SPIRE

SUBJECT: SPIRE Product Assurance Plan

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1. INTRODUCTION

This Plan describes the Product Assurance activities to be implemented for the HERSCHEL SPIRE instrument at all the contributing centres, contractors and their sub contractors.
It is based on the Product Assurance requirements as set out in the ESA PSS series of documents and past experience of AO instruments, and will be used to control all the Product Assurance activities in the manufacture, assembly and testing of the HERSCHEL SPIRE instrument*, this document is based on previous AO PA Plans submitted to ESA for a number of projects.
Certain areas of the applicable documents listed below are complied with as is normal in an AO project i.e. safety, interface specification and controls, and cleanliness.
However as the HERSCHEL SPIRE instrument is not attempting to be fully compliant with the listed Applicable Documents no compliance matrix has been produced.
Where specific rules or procedures are considered unacceptable alternative procedures will be proposed that are mutually agreeable to the HERSCHEL SPIRE instrument and the ESA Project Office.

* Hereafter referred to as the Project.

1.1 Applicable and reference documents.

1.1.1 Applicable Documents

The documents listed below form part of this PA plan to the extent specified and described herein.

AD1		
AD2		
AD3		
AD4		
AD5		
AD6		
AD7		
AD8		
AD9		
AD10		
AD11		
AD12	ESA ECSS-Q-40A	Safety Assurance
AD13	ESA ECSS-Q-70-37	Determination of the Sus septability of metals to stress-corrosion cracking
AD14	ESA ECSS-Q-70-36	Material Selection for Controlling Stress Corrosion Cracking
AD15	ESA PSS-01-728 Issue 2	Repair and Modification of Printed Circuit Boards and Solder Joints
AD16	ESA ECSS-Q-70-08	Manual Soldering of High Reliability Connections
AD17	ESA ECSS-Q-70-26	Crimping of high Reliability Connections

1.1.2 Reference Documents

The following documents are called up in this plan and used for guidance and information, selected sections of the individual documents may form part of this plan and will be followed to the extent specified.

RD1	ESA PSS-01-201 Issue 1	Contamination and Cleanliness Control
RD2	ESA PSS-01-30 Issue 2	Reliability Assurance of ESA spacecraft and associated equipment
RD3	ESA PSS-01-301 Issue 1	Derating requirements applicable to electronic, electrical and electromechanical components for ESA systems
RD4	MIL-HDBK-217F	Reliability prediction of electronic equipment
RD5	ESA PSS-01-303 Issue 1	Requirements for failure modes, effects and criticality analysis
RD6	NPRD-3	Non electrical parts reliability data
RD7	ESA PSS-01-302 Issue 1 Draft 4	Failure rates for ESA space systems
RD8	MIL-STD-975L (NASA)	NASA standard electrical and electromechanical (EEE)Parts list
RD9	ESA ECSS-Q-60-01A	European preferred parts list
RD10	-	ESA/SCC Qualified parts list
RD11	GSFC/PPL20	GGFC preferred parts list
RD12	ESA PSS-01-605 Issue 1	Capability approval programme for hermetic thin film hybrid microcircuits
RD13	ESA PSS-01-606 Issue 1	Capability approval programme for hermetic thick film hybrid microcircuits
RD14	ESA PSS-01-608 Issue 1	Generic specification for hybrid microcircuits
RD15	ESA PSS-01-70 Issue 3	Material and process selection and quality control for ESA space systems and associated equipment
RD16	ESA PSS-01-700 Issue 2	The technical and reporting and approval procedure for material and process
RD17	ESA PSS-01-701 Issue1 Rev 3	Data for selection of space materials
RD18	NASA-MSG-A Aug. 1990	Materials selection guide
RD19	ESA-RD:01 Rev 1	Outgassing and thermo optical data for spacecraft materials
RD20	NASA Ref. Publication RP1124 Rev 2 Nov 1990	Outgassing data for selecting spacecraft materials
RD21	ESA ECSS-Q-70-02A	A thermal vacuum test for the screening of space materials
RD22	ESA ECSS-Q-70-22A	The control of limited life materials
RD23	ESA PSS-01-710 Issue 1	The qualification and procurement of two sided printed circuit boards
RD24	ESA ECSS-Q-70-30A	The wire wrapping of high reliability electrical connections
RD25	ESA PSS-01-60 Issue 2	Component selection, procurement and control for ESA space systems
RD26	ESA PSS-01-21 Issue 2	Software product assurance requirements for ESA space systems
RD27	ESA PSS-05-0 Issue 2	ESA software engineering standards
RD28	MIL-H-38534	General Specification for hybrid microcircuits
RD29	MIL-I-38535	General Specification for integrated circuits (Microcircuits Manufacturer)

RD30	MIL-STD-883	Test methods and procedures for microelectronics
RD31		

2. GENERAL PRODUCT ASSURANCE REQUIREMENTS AND MANAGEMENT

2.1 General

The RAL Space Science and Technology Department Product Assurance Group will implement and operate a Product Assurance Programme for the Instrument PI. The Programme will be as described in this plan and based on:

a) The general requirements as stated in ESA PSS-01-0. and

b) The specific HERSCHEL SPIRE Instrument requirements defined in a number of documents. Ref section 1.1.1, Applicable Documents

The plan to be agreed between the Project and ESA project office.

The requirements will be applicable to the different models as shown in Table 1.

TABLE 1
APPLICABILITY OF PA REQUIREMENTS TO THE DIFFERENT MODELS

PA REQUIREMENTS	INSTRUMENT MODELS AND GSE				
	AVM	**CQM**	**PFM**	**FS**	**GSE**
2.2 PA Management	A	A	A	A	A
2.3 Material and Process Selection and Approval					
2.4 EEE Parts Selection and Control	P	P	A	A	P(3)
2.5 Cleanliness and Contamination Control	P	P	A	A	P(4)
2.6 Reliability Assurance	A	A	A	A	P(4)
2.7 Safety	A	A	A	A	A
2.8 Quality Assurance					
2.8.2 Procurement Control	P(1)	P(1)	A	A	P(3)
2.8.3 Manufacturing Control	P	P	A	A	P(3)
2.8.4 Integration and Test Control	P(5)	P(5)	A	A	P(3)
2.8.5 Handling, Storage, Packaging	A	A	A	A	A
2.8.6 Non-conformance Control	P(2)	P(2)	A	A	A
2.8.7 Alerts	A	A	A	A	N
2.11 Acceptance and Delivery	A	A	A	A	A
2.9 Software PA	A	A	A	A	A

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

1.Selection of procurement sources is applicable.
2.Applicable starting from instrument model testing.
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.

2.2 Organisation

The Space Science Department at RAL supports a Product Assurance Group staffed by qualified and experienced engineers and scientists. A PA Manager will be appointed from the group and will be responsible in collaboration with all participating groups in the HERSCHEL SPIRE project, for developing and executing product assurance plans appropriate to the needs of the project.

HERSCHEL SPIRE PA Manager - E CLARK(RAL Ref. Figs. 6 and 7).

The PA Manager will be the sole formal interface with ESA on all product assurance related mattersand the related interfaces with HERSCHEL (see Table 2 for list of interface areas).

TABLE 2

GENERAL DEFINITION OF INSTRUMENT INTERFACES

1	Safety	General
2	Cleanliness	General instrument cleanliness and materials out-gassing and including magnetic cleanliness where applicable.
3	Electrical	Interface connections: pin functions and signals Power consumption EMC/EMI Grounding
4	Reliability	
5	Mechanical	Mass, moment of inertia, centre of gravity, mounting positions, instrument envelope Mechanical properties relevant to the mechanical behaviour of the payload.
6	Processes and materials	for electrical, mechanical and thermal items

The Group will operate with the project management team to provide product assurance management for the project and PA liaison with collaborating groups, contractors, consultants and suppliers on the implementation of the agreed PA plan via their own in-house PA organisation and procedures.

Each organisation shall nominate a person to be responsible for product assurance activities including:
- Prepare a Product Assurance Plan for work package if required
- Monitor in-house product assurance system
- Witness tests etc.
- Ensure deliverable documents prepared
- Co-ordinate activities with RAL project product assurance personnel
- Monitor contractors.
- Report status of PA activities.

Where work will be performed at an establishment where no formal in-house quality assurance system exists a scheme shall be set up specifically for the project to enable the requirements of this plan to be implemented. Where a system already exists, provided it meets the requirements of this Plan it will be acceptable.

The Project organisational structure is defined in the HERSCHEL Management Plan Fig. 7 shows the position of the PA Group withinthe Rutherford Appleton Laboratory Space Science and Tecnology Department. The PA Group Manager has a direct line to the head of the Space Science Department and Technology if required.

2.3 Audits

Audits shall be carried out at regular intervals to ensure that requirements are being implemented. They shall be performed by PA against the requirements referenced herein to confirm that performance is in accordance with this plan.
Generally audits shall be implemented covering major project phases in the following main areas:-

- overall PA system
- Procurement, Manufacturing processes, e.g. prior to commencement of QM/FM manufacture
- qualification and acceptance testing

2.4 Product Assurance Planning and Documentation

Product assurance events will be highlighted by a PA "overlay" on the instrument programme. Actions and associated resource requirements will be indicated for all aspects of the programme. Specifications, designs, drawings, manufacturing, assembly, inspection and tests, together with associated documentation, will be subjected to analysis for compliance with PA requirements.

Documentation and instructions applicable to interfaces will be the subject of liaison with ESA and other interested parties as required and progress will be reported at all formal review stages.
Configuration control will be applied. (See Section 10).

2.5 ESA Right of Access

For purposes of product assurance and technical co-ordination ESA will have access, by appointment to all in-house facilities where national or commercial security permits. Such access will be for the purpose of test observations, documentation reviews, hardware examination and participation at the mandatory or key inspection points (KIP's/MIPs),MRB's and cleanliness inspections.
For purposes of product assurance and technical co-ordination ESA will have access, by appointment to all in-house facilities of consortium members when national or commercial security permits. Such access will be for the purpose of test observations, documentation reviews, hardware examination and participation at the mandatory or key inspection points (KIP's/MIPs).

2.6 Contractor and Supplier Surveillance

Where contractors are employed to provide services or equipment the product assurance requirements listed in the plan will be imposed on those contractors appropriate to the criticality of the services or products being provided.

Surveillance of PA activities will be carried out by the PA manager or delegated deputy who will ensure that appropriate inspections, tests and documentation are specified and completed. Contract reviews will include suitable examination of product assurance related matters.

Contractors shall be assessed on the basis of their product assurance system in addition to their technical capability. A PA plan shall be requested where appropriate.

2.7 Status and Facility Reviews

The status and results of the PA programme shall be included in all major project reviews.

Before the commencement of manufacturing activities, qualification or acceptance tests, facility reviews will be organised to examine acceptability of materials, facilities, tools, equipment, instruments, calibration, services, procedures and documentation. Follow-up reviews will be made to ensure that recommendations have been implemented effectively. ESA will be invited to participate in critical reviews.

2.8 Critical Items Identification and Control

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

- Single point failures
- Limited life items
- Hazardous items of categories catastrophic and critical
- Critical technologies
- Other critical items e.g. vulnerable items

NB. Items which are "extremely" critical and need special attention and treatment will be categorised MAJOR all others are minor.

2.9 Product Assurance Progress Reporting

Reporting on the progress and status of product assurance related matters will form part of the regular project reporting procedure. Reports will provide information on:

- Progress and accomplishments for each major product assurance task;
- Current problems;
- Status of FMECA and hazard analysis;
- Status of EEE parts programme;
- Status of material and process control programme;

- Status list for major non-conformances and requests for waiver;
- Status of contamination control programme;
- Overview of major events in the forthcoming period.

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3. MATERIAL AND PROCESS SELECTION AND CONTROL

3.1 General

Material and process controls will be implemented with respect to hazardous and forbidden materials, outgassing, strength and stress corrosion resistance on structural and pressurised items.

Materials which may constitute a safety hazard or can cause contamination shall not be used without prior approval.

Examples are: **Beryllium Oxide, Cadmium, Zinc, Mercury, Radioactive Materials, or PVC**

Special precautions will be required if such materials are used.

Material, process and mechanical parts lists shall be prepared and a HERSCHEL issue will be submitted in the conceptual design phase for ESA comment and approval. Lists will be updated throughout the on-going design and revisions provided for each of the project design reviews. All approval and evaluation activities should be scheduled such that they will be finalised by the instrument baseline design review (start of manufacturing of qualification flight hardware).

(Ref. Appendix C Figs. 13/14/21).

3.2 Materials

ESA (RD17) and NASA (RD18) list materials approved for use in space as well as useful advice and information on a variety of matters. These lists may be used for guidance but suitability for use must be evaluated for each application. Materials Tips for spacecraft applications issued by the Materials Branch GSFC is recommended as being particularly valuable for experimenters.

Materials not previously used in space shall be subject to a testing programme to assess their suitability for the intended application.

