HERSCHEL SPIRE	Ref: SPIRE-RAL-DOC-002055 Author: D.L. Smith	Page: 1 Issue: 0.1 Date: 02-July-2004

SPIRE PFM1 Test Plan

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Host system	Windows XP Professional
Word Processor	Microsoft Word 2002 SP3
File	PFM1 Test Plan 0-1.Doc

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Document Change Record

Date	Index	Affected Pages	Changes
02-July-2004	0.1	All	First Draft

Contents

1 Scope of Document

This document describes in detail how the SPIRE PFM1 AIV will be implemented. It describes the step-by-step sequence of activities, high-level procedures, organisation, resources and facilities required.

2 Documents

2.1 Applicable Documents

	Title	Author	Reference	Date
AD 1	Instrument AIV Plan	B. Swinyard	SPIRE-RAL-PRJ-000410 Issue 3.0D	May 2003
AD 2	Instrument Integration Plan	B. Winter	SPIRE-MSS-PRJ-000652 Issue 0.1D	Apr-2001
AD 3	SPIRE Calibration Requirements	B. Swinyard	SPIRE-RAL-PRJ-001064 Issue 0.1D	3-Jan-2002
AD 4	SPIRE PFM1 Performance Test Specification	T. Lim	TBD	
AD 5	SPIRE Optical Alignment Sequence	K. Dohlen	SPIRE-LAM-PRJ-000637 Issue 4	June 2003
AD 6	SPIRE Product Assurance Plan	D. Kelsh	SPIRE-RAL-PRJ-000017 Issue 1.0	11-Apr-2001
AD 7	Cleanliness Plan	B. Swinyard	SPIRE-RAL-PRJ-001070 Issue 1.0	9-Jan-2002
AD 8	SPIRE Alignment Tools Specification	K. Dohlen, A. Origne	LOOM.YA.SPIRE.2002.001.05	August 2002

2.2 Reference Documents

	Title	Author	Reference	Date
RD 1	SPIRE Test Facility Requirements Specification	D.L. Smith	SPIRE-RAL-PRJ-000463 Issue 1.3	2-April-2001

3 PFM1 AIV Requirements

3.1 PFM1 Definition

Unit /component	Build Standard
HSFPU	
Structure/baffles/standoffs etc	PFM
L0 straps	Mark 2
Mirrors	PFM
Filters	CFIL-1 – PFM SFIL2 – PFM SBS1 – PFM SBS2 - PFM SFIL3 to 5S – PFM SFIL3 to 5L – PFM Photometer not fitted
Beam steering mirror	PFM
3He Cooler	PFM if available
300 mK thermal straps and supports	PFM
300 mK Thermal control system	Not Fitted
Photometer LW array	Not Fitted
Photometer MW array	Not Fitted
Photometer SW array	Not Fitted
SMEC	CQM
Spectrometer SW array	PFM
Spectrometer LW array	PFM
Photometer Calibrator	PFM
Spectrometer Calibrator	PFM
FPU RF Filters	PFM
Thermometry	PFM
FPU internal harnesses	Spectrometer side – PFM Photometer side TBD
HSJFP	
JFET Structure	Not Fitted
JFET Modules	Not Fitted
JFET box RF filter modules	Not Fitted
JFET Backharness	Not Fitted
JFET/FPU Harness	Not Fitted
HSJFS	
JFET Structure	PFM
JFET Modules	PFM
JFET box RF filter modules	PFM
JFET Backharness	PFM
JFET/FPU Harness	PFM

Subsystem /component	Requirement
HSDCU	
DCU Structure	Form and fit
Electrical Interfaces	Form; fit and function
Functionality	I/F – functional; non redundant DAQ – functional; non redundant Bias -P – not required Bias -S – functional; non redundant LIA-P – not required LIA-S – all channels functional
Electrical Component Level	Commercial
HSFCU	
FCU Structure	Form and fit
MCU	
Electrical Interfaces	Form; fit and function
Functionality	Full functionality but no redundancy required
Electrical Component Level	Commercial
SCU	
Electrical Interfaces	Form; fit and function
Functionality	Full functionality but no redundancy required
Electrical Component Level	Commercial
PSU	
Electrical Interfaces	Form and function Fit desirable – else GSE to be provided
Functionality	Full functionality but no redundancy required
Electrical Component Level	Commercial
HSDPU	
DPU Structure	Form and fit
Electrical Interfaces	Form;fit and function
Functionality	Full functionality but no redundancy required
Electrical Component Level	commercial
On Board Software	
Functionality	Full functionality but no autonomy required
HSWIH	
Length/Connector type	Form and fit
Electrical Interfaces	Form; fit; function
Functionality	Full functionality on prime side only
Electrical Component Level	Commercial

3.2 PFM1 Test Objectives

The PFM1 model is primarily to qualify the design of the spectrometer half of the SPIRE instrument not covered by the CQM program. The main aims of the PFM1 program are

- Integrate the flight model FPU structure
- Install the flight model optics
- Verify the flight model optical alignment
- Verify the functional performance of the spectrometer subsystems (SMEC, SCAL)
- Verify the scientific performance of the SPIRE spectrometer

4 PFM1 AIV Flowchart

The AIV phase is broken down into a series of 'activities' and 'test campaigns'.

