SPIRE

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1. INTRODUCTION

1.1 Purpose

The purpose of this document is to describe the process for the development, integration and verification of the deliverable models of the Herschel SPIRE instrument, including the provision of the test equipment, test facilities and simulators necessary for this development.

This document, and its associated plans, are applicable documents to the subsystems development plans (RD01 - RD15), which are to be written by the SPIRE Responsible Organisations (ROs) who will implement each subsystem. (These organisations are defined in the SPIRE Management Plan, AD03).

1.2 Scope

This document covers the development of the SPIRE instrument hardware and its on-board software and the additional equipment required for its assembly, integration and test. The development of the SPIRE contribution to the FIRST Ground Segment (the Instrument Control Centre) is described in the SPIRE Science Implementation Plan (RD16).

The development activities that contribute to the provision of the SPIRE instrument take place at many different centres, both at ROs and in industry before delivery of subsystems to RAL for Assembly, Integration and Verification. Those activities relating to the development of subsystems are detailed in the individual subsystems development plans (RD1-RD15).

This document itself forms an overview of the development process, with separate detailed plans being provided for each area of activity.

1.3 Document Overview

Section 2 describes the management structure and organisation of the project, put in place to ensure optimum development of the instrument.

Section 3 describes the development of the instrument in terms of the deliverable instrument models as required in the Instrument Interface Document, Part A (AD01) and the qualification and verification activities.

Chapters 4 & 5 describe the instrument subsystems that are required to make up each instrument deliverable model and the test and support equipment needed for the AIV programme.

Chapter 6 identifies the major risk items in the development of the instrument and describes the steps taken to minimise them.

Chapter 7 describes the overall instrument schedule and relates them to the ESA delivery dates.

1.4 Glossary

DDR	Detailed Design Review

DPU	Digital Processing Unit
DRCU	Detector Readout and Control Unit
FPU	Focal Plane Unit
Herschel	The Herschel Space Observatory (formerly called FIRST, the Far Infrared and Submillimetre Telescope)
IIR	Instrument Interface Review
OBS	On-Board Software
PDR	Preliminary Design Review
PLM	Payload Module
RO	Responsible Organisation
SPIRE	Spectral and Photometric Imaging REceiver
SVM	Service Module
WIH	Warm Interconnect Harness

1.5 References

1.5.1 Applicable Documents

Document Reference	Name	Number/version/date
AD01	FIRST/Planck Instrument Interface Document Part A (IID-A)	SPIRE-ESA-DOC-000178 (PT-IID-A-04624)
AD02	FIREST/Planck Instrument Interface Document Part B (IID-B) Instrument "SPIRE"	SPIRE-ESA-DOC-000275 (PT-SPIRE-02124)
AD03	SPIRE Management Plan	SPIRE-RAL-PRJ-000029)) Issue 1.1 12th April 2001

1.5.2 Reference Documents

Document Reference	Name	Number/version/date
RD01	SPIRE Structure Development Plan	SPIRE-MSS-PRJ-000426 Issue 1.2 March 2001
RD02	SPIRE Mirrors and Alignment Tools Development Plan	(LAM.PJT.SPI.NOT.200006) v 3 30th March 2001
RD03	SPIRE 300mK Straps Subsystem Development Plan	Issue 1.0 29th March 2001
RD04	SPIRE Filters Subsystem Development Plan	Issue 2.0 11th January 2001
RD05	SPIRE BSM Development Plan	(SPIRE-AT-PRJ-003) v4.0 8th April 2001

RD06	SPIRE & PACS Sorption Cooler Development Plan	SPIRE-SBT-PRJ-000468 Issue 2.1 18th January 2001
RD07	SPIRE Detector Receivables/Deliverables List	(SPIRE 2001-1-151) 23rd February 2001
RD08	SPIRE Spectrometer Mirror Mechanism Development Plan	(LAM.PJT.SPI.NOT.200001) v 9 10th April 2001
RD09	SPIRE Calibrators Subsystem Development Plan	SPIRE-QMW-PRJ-000453 Issue 2.0 12th January 2001
RD10	SPIRE Shutter Development Plan	(SPIRE-USK-DOC-000001) Draft 0.2 15th June 2000
RD11	Herschel Space Observatory DPU/ICU Subsystem Development Plan	(IFSI/ICU/PL/2000-001) Issue 1.2 2nd April 2001
RD12	SPIRE DRCU & WIH Development Plan	(SAp-SPIRE-JLA-xxxx-00) Issue 2.0 15th December 2000
RD13	SPIRE DRCU Simulator Development Plan	(SO-2000-12-21) Issue 1.0 12th December 2000
RD14	SPIRE AIV Facilities Development Plan	SPIRE-RAL-PRJ-000477 Issue 1.0 10th April 2001
RD15	JPL Array Test Dewar Development Plan	Issue 1.2 12th January 2001
RD16	SPIRE Science Implementation Plan (SIP)	SPIRE-RAL-DOC-0018 Draft 1.0
RD17	Major Milestone List	SPIRE-RAL-PRJ-000455 Issue 1.2 Draft2 12th April 2001
RD18	Organisation of the SPIRE System Team	(SPIRE-RAL-NOT-nnnn) Issue .00 16th April 2001
RD19	SPIRE Subsystems Block Diagrams	SPIRE-RAL-PRJ-000391 Issue 1.0 5th April 2001
RD20	SPIRE AVM Definition	SPIRE-RAL-DOC-000610 Issue 1.0 29th March 2001
RD21	SPIRE STM Requirements Document	Issue 1.0
RD22	SPIRE CQM Test Requirements Document	SPIRE-RAL-PRJ-000389 Issue 1.0
RD23	SPIRE Model Philosophy	TBD
RD24	SPIRE Qualification Requirements	SPIRE-RAL-PRJ-000592

		Issue 1.1 29th March 2001
RD25	SPIRE Instrument Requirements	SPIRE-Ral-PRJ-000034 Issue 1.0 23rd November 2000
RD26	SPIRE AIV Plan	SPIRE-RAL-DOC-000410 Issue 2.1 29th March 2001
RD27	SPIRE Instrument Test Plan	TBW
RD28	SPIRE Calibration Plan	TBW
RD29	SPIRE Ground Calibration Plan	TBW
RD30	SPIRE Schedules	12th April 2001

2. ORGANISATION AND MANAGEMENT

2.1.1 Management

2.1.1.1 Responsibilities

The SPIRE overall management structure is shown in Figure 2-1 (taken from AD03). Each Responsible Organisation has appointed a Local Project Manager who is responsible for the delivery of the relevant subsystem(s). These report to the Instrument Development Manager who is responsible for the delivery of the verified Instrument Models to ESA and the support to the system-level testing of the Herschel satellite. He reports to the Project Manager.