The following guidelines will be followed when choosing materials:

a) **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(AD14) Table 1 where possible. For the listing of SCC sensitive materials MSFC-SPEC-522B can be regarded to be equivalent to ESA ECSS-Q-70-36 and for SCC testing ASTM G44-75 equivalent to ESA ECSS-Q-70-37 (AD 13)

b) **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 RD17 Table 7.2.1.

c) **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 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 ESA PSS-01-702 (RD21). ASTM-E-595-84 and JSC/SPR-0022A may be regarded as equivalent to PSS-01-702. Documents ESA RD:01 (RD19) and NASA Ref. Publication 1124 Rev 3 Sept 1993 (RD20) 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 a factor 10 to <0.1% and 0.01%, refer to section 8.

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

3.2.1 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.
Conformance Documentation
Conformance and test documentation shall be inspected and retained for traceability as part of the stock control system.

3.2.2 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.

3.2.3 Limited Life Materials

A register of limited life materials shall be maintained at each establishment. 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 (Ref. Document RD22).

3.2.4 Storage

All materials shall be held in a controlled store.

3.3 Processes

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

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 made available or accessible upon request for review so that all processing steps are adequately specified and that adequate controls are included.

Critical processes will be identified on the Declared Process List. 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.

Processes not previously qualified or approved for space use shall be subjected to a testing programme in order to assess their suitability for the intended applications.

4. EEE COMPONENT QUALITY, SELECTION AND PROCUREMENT

4.1 General

The quality levels shall be as defined in Sections 4.4.1/2 and 4.5.2. This applies to flight standard hardware and to components coming into direct contact with flight standard hardware, e.g. the interfacing connectors from GSE cables.

Nb: Connector savers should 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.

For engineering models 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.

4.2 Component Programme Management

The Experiment PA manager will monitor component quality, selection and procurement, reporting as necessary to progress meetings and will be the point of contact with ESA.

The RAL SSTD PA Group will advise consortium members on parts procurement and documentation, procurement agents and test houses will be used as necessary. Long lead items will be identified to enable effects on the project schedule to be assessed. Progress of long lead items procurement will be monitored to identify problems as early as possible.

4.2.1 Component Engineering

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.

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.

Procurement Policy

Tecnologica are the 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.

4.3 Component Engineering

4.3.1 Prohibited Materials and Components

Components containing materials which may constitute a safety hazard or can cause contamination shall not be used without the prior approval of PA. Examples are components containing:

a) Beryllium Oxide.
b) Cadmium.
c) Zinc.
d) Mercury.
e) Radioactive Materials.
f) PVC.

Special precautions may be required if such materials are used.

Components with known instability shall be avoided unless specifically approved.

Examples are:

a) Wet tantalum capacitors.

b) Plastic encapsulated semi-conductors.

c) Hollow core resistors.

d) Variable resistors and capacitors.

4.3.2 Radiation Sensitive Component

General

Expected radiation levels are defined in the Environmental and test specification TBC, if necessary analysis will be carried out to identify the local environment the SPIRE Instrument will be exposed to.

Components shall be reviewed to establish their susceptibility to radiation in terms of:-
- total dose
- cosmic ray effects

Preference shall be given to radiation hardened parts by process or to devices less sensitive to ionizing radiation.
All parts shall withstand a total dose of at least 20 Krad (SI)(TBC).
Parts which are radiation hard to above 20 Krad (SI) (x2 safety factor) (TBC) will not require Lot testing, but radiation data shall be available.
Parts which are susceptible to radiation between 10 Krad(SI) and 20 Krad(SI) (TBC) shall be judged on merit depending on the actual levels predicted in the radiation analysis, provided the x2 margin is maintained Lot testing shall not be required. For parts where the margin is not maintained further Lot testing may be necessary.
Parts susceptible to levels less than 10 Krad(SI) (TBC) shall not normally be acceptable, however if it is not possible to identify other parts meeting the 10 krad(SI)(TBC) requirement a waiver shall be submitted with a supporting case to include:-
- justification for use
- results of radiation analysis giving expected dosage at part location
- radiation test results for component
- additional shielding proposals required to demonstrate inadequate safety.

If no radiation data is available on specific components, radiation testing shall be performed.

The dose received by a component within the instrument will depend on the amount of shielding material - spacecraft structure, printed circuit boards, adjacent components and other units and systems. During the early design phase a simple shielding analysis will be carried out to optimise the location of the more sensitive

components. If a critical problem is identified a more detailed analysis may be performed and local shielding considered.

When selecting components the type of effect due to the radiation will be considered. For example, the supply current for CMOS components will increase rapidly before a functional failure - the increase in current may be the limiting factor where power is critical.

In general components with low susceptibility to this effect shall be selected.

Single Event Upsets

Cosmic rays and high energy trapped protons can produce sufficient ionisation to cause a change in logic state. This effect is independent of technology and is likely to be worse for higher density components where the change of state requires less charge.

Consideration shall be given to protection schemes such as the use of 'watchdog' timers and routine error checking in the software or by extending the word size to include parity checking by hardware.

Latch-Up

Energetic cosmic rays can deposit sufficient charge to set up a parasitic SCR type circuit in some CMOS devices.

Components designed with latch-up immunity shall be used where possible.

Current limiting or automatic trip circuits may be used to overcome this problem in which case the software will be designed to detect the events to enable the system to recover.

4.3.3 Component Derating, Component Drift and Degradation

Components shall not be stressed to the maximum rated values established by the manufacturers but only to the derated values specified in ESA PSS-01-301 (RD3).

To implement the derating 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 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.

The verification activities for these requirements are specified in Sections 6.5 (Worst Case Analysis).

4.4 Component Selection and Approval

4.4.1 Preferred Components (Standard)

The selection of components shall be based on the knowledge regarding technical performance, qualification status or qualifiability and history of previous usage in similar applications. Preference shall be given to components from sources which would necessitate the least evaluation / qualification effort.

Criteria for preferred parts:

1. Suitable specification must be available for procurement of the part to space or military high reliability standards.

2. An approved and surveyed manufacturer must exist and be used.

3. Ideally manufacturer must be QPL or QML listed.

The primary sources of such parts are as follows:

PROJECT Preferred Parts List
ESA preferred parts list ECSS –Q-60-01A (ESA:PSS-01-603)
ESA/SCC Qualified parts list www.estec.esa.nl./qcswww/eppl/
GSFC Preferred Parts List (Currently PPL21)
NASA Standard Parts List MIL-STD-975M.

Parts successfully meeting the requirement of MIL-I-38535 (RD 29) and the appropriate detail specification, and listed in QML-38535.

Parts successfully meeting the requirements of MIL-H-38534 (RD28) and the appropriate detail spec., and listed in QML-38534.

Note 1 All parts procured to specifications defined and listed in MIL-STD-975M. Sections 2 & 3 are considered acceptable whether listed in MIL-STD-975 or not. (Ref. Appendix A for extract from MIL-STD-975 Sections 2 & 3 specifications and definitions).

Note 2 As a result of recent changes to the US military specification and manufacturing of high reliability parts, the MIL-M-38510 and its QPL programmes are discontinued there will be no further M-38510 slash sheets written or updated. Some existing parts are still available to MIL-M-38510 but the numbers are falling constantly.

The entire contents of MIL-M-38510 have been added to MIL-I-38535 which is its replacement.

Detail specs for MIL-I-38535 are SMD's or DESC drawings.

Note 3 Equivalent European or National specifications may be substituted for the above if they exist (eg BS or CECC).

4.4.2 Non-Qualified Components

Only in exceptional circumstances will parts not covered by the specifications in Section 4.4.1 be used. The designer must clearly state his rationale for the choice of component identifying the particular parameters which make the component necessary.

To be acceptable a test and assessment programme must be carried out incorporating the following elements:

- Design and application assessment for the parameters of the component which are essential for the intended application and which justify the use of non-preferred part.

- Constructional analysis of the selected part to assess the standards of fabrication and assembly, potential failure modes, materials and processes which may lead to deterioration or malfunction.

- Manufacturer assessment to assure that the organisation, facilities, production control and inspection system are adequate. (This may be limited to a document check where it is not practical or possible to visit).

Evaluation plus screening and qualification tests corresponding to those defined in GSFC 311 INST 001Rev A for upgrade to Grade 2 use.

If necessary consultants or procurement agents will be used to perform these tasks.

A typical programme will be as follows:

1. Obtain from the designer a rationale for the choice of parts and any specific difficult/unusual operating conditions.

2. Assess the manufacturers in-house QA/test programme.

3. Design a programme to find out/ensure part adequate for purpose intended.

Procurement may be in three parts:

1. Initial Purchase.
2. Test Batch.
3. Flight Batch.

1. Initial Purchase

a) Use parts purchased to test in real operating conditions and confirm part useable.

b) Carry out construction analysis.

c) Radiation Test

Parts may be used for more than one purpose provide initial tests do not invalidate follow-up tests.

2. **Test Batch**

- Construction analysis or DPA) If not done to initial purchase
- Radiation Test)
- screening routine to confirm parts are capable of withstanding requirements to appropriate level (GRADE 2).
- Life test 1000 hrs @ 125C.

3. **Flight Batch**

Divide into two groups:

Group 1 Flight Use 100% screen
Plus functional test at appropriate temp. either max/min/RT or operating temperature if more appropriate on all or selected parts.

Group 2 Lot Test Selected parts from above group:
Radiation
Life Test
DPA

Note: The flight batch should be purchased from a single manufacturing lot. If more than one lot is used for flight, the lot testing above shall be carried out for each lot.

4.4.3 Component Approval

All parts used will be entered onto a Declared Components List (DCL) to be reviewed and agreed by ESA.

Component approval includes approval of the manufacturer, the procurement specification (and amendments) with definition of all technical requirements, applicable screening and lot acceptance tests and the evaluation / qualification programme if applicable.

4.4.4 Procurement Lots

All purchase orders shall state parts to be supplied from single manufacturing lot or batch.

4.4.5 Part Approval Document

Part Approval Documents (PAD's) shall only be prepared and submitted for parts which are not preferred components as defined in Section 4.4.1. For other parts all required information shall be supplied via the Declared Component List with supporting data in the form of attachments referenced on the DCL.
The PAD format is defined in RD5, however as it is difficult to use for non ESA/SCC components a simplified version (Appendix C Fig. 18) shall be prepared and submitted for approval.

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 (ie 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.
- 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.

4.4.6 Declared Components Lists (DCL) (Appendix C Fig. 12)

All components to be used on flight or flight spare hardware, shall be listed in a Declared Component List 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 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 for review/comment and approval.

4.5 Procurement Requirements

4.5.1 Procurement Specification

Existing procurement specifications will be used wherever possible. Where extra requirements are needed these will be detailed on the purchase order.

4.5.2 Component Quality Level and Screening Requirements

Parts quality is determined by whether the part is in the interface between the experiment and the spacecraft or not. If the interface to the spacecraft is protected on the spacecraft side there is no need to treat the interface in a different way to other parts of the experiment.
Where possible interface parts shall be selected from the "MSG Preferred EEE Parts List " (AD6)
Interface parts will be identified during the FMECA process and will be identified as such on the Declared Components List.

Normally passive parts, i.e. resistors and capacitors will be procured to the highest level specification for use throughout the experiment.

Parts of the following quality levels shall be used; Ref. Table 3.

TABLE 3

	UNPROTECTED INTERFACE	**PROTECTED OR NON-INTERFACE**
Connectors	ESA/SCC Level B NASA Grade 1	ESA/SCC Level C NASA Grade 2
Actives	ESA/SCC Level B NASA Grade 1 MIL-I-38535 Class V	ESA/SCC Level C NASA Grade 2 MIL-I-38535 Class Q DESC/SMD Class M
Passives	ESA/SCC Level B NASA Grade 1	ESA/SCC Level C NASA Grade 2
Hybrids	ESA: PSS-01-608 Level B MIL-H-38534 Class K	ESA/SCC Level C MIL-H-38534 Class H
Inductors/Transformers	MIL-STD-981	MIL-~STD-981

Note 1 APPENDIX A contains listings of suitable US specifications and definitions extracted from MIL-STD-975M.(To be updated).

Note 2 Parts procured to MIL-I-38535 are ordered using DESC or SMD numbers. Two quality indicators are used:

a) "Q" means part fully compliant with MIL-I-38535 and is equivalent to old Class "B".

b) "V" means extra testing carried out and is equivalent to old Class "S".

A third DESC/SMD indicator "M" means device certified by the manufacturer to comply with in-house implementation of MIL-STD-883. This is largely superseding parts fully compliant with MIL-STD-883 and will be treated in the same way.
However it should be noted that Level M or MIL-SD 883 parts shall only be used if the higher levels are not available or there are circumstances that make it necessary

Note 3 The treatment of parts procured to DESC/SMD indicator "M" will be judged on merit and depend largely on the manufacturer supplying the part. Some parts will be treated as preferred and other than requesting Quality conformance test data at the time of order no further special treatment will be applied.

Other parts may be classified "non-qualified and dealt with as in Section 4.4.2.

Note 4 Engineering Model Components : The component types shall be identical electrically and have the same geometry as flight model components. Lower Quality components with the capability of operating in the thermal and vibration environment of the qualification test programme may be used.

Cadmium plated connectors are not permitted.

4.5.3 Lot Acceptance Testing (LAT)

Lot acceptance Testing shall be carried out for ESA/SCC components only. As defined in the ESA/SCC-specification i.e.:

a) LAT 1: If LAT 1 has not been carried out within the previous 24 months then LAT 1 shall be performed.

b) LAT 2: If neither LAT 1 nor LAT 2 has been carried out within the previous 12 months then LAT 2 shall be performed.

c) LAT 3: Shall be carried out for all cases not included within a) or b) above.