'Activities' include integration of the FPU, preparation for a test campaign, single test or task within a campaign and other tasks.

A 'test campaign' covers a complete test period from the test readiness review to the completion of the test activities.

Each test campaign will start with a test readiness review, at which all test procedures must be ready and the EGSE configuration will be 'frozen'. A formal post-test review will be held at the end of the test campaign after which the instrument can proceed with the next activity.

The test campaign will be broken down into 'activities' and 'tests', see Figure 1. Activities include pump-down, cool-down, warm-up, and let-up. Each 'Test' within the campaign will comprise a series of 'test cases'. For example, a functional test will include test cases to checkout individual mechanisms, i.e. the cooler, BSM, SCAL etc. The test campaign will be controlled by a master procedure that references the specific test procedures, e.g. functional test procedure. The test procedure will identify the necessary EGSE test sequences and pass-fail criteria.

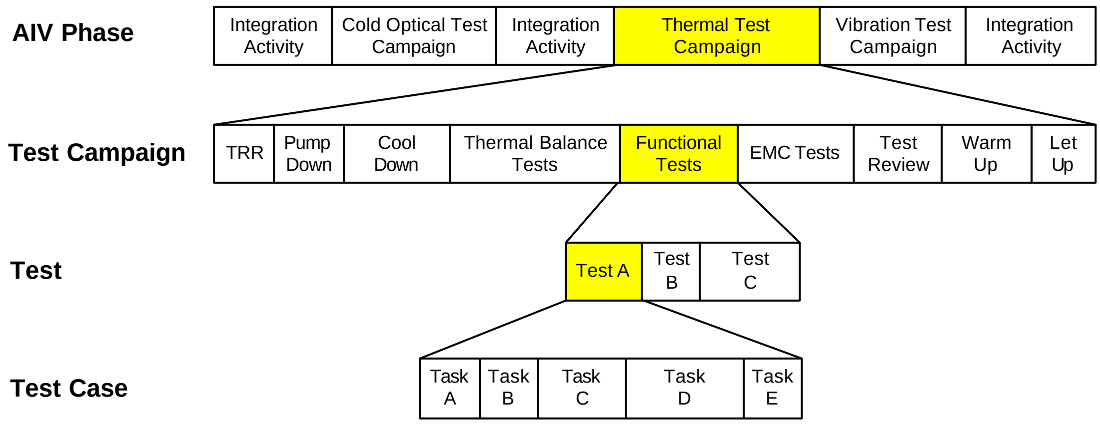

Figure 1: Definition of AIV Phase, Test Campaign, Tests and Test Case. (Note: the example given does not represent the actual SPIRE AIV)

The flowchart in this section is based on the flowchart presented in the SPIRE AIV Plan (AD 1) but expanded slightly to show each test campaign with the facilities and test equipment required to perform the activities.

Each test campaign will start with a test readiness review, at which all test procedures must be ready and the EGSE configuration will be 'frozen'. A formal post-test review will be held at the end of the test campaign after which the instrument can proceed with the next activity.

