SPIRE AIV FACILITIES DEVELOPMENT PLAN

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Update

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07-March-2001	Draft 2	Full revision Baseline schedule and milestones included
10-April-2001	Issue 1.0	Comments Incorporated First formal issue Document renamed from SPIRE-RAL-DOC-000477

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Table of contents

1 Scope of the document

This document describes the development plan for the facilities to be used for SPIRE Assembly Integration and Verification (AIV). In particular, the document describes the development of a purpose built cryogenic calibration and test facility for SPIRE. Other facilities to be provided for SPIRE are clean rooms for assembly and optical alignment, mechanical inspection facilities and vibration facilities.

The EGSE development will be covered in a separate document.

2 Documents

2.1 Applicable documents

	Title	Author	Reference	Date
AD 1	SPIRE Test Facility Requirements Specification	D.L. Smith	SPIRE-RAL-PRJ-000463 Issue 1.2	15-Nov-2000
AD 2	SPIRE Product Assurance Plan	G.Douglas	SPIRE-RAL-PRJ-000017 Draft	05-Feb-1998
AD 3	SPIRE EGSE Development Plan	J. Payne		
AD 4	SPIRE Development Plan	K. King	SPIRE-RAL-PRJ-000035 Issue 1.0	20-Jun-2000
AD 5	SPIRE Major Milestone List	K. King	SPIRE-RAL-PRJ-000455 Issue 1.0	17-Jul-2000
AD 6	SPIRE AIV Facility Milestone Plan	D.L. Smith	SPIRE-RAL-PRJ-000527 Issue 1.0	04-Apr-2001

2.2 Reference documents

	Title	Author	Reference	Date
RD 1	Space Science Department Software Engineering Standards	T.G. Dimbylow	ISO9/SPAP/SOFT/0001 Issue 1.1	19-03-1999
RD 2	AIV Facility Description	G.M. Toplis	ISO9:SPAP/AIV/000	01-07-2000

3 Glossary

AD	Applicable Document	WE	Warm Electronics
CDR	Critical Design Review		
CQM	Cryogenic Qualification Model		
DDR	Detailed Design Review		
EGSE	Electrical Ground Support Equipment		
FIRST	Far InfraRed Space Telescope		
FPU	Focal Plane Unit		
FTS	Fourier Transform Spectrometer		
MGSE	Mechanical Ground Support Equipment		
PFM	ProtoFlight Model		
RAL	Rutherford Appleton Laboratory		
RD	Reference Document		
SPIRE	Spectral and Photometric Imaging REceiver		
TBC	To Be Confirmed		
TBD	To Be Defined		
TFCS	Test Facility Control System		

4 Introduction

This document describes the development plan for the SPIRE AIV Facilities specified in AD 1. The following facilities will be required for the SPIRE AIV activities

- Cryogenic test facility, incorporating 1.7K liquid helium cryostat, calibration equipment and control system.
- Clean rooms for mechanical and electrical integration, and optical alignment.
- Mechanical inspection facilities.
- Vibration facilities for unit and instrument level tests at both ambient and cryogenic conditions.
- Electrical Ground Support Equipment

General-purpose clean rooms, vibration facilities and mechanical inspection facilities already exist within RAL and will be booked for the SPIRE AIV testing. The SPIRE specific elements (cryostat, cryolab, test equipment, control and monitoring) have yet to be built, therefore these will be covered in greater detail. The development of the EGSE will be described in a separate document.

The cryogenic test facility will comprise of two working areas: a clean room to house the cryostat and optical bench, and a control room to house the instrument EGSE and control equipment for the cryostat and calibration equipment, Figure 2. The working area around the cryostat will be class 1000, and other areas in the clean room will be class 10, 000 or better.

The SPIRE instrument will be mounted in a cryostat to simulate the thermal conditions provided by the FIRST cryostat, namely 7-11K, 4K and 1.7K. External calibration sources will be viewed via a telescope simulator situated outside the cryostat at room temperature. A cold blackbody source (4K-20K) mounted in the cryostat will provide an absolute calibration reference.

The telescope simulator is required to present the instrument with an F-8.68 beam to correctly represent the input from the FIRST telescope.

The control and monitoring of the calibration sources, the telescope simulator and cryostat temperatures will be performed via a single test facility systems computer (TFCS), connected to the main SPIRE EGSE.

5 Deliverables

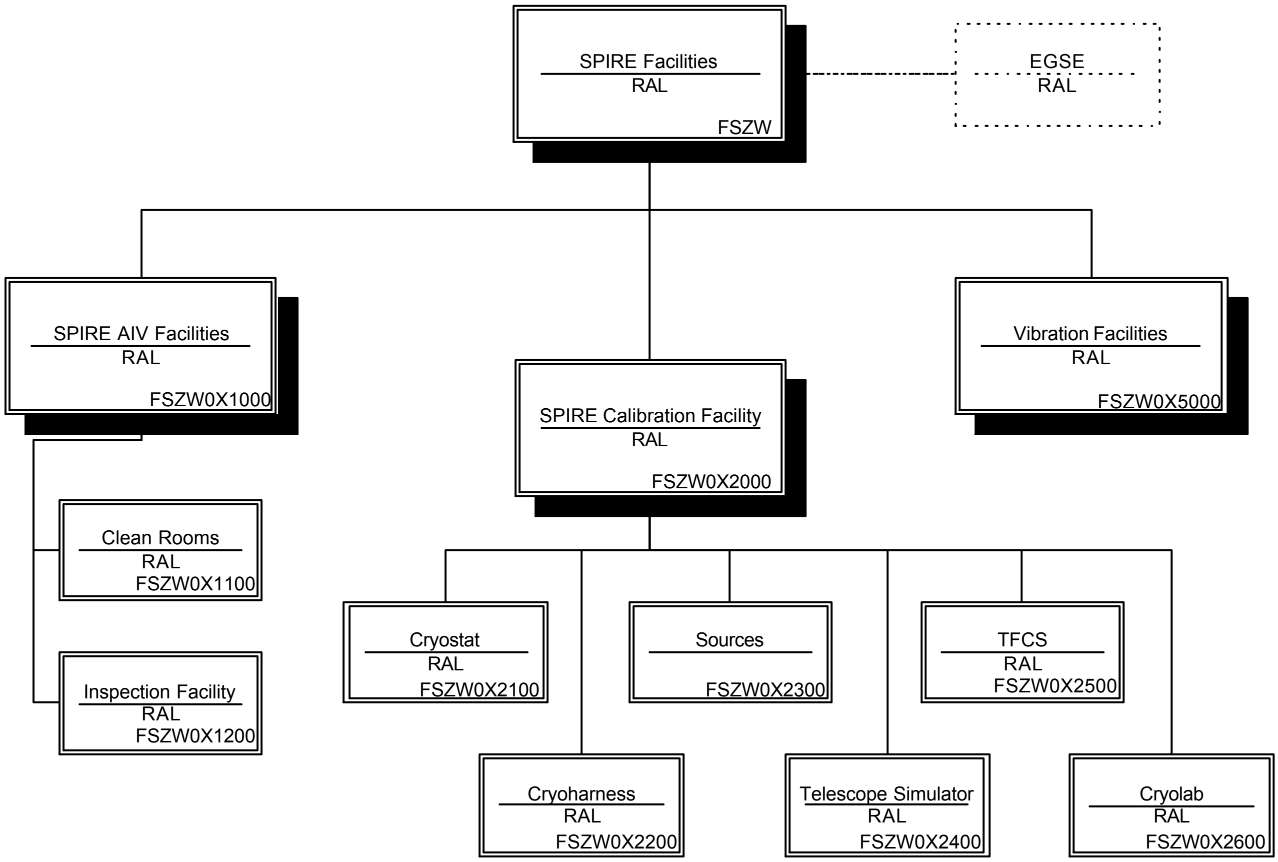


Figure 1: Breakdown of SPIRE AIV Facilities

This section describes the main deliverables of the project and the development approach taken. The following facilities have been identified for the SPIRE AIV activities

- Cryogenic test facility, incorporating 1.7K liquid helium cryostat, calibration equipment and control system.
- Clean rooms for mechanical and electrical integration, and optical alignment.
- Mechanical inspection facilities.
- Vibration facilities for unit and instrument level tests at both ambient and cryogenic conditions.
- Electrical Ground Support Equipment

5.1 Calibration Facility

SPIRE can only be operated at cryogenic temperatures. Hence, all performance testing of the instrument must be performed with the instrument cooled to operational temperatures, namely 4K for the optical bench and 1.7K for the 0.3K cooler and detector boxes. The main tests requiring cryogenic conditions are:

- Radiometric and spectral calibration
- Functional performance tests
- Thermal performance

It is also necessary to verify the optical alignment at operational conditions because the instrument optics are integrated and aligned at room temperature, and may be affected by thermal contraction.

It is a requirement that the test facility is available to the SPIRE project until launch in 2007. For this reason a purpose built test facility will be built.

The main deliverables to the SPIRE project are

- Cryolab
- Cryostat
- Cryoharness
- Telescope Simulator
- Calibration Sources
- Test Facility Control System