The only other lot acceptance testing to be carried out is as defined in
Section 2.4.4.2 when purchasing non-qualified components.

4.5.4 Hybrid Circuits

Hermetic hybrid circuits shall be procured to PSS-01-608 (RD14) plus the relevant detail specification from sources which are "capability approved" for all relevant technologies as per ESA-PSS-01-606 (RD13) for thick film and per PSS-01-605 (RD12) for thin film or the US equivalent as listed in table 3.

For US parts procurement to MIL-H-38534 or GSFC specification 311-200 are regarded as equivalent. US Suppliers must have a fully certified MIL-STD-1722 facility and be listed on the Qualified Manufacturers List (QML).

In case hybrid circuits are required from a source which is not yet approved, an evaluation and acceptance testing programme shall be performed based on PSS-01-606 or PSS-01-605 and Section 4.4.2. All add-on components shall be selected as defined herein and shall meet the requirements of this document.

Hybrid parts will be identified as such on the DCL.

4.6 Component Quality Assurance

4.6.1 Manufacturer Surveillance

It is not expected that any manufacturer surveillance will be carried out or there will be any participation in precap visual inspections or witnessing of acceptance tests except in exceptional circumstances

4.6.2 Receiving Inspections and Destructive Physical Analysis (DPA)

Receiving inspection of flight and flight spare components shall be carried out by the user or a procurement agent who is independent of the manufacturer. This shall include:

1. Review of the manufacturer delivered documentation.
2. External visual inspection.
3. Electrical measurement of critical parameters if appropriate (see following).
4. Destructive physical analysis if appropriate. (This will not be done on a routine basis).

Where components require upgrading and it is done at a test house tests 1 and 2 shall be performed at the test house prior to the screening, as well as on receipt by the user.

Receiving inspection will be carried out on a sample of parts. The batch acceptance criteria is zero failures where a batch can be identified as a set of parts from the same production run, e.g. date code, sample size is as follows:

BATCH SIZE	SAMPLE SIZE
1-20	100%
21-280	20 Parts
281-1200	80 Parts

If for any reason it is not possible to carry out individual part electrical testing, performance testing of the parts when built into the operational circuit will be acceptable. However it must be recognised that if parts do not meet specification, schedule impacts and costs may be serious and problems may arise with the supplier due to the time between delivery and fault identification. Therefore if at all possible long lead or critical items should be tested on receipt.

4.6.3 Storage

All flight and flight spare components shall be held in a controlled store compliant with the Electrostatic Discharge Control requirements (Ref. Section8.4.6).

5. CLEANLINESS AND CONTAMINATION CONTROL

The cleanliness plan (Appendix B) provides a minimum standard for contamination control . A project specific Cleanliness Control Plan (TBD) detailing the specific requirements is in preparation and will eventually supercede Appendix B, no further updates to Appendix B will take place.. The PA Manager will be responsible for monitoring cleanliness and contamination control throughout the project at all consortium establishments.
Cleanliness control and monitoring shall comply with the PROJECT requirements as defined in (TBD).

6. RELIABILITY ASSURANCE

6.1 General

No single instrument failure shall cause a safety hazard.

Interface design shall be such that no instrument failure can propagate into the spacecraft system.

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 hazard analysis reporting system. (Ref. Section 3).

Functional failure mode effects and criticality analysis (FMECA) shall be performed on the complete instrument down to block diagram level assessing the effects of failure of complete subsystem interconnections.

The instrument/spacecraft hardware interface shall be subject to FMECA on all interconnections down to component level.

Worst case analysis shall be performed at instrument/spacecraft interface.

Numerical reliability analysis may be prepared for use in trade off and optimisation studies.

Reliability assessments shall be presented at major design reviews

Reliability assurance will be based on RD2 and RD3.

6.2 Failure modes effects and criticality analysis (FMECA)

A failure modes effects and criticality analysis shall be prepared on all functional elements of the instrument including electronic circuits and mechanisms (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 experiment or damage to or interfere with, the proper functioning of the TBD 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:

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.

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 but not limited to :

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. from single event upset - ex: latch-ups.

Incorrect commands or sequence of commands
Incorrect software functions

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

Document RD5 shall be used for guidance and presentation of FMECA results (Ref. Appendix C Fig. 8).
The FMECA shall be used as a means to identify which parts shall be defined as interface parts.

6.3 Single Point Failure (Appendix C Fig. 9)

On the basis of the FMECA a Single Point Failure List shall be prepared summarising all single point failures.

6.4 Numerical Reliability Assessments

Numerical reliability assessments for use in conceptual and trade off studies may (TBD) be prepared based on methods and failure rates contained in RD4

6.5 Worst Case Analysis (Drift / Degradation Analysis)

Worst Case Analysis shall be performed (TBC) on assemblies interfacing with other spacecraft elements to demonstrate that interface requirements (e.g. leakage currents) are not violated taking into account parameter variations of components resulting from initial tolerances, environmental effects (e.g. temperature), ageing, radiation, wear out etc. over the operating life. Adequacy of margins in the design of electronic circuits, thermal and electromechanical systems shall be demonstrated by analysis or test.
Parameter-variations of electronic components which shall be taken into account in the analyses are defined in PSS-01-301 (RD3). Other values have to be substantiated with support from test data (e.g. end of long-term life test limits from qualification tests). An alternative to this may be a form of margins test. If this proves to be more useful to the designer a suitable test will be negotiated with the project and the results substituted for the above.

7. SAFETY ASSURANCE

7.1 General

All safety requirements imposed by ESA shall be complied with.

A safety assurance programme shall be implemented to assure compliance with specified safety requirements and to identify potential hazards to personnel and flight hardware to eliminate them or reduce them to acceptable levels.

This shall cover the design, fabrication, testing, transportation, ground operations, launch and post launch operations.

Responsibility for safety assurance tasks will be shared between ESA and the PI.

7.2 Safety Assurance Requirements

The design of the experiment, associated GSM and their operation shall conform to the national safety standards and regulations in the country of origin, and comply with ESA and launch authority safety requirements as defined in the following documents:-

- ESA-PPS-01-40
- CSG Safety Regulations

In order to ensure and to demonstrate that the requirements are met the following systematic method of analysis will be followed
The consequences of identified hazardous events shall be categorised as follows:

I CATASTROPHIC

- loss of life, life threatening or permanently disabling injury or occupational illness;

II CRITICAL

- temporary disabling, but not life-threatening injury, or temporary occupational illness;
- loss of major damage to flight systems, major flight system elements, or ground facilities;
- loss of, or major damage to public or private property; or
- long term detrimental environmental effects.

III MARGINAL

- minor non-disabling injury or occupational illness;
- minor damage to the PPF or other associated hardware;

- minor damage to public or private property
- temporary detrimental environmental effect

IV NEGLIGIBLE

7.3 Safety Assurance Tasks

As a first step, the Investigator shall prepare and submit a Preliminary Hazard Analysis in accordance with Appendix C, Figs. 10/11, supported by the outputs from the FMECA (see 6.2).

Hazard reports will be produced addressing all categories of hazard defined in AD12 and updated as necessary. The items covered in this report will be:

Hazardous electrical systems (e.g. high voltages > 100V).
Electro explosive devices (Pyrotechnics).

Propellants (Solid / liquid).

Pressurised items.

Chemical Products
- Corrosive (e.g. battery)
- Toxic or asphyxiating
- Explosive (also pyros)
- With biological effect

Radiation
- Non-ionising
- Ionising
- Visible, IR, UV.
- Acoustic / Vibration emission

High / Low temperature (e.g. cryogenic exposed surfaces).
Deploying mechanisms.
Other hazard sources.

Safety Testing: Where necessary testing will be carried out to verify the safety margin on critical items e.g. pressure vessel burst test.

Reviews: Safety status issues and concerns will be presented for review at major project reviews.

7.3.1 Training

training of personnel for hazardous operations shall be implemented in a systematic and timely manner. This shall apply especially for operations at Guyana Space Centre (CSR) and also for other hazardous operations as appropriate

8. QUALITY ASSURANCE

8.1 General

For quality assurance the requirements of this section shall apply to all hardware intended for qualification testing, flight or flight spares and to any Ground Support Equipment (GSE) used for lifting loads in excess of 300N.

Note: Fig. 3 shows a design / manufacture / assembly and test sequence highlighting various tasks called up in the following section and when they should be applied.

8.2 Procurement Controls

8.2.1 Selection of Procurement Sources

Manufacturers and suppliers shall be selected for their proven ability to supply materials and component parts to the required specifications together with the documentation to verify that the requirements of the procurement specifications have been met.

Only contractors with assessed capability with regard to quality control and traceability shall be used for manufacturing or carrying out processes on parts or assemblies, e.g. ISO9000/BS5750, assessed process specs., or equivalent national system. In special circumstances this requirement may be temporarily waived (with written confirmation) by PA if they are assured that processes or manufacturing have adequate control and monitoring.

8.2.2 Procurement Documents

Contracts, purchase orders etc. shall include a statement indicating the requirement for quality control and traceability and the appropriate standard. Conformance documentation shall be requested and act as a point of entry into the manufacturer's traceability system. If the contractor procures materials it shall be stated in the contract that only "released" materials shall be used and obtained from stockists assessed by a recognised organisation eg. BSI, MOD etc. to ensure traceability.

Note: Items manufactured in-house will be subject to the same controls, traceability will be required and only approved materials and processes will be permitted.

The PA manager will ensure proper witnessing of critical processes, inspections and tests and will ensure that appropriate documentation is provided.

8.2.3 Surveillance of Procurement Sources

Refer to Section 2.5.

8.2.4 Incoming Inspections

Incoming inspections on items procured from outside sources shall be performed to check compliance with applicable requirements by one or a combination of the following activities depending on the criticality of specific parameters for the application of the item and the quality assurance provisions already carried out by or with the supplier:

- review of the Certificate of Conformance and of deliverable documentation with inspection / test results;

- visual inspections for completeness and freedom from obvious damage or deficiencies (also check for lifetime of life limited items);

- sample testing or testing on all items for compliance to the most essential parameters (e.g. interface dimensions of a housing);

- inspection / test of all applicable interface and performance parameters (e.g. on a complete mechanism or sensor).

8.3 Manufacturing and Assembly Control

8.3.1 Manufacturing and Inspection Flow Chart

Low Level Flow charts will not be produced except in particularly critical areas. At higher levels the project schedule will be used to identify KIP's and MIP's.

8.3.2 Surveillance of Manufacturing and Integration

Mandatory Inspection Points (MIP's), Key Inspection Points (KIP's)The project PA manager will liase with consortium groups and ESA to agree on which manufacturing and assembly operations require mandatory or special inspection. These operations will be highlighted on manufacturing and assembly flow charts and suitable arrangements will be made for the observation of all such inspections by a representative of the group involved, the PA manager and ESA. Where necessary specialist observers will be employed.

MIPs may be carried out on the processing and installation of safety critical items and on critical manufacturing and assembly operations where subsequent work will make future inspection difficult or impossible, as well as formal qualification and acceptance tests.

The PI will ensure that ESA receives sufficient notification of proposed MIP/KIP inspections to enable them to be represented
A list of proposed KIP's and MIP's will be available for the TBD.

8.3.3 Calibration of Measuring 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.

8.3.4 Manufacturing Records

Manufacturing records ((Ref. Fig. 8)) shall be kept up to the commencement of assembly logbooks, thus providing traceability from incoming inspection through fabrication, assembly, integration and test and provide the capability of tracing backwards to the items from which fabrication originated. Manufacturing records are not deliverable. Logbooks will form part of the Acceptance Data Package (ADP).

8.4 Integration and Test Control

8.4.1 AIT Planning

A performance verification programme shall be conducted to ensure that the experiment meets the specified requirements. The programme consists of a series of functional and analytical demonstrations, physical property measurements and environmental tests that simulate the environments encountered during handling and transportation, pre-launch, launch and in-orbit flight, testing will be carried out at component, instrument subsystem and system level
Instrument qualification will be carried out using prototype, structure and engineering models, all flight and flight spare hardware will be subject to acceptance testing.

Test plans / procedures and reports shall be written to support the above.

8.4.2 Test Procedures/Facilities/Witnessing, Pre-test / Post-test Review/Test Reports AIT Plan

An AIT Plan shall be written to cover all the test requirements for the development, qualification and acceptance test phases for the different models and details of the following shall be given:

- GSE hardware configuration

- Test Objectives
- Test Parameters
- Test Sequence
- Acceptance / Rejection criteria.
- Test equipment and accuracy required
- Test Facitities involved Hazards
- Cleanlinesss of integration / test facilities

.

Critical development tests and formal qualification and acceptance tests shall be monitored or witnessed by quality assurance personnel to ensure that applicable procedures are followed without errors, that adequate records of the activities and test results are taken, and to document any deficiencies and non-conformances which are encountered and to initiate corrective and preventative actions are recorded.
Before the start of formal qualification and acceptance tests a test readiness review should be held with attendance of quality assurance personnel to determine the following:

- the as-built configuration status of the test specimen conforms to the released design baseline or potential differences are acceptable and documented;

- status and acceptability of previous non-conformances, failures, Requests for Waivers / Deviations, open work;
- availability and approval status as applicable of test procedures;
- readiness of test facility (e.g. cleanliness) and test equipment (e.g. calibration status checked);
- assignment of responsibilities during the test.