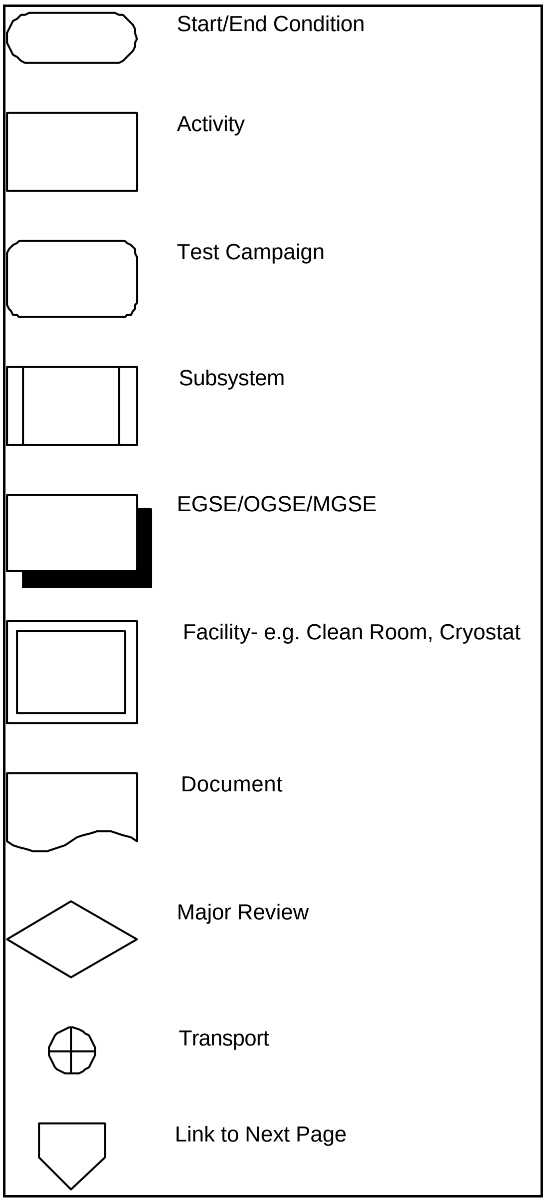

Figure 2: Legend for PFM1 AIV Flow Chart. Key Inspection Points are indicated by (**K**), Mandatory Inspection Points are indicated by (**M**).

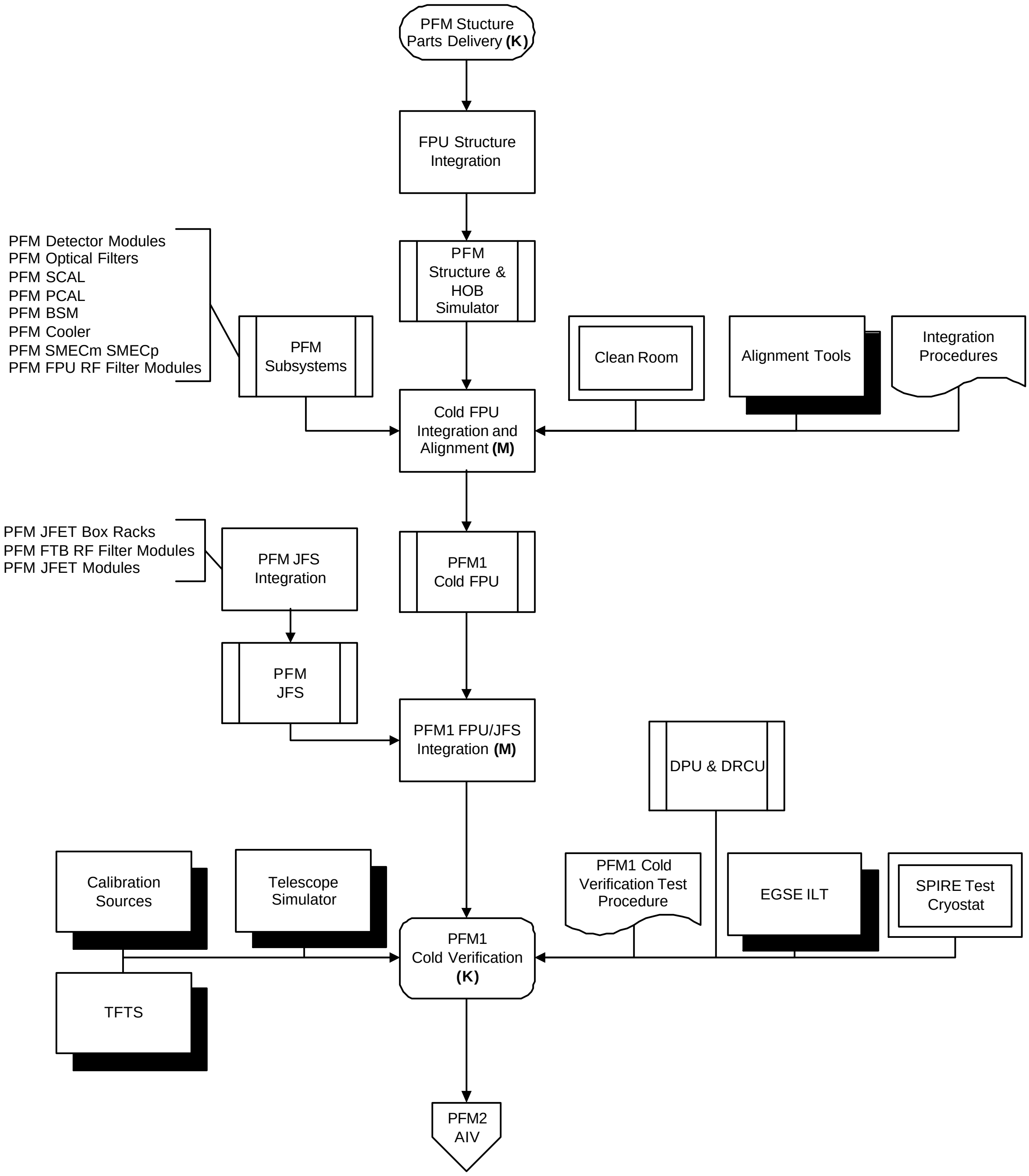

Figure 3: Flowchart for PFM1 AIV

5 Task List

The following table defines the step-by-step sequence of activities for the SPIRE PFM-1 AIV. The table will form the basis of the PFM-1 test campaign procedures.

