PRODUCT ASSURANCE

REQUIREMENTS

for

FIRST/PLANCK

SCIENTIFIC INSTRUMENTS

PT-RQ-04410 (Issue 1)

September 1997

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DOCUMENT CHANGE RECORD AND APPROVAL

Issue / Rev. Date	Pages affected / Brief description of change	Signature

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1. GENERAL

All space systems and associated equipment procured by the European Space Agency are required to conform to the Agency's Product Assurance (PA) requirements as set out in the ECSS and ESA-PSS series of documents.

In addition, safety requirements imposed on ESA by the respective Launcher Authorities are mandatory on all flight hardware and software and hence the relevant requirements are applicable for all items. It is stressed that, the safety regulations of the relevant Ariane launcher need to be complied with.

The PA requirements and guidelines defined herein are derived from the entire set of applicable documentation, and have been tailored to the scientific instruments.

The prime objectives of the PA requirements are:

- to establish confidence in the design/interfaces;
- to enhance the overall mission integrity;
- to assure the safety of the system and its operations;
- to assure that failures in one element do not have detrimental effects on other elements.

The interface between the instruments and the spacecraft must be understood in a wider sense than simply mechanical, electrical or thermal, e.g.:

- control of materials and processes that can affect the structural integrity of the equipment and hence the spacecraft, and even the launch vehicle;

- outgassing of materials that can contaminate other items of the satellite:

- degradation of surface coatings that can influence the thermal control of the equipment and the spacecraft;

- qualification and acceptance testing of the equipment alone and after integration in the system;

- control of nonconformances to avoid effects on other spacecraft items and schedule delays during integration;

- configuration control on documentation, hardware and software to assure reproducibility and traceability.

The PA Requirements defined here have been established to prevent potential problems, and past experience has shown that they are cost-effective and provide long term benefits to all parties participating in the programme.

1.1 Documents

1.1.1 Applicable Documents

The following documents form part of this requirements document to the extent specified herein.

ECSS-Q-20A	Quality assurance
ECSS-Q-60A	Electrical, electronic and electro-mechanical (EEE) components
ECSS-Q-70A	Materials, Mechanical Parts & Processes
ECSS-Q-80A	Software Product Assurance
ESA PSS-01-201	Contamination and cleanliness control
ESA PSS-01-301	Derating requirements applicable to electronic, electrical and electro-mechanical components
ESA PSS-01-700	The technical reporting and approval for materials, mechanical parts and processes
ESA PSS-01-702	A thermal vacuum test for the screening of space materials
ESA PSS-01-704	A thermal cycling test for the screening of space materials and processes
ESA PSS-01-706	The particle and UV radiation testing of space materials
ESA PSS-01-708	The manual soldering of high reliability electrical connections
ESA PSS-01-726	The crimping of high reliability electrical connections
ESA PSS-01-728	The repair and modification of printed-circuits board assemblies for space use
ESA PSS-01-736	Material selection for controlling stress corrosion cracking
ESA PSS-01-737	Determination of susceptibility of metals to stress corrosion cracking
ARIANE	Safety Regulations

1.1.2 Reference Documents

The following documents are listed for information during the Project life cycle. They may be used in case a better interpretation of a requirement may become necessary.

ESA PSS-01-202	Preservation, storage, handling and transportation of spacecraft hardware
ESA PSS-01-204	Particulate contamination control in clean rooms by particle fall-out measurements
ESA PSS-01-401	ESA fracture control requirements
ESA PSS-01-603	ESA preferred parts list (PPL)
ESA PSS-01-605	Capability approval programme for hermetic thick film hybrid micro-circuits
ESA PSS-01-606	The capability approval programme for hermetic thick film hybrid micro-circuits
ESA PSS-01-608	Generic specification for hybrid micro-circuits
ESA PSS-01-609	The radiation design handbook
ESA PSS-01-701	Data for the selection of space materials
ESA PSS-01-705	The detection of organic contamination of surfaces by infra-red spectroscopy
ESA PSS-01-709	Measurement of thermo-optical properties of thermo control materials
ESA PSS-01-710	The qualification and procurement of two sided printed circuit boards (gold plated or tin/lead finish)
ESA PSS-01-718	The preparation and mounting of RF coaxial cables
ESA-PSS-01-722	The control of limited life materials
ESA PSS-01-725	The application of the black paint Chemglaze Z306
ESA PSS-01-733	The application of the thermal control paint Pyrolac PSG120FG
ESA PSS-01-734	The application of the black electrically conductive coating Chemglaze H322
ESA PSS-01-735	The application of the black electrically conductive coating Chemglaze L300
ESA PSS-01-738	High-reliability soldering for surface-mount and mixed-technology printed circuit boards

ESA PSS-01-746 General requirements for threaded fasteners

ESA PSS-01-748 Requirements for ESA approved skills training and certification (Electronic assembly techniques)

2. PRODUCT ASSURANCE MANAGEMENT

2.1 General

The PI shall establish and implement an effective PA programme for the instrument compatible with the Project Requirements and this document. The programme the PI or his subcontractors is going to implement, shall be described in a Product Assurance Plan and shall cover the topics as described herein.