5.1.1 Cryogenic test facility (Cryolab)

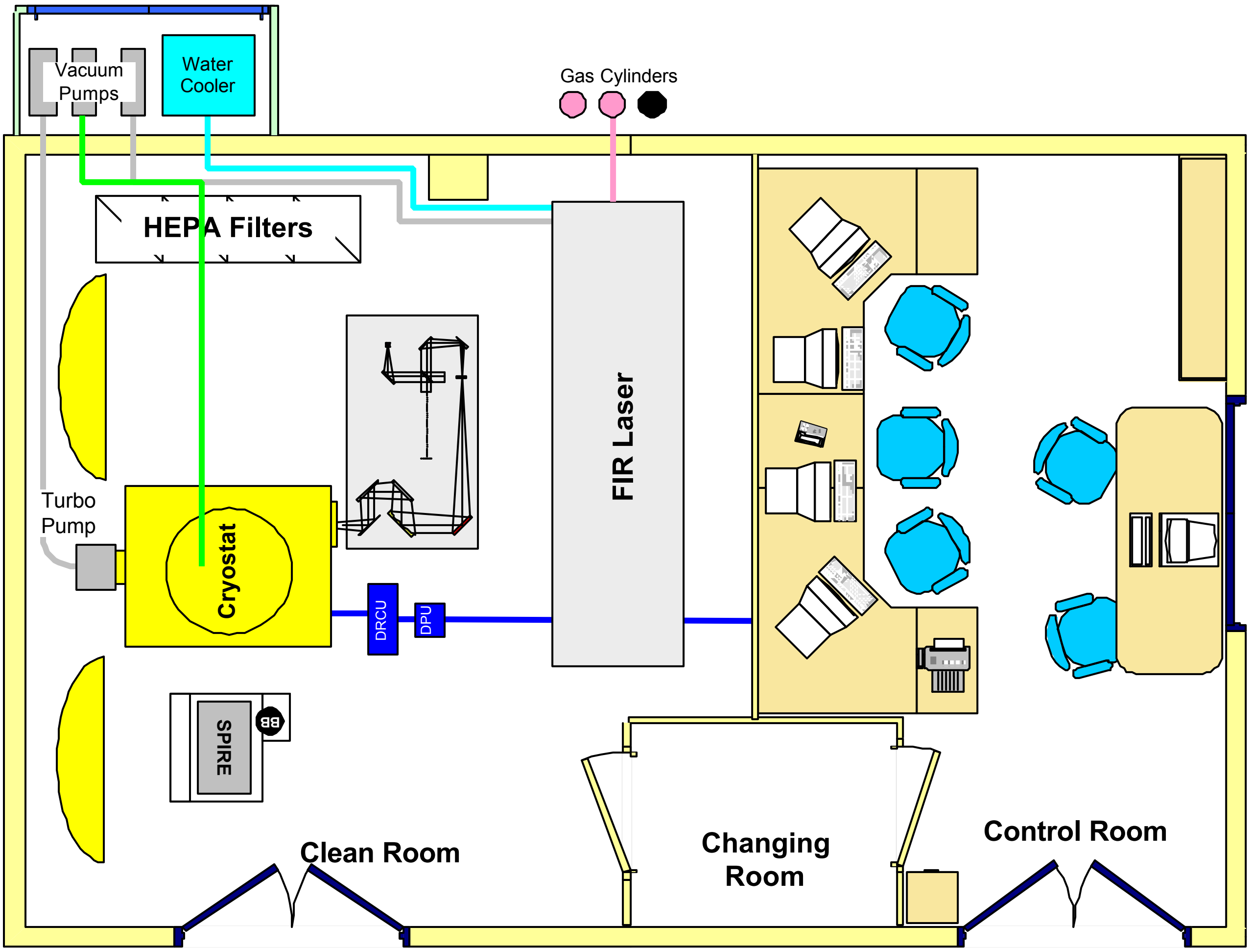


Figure 2: Proposed layout for cryogenic test facility.

The calibration facility will comprise of two working areas. A clean room to house the cryostat and optical bench, and a control room to house the instrument EGSE and control equipment for the cryostat and calibration equipment, Figure 2. The working area around the cryostat will be class 1000, and other areas in the clean room will be class 10, 000 or better.

A room at RAL, previously used for the ISO LWS calibration, has been designated as the SPIRE cryogenic test facility. This has the principal advantages of being located within SSTD at RAL, is available to the project and houses a FIR laser facility. The main drawback is the limited space available; thus restricting the range of activities that can be performed in the laboratory. Ideally, it would be better to have a facility where integration and calibration activities can be performed in the same room. Although technically possible to locate the facility in another area within RAL, it cannot be done within the current budget and schedule. The proposed solution is a compromise, allowing the calibration activities to be performed within easy reach of the other RAL SSTD facilities (clean rooms, space electronics and mechanical workshops). The available space within the clean room can be best utilised by providing adequate storage and limiting the activity in the clean room at any one time.

To accommodate the SPIRE instrument, cryostat, optical bench, laser and other support equipment the existing clean area has to be enlarged by moving the partition wall between the clean room and control room. The control room will house the EGSE and test facility control system. To minimise costs, the changing area will remain unaltered.

A further drawback to the location is that it will not be possible to move the cryostat into the clean room through the existing doors. The current size of the cryostat would have meant significant modifications to the entrance to the 'wrap around' area of the heavy-duty laboratory at considerable expense. The proposed solution is to build in an external door to the clean room so that the cryostat can be brought in directly from the outside. Although not ideal, it presents the most practical solution. Once the cryostat has been installed the doors would be sealed off.

Space does not permit a separate plant room to house the vacuum system and water coolers. Instead these will be located in a small 'shed' the other side of the clean room wall. The current shed is in a gross state of disrepair and needs replacing. The replacement shed should have some filtering to reduce the build up of dust. Gas cylinders will also be located outside of the clean room on a hard stand.

5.1.2 Cryostat

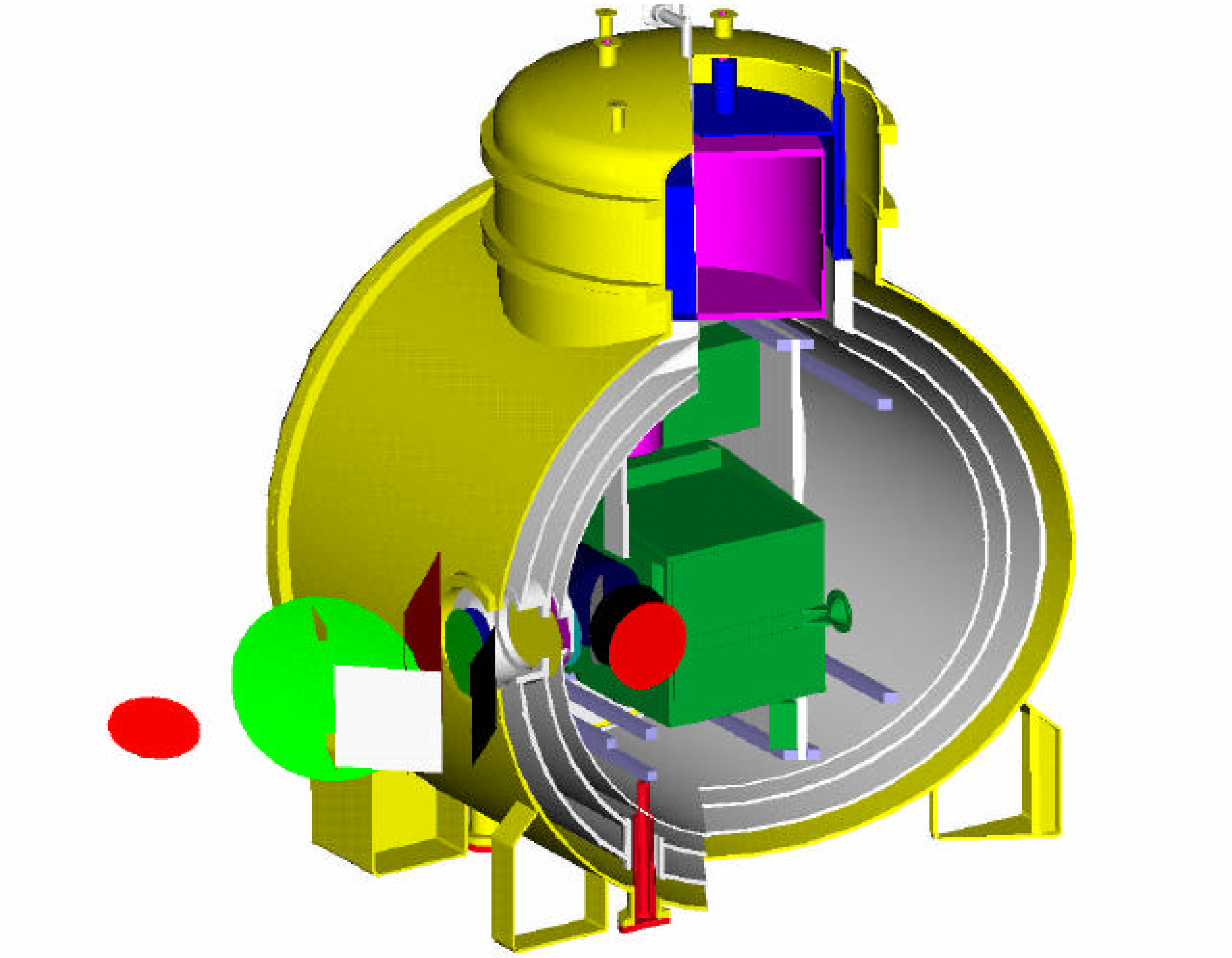


Figure 3: Design concept of the SPIRE calibration cryostat, showing the instrument, cold blackbody and filters.

5.1.2.1 Design

The calibration cryostat, Figure 3, will accommodate the SPIRE FPU, two JFET boxes and a 4-20K-blackbody calibration source. The cryostat will simulate the thermal environment provided by Herschel and cool the instrument to its operating temperatures of 7-11K, 4K and 1.7K.

It had been hoped to re-use the cryostat used for the ISO LWS calibration. However, the SPIRE instrument is significantly larger than ISO LWS was and therefore the existing cryostat is not suitable, and therefore a new cryostat design is being proposed.

The key elements of the cryostat are:

- Vacuum chamber – this will be a stainless steel vessel approximately 1.2m in diameter that can be pumped to a pressure of $<10^{-6}$mbar (with instrument and support equipment) prior to filling the cryogen tanks.

- Cryogen tanks – there will be three separate tanks containing LN_2, He at 4K and He at 1.7K. The hold time of the tanks will be at least three days when the instrument is cold to allow work to continue uninterrupted over the weekends. The tanks will be pre-cooled with LN_2 to reduce the overall cool-down time. There are no plans to regenerate the He.

- Thermal shrouds – the design of the cryostat should ensure that the instrument is completely surrounded by a 10K shroud therefore minimising stray light and unwanted thermal loads.

- Fluid links to instrument thermal interfaces – these will provide higher cooling power than conventional copper straps.

- Support structure – the SPIRE instrument and associated equipment will be mounted to a support structure outside of the vacuum chamber. The complete assembly will be moved into the cryostat and locked into position. The design will ensure that the structure and instrument are thermally isolated from the tank walls. The support structure will also be cooled via a thermal strap to the 10K shield.

- Electrical Interfaces – It is expected that there will be of the order of 1400 individual wires from the SPIRE instrument to the vacuum chamber wall. In addition there will be a significant number of wires for the cryostat thermometers and heaters. These will have a significant effect on the thermal performance of the cryostat. The electrical harnesses will be manufactured to order and will probably have a long lead-time. It will therefore be necessary to produce an accurate definition of the electrical interfaces as soon as possible to avoid potential impacts on the development schedule

- Optical Interfaces – The total heat flux incident on the SPIRE FPU during calibration should be of the same magnitude as presented by the 80K Herschel telescope. During calibration the SPIRE instrument views a scene a source at 1000K with a 300K background. Obviously, with no optical filtering the heat flux would be too great and have significant effects on the performance of the cryostat. Thus to bring the measured signal to representative levels, and to reduce the heat loading on the cryostat thermal shields, optical filters are required at each of the cryostat temperature boundaries, namely 300K, 77K and 4K. The 77K filter should block the thermal IR signal below 100μm, although this was not agreed formally at the time of writing. Neutral density filters at the 4K interface will reduce the signal further, although it may be possible to mount these at the 77K interface. Again, QMW and RAL were still defining the requirements for these filters at the time of writing. Calculations are required to determine the signal measured by SPIRE and the total heat load in the filters at each interface.

To ensure that a commissioned cryostat is ready in time for the delivery of the STM, the design of the cryostat has to be completed before the SPIRE instrument design is finalised and the calibration requirements defined. This clearly presents a major risk to the project. These risks are minimised by ensuring that the body of the cryostat is not dependent on the final instrument design. Thus the mechanical, optical and electrical interfaces are not built into the cryostat, but can be produced when the instrument design has been finalised.

