS

Special Notes:

- ensure positive pressure gradient to ambient at any time in ventline to prevent backflow of air into He-Subsystem

A1.3.13 Acoustic Noise Test (F.130.000)

Activity Number: F.130.010 **Duration:** tbd

Activity Name: **Transport to acoustic noise test facility** **Model:** PFM SAT

Objective:

Transport of STM satellite from vibration to Acoustic Noise test facility

Requirements to be verified:

- none

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM satellite mounted on MPT
- EMC tests completed
- cryostat at He-I temperature
- RCS filled and pressurised
- CVSE and CCS connected

Activity Breakdown:

- disconnect CVSE and CCS from satellite
- move the satellite mounted on MPT to the AN test facility
- install satellite with lifting device on Acoustic Noise Test Stand
- reconnect CVSE and CCS to satellite

Applicable Documents:

- PFM satellite handling and transportation procedure
- PFM satellite AN test procedure

GSE required:

- satellite Multi Purpose Trolley (MPT)
- satellite vertical lifting device; Hydraset
- working platform
- AN test adapter
- AN test stand
- test clamp band
- checkout equipment (CCS and Cryo SCOE)
- CVSE

Facility / Instrumentation:

- ESTEC test facility; AN test chamber
- overhead crane

Personnel:

crane operator

AIT engineer

AIT technician

CVSE technician

EGSE operator

QA engineer

Safety Precautions:

- standard safety precautions for cryo and crane operations
- precautions against explosion due to high pressure in RCS

Special Notes:

- NA

Activity Number: F.130.020 **Duration:** tbd

Activity Name: **He-I top up** **Model:** PFM SAT

Objective:

Perform top up of He-I in HTT before Satellite Acoustic Noise Test to achieve launch representative conditions

Requirements to be verified:

according He-I filling and top up procedure

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM Satellite mounted on Acoustic Noise Test Adapter in AN chamber
- Cryostat at He-I temperature; any HTT filling level

Activity Breakdown:

- prepare He-I supply and transfer equipment
- install He-I supply and transfer equipment
- install the exhaust line
- fill up HTT until filling level of >95% achieved

Applicable Documents:

- He-I filling and top up procedure

GSE required:

- Acoustic Noise Test Adapter
- working platform
- checkout equipment (CCS and Cryo SCOE)
- CVSE for He-I top up
- He-I supply and transfer equipment

Facility / Instrumentation:

- ESTEC test facility; Acoustic Noise Chamber

Personnel:

Test Manager

AIT Test conductor

Cryo engineer

EGSE operators

AIT / CVSE technician

QA engineer

Safety Precautions:

- standard safety precautions for cryo operations
- precautions against explosion due to high pressure in RCS

Special Notes:

NA

Activity Number: F.130.030 **Duration:** tbd

Activity Name: **Acoustic noise test** **Model:** PFM SAT

Objective:

Perform Acoustic Noise test to verify structural and functional integrity during/after submission to acoustic launch environment

Requirements to be verified:

- Acoustic noise spectrum per Environmental Specification

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM Satellite mounted on Acoustic Noise Test Stand in Acoustic Noise test chamber
- HTT at He-I temperature, filling level >95%
- CVSE and CCS connected
- RCS filled with simulation fluid and pressurised

Activity Breakdown:

- perform TRR
- remove CVSE from test chamber
- perform Acoustic Noise test at low, intermediate (tbc), and acceptance level and duration
- perform He-I top up between runs if necessary
- perform visual inspection of satellite
- perform PTR
- remove satellite from test chamber and re-install on MPT
- deplete and depressurise RCS

Applicable Documents:

- PFM satellite Acoustic Noise test procedure
- He-I filling and top-up procedure
- TGSE operations manual

GSE required:

- working platform
- AN test adapter
- test clamp band
- CVSE
- Cryo SCOE, CCS

Facility / Instrumentation:

- ESTEC test facility; AN test chamber

Personnel:

Test Conductor

AIT engineer

AIT technician

CVSE technician

EGSE operator

QA engineer

SVM support

TGSE operator

AN facility team (ESTEC)

Safety Precautions:

- standard safety precautions for cryo operations
- precautions against explosion due to high pressure in RCS

Special Notes:

NA

Activity Number: F.130.040 **Duration:** tbd

Activity Name: **Alignment check** **Model:** PFM SAT

Objective:

- check satellite mechanical axes stability
- verify ACMS/RCS sensor/actuator alignment stability
- verify telescope alignment stability
- verify LOU vs. HIFI FPU alignment

after Acoustic Noise test

Requirements to be verified:

- alignment requirements for thrusters, telescope, and satellite main axes

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM Satellite mounted on MPT
- HTT in He-I condition; any filling level
- RCS empty and at ambient (tbc) pressure
- OGSE available and set-up

Activity Breakdown:

- lift satellite and install on rotary table (tbc)
- verify alignment of LOU vs. HIFI FPU with alignment camera
- verify alignment of telescope versus CVV
- verify alignment of SVM axes versus CVV
- verify alignment of ACMS/RCS units vs. SVM
- reinstall satellite on MPT

Applicable Documents:

- PFM satellite alignment verification procedure

GSE required:

- Satellite Multi Purpose Trolley or Rotary Table (tbc)
- Satellite lifting device
- Hydraset
- OGSE

Facility / Instrumentation:

- ESTEC test facility; preparation area
- overhead crane

Personnel:

Test conductor

AIT engineer

AIT technician

crane operator

alignment technician / engineers

QA engineer

Safety Precautions:

- standard safety precautions for crane and cryo operations

Special Notes:

- NA

Activity Number: F.130.050 **Duration:** tbd

Activity Name: **SFT 6 at He-I** **Model:** PFM SAT

Objective:

- perform Satellite Short Functional Test after Acoustic Noise Test to verify good functioning of the complete satellite system

Requirements to be verified:

- as per SFT procedure

Environment:

temperature:	22 ± 3 ° C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- Satellite mounted on MPT
- HTT at He-I temperature, any filling level
- RCS tanks empty and at ambient (tbc) pressure

Activity Breakdown:

- prepare and connect check out system (CCS and Cryo SCOE)
- perform SFT
- perform PTR F11 after acoustic noise

Applicable Documents:

- Satellite short functional test procedure

GSE required:

- Multi Purpose Trolley (MPT)
- Working platform
- Check-out System (CCS incl. Cryo SCOE)
- CVSE

Facility / Instrumentation:

- ESTEC test facility; preparation area

Personnel:

Test Manager

AIT Test conductor

Cryo manager

EGSE operators

AIT / CVSE technician

QA engineer

Safety Precautions:

- standard safety precautions for cryo operations

Special Notes:

- NA

A1.3.14 Mechanical Properties (F.140.000)

Activity Number: F.140.010 **Duration:** tbd

Activity Name: **Determination of Satellite mass** **Model:** PFM SAT

Objective:

mass determination of satellite after completion of acceptance test phase and before delivery to launch site

Requirements to be verified:

- Satellite mass requirements

Environment:

temperature:	22 ± 3 °C
humidity:	40% < RH < 60%
cleanliness:	clean class 100.000

Configuration:

- PFM satellite fully integrated and mounted on MPT
- Cryostat at He-I temperature, HTT filling level tbd
- RCS tanks empty and at ambient (tbc) pressure

Activity Breakdown:

- perform TRR
- removal of protective covers of sunshield, sunshade, telescope etc
- Determination of HTT filling level
- lifting of satellite with crane and mass measurement with load cell
- re-installation of protective covers
- perform PTR
- lifting of satellite with crane back onto MPT
- perform MIP before delivery to Prime

Applicable Documents:

- PFM Satellite mechanical properties determination procedure

GSE required:

- Satellite MPT
- Satellite Vertical Lifting Device
- Test clamp band
- Mechanical Test Adapter
- Mobile Access Platform
- CVSE/CCS

Facility / Instrumentation:

- ESTEC test facility; Preparation Area CR 100,000
- Overhead crane; Hydraset
- weighing machine (load cell)

Personnel:

mechanical test engineer

mechanical AIT technicians

Cryo Operator

QA engineer

Mass Measurement Team (ESTEC)

Safety Precautions:

- standard safety precautions for cryo and crane operations

Special Notes:

- NA

uantity	Name	Dep./Comp.	Quantity	Name	Dep./Comp.
	Alberti von Mathias Dr.	ED 544		Schweickert Gunn	ED 544
1	Barlage Bernhard	ED 62		Steininger Eric	ED 522
1	Bayer Thomas	ED 532	1	Stritter Rene	ED 61
1	Faas Horst	ED 12	1	Tenhaeff Dieter	ED 544
	Grasl Andreas	OTN/TN 64		Thörmer Klaus-Horst Dr.	OTN/ED 37
	Hartmann Hans Dr.	ED 522		Wagner Adalbert	OTN/IP 35
1	Hauser Armin	ED 541		Wagner Klaus	ED 541
1	Hohn Rüdiger	ED 531		Wöhler Hans	ED 544
1	Hölzle Edgar	ED 12		Ziegler Fred	OTN/ED 522
	Huber Johann	ED 532		Zipf Ludwig	EC 32
1	Idler Siegmund	ED 521	1	Runge Axel	OTN TN 64
1	Ivády von András	EC 32	1	Schwabbauer Paule	OTN ED 171
	Jahn Gerd Dr.	ED 541			
	Kalde Clemens	ED 513			
	Kameter Rudolf	OTN/ED 37			
1	Kersting Stefan	OTN/TN 64			
	Knoblauch August	ED 51			
1	Koelle Markus				
1	Kroeker Jürgen	ED 515			
1	Lamprecht Ernst	OTN/TN 82			
	Lang Jürgen	ED 556			
1	Langfermann Michael	ED 531		Mr. J. J. Juillet	Alcatel
1	Mack Paul	OTN/TN 64		Mr. T. Passvogel	ESTEC
	Maier Hans-Ulrich	ED 61			
1	Moritz Konrad Dr.	ED 37			
1	Muhl Eckhard	OTN/TN 64			
	Peitzker Helmut	ED 37			
	Peltz Heinz-Willi	ED 515			
	Peters, Gerhard	ED 533			
	Pietroboni Karin	ED 37			
	Puttlitz Joachim	OTN/TN 64			
	Raupp Helmut	ED 543			
1	Rebholz Reinhold	ED 531			
	Reuß Friedhelm	ED 7			
1	Rühe Wolfgang	ED 3			
	Sachsse Bernt	EC 34			
1	Sagner Udo	OTN/TN 42			
1	Schink Dietmar	ED 522			
1	Schlosser Christian	OTN/TN 42			