2.2 Organisation

A PA representative for the Instrument shall be designated, to manage the PA activities and to coordinate these activities within his organisation, the prime contractor for the satellite and with ESA.

2.3 Product Assurance Plan

A PA Plan shall be prepared to describe how the PI will implement the PA requirements defined here. The PA Plan shall cover the following disciplines:

- Design Assurance (e.g. Reliability, Safety, Maintainability, Selection of Components/Parts, Materials and Processes);
- Quality Assurance, including Procurement and Control of Components/Parts, Materials and Processes, Contamination Control;
- Configuration Management & Control;
- Software Quality Assurance as applicable.

The PA Plan shall serve as the master planning and control document for the PA programme, and shall be submitted to ESA for review.

2.4 ESA Right of Access

For the purpose of product assurance and technical coordination ESA shall have the right to perform or participate in audits, surveys, source inspections, test reviews, mandatory inspections, etc., at the PI's facilities and his sub-contractors and suppliers.

Arrangements shall be made by the PI to permit designated ESA personnel free access to all technical and programmatic documentation, areas and operations within the PI's facilities and his sub-contractors and suppliers in which work related to the project is being performed. Proprietary rights of the PI and third parties will be fully respected.

2.5 Reviews and Audits

A review of the status and the results of the PA programme shall be included in the project reviews. Audits shall be performed when necessary to overcome deficiencies or poor quality.

2.6 Critical Items Identification and Control

The PI shall assure that critical items derived from the different PA disciplines (e.g. reliability, safety, parts procurement, materials and processes) are followed up with the required emphasis.

A Critical Items List (CIL) shall be prepared as a summary of data from the different disciplines and with identical information as well as how the criticallity will be removed or reduced. Critical items can be i.e. new technologies, non qualified / non standard processes, limited life items, single point failures, long lead time items etc.

3. MATERIAL AND PROCESS SELECTION AND CONTROL

3.1 General

ESA ECSS-Q-70A and PSS-01-700 have been tailored and summarised here for the definition of the materials, mechanical parts and processes requirements.

3.2 Evaluation Programme

Materials and processes for which positive and negative experience has been gathered in previous space projects are listed in ESA PSS-01-701. The use of ESA-known materials and processes is highly recommended; however, their suitability for use on the programme shall be evaluated for each application.

Materials which may constitute a safety hazard or can cause contamination are prohibited from being used without prior approval by ESA. Examples are of these materials are:

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

Material and processes which cannot be considered either space proven or standard/established shall be subjected to an evaluation programme, to assess the suitability for the intended application. Typical elements of an evaluation programme are:

- Thermal vacuum. Materials shall have their outgassing properties assessed by thermal vacuum tests. The ESA standard outgassing test is described in PSS-01-702. Additional tests may be required for materials sensitive to contamination.

- Thermal cycling. Materials or material combinations subjected to thermal cycling in orbit shall be assessed to determine their suitability for the intended application. ESA standard thermal cycling test is described in specification ESA PSS-01-704.

- Radiation. Materials which will be exposed to charged particles (electrons and protons) / ultraviolet (UV) radiation shall be assessed to determine their ability to withstand the type and degree of radiation dosage expected during the mission. Tests to simulate the effects of the radiation environment are described in specification ESA PSS-01-706.

- Stress corrosion. Materials which are sensitive to stress corrosion and which are exposed to long term external tensile stresses (including assembly stresses) or residual internal tensile stresses (frequently present in welded constructions) in the terrestrial atmosphere shall not be used. This requirement shall also apply to GSE lifting devices for loads higher than 300 N.

The ESA standard test for the determination of susceptibility to stress corrosion cracking is described in specification ESA PSS-01-737 while PSS-01-736 defines materials which have been identified as not being sensitive to stress corrosion cracking.

- Fracture mechanics. As determined by the fracture control programme, the crack growth properties and initial crack sizes shall be determined for materials in critical structural applications.

3.3 Materials and Process Selection and Approval

The PI shall be responsible for the selection of materials and processes, and for demonstrating their suitability for the intended application.