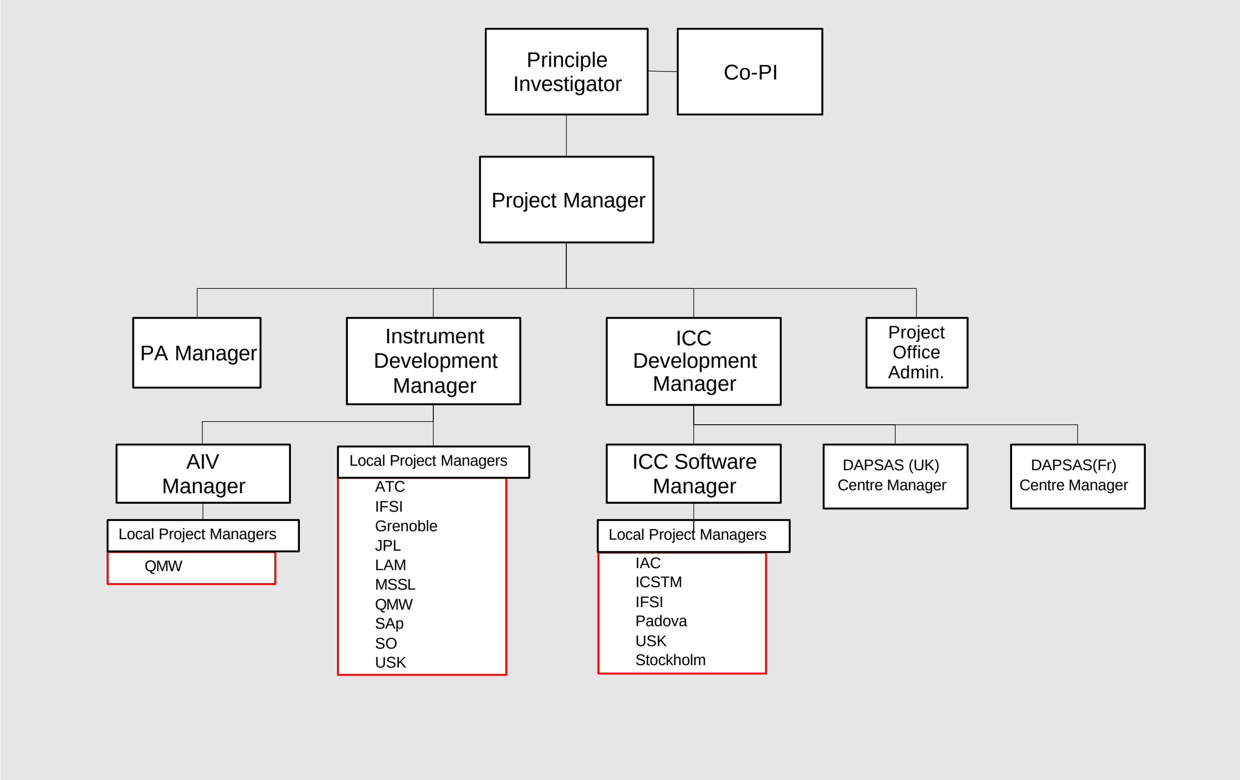

Figure 2-1 SPIRE Management Structure

2.1.1.2 The Project Team

The Project Manager, Instrument Development Manager, Instrument Scientist, Principle Investigator and System Engineers meet regularly (nominally every two weeks) as a Project Team to assess the status of the project and subsystem development activities and to plan future activities (preparation for Reviews; preparation for technical/management meetings with ESA and the Prime Contractor; calling for design/status meetings with subsystems etc).

2.1.2 Monitoring and Control

Monitoring of subsystem delivery for each model is carried out with reference to a Major Milestone List (RD17). Each subsystem provides in its development plan a set of planned delivery dates and internal milestones such that progress of the development may be monitored on a monthly basis. These milestones are transferred to RD17 along with an estimate of the margin available between these dates and the project milestones derived from the ESA delivery dates.
Each month the subsystem Project Managers will report progress against these milestones and the current margin available.

Weekly teleconferences are held to report status and discuss any problems that may have arisen, which threaten the schedule, and to communicate decisions made by the Project Team.

2.1.3 Technical Organisation

Decisions on technical aspects of the development are made by the System Design Co-ordination Team, shown in Figure 2-2, taken from RD18.