5.1.2.2 Manufacture

The estimated cost to manufacture the cryostat is ~£90000 hence the manufacturer must be selected by competitive tender. The tender exercise is planned to take place in January 2001 and is expected to take approximately eight weeks. The cryostat will then take approximately 25 weeks to build.

The cryostat manufacturer will be required to produce a schedule highlighting the key milestones and keep informed RAL of progress.

The SPIRE project does not require that the contractor is ISO9000 accredited, although the contractor should be able to demonstrate that quality control procedures are in place and being followed. Key inspection points will be reviewed by RAL. The contractor will ensure that the project is notified of all major non-conformances and changes to the agreed design. A certificate of conformance will be required as part of the delivery to RAL.

5.1.2.3 Test and Integration

On delivery to RAL the cryostat will be installed in the cryolab and a series of commissioning trials performed. A test plan and procedures will be produced in advance of the tests. The initial trials should include the cold blackbody and the reference detector.

5.1.3 Cryogenic Test Harness (Cryoharness)

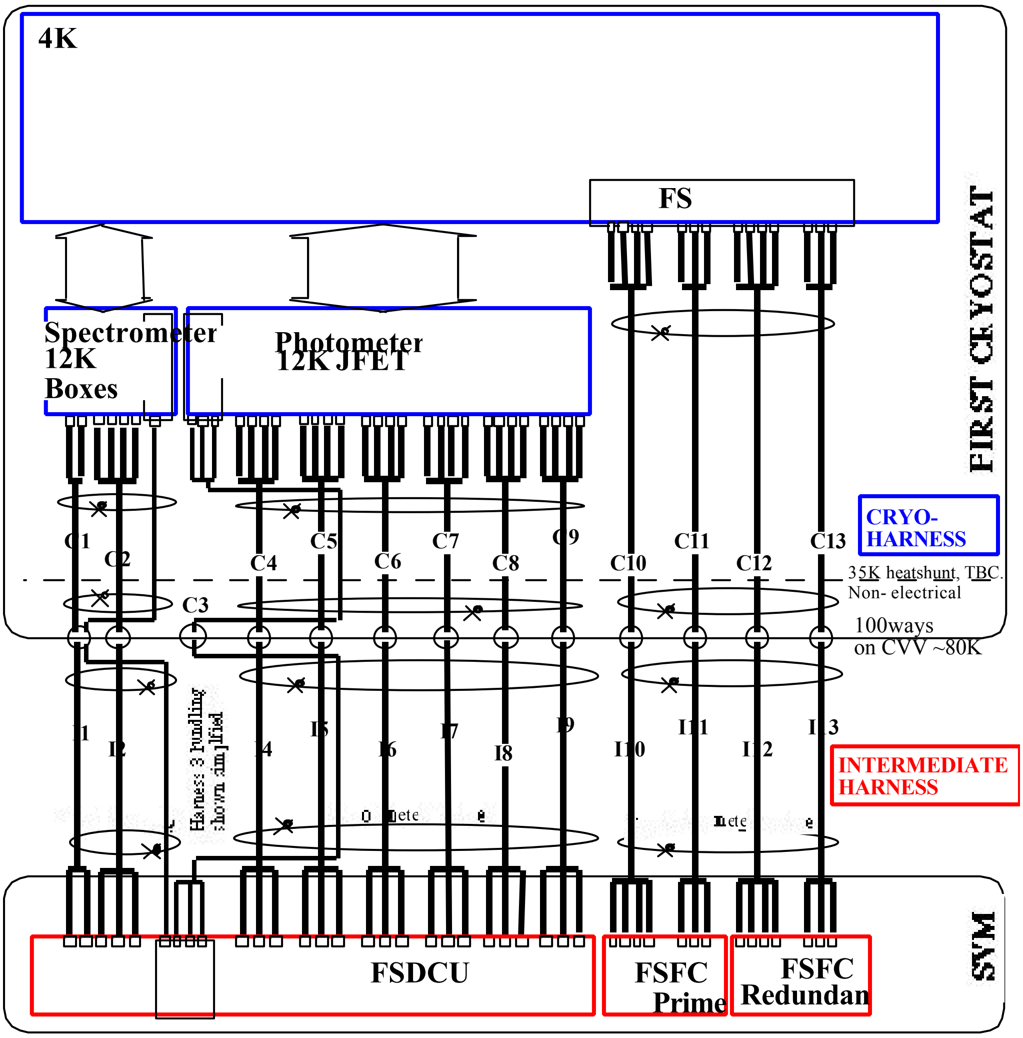


Figure 4: Proposed scheme for SPIRE cryoharness.

The cryoharness is the internal harness between the SPIRE DRCU and the JFET boxes and FPU and is essentially a replica of the flight harness, Figure 4. The harness will consist of two main sections. An airside section running from the cryostat wall to the warm electronics, and a vacuum side harness from the tank wall at 300K, through the 77K and 10K shields to the cold electronics at 4K. The design of the harness is simplified by separating the harness into a number of identical smaller items for the detector signals and a separate harness for power. Furthermore, thermal model calculations have shown that with adequate clamping arrangements, the heat load into the SPIRE instrument can be kept below the 5mW limit. The eventual design will be based on the flight model harness specification.

A harness supplier, Tekdata, has been approached to explore the design of the harness. The method proposed is to weave groups of twisted triples into a single ribbon, which provides strength and flexibility. The company has stated that they are able to produce a harness in an acceptable timescale for the project.

The main cost driver is the number of connections. Initially, three sections were proposed, but with 12000 connections the cost had been estimated at £50000 plus the cost of the wires, and was therefore too expensive. Using only two sections will reduce the number of connections to 8000 and require fewer connectors, and should therefore reduce the overall cost.

Because the harness is a critical item, an invitation to tender will not be issued until the design has reached a sufficient level of maturity (i.e. the materials, screening method…). This presents a risk to the project because the harness is a long lead item (40wks) and delay in manufacture could have a significant effect on the overall AIV schedule. To mitigate this, it is advised that the main specifications of the harness should be frozen by the end of April 2001.

A test campaign for the harness will be conducted between the cryostat commissioning and the start of the STM tests. The main purpose will be to characterise the harness at cryogenic temperatures, in particular to determine any effects that could impact the overall instrument performance. The tests to be performed will be defined by JPL.

5.1.4 Telescope Simulator

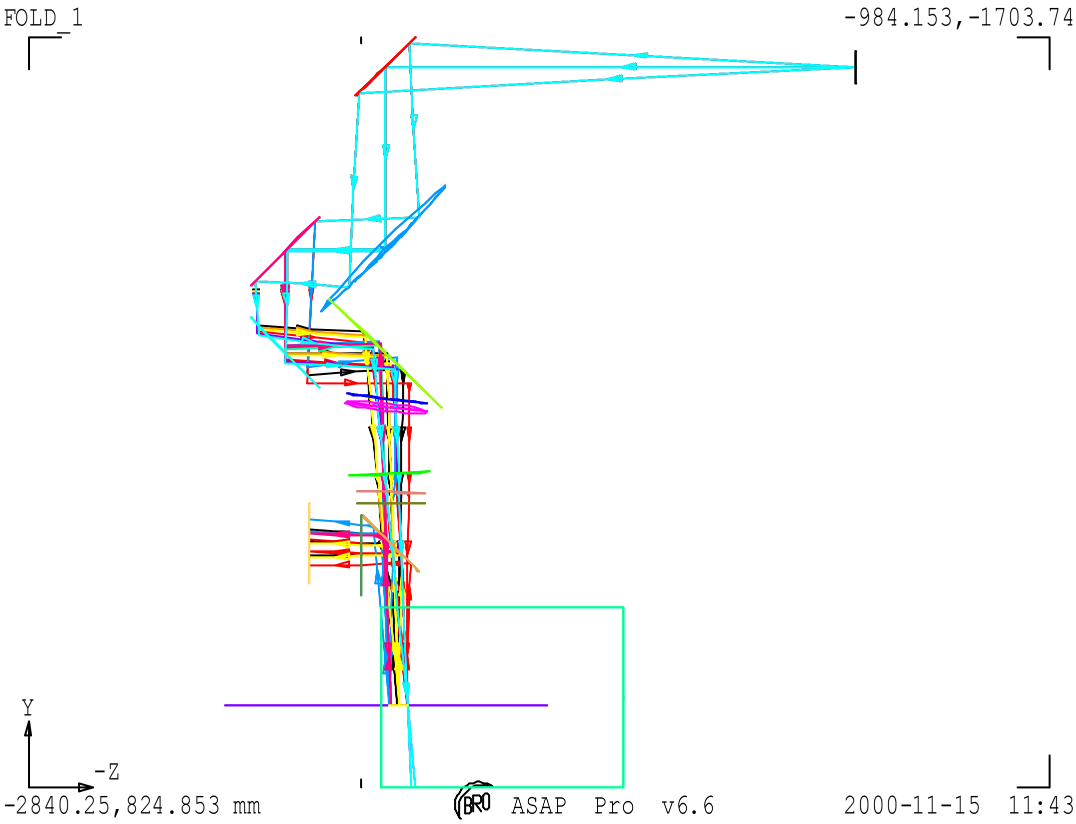


Figure 5: Optical Design Concept of SPIRE Telescope Simulator

The telescope simulator will generate a point-source beam that is representative of that which is seen by the instrument in flight, i.e. viewing an astronomical source.

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.

The beam control system is to use a series of movable mirrors to steer & focus the beam. In order to generate the required beam motion the mirror positions must be co-ordinated in tip, tilt & translation according to geometric 'control laws'.

The motions are to be generated using automated actuators, with software control (using e.g. Labview™) to generate scans of instrument response versus beam positions. A total of five actuators are required, 4 for steering and one for focus.

The control laws are complex, and the actuation methods are possibly imperfect (e.g. non-linear, hysteresis). Furthermore the system must be 'self-checking' because it is the prime source for spatial (angular & focus) calibration of the instrument.

The imaging mirror is also a critical component of the simulator. The design has so far considered the aberrations due to a spherical mirror design, and then moved on to an ellipsoidal design, with a fold angle of 90 degrees. Although this option gives near perfect imaging, it is likely to be difficult to procure & to align, due its conjugate distances being large (>2m), and due to its conic form.

The design task will consider

- The potential to reduce the fold angle to simplify the mirror (brings foci closer together & reduces mirror size).
- The use of a toroidal mirror. Whether this could meet the aberration requirement and if so whether it has advantages for alignment. Such advantage could be had e.g. by setting up the mirror at normal incidence & locating the point source with respect to the astigmatic focal points, before rotating the mirror to the required fold angle.
- For whichever mirror type is recommended a procedure for setting up the source/mask/mirror alignment to the accuracy required.
- A manufacturer's specification for the mirror, including tolerances.