Materials, mechanical parts and processes shall be approved by ESA before they can be used for the production of flight standard hardware as outlined below; detailed regulations are provided in PSS-01-700.

The PI shall submit to ESA for approval a Declared Material List (DML), a Declared Mechanical Parts List (DMPL) and a Declared Process List (DPL). Materials and process used by Sub-contractors and/or suppliers shall be consolidated in the lists produced by the PI's.

Each process used by the PI and listed in the DPL shall be covered by a process specification or standard, i.e.:

- PSS-01-708, for soldering of high reliability connections
- PSS-01-726, for crimping of high reliability connections
- PSS-01-728, for repair and modifications on PC boards.

When developed by the PI, process specifications / procedures shall include sufficient in-process and final inspections and controls to ensure that characteristics of the product are within the required limits. Process procedures shall be made available or accessible to ESA upon request for review.

4. EEE PARTS SELECTION AND CONTROL

4.1 General

Electrical, Electronic and Electro-mechanical Parts quality play an essential role for the overall success of the mission, and therefore their selection and control shall be given high attention and follow the requirements of ECSS-Q-60A.

A section of the Product Assurance Plan shall describe how the component programme will be carried out identifying the tasks which will be carried out by the PI, or by procurement agents, test houses or consultants as applicable.

The terms "Parts" and "Component" are used here as synonymous.

4.2 Component Engineering

4.2.1 Prohibited Materials and Components

Components containing the materials identified as prohibited materials in 3.2 shall not be used without prior approval by ESA. Special precautions may be required if such materials are used.

Use of components with known instability shall be avoided unless specifically approved. Examples of unstable components are:

a. Wet electrolytic capacitors (except CLR 79 type)
b. Plastic encapsulated semi-conductors
c. Hollow core resistors
d. Variable resistors and capacitors
e. Feedthrough filters
f. Wire link fuses

It must be noted that the requirements of this paragraph apply to the entire instrument programme, not only to critical interface circuits.

4.2.2 Radiation Sensitive Components

The radiation environment to be considered for the project is that related to the orbit. The relevant radiation doses are defined in the satellite system specification.

ESA is prepared to provide advice as far as possible on the selection of radiation hard component types, or potential precautions or testing as may be necessary.

4.2.3 Component Derating

In order to enhance the reliability during operation, the components shall not be stressed to the maximum rated values established by the manufacturer, but only to the derated values specified in PSS-01-301.

Drift and degradation of performance parameters (e.g. increase of leakage current 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 section 6.5 (Worst Case Analysis).

4.3 Component Selection and Approval

4.3.1 Preferred Components

The ESA Preferred Parts List (PPL) ESA PSS-01-603 and the ESA/SCC Qualified Parts List shall be used as the primary basis for component selection. However, the PI shall introduce a rigorous type reduction so as to reduce the number of component types and also to reduce problems and costs.

4.3.2 European Components

The use of European components shall be maximised. The PI is encouraged to select components which are being used already in the spacecraft, thus avoiding to duplicate lot charges, minimum buy and qualification costs.

4.3.3 Component Approval

Components used in flight standard hardware are subject to ESA approval.

The quality level for components is recommended to be in general level B according to ESA SCCG-system for active parts and level C for passive parts.

The PI is encouraged to consolidate component types among the different Principal Investigators and to perform a stringent type reduction and standardisation effort. The Procurement specifications shall be ESA/SCC or equivalent to ESA/SCCG. In the early stage of the programme the PI shall identify and signal to ESA for review and approval any non-qualified or sensitive component with its characteristics etc. as required in ECSS-Q-60A.

ESA reserves the right to reject components which may cause degradation of any part of the system.

4.3.4 Declared Components List (DCL)

All components to be used on flight standard hardware, shall be listed in a Declared Component List, which shall be completed stepwise as the selection of components and the approval process progresses. This list will be used for comments and advice by components experts from ESA for type reduction or substitution and for evaluation of potential for a coordinated procurement.

The DCL's shall be submitted with information giving the following: e.g. quality level, specification, manufacturer, LAT level, radiation test (characterisation, total dose, SEU etc.) according to ECSS-Q-60A.

4.4 Procurement Requirements

4.4.1 Lot Acceptance Testing (LAT)

All components shall be subjected to Lot Acceptance Testing (LAT) as defined in the related specification of the item under procurement.

4.4.2 Procurement Scheme for Components

The project team (Prime and co/subcontractors) will be setting up a coordinated parts procurement scheme.
ESA invites the PI's to participate in that procurement system for economical reasons.