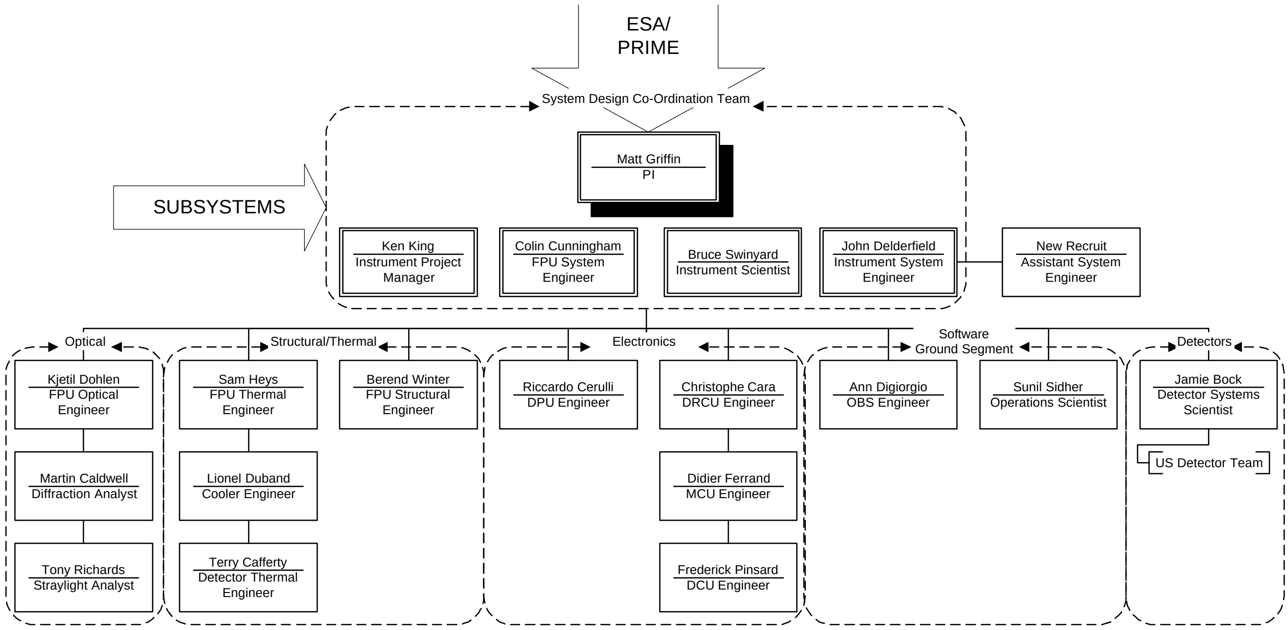

Figure 2-2 System Team Organisation and Information Flow

3. DEVELOPMENT

3.1 Development Items

3.1.1 The Instrument

A description of the SPIRE instrument and its capabilities is given in AD02. The instrument consists of 7 units;

- **Focal Plane Unit (HSFPU)** - this consists of all the subsystems contained within the FIRST cryostat, excluding the cold electronics (i.e. FET amplifiers).
- **2 FET Boxes (HSJFP and HSJFS)** -these contain the cold preamplifiers for the detector signals from the FSFPU photometer and spectrometer respectively. They are assembled with the HSFPU and they are then mounted on the optical bench as one unit.
- **Detector Readout and Control Unit (HSDRC, comprising the HSFCU and HSDCU) - t**he two electronics boxes external to the cryostat that house the detector control and read out electronics (HSDCU); the mechanism control electronics, the subsystem housekeeping electronics and their power supply (HSFCU).
- **Digital Processing Unit (HSDPU)** - the instrument on board computer handling the command and telemetry interface to the spacecraft and the control of the operation of the instrument through the HSDRC.
- **Warm Interconnect Harness (FSWIH)** - the harness connecting the HSDPU and HSFCU. Note the interconnect harness between the HSFCU and HSDCU is currently considered to be an internal harness of the HSDRC and has not been allocated a separate designation.

All other harnesses; the cryoharness connecting the FPU and DRCU and the power, telemetry and telecommand harnesses are provided by ESA and do not form part of the instrument.

3.1.2 Simulators

Additional deliverable items will be the support equipment necessary to install and verify the installation of Instrument Units. These additional items include:

- **Individual Subsystem GSE -** Mechanical, Optical and Electrical GSE necessary to mount, align and test the correct installation of the subsystem.
- **FPU Simulator -** this item simulates the FPU and JFET boxes as far as their interfaces with the DRCU are concerned. It is used at RAL to test integration of the SPIRE warm electronics units prior to their use with the cold instrument. It will be made available to ESA at the time of installation of the warm electronics on the satellite SVM, or equivalent platform, for the CQM, PFM and, if necessary, the FS instrument models.
- **DRCU Simulator -** this item simulates the cold FPU and the warm electronics in the DRCU. It is used to test the correct operation of the DPU and OBS and forms part of the AVM, simulating the instrument response to commands from the spacecraft and generating simulated telemetry data.

Figure 3-1 (taken from RD19) is a block diagram of the instrument showing the different units and the subsystems they contain. **Figure 3-2** shows the system-level breakdown of the instrument.

3.1.3 Test facility

This facility provides; a cryostat to simulate the thermal environment in which the instrument will operate; a telescope simulator and calibration sources to allow verification of the instrument specifications and its calibration; and EGSE to control and monitor the instrument and test equipment during the test and calibration activities. A description of the facility is given in RD14.