Step	Activity	Identifier	Brief Description	Instrument Requirement
PFM1 1	**PFM1 FPU Integration**	**PFM1_ILT_INTG**		
PFM1 1-1	Integrate FPU box	ILT_INTG	Assemble the FPU box components and install mirror mounts	
PFM1 1-2	Verify alignment of optical components	ILT_ALIGN		VRD-06, VRD-07 VRD-10, VRD-11
PFM1 1-3	Photometer detector box integration	ILT_INTG	Assemble photometer detector box	
PFM1 1-4	Spectrometer detector box integration	DET_INTG	Install fully functional long- and short wavelength spectrometer arrays.	VRD-06, VRD-10 VRD-11
PFM1 1-5	Detector box integration into FPU structure	ILT_INTG	Integrate detector boxes into structure and verify the alignment. Photometer detector box could be left off as it is not required for the test.	VRD-06, VRD-10 VRD-11
PFM1 1-6	Subsystem Integration	ILT_INTG	Install instrument subsystems, filters and baffles.	VRD-04, VRD-05
PFM1 2	**PFM1 FTB Integration**	**PFM1_ILT_INTG**		
PFM1 2-1	Inspect JFET modules on arrival	FTB_INTG	Visual inspection of JFET modules	VRD-04, VRD-05
PFM1 2-2	Mount JFET modules into box structures	FTB_INTG	Integrate JFET Boxes	VRD-04, VRD-05
PFM1 2-3	Perform warm functional test	FTB_WFT	Check function of JFET modules at room temperature.	VRD-24
PFM1 3	**PFM1 FPU/FTB Integration**	**PFM1_ILT_INTG**		
PFM1 3-1	Mount JFET Boxes on HOB simulator and connect to FPU	PFM1_ILT_INTG		VRD-04, VRD-05
PFM1 3-2	Connect to Warm Electronics units	PFM1_ILT_INTG		VRD-04, VRD-05
PFM1 3-3	Perform warm functional test	ILT_WFT		VRD-21, VRD-24 VRD-27, VRD-28 VRD-29

Step	Activity	Identifier	Brief Description	Instrument Requirement
PFM1 4	**PFM1 Cold Verification**	**PFM1_ILT_VER**		
PFM1 4-1	Integrate SPIRE onto support frame	PFM1_ILT_INTG	Bolt down covers, secure structure to HOB simulator. Lift instrument onto MGSE and build up support frame.	
PFM1 4-2	Transfer SPIRE to Cryolab	PFM1_ILT_INTG	Bag up the FPU and HOB simulator and transfer to cryolab.	
PFM1-4-3	Integrate SPIRE into cryostat	CRY_INTG	Move instrument into cryostat, connect thermal straps, harness. Close up radiation shields, making light tight.	
PFM1-4-4	Perform warm functional test	ILT_WFT		VRD-21, VRD-24 VRD-27, VRD-28 VRD-29
PFM1-4-5	Test Readiness Review			
PFM1-4-6	Pump Down	CRY_PUMP		
PFM1-4-7	Cool Down to operational temperatures	CRY_COOL		VRD-12, VRD-14
PFM1-4-8	Perform cold functional tests	ILT_CFFT		VRD-16, VRD-17 VRD-21, VRD-24 VRD-27 to 42
PFM1-4-9	Micro phonics Susceptibility	ILT_PERF	Measure susceptibility of detector signals to low-level vibration inputs.	VRD-15
PFM1-4-10	Measure instrument performance characteristics	ILT_PERF	Spectrometer detector performance and characterization, Spectrometer optics characterization, spectrometer performance, Calibrator performance and characterization,	VRD-06, 07, 08, 09, 11, 12, 15, 16, 17, 18, 19, 20, 22, 24, 25, 27, 28, 29, 30
PFM1-4-11	Instrument Calibration	ILT_CAL	Optical throughput, cross talk, point spread function, beam profile, detector time constants, spectral response, field distortion (Defined in AD 4)	VRD-43-49
PFM1-4-12	Exercise instrument operations modes	ILT_OPS	SOF-1, SOF-2 (Defined in AD 4)	VRD-48, VRD-49
PFM1-4-13	Perform cold functional tests	ILT_CFFT		VRD-16, 17, 21, 24, 27 - 42
PFM1-4-14	Post Test Review			

