

Herschel SPIRE Beam Steering Mirror Product Assurance Plan

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Herschel SPIRE Beam Steering Mirror Product Assurance Plan v 1.5

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1 OVERVIEW

1.1 Introduction

Given the high cost, the adverse environments and remote location of space missions, a rigorous quality assurance framework is adopted as a normal requirement. This approach applies to the ESA Herschel SPIRE instrument.

The ATC's contribution to the flight hardware – the Beam Steering Mirror - is a critical part of the SPIRE mission, and is required to embody, and to demonstrate, the required quality and performance levels.

The end customer is the SPIRE PI (Dr. Matt Griffin). However, the direct delivery of the hardware and documentation by ATC is to the SPIRE project office at the Rutherford Appleton Laboratory Space Science Department (RAL SSD). The integrated SPIRE instrument is then delivered by RAL to ESA. The ATC funding stream is from the UK SPIRE budget, via PPARC Swindon Office.

The typical assurance process for space missions is to develop a Product Assurance (PA) plan - which deals with product specific aspects of space qualification - within a global organisational Quality Assurance (QA) framework.

Given the UK ATC's organisation, a single document describing both the QA and PA aspects of the BSM development is appropriate.

The end goal of the ATC's PA plan is to

- provide a level of traceability and assurance to the customer of overall quality levels,
- provide a specific assurance that the product is fit for purpose in the space environment.

In addition to retained in-house records, the end deliverable of the PA plan is the Acceptance Data Package (ADP) which accompanies the delivered hardware to the customer.

1.2 Documents

Scope of this document

This document contains three main sections:

1. The Quality Assurance section outlines the overall framework of product design, manufacture, integration and test within the UK ATC as applied to the BSM.
2. The Product Assurance section describes the space-specific processes and procedures applied by the UK ATC to the design, manufacture, integration, test and delivery of the BSM to ensure and demonstrate quality.
3. The Appendices include detailed procedures, pro-forma and flowcharts.

2 APPLICABLE DOCUMENTS

Applicable documents are project specific and may be assumed to apply fully to the BSM, unless stated otherwise

| Ref | Title | Author | Reference | Date |
|------|---|---------------------------|--------------------------------|-----------|
| AD 1 | SPIRE Beam Steering Mirror Subsystem Specification | Ian Pain | SPIRE-ATC-PRJ-000460 v3.3 | 30.Jan.02 |
| AD 2 | SPIRE Beam Steering Mirror Subsystem Development plan | Ian Pain | SPIRE-ATC-PRJ-0466 v4.0 | 08.Apr.01 |
| AD 3 | SPIRE Beam Steering Mirror Design Description | Ian Pain | SPIRE-ATC-PRJ-000466 v4.1 | 08.Feb.02 |
| AD 4 | SPIRE Product Assurance Plan | Dave Kelsh, G. Douglas | SPIRE-RAL-PRJ-000017 issue 1.1 | 11.Apr.01 |
| AD 5 | Parts Procurement Agreement between the Principal Investigators and ESA | N/A | SPIRE-ESA-DOC-000684 | latest |

Reference documents

Reference documents are generic and may only apply in part to the project, or may be for information or reference only.

| Ref | Title | Author | Reference | Date |
|-------|---|-------------|--|-----------|
| RD 1 | UK ATC project management procedures | I. Egan | 189-PMG-01-001 Issue 1 | May 2001 |
| RD 2 | SPIRE Instrument Development Plan | K.J.King | SPIRE-RAL-PRJ-000035 issue 1.1 (draft) | 12.Apr.01 |
| RD 3 | PPARC financial memorandum Procurement Policy and Procedure | PPARC/NE RC | FM-401 | 7.Nov.00 |
| RD 4 | SPIRE Document Management Plan | K.J.King | SPIRE-RAL-PRJ-000032 issue 1.1 | 13.Sep.00 |
| RD 5 | SPIRE AIV plan | B.Swinyard | SPIRE-RAL-DOC-000410 issue 2.0 | 23.Feb.01 |
| RD 6 | SPIRE Instrument Interface Document – Part A (IID-A) | ESA | SCI-PT-IIDA-04624 rev 1/0 | 1/9/00 |
| RD 7 | SPIRE Instrument Interface Document – Part B, SPIRE (IID-B) | ESA | SCI-PT-IIDB-02124 issue 1/0 | 1/9/00 |
| RD 8 | SPIRE Instrument Requirements Document (IRD) | B.Swinyard | SPIRE/RAL/N/0034 iss 0.30 | May.00 |
| RD 9 | MAPTIS database | MSFC | Search engine for MSFC-HDBK-527 | latest |
| RD 10 | Material Selection List for Space | MSFC | MSFC-HDBK-527 Rev | 30.Sep.88 |

| Ref | Title | Author | Reference | Date |
|-------|---|-------------|------------------------------------|-----------|
| | Hardware Systems | | F | |
| RD 11 | Spectrometer Mirror Mechanism Subsystem Development Plan | D.Pouliquen | LAM.PJT.SPI.NOT.200 001 Ind 8 | 03.Apr.01 |
| RD 12 | Data for selection of space materials | ECSS | ESA-PSS-01-701 iss 1 rev 3 | |
| RD 13 | Contamination and Cleanliness Control | ECSS | ESA-PSS-01-201 Issue 1 | |
| RD 14 | Reliability Assurance of ESA spacecraft and associated equipment | ESA | ESA-PSS-01-30 Issue 2 | |
| RD 15 | Space product Assurance: Failure modes, effects and criticality analysis (FMECA) | ESA | ECSS-Q-30-02A | 7.Sep.01 |
| RD 16 | Failure rates for ESA space systems | ESA | ESA-PSS-01-302 Issue 1 Draft 4 | |
| RD 17 | Component selection, procurement and control for ESA space systems | ESA | ESA-PSS-01-60 Issue 2 | |
| RD 18 | Material and process selection and quality control for ESA space systems and associated equipment | ESA | ESA-PSS-01-70 Issue 3 | |
| RD 19 | The Technical Reporting and Approval Procedure for Materials, Mechanical Parts and Processes | ESA | ESA-PSS-01-700 2 | |
| RD 20 | Measurement of Thermo-optical Properties of Thermal Control Materials | ESA | ESA-PSS-01-709 1 | |
| RD 21 | The Repair and Modification of Printed-Circuits Boards and solder Joints | ESA | ESA-PSS-01-728 2 | |
| RD 22 | Outgassing and thermo optical data for spacecraft materials | ESA | ESA-RD:01 Rev 1 | |
| RD 23 | Outgassing data for selecting spacecraft materials | NASA | NASA Ref. Publication RP1124 Rev 2 | Nov 1990 |
| RD 24 | GGFC preferred parts list | GGFC | GSFC/PPL20 | |
| RD 25 | Materials selection guide | NASA | NASA-MSG-A | Aug. 1990 |
| RD 26 | Test methods and procedures for microelectronics | | MIL-STD-883 | |
| RD 27 | Airborne particulate cleanliness classes in clean rooms and clean zones | | ISO EN 14644-1999 | |
| RD 28 | Reliability prediction of electronic equipment | | MIL-HDBK-217F | |
| RD 29 | NASA standard electrical and electromechanical (EEE)Parts list | | MIL-STD-975L (NASA) | |
| RD 30 | Non electrical parts reliability data | | NPRD-3 | |
| RD 31 | European preferred parts list | ESA ECSS | ESA ECSS-Q-60-01A | |
| RD 32 | Space Product Assurance – Quality | ESA ECSS | ECSS-Q-00 A | |

| Ref | Title | Author | Reference | Date |
|-------|---|------------|--------------------------------|-----------|
| | and principle | | | |
| RD 33 | Space Product Assurance – Quality Assurance | ESA ECSS | ECSS-Q-20 B | 8.Mar.02 |
| RD 34 | Non conformance control system | ESA ECSS | ECSS-Q-20-09 A | |
| RD 35 | Space Product Assurance – Dependability | ESA ECSS | ECSS-Q-30 A | |
| RD 36 | Space Product Assurance – Material, Mechanical Parts and Processes | ESA ECSS | ECSS-Q-70 A | |
| RD 37 | A thermal vacuum test for the screening of space materials | ESA ECSS | ESA ECSS-Q-70-02A | |
| RD 38 | The control of limited life materials | ESA ECSS | ESA ECSS-Q-70-22A | |
| RD 39 | The wire wrapping of high reliability electrical connections | ESA ECSS | ESA ECSS-Q-70-30A | |
| RD 40 | Space Product Assurance – Software product Assurance | ESA ECSS | ECSS-Q-80 A | |
| RD 41 | ECSS Glossary of terms | ESA ECSS | ECSS-P-001 A | |
| RD 42 | The Manual Soldering of High-Reliability Electrical Connections | ESA ECSS | ECSS-Q-70-08 A | 6.Aug.99 |
| RD 43 | The Crimping of High Reliability Electrical Connections | ESA ECSS | ECSS-Q-70-26 A | |
| RD 44 | Material selection for controlling stress-corrosion cracking | ESA ECSS | ECSS-Q-70-36 A | 20.Jan.98 |
| RD 45 | (SCC sensitive materials) | MSFC | MSFC-SPEC-527-B | |
| RD 46 | Practice for evaluating SCC resistance of materials and alloys by alternate immersion in 3.5% sodium chloride solution | ASTM | ASTM G44-75 | |
| RD 47 | Determination of the susceptibility of metals to stress-corrosion cracking | ESA | ECSS-Q-70-37 A | 20.Jan.98 |
| RD 48 | Compatible couples for Bi-metallic contacts | | P50 DOC | |
| RD 49 | A thermal vacuum test for screening of space materials | ESA | ESA-PSS-01-702 | |
| RD 50 | Standard test method for total mass loss and collected volatile condensable materials from outgassing in a vacuum environment | ASTM | ASTM-E-595-84 | |
| RD 51 | Xxx | JSC | JSC/SPR-0022A | |
| RD 52 | Derating requirements applicable to EEE components for ESA space systems | ESA | ESA-PSS-01-301 | Apr.1992 |
| RD 53 | Space Engineering, Mechanical - Part 3: Mechanisms | ESA ECSS | ECSS-E-30-3A | 25.Apr.00 |
| RD 54 | Outgassing data for selecting spacecraft materials | NASA | Publication 1124 Rev 3 | Sept 1993 |
| RD 55 | ATC SPIRE Document Numbering System | G.Reynolds | SPI-BSM-DOC-0004 Issue: 1.0 | 6-July-01 |

| Ref | Title | Author | Reference | Date |
|-----|-------|--------|-----------|------|
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3 GLOSSARY

| | | | |
|-------|---|---------|---|
| AD | Applicable Document | LAM | Laboratoire d'Astrophysique de Marseille |
| ADP | Acceptance Data Package | LAT | Lot Acceptance Tests |
| ARB | The Acceptance Review Board | MAPTIS | Materials and Processes Technical Information Service |
| BSM | Beam Steering Mirror | MSFC | Marshall Space Flight Centre |
| BSMe | Beam Steering Mirror electronics | MCU | Mechanism Control Unit |
| CAE | Computer Aided Engineering | MIP | Mandatory Inspection Point |
| CDR | Critical Design Review | MGSE | Mechanical Ground Support Equipment |
| CoG | Centre of Gravity | MPIA | Max Planck Institute for Astronomy |
| CIL | Critical Items List | MSSL | Mullard Space Science Laboratory |
| CQM | Cryogenic Qualification Model | NASA | National Aeronautical Space Agency |
| CTD | Change to Drawing/Document | NA | Not Applicable |
| DCL | Declared Components List | NCR | Non Conformance Report |
| DDR | Detailed Design Review | NCRP | Non Conformance Review Panel |
| DM | Development Model | OGSE | Optical Ground Support Equipment |
| DML | Declared Materials List | PA | Product Assurance |
| DPA | Destructive Physical Analysis | PAD | Part Approval Document |
| ECSS | European Cooperation for Space Standardisation | PFM | Proto Flight Model |
| EGSE | Electrical Ground Support Equipment | PPARC | Particle Physics and Astronomy Research Council |
| ESA | European Space Agency | PI | Principal Investigator |
| FMEA | Failure Modes and Effects Analysis | QA | Quality Assurance |
| FMECA | Failure Modes, Effects and Criticality Analysis | RAL | Rutherford Appleton Laboratory |
| FPGA | Field Programmable Gate Array | RAL SSD | RAL Space Science Department |
| FPU | Focal Plane Unit | RD | Reference Document |
| FSM | Flight Spare model | SMEC | Spectrometer Mechanism |
| GSFC | Goddard Space Flight Center | SPIRE | Spectral and Photometric Imaging REceiver |
| GSE | Ground Support Equipment | TBC | To Be Confirmed |

| | | | |
|----------|-----------------------------------|--------|--|
| HoS | Head of Group | TBD | To Be Defined |
| Herschel | ESA Mission name (formerly FIRST) | TBW | To Be Written |
| IBDR | Instrument Baseline Design Review | UK ATC | United Kingdom Astronomy Technology Centre |
| KIP | Key Inspection Point | UK SPO | UK SPIRE Project Office |
| | | WE | Warm Electronics |
| | | | |