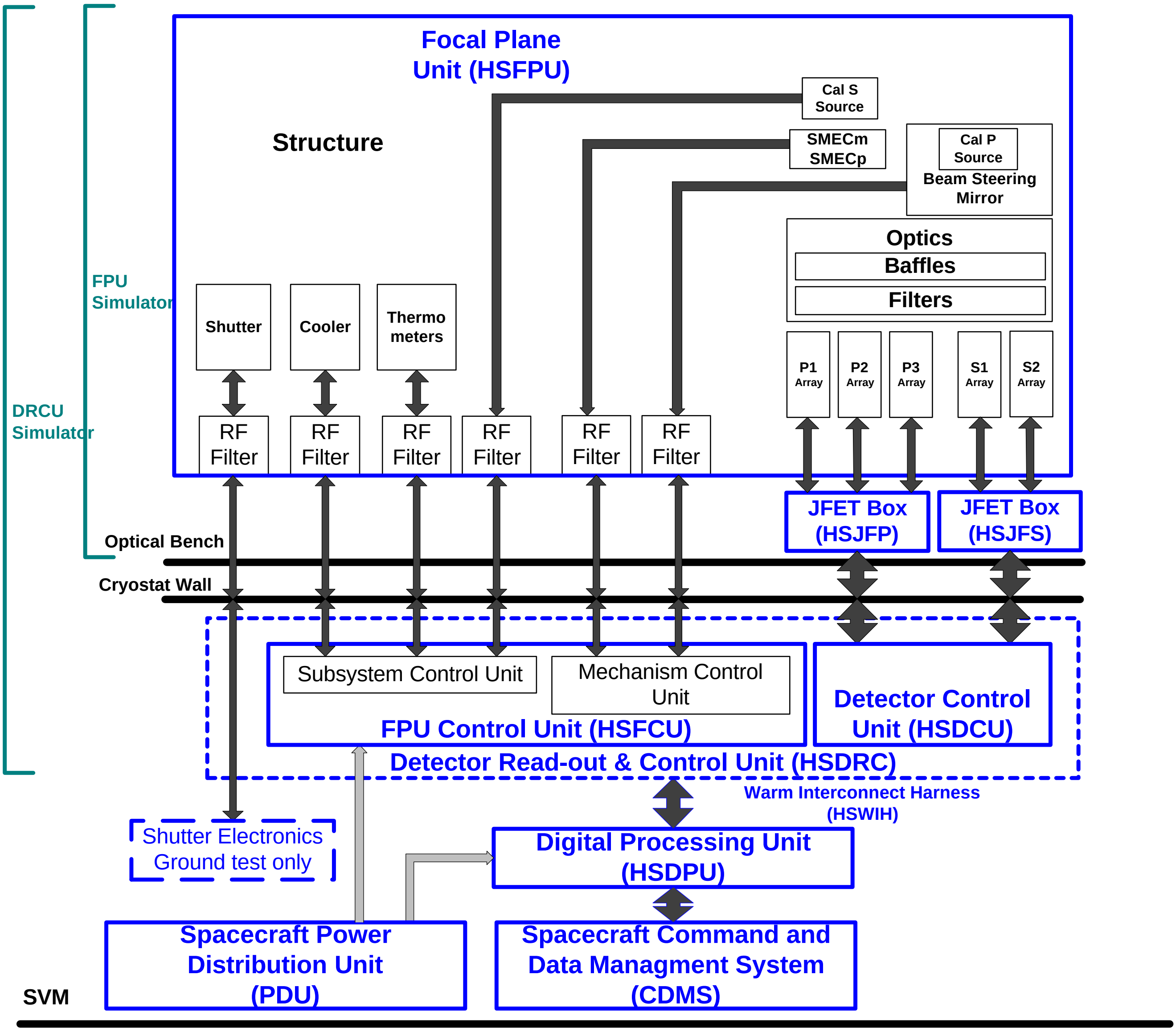

Figure 3-1 Instrument Block Diagram

3.2 Model Philosophy

A detailed rationale for the SPIRE approach to model definition and testing is contained in RD23. The following SPIRE models will be produced during the development and manufacturing phases;

- Avionics Model (AVM)
- Structural Thermal Model (STM)
- Cryogenic Qualification Model (CQM)
- Electronics Qualification Model (EQM)
- Proto-Flight Model (PFM)

- Flight Spare Model (FS)

The STM and EQM are for internal SPIRE use and will not be delivered to ESA

Additional qualification/test models of subsystems will be produced by each subsystem RO. These are detailed in the appropriate development plans. The following sections describe each model and **Table 3-1** summarises the contents of each model in terms of the subsystem models.

3.2.1 Avionics Model (AVM).

This model is required to validate the instrument electronics and software and their interfaces with the S/C (see AD01). This will include:

- verification of information exchange with the S/C computer, mass memory and attitude control systems
- verification of the instrument autonomy functions.
- validation of on-board software updates
- validation of AIV procedures

The AVM will consist of a DPU (HSDPU) plus a DRCU Simulator. The DRCU Simulator will provide sufficient simulation of the operation of the FPU, DRCU and WIH to allow the activities given above to be carried out.

The DPU will be built to flight representative standards using commercial parts, where possible with the same technology and from the same supplier as the PFM. This model will be form and fit identical to the PFM but will not implement any redundancy.

In addition the AVM DPU will be used during testing of the CQM (see below) both at instrument-level (TBC) and during CQM testing at ESA.

A fuller description is provided in RD20.