The coordinated parts procurement is intended to harmonise the selection of parts, to perform a stringent type reduction and therefore to reduce the non-recurring costs like: minimum buy, lot charges, LAT costs, sample test costs etc. and to gain on higher quantities and to have only one single procurement management.

Therefore each PI is encouraged to participate to such a procurement scheme where the number of non-recurring costs are distributed amongst the number of users for a particular component.

5. CLEANLINESS AND CONTAMINATION CONTROL

5.1 General

The PI shall define in the PA plan the criteria and tasks for the contamination control, taking into account the applicable document PSS-01-201.

After establishing the cleanliness requirements, the Contractor shall identify the provisions, activities and verification methods necessary to achieve the cleanliness levels through all stages of fabrication, handling, transportation and testing. Also the precautions and provisions to be taken during the integration, transportation and launch preparations of the spacecraft shall be defined, and ESA shall be notified accordingly so that the necessary arrangements can be made in due time.

The following potential contamination sources shall be considered:

- molecular and particle contamination in air;
- choice of materials;
- lack of degreasing of raw materials;
- residues from cleaning agents, fluxes or machine lubricant;
- insufficient curing and bake-out of materials;
- handling of flight hardware with bare hands or dirty tools;
- inadequate clean room clothing or discipline of personnel in clean rooms;
- condensation of moisture or contaminants on cold surfaces during tests or transportation;
- suitability and cleanliness of packing and packaging materials.

Appropriate provisions for their control shall be defined for facilities and procedures, and their implementation shall be verified.

During the design of the instrument it must be kept in mind that the environment encountered during the integration phase and launch preparations of the spacecraft is not of the same high cleanliness standard as can be achieved in a laboratory where sensitive equipment is assembled. Therefore, protection devices shall be incorporated in the design, and also provisions for cleaning sensitive areas at later integration phases shall be identified, if necessary.

Bake-out in vacuum at elevated temperatures of contamination sensitive items before integration shall be considered as an effective method to reduce the molecular contamination accumulated, and the potential for cross-contamination when in orbit.

5.2 Particulate contamination

Instruments (located in the cryostat) shall be handled under extreme care to meet the cleanliness requirements. The particle cleanliness level, at the point of delivery to ESA, shall be less than $3x10^{-4}$ (obscuration factor) (300 ppm) inside the cold instrument units and less than $1x10^{-4}$ obscuration factor (100 ppm) on the outside of these units. These levels can be achieved through final outside cleaning according to a well defined procedure.

In addition, the instrument must be designed such that it is cleanable on the outside surfaces according to procedures to be defined. To avoid, however, any contamination into the instrument a cover shall be provided on the aperture.

Note 1: Cleanliness level of $1x10^{-4}$ obscuration factor (100 ppm) corresponds to:

66	days in cleanroom class	100
8	days in cleanroom class	1.000
1,5	days in cleanroom class	10.000

Note 2: Cleanliness level of $2x10^{-4}$ obscuration factor (200 ppm) corresponds to:

130	days in cleanroom class	100
17	days in cleanroom class	1.000
3,5	days in cleanroom class	10.000
1	day in cleanroom class	100.000

Note 3: Cleanliness level of $3x10^{-4}$ obscuration factor (300 ppm) corresponds to:

200	days in cleanroom class	100
25	days in cleanroom class	1.000
5	days in cleanroom class	10.000
1,5	days in cleanroom class	100.000

Obscuration factor

The relationship of contamination area to total area also measured in “PPM” (3x10-4 = 300 ppm).

All assembly and handling/testing operations shall be performed in a clean area in accordance with PSS-01-201 and meeting at least the cleanroom class 1.000 or better for focal plane instrument; other units may be handled in class 100.000. However, it is the responsibility of the instrument to verify that the used cleanroom class with the necessary exposure time is compliant with the cleanliness requirements.

5.3 Molecular contamination

In connection with the proper selection of materials from outgassing point of view the organic deposition on surfaces of the focal plane units shall be less than $2x10^{-7}$ gcm^{-2} at delivery. The molecular contamination coming from materials used in the instrument and from the environment shall be reduced by material selection and baking. Therefore, the instruments shall be baked out on subassembly and instrument level to the highest safe temperature at that level. The duration will depend on the temperature the subassembly/instrument can accept.
Typical bake-out conditions for different materials/masses are defined in Annex A.

6. RELIABILITY ASSURANCE

6.1 Single Point Failures

The PI shall identify Single Point Failures (SPF) and take the necessary actions to eliminate or reduce them. All residual SPFs shall be identified in a SPF List, with a rational for retention. This rationale shall include an engineering assessment of the likelihood of occurrence, a definition of the measures, if any, that might be taken to eliminate the SPF, and special provisions to reduce the probability of occurrence or the potential failures effects. SPF's shall be identified through the FMECA process.

