# SPIRE FPU AND JFET BOXES MECHANICAL/THERMAL DUMMY

## Technical Proposal

in response to

Astrium GmbH RfQ: HP-ASED-LT-0884-02

Rutherford Appleton Laboratory
Chilton, Didcot
Oxfordshire OX11 0QX
www.clrc.ac.uk

Contact: Ruben Edeson
e-mail: r.l.edeson@rl.ac.uk

February 2003

**PREPARED BY:** **R. Edeson**

**CHECKED BY:**

**APPROVED BY:**

.

# CHANGE RECORD

| ISSUE | DATE | REASON FOR CHANGE |
|---|---|---|
| 1 | 10/2/03 | First issue |

# CONTENTS

# 1. INTRODUCTION

This document outlines the technical proposal to supply Astrium GmbH with mechanical and thermal dummies (MTDs) for the SPIRE focal plane unit (FPU), Photometer JFET box and Spectrometer JFET box. It makes reference to, and responds to, AD2 and Procurement Specification issued by Astrium for this project.

# 2. APPLICABLE DOCUMENTS

| | | |
|---|---|---|
| AD1 | Special Conditions of Tender | HP-2-ASED-AO-0020 |
| AD2 | Statement of Work | HP-2-ASED-SW-0029 |
| AD3 | Procurement Specification | HP-2-ASED-PS-0027 |

# 3. LIST OF ACRONYMS/TERMS

| | |
|---|---|
| MTD | Mechanical Thermal Dummy |
| AIV | Manufacture, Assembly, Integration and Verification |
| FM | Flight Model (or equivalent) |
| FEA | Finite Element Analysis |
| FPU | Focal Plane Unit (of SPIRE) |
| BDA | Bolometer Detector Array (subsystem of SPIRE) |
| CAD | Computer Aided Design |
| CoG | Center of Gravity |
| MoI | Moment of Inertia |
| ESATAN | Thermal modelling software |
| WP | Workpackage |

# 4. PROPOSED DESIGN

## 4.1 SPIRE FPU

### 4.1.1 Overview

It is proposed to supply the FPU and JFET units which make heavy use of structural parts made to FM specifications, with dummy masses used to represent internal subsystems such as mirrors and detectors. Thermally, the external interfaces would be the same as the FM. External electrical interfaces will mechanically be identical to the FM. Mounting and other mechanical interfaces will be the same as the FM.

### 4.1.2 Mechanical Design

The following table outlines the proposed breakdown between FM structural and dummy mechanical parts: The parts described as "As FM" will be manufactured from the FM drawings using the same materials as for FM. In this way we can ensure that the mechanical properties and dynamic behaviour of the MTD will be very close to that of the FM.

| Part | Source | Comments |
|---|---|---|
| SPIRE Optics Bench | As FM | |
| Photometer Cover | As FM | |
| Spectrometer Cover | As FM | |
| Photometer Detector Enclosure | As FM | |
| Spectrometer Detector Enclosure | As FM | |
| Spectrometer Box A-frames | As FM | |
| Mirror mounts | As FM | |
| Mirrors | Dummy Mass | |
| Baffles | Dummy Mass | |
| Cooler | Dummy Mass | |
| Bolometer Detector Arrays | Dummy Mass | |
| Spectrometer Mechanism | Dummy Mass | |
| Beam Steering Mechanism | Dummy Mass | |
| RF Filtering Connector Feedthroughs | Dummy Mass | Connectors to be as FM |
| Spectrometer Calibration Source | Dummy Mass | |
| Photometer Calibration Source | Dummy Mass | |
| L0 Thermal Straps to Cooler | Dummy Mass | |
| L0 Thermal Strap to Spectrometer Enclosure | As FM | |
| FPU Mounts | As FM | Supplied by customer |
| Optical Alignment Cube | As FM | |
| Harnesses | Dummy Mass | |

Dummy masses will be constructed from Aluminium Alloy, and will be mounted internally as per the FM interfaces.

A 3-D CAD model will be generated for the FPU MTD for direct comparison with the FM model. The MTD model will be used to size and place the various dummy masses.

It is proposed that an FEA model for the FPU MTD will not be generated, as it is not likely to differ significantly from the FM FEA model. A matrix will be presented with the delivery documentation showing any variances from the FM model. An FEA analysis will be performed for individual dummy masses if there are likely to be stiffness or stress problems. FEA work performed at RAL will be done using the package ANSYS 6.1 (or higher). If the customer requires the delivery of any models, an export to NASTRAN or a common format will be performed.

#### 4.1.3 Thermal Design

A current ESATAN model of the FM FPU will be altered to reflect the MTD design. Heaters and thermistors will be applied as per AD3. Thermal interfaces between the different stages will use FM designs and materials with the following exceptions:

- The L0 thermal straps to the cooler pump and evaporator will be terminated inside the FPU cover. Resistors will be mounted on the strap-ends to simulate the heat load, as per AD3.
- All thermal straps will be supported as they enter the FPU enclosure with thermally isolating mounts which will ensure the parasitic heat loss is less than 5% of the minimum heat dissipation of the resistor.
- Parasitic heat flow between JFET boxes and BDAs will be simulated with a dummy harness. This harness will be connected at the JFET end using FM type connectors, but will be fixed to the BDA dummies using either an epoxy or mechanical clamp.

This approach will ensure that the thermal behaviour of the MTD is very close to that of the FM

#### 4.1.4 Internal Harness Routing

Routing to internal resistors and thermistors will be subject to thermal design. Parasitic heat loss and ohmic resistance will comply with AD3.

### 4.2 SPECTROMETER JFET

#### 4.2.1 Overview

The spectrometer JFET will be a dummy mass. The mass will be mounted using FM equivalent isolating feet and fasteners.