Step	Activity	Identifier	Brief Description	Instrument Requirement
PFM1-4-15	Warm up	CRY_WARM		
PFM1-4-16	Let up to air	CRY_LETUP		
PFM1-4-17	Perform warm functional test	ILT_WFT		VRD-21, 24, 27, 28, 29
PFM1-4-18	Remove from cryostat	CRY_DEINT	Disconnect FPU from cryostat, remove HOB simulator from cryostat and install on support trolley.	

6 Test Procedure List

This section lists the main test procedures to be used for the STM AIV. For each major step there is a high level procedure that references other standard procedures such as those for operating the facilities.

6.1 PFM1 structure Mechanical Integration (PFM_ILT_INTG)

This procedure will describe the integration of the CQM subsystems into the instrument (ILT_ALIGN), and preparation of the instrument for thermal verification and delivery to ESTEC. The mechanical integration will also include optical alignment verification(ILT_ALIGN).

6.2 PFM1 Cold Verification Master Procedure (PFM_ILT_VER)

Umbrella procedure for cold verification tests. The procedure will call up sub-procedures for specific test activities, i.e. thermal performance, instrum ent performance, calibration and operating mode tests.

6.2.1 ILT Performance Test Procedures (ILT_PERF)

This procedure will describe all instrument performance tests to be performed during cold thermal verification. The procedure will define the EGSE test scripts, data analysis, test conditions, all instrument operations and all success/failure criteria.

6.2.2 ILT Calibration Procedure (ILT_CAL)

This procedure will describe all instrument level calibration tests to be performed during cold thermal verification. The procedure will define the EGSE test scripts, data analysis, test conditions, all instrument operations and all success/failure criteria.

6.2.3 SPIRE Operating Mode Test Procedure (ILT_OPS)

This procedure will describe the operating mode tests. The procedure will define the EGSE test scripts, data analysis, test conditions and all success/failure criteria.

6.2.4 ILT Functional Test Procedures

To ensure that the instrument subsystems are performing correctly, functional tests will be executed at the various stages of the AIV phase. The test procedures will identify the EGSE test scripts that are to be used, the instrument configuration and all success criteria. The following test levels are proposed:

6.2.4.1 Warm Functional Test (ILT_WFT)

This will be a basic test performed at room temperature to check the integrity of the electrical interfaces.

6.2.4.2 Cold Full Functional Test (ILT_CFFT)

An end-to-end test verifying all instrument subsystem functions will be exercised and where applicable will be repeated for redundant units. This test will be performed during the cold verification campaigns.

6.2.4.3 Cold Short Functional Test (ILT_CSFT)

The minimum level of tests required for checking that the instrument subsystems are functioning correctly.

6.3 General Procedures

The following are more general procedures that will be called up by the main test procedures.

6.3.1 Cryostat integration procedures

SPIRE test facility procedure describing the steps to prepare and install SPIRE into the test cryostat (CRY_INT) and removal of SPIRE from the test cryostat (CRY_DEINT)

6.3.2 Cryostat operations procedures

This will be a set facility procedures describing the safe operation of the calibration cryostat. The procedures will cover the sequence for pumping down (CRY_PUMP), cryogenic cool-down (CRY_COOL), operation at test conditions, warm-up (CRY_WARM) and let-up to air (CRY_LETUP).

6.3.3 Contamination Control and Monitoring Procedures

These define how the contamination control process is to be implemented and describes the process to monitor the contamination levels in the facility during integration.