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4 ATC QUALITY ASSURANCE

4.1 Framework

4.1.1 Quality Assurance Statement

The UK Astronomy Technology has a mission to *"be the UK's National Centre for the design and production of state of the art astronomical technology"*.

Quality management is the process of ensuring that the quality expected by the customer is achieved. The customer's quality expectations must be understood at the beginning of a project and balanced against any constraints that time and cost may impose. All work packages must be traceable back to the customer requirements to ensure that all requirements are met.

This document, in conjunction with the Project Development Plan [AD 2] acts as the Quality Plan for the management of the project.

ATC practice is that the project engineers are responsible for the quality of the work they carry out with supervisory aspects covered by their Head of Group. The Chief Engineer is responsible for approving the overall quality of the products delivered to customers.

4.2 ATC Organisation

The UK Astronomy Technology Centre (ATC) has an established history of delivering world class facility instruments for ground based astronomical observatories. Space based products (e.g. ISOCam) have also been developed.

The ATC is a matrix managed structure with vertically organised disciplines (science, applied optics, mechanical engineering, electrical engineering) and strong horizontal project teams. The ATC Project Management Procedures are described fully in **RD 1**.

The ATC has a quality assurance framework appropriate to the organisation's primary customers, who do not generally require a formal QA framework. Projects are run by a team including: a project manager; a project engineer (where appropriate); and a project scientist.

The quality of the product is assured by the close attention of the project management and science team, by the Heads of Group (HoG) responsible for the output from each discipline, and by a process of comprehensive internal and external review. Adherence to **RD 1** is ensured by the HoG for project management, the ATC Programme Manager.

The Beam Steering Mirror has a tighter requirement for documented Product Assurance (PA), and this PA Plan addresses that need. For the SPIRE BSM project, a Product Assurance Manager is designated to ensure that the unique quality aspects of space flight projects are fully met.

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4.3 Personnel

4.3.1 Project Team

The dedicated BSM project team includes significant proportions of the following staff's time:

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|-----------------------------------|--|
| Dr Gillian Wright | Local Co-I, Project Scientist |
| Philip Parr Burman | Project Manager, Lead/Mechanical Engineer, Product Assurance manager |
| Colin Cunningham, CEng | Deputy Director/Chief Engineer, SPIRE systems engineer, BSM consultant |
| Tully Peacocke, | Optical Engineer |
| Brian Stobie, CEng, Brenda Graham | Electronics & Controls engineer |
| Tom Paul, | Mechanical Design Engineer |
| Ken Wilson, Tom Baillie | Project Technicians |
| Vivienne Bon | Project Assistant |

4.3.2 PA Manager

Given the ATC's organisational structure, and small scope of the BSM project, the most appropriate person to perform the role of PA manager is also the project manager and lead engineer.

This consolidation of roles in a single post provides for a strong product overview and enhanced ownership of product quality. An appropriate balance between time/cost issues and quality/performance issues is retained given the strong role of the Project Scientist and the Heads of Group. In the event of unresolved issues, resolution will be upwards within the ATC reporting chain, or by consultation with the SPIRE PI.

Limited support on specialist space PA advice (e.g. radiation sensitivity), is anticipated from the UK-SPO (RAL) QA function.

4.4 UK ATC Organogram

The latest version of the UK ATC organogram is maintained on the ATC intranet at <http://intra.roe.ac.uk/atc/admin/personnel/orgatc.pdf>

A copy at the date of issue of this document is attached in Appendix 1

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5 PROCUREMENT CONTROL

5.1 General

This section outlines the QA requirements for purchase of components and materials

5.2 Purchasing procedures

The responsible engineer specifies components to meet the requirements of the project. These are communicated to the ATC finance section via a CD1 or CD2 form, [per RD 2], see Appendix 2.

Purchase orders and attached specifications are processed and documented in accordance with UK ATC and PPARC procedures, [RD 3]. Full records are retained by the finance office and an information copy by the project team.

The Purchase Orders or attached specifications will identify the required QA level, traceability and accompanying documentation of components.

5.3 Supplier Selection

Suppliers will be selected based primarily on their ability to meet the specification, including quality assurance levels. As the requirements of the space environment are substantially more rigorous than those applying to many ATC projects, special criteria will be applied in selecting suppliers.

Where a choice of qualifying suppliers exists, preference will be given, to those:

- supplying components with proven space heritage
- with a proven track record with the UK ATC,
- with a proven track record with a SPIRE consortium member
- European based
- US based

5.4 Incoming Inspections

Upon receipt at the ATC, the products will be inspected for compliance with the purchase order's requirements. Until inspected, goods will be quarantined such that they cannot be incorporated into a higher level build. Goods will be released from quarantine only when accompanying documentation (see Route Card Documentation section) has been raised

Incoming inspection activities include:

- verification of the packaging conditions and status of environmental sensors,
- visual inspection,
- verification of correct identification and conformance to ordering data,
- certificate of conformance,
- supplier's inspections and control results,
- remaining lifetime (for products with limited lifetimes).

For non-configuration controlled items, the PO invoice section alone will be completed [RD 2].

For components to be incorporated in a configuration controlled model , as outlined in AD 2 (Model Philosophy) an inspection report will be completed, as outlined in the Inspection Records section of this document.

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6 MANUFACTURING AND ASSEMBLY CONTROL

6.1 General

This section describes the QA management of in-house manufacture and assembly. The ATC has a dedicated workshop with a wide range of precision machines and experienced staff. The decision to place work in-house versus outside manufacture is made by the BSM Project Manager in consultation with the workshop manager and in accordance with guidelines in **RD 1**.

6.2 In- house manufacture requests

Components for in-house manufacture rework or repairs are passed to the workshop, together with appropriate manufacturing specifications, including drawings.

A workshop effort request document will be raised for all work performed, see Appendix 3.

This information is entered into a database of work in progress, and is retained upon completion. Each request is allocated a unique work request reference number which accompanies the component through to delivery to the project.

6.3 Route Card Documentation

For BSM components where a work request document has been raised, a route card document will be created, see Appendix 3.2. The unique work request reference is marked on the manufacturing drawings which will accompany (travel with) the request and will be closely associated with the component material through manufacture, inspection and assembly.

The route card is created electronically, and a hardcopy will accompany the component from issue of material through to manufacture, inspection and assembly. The route card identifies, as a minimum:

- The work request number/document
- The drawing number and additional specifications
- The responsible engineer
- The required manufacturing, including any off-site processing stages
- Required inspection stages
- Provision for sign off of work and inspection at each stage

6.4 Inspection Points

The quality of work performed at each stage is the responsibility of the staff member performing the work. Usually they will also sign off the inspection at each stage. At the discretion of the ATC Workshop Manager, an independent qualified staff member will perform final inspection.

Where required, any SPIRE project level Key Inspection Points (KIPs) or Mandatory Inspection Points (MIPs) will be identified. A KIP or MIP will be witnessed by an independent member of the SPIRE consortium, or ESA team.

6.5 Inspection Records

All inspections will be documented. As a minimum, the inspection record included in Appendix 3.3 will be completed. Additional inspection information, such as critical dimensions, coordinate measurement machine data or photographs will also be added where required. Critical dimensions are identified by an enclosing box on the drawing.

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6.6 Document Package

Upon delivery of a component to final assembly the full documentation: work request hardcopy, route card and a copy of the inspection records will be delivered to the BSM PA manager.

6.7 Calibration of Measuring, Inspection and Test Equipment

Calibrated instruments shall be used at least for all measurements which are to be verified against interfaces or functional specifications.

Calibrated instrumentation with the accuracy, stability and range appropriate to the intended application shall be available when needed in the various phases of manufacturing, integration and tests.

Calibration of instruments shall be traceable to national standards. Re-calibration shall be performed at intervals on the basis of the stability, purpose and use of the instrument.

Calibration labels attached to instruments shall indicate the last and next date of calibration and they shall allow traceability to the applicable calibration records.

Certain equipment is maintained in calibration by the relevant ATC discipline, but other equipment used less frequently is calibrated immediately before use. To avoid program delays the BSM PA manager will wherever practical discuss inspection requirements with the relevant HoS in advance to allow sufficient time for calibration.

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7 NON-CONFORMANCE PROCESS

7.1 General

A non-conformance reporting (NCR) system will be implemented for the BSM. The aim of the NCR system is to document problems, allow tracking of their close-out and identify required improvement areas.

7.2 Non-conformance Reporting System

A non-conformance report shall be raised whenever an inspection indicates that a component or assembly does not comply with the drawing or specification. The BSM project will use an electronic NCR system, Q-Pulse. The system and NCR format is described in Appendix 5.

Additionally, an NCR may be raised for any other design, process or product non-conformance.

7.3 Quarantine

Components identified as non-conforming will be quarantined such that they cannot be incorporated into a higher level build until the NCR is resolved.

7.4 Non-conformance Classification

An NCR shall be classified as major where the following are potentially affected:

- an interface control document to the SPIRE system is affected
- where the sub-system specification [AD 1] is affected, particularly form, fit, function, performance
- where the instrument AIV plan [RD 5] is affected.

Major non conformances shall be reported to the UK-SPO PA Manager within 72 hours. All other NCR's shall be classified as minor.

7.5 Non-conformance Disposition and Reporting

NCR's will be reviewed as soon as practicable after being raised and at a minimum within two weeks. The NCR register will be reviewed at BSM project meetings, and will be available to the SPIRE project office.

For components or assemblies, the NCR review panel (NCRP) will be at a minimum:

- the responsible engineer identified on the Workshop Effort Request,
- the BSM PA manager
- the member of staff raising the NCR.

Additional staff will be involved as required. The UK-SPO and/or ESA may be involved in review of major NCR's.

The objective of the NCR review is to investigate and close out each NCR, with a recommendation for disposition of the item and corrective action required to prevent re-occurrence. The classification for each NCR will be reviewed or, where missing, allocated. The NCR will be then be identified for disposition as:

- 'Use as is', without requirement for waiver
- 'Use as is', but with a Request for Waiver or Specification Change request being raised where a formal specification is not met. See Appendix 10 for the relevant request formats.
- 'Re-work or Repair', with attached repair instructions where required.
- 'Scrap'

Corrective action will be noted in a BSM project document and circulated to the relevant HoS.