#### 4.2.2 Mechanical Design

An Aluminium Alloy plate with FM representative feet will be used for the JFET base. A dummy mass will be attached to this. This mass will be used for mounting the FM representative connectors. The whole assembly will be designed to match the FM in terms of mass, CoG and MoI.

#### 4.2.3 Thermal Design

Thermal interfaces will be the same as the FM, with resistors and thermistors mounted as per AD3. An ESATAN model of the JFET will be produced.

## 4.3 PHOTOMETER JFET

### 4.3.1 Overview

The photometer JFET will be a dummy mass. The mass will be mounted using FM equivalent isolating feet and fasteners.

### 4.3.2 Mechanical Design

An Aluminium Alloy plate with FM representative feet will be used for the JFET base. A dummy mass will be attached to this. This mass will be used for mounting the FM representative connectors. The whole assembly will be designed to match the FM in terms of mass, CoG and MoI.

### 4.3.3 Thermal Design

Thermal interfaces will be the same as the FM, with resistors and thermistors mounted as per AD3. An ESATAN model of the JFET will be produced.

# 5. OUTLINE OF WORK

## 5.1 WORKPACKAGE BREAKDOWN

The following workpackages are proposed:

1000 Management
1100 • Project Management
1110 - Scheduling and Control
1120 - Meetings
1200 • PA
1210 - Preparing Procedures
1220 - Audits
1300 • Documentation
1310 - ADP
1320 - Reports
1330 - Reviews

2000 Design and analysis
2100 • Thermal analysis
2110 - Modelling and design
2120 - Reports
2200 • Mechanical analysis
2210 - Collating mass/cog info
2220 - Analysis of subsystems
2230 - Interface load calcs
2240 - Reports
2300 • Mechanical Design
2310 - Instrument modelling
2320 - Dummy mass modelling
2330 - Detailing

3000 Manufacture/Procurement
3100 • Structural Parts
3200 • RAL Parts
3210 - Dummy Masses
3220 - JFET Mounts
3300 • Electrical and Thermal parts/harnessing
3310 - Electrical Parts Procurement
3320 - Thermal Parts Procurement
3400 • Dummy harness assy.

4000 AIV
4100 • Mechanical Assembly
4110 - Part cleaning
4120 - Assembly
4130 - Locking/staking
4140 - Alignment cube

4200 • Assembly of Thermal Parts
4300 • Electrical Assembly
4310 - Attach connectors
4320 - Attach and route internal wires
4400 • Inspection
4410 - Electrical checkout
4420 - Final assembly
4430 - Mass and C of G
4500 • Vibration test
4510 - Test Fixture
4520 - Planning
4530 - Conducting
4540 - Report
4600 • Bakeout
4610 - Clean Surfaces
4620 - Bakeout
4630 - Inspection
4640 - Bagging

5000 GSE
5100 • Transport design and mfr
5110 - Design
5120 - Procurement
5130 - Assembly
5200 • Handling Equipment

6000 Delivery
6100 • Delivery and acceptance testing
6200 • Integration
6300 • Post delivery support

## 5.2 WORKPACKAGE DESCRIPTIONS

The proposed work packages are as follows:

| *WORK PACKAGE DESCRIPTION* | | | **WP No:** | 1100 |
|---|---|---|---|---|
| **Project:** | SPIRE MTD | | **Date:** | 4/Feb/2003 |
| **Major Subsystem:** | FPU and JFETs | | | |
| **Subsystem:** | - | | | |
| **WP Title:** | Management Scheduling and Control | | | |
| **WP Start Event:** | Authorisation to proceed | | | |
| **WP End Event:** | Project Closed | | | |
| **WP Manager:** | R. Edeson | **Organisation Responsible:** | | RAL |

**WP Aims**

1. Delivery and acceptance of Spire MTD as per contract.

**Inputs**

1. Task estimates from WP managers. Quotes from suppliers

**Outputs**

1. Project plan, associated documents, schedules, review documents
2. Regular updates on progress to the customer.

**Tasks**

1. 1110 – Scheduling and Control, including routine updating of schedules for comparison with the baseline.
2. 1120 – Meetings, including teleconferences.

*WORK PACKAGE DESCRIPTION* **WP No:** 1200

**Project:** SPIRE MTD **Date:** 4/Feb/2003

**Major Subsystem:** FPU and JFETs

**Subsystem:**

**WP Title:** Product Assurance

**WP Start Event:** Authorisation to proceed

**WP End Event:** Project Closed

**WP Manager:** PA **Organisation Responsible:** RAL

**WP Aims**

1. Conduct the project PA activities in order to ensure that the design meets the specified technical requirements using the SIRE PA PLAN (SPIRE-RAL-PRJ-000017) where applicable

2. Prepare deliverable PA documentations

**Inputs**

1. PA requirements from customer

**Outputs**

1. PA plan, related documents, with the emphasis place on reliability engineering selelction of materials and test documentation and inspection reports

**Tasks**

1. 1210 – Document preparation
   This includes a PA plan and other procedural documents.
2. 1220 – Audits
   This includes any periodic audits specified in the PA plan as well as general monitoring of procedures and report preparation and document control.