7 Organisation

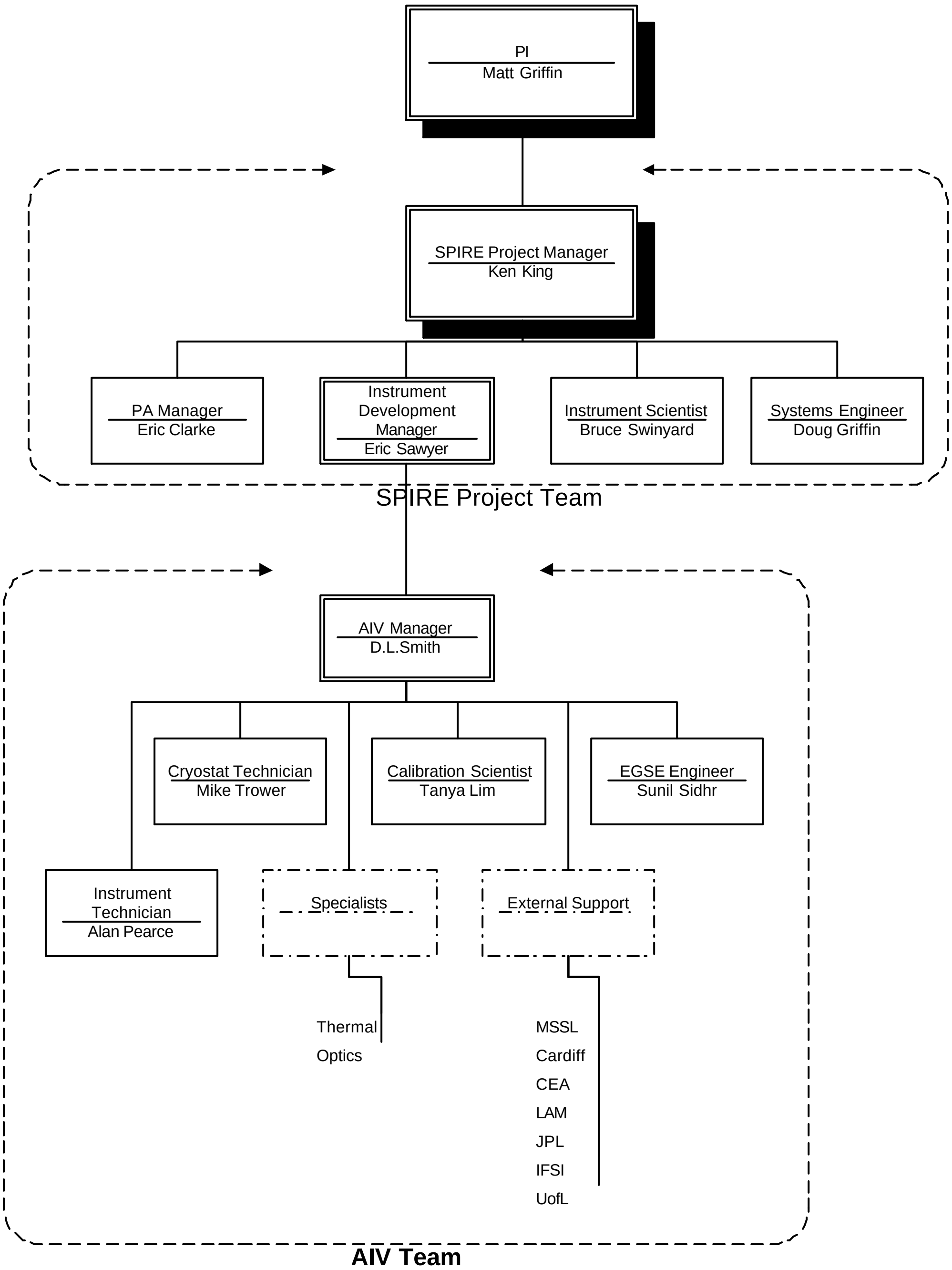

Figure 4: Organisation of AIV team for PFM1 testing.

8 Resource Requirements

8.1 Manpower

This section describes the roles and responsibilities of the personnel required to support the CQM integration and test activities. The roles defined are specific to the CQM AIV activities and do not necessarily reflect overall roles and responsibilities within the SPIRE project. The majority of the team will be from RAL, but specialists from the SPIRE subsystem providers will also be required to support the AIV activities.

8.1.1 AIV Team

8.1.1.1 AIV Manager

- Planning and coordinating the AIV verification tests and calibration.
- Responsible for obtaining agreement, prior to the commencement of any activity, of test plans and procedures.
- Responsible for decisions requiring work-around plans, modification of test procedures, repeat tests etc arising from non-conformance reports.
- Co-ordinate activities of technical experts, technicians during AIV testing.
- Reports to Instrument Development Manager

8.1.1.2 Calibration Scientist

- Definition of the instrument calibration, performance and operations modes tests.
- Preparation analysis software
- Execution of calibration tasks
- Real-time assessment of the test results using QLA
- Detailed analysis of test data.
- Preparation of calibration report.
- Preparation of the instrument calibration database and associated documentation.

8.1.1.3 Instrument Specialist

- Preparation of instrument test sequences on EGSE
- Execution and analysis of instrument functional tests
- Maintenance and development of EGSE
- On-board software maintenance
- Definition of instrument flight operations procedures

8.1.1.4 Cryostat Engineer

- Preparation of cryostat for instrument tests
- Operation of cryostat during instrument tests
- Ensure supply of cryogens
- Clean room maintenance

8.1.1.5 Technicians

- Mechanical integration of instrument
- Test support
- Preparation of instrument for testing and transport

8.1.2 Specialist Support

8.1.2.1 Optics Specialist

- Optical alignment verification

8.1.2.2 Thermal Engineer

- Thermal modeling and analysis
- Thermal test plan
- Support for thermal testing.