After major portions of qualification and acceptance tests (e.g. at the end of EMC tests and at the end of vibration tests) a post-test review should be held to determine that:

- all required data records are complete and at least a HERSCHEL assessment has been made to determine whether the parameters were within required limits;

- non-conformances / failures have been recorded and at least initial dispositions affecting continuation / completion of the test have been made by the appropriate Material or Failure Review Board;

- all deviations from or modifications to the initial test procedure which had to be made during the test were properly authorised;

- all portions and steps of the applicable procedure have been completed, the test specimen and test equipment have been brought into a safe conditions and the test set-up can be dismantled.

A test report containing the following has been provided:

- summary of test results
- an evaluation of test results
- a list of non-conformances raised during test
- the as-run filled in test procedure
- facility test data (e.g. vibration plots, vacuum/temperature figures during text).

Ref. Appendix C Figs 19 a/b/c.

ESA will monitor or witness some of the formal qualification and acceptance tests and participate in some Test Readiness Reviews and Post Test Reviews. ESA shall be notified at least one week in advance of the Test

Readiness Review at the start of environmental tests, EMC tests and interface verification tests. Test procedures should be available at least 1 month before the start of the test.

8.4.3 Logbooks

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 C Fig. 3);

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 C Fig. 4):

- operating time/cycle record for limited life items
- and as applicable connector mating records
- age sensitive items records
- pressure vessel history log
- temporary installations record
- open work/deferred work records

Ref. Appendix C for selection of standard forms.

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 instrument log book will form part of the Acceptance Data Package which will accompany the instrument at the time of acceptance / delivery (Section 11).

Printed Circuit Boards

Design rules shall follow guidelines recommended by ESA/NASA to ensure high reliability (ESA: PSS-01-710 (RD23). NASA: NHB5300.4 (31)) including the placement of a test pattern on each board.

Printed circuit boards shall be manufactured by a facility which has a minimum capability approval under BS 9761 for multi-layer boards and BS 9762 for double-sided boards. Or other national equivalent.

Solder resist coatings and component placement labelling shall not be used. Base laminates shall be woven glass re-inforced epoxy resin, NEMA grade FR4 or equivalent.

The test pattern on each board should be microsectioned to allow inspection of the plating quality on the surface and in through plated holes.

NB: Boards should be considered limited life items and be inspected and loaded as soon as possible after manufacture. If not they must be stored in dry distortion free conditions, and if not used within 6 months of manufacture pass a solderability test HERSCHEL.

All boards to be conformal coated after loading and test.

NB: Coated boards must not be handled with fabric gloves.

8.4.4 Wiring Standards

Loading of printed circuit boards electronic wiring or permitted rework shall only be carried out by personnel trained and certified in space wiring techniques as defined in ESA: PSS-01-708 (AD16), PSS-01-728 (AD15) and PSS-01-726 (AD17) or NASA equivalent. Work shall only be carried out at workstations which comply with project cleanliness requirements and follow the recommendations of Para. 8.4.6 regarding protection against damage from electrostatic discharge.

8.4.5 Electrostatic Discharge Control

Electrical and Electronic Parts, assemblies and equipment susceptible to damage caused by static electricity shall be handled in accordance with BS 5783: 1987 "British Standard Code of Practice for Handling of Electrostatic Sensitive Devices", or national or Agency equivalent.

8.5 Handling, Storage, Packaging, Marking, Labelling and 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.

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.

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.

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.

8.6 Non-conformance Control

The consortium and their contractors and suppliers shall operate a Non-conformance Control System which will provide a disciplined approach to the identification, segregation, reporting, review, disposition, analysis, corrective action, re-verification and prevention of recurrence of confirmed or suspected non-conformances or failures. It will cover manufacture assembly and test of qualification and flight standard hardware, checkout and flight software, and any GSE interfacing with the above.
When a non conformance or failure is detected during any of the above actives it shall be recorded on a suitable form and allacated a unique sequential number which shall be recorded in a register with the details of the non conformance and its current status. The register shall be made available for periodic inspection and copies provided as necessary.

8.6.1 Non-conformance Classification

Non-Conformances shall be classified MAJOR (LEVEL 1) or MINOR (LEVEL 2). The definition of MAJOR and MINOR non-conformances shall be as follows

Major non-conformances are non-conformances, or failures, which may affect:

- Approved design requirements with respect to form, fit, function, performance, materials and safety as specified in applicable design requirement specifications.

- Approved configuration baselines.

- Approved test requirements and procedures (which includes formal qualification and acceptance tests with vibration, thermal vacuum and EMC).

- Approved Interface Control Documents.

ESA reseve the right to participate as voting member on the MRB for all Major NCRs at intrument level and to invite experts to participate in the failure analysis and MRB

A MINOR non-conformance is a non-conformance, which does not affect any points on any of the above. It is of inconsequential nature as regards the requirements and does not influence fitness-for use and safety, or is trivial with regard to workmanship criteria applicable to deliverable items.

The contents of MINOR non-conformance reports shall be the same as for MAJOR non-conformance reports. They shall be dispositioned by local MRB and kept under QA control. Minor NCR's shall be made available to ESA for review as requested, eg. at the times of Mandatory Inspections, Test Readiness Reviews or Acceptance Reviews.

SOFTWARE non-conformances shall be dispositioned and processed as hardware non-conformances. Non-conformances found during formal acceptance testing of flight and checkout software shall be regarded as MAJOR non-conformances.

Non-conformances found during formal acceptance testing of deliverable GSE shall be regarded as MAJOR non-conformances if they cannot be corrected and re-verified before the end of the acceptance tests.

8.6.2 Non-conformance Reporting and Disposition

When a non-conformance or failure is detected during an inspection or test or during any other activity it shall be recorded on a suitable form and allocated a unique number from the NCR register maintained by the PA Dept All affected bodies shall be informed.
A Material Review Board (MRB) shall decide what action to take.
The Material Review Board shall consist at least of one representative of the Product Assurance Organisation and one representative of the Engineering Organisation. Specialists may be invited and consulted and representatives of other organisations may also participate as necessary in the MRB.

The MRB shall determine:

- the cause of the discrepancy, with the help of experts or outside organisations;
- the disposition with corrective and preventive actions including:

“scrap”
"use as is": If a formal specification requirement remains violated, preparation and acceptance of a Request for Waiver or a specification change (Appendix C Figs. 15,16) may be recommended. They are both subject to approval by the appropriate "Change Control Board", see Configuration Control procedures (Section 10);
"repair": (Standard or non-standard methods to be defined.)

"change / modify: the design" (Engineering Change Requests are subject to separate approval);

preventive and corrective actions which may also be necessary for other models or similar items;

re-verification to be performed after repair or modification which may consist of re-inspection, re-test (a late modification may also affect the validity of previous qualifications tests) and updating of previously established design analyses.

8.6.3 ESA Involvement in Major Non-Conformances

Non-conformances affecting interfaces with the Spacecraft or ESA requirements defined in the HERSCHEL Requirement Specification are regarded as major and are to be reported to ESA within 72 hours of the discovery of the anomaly. Copies of the non-conformance report are to be supplied to ESA on completion of all actions and on request at earlier stages (likely to be requested only for major anomalies).
The non-conformance register listing all NCR’s will be available at project progress meetings for viewing by ESA if required, copies of lower level NCR’s will be provide on request, and will be contained in the ADP.

Fig. 1 shows the NCR procedure flow chart.

8.6.4 Non-conformance Close Out

The cause of the discrepancy and the dispositions and actions agreed by the MRB are to be documented on the Non-conformance Report (Appendix C Figs. 6/7) or in associated MRB minutes. Quality Assurance personnel shall verify the completion of all actions and re-verification defined by the MRB 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.

8.7 Alerts

The RAL Space Science Department PA Group are recipients of NASA alerts, it is anticipated that they will also receive ESA alerts if and when they are generated. These will be screened by the PA Group using project parts lists before being distributed to Co-Investigators/sub contractors for further evaluation.

9. SOFTWARE PRODUCT ASSURANCE

9.1 General

For software (flight and test/checkout software), the Investigator shall prepare and implement a product assurance programme including the following:

Responsibilities for software development and verification and the relationship to other organisational elements shall be clearly defined.

Software standards and specifications shall be checked to assure completeness of performance and interface-requirements, and of all operational and environmental constraints.

Software verification shall be carried out including reviews, audits and formal acceptance testing in which compliance to all applicable requirements shall be demonstrated.

Potentially critical failure effects caused by software errors shall be analysed in the framework of the FMECA, Ref. Para.6.2.

Configuration control shall be exercised on requirements specifications, design documentation, source listings and test-plans, procedures and reports and it shall include labelling and version control of software carriers.

Software shall be subject to non-conformance control as defined in para.8.6.

Documentation shall be supplied with the software for acceptance.

Standards will be tailored to project requirements and be consistent with the cost/reliability aims of the project . They will be described in a number of technical documents and plans, which may be combined into a single document where appropriate.

9.2 SOFTWARE PRODUCT ASSURANCE ACTIVITIES

The on-board and ground support equipment software shall be developed and documented using methods which promote visibility, reliability and testing.
In general the software production will be grouped into phases which may be described as a life cycle, the various phases of the life cycle will usually occur sequentially, however occasionally overlap will occur.

The stages of the life cycle are:-
requirements definition
architectural design
detailed design
coding
verification
operation and maintenance

Plans must be established for:

* Software project management.
* Software configuration management.
* Software verification and validation.
* Software quality assurance.

Technical documents will be required to describe:

* User requirements.
* Software requirements.
* Architectural design.
* Detailed design.
* Software user manual.
* Software transfer document.

Note: Documents may be combined where appropriate.

9.2.1 Planning

Software management plan

The software project management plan is the controlling document for managing a software project and defines the technical and managerial project functions, activities and tasks necessary to satisfy project software requirements. It should described the organisation, work breakdown and schedule for each development phase.

Software configuration management plan

Software configuration management is essential for control of a software product. The software configuration management plan should define the method of:

identifying and defining the configuration items in a system;
controlling the release and change of these items throughout the system life cycle;
recording and reporting the status of configuration items and change requests;
verifying the completeness and correctness of configuration items.

Software verification and validation

Verification is essential to ensure the product is fit for its purpose; validation is the evaluation at the end of the development process to ensure compliance with user requirements. The verification and validation plan should state the procedures for testing the software and verifying that the products of each phase are consistent with their inputs.

The plan shall address the following:

Module tests - Exercising code
- Control paths
- Data access
- Calculations
- Corrupt data response

Hardware/software interface tests:

- I/O status
- Error indicators
- Timing
- Response to single event upsets (bit changes)
- Latch up recovery (if appropriate)
- Operational System tests

Software Quality Assurance

The quality assurance activity is the process of verifying that the standards are being applied. In a small project it may be carried out by the development team.

The software quality assurance plan will define how adherence to the standards will be monitored.

9.2.2 Technical Documents

User Requirements Document

The document shall be prepared by the contractor based on the work package requirement specification and applicable documents referenced therein and discussions with the Project.. This will be an iterative process ensuring all the requirements are understood. The document will be used as the reference against which the delivery acceptance test is performed.

Software Requirements Definition

The software system functional and interface requirements will be defined in this document and include:

- Timing requirements
- Hardware/software interfaces
- Software/software interfaces
- User interfaces (EGSE)
- Resources: Memory, CPU capability, Network capability etc.

- Patching requirements (onboard)

The contents of this document shall be referenced back to the user requirements document.

Architectural Design Document

This document will specify the 'physical' implementation of the software system including:

- Language, compilers, assemblers etc.
- Hardware/software system block diagram
- Software structure tree
- Module descriptions
- Data Structures
- Control and data flow
- Timing diagrams
- CPU Loading
- Memory usage

Module/component listings derived from the Architectural Design shall be used to provide traceability backwards to the requirements and forward into the configuration control of developed software.

Detailed Design Document

Detailed design and code listing of each module including:

- Module name
- Revision number
- Revision Date
- Module Function
- Data accessed
- Parameters transferred
- Position in module hierarchy(i.e. called and called-by modules)
- Critical timing characteristics
- Change record
- Verification test results

The coding shall be adequately commented and assembly language code shall be described in pseudo-high level language.

Software User Manual

The manual shall include sufficient information to enable the user (EGSE operator or Instrument system engineers) to understand the system using this document alone.

The contents may include:

- System overview
- Operation description
- Instructions and responses
- Constraints
- Error conditions and actions

Software Delivery Package Document

This will identify the software being delivered and will form part of the Acceptance Data Package (Ref.: section 11.1).

9.3 Design Reviews

The software shall be reviewed in conjunction with the equipment design reviews.
In addition 'walk-through' reviews shall be organised as part of the system and module development programme.

A formal set of acceptance tests referencing the user requirements document shall be agreed with the project.

9.4 Hardware/Software Interaction Analysis (HISA)

FMECA shall be extended to cover a Hardware/Software interaction analysis, the objective being to ensure that the hardware failure modes identified in the FMECA are taken into account, and also to ensure that any software failure modes cannot have a catastrophic effect on the instrument or propagate through into the spacecraft.