*WORK PACKAGE DESCRIPTION* **WP No:** 1300

**Project:** SPIRE MTD **Date:** 4/Feb/2003

**Major Subsystem:** FPU and JFETs

**Subsystem:**

**WP Title:** Ongoing Documentation

**WP Start Event:** Kickoff

**WP End Event:** Project closure

**WP Manager:** R. Edeson **Organisation Responsible:** RAL

**WP Aims**

1. To assemble deliverable documents
2.

**Inputs**

1. Ongoing inputs from all WP's

**Outputs**

1. Documents deliverable throughout the project
2. Documents deliverable with hardware.
3. Internal documents.

**Tasks**

1. 1310 – ADP: Assemble documents required in the ADP.
2. 1320 – Reports: Generate relevant project reports on schedule.
3. 1330 – Reviews: Prepare for and attend PDR and CDR level reviews.

*WORK PACKAGE DESCRIPTION* **WP No:** 2100

**Project:** SPIRE MTD **Date:** 4/Feb/2003

**Major Subsystem:** FPU and JFETs

**Subsystem:**

**WP Title:** Thermal Analysis

**WP Start Event:** Kickoff

**WP End Event:** Completion of design/analysis

**WP Manager:** Anne-Sophie Goizel **Organisation Responsible:** RAL

**WP Aims**

To assist in the design of the SPIRE Mechanical Thermal dummies by:

1. Confirming by analysis that the SPIRE Thermal mass dummies simulate the SPIRE instrument dissipation and cryogenic behaviour.
2. Providing thermal control subsystem hardware to control and monitor dummies thermal behaviour.
3. Confirming the heater and temperature sensors are operational through review of design and testing (electrical).

**Inputs**

1. MTD Mechanical drawings
2. Herschel MTD Procurement Specification and Statement of Work (Astrium)
3. SPIRE Instrument Design Requirement and Specifications document
4. Thermal performances of SPIRE Instrument for various operating modes – SPIRE thermal analysis report

**Outputs**

1. Simplified Thermal model of the SPIRE MTD.
2. MTD TMM Description Report (should include voltage profile for heater utilisation according to the Spire operation timeline).
3. Thermal Analysis Reports describing SPIRE MTD performances in terms of dissipated heat, decoupling L1/L0 and parasitic loads.
4. Acceptance Test Report for thermal control hardware (electrical).
5. Contributions to all mass dummies design thermal issues.

**Tasks**

1. 2110 - Analysis
   Review proposed mechanical design of MTD.
   Generate simplified Thermal model of SPIRE MTD.
   Provide input for the L1/L0 decoupling interface design.
   Provide input for the design of harness between JFETS and FPU.
   Support design evolution,
   Analyse MTD thermal design and assess performances in terms of dissipated heat, decoupling L1/L0, parasitic loads, interface temperatures and loads at L0, L1, and JFETs enclosures.

| | | | |
|---|---|---|---|
| 2. | 2120 - Reports<br>Report analyses results and attend design reviews.<br>Generate MTD TMM Description report and provide input for heater operation voltages during SPIRE operation | | |

*WORK PACKAGE DESCRIPTION* **WP No:** 2200

**Project:** SPIRE MTD **Date:** 4/Feb/2003

**Major Subsystem:** FPU and JFETs

**Subsystem:**

**WP Title:** Mechanical Analysis

**WP Start Event:** Kickoff

**WP End Event:** Completion of design/analysis

**WP Manager:** R. Edeson **Organisation Responsible:** RAL

**WP Aims**

1. Ensure mechanical analysis requirements are met
2. Ensure mechanical performance and safety margin requirements are met.

**Inputs**

1. Subsystem interface documents and drawings
2. 3D CAD model of current FM
3. FEA report on FM.
4. Herschel MTD Procurement Specification and Statement of Work (Astrium)

**Outputs**

1 Report on all deviations from the FM FEA model

2 Specific reports on subsystem dummy masses which require separate analysis.

**Tasks**

1. 2210 – Collate all mass and CoG information on the FM FPU model. Define the mass and location for internal dummy masses.
2. 2220 – Perform FEA analysis on specific internal mass dummies where necessary to determine compliance with stiffness requirements. Perform FEA analysis on dummy JFETs.
3. 2230 – Calculate interface loads to demonstrate compliance with Margin of Safety requirements. Use FM FEA results.

   2240 – Reports on mechanical analysis.

*WORK PACKAGE DESCRIPTION* **WP No:** 2300

**Project:** SPIRE MTD **Date:** 4/Feb/2003

**Major Subsystem:** FPU and JFETs

**Subsystem:**

**WP Title:** Mechanical Design

**WP Start Event:** Kickoff

**WP End Event:** Completion

**WP Manager:** R. Edeson **Organisation Responsible:** RAL

**WP Aims**

1. To create a CAD model of the MTD for direct comparison with the flight model.
2. To generate dummy mass models and detailed drawings for SPIRE subsystems.

**Inputs**

1. CAD model of FM from MSSL
2. Interface document of subsystems within SPIRE.
3. SPIRE interface control drawings.

**Outputs**

1. Full CAD model of MTD
2. Models of dummy masses
3. Detailed drawings of dummy parts

**Tasks**

1. 2310 – Instrument modelling – the MSSL CAD model of the instrument will be used to produce a Pro-Engineer model.
2. 2320 – Dummy mass modelling. Dummy masses will be designed to give FM representative mass properties.
3. 2330 – Produce detailed drawings of all dummy parts for quotation and manufacture.