6.2 Worst Case Analysis

The PI shall perform a Worst Case Analysis (WCA) of the design. The WCA shall cover assemblies interfacing with other spacecraft elements to demonstrate that interface requirements (e.g. leakage current) are not violated, taking into account parameter variations of components resulting from initial tolerances, environmental effects (e.g. temperature), ageing, radiation doses, wear-out etc. over the operating life.
For electronic components the parameter variations defined in PSS-01-301 shall be taken into account. Other values have to be substantiated with support from test data (e.g. end of long-term life test limits from qualification tests).

The replacement of sensitive parts or circuit redesign shall be considered if the WCA indicates a potential problem due to violation of derating requirements or marginal end-of life performance due to aging. The adequacy of margins in the design of electronic circuits, thermal and electromechanical systems shall be demonstrated by analysis or test.

The analysis work shall start during the early design phase and reflect the current design status, and updated as necessary at least for the design reviews.

Any noncompliance to PSS-01-301 shall be reported to ESA immediately for review. Noncompliances that cannot be settled are subject to a Request for Waiver.

7. SAFETY ASSURANCE

The rules of national safety authorities shall be met by the PI and his subcontractors as well as the safety regulations of the launch vehicle and launch pad.

8. QUALITY ASSURANCE

8.1 General

ECSS-Q-20A has been tailored for the definition of the Quality Assurance (QA) requirements to be applied for the required equipment.

These requirements are applicable to:

- flight models and spares;
- hardware subjected to or participating in design verification / qualification testing;
- portions of the GSE which interface directly with flight hardware or which can have an impact on safety (e.g. lifting devices).

Implementation of the QA requirements shall ensure that:

- confidence of achieving technical success is enhanced;
- the occurrence of deviations and marginal quality is prevented;
- nonconformances are detected and resolved, and corrective and preventive actions are implemented to prevent their recurrence;
- verification of conformance to applicable requirements is performed.

The quality assurance activities shall be tailored by the PI or its subcontractor according to the complexity of each instrument and to the needs to assure compliance to formal requirements. They shall be described in sufficient detail in the QA section of the PA Plan.

8.2 Procurement Control

8.2.1 Incoming Inspections

Incoming inspections shall be performed on procured items according to procurement specification to check their compliance with applicable requirements. Records of inspection shall be established and maintained.

8.3 Manufacturing and Assembly Control

8.3.1 Manufacturing and Inspection Flow Chart

The manufacturing and assembly process shall be analyzed and the sequence of the various steps thoroughly planned. Surveillance of manufacturing and assembly activities shall be performed by the designated quality assurance personnel, by means of inspections for:

- critical parameters of the process;
- satisfactory workmanship;
- completion of individual manufacturing and assembly steps;
- workmanship samples to be taken with each batch / lot of hardware.

The planning of inspections shall take into account the complexity of the operations the outcome of the critical items list and their potential effect on the properties and integrity of the end product.

The manufacturing and assembly sequence, together with associated inspections, relevant procedures, facilities used and their cleanliness conditions, shall be documented in a Manufacturing and Inspection Flow Chart.

8.3.2 Key and Mandatory Inspection Points (KIP/MIP)

Among the inspections and test as part of the production sequence, some selected inspections may be performed with participation of representatives from ESA.

The Contractor shall identify Key and Mandatory Inspection Points (KIP/MIP) in accordance with the following criteria:

- when critical processes are performed;
- where the next step of the manufacturing sequence renders the location inaccessible for inspection;
- during assembly of mechanisms;
- processing or installation of safety critical items;
- at the end of manufacturing, prior to box closure;
- formal qualification and acceptance tests.

A MIP shall require invitation at least one week before the event, and participation of ESA or its written agreement to proceed without ESA participation. A KIP shall require the same invitation, but the notified activity may be performed by the PI's inspector as scheduled if there is no reaction from ESA.

8.3.3 Calibration of Measuring, Inspection and Test Equipment

Equipment shall be calibrated against standards of suitable accuracy, which are traceable to national calibration standards, when feasible, or to other standards to be authorised for this purpose by ESA. Calibrations shall be performed in accordance with documented procedures.

The total error resulting from a calibration and measurement process attributable to the instrument, personnel, procedures and environment shall not exceed a significant amount (e.g. 10%) of the tolerance for the parameter to be measured. Where practical limitations do not allow measurement with the required accuracy, an estimate of the cumulative calibration and measurement error has to be provided.