7.6 Non-conformance Close Out

The cause of the discrepancy and the dispositions and actions agreed by the NCRP are to be documented on the Non-conformance Report or in associated NCRP minutes. The BSM PA manager shall verify the completion of all actions and re-verification defined by the NCRP and when that has been achieved successfully, the NCR may be "closed out" with reference to re-verification reports or updated documents and QA-signature on the NCR form.

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8 PRODUCT ASSURANCE MANAGEMENT

8.1 GENERAL

8.1.1 Product Assurance Plan

This section describes the processes and procedures hardware applied by the UK ATC specific to a space-qualified item.

8.1.2 Right of Access

For the purpose of PA and technical coordination, the SPIRE PI, UK-SPO (RAL) and ESA will have right of access by appointment to all relevant in-house facilities [RD 4].

Where audit of suppliers for PA purposes is required, ATC will arrange for equivalent visits by appointment.

8.1.3 Reviews

A minimum internal review structure is described in RD 1. The SPIRE Project Development Plan [RD 2] indicates the external review structure. All relevant reviews will include a PA section. Of particular relevance to the PA program for the BSM:

- the sub-system Detailed Design Review will mark the commencement of general configuration control for flight qualified design and associated hardware models, and the full introduction of the PA plan across the project
- The acceptance test review will demonstrate close-out of NCR's
- The IBDR will finalise material and process selection.
- The Acceptance Data Pack (ADP) will document the full PA process for each delivered hardware item.

The BSM project will hold monthly project meetings involving the full BSM team, where PA items will be reviewed, in particular this will include review of the project risk analysis, the NCR register and all open PA related actions.

8.2 DESIGN QUALITY ASSURANCE

8.2.1 Design Process

The ATC design process is described in overview in **RD 1**. The BSM Design Description [RD 3] documents the current design state, and design history is obtained via electronic documents describing the evolution of the design.

Product assurance during the design process consists of:

- • Verifying the presence of all necessary inputs,
- • Safety and reliability studies,
- • The formalisation of the functional analysis,
- • Verifying interactivity between mechanical-electrical and software design,
- • Verifying the presence and compliance of "latest design" files and documents.

8.2.2 Design Staff

The BSM project team incorporates a team of experienced professional engineers, and additional expertise is available for design input from the relevant ATC Specialism.

8.2.3 Design Review Framework

A minimum internal review structure is described in **RD 1**. The SPIRE project development plan [RD 2] indicates the external review structure.

8.3 CONFIGURATION MANAGEMENT AND CONTROL

8.3.1 Science Performance

The requirements of the science mission are specified in RD 8 and incorporated into the BSM specification, AD 1. The relevance of the science goals and the ability of the BSM to meet these requirements is assured by the ATC project scientist, who holds co-PI status within the consortium.

The Co-PI ensures any changes required in the light of developments (within the BSM program, the SPIRE program, or the general astronomy field) is fed into the SPIRE consortium.

8.3.2 Engineering Specification

The BSM specification is described in AD 1. The relevance of the specification is assured by the external review structure and the operations of a Systems Engineering approach by the SPIRE project office.

8.3.3 Document Control

ATC documents shall be stored in an electronic database management system, Q-Pulse. Each document is uniquely identified and stored, and status and versions are correctly identified. Q-Pulse may be used for document circulation and approval within the ATC. The Q-pulse system is secure, being subject to ATC Information Services Group security procedures and individual PIN number access. The ATC Information Services Group maintains a system of network backups.

Documents formally circulated outside ATC will be via the SPIRE Project Office, where the ESA Livelink System will be used. The internal Q-Pulse system provides a field for entry of external reference numbers, such as those generated by RAL or ESA to allow cross reference of ATC and external documents.

The outline procedure for filing and accessing documents is described in Appendix 7.

8.3.4 CAE/Drawing Control

The control of engineering drawings and data is via the PTC Intralink software application and is administered by the ATC Information Services Group in conjunction with the engineering specialisms. Following a CTD being actioned the drawing is updated using the Pro/Intralink system.

Electronic files are allocated a directory space for SPIRE, within which the following version and release level scheme operates:

For Pro/Engineer drawing files, access and configuration is controlled by the Pro/Intralink database application. The ATC BSM drawing numbering scheme is:

ATC-SPIRE-BSM-bbb-aaa-ppp

The assembly, model and related 2D drawings each have a filename and a description, as well as a release level, revision and version.

Where bb is the 'build', aaa is the assembly or sub assembly within that build, ppp is the part number within the assembly (note for the assembly itself, the field -ppp is blank)

8.3.4.1 Build

| | |
|-------------------|---|
| Build 000 and 010 | are reserved for uncontrolled prototype and in house test equipment |
| Build 020 | DM1 |
| Build 023 | DM2 |
| Build 030 | the STM |
| Build 040 | the QM |
| Build 050 | the CQM |
| Build 060 | the PFM |
| Build 070 | the FSM |

Within each build, the following blocks of numbers are allocated:

- bb0 : assembly and component drawings (e.g. SPIRE-BSM-020-001)
- bb1 : ICD drawings (e.g. SPIRE-BSM-021-001)
- bb2 : supplementary process instructions, manufacturing jigs etc (e.g. SPIRE-BSM-022-001)

The build identifier is used to allow tracking of the configuration status of an assembly. The DM, build 020, will be released as the first configuration controlled set.

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Where a part differs from that used in other builds (e.g. the STM flex pivots may be replaced by a fixed stub shaft, a modification may be made to a model after testing on an earlier model, etc) the new/modified part will have the new build number applied.

A subsequent build may in general incorporate a preceding build's component where the design and PA requirements are unchanged. For example, it is expected that the PFM (build 060) will be substantially similar to the QM (build 040), so majority of PFM parts will be numbered SPIRE-BSM-04-aaa-ppp.

A change to a part which results in its release as a higher level revision will apply to all builds in which that part is incorporated.

For NC machining within the ATC, CAD drawings are sometimes required in AutoCAD rather than native Pro/E format. These are numbered and controlled using the ATC's 'Ambush' system. The outline procedure for filing and accessing files is described in Appendix 5. A database is kept in the CTD register of equivalence between any master Pro/E drawing and the respective AutoCAD format file.

8.3.4.2 Component Control

Where possible, all manufactured components will be identified by a part number marked on the component or physically attached. These markings will be placed in accordance with the engineering drawing instructions, and in general will be engraved on mechanical parts.

The marking will include the drawing number and revision, and a unique serial number for each manufactured component, where required. A register of serial numbers produced will be kept, and each assembly log will record the serial numbers of items as assembled.

For small components (e.g. fasteners), or consumables (e.g. adhesives) control will be identification of the storage container and control of the storage area to prohibit uncontrolled movement of parts.

8.3.5 Engineering Change Requests

An Engineering Change Request will be raised for any design change requests.

The ECR handling procedure and blank forms is described in appendix 12. The ECR is raised by a Change to Drawing/Document (CTD) form. CTD's are uniquely identified for the project and work-scope module. (Although module numbers do not apply to the BSM, as the entire sub-system is treated as a single module).

A CTD log book is raised for the project and contains a register of CTD's raised, to be actioned or completed. At the time of writing this is a paper based procedure.

Each CTD request will be reviewed by the Project Manager and at least one project engineer. The change request will be actioned appropriately, including:

- actioned as described
- actioned with modifications
- held for review at a later stage (for example where the CTD request addresses a model yet to be designed fully)
- rejected, with reasons.

8.4 Applicability of PA Requirements to the Different Models

The BSM model philosophy is described in AD 2. The models are identified below. Note that the single and 2 axis prototypes are not subject to PA requirements (though they may be used to exercise newly introduced PA procedures for subsequent models).

| PA REQUIREMENTS | INSTRUMENT MODELS AND GSE | | | | | |
|---|---------------------------|-------|------|------|------|------|
| | DM | QM | CQM | PFM | FS | GSE |
| PA Management | P | A | A | A | A | A |
| Material and Process Selection and Approval | P | A | P(1) | A | A | P |
| EEE Parts Selection and Control | N | P(5) | P(1) | A(2) | A(2) | P(3) |
| Cleanliness and Contamination Control | P | A | A | A | A | P(4) |
| Reliability Assurance | N | A | A | A | A | P(4) |
| Safety | N | A | A | A | A | A |
| <u>Quality Assurance</u> | | | | | | |
| Procurement Control | P(1) | P(1) | P(1) | A | A | P(3) |
| Manufacturing Control | P(5) | P | P | A | A | P(3) |
| Integration and Test Control | P(5) | P(5) | P(5) | A | A | P(3) |
| Handling, Storage, Packaging | N | P (5) | A | A | A | A |
| Non-conformance Control | P(5) | P(5) | P(5) | A | A | A |
| Alerts | | A | A | A | A | N |
| Acceptance and Delivery | | N | A | A | A | A |
| Software PA | N | N | N | N | N | N |

A = Applicable; P= Partially Applicable; N = Non-Applicable

1. Space rated parts are not required, but performance should be equivalent (e.g. Mil-Spec)
2. Applied via LAM
3. Applicable for components coming into direct contact with flight standard hardware (e.g. interfacing connectors from GSE cables).
4. Applicable to elements directly interfacing with the flight hardware, when an impact on the flight hardware is possible.
5. Applicable to all activities related to design verification

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8.5 MATERIAL AND PROCESS SELECTION AND CONTROL

8.5.1 General

Space missions experience an arduous environment, with complex interactions of components. Materials choice is critical in ensuring no degradation in the space environment. The engineering requirements of vacuum and cryogenic engineering are well known to the UK ATC. Additional risks are imposed by:

- integration bake-out procedures (thermal cycles)
- cleanliness requirements (outgassing, design for clean room compatibility)
- prolonged storage prior to launch (deterioration, stress corrosion cracking)
- launch loads (vibration, shock)
- microgravity
- radiation
- fail safe and criteria

8.5.2 Materials and Processes

Material and process controls will be implemented with respect to hazardous and forbidden materials, outgassing, strength and stress corrosion resistance on structural items. Materials that may constitute a safety hazard or can cause contamination shall not be used without prior approval from the UK-SPO.

Space missions express a strong preference for previously used materials as a method of risk mitigation. The BSM will select materials from

- the ESA approved materials list RD 12
- NASA approved materials, RD 9, RD 10

Preference will be given to materials with:

- Proven flight heritage within the SPIRE consortium,
- proven cryogenic heritage within ATC or SPIRE consortium

A Declared Materials List (DML) will be maintained as part of the design package, presented at relevant design reviews and incorporated into the ADP. See Appendix 14.

Material approval and evaluation activities will be scheduled such that they will be finalised by the Instrument Baseline Design Review (IBDR) (start of manufacturing of qualification flight hardware).

8.5.3 Selection and Approval

The following guidelines will be followed when choosing materials:

8.5.3.1 Stress Corrosion

Materials which are sensitive to stress corrosion and which are exposed to long term external (including assembly stresses) or residual internal (frequently present in welded constructions) tensile stresses in the terrestrial atmosphere shall not be used. This requirement shall also apply to GSE lifting devices for loads higher than 300N. Metals shall be selected from ESA: ECSS-Q-70-36 [RD 44] Table 1 where possible. For the listing of SCC sensitive materials MSFC-SPEC-522B [RD 45] can be regarded to be equivalent to ESA ECSS-Q-70-36 [RD 44] and for SCC testing ASTM G44-75 [RD 46] equivalent to ESA ECSS-Q-70-37 [RD 47]

8.5.3.2 Corrosion

All steps possible will be taken to minimise galvanic and surface corrosion by the correct selection of materials and surface finishes. Where electric currents flow through metallic junctions, e.g. grounding, only contacts having a compatible coupling of less than 0.5V should be chosen. Ref.: Compatible couples for Bi-metallic contacts. P50 document [RD 48] Table 7.2.1.