The design, manufacture and testing of the telescope simulator will be done under the direction of Martin Caldwell of the SSTD Optics group. M. Ferlet will carry out the design of the imaging system. The control-law will be developed as part of a MPhil project. The stepwise development tasks are:

- Finalise imaging mirror design, including alignment procedures.
- Set up of a software model (ray tracing) of the optics, to determine the control laws required. This must be maintained for consistency with the optical design & layout of the facility.
- Finalise overall optical layout & equipment. Sign off simulator requirements & design documents.
- Specify the mirrors, optics bench and mirror mounts.
- Specify actuators & their interface to the mounts.
- Purchase hardware.
- Make bench tests of single-axis system. Refine control laws in light of results (i.e. add corrections for imperfect response).
- Construct system.
- Test visible performance.

5.1.5 Calibration Sources

5.1.5.1 Fourier Transform Spectrometer

A Fourier transform spectrometer (FTS) will be provided by QMW to allow the spectral response of the photometer channels to be measured.

5.1.5.2 FIR Laser

The FIR laser used for the ISO LWS calibration will be used. This is an Edinburgh Instruments PR5 gas FIR laser with lines from 30μm to 1000μm and power up to 100mW. Some modifications will be required to improve the output stability and a Fabry-Perot interferometer will be used to improve the spectral quality.

5.1.5.3 Cold Blackbody

A 4K-20K-blackbody source provided by QMW 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.

5.1.5.4 Hot Blackbody

RAL intend to borrow a 1000ºC-blackbody target from another group within RAL. Failing this an off-the-shelf item can be purchased. Suppliers of these targets include ISOTECH, Santa Barbara Infrared Inc.

5.1.5.5 Reference Detector

A calibrated reference detector to be fitted in the cryostat is required to measure the FIR transmission through the cryostat filters, and to measure the straylight in the closed cryostat. This will be supplied by QMW.

5.1.5.6 Beam Monitor

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

5.1.6 Test Control System

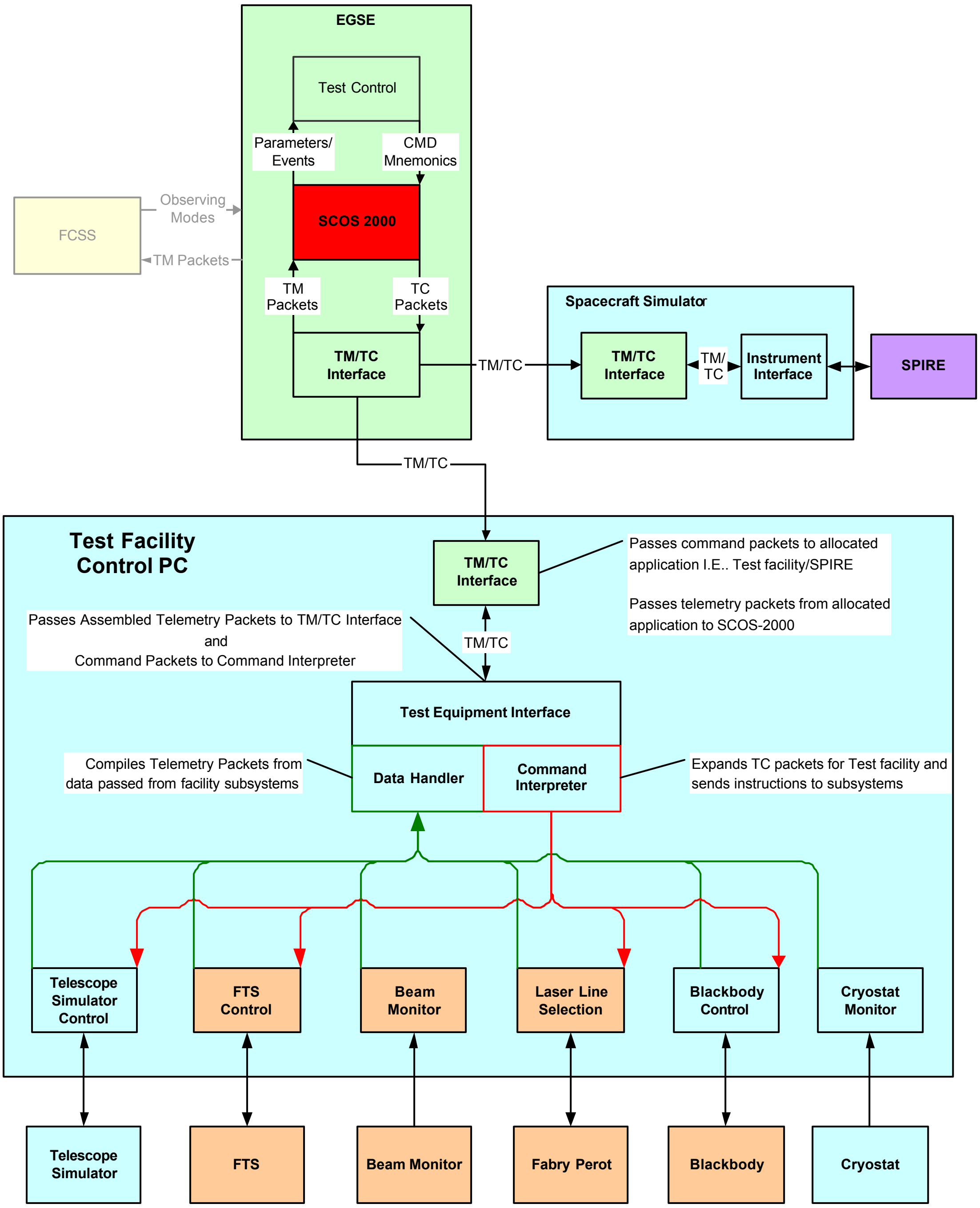


Figure 6: Schematic diagram of the Test Facility Control System

The Test Facility Control System (TFCS) will provide control and monitoring for the cryostat and calibration sources. The key functions include:

- Monitor cryostat temperatures and cryogen levels
- Monitor the cold blackbody temperatures
- Control the cold blackbody heater
- Control the blackbody flip mirror
- Monitor the output of the beam monitor
- Control and monitor the FTS
- Control the telescope simulator

The design of the TFCS is still under consideration. However there are a few basic principles that will be applied.

To allow independent development of the test equipment, Labview™ will be used as the basis of the control system. This will reduce the overall development time since Labview™ is widely used and many instrument drivers are available.

Where possible, propriety electronics units will be used to perform the data acquisition and mechanism control (e.g. National Instruments data acquisition cards).

An outline of the development process is given in the following subsections.

5.1.6.1 Define System Requirements

Establish the hardware and software components of the system. This will include the analogue I/O (number of thermometers, level gauges, sampling rates etc.), the calibration subsystem interfaces (e.g. FTS commands and telemetry) and the interfaces to the SPIRE EGSE (e.g. packet formats.). The requirements will also define the specification of the control PC.

5.1.6.2 Software Development

The TFCS is neither embedded flight or ground segment software and therefore does not strictly come under the scope of the RAL space science department ISO-9000 plan (RD 1). However, the SPIRE project does require that software used for testing the instrument should conform to quality assurance procedures and follow good design practice.

As a minimum there will be

- User Requirements Document – Identify the main functions that the TFCS is expected to perform. For example measure cryostat temperatures and display these as trend plots. The user requirements must be written down and formally agreed between the provider and the end user.
- Software Configuration Management Plan – This document will be produced and maintained by the AIV project manager. The SCMP shall define the method of
- Identifying and defining the configuration items in the system
    - Controlling the release and change of these items throughout the software lifecycle.
    - Recording and reporting the status of configuration items and change requests
    - Verifying the completeness and correctness of configuration items
    - Tracing each location of use of software item to ensure consistent version updating occurs.
- Software Requirements Document – concentrates on the expectations for the software functionality. The document identifies which of the system requirements the software affects. The requirements analysis should identify the interactions needed with other applications and databases, performance requirements, user interfaces requirements etc.
- Software Design Specification – incorporating the architectural and detailed design.
- User Manual - this will include sufficient information to enable the user to understand and use the test facility control system.
- Software test plan, test report and compliance matrix (including acceptance tests). The software test plan should address all software requirements and describe the test activities.

5.1.6.3 Hardware Development

Once the main hardware requirements have been identified the key components can be purchased or manufactured. For some analogue channels (e.g. low temperature thermometry) it may be necessary to design and build bespoke items (i.e. 10μA constant current supply and resistance measurement).

As the facility is to be used for calibrating space instrumentation it is essential that all analogue channels be calibrated to national standards in accordance with the SPIRE PA plan (AD 2).

- Integrate and Test
- The integration and testing of the TFCS will be performed, as components become available. Major stages include
- Integration of the TFCS computer – checkout of interface cards.
- Integration and test of cryostat monitor subsystem
- Cryostat commissioning

- Interface tests with components of the EGSE
- Integration and test of telescope simulator
- Integration and test of sources, including the FTS and cold blackbody
- All up system tests with EGSE

5.2 EGSE

The development of the SPIRE EGSE is covered in AD 3.

5.3 AIV Facilities

The SPIRE project will use the RAL Space Science and Technology Department AIV facilities.

5.3.1 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 [1]

- 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

A larger class 10000 area also within R25 at RAL will be used to transfer SPIRE to the calibration facility support frame. More details of the RAL facilities can be found in RD 2.

5.3.2 Inspection Facility

RAL has temperature-controlled inspection facilities having the ability to measure components by conventional or optical means. Co-ordinate Measuring Machines (CMM) are also available. These can be used conventionally, or in a non-contact mode using an optical microprobe.

5.3.3 Vibration Facilities

Vibration facilities are required for warm (room temperature) and cryogenic (~10K) vibration tests on the STM and PFM instruments.

The vibration facility at RAL will be used for the warm vibration tests. Details of this facility can be found in RD 2.

The RAL vibration facility has the capability of running tests at cryogenic temperatures. However, the cryostat has not been used since ISO LWS testing and will require at least six months effort to rebuild. A decision to use this facility must be taken by June 2001 if cryogenic vibration tests are to be performed in mid 2002.