*WORK PACKAGE DESCRIPTION* **WP No:** 3100

**Project:** SPIRE MTD **Date:** 4/Feb/2003

**Major Subsystem:** FPU and JFETs

**Subsystem:**

**WP Title:** Structural Parts

**WP Start Event:** Kickoff

**WP End Event:** Acceptance by RAL of structural items

**WP Manager:** R. Edeson **Organisation Responsible:** MSSL

**WP Aims**

1. Produce structural parts

**Inputs**

1. FM Drawings

**Outputs**

Structural parts

**Tasks**

1. **Produce the following as per FM:**
   - Photometer cover
   - Spectrometer cover
   - SOB
   - Phot. det. box
   - Spec. det. box
   - SCAL - supports for RF
   - Fasteners, clamps, coils
   - Optical supports
   - Mounting plate
   - FEM (model of the FM structure)

*WORK PACKAGE DESCRIPTION* **WP No:** 3200

**Project:** SPIRE MTD **Date:** 4/Feb/2003

**Major Subsystem:** FPU and JFETs

**Subsystem:**

**WP Title:** RAL Parts

**WP Start Event:** CDR

**WP End Event:** Delivery of parts

**WP Manager:** R. Edeson **Organisation Responsible:** RAL

**WP Aims**

1. Produce internal and JFET dummy masses
2. Produce JFET support structures

**Inputs**

1. Detailed drawings (WP2430).

2. Detailed drawings of FM JFET support components.

**Outputs**

1. Dummy mass parts.
2. Dummy JFET parts

**Tasks**

1. 3210 - Manufacture dummy masses in-house or through local contractors. Surface treatment as necessary.
2. 3220 – Manufacture of JFET support structures as per FM drawings

| *WORK PACKAGE DESCRIPTION* | | | **WP No:** 3300 |
|---|---|---|---|
| **Project:** | SPIRE MTD | **Date:** | 4/Feb/2003 |
| **Major Subsystem:** | FPU and JFETs | | |
| **Subsystem:** | | | |
| **WP Title:** | Electrical and Thermal Parts Procurement | | |
| **WP Start Event:** | Kickoff | | |
| **WP End Event:** | Arrival of parts at RAL | | |
| **WP Manager:** | J. Firth | **Organisation Responsible:** | RAL |

**WP Aims**

1. Procure electrical parts

**Inputs**

1. Procurement Specification (Astrium doc. No. HP-2-ASED-PS-0027

**Outputs**

1. Parts in electronic store.

**Tasks**

1. 3310 - Procure Connectors
2. 3320 – Procure thermistors and heaters

| *WORK PACKAGE DESCRIPTION* | | | **WP No:** 3400 |
|---|---|---|---|
| **Project:** | SPIRE MTD | **Date:** | 4/Feb/2003 |
| **Major Subsystem:** | FPU and JFETs | | |
| **Subsystem:** | | | |
| **WP Title:** | Dummy Harness Manufacture | | |
| **WP Start Event:** | CDR | | |
| **WP End Event:** | Completion of harness | | |
| **WP Manager:** | John Firth | **Organisation Responsible:** | RAL |

**WP Aims**

1. Produce dummy harnesses from JFETs to FPU

**Inputs**

1. Thermal Report
2. Electrical ICD

**Outputs**

Dummy harnesses

| **Tasks** | | |
|---|---|---|
| 1. Produce dummy harnesses between JFETs and the FPU. Harnesses to be thermally and mechanically representative. Connectors should only be necessary at the JFET ends, with wires bonded or mechanically fastened at the dummy detector ends. | | |

*WORK PACKAGE DESCRIPTION* **WP No:** 4100

**Project:** SPIRE MTD **Date:** 4/Feb/2003

**Major Subsystem:** FPU and JFETs

**Subsystem:**

**WP Title:** Mechanical Assembly

**WP Start Event:** Conclusion of WPs 3000

**WP End Event:** Assembly complete

**WP Manager:** R. Edeson **Organisation Responsible:** RAL

**WP Aims**

1. Mechanically assemble the FPU and JFETs
2.

**Inputs**

1. All parts

**Outputs**

Assembled items

**Tasks**

1. 4110 – Clean all parts to RAL internal spec.
2. 4120 – Assemble all parts except photometer and spectrometer covers (access required for wiring).
3. 4130 – Lock and stake assembly
4. 4140 – Attach and align the optical alignment cube.

| *WORK PACKAGE DESCRIPTION* | | | **WP No:** 4200 |
|---|---|---|---|
| **Project:** | SPIRE MTD | **Date:** | 4/Feb/2003 |
| **Major Subsystem:** | FPU and JFETs | | |
| **Subsystem:** | | | |
| **WP Title:** | Assembly of thermal parts | | |
| **WP Start Event:** | Completion of mechanical assembly (WP4100) | | |
| **WP End Event:** | All thermal parts integrated | | |
| **WP Manager:** | AS Goizel | **Organisation Responsible:** | RAL |

**WP Aims**

1. Integrate all thermal parts
2.

**Inputs**

1. Locations of heaters and thermistors from WP2100
2. Mechanical FPU assembly without covers.

**Outputs**

1. All thermal parts integrated

| **Tasks** | | |
|---|---|---|
| 1. Attach all heaters and thermistors to the mechanical assembly in the correct locations. | | |

*WORK PACKAGE DESCRIPTION* **WP No:** 4300

**Project:** SPIRE MTD **Date:** 4/Feb/2003

**Major Subsystem:** FPU and JFETs

**Subsystem:**

**WP Title:** Electrical Assembly

**WP Start Event:** Completion of Mechanical Assembly (WP4100)

**WP End Event:** Completion of Wiring

**WP Manager:** J. Firth **Organisation Responsible:** RAL

**WP Aims**

1. Make all internal electrical connections
2.

**Inputs**

1. Mechanical assembly, thermal parts integrated

**Outputs**

Complete internal wiring

**Tasks**

1. 4310 – Attach all connectors as per FM specification
2. 4320 – Attach all internal wires by soldering or crimping as necessary.