8.4 Integration and Test Control

8.4.1 Assembly, Integration and Test (AIT)

An AIT planning shall be prepared to cover all assembly, integration and test requirements for development, qualification and acceptance test phases for the different models. Details shall be given of :

- hardware configuration;
- assembly operations, alignment;
- test objectives;
- test parameters;
- test sequences;
- acceptance/rejection criteria;
- test equipment and accuracy required;
- facilities involved;
- hazards identified;
- cleanliness of integration/test facilities.

8.4.2 Test Procedures

Test procedures are required for all tests on deliverable hardware.

Accept/reject limits shall be set allowing for test equipment accuracy and measurement uncertainty so that measured/indicated values can immediately be related to the required specification.

Each necessary step to carry out the test shall be described and assigned with expected results parameter and pass/fail criteria. Special notes for potential hazards shall be noted.

8.4.3 Test Witnessing

Critical development tests and formal qualification and acceptance tests shall be monitored or witnessed by QA personnel to ensure that applicable procedures are followed without errors and that adequate records of the activities and test results are taken.
The QA personnel shall document any variations to test procedures, deficiencies and nonconformances during the test, and monitoring the implementation of dispositions and corrective actions.

8.4.4 Test Reviews

A **Test Readiness Review** (TRR) shall be held prior to any formal qualification and acceptance tests, to determine the following:

- that the as-built configuration status of the test specimen conforms to the released design baseline or differences are acceptable and documented to assure that test objectives can be met;
- status of existing nonconformances/failures, Requests for Waivers, open work and assessment that open actions do not affect the test;
- availability and ESA approval status of test procedures;
- verification that hazards and hazardous operations have been clearly identified within the test procedure and appropriate actions are implemented;
- readiness of test facility and associated equipment (cleanliness of test facility, calibration status and validity of all test equipment, including any software programme);
- assignment of responsibilities during the test;
- conclusion whether to release for testing.

After major portions of qualification and acceptance tests a **Post-Test Review** shall be held to determine that:

- all portions and steps of the applicable procedure have been properly executed, and the test specimen and test equipment have been brought into a safe condition;
- all deviations from or modifications to the initial test procedure which had to be made during the test were properly authorised;
- all required data records are complete and at least a first assessment has been made to determine whether the parameters were within required limits, or whether there is a need for additional testing and/or further analysis of the results before a conclusion can be reached;
- non-conformances/failures have been recorded and at least initial dispositions affecting continuation/completion of the test have been made by the appropriate Material Review Board;
- conclusion, whether the test article can be released to the next step and the test set-up can be dismantled.

Test Review Boards shall include the following representatives of the contractor: project management, engineering, AIT and product assurance.

ESA shall be invited to attend Test-Readiness Reviews and Post Test Reviews, with a notification at least one week before the event.

8.4.5 Test Reports

A test report shall be provided for each test, including as a minimum :

- a summary of test results;
- an evaluation and verification of test results;
- a list of Non-Conformance Reports raised during the test;
- the as-run filled-in test procedure;
- all test data including environmental test facility records (i.e. vibration plots, vacuum values, temperature and humidity figures, during tests);
- clean room environmental control data i.e. temperature, pressure and humidity, during qualification and acceptance tests;
- a final synthesis report of the combined test programme (qualification acceptance or other formal tests).

8.4.6 Historical Record (Logbook)

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

The log books shall accompany the hardware whenever it is placed under the custody of another organisation and this organisation shall update and maintain these records. The log books will form part of the End Item Data Packages which are to be delivered for every item at the time of acceptance.

8.5 Handling, Storage, Packaging, Marking and Labelling Transportation Control

Procedures and instructions shall be made available and be used for handling, storage, packaging and transportation which ensure that the integrity of the item and tolerable environmental conditions including cleanliness, humidity, pressure, temperature, electrostatic discharge, vibration and shock will be maintained to prevent deterioration and damage. Effective implementation of applicable procedures and instructions shall be verified by the quality assurance activity.

8.6 Non Conformance Control

A nonconformance is an observed condition of any article or hardware or software in which one or more characteristics do not conform to drawings or specifications. Failures, malfunctions, discrepancies, anomalies, deficiencies and defects are all nonconformances,

The contractors and their sub-contractors and suppliers shall establish a nonconformance control system for a disciplined approach to the identification, segregation, reporting, review, disposition, analysis, corrective and prevention of recurrence of confirmed or suspected non-conformances, throughout all manufacturing, integration and test phases.

8.6.1 Nonconformance Classification

Nonconformances shall be classified as MAJOR or MINOR.

A nonconformance shall be classified as MAJOR when it may affect:

- requirements with respect to form, fit, function, performance, materials, safety and cleanliness as specified in applicable requirements and specifications;
- ESA approved test requirements and procedures (which include formal qualification and acceptance tests);
- ESA approved Interface Control Documents.