[1] Extracted from RAL document ISO9:SPAP/AIV/000

6 Work Breakdown

WP NO.	**Description**	**WP Manager**	**Org.**
FSZW0X…	**SPIRE Facilities**		RAL
1000	**SPIRE AIV Facilities**	**D.L. Smith**	**RAL**
1100	Integration Clean Rooms	G.M. Toplis	RAL
1200	Inspection Facilities		RAL
2000	**SPIRE Calibration Facility**	**D.L. Smith**	**RAL**
2100	**Cryostat**	**D.L. Smith**	**RAL**
2110	Design	D.L. Smith	RAL
2111	Thermal Design	T. Bradshaw	RAL
2112	Outline Design	M. Harman	RAL
2113	Thermal Model	S. Heys	RAL
2114	Design Specification	M. Harman	RAL
2115	Detailed Design	Manufacturer	TBD
2120	Manufacture	M. Harman	RAL
2121	Build Cryostat	Manufacturer	TBD
2122	Procure Vacuum System	M. Harman	RAL
2123	Build Support Frame	M. Harman	RAL
2124	Produce Filters	P. Hargrave	QMW
2125	Procure Electrical Feedthroughs		RAL
2130	Integration	D.L. Smith	RAL
2131	Install Cryostat	AIV Team	RAL
2132	Install Pumping System	AIV Team	RAL
2133	Install Cold BB	P. Hargrave	QMW
2134	Install Filters	P. Hargrave	QMW
2135	Connect Instrumentation	AIV Team	RAL
2136	Install Services	AIV Team	RAL
2140	Test	D.L. Smith	RAL
2141	Produce Test Plan	D.L. Smith	RAL
2142	Execute Tests	D.L. Smith	RAL
2143	Produce Test Report	D.L. Smith	RAL
2200	**Cryoharness**	**D.L. Smith**	**RAL**
2210	Design	J. Delderfield	RAL
2211	Thermal Design	J. Rochford	RAL
2212	Design Specification	J. Delderfield	RAL
2213	Detailed Design	Supplier	TBD
2220	Manufacture	D.L. Smith	RAL
2221	10K-80K Harness	Supplier	TBD
2222	80K-300K Harness	Supplier	TBD
2223	Airside Harness	Supplier	TBD
2300	**Sources**	**D.L. Smith**	**RAL**
2310	Fourier Transform Spectrometer	P. Hargrave	QMW
2320	FIR Laser	B.M. Swinyard	RAL
2330	Cold Blackbody	P. Hargrave	QMW
2340	Hot Blackbody	D.L. Smith	RAL
2350	Reference Detector	P. Hargrave	QMW
2360	Beam Monitor	D.L. Smith	RAL
2400	**Telescope Simulator**	**M. Caldwell**	**RAL**
2410	Design	M. Ferlet/T.Grundy	RAL
2420	Manufacture	M. Ferlet/T.Grundy	RAL
2430	Develop Test Software	T. Grundy	RAL
2430	Integration	M. Ferlet	RAL
2440	Test	M. Ferlet	RAL

WP NO.	**Description**	**WP Manager**	**Org.**
2500	**Control System**	**D.L. Smith**	**RAL**
2510	Design	D.L. Smith	RAL
2511	System Specification	D.L. Smith	RAL
2512	User Requirements	D.L. Smith	RAL
2520	Hardware Development	A. Matheson	RAL
2530	Software Development	G. Hutchinson	RAL
2540	Integrate and Test	D.L.Smith	RAL
2600	**Cryolab**	**D.L. Smith**	**RAL**
2610	Design	D.L. Smith	RAL
2611	Layout and requirements	D.L. Smith	RAL
2612	Detailed drawings	Engineering	RAL
2620	Rebuild	Engineering	RAL
2621	Preparation	D.L. Smith	RAL
2622	Building Work	Engineering	RAL
2623	Install Services	Engineering	RAL
2624	Refurbish Air Filters	AIV Facility	RAL
2630	Commission Clean Room	AIV Facility	RAL
2640	Furnish	D.L. Smith	RAL
5000	**Vibration Facilities**	**G. T oplis**	**RAL**

7 Constraints

7.1 Requirements

The requirements for the AIV facilities are defined in SPIRE-RAL-PRJ-000463, 'SPIRE Test Facility Requirements Specifications' (AD 1).

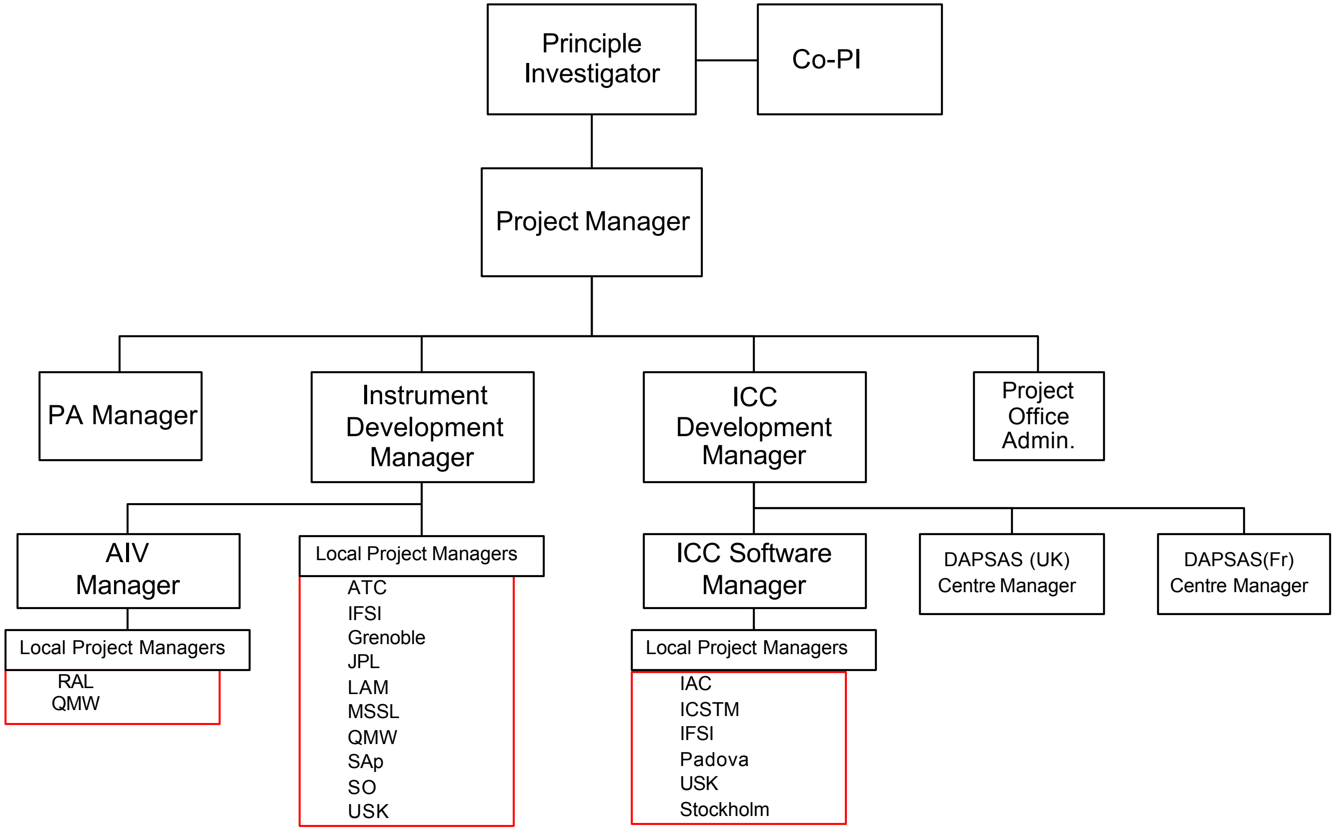
7.2 Milestones

The AIV facility milestone plan will be maintained as a separate document (AD 6). All updates to this plan will be agreed by the SPIRE project. The baseline plan is included here for completeness.

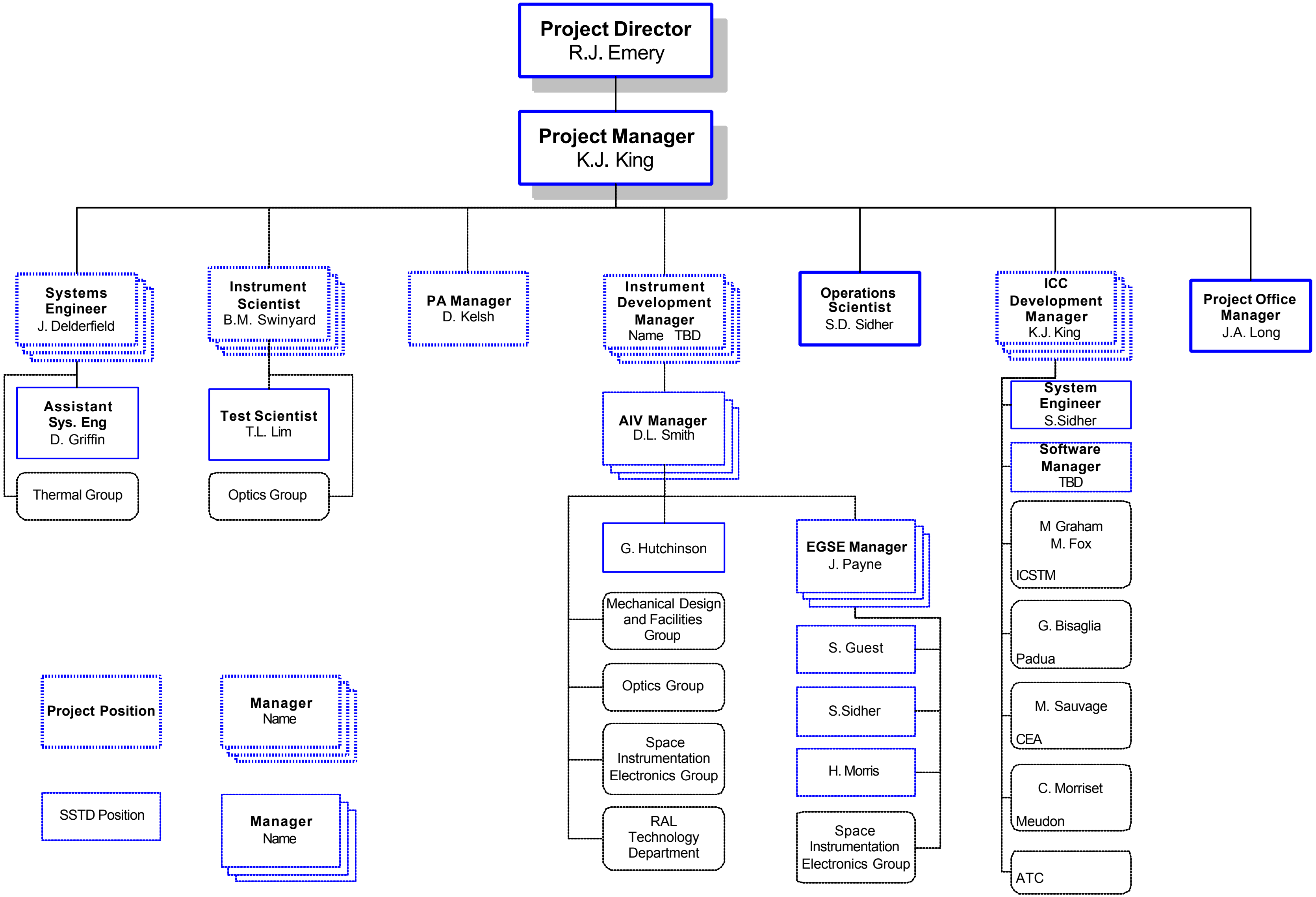
Milestone	Ref.	Resp.	Baseline	Current	Actual
SPIRE Project Milestones					
SPIRE STM Program Starts	AD1	RAL	01/08/02	01/08/02	
SPIRE EGSE Delivered	AD1	RAL	01/02/02	01/02/02	
SPIRE CQM Program Starts	AD1	RAL	01/02/03	01/02/03	
SPIRE PFM Program Starts	AD1	RAL	01/06/03	01/06/03	
AIV Facility Milestones					
Cryostat Design Complete	RD2	RAL	31/12/00	31/12/00	08/01/01
Cryostat Manufactured	RD2	RAL	01/11/01	01/11/01	
Cryostat Integrated	RD2	RAL	30/01/02	30/01/02	
Cryostat Commissioned	RD2	RAL	01/04/02	01/04/02	
Cryoharness Delivered	RD2	RAL	01/03/02	01/03/02	
Cryolab Available	RD2	RAL	01/07/01	01/07/01	
Telescope Simulator Delivered	RD2	RAL	21/12/01	21/12/01	
TFCS Cryostat Monitoring	RD2	RAL	31/12/01	31/12/01	
TFCS Complete	RD2	RAL	30/04/02	30/04/02	
FTS Delivered	RD2	QMW	01/09/02	01/09/02	
Cold BB Delivered	RD2	QMW	02/12/01	02/12/01	
Reference Detector	RD2	QMW	30/10/01	30/10/01	
Hot BB Delivered	RD2	RAL	01/03/02	01/03/02	
FIR Laser	RD2	RAL	08/06/01	08/06/01	
Beam Monitor	RD2	RAL	01/03/02	01/03/02	
Clean Rooms		RAL	31/07/02	31/07/02	
Inspection Facility		RAL	31/07/02	31/07/02	
Vibration Facility		RAL	01/08/02	01/08/02	
Bakeout Chamber		RAL	01/08/02	01/08/02	