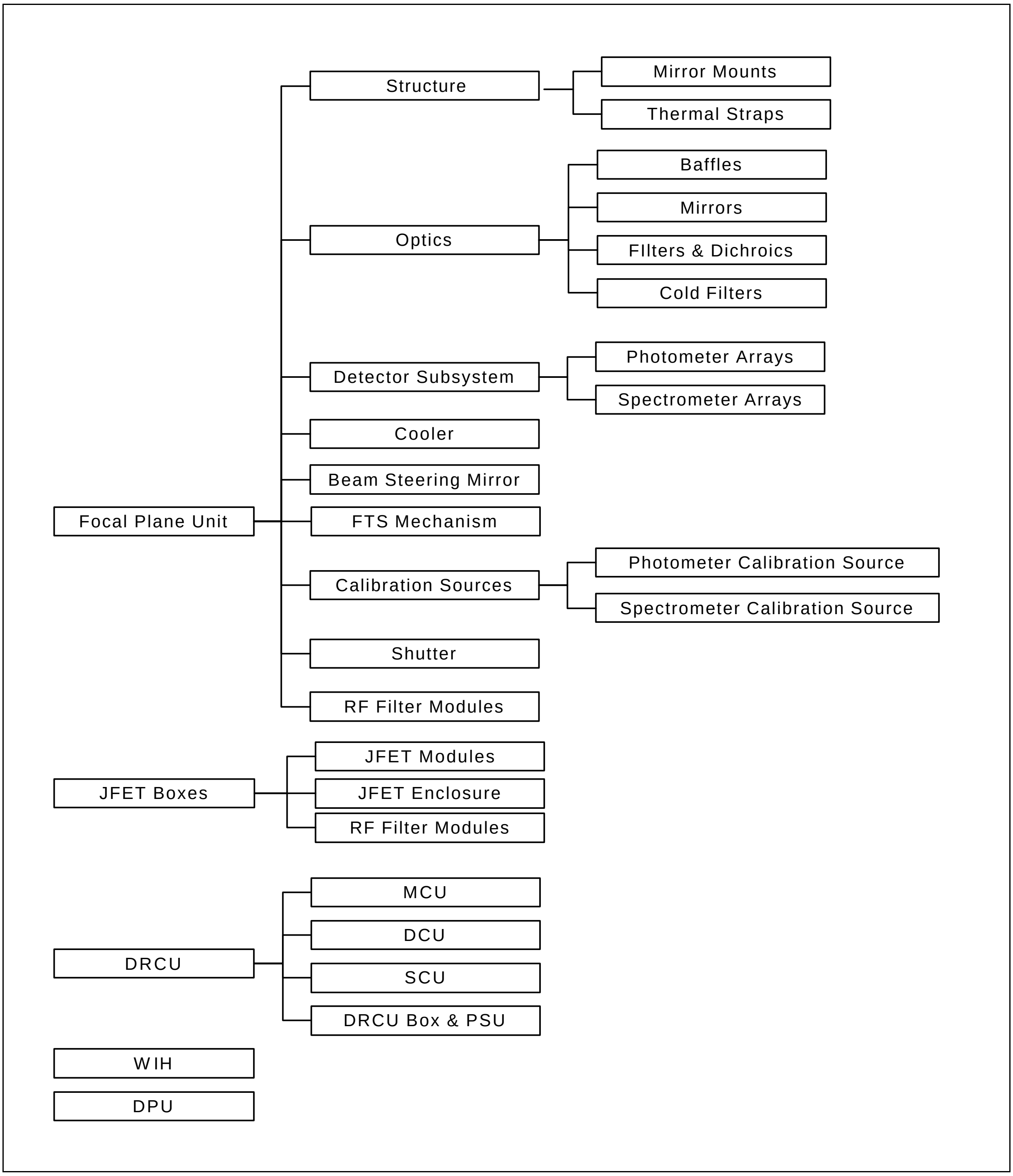

Figure 3-2 Instrument Product Tree

3.2.2 Structural Thermal Model

This model is provided early in the development phase. Its purpose is;

- to gain confidence in the mechanical model of the structure, by comparison of the vibration response when warm with the Finite Element Analysis.
- To determine the vibrational levels transmitted to the subsystems and to which the subsystem qualification models will be subjected.
- To qualify the cold instrument structure against the proposed vibration test levels
- To validate the thermal model of the instrument at the higher temperature levels (2K, 4K and 10K)
- To verify the optical alignment procedure

The model is not complete in itself. It consists of the CQM structure with additional mass/thermal models of subsystems (some also acting as optical dummies) integrated. A fuller description is provided in RD21.

3.2.3 Cryogenic Qualification Model

This model will be used by the SPIRE consortium to qualify the cold instrument design in the proposed thermal/EMC environment. On delivery to ESA it will be used to ensure the compatibility of the FIRST payload and spacecraft by performing a series of functional tests and a set of conductive EMC tests in the, suitably adapted, ISO Flight Spare Cryostat.

This model consists of a cold instrument (HSFPU HSJFP and HSJFS). In addition, to allow its integration and test, the following units will be provided; HSDRC, HSWIH, FPU Simulator and EGSE. It is assumed that the AVM DPU will be available for use for the duration of the CQM tests.

The FPU will be built to flight quality standards as far as possible, but the performance capabilities of the instrument may be less than the PFM - i.e. fewer pixels in the focal plane arrays. It will mimic as exactly as possible the thermal, electrical and mechanical properties of the flight instrument, but willl not be used to fully qualify the instrument. This will be done using qualification models of the subsystems.

The DRCU will be built from non-flight grade components, but will be form and fit identical to the PFM. It will not provide any redundancy.

A fuller description of the CQM may be found in RD22.

3.2.4 Electronics Qualification Model

This additional model is built to allow qualification testing of the warm electronics units independently of the CQM test programme. The following tests will be performed at the instrument level:

- EMC tests (Conduction, Emission, Susceptibility)
- Thermal Vacuum Test (TBC, the individula units will be tested by the ROs)
- Warm Vibration (TBC, the individual units will be tested by the ROs)

This model will also be used to carry out the first testing of the PFM FPU while the PFM electronics is being manufactured.

The model consists of a DPU, DRCU and WIH. Each will be electrically, thermally and mechanically representative of the flight units, including redundancy. Components will be of the same type as the flight model, but at a lower quality level.

3.2.5 Proto-Flight Model

This is the instrument model that is intended for flight. It consists of all SPIRE Instrument Units. It will be built to full flight standards and will only have minor differences in thermal, electrical and mechanical properties to the CQM. It will have the same mechanical, thermal and electrical interfaces to the satellite as the CQM but, may, however, have minor internal design changes compared to the CQM. For instance the bolometer arrays may have many more pixels.

The PFM will undergo environmental testing to qualification levels for acceptance times - this applies to both the warm electronics boxes and the cold FPU.

3.2.6 Flight Spare Model

The Flight Spare Model provides for replacement of failed, or damaged, units during system level testing.

The current baseline is to provide a full flight standard, calibrated (TBC) FPU and tested spare parts (normally at board level) for the DPU and DRCU.

It is currently planned to refurbish the Structure and FET box enclosures from the CQM for use as the Flight Spare. Other subsystems may also follow this route.

	AVM	CQM	EQM	PFM	FS	Comments
Instrument Units						
FPU		CQM		PFM	FS	
FET Boxes		CQM		PFM	FS	
DRCU		QM1	QM2	PFM	FS[1]	
WIH		QM1	QM2	PFM	FS	
DPU	AVM		QM	PFM	FS[2]	AVM Unit will be used for CQM testing at ESA
Support Equipment						
FPU Simulator		#1				One unit (#1) will be available at ESA for use with all models
DRCU Simulator	#3					
EGSE		#4				One unit (#4) will remain at ESA for use with all models

Notes:

1. Possibly only spare cards will be provided
2. Only spare cards (shared with other FIRST instruments) will be provided

Table 3-1 Instrument Model summary of constituent Units

3.3 Qualification

Qualification and verification of the instrument will be carried out both at subsystem and instrument levels. The detailed requirements on testing at the subsystem and instrument levels is given in RD24. A summary is given below

1. All sub-systems will go through a type approval programme of one or more models, as necessary, before the Cryogenic Qualification version of the sub-system is delivered for the instrument AIV. The testing carried out on the CQM instrument is not considered to be the qualification test for each individual sub-system as the tests carried out on the instrument CQM will be neither exhaustive nor at the correct level for sub-system qualification.
2. The CQM will undergo a series of qualification and compatibility tests at levels and temperatures agreed between SPIRE and ESA.
3. Acceptance tests will be performed on each subsystem prior to delivery for the PFM and FS models.
4. An acceptance test programme will be performed on the instrument prior to delivery to ESA.
5. Characterisation and calibration of the subsystems will be made prior to delivery of all models.
6. Characterisation and calibration of the instrument will be made prior to delivery of all models.