9.5 Status and Progress Monitoring

Software development/progress shall be reported at regular project progress meetings.
The development shall be documented using the software structure tree format with each module represented with the following information

- Module Name
- Status e.g. Not started
  Designed + date
  Coded + date
  Tested + date
- Revision Number
- Revision Date

10. CONFIGURATION MANAGEMENT AND CONTROL

10.1 General

The instrument and associated test equipment will be defined by a set of specifications and drawings etc. These documents shall be updated to reflect the current configuration of the equipment. The process of changing the equipment design shall be controlled by the formal procedure described in section 10.2. These activities are applicable to both hardware and software.

A person shall be identified as responsible for configuration control to ensure the implementation of the following system.

10.2 Configuration Control System

The baseline design shall be established by a set of design documents approved by the Project. It will be derived from the hardware and software used for qualification purposes. The baseline will be updated as the design and test programme progresses. A Configuration Status List shall be prepared which identifies the documents and their current issue. The list shall reflect the history of the design showing the dates of all the revisions and reference the Engineering Change Proposals.

To change the baseline design the following actions shall be taken:

- Engineering Change Proposal submitted to the configuration manager

- Configuration Manager will convene a Change Control Board of project personnel from appropriate disciplines and affected systems to assess the change and its possible repercussions. Where spacecraft or system interfaces are affected the prime contractor, ESA and spacecraft engineers will be represented as necessary.

If approved:

- Identify documents affected by the change
- Update documents and reissue with approval signatures.
- Update Configuration Status List
- Implement Change

(Ref. Fig. 4 for Change Procedure).

If a requirement specification cannot be changed a waiver may be requested against the particular requirement.

An 'As-built' Status List giving the current configuration shall be presented at the major milestone reviews. e.g. Test readiness, Qualification, Acceptance, Flight Readiness and will form a section of the acceptance data package delivered with each model (ref. section 11).

All verification documents including design analyses and test reports must make reference to the current configuration status of the design being evaluated.

Configuration control will be applied to all models used for qualification purposes, flight and flight spares and GSE used with any of the above.

10.3 Configuration Identification

The instrument and the major subsystems within the instrument which have readily identifiable mechanical and electrical interfaces with each other, MGSE, EGSE or the payload are categorised as Configuration Items.

The hardware items shall be given a configuration identity number and name thus providing the HERSCHEL link in the chain of traceability, down through logbooks, test/assembly and manufacturing records to individual part drawings.

Where size permits hardware shall be permanently labelled with the serial number, name and model identification.

10.4 Documentation Management

The documentation numbering system defined in **TBD** shall be used, (Ref. Fig 5 for Summary.)

A project register and copies of all configuration controlled documents and interface and general assembly drawings shall be maintained by the RAL HERSCHEL Project Office on a project database (TBC). Consortium Members and/or their Sub-contractors shall also maintain a list of all documents and drawings related to their work packages and shall be responsible for communicating changes, revisions, etc. to the RAL Project Office, using Engineering Change Proposals where the baseline design is affected.

11. ACCEPTANCE REVIEW, ACCEPTANCE DATA PACKAGE

Acceptance Review Board (ARB)

Upon completion of final tests and inspection and before shipment of a deliverable item a review will be held covering all deliverable documentaion, hardware and software items.The object of this board is establish that there is adiquate documentary evidence to demonstate that the product satisfies all the requirements.
The ARB shall compose of the following members or nominated representatives
:
Project Manager
PA Responsible
Representatives from ESA and HERSCHEL SPIRE project team (TBD)

The ARB shall cover the following points under the headings:
Software
Hardware
EGSE

All listed below(The Acceptance data package will provide most of the data for the review and will be part of the review and deliverable item).

11.1 Software

1 Shipping Documents
2 Identification and handling procedures for S/W carriers
3 DRB-MoM, Open Work, Deferred Work, Open Tests
4 Certificate of conformance
5 Historical Records and S/W Inspection Reports
6 Software Configuration status list
7 Waiver summary list
8 Copies of Software Waivers
9 Non-conformance summary list
10 Applicable non-conformance reports
11 Software Test Plan
12 Software Test Reports
13 Software manuals (inc. User Manual)
14 Temporary modification (patches)
15 Supporting Documentation

- Source Listings
- Index of Directories and Files
- URD, SRD, ADD
- Algorithms-TN

11.2 Hardware (Inc MGSE)

1. Shipping documents/ photographs.
2. Procedures for transport handling and installation.
3. Certificate of conformance.
4. Qualification status list.
5. Top level drawings including drawing tree.
6. Interface drawings.
7. Electrical circuit diagrams.
8. Configuration status list.
9. Serialised component list.
10. List of waivers.
11. Copies of waivers.
12. Operations manual.
13. Historical record.
14. Logbook/diary of events.
15. Operating/time cycle record.

16. Connector mating records.
17. Age sensitive items record.
18. Pressure vessel history/test record.
19. Calibration data.
20. Temporary installation record.
21. Open/deferred work and tests.
22. List of non-conformance reports.
23. Copies of major non-conformance reports.
24. Test reports.
25. Proof load certificates.
26. Reference list of lower level ADP's
27. Other useful information: * mass properties/ Power Budget
    * cleanliness statement
    * compliance matrix.

11.3 EGSE (Including GSE Software)

1. Delivery Certificate.
2. List of Waivers.
3. Copies of Waivers.
4. List of Non-Conformances.
5. Copies of Non-Conformances
6. Configuration Status List.
7. Details of Hazards associated with Equipment.
8. Maintenance Instructions/Manuals.
9. Index for Directories and Files.
10. Open Work.
11. Temporary Modifications (Patches).

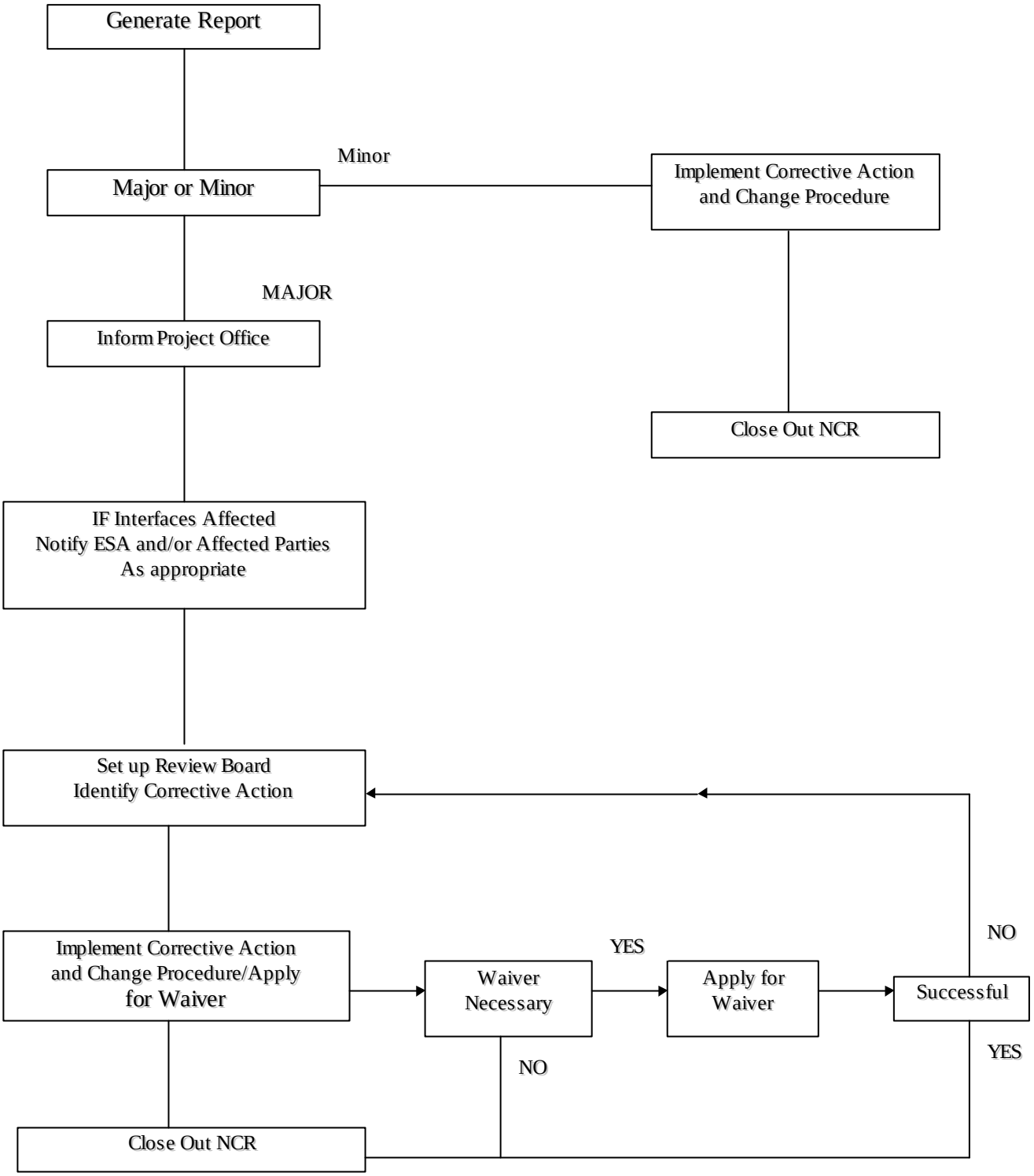


FIG. 1 NCR PROCEDURE FLOW CHART

TBW

FIG. 2 DOCUMENT TREE

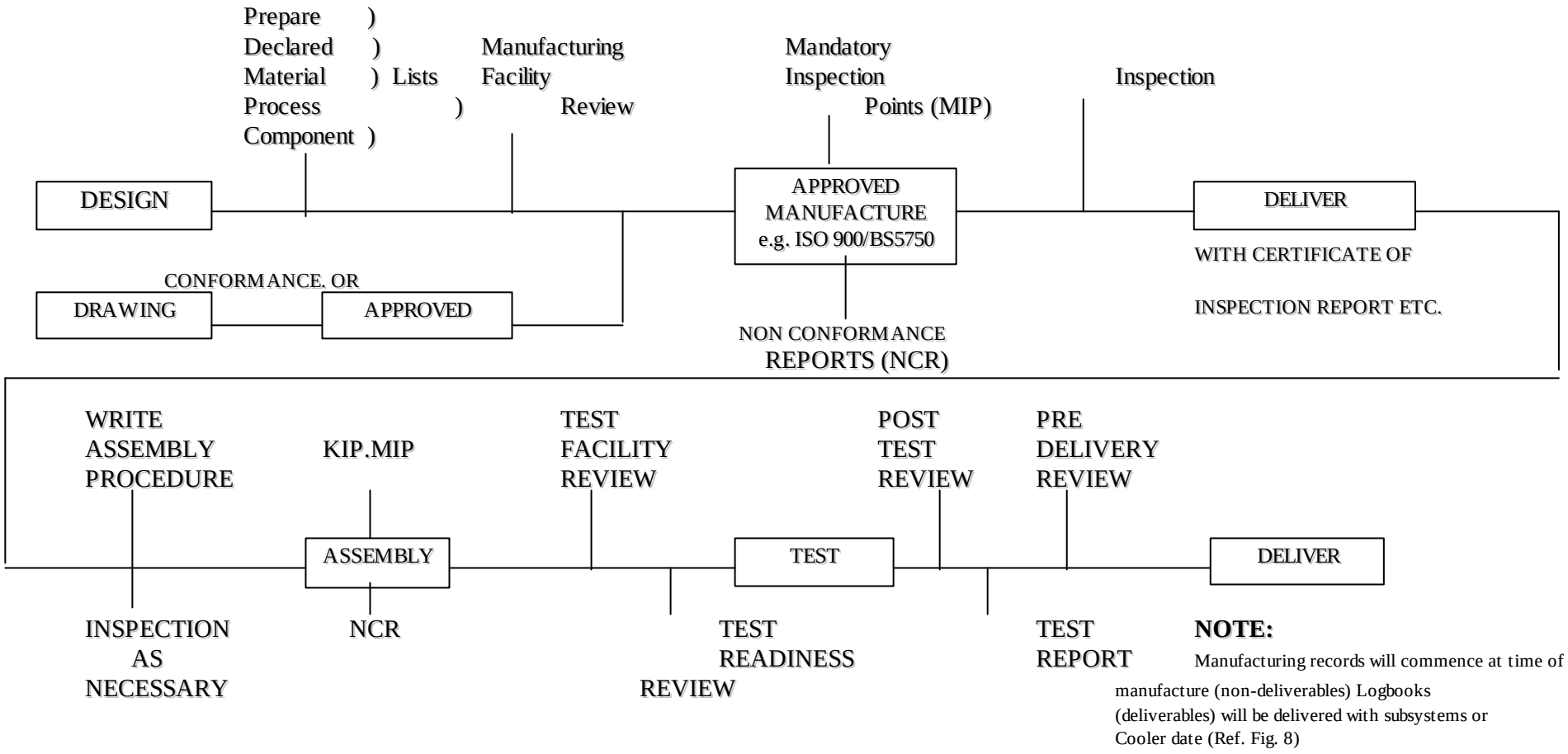


FIG. 3 PA REQUIREMENTS IN DESIGN, MANUFACTURE, ASSEMBLY AND TEST SEQUENCE
(To be read in conjunction with Fig. 8)