8 Organisational Structure

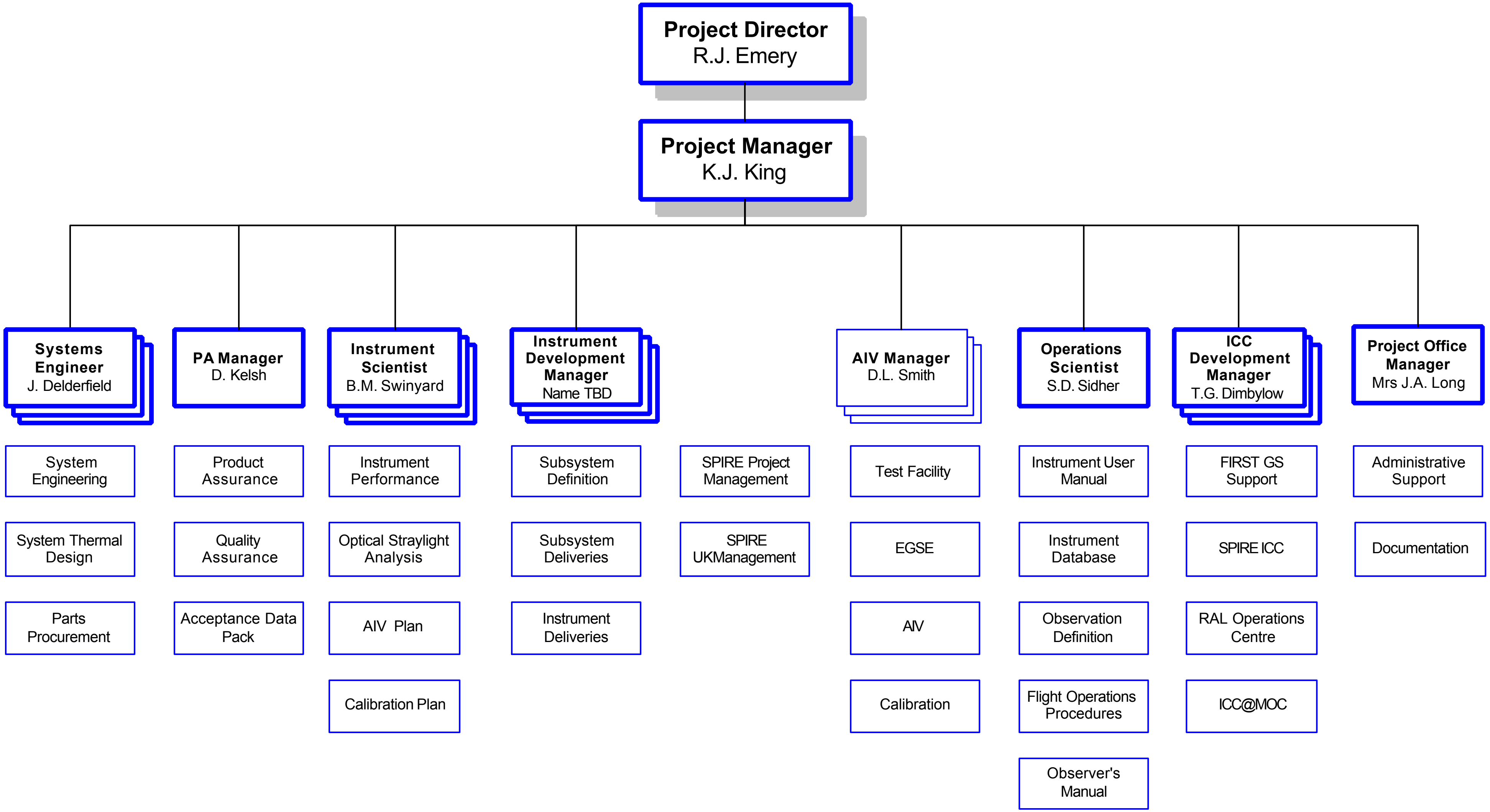
8.1 SPIRE Management



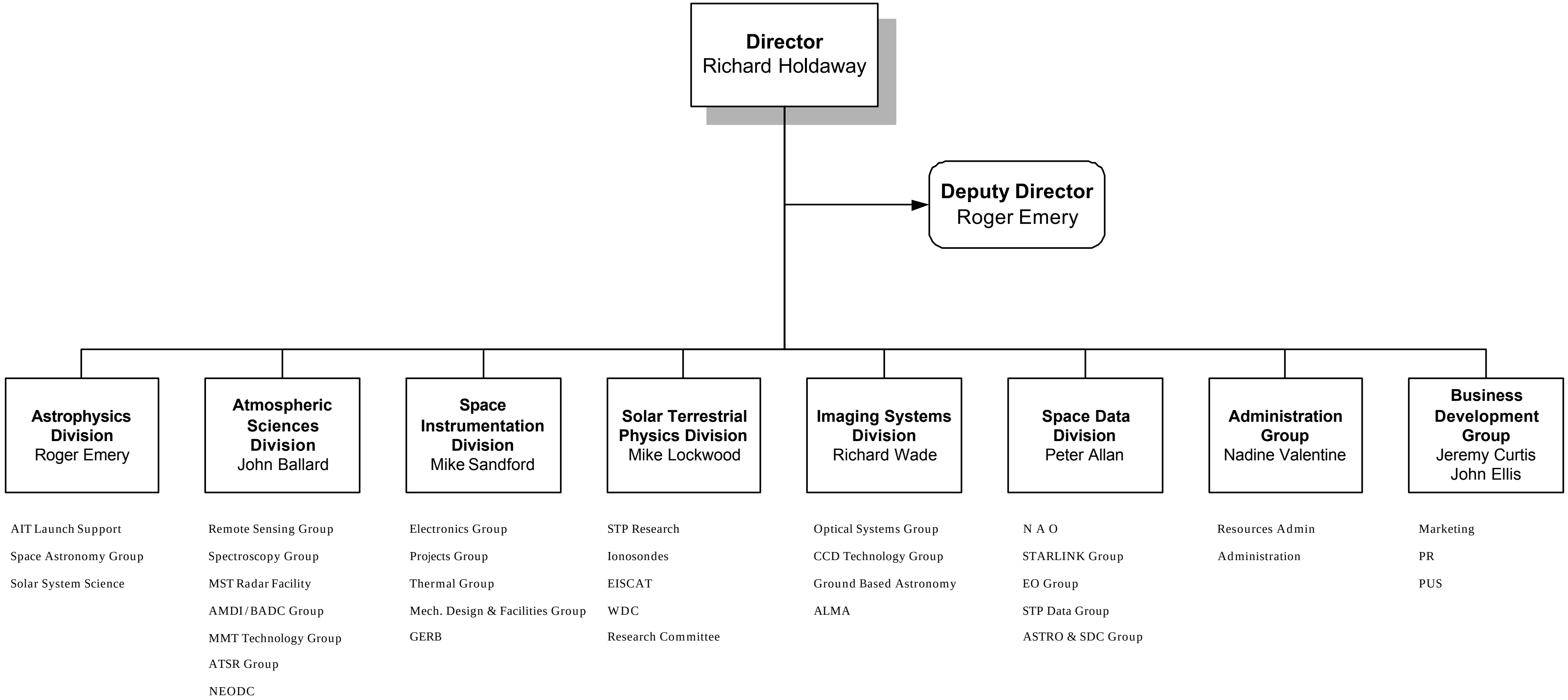
8.2 RAL-SPIRE


Project Director
R.J. Emery
Project Manager
K.J. King
Systems Engineer
J. Delderfield
Instrument Scientist
B.M. Swinyard
PA Manager
D. Kelsh
Instrument Development Manager
Name TBD
Operations Scientist
S.D. Sidher
ICC Development Manager
K.J. King
Project Office Manager
J.A. Long
Assistant Sys. Eng
D. Griffin
Thermal Group
Test Scientist
T.L. Lim
Optics Group
AIV Manager
D.L. Smith
G. Hutchinson
Mechanical Design and Facilities Group
Optics Group
Space Instrumentation Electronics Group
RAL Technology Department
EGSE Manager
J. Payne
S. Guest
S.Sidher
H. Morris
Space Instrumentation Electronics Group
System Engineer
S.Sidher
Software Manager
TBD
M Graham
M. Fox
ICSTM
G. Bisaglia
Padua
M. Sauvage
CEA
C. Morriset
Meudon
ATC
Project Position
Manager
Name
SSTD Position
Manager
Name

8.3 SPIRE/RAL Project Responsibilities



8.4 RAL Space Science and Technology Department



9 Risks

A breakdown of the potential sources of risk is listed below. Each work package has been assessed for the applicability of these categories. The risk categories are inter-related and a single potential problem may incur risk in all three major categories.

Cost Overrun
A.1 Procurement costs underestimated
A.2 Performance requirement change
A.3 Staff costs increase
A.4 Production costs increase
Schedule Overrun
B.1 Task scope underestimated
B.2 Task delays
B.3 Staff not available
B.4 Production delays
Performance Objectives not met
C.1 Functional Requirements
C.2 Performance requirements

Risk rankings suggested by BS6079 - Impact: Negligible, Marginal, Critical, Catastrophic; Likelihood: Low, Medium, High

Risk status: Red = Active & impacting project; Amber = Active but contained without impact to cost & schedule; Green = not yet active.