3.3.1 Qualification Tests

Vibration: All sub-systems are to be vibrated at levels appropriate to their location within the instrument. The temperature at which the vibration will be done is subject to negotiation between the project and ESA. The group responsible for the structure (MSSL) will define the level at which each sub-system will be vibrated. This will either be by calculation or vibration of test structures (e.g. STM).

Thermal cycle: All FPU sub-systems will be cooled down and warmed up a large number of times over the period leading up to launch. An accelerated thermal cycle test is therefore required for all FPU sub-systems. The temperatures, rate of temperature change and number of cycles are TBD.

Vacuum cycle: All sub-systems will be operating *in vacuo*. The long-term performance of all sub-systems *in vacuo* as well as their response to vacuum cycling must be assessed. All sub-systems will be vacuum cycled and critical items will undergo long-term life tests under vacuum conditions.

Lifetime: Where novel material processing or unqualified mechanisms are employed in a sub-system, accelerated life tests will be mandatory. For all ASICs and micro-machined components a programme of device selection will be required to guard against infant mortality.

Soak/cycle: All electronic sub-systems and/or components will need to be soak tested and operationally cycled as part of their lifetime test programme.

Radiation tolerance: All unqualified electronics sub-systems and/or components will have to be exposed to the appropriate level of radiation dose to ensure survival in orbit.

Thermal range: The operating temperature range of a sub-system will be characterised. If a sub-system does not operate within specification, or at all, at temperatures that are within the expected limits, it cannot be considered qualified.

Thermal stability: The response of a sub-system to thermal instabilities will be characterised as will the impact of sub-system operation on the thermal stability of the instrument. A sub-system that causes large thermal instability in the instrument during its normal operational cycle or is over sensitive to the expected level of thermal instability cannot be considered qualified.

Microphonics: The level of mechanical vibration from a sub-system will be characterised as well as the response of the sub-system to microphonic interference. Any sub-system that causes excessive mechanical vibration during its normal operation or is over sensitive to the expected level of mechanical vibration cannot be considered qualified.

Ionising radiation: The response of a sub-system (e.g. the detectors) to high energy ionising radiation (simulating cosmic ray proton hits), will be characterised. A sub-system will not be considered qualified if its performance is significantly reduced by the impact of high energy ionising radiation.

EMI: The sensitivity of a sub-system to electromagnetic interference will be characterised. If a sub-system is over sensitive to the expected level of electromagnetic emission it will be deemed not qualified.

EMC: The radiated and conducted electromagnetic emission of a sub-system will be characterised. Any sub-system that emits significant levels of electromagnetic radiation or interferes with power supplies or ground lines will not be considered qualified.

Materials conformance: All materials used in the manufacture of a sub-system must be approved for space use by ESA. Any materials not on an approved list must under go a materials approval test as laid down by ESA.

For some sub-systems the qualification and lifetime testing will be more appropriately carried out at component or test item level rather than at the level of the integrated sub-system. At what stage and under what conditions the tests are to be carried out is a matter for detailed consideration by the groups responsible for the sub-systems delivery.

3.4 Assembly, Integration and Verification

All assembly, integration and testing at instrument-level is the responsibility of RAL. RAL will make use of its own facilities wherever possible for these activities and requires only external facilities to perform the cold vibration of the STM, PFM (and FS models, TBC). It is assumed that ESA will provide these facilities.

The majority of the instrument-level testing will take place in the RAL AIV Facility described in RD14.

3.4.1 Assembly and Integration

RAL will use its clean room and integration facilities to carry out these activities. Subsystem providers will be expected to attend and support these integration activities.

3.4.2 Verification

Verification of the instrument characteristics and performance is a multi-level activity;

3.4.2.1 Subsystem Verification

Each RO will be responsible for testing their delivered subsystems against the subsystem requirements, provided in subsystem specification documents. A test plan will be developed by each RO to describe the tests and setup to be used for each identified test. Test reports will be written and delivered with each subsystem model.

3.4.2.2 Instrument Verification

At the instrument level the Instrument Requirements Document (RD25) will used as the basis of the tests to be carried out during the AIV phase at RAL. The AIV Plan (RD26) indicates the order and time available for the tests to be carried out. The Instrument Test Plan (RD27) details the tests themselves.

3.4.2.3 Calibration

The Calibration Plan (RD28) describes the calibration activities to be carried out and those needed to be performed on the ground are detailed in the Ground Calibration Plan (R29).

4. SPIRE SUB-SYSTEMS

The SPIRE Product Tree (RD20) breaks the instrument down into deliverable items and identifies the responsible RO. Figure 4-1 shows how these items are assembled into the instrument units.