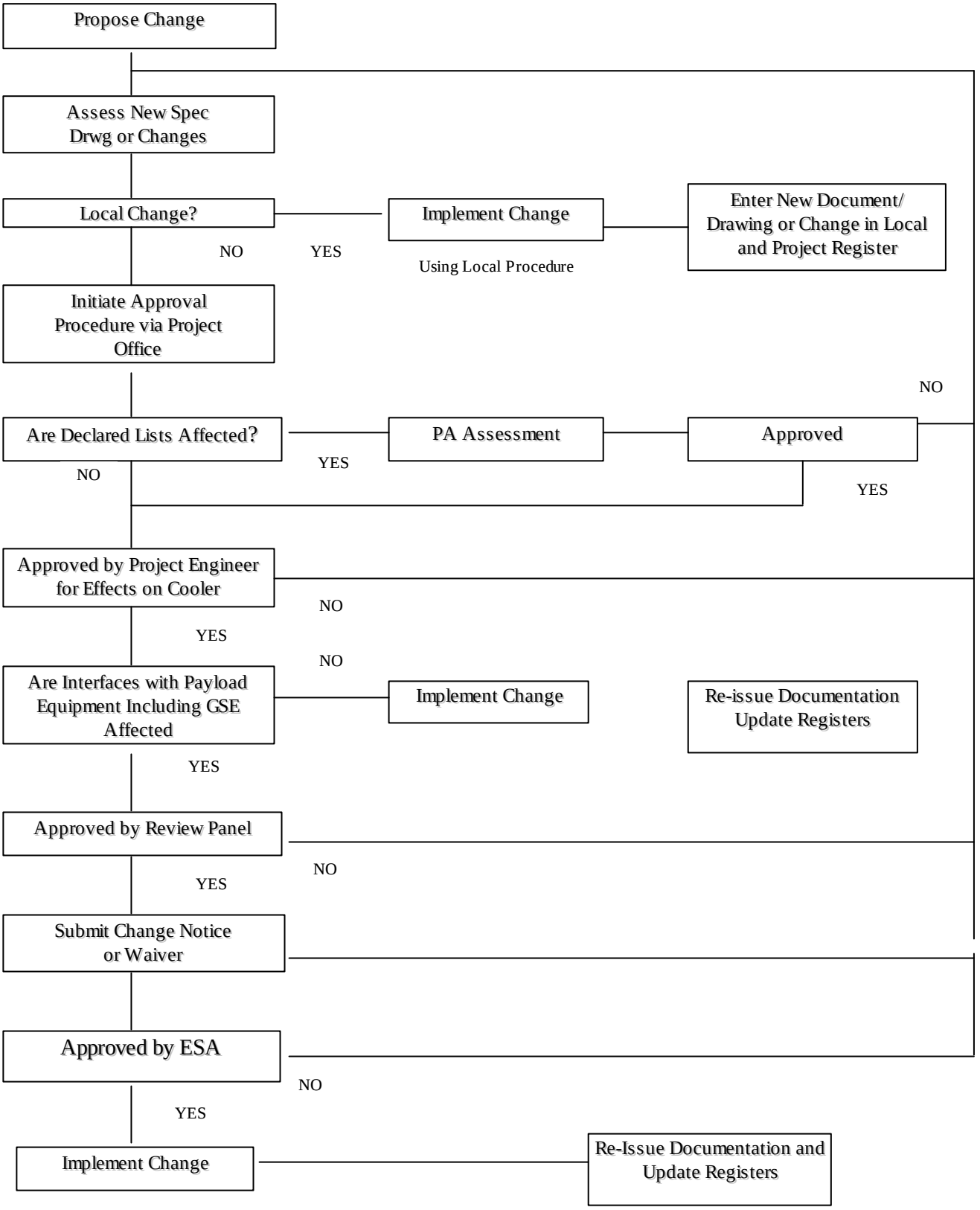
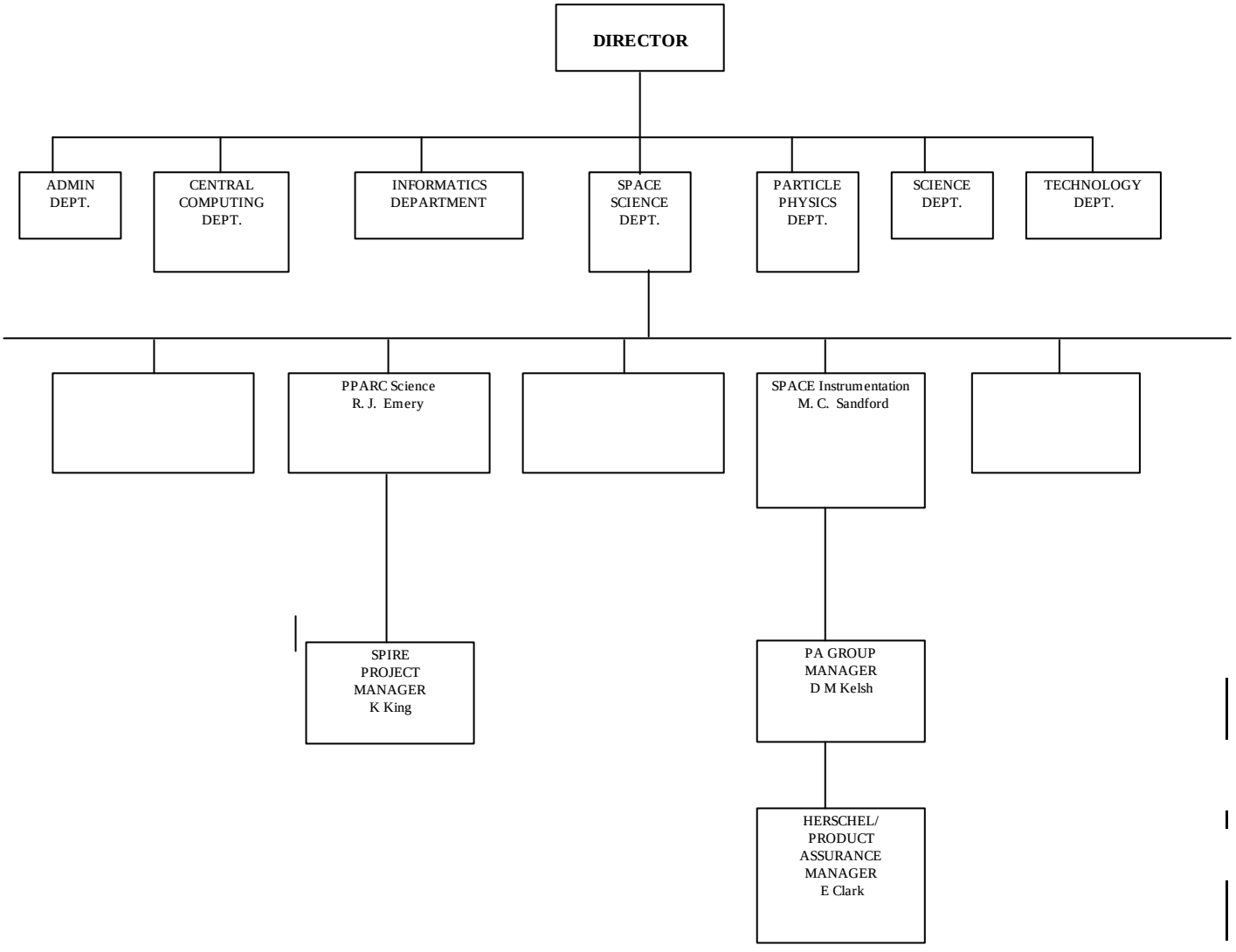


FIG. 4 DOCUMENT CHANGE APPROVAL PROCEDURE FLOW CHART

FIG. 5 DOCUMENTATION/CORRESPONDENCE NUMBERING SYSTEM (TBD).

REFER TO SPIRE Management Plan (TBD).

FIG. 6 HERSCHEL MANAGEMENT STRUCTURE



Note: SSD PA Group manager has direct line to SSD Department Head if required.

FIG. 7 RUTHERFORD APPLETON LABORATORY ORGANISATION

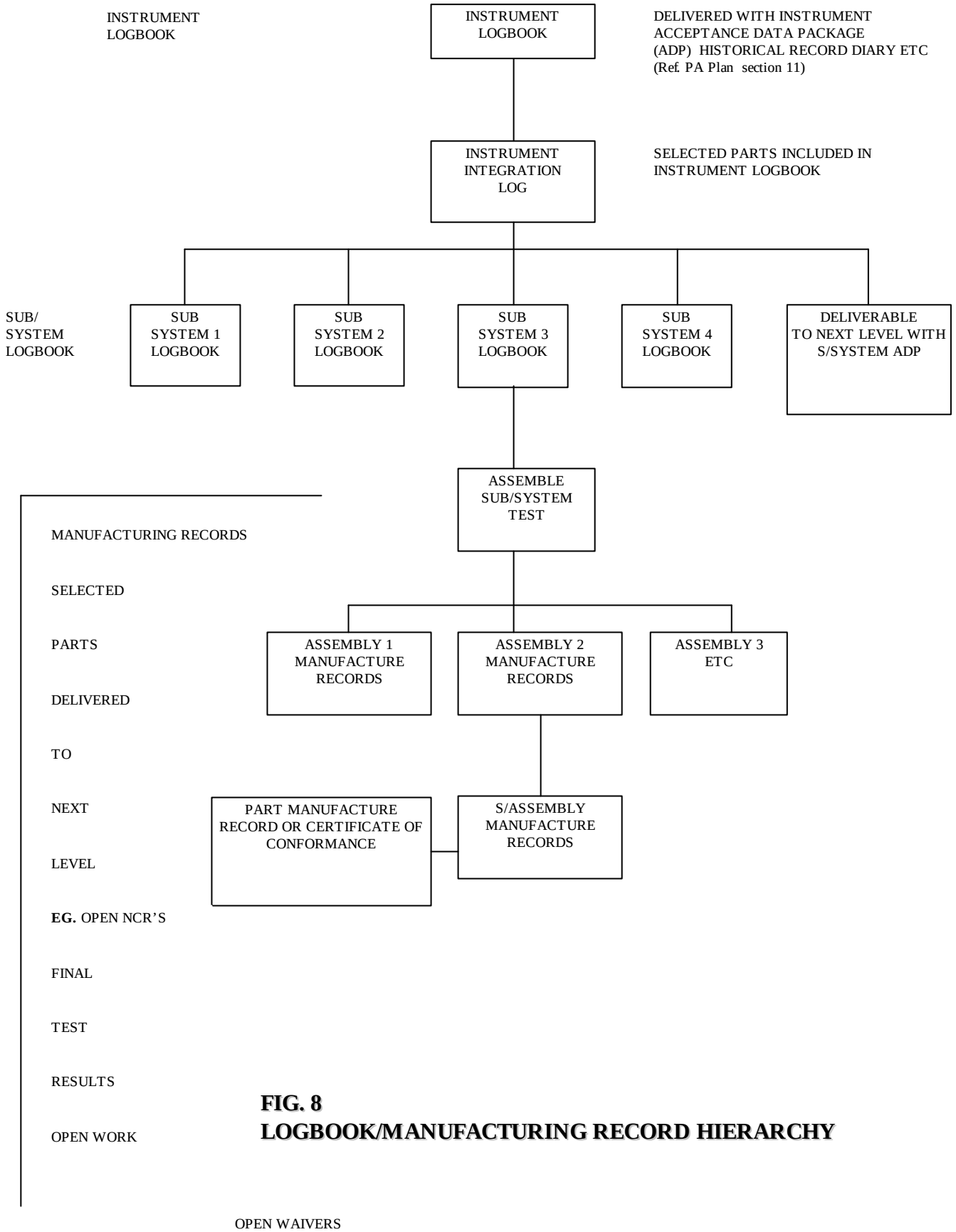


FIG. 8
LOGBOOK/MANUFACTURING RECORD HIERARCHY

SPIRE

PRODUCT ASSURANCE PLAN

APPENDIX B

TITLE: CLEANLINESS PLAN

This cleanliness plan provides a minimum standard for contamination control.

A project Cleanliness Control Plan (TBW) detailing the specific requirements will eventually supercede Appendix B

CONTENTS

7. CLEANLINESS MONITORING

7.1 Methods

7.1.1 Particulate Contamination
7.1.2 Organic Contamination
7.1.3 Inorganic Contamination

8. CLEANING

8.1 Equipment
8.2 Solvents

9. PACKAGING AND STORAGE

9.1 Instrument
9.2 Subsystems
9.3 Packaging Materials
9.4 Labelling

1. SCOPE

This document specifies the standards and practices to be employed in the design, manufacture, assembly and test of the HERSCHEL/SPIRE Instrument to achieve the required cleanliness. It is intended as a preliminary document identifying the methods to be used. An analysis will take place and as specific cleanliness requirements are identified this document will be subsumed into its replacement which will become the sole project cleanliness plan. (Document To Be Written.)