8.5.3.3 Outgassing

Condensable outgassing products of materials may obscure optical elements and detectors severely degrading their performance. Water vapour condensing on cold moving parts and forming ice may

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cause mechanisms to cease functioning; similarly water vapour condensing on cooled detectors can cause failure.

Materials shall have a low outgassing rate with Total Mass Loss (TML) <1% and Volatile Condensable Material (VCM) < 0.1% when tested per specification ECSS-Q-7002A [RD 37]. ASTM-E-595-84 [RD 50], ESA-PSS-01-702 [RD 44] and JSC/SPR-0022A [RD 51] may be regarded as equivalent to ECSS-Q-7002A [RD 37]. Documents ESA RD: 01 [RD 22] and NASA Ref. Publication 1124 Rev 3 Sept 1993 [RD 54] contain data from many previous outgassing tests. If the instrument is determined to be particularly susceptible to outgassing contamination the figures for TML and VCM will be reduced by the UK-SPO by a factor 10 to <0.1% and 0.01%,

NB: Volatile metals e.g. Cadmium, Zinc shall not be used.

8.5.4 Material Sources

8.5.4.1 Stockist and Specifications

Materials shall only be procured from stockists registered with the British Standards Institute or equivalent national organisation to recognised national or international specifications.

8.5.4.2 Conformance Documentation

Conformance and test documentation shall be inspected and retained by the BSM PA manager for traceability as part of the stock control system.

8.5.4.3 Contamination and Corrosion

Materials shall be examined for cleanliness and corrosion. The tolerable level will depend on the material and the possibility of cleaning. The required condition of the material on delivery will be stated in the procurement specification if critical.

8.5.5 Limited Life Materials

A register of limited life materials shall be maintained. The expiry date shall be recorded and the use of the materials shall be controlled to ensure out-of-date materials are not used in an uncontrolled manner. Out-of-date materials may be used if certain requirements are met. Appropriate tests of the material shall demonstrate that the required properties of the material have not been compromised for their intended use.

Where no date is provided an expiry date (current date + 0.5 shelf life) shall be marked on the container on incoming inspection.

8.5.6 Storage

All materials shall be held in a controlled store.

8.5.7 Processes

Previously qualified and/or approved aerospace processes and techniques shall be used in the fabrication of the BSM.

Process procedures shall include sufficient inspections and controls during and at the end of the processing steps to assure that the characteristics of the product are within the required limits. Process procedures will be documented. Any processes related to, any declared material should be identified on the DPL and cross referenced accordingly, refer to Appendix 14.

A process will be considered critical if it falls into one or more of the following categories:

- The end product cannot be assessed by final inspection and/or test alone.
- Contamination cannot be removed after completion of the process.
- Process not qualified or approved for space applications.

8.5.8 Evaluation Program

No materials or processes not previously evaluated for space or cryogenic use will be identified or specified for the BSM.

8.5.9 Alerts

ATC will participate in the ESA alert scheme via the UK-SPO.

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8.6 ELECTRONIC PARTS SELECTION AND CONTROL

8.6.1 General

The SPIRE instrument design and resulting consortium structure is such that the control electronics for the BSM are detailed for manufacture, produced and space qualified by the Laboratoire d'Astrophysique de Marseille (LAM) as part of the SMEC Mechanisms Control Unit (MCU).

The MCU includes the MAC board for the control of the mechanisms and the interface FPGAs; the analog boards for the SMECm and the BSMm and the backplane board. The MCU is integrated in the SPIRE DRCU Unit.

8.6.2 BSMe Warm Electronics Scope

In overview, ATC remain responsible for the specification and outline design of the BSM electronics (BSMe) and for integration and test of the BSMe in conjunction with LAM.

Per RD 11, LAM responsibility covers:

- The performance requirements of the SMEC subsystem (SMECm+MAC+SMEC analog board).
- the technical requirements at the MCU level
- the technical requirements at the SMECm level.
- the interface requirements MCU – DPU, MCU – DRCU, MCU – BSMm and SMECm – Structure and optics.
- development, manufacture and qualification / acceptance of the SMECm and MCU.
- implementation of the UKATC electronic functional design on the BSMm analog board in the MCU.
- implementation of the UKATC BSMm control algorithms.
- delivery of the SMECm and MCU models, their associated simulators, tools and documentation to RAL.

The ATC is responsible for

- the functional design of the BSMm analog board.
- the BSMm development, manufacturing and qualification / acceptance.
- the BSM end to end performances.
- the BSMm control algorithms.

8.6.3 BSMe cryogenic electronics scope

In addition to the BSMe WE, the BSM requires a limited set of electronics incorporated to the cold mechanism, as detailed in RD 3. Broadly, this includes a set of cryogenic actuator coils, feedback sensors; thermometry and the appropriate harness and connectors.

The BSM project participates in the SPIRE Common Parts Procurement Process described in AD 5.

NB: Connector savers will be used on all interfaces where connections are likely to be mated/demated for test/integration purposes on flight and flight spare equipment. The mate/demate log must be completed for each mate/demate. See Appendix 11 for format.

8.6.4 Parts Procurement

8.6.4.1 Parts Procurement Agency (CPPA)

The parts procurement agency will procure all of the hi-rel parts required by the programme to the project requirements, if ordered in time.

8.6.4.2 Use of Third party Facilities

The use of other contractors for hi-rel parts related activities requires the approval of ESA unless the facility is already approved by ESA.

8.6.4.3 Procurement Policy

Tecnologica are the SPIRE CPPA's. It should be noted that there is the cut off date for the common procurement programme. All purchase orders must be with CPPA by that date.

8.6.4.4 Engineering models

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For engineering models (prototype models, DM) components shall be used which are equivalent in form, fit, function and materials with the capability of operating in the thermal and vibration environment (including cleanliness) of the qualification test programme but otherwise may be of an agreed lower quality.

8.6.5 Part Selection and Approval

8.6.5.1 Prohibited Materials and Parts

No prohibited materials and parts are envisaged.

8.6.5.2 Radiation Sensitive Parts

Radiation sensitivity issues will be referred to the UK-SPO (RAL) PA manager and/or LAM for advice.

8.6.5.3 Part Derating

Components shall not be stressed to the maximum rated values established by the manufacturers but only to the de-rated values specified in ESA-PSS-01-301 [RD 52].

To implement the de-rating requirements the component operating conditions and environment shall be assessed.

Drift and degradation of performance parameters (e.g. increase of leakage currents of diodes) as specified in ESA-PSS-01-301 shall be taken into account in the design of electronic circuitry. If insufficient data are specified there, the end-of-life limits of qualification tests may be used.

8.6.5.4 Purchase orders

The following apply to purchases of EEE parts in addition to the general QA procurement requirements:

- The quantities of parts procured include needs + attrition + parts for LAT and DPA if required.
- All purchase orders shall state parts to be supplied from single manufacturing lot.
- All parts shall be delivered with a certificate of conformance and supplier's inspections and tests results (when applied).

8.6.5.5 Non qualified components.

It is envisaged that the BSMe cryogenic actuator coils and magneto-resistive position sensors will be electronic components which are not on the preferred or qualified parts list.

Selection of these components will be made through the following process:

- Selection of the best quality level available for the part,
- Definition of a test program (up-screening + LAT + DPA...) to reach the overall quality level required /for the project; in compliance with ESA SCC. ATC will request RAL and specialist advises and technical validation of the test program.
- Contact is made with the supplier to define the implementation of the tests (who, where and when), with the best cost/efficiency criteria.

Part Approval Documents (PADs) are required for all self procured parts i.e. not purchased via the CPPA (Tecnologica). A simplified PAD format is defined in Appendix 13

The PAD shall include:

- Non-repetitive PAD number/Issue/Date
- DCL Number and Issue on which parts listed
- Project/Experiment/Sub-System/Assembly
- Part number (i.e. Procurement Specification)
- Similar To Style (Generic or commonly used identification number)
- Manufacturer.
- Country of origin
- Part category.
- Part Description
- Specification (inc. Issue) and date
- Quality Level
- Number used
- Present qualification status (with reference)
- Applied screening level.

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- Extra Testing / LAT Level
- Radiation hardness data.
- Proposed evaluation programme.
- Results of preliminary evaluation, Functional Test SEM/Precap/DPA Analysis/Life Test.
- Rationale/Justification for use.
- Additional supporting comments/information.

8.6.6 Declared Component List

All components to be used on flight or flight spare hardware, shall be listed in a Declared Component List (DCL) which is to be completed stepwise as the selection of components and the approval process progresses. Formal issues are to be submitted to every Design Review, the HERSCHEL list submitted for the Instrument Baseline Design Review may be regarded as the HERSCHEL choice of components which is subject to further efforts on standardisation and co-ordination. The DCL format is shown in Appendix 14.

The final version must be available at the time of the Instrument Critical Design Review.

The DCL shall identify the instrument/experiment unit and the design status to which it is applicable. The parts shall be grouped according to the families or categories identified in the PPL and the list shall contain the following entries for each part:

- Part I/D i.e. generic or commonly used number.
- Description
- Manufacturer.
- Country of Origin.
- Specification. (Specification used to procure part)
- Quality (i.e. Screening Level).
- Notes: to include, Interface part, LAT level if appropriate, PAD reference, reference to supporting information e.g. radiation test data.

The Declared Components List with supporting information will be supplied to ESA via the UK-SPO.

8.7 CLEANLINESS AND CONTAMINATION CONTROL

8.7.1 General

A clean room is available at ATC premises, from range 5 to 6. Cleanliness, temperature and hygrometry are monitored intermittently during periods where the room is not in active use by a project.

For the BSM project, cleanliness will be checked and logged on a weekly basis. During final assembly of the delivery models cleanliness will be monitored on a daily basis.

All assembly operations on qualification and deliverable models are performed in the clean room, and where possible these models will also be integrated to the ATC test dewar within the clean room (space and safety constraints permitting). The ATC clean room procedures are listed in Appendix 9.

In addition to clean room practice, the adjacent laboratory and all SPIRE BSM related equipment will be operated in a best practice manner, including:

- minimisation of dirt ingress to laboratory
- covering of exposed components
- surfaces to be cleaned or covered with lint-free material prior to placing components on them
- routine use of gloves when handling all cryogenic equipment

8.7.2 Particulate contamination

The BSM will be built in a controlled class 6 clean room. Work on the BSM where possible will be done in the laminar flow cabinet. When the BSM is being stored it will be kept in a bell jar backfilled with dry nitrogen. There is a 0.3um filter on the N2 line to ensure it is clean. Particle checks will be performed in the cleanroom and at the laminar flow bench on a daily basis.

A log of the location of the BSM will be kept during its build and test enabling an account of contamination to be assessed.

During the test phase, including warm test the BSM will be kept under vacuum in the cryostat. Where this is not possible the tests will be performed in the cleanroom. The BSM will be installed in the cryostat in the cleanroom and should therefore never be exposed to the general uncontrolled lab area.

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Face masks, gloves and cleanroom garments will be worn at when handling the BSM.

8.7.3 Molecular contamination

See above section 5.7.2

8.8 SOFTWARE PRODUCT ASSURANCE

8.8.1 General

The BSM is controlled by a combination of spacecraft software and programmable electronics incorporated in the DRCU. Supporting test software is also developed for use with BSM model testing at the ATC.