*WORK PACKAGE DESCRIPTION* **WP No:** 4400

**Project:** SPIRE MTD **Date:** 4/Feb/2003

**Major Subsystem:** FPU and JFETs

**Subsystem:**

**WP Title:** Inspection

**WP Start Event:** Completion of wiring

**WP End Event:** Inspection successful

**WP Manager:** J. Firth **Organisation Responsible:** RAL

**WP Aims**

1. Check the wiring.
2. Check the mechanical properties

**Inputs**

1. Completion of wiring

**Outputs**

1. Report on compliance with Procurement Specification

**Tasks**

1. 4410 - Perform a check of the wiring. Undertake hardware functionality verification tests:
   Milli-ohms resistance test
   Wire-to-wire, wire-to-shield and shield-to-shield high voltage isolation resistance test (representative bridges from signal to return lines required for each channel).
   4420 – Perform the final FPU assembly (attach covers)
   4430 – Measure mass and C of G of the FPU as well as JFET dummies.

*WORK PACKAGE DESCRIPTION* **WP No:** 4500

**Project:** SPIRE MTD **Date:** 4/Feb/2003

**Major Subsystem:** FPU and JFETs

**Subsystem:**

**WP Title:** Vibration Tests

**WP Start Event:** Completion of inspection

**WP End Event:** Completion of vibration test

**WP Manager:** R. Edeson **Organisation Responsible:** RAL

**WP Aims**

1. Qualify FPU and JFETs as per AD3.

**Inputs**

1. Completion of Assembly
2. Required test levels
3. FPU mounts from customer

**Outputs**

1. Vibration test report

**Tasks**

1. 4510 – Design and procure test fixtures.
2. 4520 – Prepare test specification
3. 4530 – Perform tests on JFETs and FPU
4. 4540 – Generate report

| *WORK PACKAGE DESCRIPTION* | | **WP No:** | 4600 |
|---|---|---|---|
| **Project:** | SPIRE MTD | **Date:** | 4/Feb/2003 |
| **Major Subsystem:** | FPU and JFETs | | |
| **Subsystem:** | | | |
| **WP Title:** | Bakeout | | |
| **WP Start Event:** | Successful completion of vibration test (WP4500) | | |
| **WP End Event:** | Bagging of FPU and JFETs for delivery | | |
| **WP Manager:** | R. Edeson | **Organisation Responsible:** | RAL |

**WP Aims**

1. Bake out the deliverable items as per AD3.

**Inputs**

1. Bakeout temperature levels and tolerances.

**Outputs**

1. Bagged deliverables conforming to cleanliness requirements

**Tasks**

1. 4620 - Clean exterior surfaces of FPU and JFETs.
2. 4620 - Conduct the bakeout
3. 4630 - Perform cleanliness inspection – verify particulate and molecular contamination is acceptable.
4. 4640 – Double bag deliverable items.

*WORK PACKAGE DESCRIPTION* **WP No:** 5100

**Project:** SPIRE MTD **Date:** 4/Feb/2003

**Major Subsystem:** FPU and JFETs

**Subsystem:**

**WP Title:** Transport design and manufacture

**WP Start Event:** Kickoff

**WP End Event:** Completion of assembly

**WP Manager:** R. Edeson **Organisation Responsible:** RAL

**WP Aims**

1. Provide a secure and clean transportation system for delivery.

**Inputs**

1. Interface control documents.
2. Transport requirements for deliverables, including cleanliness.

**Outputs**

1. Assembled transport gear

**Tasks**

1. 5110 – Design and mfr. transport plates for each of the deliverables
2. 5120 – Procure transport containers and anti-vibration mounts.
3. 5130 – Assemble transport gear

*WORK PACKAGE DESCRIPTION* **WP No:** 5200

**Project:** SPIRE MTD **Date:** 4/Feb/2003

**Major Subsystem:** FPU and JFETs

**Subsystem:**

**WP Title:** Handling equipment

**WP Start Event:** Kickoff

**WP End Event:** Completion of handling

**WP Manager:** R. Edeson **Organisation Responsible:** RAL

**WP Aims**

1. Provide fixtures for the handling of the FPU

**Inputs**

1. Interface control drawings.

**Outputs**

1. Handling fixtures

| **Tasks** | | |
|---|---|---|
| 1. Design and manufacture fixtures for the handling of the FPU. | | |

| *WORK PACKAGE DESCRIPTION* | | **WP No:** | 6100 |
|---|---|---|---|
| **Project:** | SPIRE MTD | **Date:** | 4/Feb/2003 |
| **Major Subsystem:** | FPU and JFETs | | |
| **Subsystem:** | | | |
| **WP Title:** | Delivery | | |
| **WP Start Event:** | Completion of WP4000 | | |
| **WP End Event:** | Acceptance by customer. | | |
| **WP Manager:** | | **Organisation Responsible:** | RAL |

**WP Aims**

1. Deliver FPU and JFETs

**Inputs**

1. Items bagged and ready for transport

**Outputs**

1. Transport

| **Tasks** | | |
|---|---|---|
| 1. Transport the deliverables to Astrium. Help with any acceptance testing at the delivery point. | | |

| *WORK PACKAGE DESCRIPTION* | | | **WP No:** 6200 |
|---|---|---|---|
| **Project:** | SPIRE MTD | **Date:** | 4/Feb/2003 |
| **Major Subsystem:** | FPU and JFETs | | |
| **Subsystem:** | | | |
| **WP Title:** | Integration | | |
| **WP Start Event:** | Customer defined | | |
| **WP End Event:** | Integration complete | | |
| **WP Manager:** | R. Edeson | **Organisation Responsible:** | RAL |

**WP Aims**

1. Integrate units

**Inputs**

1. Torque settings, locking instructions and other integration information.

**Outputs**

1. Integrated units

| **Tasks** | | |
|---|---|---|
| 1. Fix the dummies to the FM Herschel OB as per FM unit specifications. | | |