8.1.3 SPIRE Project Team

8.1.3.1 SPIRE Project Manager

- SPIRE Project Management
- UK SPIRE Management

8.1.3.2 Instrument Development Manager

- Subsystem Development
- Subsystem Deliveries
- Instrument Deliveries
- PFM integration management

8.1.3.3 Instrument Scientist

- Instrument performance
- Verification Matrix
- Calibration Plan
- Optical Straylight Analysis

8.1.3.4 Systems Engineer

- Systems engineering
- System thermal design
- Parts procurement

8.1.3.5 PA Manager

- Product assurance
- Quality assurance
- Acceptance data packages

8.1.4 External Support

Support from the instrument subsystem providers will be required during the AIV activities. They will not be expected to perform the integration tasks but rather be on hand to provide technical support when needed.

8.1.4.1 MSSL

- Support mechanical integration.

8.1.4.2 LAM

- Support optical alignment activities.
- Support the integration and testing of the SMEC.

8.1.4.3 Cardiff

- Support integration of the SCAL, PCAL, 300mK strap system, optical filters
- Support the cold thermal verification and instrument performance tests.

8.1.4.4 JPL

- Support integration and alignment of detector modules, and integration of JFET units.

8.1.4.5 ATC

- Support integration and testing of the BSM units.

8.1.4.6 Grenoble

- Support integration of the cooler systems and thermal verification tests.

8.1.4.7 UofL

- Setup and operation of the SPIRE test equipment
- Maintenance of TFTS system
- Support instrument test activities
- Preparation of test sequences to be run on EGSE
- Support of EGSE and Warm Electronics Testing

8.2 Facilities

The following facilities will be used for the SPIRE CQM AIV activities.

8.2.1 Cryogenic Test Facility

The SPIRE dedicated cryostat facility will be used for the cold optical alignment and thermal verification tests [RD 2]. The instrument and cryostat will be in a class 1000 clean area. Access to the clean room will be limited to key personnel to minimise any potential contamination of the optics.

8.2.2 Assembly Clean Rooms

Mechanical and electrical integration of the SPIRE FPU will be conducted in Clean Room 2 within building R25 at RAL. The room comprises

- Main area: 12m x 7m class 10,000
- Horizontal laminar flow unit: 5m x 3m at class 100
- 2 laminar flowbenches: 1m x 0.5m at class 100
- Central changing room: lockers for up to 20 people
- Cleaning facility: Ultrasonic bath, fume cupboards

8.3 EGSE

The full EGSE-ILT configuration will be required for the CQM test campaign, Figure 5. The main components that are required are: -

- TFCS
- TFTS
- CDMS simulator
- Packet Router
- SCOS-2000
- Test Control
- RTA
- MIB
- HCSS
- QLA
- OBSM