8.8.2 FPGA specification

N/A

8.8.3 GSE & Test software

DSPACE will be used to control the BSM during tests at the ATC. A Labview program will be use to record the position of the BSM from the TMA via an RS 232 link. Labview can also be used to record voltages via a DAQ card if required.

8.9 RELIABILITY ASSURANCE

8.9.1 General

Product reliability is built in through design and manufacture and verified against the specification by test. Reliability assurance activities will:

- verify compliance with the above
- increase reliability and safety by identifying and/or eliminating failure modes
- provide useful input to the instrument operating manual in the identification and recovery action for non-nominal conditions
- identify hazardous conditions required to be notified in the UK-SPO hazard analysis reporting system.

8.9.2 Reliability Block Diagram

The Reliability Block Diagram (RBD) differs from an assembly drawing or bill of materials in identifying the functional performance tree and indicating redundant or fallback modes.

An RBD will be created for the BSM, and placed under configuration control. It will clearly cross reference the design and specification state at which it is performed.

8.9.3 Single Point Failures

Single Point Failures (SPF) identified in the RBD will be clearly reported via the BSM Design Description [AD 2] and BSM Development Plan [AD 3].

8.9.4 FMEA/FMECA

Failure Mode and Effects Analysis (FMEA) is a systematic study of the potential failure modes of a system. The technique assists in identifying failure behaviour which might lead to loss of functionality or equipment FMEA may be extended to cover criticality of effects on the system. Where full data exists (typically for electronic parts) this analysis may be extended numerically.

A Failure Modes Effects And Criticality Analysis (FMECA) shall be prepared on all functional elements of the BSM including electronic circuits (but excluding structural elements whose integrity will be assessed with stress analysis and fracture mechanics analysis as necessary) which can cause failure effects within the subsystem or damage to or interfere with, the proper functioning of the instrument or spacecraft

Interfacing elements of GSE supplied with the instrument shall also be evaluated to demonstrate that single point failures in the GSE cannot damage or degrade the instrument or the spacecraft.

Each failure effect identified will be given a criticality category according to the definition below:

| | | | |
|--|-----------------------|--|--|
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Category 1: The failure effect is not confined to the instrument. When this failure results also in loss or degradation of the instruments function this shall be stated.

Category 2: The failure results in loss or degradation of the instruments function but the effect is confined to the instrument.

Category 3: Minor internal instrument failures [confined to the subsystem].

The following attributes shall be added to the criticality category as appropriate:

- "R", if the design contains a redundant item which can perform the same function
- "SH", if the failure effect causes a safety hazard
- "SPF" if the failure is caused by a single point failure.

The following failure modes shall be considered as a minimum:

- Premature operation
- Failure to operate (at the prescribed time)
- Failure to cease operation (at the prescribed time)
- Failure during operation
- Degradation or out of tolerance operation
- For failure at component level e.g. hardware interface
 - short circuit, open circuit, incorrect function e.g. out of range value from sensor
 - Incorrect commands or sequence of commands
 - Incorrect software functions

Design specifications, descriptions functional diagrams etc. used in the preparation of the FMEA/FMECA shall be attached or referenced.

RD 15 shall be used for guidance and presentation of FMEA/FMECA results.

8.9.5 Cumulative Operating Time

The BSM mechanism and electronics are subject to repeated cycles of use both on the ground and in orbit. Cumulative operating time on the ground must be carefully monitored to ensure that component life is not exceeded.

The design life of these components will be in accordance with RD 6, RD 53 and incorporates an element of on-orbit life and ground test life each with appropriate margins applied. The design is verified by analysis, by Qualification Model life tests and by component tests at the manufacturer, where specified.

A list of life sensitive components will be compiled, and maintained as part of the Critical Items List (CIL) described in the Critical Items Identification and Control section of this document. A log of all tests that impact the life sensitive components will be maintained to indicate the number of tests and the mechanism environment. This log will be supplied with the ADP and maintained thereafter during the AIV program by the SPIRE Project Office.

8.9.6 Environmental Assurance

The survival of the hardware to the environment before reaching operational conditions and the performance of the hardware in the operational environmental conditions will be verified as described in the Development plan [AD2].

8.9.7 Environmental Testing

Environmental testing will include bake-out, cryogenic cooldown, warm vibration, cold vibration, thermal interface tests. The test programme is described in AD 2.

8.9.8 Critical Items Identification and Control

A critical items list (CIL) shall be prepared as a summary of data from different sources to ensure critical items are highlighted and recognised at the next higher level. See Appendix 14 for format. The list will be derived mainly from the following sources:

- Single point failures
- Limited life items
- Hazardous items of categories catastrophic and critical

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- Critical technologies
- Other critical items e.g. vulnerable items

NB. Items which are equivalent to FMECA category 1, and need special attention and treatment will be categorised MAJOR. All others are minor.

8.10 INTEGRATION AND TEST CONTROL

8.10.1 Assembly, Integration and Test

8.10.2 Test Procedures

Test procedures will be documented.

8.10.3 Test Witnessing

Where required, tests will be witnessed by a representative of the SPIRE PI or UK-SPO.

8.10.4 Test Reports

Test results will be documented. Where appropriate they will be issued as reports.

8.10.5 Fault Logging

During test phases of the development plan, the option is open to use the ATC Fault Logging system, Appendix 6 rather than to raise an NCR.

This will be used to log test events to facilitate diagnosis, particularly for recurrent problems (e.g. software reboots, test dewar warm-ups). The fault logs, where used, will be reviewed on an approximately monthly basis and where applicable an NCR will be raised.

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8.10.6 Historical Record (Logbook)

Equipment logbooks shall be established for all operations and tests starting with the final inspection of the hardware after the manufacturing / assembly phase and they shall include:

- historical record sheets (an index to the diary of events Appendix **14.6**);
- with:
 - dates of operation / test / transport
 - name of operation / test / transport from / to
 - applicable procedure and / or report
 - responsible organisation and signature for entry
 - remarks e.g. on NCR's or unplanned events
- Diary
- chronological logbook for recording the details and progress or otherwise of all activities shall form the major part of the logbook. The pages shall be numbered and referenced by the history record. The diary shall be used freely and include comments on operations as they take place.
- When future action is required a note of the action shall be made in the diary and flagged for easy identification:
 - Connector Mate / Demate Log
 - Every mate or demate of a flight or flight spare connector shall be logged by the operator responsible for the current activity to ensure the number of these operations is restricted - connector savers shall be used wherever possible. Inspections of the connectors will be carried out at regular intervals as defined on the mate - demate log: (Appendix **11**):
 - operating time/cycle record for limited life items
 - age sensitive items records
 - temporary installations record
 - open work/deferred work records.

The log books shall accompany the hardware whenever it is placed under the custody of another organisation and this organisation shall update and maintain these records. The log book will be available if required as part of the ADP.

8.10.7 Handling, Storage, Packaging, Marking and Labelling, Transportation

Mechanical ground support equipment will be provided for lifting and manipulating the instrument as required during integration and testing. When components and sub-systems are handled appropriate precautions will be taken to prevent contamination or damage.

Handling requirements will be clearly displayed on all equipment and packaging and detailed in the ADP.

ATC will implement a controlled storage of parts, per AD 4 "Each operational group in the consortium will operate a controlled store for parts and assemblies to be used on flight, flight spare and qualification equipment." The storage location comprises lockable storage cabinets (keys held by nominated BSM project team members) within a secure laboratory (keys held by nominated ATC staff).

When the instrument, sub-assemblies or associated units are to be stored or transported they will be placed in air-tight bags, or air-tight transit containers, which will act as a moisture barrier. When contamination sensitive items are bagged they will be flushed with dry nitrogen. An additional or outer bag will be used when transporting items and that bag will not enter controlled clean areas. Desiccant and humidity indicators will be placed between the inner and outer bags.

All packaged or bagged items will be clearly marked or labelled to identify the item and specify the environment and conditions required when the package is opened.

Transport containers will be used to protect the equipment and its packaging in transit and where necessary arrangements will be made for purging and flushing the equipment with clean, dry nitrogen. Containers will be fitted with castors, shock absorbers, lifting attachments, etc as necessary to facilitate transportation and prevent damage.

| | | |
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As necessary recording equipment will be employed during storage and transit to record temperature and humidity fluctuations, vibration, shock, etc, the resultant records will for part of the equipment log book.

8.11 ACCEPTANCE AND DELIVERY

8.11.1 Development plan delivery flow

The BSM development plan [AD 2] outlines the flow of deliverables.

All BSM deliverable models are integrated with an equivalent PCAL model.

For the deliverable BSM models (except the STM), the BSMm is accepted and tested at the UK ATC before delivery to LAM. It is then integrated with the BSMe and undergoes final acceptance testing before delivery to RAL for integration to SPIRE.

8.11.2 Acceptance and Delivery Process

Upon completion of final tests and inspection and before shipment of a deliverable item to LAM or RAL a review will be held covering all deliverable documentation, hardware and software items. The object of this Acceptance Review is to establish that there is adequate documentary evidence to demonstrate that the product satisfies all the requirements applicable at that stage. The Acceptance Review Board (ARB) shall compose of the following members or nominated representatives

- ATC Project Manager
- ATC PA manager
- ATC Project Scientist
- Representatives of the SPIRE project team
- Additional staff as required.

The ARB shall cover the following points under the headings:

- Acceptance Data Package
- Hardware, including GSE
- Software, where applicable

8.11.3 Acceptance Data Package

The acceptance data pack (ADP) forms the primary deliverable document to accompany each model. The STM, CQM, PFM and FSM will be delivered with an ADP. The QM ADP will be maintained at ATC but is not deliverable.

The PFM ADP will contain the items below.

| ADP Section | Contents | Required | Comments |
|-------------|---|-----------------|--|
| 1 | Shipping Documents | Yes | |
| 2 | Procedures for Transport Handling & Installation | Yes | |
| 3 | Certificate of Conformance/Delivery Review board MOM AI Lists | Yes | |
| 4 | Qualification Status/Test Matrix | Yes | |
| 5 | Top Level Drawings incl. Family Tree | Yes | |
| 6 | Interface Drawings | Yes | |
| 7 | Functional Diagrams (Block Diagram) | Yes | |
| 8 | Electrical Circuit Diagrams | Yes | Flight circuitry from LAM |
| 9 | As built configuration lists | Yes | Incl. drawing numbers & issues, mod sheets and manufacturing NCR's |
| 10 | Serialised Components List | Yes | Electronics as part of LAM ADP. Mechanical per ATC serial number logbook |
| 11 | List of Waivers | Yes | |
| 12 | Copies of Waivers | Yes | |
| 13 | Operation Manual | Yes | Liaison with LAM required, operation via MAC |
| 14 | Historical Record | Yes | Linear log of assembly & test activities |
| 15 | Logbook/Diary of Events | Not deliverable | Available as required, but not delivered |
| 16 | Operating Time/Cycle Record | Yes | |
| 17 | Connector Mating Record | Yes | Includes connector savers |
| 18 | Not used | N/A | |
| 19 | Test Record | Yes | |
| 20 | Calibration Data record | Yes | |
| 21 | Temporary Installation Record | Yes | Shipping locks, Red Tag (remove before flight), Green Tag (insert before flight) Items |
| 22 | Open Work / Deferred Work / Open Tests | Yes | Expected on STM, CQM, QM |
| 23 | List of Non-Conformance reports (NCR's) | Yes | |
| 24 | Copies of Non-Conformance reports (NCR's) | Yes | Includes manufacturing NCR's and fault logs |
| 25 | Test Reports | Yes | |
| 26 | Not used | N/A | |
| 28 | Mass records / Power Budgets | Yes | Or Ref. to ADP section 6 |
| 29 | Cleanliness Statement | Yes | |
| 30 | Compliance Matrix | Yes | |
| 31 | Photographs | Yes | Or Ref. to ADP section 13 |

| | | |
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8.11.4 Post Delivery Operations

ATC staff will support integration at LAM and the AIV programme at RAL, either remotely whilst based at ATC or at the local site.