*WORK PACKAGE DESCRIPTION* **WP No:** 6300

**Project:** SPIRE MTD **Date:** 4/Feb/2003

**Major Subsystem:** FPU and JFETs

**Subsystem:**

**WP Title:** Post delivery support

**WP Start Event:** Customer defined

**WP End Event:** Customer defined

**WP Manager:** R. Edeson **Organisation Responsible:** RAL

**WP Aims**

1. Provided and support required after integration.

**Inputs**

1. Future customer requirements

**Outputs**

1. Assistance to customer.

**Tasks**

1. Provide information and/or services to the customer at a later point in the SPIRE program.

# 6. PROPOSED MAIV PROGRAMME

## 6.1 MANUFACTURE AND PROCUREMENT

### 6.1.1 Procurement of structure

Flight Model parts to be supplied by subcontractors.

### 6.1.2 Manufacture of dummy parts

Dummy masses will be made in-house, or by local contractors. All parts will be given an Alocrom surface finish.

### 6.1.3 Procurement of thermal straps

All thermal straps and isolating support structures will be manufactured in-house or by local contractors.

### 6.1.4 Procurement of resistors, thermistors and connectors

These parts will comply with AD3. Where possible, they will be sourced through the Herschel Common Parts Procurement Programme.

## 6.2 ASSEMBLY

### 6.2.1 General

Assembly will take place at RAL. All assembly will take place in Class 100 conditions.

### 6.2.2 Mechanical

Mechanical assembly will follow FM assembly procedures. The FM fastener locking philosophy will be followed.

### 6.2.3 Harnessing

Internal harnessing for resistors and thermistors will be done in-situ.

### 6.2.4 Thermal

Resistors and thermistors will be attached as per the manufacturer's specifications.

### 6.2.5 Cleaning

The RAL procedure for cleaning hardware parts will be followed. For metallic parts, this will include rinsing in acetone, ultrasonically in detergent, de-ionised water and alcohol. The baking out of parts prior to assembly will also be considered, since higher bakeout temperatures will be possible for externally exposed metallic parts without harnessing, electrical parts and locking or staking compounds.

## 6.3 VERIFICATION

### 6.3.1 Mechanical Inspection

Center of Gravity and Mass measurements will be made in the RAL cleanroom.

### 6.3.2 Electrical

Electrical connections will be tested before final integration of the external covers. Resistor values will be checked through connector pins.

### 6.3.3 Thermal

Thermal verification will be by analysis. Thermal vacuum or balance tests will not be conducted by RAL.

### 6.3.4 Vibration Test

The FPU and JFETs will undergo qualification level vibration testing at room temperature in air as per AD3. The tests will be carried out at RAL's vibration test facility.

### 6.3.5 Cleanliness

The surface contamination allowed of 50 ppm corresponds (from MIL-STD-1246B) to a maximum exposure of 31 days to Class 100 conditions. When not being worked on, parts and assemblies will be bagged or covered.

Other sources of contamination will be during transport and testing. Contamination will be minimised by double bagging items when leaving the assembly area. The vibration test will be conducted with test items double-bagged.

The FPU and JFETs will be thoroughly cleaned externally with isopropyl alcohol and baked out together as per AD3.

### 6.3.6 Verification of cleanliness

Surface contamination will be assessed using a tape-peeling test. Molecular contamination will be assessed using witness mirrors and infra-red spectroscopy. The locations on the structures for these tests to take place, as well as the frequency of testing are both TBD. RAL has the capacity to perform both these tests.

## 6.4 DELIVERY AND INTEGRATION

### 6.4.1 Transport

The FPU and JFETs will separately be sealed in double layers of Class 100 bagging material. They will be mounted on clean transport plates which will then be mounted in clean transport containers via anti-vibration mounts. Delivery will be by road.

### 6.4.2 Integration

A RAL engineer and technician will be made available to integrate the units on the Herschel optical bench either on delivery or with a reasonable period of notice after the delivery.

# 7. COMPLIANCE MATRIX

## 7.1 GENERAL REQUIREMENTS

| Requirement | Title | Compliance | Justification |
|---|---|---|---|
| R-DCG-010 | Interface Loads | Yes | Same as FM |
| R-DCG-020 | Cryogenic Interfaces | Yes | Same as FM |
| R-DCG-030 | Thermal Interfaces and | Yes | Analysis |