A MINOR nonconformance is a nonconformance which does not affect any of the points above. It is of inconsequential nature, or is trivial with regard to workmanship criteria.

Software nonconformances shall be disposed and processed as described in this section, although the terminology used may be different. Nonconformances found during formal acceptance testing of flight and checkout software shall be classified as MAJOR nonconformances.

Nonconformances found during formal acceptance testing of deliverable GSE shall be classified as MAJOR nonconformances if they cannot be corrected and reverified before the end of the acceptance tests.

8.6.2 Nonconformance Disposition and Reporting

PIs internal MRB shall dispose of minor NCRs deciding corrective action, preventive action and closure. A list of minor NCRs shall be sent to ESA for review.

All MAJOR nonconformances, either originated by the PI or by his sub-contractors, shall be reported to ESA within a time period to be agreed upon.
After receipt of a notification of a major nonconformance, either originated by the PI or his sub-contractors, ESA will respond to the initiator if further information, evaluation, or analysis is required.

After receiving a copy of a major NCR processed by the local Material Review Board (MRB), ESA will react if disagrees with the proposed disposition, corrective actions or re-verification, and/or will communicate whether an ESA representative intends to participate in follow-on MRB.

ESA reserves the right to participate as voting member on MRB's for any major nonconformances at instrument level, and to invite experts to participate in failure analysis and MRB meetings.

8.7 Acceptance and Delivery

8.7.1 Acceptance Process

All hardware and software deliverable items provided by the PI shall be submitted for acceptance to ESA. The hardware will be accepted at the PI's premises on the basis of mutually agreed acceptance test programme, most likely together with the Prime Contractor to avoid multiple handover meetings.

An acceptance review shall be held, supported by an Acceptance Data Package (ADP) to be provided by the PI.

This acceptance review could be combined with the post qualification review or as part of the Delivery Review and shall be thoroughly prepared by the PI.

After formal acceptance by ESA, the deliverable items shall be shipped by the PI and after successful incoming inspection they are cleared for integration into the satellite or for operation with the satellite (or storage in the case of flight spares).

The responsibility for the transport lies with the PI. As a principle all flight hardware shall be accompanied by PI personnel during transport.

8.7.2 Acceptance Data Package (End Item Data Package)

The ADP shall contain all documentation which provides visibility over the configuration, fabrication, assembly and test operations performed on the equipment to be delivered to ESA.

The ADP shall be initiated prior to and maintained during all stages of assembly, inspection and test for each of the equipment specified.

The interface control document/drawings to be provided with the ADP shall reflect the latest design status for the item. Design modifications resulting from NCRs shall be covered by updated design documentation.

The original ADP shall remain with the equipment at all times.

Five sets of the ADPs shall be submitted to ESA at least 10 working days prior to the Delivery Review (final updates may be given at the review).

Updates for ADPs have to be provided if units are returned for any modification/ corrective action.

8.7.3 Delivery Review Board (DRB)

Upon completion of final test and inspection and before shipment of a deliverable item, a formal review by a DRB shall take place. The objective of this review shall be to establish that there is

adequate documentary evidence to demonstrate that the instrument has satisfied all requirements and identify any possible open work.

The DRB shall be composed of the following members or their nominated representatives as a minimum:

- PI Project Manager
- PI PA responsible
- Instrument responsible engineer
- ESA representative
- Satellite Prime Contractor representative

Delivery Review Boards shall be chaired by the customer and shall cover the following subjects which shall be in form of documents as part of the ADP:

1. Confirm list of deliverable items.
2. Review the Configuration Status List (as-design).
3. Review of relevant change proposals status.

4. Establish the actual build status for hardware and software (as-built).
5. Establish potential deviations to the design qualification baseline or to different models.
6. Evaluation of inspection results including cleanliness status.
7. Establish the status of non-conformance (major + minor).
8. Establish the status of waivers.
9. Establish the status of the test programme/test flow and test reports.
10. Acceptability of Residual Hazards.
11. Historical Records, limited Life Item Records, open Work Records, Temporary Installation Records and other sections of ADP for content and completeness.
12. Operational constraints, Operating and Maintenance Manuals.
13. Establish the hardware status and procedure of packaging, handling and shipping operations.
14. Review requirements verification status.
15. Authorise shipment.

Documents to support the review subjects listed above shall be provided.

Shipment shall not take place until all above actions are complete or action items have been placed and consent to ship is authorised by the board.