Where applicable, ATC staff will follow PA procedures at the host site. Where relevant, a record of work performed will in addition be recorded within the ATC PA framework.

| | | |
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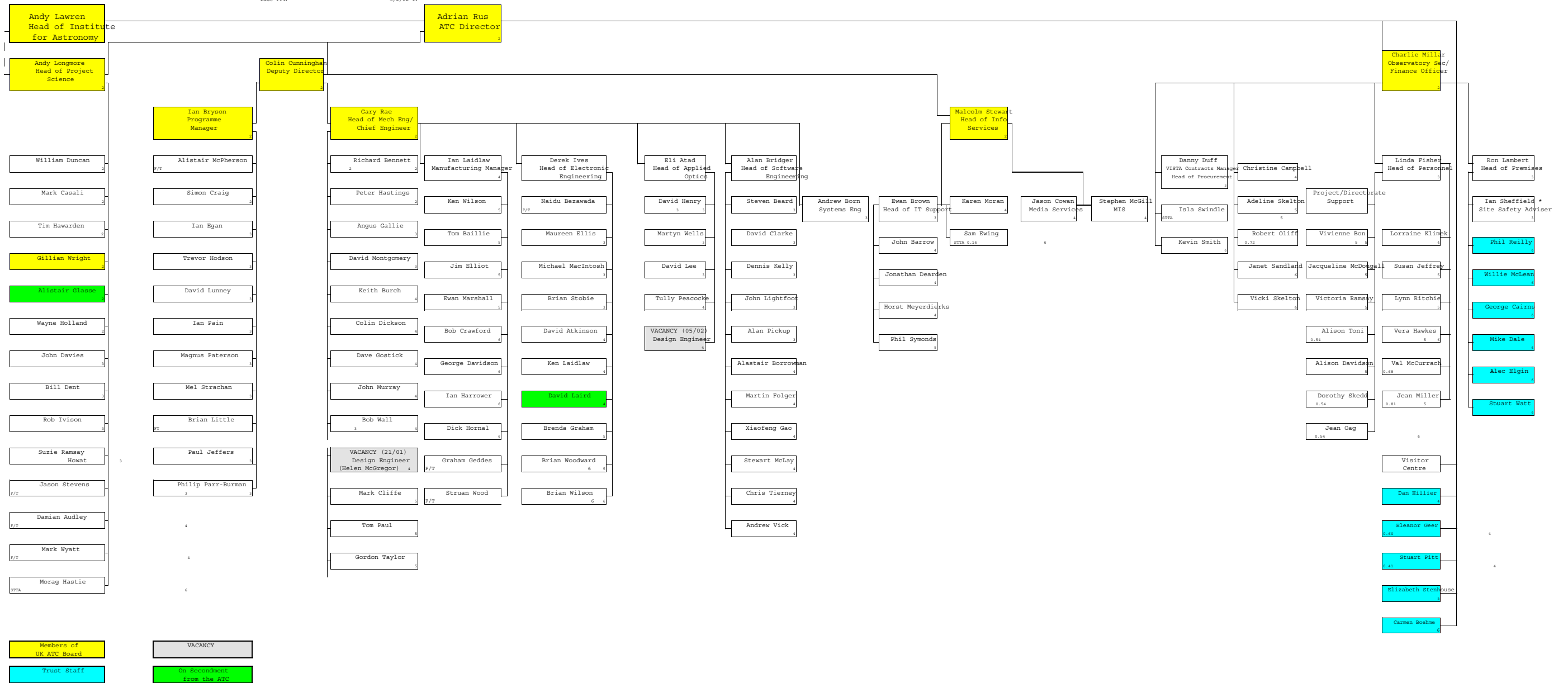
1 UK ATC ORGANOGRAM

n:\personnel\123\staff\orgLive.xls UK ATC - AS AT 30 April 2002

Last Pri:

5/2/02 11

Sheet1



V = VISTA
F/T = Fixed Term
STTA = Short-Term Temporary Appointment
TP = Temporary Promotion

SUMMARY TABLE OF STAFF IN POST AS AT 30/04/2002

| Bands | ATC @ ROE | TRUST | On SLWOP | ON SEC TO ATC | ON SEC FROM ATC | AGENCY | Bands | Ind | F/T | STTA | Trust | On SLWOP | On SEC to ATC | On SEC from ATC | Agency | Total | Vacancies |
|--------------|---------------|---------------------|-------------|---------------|-----------------|-------------|--------------|---------------|-------------|-------------|--------------|-------------|---------------|-----------------|-------------|---------------|--------------------|
| 1 | 0.00 | | | | | | 1 | | | | | | | | | 0.00 | |
| 2 | 19.00 | | | | | 1.00 | 2 | 18.00 | 1.00 | | | | | | 0.00 | 20.00 | 0.00 |
| 3 | 34.00 | | | | | 0.00 | 3 | 31.00 | 3.00 | | | | | | 1.00 | 34.00 | 0.00 |
| 4 | 25.00 | 2.01 | | | | 1.00 | 4 | 23.00 | 2.00 | | 2.01 | | | 1.00 | 28.01 | 2.00 | |
| 5 | 19.80 | 1.00 | | | | | 5 | 18.80 | 0.00 | 1.00 | 1.00 | | | | 20.80 | 0.00 | |
| 6 | 14.19 | 7.00 | | | | | 6 | 10.03 | 2.00 | 2.16 | 7.00 | | | | 21.19 | 0.00 | |
| 7 | 0.00 | | | | | | 7 | 0.00 | | | | | | | 0.00 | 0.00 | |
| Total | 111.99 | 10.01 | 0.00 | 0.00 | 2.00 | 0.00 | Total | 100.83 | 8.00 | 3.16 | 10.01 | 0.00 | 0.00 | 2.00 | 0.00 | 124.00 | 2.00 |
| Total | 124.00 | 4 (Visitors) | | | | | | | | | | | | | | 124.00 | Check Total |
| Total | 128.00 | | | | | | | | | | | | | | | | |

Last Updated 2-May-02

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2 PROCUREMENT CONTROL PROCEDURE

UK ATC PURCHASING PROCEDURES

Small Value Orders (CD2)

1. An order requisition (CD2) must be filled in with supplier name, description of goods, quantity & price, T2 budget code, demanding officer and authorising signature for the relevant budget.
2. It is the demanding officer's responsibility to source the supplier, price and delivery of the requested goods and any preference for the purchase order being telephoned, faxed or sent by post to the supplier. It is essential that the demanding officer informs purchasing that the company is being used for the first time and gives all address details.
3. The (CD2) can either be filled in, in ink or [electronically](#).
4. If the demanding officer doesn't have signing authority on the relevant T2 budget code then the (CD2) must be passed or e-mailed to the appropriate person for authorisation. The budget holder, if other than the demanding officer, is responsible for passing or e-mailing the (CD2) to purchasing in the finance office for processing. If the supplier has issued a quotation attach this to the (CD2).
5. The purchase order will then be processed timeously. The green and yellow copy of the purchase order is returned to the demanding officer.
6. If there is any communication between the supplier and the demanding officer or purchasing, concerning any matters relevant to the order this should be passed on immediately e.g. change in delivery date, availability etc. It is the responsibility of purchasing to follow up late deliveries and pass on this information.
7. When the goods arrive it is essential that the demanding officer checks the delivery. The green copy should be signed, dated and returned without delay to the finance office. If a part order is received then the green should be photocopied, signed dated with the quantity received indicated and passed immediately to the finance office. The green is signed, dated and passed to the finance office when the whole order has been received. The yellow copy is retained by the demanding officer.

Tenders (CD1)

A (CD1) form must be filled in for orders £2000 or more excluding vat. This form is available from the finance office. All contracts are placed under PPARC standard terms & conditions.

(a) Multi Tenders

1. The (CD1) should be filled in by the demanding officer with a description of the required goods along with at least three company names, addresses, telephone number, contact name and the date the invitations to tender are due back. The form needs to be signed by the relevant budget holder. Any documentation that the companies require to enable them to tender should be included, and a copy for the contract file.
2. The invitations to tender responses from companies come back to the finance office and are all opened at 12 noon on the appropriate date. The demanding officer will then receive the file containing all documentation. It is PPARC policy to accept the lowest tender unless it can be shown otherwise.
3. The purchase order will then be issued per the conditions on the tender and the green and yellow returned to the demanding officer. All correspondence in relation to the tender must go through the finance office. It is the responsibility of purchasing to follow up on delivery date.
4. When the goods arrive and after checking the green should be signed, dated and sent immediately to the finance office by the demanding officer.

(b) Simplified Method

1. If the goods are "off the shelf items" but over the tender limit then it is possible to source three price quotations from companies and fill in the (CD1). The budget holder must authorise and pass all quotes with the (CD1) to purchasing for processing. It is PPARC policy to accept the lowest quotation.

| | | |
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2. The purchase order will be issued under PPARC terms and conditions with reference to the quotation number, price and delivery. The green and yellow copy is sent to the demanding officer. All correspondence in relation to the tender must go through the finance office. It is the responsibility of purchasing to follow up on delivery date.
3. When the goods arrive and after checking the green should be signed, dated and sent immediately to the finance office by the demanding officer.

(c) Single Tenders

1. In some cases there is only one company that can supply the requested goods. If this is so then the reverse side of the (CD1) should be completed with reasons for single tender action and authorised by the budget holder before passing to purchasing for processing along with any quotation.
2. The invitation to tender documentation will be sent to the company for them to complete.
3. When this is received back the purchase order will be issued under PPARC terms and conditions with reference to the information on the tender documents. The green and yellow copies will be sent to the demanding officer. All correspondence in relation to the tender must go through the finance office. It is the responsibility of purchasing to follow up on delivery date.
4. When the goods arrive and after checking the green should be signed, dated and sent immediately to the finance office by the demanding officer.

Procedure written by:

Adeline Skelton


Senior Finance Assistant

12th June 2000

3 UK ATC WORKSHOP PROCEDURES

3.1 Effort Request document.

The entry screen for a typical workshop request (in this case a SPIRE prototype part) is shown. The entry form and workshop database are accessed from the URL: <http://saturn.roe.ac.uk/workshopdb/>



Edit Record's Details

| | |
|---------------------------|---|
| Ref no.: | <input type="text" value="10086"/> |
| Drg No.: | <input type="text" value="01a24a"/> |
| Description: | <input type="text" value="Structure Assy machining"/> |
| Project: | <input type="text" value="115 Spire"/> |
| Module: | <input type="text" value="11510 Beam Steering Mirror"/> |
| Issue: | <input type="text" value="A"/> |
| Work Detail: | <input type="text" value="machine 9.5mm bores"/> |
| Priority: | <input type="text" value="1"/> |
| Quantity: | <input type="text" value="1"/> |
| Make Time hrs (est): | <input type="text" value="8"/> |
| Required Date (dd/mm/yy): | <input type="text" value="06/07/01"/> |
| Status: | <input type="text" value="INW"/> |

The database is accessible on a read only basis to all ATC users, and on a password restricted basis to Workshop staff for entry of records.