| | | | |
|---|---|---|---|
| | Behaviour | | |
| R-DCG-040 | Electrical Interfaces | Yes | Use of FM wiring instructions |
| R-DCG-050 | Dismountability | Yes | Design |
| R-DCG-060 | Thermal, pressure, humidity | Yes | Use of material (mainly metallic) |
| R-DCG-070 | Outgassing | Yes | Use of known materials |
| R-DCG-080 | Standard cleaning | Yes | SPAS-PA-001 |
| R-DCG-090 | Cleaning procedure | Yes | Sent with proposal |
| R-DCG-100 | Stiffness | Yes | Same as FM |
| R-DCG-110 | Safety factors | Yes | Same as FM, dummy masses by analysis/hand calculations. |
| R-DCG-120 | MOS | Yes | Same as FM, dummy masses by analysis/hand calculations. |
| R-DCG-125 | Reliability | Yes | Design |
| R-DCG-130 | Maintainability, interchangability | Yes | Same interfaces as FM |
| R-DCG-140 | Lifetime | Yes | Design – materials will be chosen not to degrade over this time. |
| R-DCG-145 | Safety | Yes | Handling will be as per FM |
| R-DCG-150 | General I/F | Yes | Interfaces will be the same as FM |
| R-DCG-160 | Brackets I/F | Yes | Information provided with ADP |
| R-DCG-170 | Mounting I/F | Yes | All mountings will be the same as FM |
| R-DCG-180 | Mounting I/F characteristics | Yes | Same as FM |
| R-DCG-190 | Material and thickness | Yes | Same as FM |
| R-DCG-200 | Form, fit and envelope | Yes | FPU same as FM |
| R-DCG-210 | Attachment of thermal H/W | Yes | Same as FM |
| R-DCG-220 | Connector location | Yes | By design |
| R-DCG-230 | Connector quality | Yes | FM type connectors will be used |
| R-DCG-240 | Connector types | Yes | FM type connectors will be used |
| R-DCG-250 | Wire connection | Yes | The type of wires to be used is TBD pending thermal analysis. |
| R-DCG-260 | Wiring test | Yes | Inspection and test. |
| R-DCG-270 | Shield interconnections | Yes | Shields to be grounded at one point only. |
| R-DCG-280 | Thermal design compliance | Yes | Design and analysis |
| R-DCG-290 | Thermal control equipment integration | Yes | This equipment is to interface through the cryo-harness, provided by the customer. |
| R-DCG-300 | Used material | Yes | A declared materials list will be provided. |
| R-DCG-310 | Thermal effects | Yes | Material properties considered during design. |
| R-DCG-320 | Internal heaters | Yes | Heaters to be mounted as per manufacturers instructions |
| R-DCG-330 | Heat capacity accuracy | Yes | By analysis |
| R-DCG-340 | External geometry | Yes | By design |
| R-DCG-350 | Deviation from geometry | Yes | TBD |
| R-DCG-360 | Heat path | Yes | By design – the suggested heaters will be used. |
| R-DCG-370 | Internal wiring restraint | Yes | Wires to be tied down where necessary |

| | | | |
|---|---|---|---|
| R-DCG-380 | Resistors wiring | Yes | Procurement Specification suggestions to be followed. |
| R-DCG-390 | Heater redundancy | Yes | Redundant heaters to be used. |
| R-DCG-400 | Reserved areas | Yes | Locations TBD by customer |
| R-DCG-410 | Handling points | Yes | Handling points to be as FM. |
| R-DCG-420 | Handling loads | Yes | Loads will be as FM |
| R-DCG-430 | Non-degradation | Yes | Materials will not degrade (note that this requirement potentially conflicts with cleanliness requirements) |
| R-DCG-440 | Material selection | Yes | All structural materials will be aluminium alloy. Stainless steel fasteners will be used. Harness and connector materials will be as FM. |
| R-DCG-450 | Dissimilar material | Yes | All aluminium structure |
| R-DCG-460 | Composite material | Yes/No | JFET mounting spacers are currently being tested. |
| R-DCG-470 | Outgassing | Yes | All materials will be known to have TML<1% and CVCM<0.1% |
| R-DCG-480 | Ferro-magnetic material | Yes | Stainless steel fasteners and wires will be necessary. Fasteners will be metric as far as possible. |
| R-DCG-490 | Provision of shims | Yes | Shims are not required |
| R-DCG-500 | Venting | Yes | Design. |
| R-DCG-510 | Bonding | Yes | All aluminium structure. Shielding to be grounded. |
| R-DCG-520 | Workmanship | Yes | By inspection |
| R-DCG-530 | Item marking | Yes | Deliverables will be labelled |
| R-DCG-540 | Connector labelling | Yes | Connectors will be labelled |
| R-DCG-550 | Math. Models | Yes | A thermal model will be provided. The mechanical model will be as per FM. |
| R-DCG-560 | Parts/materials protection | Yes | Units will be sealed in bags in Class 100 area. |
| R-DCG-570 | Marking/labelling procedure | Yes | During part manufacture |
| R-DCG-580 | Marking/labelling | Yes | Permanent labels will be used |
| R-DCG-590 | Serial number | Yes | Serial numbers will be generated |
| R-DCG-600 | Handling procedures | Yes | Procedures to be supplied. |
| R-DCG-610 | Packaging | Yes | During assembly |
| R-DCG-620 | Protection procedures | Yes | With delivery documentation |
| R-DCG-630 | Data package | Yes | With delivery documentation |
| R-DCG-640 | Handling procedures | Yes | See R-DCG-600 |
| R-DCG-650 | Storage conditions | Yes | Design of transport container. |
| R-DCG-660 | Packing | Yes | Design of transport container. |
| R-DCG-670 | Transportation | Yes | Design of transport container |

## 7.2 FPU SPECIFIC REQUIREMENTS

| Requirement | Title | Compliance | Justification |
|---|---|---|---|
| R-DSF-010 | Alignment cube | Yes | As FM |

| | | | |
|---|---|---|---|
| R-DSF-020 | Dimensions | Yes | FM structure design is used |
| R-DSF-030 | Mass | Yes | Test |
| R-DSF-040 | CoG | Yes | Test |
| R-DSF-050 | MoI | Yes | CAD model |
| R-DSF-060 | Eigenfrequency | Yes | FM FEA model |
| R-DSF-070 | Cleanliness | Yes | Cleaning procedures; test/inspection |
| R-DSF-080 | Design loads | Yes | Analysis/hand calculations |
| R-DSF-090 | Test loads | Yes | Test |
| R-DSF-100 | Reserved area | Yes | Customer defined |
| R-DSF-110 | Heaters | Yes | Customer recommended resistors will be used |
| R-DSF-120 | Heater location | Yes | Thermal design |
| R-DSF-130 | Parasitic heat | Yes | Thermal design |
| R-DSF-140 | Dissipated heat | Yes | Thermal design |
| R-DSF-150 | L0/L1 I/F decoupling | Yes | I/F either identical to FM or through thermal design (strap supports) |
| R-DSF-160 | Internal temp. sensors | Yes | The specified sensors will be used |
| R-DSF-170 | Heaters | Yes | The specified heaters will be used |
| R-DSF-180 | Connectors | Yes | The specified connectors will be used |