1.1 General Requirement for HERSCHEL/SPIRE.

Although the SPIRE instrument can accept a reasonably large degree of particulate contamination, the analysis here shows that, in order to maintain the optical throughput per surface >99% some caution is required in their handling

1.2 Target Levels

1. Use at least class 1000 laminar flow environments wherever possible when assembling and aligning the optical system. Wherever possible class 100 laminar flow environments are preferred for bare optical elements.
2. Where this is not feasible the maximum allowed cleanroom class is 10000 and the exposure of any optical surface should be no more than one day.
3. When the instrument is stored for prolonged periods of time (>1 day) with optical elements exposed it must be in a class 100 laminar flow environment or equivalent (vacuum chamber or suitable cover)
4. Particle counters and witness mirrors must be provided in all environments where bare optics are exposed.
5. Whatever the general cleanroom class in which the instrument is held, all operations carried out on the optics or in the vicinity of the optics should be done by personnel with cleanroom standard coat; hat; shoes and gloves. Facial hair must also be covered with a mask.
6. When optical elements have been exposed to non-clean (i.e. class >1000) environments they should be inspected and, if necessary, particulate contamination removed using dry nitrogen gas to blow the contamination away in a safe direction.
7. Structure and other non-optical surfaces that have been exposed to non-clean environments must be inspected and, where necessary, cleaned before introducing optical elements into their vicinity.
8. Once the instrument is fully integrated and with a cover fitted to the optical aperture to protect the input filter, it may be exposed to relatively dirty environments without affecting the performance of the instrument. However it is not recommended that environments greater than class 10000 are used for prolonged periods of time as particulate contamination on the outside of the instrument may find its way to the inside following removal of the cover. The instrument should be inspected following prolonged (>1 day) exposure to class>1000 and, if necessary, the outside cleaned by blowing off particulate contamination using dry nitrogen.

1.2.1 Molecular Contamination

No significant degradation of performance with thickness of MIL-STD-1246B Level .

Time to achieve the above in:-

a) Normal clean room with contamination rate of 2 x 10^{-7}g/cm^2/week TBC.

b) Clean TV facility with contamination rate of 1 x 10^{-7}g/cm^2/24 hour TBC.
Note: Above figures taken from ESA:PSS-01-201.

1.2.2 Particulate Contamination

No significant degradation of signal will occur with an obscuration figure of uniformly distributed.

Max particle size (TBD) (visible under high intensity bright white light 10-30 cm from surface). (TBD)

A single particle of (TBD) diameter may seriously degrade the performance.

Time to reach e.g. 1000 (or 1% obscuration) ppm in

a)	Class 100	6666 days	18 years
b)	Class 1,000	833 days	2.3 years
c)	Class 10,000	166 days	-
d)	Class 100,000	4.4 days	-

1.2.3 Philosophy (TBC)

If it looks clean under good lighting it is acceptable.
If it looks dusty (just visible) clean it.
It will be cleaned prior to delivery for integration and at the last possible moment after integration.

Covers will be fitted at all times other than when necessary to remove for testing. Witness mirrors will be mounted in the inside surface of the main cover to monitor molecular contamination. Two mirrors, one for cumulative dose the other to monitor individual tests. (TBC).

1.2.4 Summary

Molecular

- on delivery to integration facility (TBD)
- at launch (TBD)
- end of life (TBD)

Particulate

- on delivery to integration facility (TBD)
- on launch (TBD)
- end of life

2. RELATED DOCUMENTS

ESA PSS-01-201	Contamination Control
ESA PSS-01-205	Guidelines for Spacecraft Cleanliness
ESA PSS-01-701	Guidelines for Space Materials Selection
NASA SP-50576	Contamination Control Handbook
MIL-HDBK-406	Contamination Control Technology
JSC 08962	Compilation of VCM data of non-metallic materials
FED-STD-209B	Clean Room and Work Station Environments
MIL-STD-1246b	Product Cleanliness Levels and Contamination Control Program.
TBW	HERSCHEL/SPIRE Cleanliness Control Plan

3. MATERIAL

3.1 Outgassing

Materials shall be chosen for their low outgassing properties.

General Criterion as measured by the micro-VCM test

Total Weight Loss (TWL) < 1%
Collected Volatile Condensable Materials (CVCM) < 0.1%

In more critical areas the more stringent requirement of TLM<0.1% and CVCM<0.01% may be necessary.

Condensable outgassing products of materials visible to the optical elements and detectors may degrade their performance.

Materials shall be carefully selected taking into account:

- CVCM
- Outgassing products
- Quality of material
- Outgassing timescale
- Proximity to sensitive surfaces

NOTE: Volatile metals, e.g. cadmium and zinc will not be used.

3.2 Pre-Outgassing Treatment

Units or parts likely to produce significant outgassing contaminants in orbit or require a high degree of cleanliness before assembly will be subjected to a pre-outgassing operation (i.e. bakeout). The temperature, vacuum and time required for this operation will be assessed for each unit or part. A minimum of 24 hours under space vacuum at a temperature in excess of the expected exposure, but below the recommended maximum for the material in question would normally suffice.

Examples of possible candidates are

- harness
- multi-layer blankets
- electronics boxes
- painted surfaces

3.3 Gases

Purge gas - Dry Nitrogen Specification TBD.

4. INSTRUMENT DESIGN

4.1 Accessibility for Cleaning

As the assembly and integration of the instrument proceeds the internal parts will become less accessible for cleaning and the degree of cleanliness control will need to be increased. To avoid the operational penalties of a high degree of control the instrument design shall take into account cleaning operations to remove particulate, organic and inorganic contamination.

4.2 Venting

All enclosed volumes, e.g. electronics boxes and component packaging, shall either be hermetically sealed or venting holes shall be provided. The total minimum area of the venting holes will be calculated as follows:

Area = f x volume
where = $f = 0.0001\ cm^2/cm^3$

in order not to exceed EMC requirements hole diameter should not exceed 4mm. All honeycomb type of materials used shall be perforated to allow outgassing. The open sides of the honeycomb structure shall be covered by perforated tape to prevent ingress/egress of dust.

4.3 Configuration for Low Contamination

The organic contamination of the sensitive elements of emissions from surrounding units or structure can be minimised by ensuring the material visible to the elements generates negligible outgassing products.

The location of vent holes shall be arranged to direct potential contaminants away from sensitive surfaces, or close to the box bottom if possible and spaced as wide apart as possible.

5. MANUFACTURE, ASSEMBLY, INTEGRATION AND TEST

Details of the contamination control and monitoring operations to be implemented at each stage shall be included in the appropriate procedures.

5.1 Facility Environment

Throughout all stages of instrument construction an environment suitable for each operation shall be maintained. There shall be careful controls during procedures requiring changes of environment. The facilities shall be screened before use to ensure the required standards can be achieved and appropriate cleaning operations shall be carried out at the facilities on a routine basis to ensure the standards are maintained.

5.1.1 Particulate Contaminants

Operation	Cleanliness Standard (Fed. Std. 209B)
Detector Assembly	100 (TBC)
Optics Assembly	TBD
Structure Assembly	1000,000
Multi-layer Insulation Fabrication	100,000
Instrumentation, Integration and Test:	
Optics exposed	100 (TBC)
Instrument covers removed	TBD
Optics/Detectors covered	1000,000
Instrument covers in place	TBD

The instrument will be fitted with a cover that will be removed before flight (TBC).

The facilities will be monitored at regular intervals (see Section 7).

5.1.2 Organic Contaminants

Facility Acceptance Limits
- Clean Room 2×10^{-7} g/cm^2/week
- Vacuum Tank 1×10^{-7} g/cm^2/24 hour

Vacuum facilities shall use clean pumping systems e.g. cryopumps, turbo-pumps. Where this is not possible cold traps shall be used. Vacuum tanks shall be back filled with dry nitrogen when let up to atmospheric pressure.

Facilities shall be tested for organic contaminants using a surface wipe technique and/or witness mirrors or windows (see Section 7).

5.1.3 Inorganic Contaminants

The acceptability of the level of inorganic contaminants will be assessed by visual inspection.

Examples of inorganic contamination
- corrosion products
- finger print transfer
- solder fluxes.

5.1.4 Temperature

Clean Room Temperature: 20 ± 5^{o}C.

5.5.1 Relative Humidity

Clean Room Humidity: 30-65%.

5.2 Processes

The manufacturing processes shall not produce significant levels of non-removable and possibly corroding contamination. Where necessary processes will be controlled by documented procedures.

5.3 Assembly Tools

A dedicated set of assembly tools and equipment shall be used and maintained in a clean condition.

5.4 Test Equipment

All equipment e.g. handling gear, vacuum tanks, calibration instrumentation, vibration system used for testing the instrument or sub-assemblies will not produce significant levels of non-removable contaminants.

In vacuum facilities cold traps and heaters will be used where necessary.

5.5 Clean Room Control

- All equipment shall be cleaned prior to entry into clean area;
- Lint free coats, head covers and overshoes shall be worn;
- Gloves shall be worn when handling flight equipment;
- Non-shedding paper shall be used and only ballpoint pens used for writing;
- Non clean room paper shall be contained in transparent container;
- When sensitive items are exposed, e.g. optics, thermal control surfaces, mechanisms, the movement of personnel will be restricted with regard to the airflow to avoid contamination.
- When working close to exposed optical surfaces face masks shall be worn.

5.6 Contamination Control Procedures

The precautions, cleaning and monitoring operations required during manufacture, assembly, integration and test will be specified in the procedure document for the particular activity.

6. PURGING

If required, a clean dry nitrogen gas system will be provided to maintain an atmosphere inside the instrument free from water vapour and organic contaminants.

The instrument interior will be flushed with dry nitrogen in the following circumstances:

Storage.
Transport of instrument.
Whenever instrument is in an environment with cleanliness levels below those specified in Section 5.1.

6.1 System Description

Materials	-	As Section 3.
Gas	-	Dry Nitrogen Spec. TBD.
Supply Pressure	-	TBD
Flow Rate	-	TBD
Filtration	-	Better than TBD.

7. CLEANLINESS MONITORING

All controlled facilities shall be tested for contamination before and after use and at regular intervals where possible during use of the facility. The monitoring technique and results shall be recorded in the logbook of the operation.

7.1 Methods

7.1.1 Particulate Contamination

- Visual Inspection.
- A UV light will be used where practicable to enhance detection capability.

- Airborne Particle Counting.

- Light Scatterometer.
  To provide real time assessment of cleanliness.

7.1.2 Organic Contamination

- Visual Inspection.
  A wipe technique with lens tissue may be used to increase sensitivity.

- Witness mirrors or windows.
  Witness surfaces shall be placed in appropriate positions in the vacuum test tank and on the instrument.

The potential degradation of instrument performance due to organic contamination shall be assessed by measuring the scatter from witness mirrors at instrument wavelengths.

An infrared spectrophotometer shall be used to determine the contamination and possible sources.

7.1.3 Inorganic Contamination

- Visual Inspection

8. CLEANING

The cleaning equipment and methods shall not increase the contamination of the items to be cleaned.

8.1 Equipment

Wipes and Brushes - Non-fluffing, dirt and dust free. Organic contaminant level less than 25 ppm - wipes pre-cleaned with solvent.

Vacuum Cleaners - Used with brush or fine soft nozzle.
Filtered exhaust.

Ultrasonic Bath - **MUST NOT** be used for electronic components e.g. mounted on printed circuit board or delicate parts e.g. optics.

8.2 Solvents

The solvents shall be compatible with the materials to be cleaned and for metals not cause corrosion.

The solvents in general use:

Contaminant	Detergent / Solvent
Organic	Surfact UN65
Inorganic	Isopropyl Alcohol

The solvents and cleaning methods will be chosen with reference to the recommendations in the following documents:

ESA PSS-01-201
NASA SP-5076
MIL HDBK-406
MIL-STD-1246

9. PACKAGING AND STORAGE

9.1 Instrument

The instrument will be transported in a container which shall provide the required cleanliness conditions and protection from mechanical damage. The instrument will be flushed with dry nitrogen when necessary e.g. air transport, long term storage
When it is not possible to store the instrument in a clean room it will be packaged and placed in the transport container.

For particularly sensitive instruments a shock monitor should be mounted in the container.

9.2 Sub-systems

When units or sub-assemblies are to be stored for long periods of time or transported they will be put into an air tight bag which will act as a moisture barrier. Bags for contamination sensitive items will be flushed with dry nitrogen. An outer bag shall be used when transporting items and this bag shall not enter controlled clean areas.

When desiccants are used they shall be in bags which are clean and do not produce particulate contamination. Humidity indicators shall be used.

9.3 Packaging Materials

Only approved materials which have been procured as cleaned films will be used:

e.g. Polyethylene
Polypropylene
Kapton.

Static sensitive items shall use metallised films.

9.4 Labelling

All packaged items shall be labelled to provide identification of the item and the environment in which the package may be opened .

SPIRE

PRODUCT ASSURANCE PLAN

APPENDIX C

TITLE: STANDARD FORMS

CONTENTS

The use of the above is not mandatory except where ESA demand it. If a local form exists which adequately covers the requirement it will be acceptable.