3.3 Manufacturing and Assembly Control (Inspection Forms)

| ASSEMBLY / INTEGRATION TEST LOG | | | | |
|---------------------------------|----------|------|-------------|------|
| PROJECT: | | | PAGE: | |
| UNIT: | | | | |
| ITEM: | | | DRAWING NO: | |
| SERIAL NO: | | | | |
| DATE | ACTIVITY | NAME | SIGNATURE | Q.A. |
| | | | | |



Herschel

SPIRE

**Herschel SPIRE Beam Steering Mirror
Product Assurance Plan**

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ASSEMBLY / INTEGRATION / TEST RECORD

| PROJECT | | PAGE: |
|----------------|-----------------|------------------|
| DATE | ACTIVITY | SIGNATURE |
| | | |

| | | |
|---|--|--|
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|---|--|--|

4 CALIBRATION OF MEASURING, INSPECTION AND TEST EQUIPMENT

All measuring, inspection and test equipment will be calibrated either by sending them to a calibration house or by verifying with a known calibrated source. All calibration records will be kept.

For SPIRE BSM models, measurement equipment used will be noted in inspection records, and a note made to confirm that the equipment was in valid calibration at the time of the test.

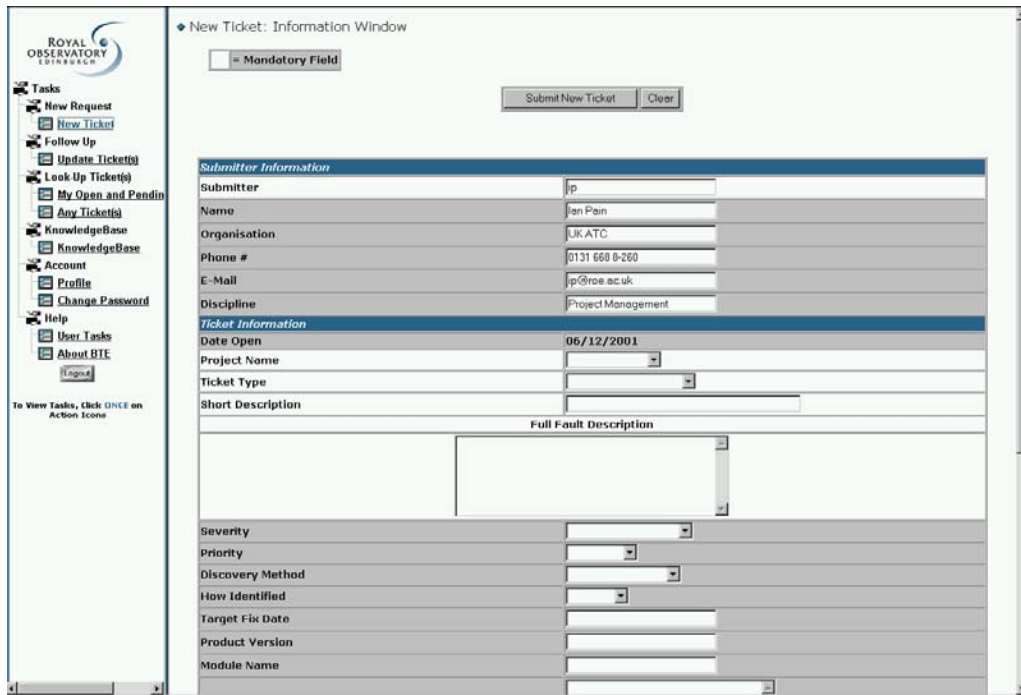
5 NON CONFORMANCE REPORTING SYSTEM

- The ATC will utilise the Q-PULSE documentation control software application to raise, record, track and manage NCR's.
- Q-Pulse has a dedicated NCR module, and example form is shown below.
- The following fields are completed as a minimum:
- NCR number (assigned automatically)
- NCR description. The NCR should cover a single item, enabling close-out of the NCR. The description to identify component part, build and drawing number, serial number and defect found
- selected from pull down menus.
- Source,
- Project,
- Department/Supplier,
- Name of person raising NCR,
- Name of person responsible for CA (corrective action),
- Cause/reason ,
- Severity, status,
- Corrective action is identified at a n NCR review Panel and the CA fields completed, including :
 - Corrective action description
 - Person responsible for CA
- Supporting actions may be identified - these also have a person responsible assigned.
- Preventative actions (PA) may also be identified, with named persons
- upon completion of CA, PA, SA
- CA completion date
- Closure of CA and amendment of NCR status to closed
- Note - All supporting, preventative actions must be closed before a CA may be marked as complete.
- A number of reports are available from Q-Pulse to flag outstanding actions by person, etc. These tools are used by the BSM PA manager to assist in tracking of progress and close-out of NCRs

6 ATC FAULT LOGGING SYSTEM

The ATC uses a fault logging system available site-wide at <http://helpdesk.roe.ac.uk/scripts/bugup.exe>.

The following screenshots indicate the fault logging tool's functionality.



New Ticket: Information Window

Mandatory Field

Submit New Ticket Clear

Submitter Information

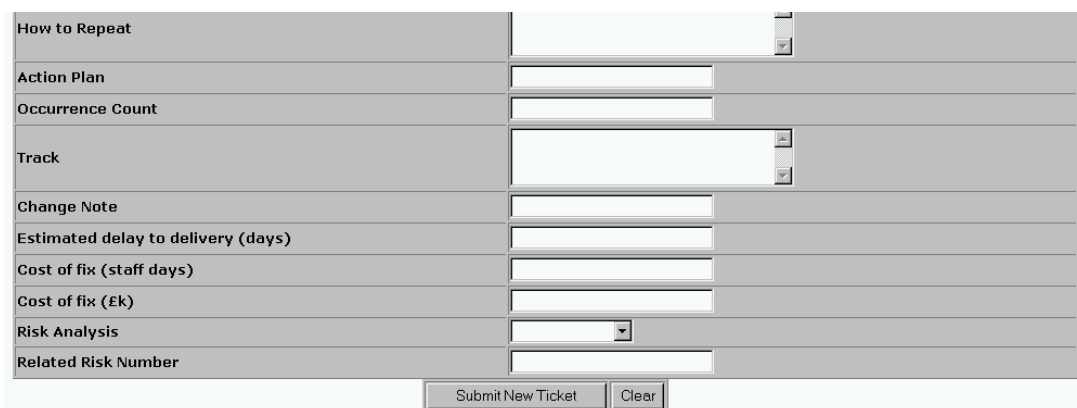
| | |
|--------------|--------------------|
| Submitter | jp |
| Name | Jan Pain |
| Organisation | UK ATC |
| Phone # | 0131 660 8-260 |
| E-Mail | jp@roe.ac.uk |
| Discipline | Project Management |

Ticket Information

| | |
|------------------------|------------|
| Date Open | 06/12/2001 |
| Project Name | |
| Ticket Type | |
| Short Description | |
| Full Fault Description | |

Severity: []
Priority: []
Discovery Method: []
How Identified: []
Target Fix Date: []
Product Version: []
Module Name: []

Figure 3 : Fault logging entry screen 1/2



| | |
|------------------------------------|-----|
| How to Repeat | [] |
| Action Plan | [] |
| Occurrence Count | [] |
| Track | [] |
| Change Note | [] |
| Estimated delay to delivery (days) | [] |
| Cost of fix (staff days) | [] |
| Cost of fix (£k) | [] |
| Risk Analysis | [] |
| Related Risk Number | [] |

Submit New Ticket Clear

Figure 4 : Fault logging entry screen 2/2

| | | | |
|--|-----------------------|--|--|
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|--|-----------------------|--|--|

7 DOCUMENT CONTROL

- The ATC uses a document management system available site wide.

Document entry into the database is restricted to ensure control of the data. In addition to system administrators, only the Project Assistant and project manager can add or edit entries in the document database.

Documents are numbered per **RD 55**

Procedure:

1. Project staff passes a document to the project assistant, or indicates the document location for items on the server.
2. The title, document type and author must be clear, and are confirmed before entry
3. The document is entered into Q-Pulse and a unique number assigned automatically
4. The master document is held by Q-pulse and when accessed via Q-pulse only a temporary file is available.
5. The master document is stored automatically on H:\SPIRE\documents

8 CAE/DRAWING CONTROL

The ATC drawings are help on our product data management system called Intralink. Entry and changes to drawings in the system is restricted to the project draftsman.

Procedure

1. Change request is raised detailing the reasons for the change, refer to section 12.
2. Approval given for the change either directly or from discussion at weekly meeting.
3. Drawing or part updated within Intralink
4. Drawing is up-issued and distributed, with the old version being removed from the drawing packs.
5. CTD/NCR closed off

9 CLEAN ROOM PROCEDURES

NOTE: ONLY PERSONNEL AUTHORISED BY HEAD OF ELECTRONICS MAY ENTER THE CLEAN ROOM.

Before entering the clean room select the appropriate size garments from one of the lockers in the changing (grey) area. Each locker contains one complete set and is labelled with that set's size and number. The garments must then be donned in the following order;

1. Hood. Ensure that all of your hair is tucked into the hood.
2. Coverall. Prevent coverall from touching the floor as much as possible. Ensure that the hood is tucked into the coverall and it is zipped up.
3. Overboots. Ensure that the coverall trousers are tucked into the overboots.
4. Mask. Ensure that your mouth and nose is covered, preventing contamination when breathing.
5. Gloves. Ensure that the coverall cuffs are tucked into the gloves.

As you enter the clean room ensure that you step (with both feet) onto the tacky mat to remove any dirt from your feet that may be picked up in the changing area.

Note the date and your purpose for using the clean room in the log on the bench.

| | | |
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When leaving the clean room the garments must be removed in the opposite order from above and placed in the same locker that they were taken from. You can then use this set for the remainder of the week.

The dirty garments will be collected on Monday afternoon ready for uplift by Microclean, who will deliver clean garments from the previous week on the Tuesday morning. These will then be placed in the lockers.