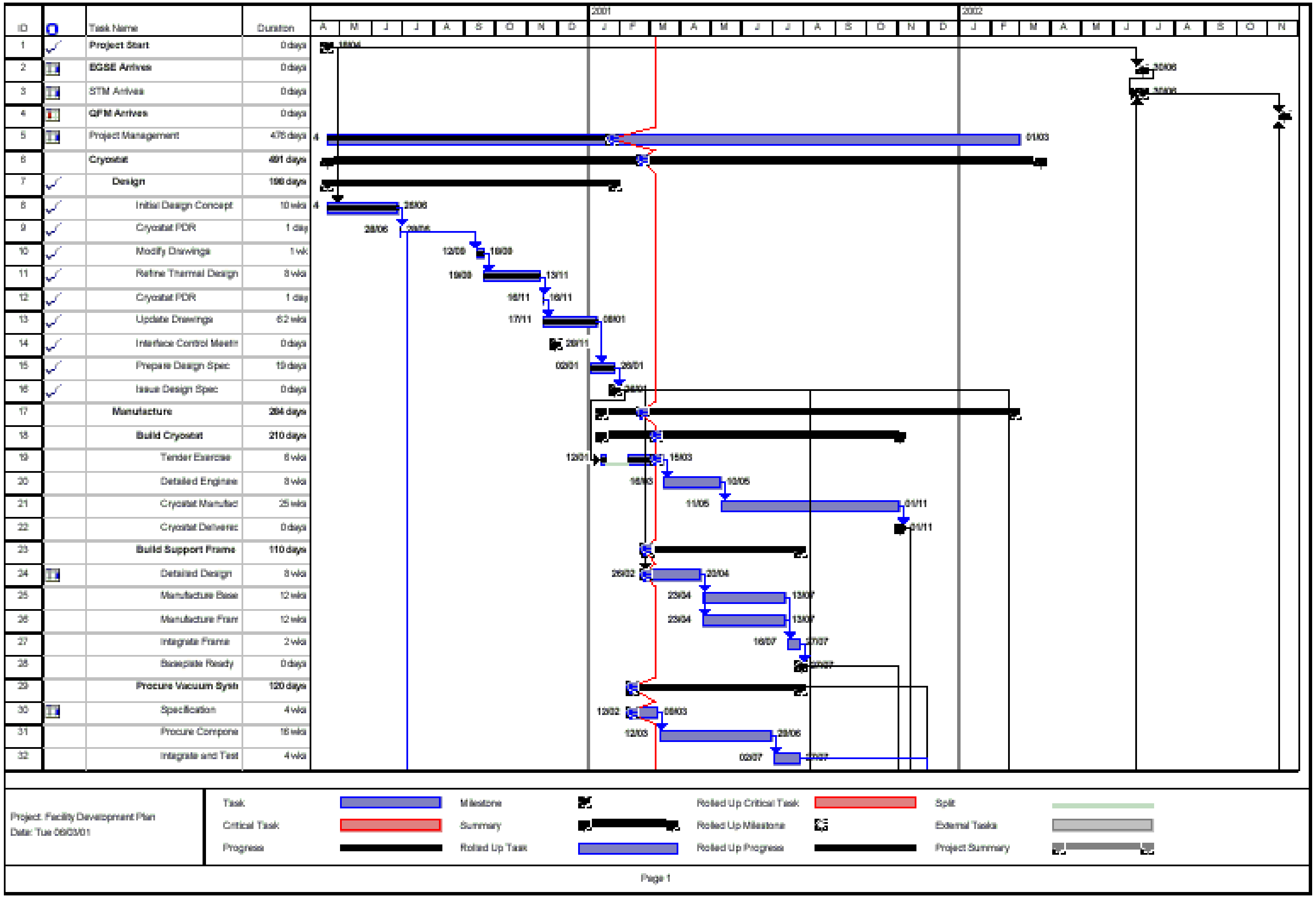
It should be noted that the list quoted here is by no means comprehensive. Additional risks will be identified throughout the lifetime of the project. A list of all risks and their status will be maintained in a separate risk register.

WBS/ Risk No	WBS Title	Risk Category	Risk Sources	Likeli-Hood	Impact	Mitigation Strategy
2000-01	SPIRE AIV Facilities	B3	Dave Smith tied up with AATSR commissioning activities	H	C	Ensure that SPIRE project is aware of AATSR/ENVISAT schedule. Dave Smith to ensure that project plans are in place before start of AATSR commissioning. Provide cover during AATSR commissioning.
2000-02	SPIRE AIV Facilities	B3	Ken King and Bruce Swinyard not contactable due to busy workloads.	H	M	Ensure that Dave Smith has sufficient authority and signing powers to allow work to proceed. Ken and Bruce to maintain outlook calendars.
2000-03	SPIRE AIV Facilities	A3	Pay rates exceed budgeted increases	L	M	Ensure sufficient margin in budget.
2110-01	Cryostat Design	B3	Tom Bradshaw's team on other projects. SPIRE not the main priority	H	C	Keep lines of communication open – weekly updates on progress.
2110-02	Cryostat Design	B3	Mark Harman's time taken up by other projects – ALMA, TOPSAT	H	C	Obtain agreement with Mark Harman and his management to complete work within agreed schedule. Bring in external contractors to complete design effort.
2110-03	Cryostat Design	B3	Sam Hey's time taken up by other projects	H	M	Obtain agreement with Sam to allocate time to carry out work. Specify scope of work.
2110-04	Cryostat Design	B1	Design of cryostat not finalised due to changes in instrument design.	M	H	Formally agree cryostat design requirements. Formally freeze instrument interfaces. Introduce change control procedures
2120-01	Cryostat Manufacture	A1	Cost of cryostat higher than planned budget.	L	C	Obtain quotes from supplier Produce detailed specification for tender exercise. Agree cost for manufacture
2120-02	Cryostat Manufacture	B4	Cryostat manufacture delayed	M	C	Agree delivery schedule with manufacturer Hold Regular Progress Meetings with manufacturer
2020-03	Cryostat Manufacture	C1	Cryostat does not meet requirements for AIV.	M	Cat	Formally approve test facility requirements. Formally approve cryostat design. Review detailed design produced by manufacturer. Inspect before delivery to RAL Inspect on delivery to RAL
2120-04	Cryostat Manufacture	B2	Additional components for cryostat not delivered on time. e.g. Pumps, Filters, Electrical Feedthroughs	M	C	Identify delivery times for procurement of components. Agree delivery schedule with suppliers
2140-04	Cryostat Test	A2	Cryostat does not reach low enough pressure to start cooldown	M	Cat	Ensure pumping system can cope with worst case outgassing from SPIRE.
2300-01	Sources	B4	QMW unable to deliver sources to RAL due to move to Cardiff	L	L	Agree specification early so that QMW can start work before move. Agree delivery dates Provide lab-space within RAL to perform alignment work on FTS.
2600-01	Cryolab	A2	Budget for cryolab insufficient.	H	M	Agree requirements for cryolab Identify all areas of work required.

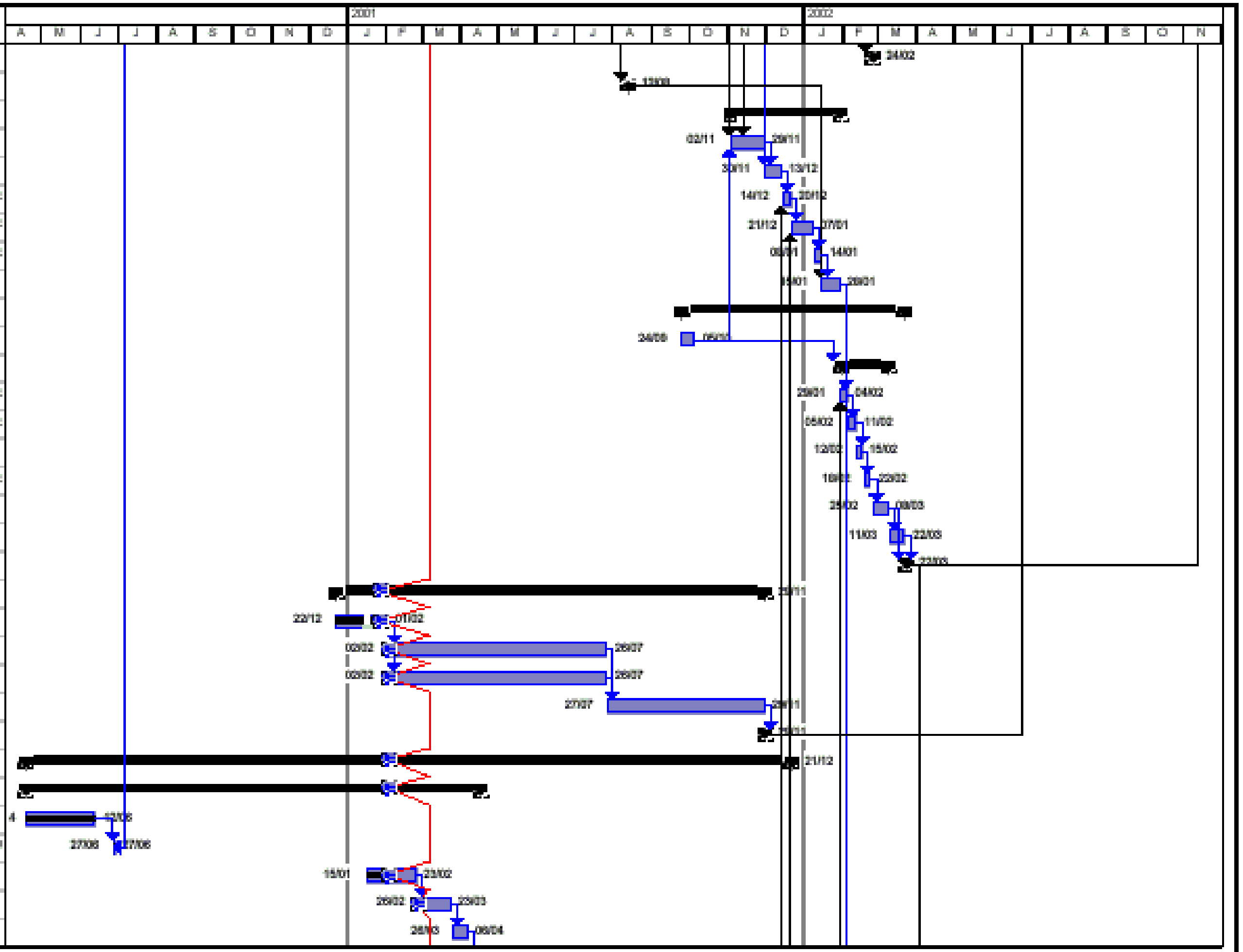
2600-02	Cryolab	C2	Clean room does not meet cleanliness requirements	M	C	Agree specification Ensure adequate ventilation/airflow Employ best practice procedures.
2600-03	Cryolab	C1	Cryostat cannot be installed in room	H	Cat	Ensure cryostat can be rotated on its side to fit through doors Build external door.
2200	Cryoharness	A1	Harness is overbudget	M	M	Obtain quotations from suppliers for accurate estimation. Go for cost effective solution yet keeping to requirements
2200	Cryoharness	B2	Harness not ready for STM testing	M	C	Finalise harness specification by the end of April 2001 to allow for long-lead item
2200	Cryoharness	B4	Harness manufacture takes longer than expected	M	C	Agree delivery schedule with manufacturer Hold Regular Progress Meetings with manufacturer
2200	Cryoharness	C2	Harness impedance does not match flight spec.	M	C	Ensure that flight harness specification is sufficiently mature before proceeding with test harness manufacture

10 Schedule

The schedule shown in this document is the baseline at 07-March-2001.