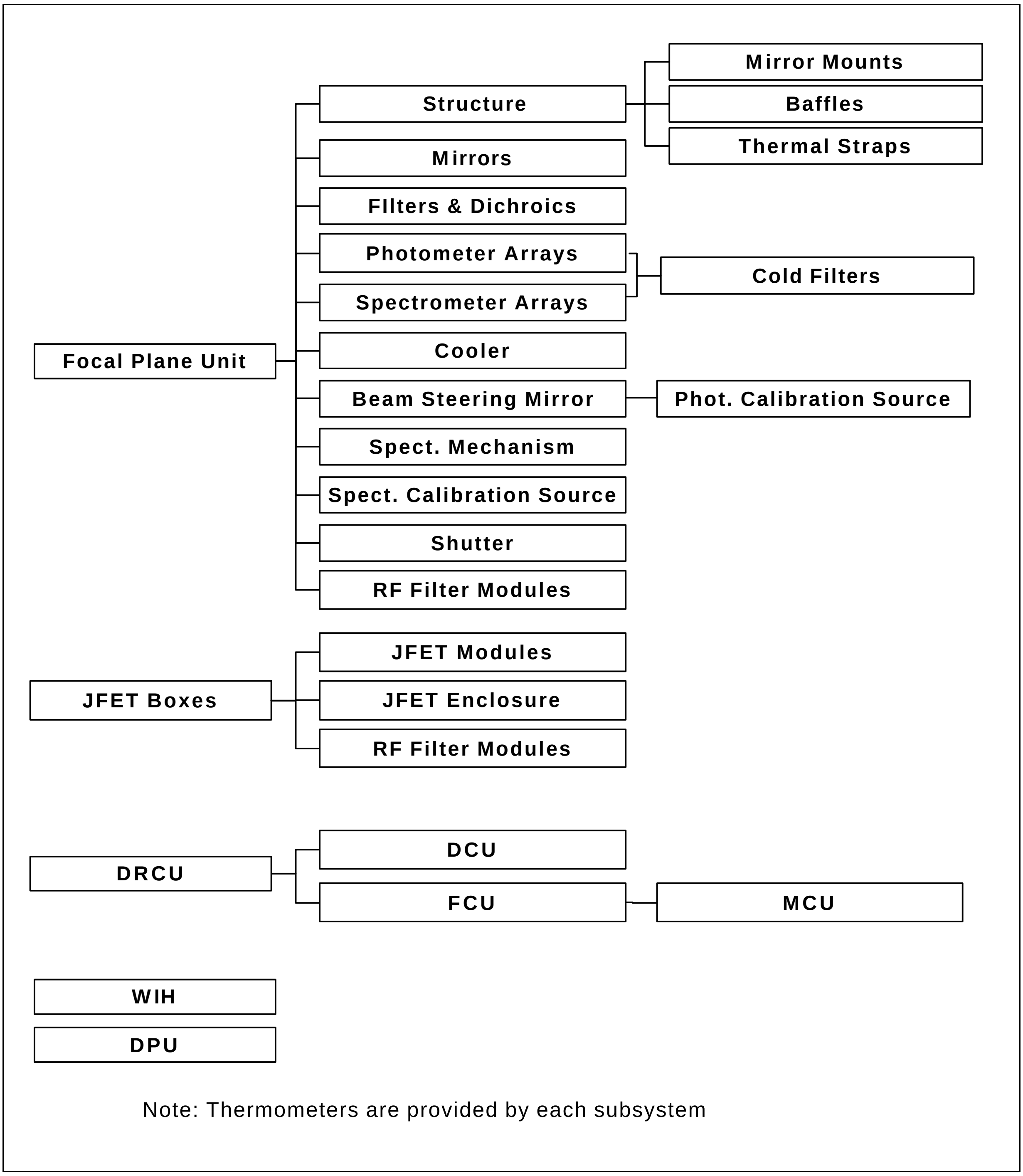

Figure 4-1 Instrument Assembly Tree

The following sections define the contents of each unit for each instrument model to be provided

4.1.1 Focal Plane Unit

Table 3-1 is a summary of the FPU subsystem models to be delivered;

	Resp.	STM	CQM	PFM	FS	To	Comments
FPU Subsystems							
Mechanical							
Structure	MSSL	CQM		PFM	FS	RAL	FS is refurbished CQM
Mirror Mounts	MSSL	CQM		PFM	FS	RAL	FS is refurbished CQM
300 mK Straps	QMW	CQM		PFM	FS	RAL	
Optics							
Mirrors	LAS	CQM		PFM	FS	RAL	
Filters & Dichroics	QMW	STM	CQM	PFM	FS	RAL	Only input filter required for STM
Cold Filters	QMW		CQM	PFM	FS	JPL	
Baffles	MSSL	CQM		PFM	FS	RAL	
Detectors							
Photmeter Arrray 1	JPL	STM	CQM	PFM	FS	RAL	
Photometer Array 2	JPL	STM	CQM	PFM	FS	RAL	
Photometer Array 3	JPL	STM	CQM	PFM	FS	RAL	
Spectrometer Array 1	JPL	STM	CQM	PFM	FS	RAL	
Spectrometer Array 2	JPL	STM	CQM	PFM	FS	RAL	
Cooler	Grenobl	STM	CQM	PFM	FS	RAL	
Beam Steering Mirror	ATC	OD	CQM	PFM	FS	LAM	Optical Dummy delivered direct to RAL
Spectrometer Mechanism	LAM	OD+STM	CQM	PFM	FS	RAL	
Calibration Sources							
Photometer	QMW		CQM	PFM	FS	ATC	
Spectrometer	QMW	STM	CQM	PFM	FS	RAL	
Shutter	USK	STM					
RF Filter Modules	JPL	CQM		PFM	FS	RAL	

Table 4-1 FPU Subsystem Deliverables

4.1.2 JFET Boxes

The table below gives a summary of the subsystems to be delivered;

	Resp.	STM	CQM	PFM	FS	To	Comments
JFET Box Subsystems							
JFET Modules	JPL	STM	CQM	PFM	FS	RAL	
FET Box RF Filter Modules	JPL	STM	CQM	PFM	FS	RAL	
JFET Enclosure	MSSL	CQM		PFM	FS	RAL	

Table 4-2 FET Box Subsystem Deliverables

4.1.3 DRCU

The table below gives a summary of the subsystems to be delivered;

	Resp.	CQM	EQM	PFM	FS	To	Comments
DRCU Subsystems							
DCU	SAp	QM1	QM2	PFM	FS	RAL	
FCU	**SAp**					**RAL**	
MCU	LAM	QM1	QM2	PFM	FS	SAp	
SCU	SAp	QM1	QM2	PFM	FS		
PSU	SAp	QM1	QM2	PFM	FS		
DRCU Boxes	SAP	QM1	Qm2	PFM	FS		

Table 4-3 DRCU Subsystem Deliverables

4.1.4 WIH

The table below gives a summary of the subsystems to be delivered;

	Resp.	CQM	EQM	PFM	FS	To	Comments
WIH Subsystems							
WIH	SAp	QM1	QM2	PFM	FS	RAL	

Table 4-4 WIH Subsystem Deliverables

4.1.5 DPU

The table below gives a summary of the subsystems to be delivered;

	Resp.	AVM	EQM	PFM	FS	To	Comments
DPU Subsystems							
DPU	IFSI	AVM	QM	PFM	FS	RAL	

Table 4-5 DPU Subsystem Deliverables

5. TEST AND SUPPORT EQUIPMENT AND FACILITIES

The table below gives a summary of the test and support equipment and facilities required for development, test and calibration of the instrument models.