When working in the clean room always be aware of actions that may cause particles such as cutting. Think carefully before taking anything in to the clean room

If there are any problems with the area, consumables, garments contact Brenda Graham.

| CLEANLINESS CERTIFICATE |
|--|
| Use one sheet for each item of hardware (box, harness and MLI) |
| UNIT IDENTIFICATION (Instrument Box Name and Model) |
| HARNES BAKEOUT CONDITIONS AND TIME |
| MLI BAKEOUT CONDITIONS AND TIME |
| SUPPLIER |
| MATERIALS LIST REFERENCE |
| THERMAL VACUUM/BALANCE TEST DATES AND REPORT NUMBER |
| QCM AND REGA NUMBER |
| RESULTS OF WITNESS PLATE MEASUREMENTS FROM TV TEST |
| RESULTS OF WIPES FROM TV TEST (Wipe Positions and Data) |
| RESULTS OF WIPES AT ACCEPTANCE (Wipe Positions and Data) |
| PARTICLE CLEANLINESS (Positions and Data, e.g. Tape Lift) |
| CERTIFIED (PI Representative) AND DATE OF ACCEPTANCE |

10 REQUEST FOR WAIVER OR SPECIFICATION CHANGE

| PROJECT: | | Request for Waiver/Deviation | | |
|---|--------------------------|--------------------------------|---------------------|---------------------------|
| [1] Title (Max 25 Spaces): | | RFW-Nr. | | |
| | | Issue/Rev.: | | |
| | | Date: | Page | of |
| | | Related NCR (if any) | | |
| [2] End Item(s) affected (hardware, software): | | | | |
| Name | | CI-Number | | Model(s) |
| | | | | |
| [3] Requirement/Interface Documents affected: | | | | |
| Specification/Drawing Title | Number | Issue | Date | Appl. Paragr. |
| | | | | |
| [4] Description of Deviation/Discrepancy/Non-Conformance: | | | | |
| [5] Other Items or Requirements (potentially) Affected | | | | |
| [6] Need for RFW and Rationale for Acceptance: | | | | |
| [7] Originator: | | Sign: | Attachments | |
| | | Date: | | |
| [8] Approvals: | | | | |
| | Engineering Name/Date | Product Assurance Name/Date | | CCB Chairman Name/Date |
| Prin. Investigator | [] Appr [] Rej | [] Appr [] Rej | [] Appr [] Rej | [] Appr [] Rej |
| Co-Investigator | [] Appr [] Rej | [] Appr [] Rej | [] Appr [] Rej | [] Appr [] Rej |
| | [] Appr [] Rej | [] Appr [] Rej | [] Appr [] Rej | [] Appr [] Rej |
| Prime Contractor | [] Appr [] Rej | [] Appr [] Rej | [] Appr [] Rej | [] Appr [] Rej |
| ESA Project Office | [] Appr [] Rej | [] Appr [] Rej | [] Appr [] Rej | [] Appr [] Rej |

11 MATE/DE-MATE LOG

| CONNECTOR MATE / DEMATE LOG | | | | | | | | | |
|---|-------------|-----------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|
| PROJECT | | | | | EXPERIMENT | | | | |
| S / SYSTEM | | | UNIT | | | IDENT NO. | | | |
| ID | | ID | | ID | | ID | | ID | |
| Mate Date | Demate Date | Mate Date | Demate Date | Mate Date | Demate Date | Mate Date | Demate Date | Mate Date | Demate Date |
| AFTER 5 CYCLES CARRY OUT VISUAL INSPECTION (RECORD RESULT BELOW) | | | | | | | | | |
| CONNECT I/D | DEBRIS | BENT PINS | REMARKS | PASS | FAIL | SIGNATURE | | | |
| | | | | | | | | | |
| Mate Date | Demate Date | Mate Date | Demate Date | Mate Date | Demate Date | Mate Date | Demate Date | Mate Date | Demate Date |
| AFTER 10 CYCLES VISUAL INSPECTION WITH MAGNIFICATION (RECORD RESULTS BELOW) | | | | | | | | | |
| CONNECT I/D | DEBRIS | BENT PINS | PIN HTS | REMARKS | PASS | FAIL | SIGNATURE | | |
| | | | | | | | | | |
| NB: IN CASE OF FAILURE AN NCR IS REQUIRED, INFORM PA Manager | | | | | | | | | |

| | | |
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12 CHANGE REQUEST PROCEDURE AND FORMS

The SPIRE Change to Document (CTD) procedure is noted below, it is based on the ATC procedures with SPIRE specific additions. The system is essentially paper based, using books of pink CTD pro-formas and white carbonless copies.

- The Project Master CTD Folder is held by the Project Assistant and consists of three sections:-
 1. The Register – which enables one to see the overall state of CTD's and outstanding CTD's in the system. An access database is used for this purpose.
 2. List of CTD's to be actioned, with description of contents.
 3. Original pink copies of CTD's actioned and signed off.

12.1 CTD System procedure:-

- A CTD may be raised by any member of the SPIRE BSM project team or ATC staff member. CTD's will not only be used for drawings, but will also be raised for changes required to such items as specifications and documents.
- Each CTD request will be reviewed by the Project Manager and at least one project engineer. The change request will be actioned appropriately, including:
 - actioned as described
 - actioned with modifications
 - held for review at a later stage (for example where the CTD request addresses a model yet to be designed fully)
 - rejected, with reasons
- The completed pink request will be passed to the project assistant, who will input the details into the tracking database and then forward the pink to the person actioned. The project assistant may chase CTD's when they have been outstanding for a reasonable length of time, and more usually, prior to monthly Product Assurance Project Meeting. When work is complete it will be signed off on the pink by both the person actioned and a counter-signature, usually that of the Project Manager, the pink copy is then returned to the project assistant for filing in the Master CTD Folder. (The white copy in the book is the safety net in case the pink gets lost.)
- When a CTD is raised, the initiator/person responsible for that module/area of change usually actions the CTD there and then. This should be encouraged as it keeps outstanding paperwork to a minimum, but does not preclude the requirement to review the CTD as noted above.
- If the CTD cannot/does not require to be actioned immediately, the change should be made very explicit. i.e. attaching marked up drawings/documents if required. It should then be placed in the CTD Master Folder along with any actioned CTD's in the appropriate section and the Register filled in.
- When the Drawing/Documentation is updated, it will be re-issued with the next issue letter/number and the relevant modification area filled in together with the CTD no.

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| | | | | |
|-----------------------------------|--------------|--------------------------|-------|-----|
| Change to drawing/document | | Project | Book | No. |
| To : | Originator : | Date : | | |
| Drawing/document numbers | Issue | Drawing/document numbers | Issue | |

Description of and reason for change :

Action taken :

Certified :

Date :

Figure 5: Sample ATC CTD document

13 PAD SHEET

| PART APPROVAL DOCUMENT (PAD) | |
|---|--|
| Spacecraft / Project: | PAD No.: |
| System / Experiment: | Issue No.: Date : |
| Sub-System: | Ref. DCL No.: |
| Assembly: | DCL Issue No.: |
| | Sheet...1.... of |
| Part Number : | Similar to style : |
| Manufacturer : | Country of Origin : |
| Part Category : | |
| Description : | No. Used : |
| Specification : | Date: |
| Quality Level : | |
| Present Qualification Status | |
| Applied Screening Level: | |
| Extra Testing / LAT Level: | |
| Radiation Hardness: | |
| Total Dose in kilorads: | |
| Project Required Level : |) |
| Fails to Meet Specification at : | : |
| Functional Failure at : | : |
| SEU : | |
| Latch Up : | |
| Source Reference /. | |

| | | |
|---|--|--|
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14 DECLARED LISTS

The following are blank ATC formats for:

- Critical Items List (CIL) & Single Point Failures (SPF)
- Declared Components List (DCL)
- Declared Materials List (DML)
- Declared Processes List (DPL)
- FMECA format
- Integration and Test Logs



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14.1 Critical Items List (CIL) & Single Point Failures (SPF)

| CRITICAL ITEMS AND SINGLE POINT FAILURE LIST | | | | ORIGINATOR: | | |
|--|--------------------------|--|--|--------------------|--|----------------|
| EQUIPMENT / INSTRUMENT: | | Subsystem / System: | | Doc. Number: | | |
| Operating Mode: | | Operating / Mission Phase: | | Issue/ Rev: | | |
| Diagram / Drawings: | | Related FMECA: | | Date: | | |
| | | | | Page | of | |
| (a) No. | (b) FMECA Ref. No. | (c) Single Point Failure Critical Component / Function | (d) Failure Effect and Estimated Probability | (e) Criticality | (f) Retention Rationale (References as Applicable) | (g) Remarks |
| | | | | | | |



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14.2 Declared Components List (DCL)

| | | | |
|--------------------------------|----------|---------------------------|--------------------------|
| DECLARED COMPONENT LIST | | ORIGINATOR: UK ATC | |
| SPACECRAFT / PROJECT: | Herschel | Doc. Number | SPIRE-ATC-PRJ-xxx |
| SYSTEM / EXPERIMENT: | SPIRE | Sheet No | Page 56 of 69 |
| SUB-SYSTEM: | BSM | Issue: | 0.1 |
| | | Date: | 24.Jun. 01 |

| Part ID (used on) | Description | Manufacturer/ Supplier | Country | Specification | Quality | Notes |
|-------------------|-------------|------------------------|---------|---------------|---------|-------|
| | | | | | | |
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14.3 Declared Materials List (DML)

| | | | |
|-------------------------------|--------------|---------------------------|--------------------------|
| DECLARED MATERIAL LIST | | ORIGINATOR: UK ATC | |
| SPACECRAFT / PROJECT: | Herschel | Doc. Number | SPIRE-ATC-PRJ-xxx |
| SYSTEM / EXPERIMENT: | SPIRE | Sheet No | Page 57 of 69 |
| SUB-SYSTEM: | BSM | Issue: | 0.1 |
| | | Date: | 24.Jun. 01 |

| BSM Material List ID | Component ID | Name & Type of Product, Form and Condition | Specification | Size Code | Processing Parameters | Outgassing SCC-Res. Data and Refer | OK to bake at 80°C? | Thermal & Vacuum stable? | OK at 4°K? | Manufacturer | Remarks, Approval Reference |
|----------------------|--------------|--|---------------|-----------|-----------------------|------------------------------------|---------------------|--------------------------|------------|--------------|-----------------------------|
| 1. | | | | | | | | | | | |
| 2. | | | | | | | | | | | |
| 3. | | | | | | | | | | | |
| 4. | | | | | | | | | | | |
| 5. | | | | | | | | | | | |



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14.4 Declared Processes List (DPL)

| | | | |
|------------------------------|----------|---------------------------|--------------------------|
| DECLARED PROCESS LIST | | ORIGINATOR: UK ATC | |
| SPACECRAFT / PROJECT: | Herschel | Doc. Number | SPIRE-ATC-PRJ-xxx |
| SYSTEM / EXPERIMENT: | SPIRE | Sheet No | Page 58 of 69 |
| SUB-SYSTEM: | BSM | Issue: | 0.1 |
| | | Date: | 24.Jun. 01 |

| Process ID | Process | Specification (Incl. Issue) | Description / Identification | Use and Location | User Code | Associated DML Items | Criticality of Process | Approval / Status |
|------------|---------|-----------------------------|------------------------------|------------------|-----------|----------------------|------------------------|-------------------|
| 1. | | | | | | | | |
| 2. | | | | | | | | |
| 3. | | | | | | | | |
| 4. | | | | | | | | |
| 5. | | | | | | | | |
| 6. | | | | | | | | |
| 7. | | | | | | | | |
| 8. | | | | | | | | |
| 9. | | | | | | | | |
| 10. | | | | | | | | |



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14.5 FMECA format

Mechanical Failure Modes Effect and Criticality Analysis

| | | |
|---|--------------------------|---|
| Product: SPIRE | Prepared by: I.Pain | Document Reference: SPIRE-ATC-PRJ-0711 |
| Project/Phase: Mission Observing | Approved by: G.Wright | Issue: 2 |
| System/Subsystem/Equipment: BSM | Date: 22.Jan.02 | Page 1 of 1 |

| Ident. number | Item/block | Function | Failure Mode | Failure Cause | Mission phase/ op.mode | Failure effects a. Local effects b. End effects | Severity | Failure detection method/ observable symptoms | Compensation provisions | Correction actions | Remarks |
|---------------|------------|----------|--------------|---------------|---------------------------|---|----------|--|-------------------------|--------------------|---------|
| | | | | | | | | | | | |
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14.6 Integration and Test Logs

| EXPERIMENT: | | HISTORICAL RECORD | | | CORRAC | TEST | Trans | STORAG | FAILURE | PAGENO | | | | |
|------------------|---------------------------------|-------------------|----------------|---------------------|------------|------|-------|--------|---------|----------|------|------|---------|--|
| UNIT / ASSEMBLY: | | DRAWING NO: | | SERIAL NO: | | | | | | | | | | |
| NO | DESCRIPTION OF ACTIVITY / EVENT | TIME From/To | OPERATING TIME | REMARKS / REF. DOC. | (tick box) | | | | | PERF .BY | DATE | SIG. | QA Sig. | |
| | | | | | | | | | | | | | | |
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Document Ends