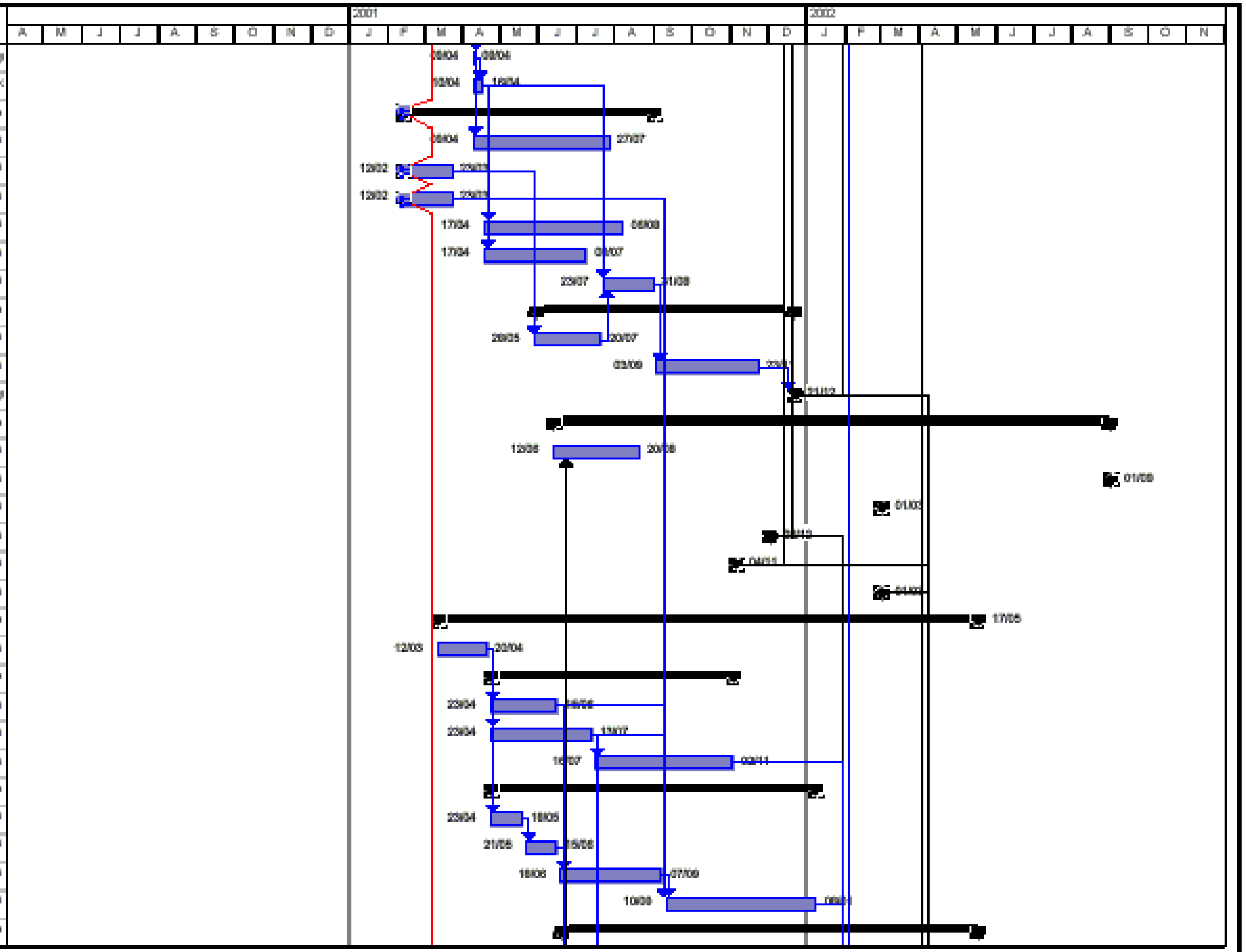


ID		Task Name	Duration
33		**Produce Filters**	0 days
34		**Procure Electrical Fac**	0 days
35		**Integration**	55 days
36		Install Cryostat	4 wks
37		Install Pumping System	2 wks
38		Install Reference Detect	1 wk
39		Install Cold Blackbody	1 wk
40		Install Support Frame	1 wk
41		Connect Instrumentation	2 wks
42		**Test**	123 days
43		**Test Plan**	2 wks
44		**Execute Tests**	29 days
45		Leak test at Room	1 wk
46		Bakeout	1 wk
47		Cooldown/Therma	4 days
48		Radiometric/Stray	1 wk
49		EMC Tests	2 wks
50		**Produce Test Report**	2 wks
51		**Cryostat Commissioned**	0 days
52		**Cryoharness**	239 days
53		Specify Harness	4 wks
54		Procure Wire	25 wks
55		Procure Connectors	25 wks
56		Make up Harness	16 wks
57		Harness Complete	0 days
58		**Telescope Simulator**	433 days
59		**Design**	254 days
60	✓	Initial Optical Design	8 wks
61	✓	Preliminary Design Rev	1 day
62		Finalise Imaging Desig	6 wks
63		Finalise Optical Layout	4 wks
64		Produce Design Specifi	2 wks



Project: Facility Development Plan Date: Tue 06/03/01	Task	Milestone		Rolled Up Critical Task		Split	
	Critical Task	Summary		Rolled Up Milestone		External Tasks	
	Progress	Rolled Up Task		Rolled Up Progress		Project Summary	

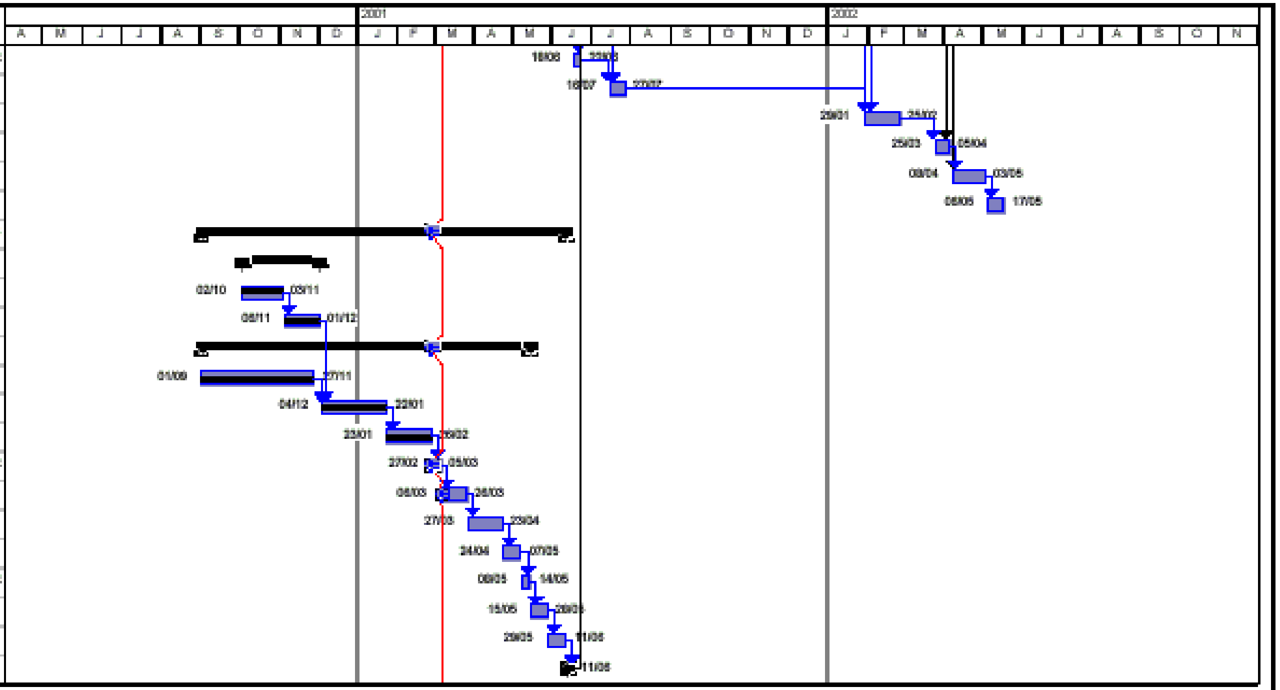
ID	Task Name	Duration
65	Review Design	1 day
66	Update Following Revie	1 wk
67	**Parts Procurement**	**145 days**
68	Optical Bench	16 wks
69	Controller	6 wks
70	Translation Stage	6 wks
71	Elliptical/Toroidal Mirro	16 wks
72	Optical Flats	12 wks
73	Other Optical Compone	6 wks
74	**Integration**	**150 days**
75	Test Control Law Softwa	8 wks
76	Complete Integration an	12 wks
77	Review and Accept	1 day
78	**Sources**	**312 days**
79	Laser Reconfiguration	10 wks
80	FTS	0 days
81	Hot BB	0 wks
82	Cold BB	0 wks
83	Reference Detector	0 days
84	Beam Monitor	0 days
85	**Test Facility Control System**	**303 days**
86	System Specification	6 wks
87	**Hardware**	**140 days**
88	Procure Control PC	8 wks
89	DAQ System	12 wks
90	Build Thermometry Can	16 wks
91	**Software**	**180 days**
92	User Requirements	4 wks
93	Software Requirements	4 wks
94	Software Design	12 wks
95	Code	16 wks
96	**Test**	**233 days**



Project: Facility Development Plan
Date: Tue 06/03/01

Task | Milestone | Rolled Up Critical Task | Split
Critical Task | Summary | Rolled Up Milestone | External Tasks
Progress | Rolled Up Task | Rolled Up Progress | Project Summary

ID		Task Name	Duration
97		Checkout of control PC	1 wk
98		Checkout of DAQ system	2 wks
99		Cryostat Monitor Tests	4 wks
100		TEI Interface Tests	2 wks
101		Subsystem Tests	4 wks
102		All up system tests	2 wks
103		**Cryolab**	**196 days**
104	✓	**Design**	45 days
105	✓	Layout and Requiremen	5 wks
106	✓	Detailed Design	4 wks
107		**Rebuild Facility**	176 days
108	✓	Clear Out Junk	12.4 wks
109	✓	Rebuild Facility	8 wks
110	✓	Feedhorn Measurement	5 wks
111		FTS Test	1 wk
112		Move Laser	3 wks
113		Install External Door	4 wks
114		Redecorate	2 wks
115		Clean Floors, walls etc	1 wk
116		Commission Clean Room	2 wks
117		Move In	2 wks
118		Clean Room Ready	0 days



Project: Facility Development Plan
Date: Tue 06/03/01

Task		Milestone		Rolled Up Critical Task		Split	
Critical Task		Summary		Rolled Up Milestone		External Tasks	
Progress		Rolled Up Task		Rolled Up Progress		Project Summary	