### 7.3 SPECTROMETER JFET SPECIFIC REQUIREMENTS

| Requirement | Title | Compliance | Justification |
|---|---|---|---|
| R-DSS-010 | Dimensions | Yes | Design of dummy mass envelope. |
| R-DSS-020 | Mass | Yes | Test |
| R-DSS-050 | Eigenfrequency | Yes | Analysis |
| R-DSS-060 | Cleanliness | Yes | Cleaning procedures; test/inspection |
| R-DSS-070 | Design loads | Yes | Analysis |
| R-DSS-080 | Test loads | Yes | Test |
| R-DSS-090 | Reserved area | Yes | Customer defined |
| R-DSS-100 | Heaters | Yes | Customer recommended resistors will be used |
| R-DSS-110 | Dissipated heat | Yes | Thermal design |
| R-DSS-120 | Internal temp. sensors | Yes | The specified sensors will be used |
| R-DSS-130 | Heaters | Yes | The specified heaters will be used |
| R-DSS-140 | Connectors | Yes | The specified connectors will be used |

### 7.4 PHOTOMETER JFET SPECIFIC REQUIREMENTS

| Requirement | Title | Compliance | Justification |
|---|---|---|---|

| | | | |
|---|---|---|---|
| R-DSS-010 | Dimensions | Yes | Design of dummy mass envelope. |
| R-DSS-020 | Mass | Yes | Test |
| R-DSS-050 | Eigenfrequency | Yes | Analysis |
| R-DSS-060 | Cleanliness | Yes | Cleaning procedures; test/inspection |
| R-DSS-070 | Design loads | Yes | Analysis |
| R-DSS-080 | Test loads | Yes | Test |
| R-DSS-090 | Reserved area | Yes | Customer defined |
| R-DSS-100 | Heaters | Yes | Customer recommended resistors will be used |
| R-DSS-110 | Dissipated heat | Yes | Thermal design |
| R-DSS-120 | Internal temp. sensors | Yes | The specified sensors will be used |
| R-DSS-130 | Heaters | Yes | The specified heaters will be used |
| R-DSS-140 | Connectors | Yes | The specified connectors will be used |

# 8. RISKS

The following technical risks to the project have been identified:

| Risk | Description | Management Strategy |
|---|---|---|
| Subcontractor parts | Subcontractor part lead times cause late delivery | Procure FM type structure parts soon after kickoff. |
| Electronic/ thermal parts | Electronic/thermal part lead times cause late delivery | Procure these parts soon after kickoff. |
| Cleanliness | Non – compliance; | Class 100 assembly<br>IPA wipe – bakeout<br>Possible bakeout required for Al alloy parts prior to assembly |
| Cleanliness verification | Inability to verify compliance by test or inspection. | Use Astrium's suggested method for assessing particle contamination.<br>Molecular contamination may be difficult to verify (use witness mirrors with Fourier transform IR spectroscopy or dual quartz crystal).<br>A cleanliness plan might be required. |
| Wiring | Conflict between parasitic heat loss and ohmic resistance properties of wire | Unlikely as much larger bundles will be routed in the FM, so heat loss will be greater there. |
| Wiring difficult | Connecting stainless wire may be problematic – we may need to practice | Practice making these joints before MTD wiring takes place. |
| FPU structure Information unavailable | Import of CAD geometry from MSSL may cause problems | There is some slack on the mechanical design tasks. Use this as contingency to sort out CAD problems. |
| FPU FM mechanical analysis unavailable | We need to outline difference between the FM FEA model and the MTD. | There is a long slack period while thermal work is being done. This time would be used to re-generate relevant parts of the FEA model. |
| Vibration test need to be done elsewhere | If the RAL shaker is not big enough, or unable to design a suitable mount | Investigate shake at Astrium Stevenage. |
| Vibration failure | Failure during test | STM will be tested before the MTD. |
| First mode too low | If the first mode of vibration is lower than 120 Hz | The same will probably be true of the FM. If the FM is different, we will need to design in some stiffening. |
| FM design changes | Design of the FM structure changes after we have designed or procured parts. | Change schedule to accommodate re-design. |
| Thermal analysis | The current model is not sufficient, and a new one is required from scratch | Contingency at end of schedule. |
| L0-L1 thermal isolation | It might be difficult to isolate thermal straps | This analysis work should be done early on in the task, so any iteration with mechanical design does not impact the schedule. |
| Cube Alignment | Alignment of cube may pose problems. | This level of alignment should be easy to achieve. Use FM design. |

# 9. PROPOSED PRODUCT ASSURANCE PLAN

The proposed PA plan is the SPIRE instrument plan, doc no SPIRE-RAL-PRJ-000017.

# 10. DELIVERABLE ITEMS

| Item | Description | Quantity | Comments |
|---|---|---|---|
| | | | |
| 1 | FPU MTD | 1 | |
| 2 | Spectrometer JFET MTD | 1 | Includes mounting feet |
| 3 | Photometer JFET MTD | 1 | Includes mounting feet |
| 4 | Harness | 2 | |
| 6 | Documentation | Refer to Statement of Work. | As required in AD2 |
| 7 | Transport Containers | 3 | Containers suitable for the transport and storage of all three MTDs |
| 8 | MGSE | As Required | Handling plates for FPU as per FM |