8.7.4 Shipping

Provisions shall be made for inspection and control of all equipment shipped to ensure that:

- All equipments have been subjected to and have satisfactorily passed all applicable inspections and tests. Emphasis shall be given to physical segregation of conforming equipments from those awaiting test results or final dispositions.

- All equipments are complete and assembled as required and documentation is complete.

- All equipments have been preserved and packed in accordance with applicable procedures and specifications.

- All packed equipments have been identified and marked in accordance with applicable procedures and specifications.

- Equipments are accompanied by the ADP or as a minimum necessary technical documents, e.g. handling instructions, operating manuals, installation manuals, historical records, drawings, indication of remaining useful life of limited life items.

- Handling devices and transportation vehicles are adequate for the items involved.

- Loading and transportation methods conform to agreed requirements.

- Shipping container shall identify the location of the documentation package.

- A shipment notification prior to arrival of any item has to be given to the next user by telex which shall contain as a minimum:

  . project title, item identification, quantity
  . flight or other transportation details, such as flight no., time and place of arrival, airwaybill no,

8.7.5 Post Delivery Operations

Subsequent to receipt of the items at the next higher level, the PI shall provide support in respect of the delivered items which shall consist of the following:

- responding to non-conformance reports/MRBs generated by the spacecraft contractors;

- performing receipt inspections on returned items;

- performing the required operation to return the item to on acceptable condition in accordance to the requirements of this document.

9. SOFTWARE PRODUCT ASSURANCE

9.1 General

An effective Software Product Assurance (SPA) programme shall be implemented in accordance with ECSS-Q-80A. It shall ensure that :

- software design requirements are properly specified;
- formal definition documents are issued;
- standards, practices and conventions are applied (e.g. logic structure, coding, commentary);
- design and development activities are subjected to formal reviews;
- all testing carried out to formal test procedures;
- configuration management control procedures are applied.

The SPA requirements are applicable for :

- flight S/W (application and operating S/W);
- GSE S/W.

9.2 Software Reviews and Inspections

The Software Development shall be done in accordance with ECSS-Q-80A. During the development the following key reviews and inspections shall be performed :

- User Requirements Review (URR);
- Software Requirements Review (SRR);
- Architectural Design Review (ADR);
- Detail Design Review (DDR);
- Review of Test procedures and test plans;
- Witnessing of tests;
- Software acceptance/delivery review.

The traceability shall be ensured during all development and test phases from requirements via intermediate steps, down to code.

Formal acceptance release is mandatory for each step.

9.3 Hardware/Software Interaction Analysis (HSIA)

A Hardware/Software Interaction Analysis (HSIA) shall be performed in conjunction with the FMECA at least for all functions interfacing the spacecraft.

The objective of the HSIA is to systematically examine the hardware/software interface of a design to ensure that hardware failure modes are being taken into account in the software requirements. Further, it is to ensure that the hardware characteristics of the design will not cause the software to overstress the hardware, or adversely change failure severity when hardware failures occur. The analysis findings are resolved by changing the hardware and/or software requirements, or by seeking ESA approval for the retention of the existing design.

The HSIA may be annexed to the FMECA. It shall be performed for flight H/W which will be controlled via on-board S/W.

9.4 Software Configuration Management

Software and software related documents shall be placed under configuration control not later than the start of formal verification and acceptance testing. Configuration management and change control activities shall be performed in accordance to the project configuration management requirements.

9.5 Software Non-Conformance Control

Software non-conformances shall be treated as defined in the Non-Conformance Control section, but the terminology used may be different.

10. CONFIGURATION MANAGEMENT AND CONTROL

Configuration management is the discipline of providing systematic and uniform configuration identification, control and accounting of an equipment its parts and software, throughout the design, development, fabrication and testing, up to and including the acceptance by the Agency of a deliverable item.

The PI's Configuration Management System shall ensure that all affected organisations and parties are cognizant of applicable baselines, will be kept informed of the impact of changes and will participate, as appropriate, in the change decision-making process. The configuration management requirements apply to all changes irrespective of whether Agency directed or PI proposed.

The PI shall prepare a Configuration Management and Control Plan based on these requirements showing how his Configuration Management System will operate, and defining the persons who will be responsible. This Configuration Management and Control Plan shall be submitted to the Agency for approval.

The Configuration Management & Control Plan shall include but not be limited to:

- definition of Configuration Baseline
- change control
- status accounting
- as-built status definition
- as-design/as-built configuration and reconciliation of the changes

The PI shall submit to the Agency for approval any change to the approved Configuration Management System.

The PI shall ensure that his Configuration Management & Control Plan is strictly implemented and observed by his personnel.

The contractual implications of configuration changes are governed by the contract proper.