ASSEMBLY / INTEGRATION TEST

(INDEX)

PROJECT:			**PAGE:**	
UNIT:				
ITEM:			**DRAWING NO:**	
SERIAL NO:				
DATE	**ACTIVITY**	**NAME**	**SIGNATURE**	**Q.A.**

FIG. 1

ASSEMBLY / INTEGRATION / TEST RECORD

PROJECT		PAGE:
DATE	ACTIVITY	SIGNATURE

FIG 2

EXPERIMENT:	HISTORICAL RECORD			COR ACT	TEST	TRANS	STORAGE	FAILURE	PAGE NO	
UNIT / ASSEMBLY:	DRAWING NO:		SERIAL NO:							

NO	DESCRIPTION OF ACTIVITY / EVENT	TIME From/To	OPERATING TIME	REMARKS / REF. DOC.							PERF .BY	DATE	SIG.	PRODUCT ASSUR.

FIG 3

PROJECT EXPERIMENT	CONNECTOR MATE / DEMATE LOG

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

FIG 4

SPACECRAFT/PROJECT:					**ORIGINATOR:**			
INSTRUMENT:			**MODEL:**		**DOCUMENT NO:**		**ISSUE:**	
SUBSYSTEMS:					**DATE:**			
NCR Serial No.	Level	Subsystem/ Assembly	Model	NCR Title	Issue Date	Actions / Remarks	References	Close Out Date

FIG. 5 REGISTER OF NCR

<table>
<tr><td colspan="3">PROJECT</td><td colspan="2">NON-CONFORMANCE REPORT</td><td>NCR NO:
SHEET:</td></tr>
<tr><td colspan="3">S/SYSTEM</td><td colspan="3">UNIT:</td></tr>
<tr><td colspan="3">MODEL:</td><td colspan="3">IDENT NO:</td></tr>
<tr><td colspan="6">NCR OCCURRED DURING: M/FAC [ ] INSPEC [ ] TEST [ ] INTEG [ ] OTHER [ ]
REF. DOC:</td></tr>
<tr><td colspan="6">NCR TITLE (25 Max)</td></tr>
<tr><td colspan="6">NCR DESCRIPTION:</td></tr>
<tr><td colspan="2">ORIGINATOR NAME:</td><td>DATE:</td><td colspan="3">SIGNATURE:</td></tr>
<tr><td colspan="2" rowspan="2">a) CAUSE OF NCR
b) DISPOSITION/ CORRECTIVE ACTION</td><td>LEVEL</td><td>1
MAJOR</td><td>2
MINOR</td><td>CORRECTIVE ACTION CARRIED OUT NAME, DATE</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">MRB ACTION PARTICIPANTS

NAME: SIGNATURE: DEPT: DATE:</td><td>DATE:
PLACE:</td><td colspan="3">RESPONSIBLE FOR CORRECTIVE ACTIONS</td></tr>
<tr><td colspan="5"></td><td>DISTRIBUTION:</td></tr>
<tr><td colspan="2">ALL CORRECTIVE ACTION CARRIED OUT</td><td>DATE:</td><td>NAME:</td><td colspan="2">SIGNATURE:</td></tr>
</table>

FIG 6

PROJECT	RAL	NCR No. Sheet of Date:

NON-CONFORMANCE REPORT
(Continuation Sheet)

FIG 7

FAILURE MODES, EFFECTS AND CRITICALITY ANALYSIS (FMECA) **ORIGINATOR:**

EQUIPMENT / INSTRUMENT: **Subsystem / System:** **Doc. Number:**
Operating Mode: **Operating / Mission Phase:** **Issue:**
Functional Diagram / Drawings: **Date:**
Page **of**

(a) No.	(B) Item and Function	(c) Assumed Failure Mode	(d) Resulting Performance of and Effects on Equipment / Subsystem / System	(e) Observable Symptoms (Housekeeping, Test)	(f) Prevention or Compensation Methods (back-up, redundancy)	(g) Criticality	(h) Recommendations and Remarks

FIG 8

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) FMECARef. No.	(c) Single Point Failure Critical Component / Function	(d) Failure Effect and Estimated Probability	(e) Criticality	(f) Retention Rationale (References as Applicable)	(g) Remarks

FIG. 9

HAZARD SOURCES, CHECKLIST		ORIGINATOR
SPACECRAFT / PROJECT: SYSTEM / EXPERIMENT: EXPERIMENT:		Doc. No.: Issue: Date: Sheet of
Hazard Source (Potential)	Applicable to Payload Element(s) (e.g Sensor, Boom, Electron. Box)	GES
Hazardous Electrical Systems (e.g High Volt.)		
Electroexplosive Devices (Pyrotechnics)		
Propellants, Solid, Liquid		
Pressurised Items		
Chemical Products - Corrosive (e.g Battery) - Toxic or Asphyxiating - Explosive (also Pyros) - With Biological Effect		
Radiation - Non-Ionising ..... - Ionising ..... - Visible, IR, UV..... - Acoustic / Vibr. Emission		
High / Low (e.g Cryogenic) Temper. (Exposed Surface)		
Deploying Mechanisms		
Other Hazard Sources		

FIG 10

RESIDUAL HAZARD REPORT	
[1] INSTRUMENT/EQUIPMENT/SUBSYSTEM:	Doc. No: Issue / Rev: Date: Sheet: Of
[2] TITLE (Max. 25 Spaces):	[3] HAZARD CATEGORY:
[4] DESCRIPTION OF HAZARD SOURCE AND POTENTIAL EFFECTS OF HAZARD:	
[5] APPLICABLE SAFETY REQUIREMENTS:	
[6] HAZARD CONTROLS AND ACCEPTANCE RATIONALE:	
[7] ATTACHMENTS:	
[8] SIGNATURE ORIGINATOR:	
[9] APPROVALS:	

FIG. 11

DECLARED COMPONENT LIST **ORIGINATOR:**

SPACECRAFT / PROJECT: **Doc. Number:**
SYSTEM / EXPERIMENT: **Issue:**
SUB-SYSTEM: **Date:**
Sheet No.:

Part ID	Description	Manufacturer	Country	Specification	Quality	Notes

FIG. 12

DECLARED MATERIALS LIST **ORIGINATOR:**

SPACECRAFT / PROJECT: **Doc. Number:**
SYSTEM / EXPERIMENT: **Issue/Rev:**
EXPERIMENTERS: **Date:**
Sheet No:

Item number	Name and Type of Product, Form and Condition	Manufacturer, Specification	Processing Parameters	Outgassing or SCC-Res. Data and Refer	Application and Where Use	Environment	Size Code	Remarks, Approval Reference

FIG. 13

DECLARED PROCESS LIST **ORIGINATOR:**

SPACECRAFT / PROJECT: **Doc. Number:**
SYSTEM / EXPERIMENT: **Issue/Rev:**
EXPERIMENTERS: **Date:**
Sheet No.:

Item number	Process	Specification (Incl. Issue)	Description / Identification	Use and Location	User Code	Associated DML Items	Criticality of Process	Approval / Status

FIG. 14

PROJECT: **SYSTEM:** **S/SYSTEM:**	**(1) ENGINEERING CHANGE REQUEST NUMBER:**	
(2) Title of Change		
(3) Affected Items / Work Packages:		
(4) Classification of Change:	[ ] Routine [ ] Urgent	
(5) Documents Affected (title, number, issue, paragraph):		
(6) Description of Change:		
(7) Related Factors: [ ] Spacecraft [ ] Performance [ ] power [ ] Others [ ] Ground Segment [ ] Electr. Interfaces [ ] Weight (Specify) [ ] Launch Vehicle [ ] Mechan. Interfaces [ ] Schedule [ ] Payload [ ] Test / Verification [ ] Cost		
(8) Need / Justification for Change:		
Originator: Signature: Date:		
Attachments:	Distribution:	Change Approved : Date: Signature:

FIG. 15

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: Date:		Attachments	

[8] Approvals:

	Engineering Name/Date	Product Assurance Name/Date		CCB Chairman Name/Date
Princ. 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

FIG. 16

MANUFACTURING RECORD CARD No. ..... Of				
PROJECT NO.		JOB TITLE:		
CDS	SOHO	ISSUED BY	DATE	DEMANDING OFFICER
DRAWING NO.		TITLE:		NO. OFF
REF NO.	MATERIAL REQUIRED		DML NO.	TEST CERT NO.

WORKSHOP SECTION	OPERATION DETAILS	TIME	DETAILS OF ACTION TAKEN	SIGNATURE AND DATE

FIG. 17a

Continued Overleaf

WORKSHOP SECTION	OPERATION DETAILS	TIME	DETAILS OF ACTION TAKEN	SIGNATURE AND DATE

FIG 17b

PART APPROVAL DOCUMENT (PAD)

Spacecraft / Project: System / Experiment: Sub-System: Assembly:	PAD No.: Issue No.: Date : Ref. DCL No.: DCL Issue No.: Sheet ..1.... of .....

Part Number	:		Similar to style	:
Manufacturer	:		Country of Origin	:
Part Category	:			
Description	:			:
Specification	:	Date:	No. Used	
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 /.

FIG. 18a

Continued Overleaf

PROPOSED EVALUATION PROGRAMME

RESULTS OF PRELIMINARY EVALUATION

Functional Test:

SEM / Precap:

DPA Analysis:

Life Test:

RATIONALE / JUSTIFICATION FOR USE (INCL. PREVIOUS USE)

ADDITIONAL COMMENTS

Prepared By .....
Date.....

Approved By ..... (RAL/SSD/PA) Date.....

Approved By ..... (Agency/Prime Contractor) Date
.....

FIG. 18b

PERFORMANCE VERIFICATION DOCUMENTATION

Page of

VERIFICATION TEST REPORT

PROJECT:_____
___

TEST ITEM:_____

Manufacturer _____

Serial Number _____

Level of Assembly: [ ] Component [ ] Subsystem [ ] Payload
Type Hardware: [ ] Prototype [ ] Protoflight [ ] Flight [ ] Spare

TYPE TEST:

[ ] Structural Loads
[ ] Vibration
[ ] Acoustics
[ ] Mechanical Shock
[ ] Mechanical Function
[ ] Comprehensive Performance
[ ] Pressure Profile
[ ] Mass Properties
[ ] Electromagnetic Compatibility
[ ] Magnetic Properties
[ ] Leakage
[ ] Thermal-Vacuum
[ ] Thermal Balance
[ ] Thermal Cycling
[ ] Temperature-Humidity
[ ] Modal Survey

[ ] Other (explain)
_____

Verification Procedure No. _____ Rev. _____ Date: _____

[ ] Initial Test
[ ] Retest ([ ] Partial or [ ] Full; Starting date of initial test _____

Applicable Verification Plan: _____

Facility Description:
_____

Location:
_____

Test Log Reference:
_____

Comments:

Signature:

Quality Assurance Representative: _____Date: _____

Cognisant Engineer for Test Item: _____Date: _____

FIG 19a

PERFORMANCE VERIFICATION DOCUMENTATION

Page of

VERIFICATION TEST REPORT (Continued)

Date (add time for thermal and temperature tests).	Note beginning and end of actual activity, deviations from the planned procedure, and discrepancies in test times performance. (State if there were no deviations or discrepancies).	Malfunction Rep. No. and Date (if applicable).

(Use additional paper as required)

FIG 19b

PERFORMANCE VERIFICATION DOCUMENTATION

Page of

VERIFICATION TEST REPORT (Continued)

Date (add time for thermal and temperature tests).	Note beginning and end of actual activity, deviations from the planned procedure, and discrepancies in test times performance. (State if there were no deviations or discrepancies).	Malfunction Rep. No. and Date (if applicable).

(Use additional paper as required)

The activities covered by these reports include tests and measurements performed for the purpose of verifying the flight worthiness of hardware at the component, subsystem, and payload levels of assembly. These reports shall also be provided for such other activities as the project may designate.

Material felt necessary to clarify this report may be attached. However, in general, test logs and data should be retained by those responsible for the test item unless they are specifically requested.

The forms shall be signed by the quality assurance representative and the person responsible for the test item or his designated representative; the signatures indicate concurrence that the data is as accurate as possible given the contraints of time imposed by quick-response reporting.

This report does not replace the need for maintaining complete logs, records, etc; it is intended to document the implementation of the verification programme and to provide a minimum amount of information as to the performance of the test item.

FIG. 19c

CLEANLINESS CERTIFICATE
Use one sheet for each item of hardware (box, harness and MLI)
UNIT IDENTIFICATION (Instrument Box Name and Model)
HARNESS BAKEOUT CONDITIONS AND TIME
MLI BAKEOUT CONDITIONS AND TIME
SUPPLIER
MATERIALS LIST REFERENCE
THERMAL VACUUM/BALANCE TEST DATES AND REPORT NUMBER
QCM AND REGA NUMER
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

FIG 20

DECLARED MECHANICAL PARTS LIST **ORIGINATOR:**

SPACECRAFT / PROJECT: **Doc. Number:**
SYSTEM / EXPERIMENT: **Issue/Rev:**
EXPERIMENTERS: **Date:**
Sheet No:

1	2	3	4	5	6	7	8	9		10
								9.1	9.2	
Item No.	Commercial Identification	Type of Part	Procurement info 1. Manufacturer 2. Supplier 3. Proc. Spec. Issue/Rev	1. Elementary Functions. 2. Main Characteristics	1. Use 2. Location	Environment Code 1. Radiation 2. Ambiance 3. Temp	Criticality and Hazards	Justification for Approval and Prime Comments	PrimeApp.	ESA App.

12. FIG. 21