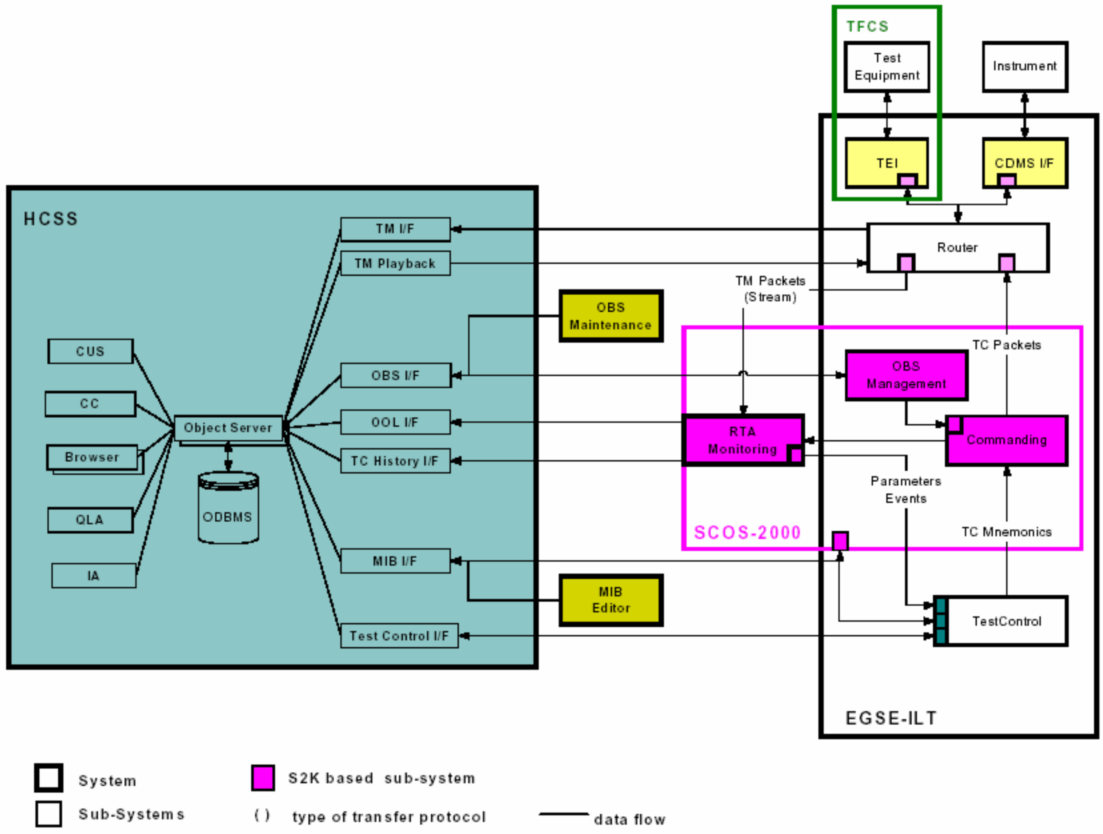

Figure 5: EGSE-ILT Configuration

At the start of each test campaign (e.g. Thermal Verification), the EGSE configuration will be 'frozen' and will be run continuously until the completion of the test campaign, i.e. when the cryostat has fully warmed up. The only breaks in operation will be for routine maintenance or troubleshooting as agreed by the AIV manager. All changes to the EGSE configuration shall be through a formal change request to ensure that any changes do not have any negative impact on the test campaign. Changes to the EGSE configuration that are not essential to the success of the test campaign may have wait before implementation. The main priority throughout the test campaign will be the safety of the instrument, and it is therefore vital that the thermal environment and instrument status is monitored and logged continuously.

8.3 OGSE

8.3.1 Alignment Tools

A Suite of dedicated alignment tools will be provided by LAM as defined in AD 8.

8.3.2 Telescope Simulator

The telescope simulator will reproduce the Herschel telescope f8.68 beam, such that a point source is imaged at the SPIRE input focal plane. Many of the test & calibration procedures will require this beam to be steered & focused over the field-of-view range of the instrument, in order to check or measure such properties as pixel response, spatial resolution and image scale. A beam control system will use a series of movable mirrors to steer & focus the beam according to geometric 'control laws'.

8.3.3 Cold Blackbody

A 4K-20K-blackbody source provided by Cardiff University will be used as an absolute radiance standard. This will be mounted within the 4K enclosure of the cryostat and viewed via a relay mirror.

8.3.4 Fourier Transform Spectrometer

The Test Fourier Transform Spectrometer (TFTS) provided by University of Lethbridge, Canada will allow the spectral response measurements to be performed

8.3.5 Hot Blackbody

An ISOTEC Pegasus hot, 1000°C blackbody with wavelength coverage over 200µm to 700µm will be used to back illuminate a point source at the input of the telescope simulator.

8.3.6 FIR Laser

An Edinburgh Instruments PR5 gas FIR laser with lines from 30µm to 1000µm and power up to 100mW will be used.

8.3.7 Beam Monitor

The output of the telescope simulator (i.e. input signal to SPIRE) will be picked off by a beam splitter and measured using a Golay cell. The output of the detector will be logged by the TFCS to allow correlation with the SPIRE measurements.

8.4 MGSE

8.4.1 Transportation Container

A purpose built transportation container provided by MSSL will be used whenever SPIRE is to be moved between facilities (i.e MSSL, RAL, CSL, ESTEC).

8.4.2 Integration Frame

A framework provided by MSSL mounted on the HOB simulator will be used to support the SPIRE FPU during integration.

8.4.3 HOB Simulator

The HOB simulator will be the primary mechanical interface between the SPIRE FPU and the calibration cryostat. It will have a number of optical references to enable optical alignment measurements to be performed. To ensure that optical alignment between the references on the SPIRE optical bench and the HOB are maintained throughout integration and testing, the HOB simulator will act as the main integration plate and will travel with the instrument in the transportation container.

8.4.4 Support Trolley

SPIRE will be mounted on the HOB simulator with the +X axis up during mechanical integration and transport. However, because the SMEC cannot work against gravity the instrument has to be rotated by 90° so that the +Y axis is up. A purpose built support trolley will be provided to rotate the integrated FPU and JFET units on the HOB simulator about 90° in a controlled manner. The trolley will also allow the instrument to be moved between the AIV clean rooms and the cryogenic test facility.