	Resp.	No.	To	Comments
Simulators				
FPU Simulator	SAp	2	RAL	One is delivered to ESA
DRCU Simulator	SO	3	IFSI/RAL(2)	One is delivered to ESA
Support Equipment				
EGSE	RAL	4	RAL	One is delivered to ESA, one to IFSI
Test Facilities				
Calibration Cryostat	RAL	1		
Telescope Simulator	RAL	1		
Black Body Source	RAL	1		
Infrared Laser	RAL	1		
FTS Source	RAL	1		

Table 5-1 Test and Support Equipment Deliverables

6. Risk Assessment

6.1.1 Technical Risks

Risk	Impact	Preventative Action
Structure or other subsystem failure during cold vibration	Delay to programme while subsystem is modified	Use of STM allows early testing of structure and determination of vibration loads on other subsystems. Vibration qualification of subsystems can be carried out in parallel to CQM testing in preparation for PFM
Thermal Design of instrument does not meet requirements	Delay to programme while thermal design is modified	STM testing will provide early indication of possible problems. These can be addressed in parallel to CQM testing, provided that they do not prevent operation of the CQM
Optical alignment does not meet requirements	Delay to programme while optical design is modified	Optical design minimises alignment requirements. STM testing will provide early indication of possible problems. These can be addressed in parallel to CQM testing, provided that they do not prevent operation of the CQM
Need for thermal control of detector temperature	Additional sensor and OBS control algorithms required	Baseline is to include the necessary hardware. OBS will be updated if needed.

6.1.2 Programme Risks

Risk	Impact	Preventative Action
Late delivery of subsystem	Possible delay to instrument delivery	Regular monitoring of milestone status and margin will identify problems early. This will allow corrective action to be taken.
Late delivery of shutter, which has started development later than other subsystems	Delay to programme or inability to test detectors at the satellite level.	Check possible options for testing detectors in high background environment
Delay to provision of Cold Vibration facility by ESA	Cold STM Vibration testing will be delayed	Cold vibration qualification of subsystems (apart from structure) has been removed from CQM delivery programme and can be carried out later, provided it is done in time for PFM manufacture. Structure testing remains a problem
Late definition of S/C interfaces	Delay in completing Detailed Design Reviews and starting manufacture	An approach to quick resolution of these items needs to be put in place immediately. Alcatel-Instrument meetings are a good start.

Resources not sufficient to handle Alcatel/ESA joint management scenario	Inability to manage / monitor instrument programme adequately	Minimise extra work associated with this; No extra reporting requirements Minimise meetings, using telconferences in preference.

7. SCHEDULE

7.1.1 Overall Schedule for the FIRST Programme

Table 7-1shows the current ESA high-level milestones defined for the Herschel development phases and the delivery dates of the instrument models in AD01.

Milestone	Date
Issue of ITT to industry	September 2000
Start Phase B	June 2001
Start of Phase C/D	June 2002
End of Phase C/D	July 2006
Launch	Q1 2007
Delivery of Instrument AVM	April 2003
Delivery of Instrument CQM	April 2003
Delivery of Instrument PFM	July 2004
Delivery of Instrument FS	July 2005

Table 7-1 ESA High-level Milestones

Figure 7-1shows the corresponding SPIRE baseline development schedule, which does not meet these milestones.

A more detailed set of schedules is provided in RD 30

The Major Milestone List (RD17) contains all the dates for deliverable items identified in this plan and the estimated margin.

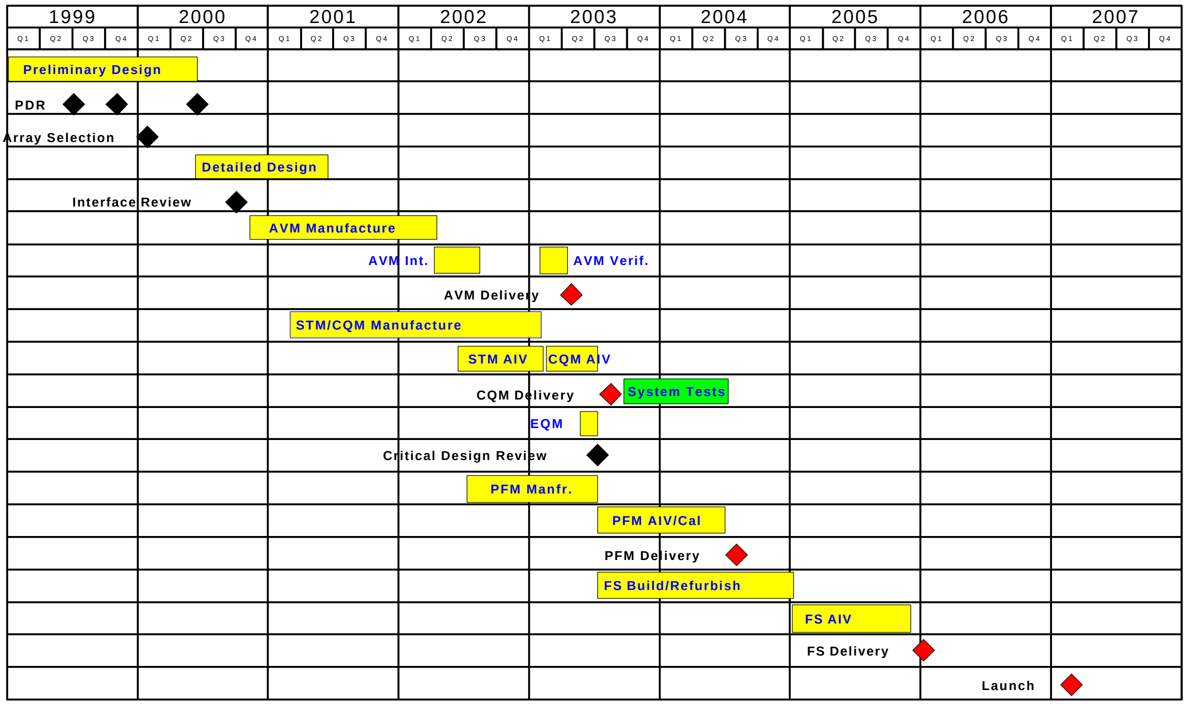

Figure 7-1 SPIRE Overall Schedule