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PRODUCT ASSURANCE

REQUIREMENTS

for

FIRST/PLANCK

SCIENTIFIC INSTRUMENTS

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TABLE OF CONTENTS

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 ar e 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 r elevant Ariane launcher need to be complied with.

The PA requirements and guidelines defined herein are derived from the entire set of applicabl e 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 influenc e 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 delay s during integration;

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

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

1.1.2 Reference Documents

The following docu ments 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-ou t 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 f or 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 condu ctive 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 printe d circuit boards

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.

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.

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 components types, or potential precautions or testing as may be necessary.

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 proces s progresses. This list will be used for comments and advice by compone nts experts from ESA for type reduction or substitution and for evaluation of potential for a coordinated procurement.

The DCL's shall be submitted with i nformation 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 relate d 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, lo t 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.

In addition, the instrument must be designed such that it is cleanable on the outside surface s 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 th e cleanliness requirements.

5.3 Molecular contamination

In connection with the proper selection of materials from outgassing point of view the organi c 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 fro m the environment shall be reduced by material selection and baking. Therefore, the instruments shall be baked out o n subassembly and instrument level to the highest safe temperature at that level. The duration wil l depend on the temperature the subassembly/instrument can accept.
Typical bake-out conditions for different materials/masses are defined in Annex A.

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.

- 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.

8.4.4 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.

8.6.1 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.

adequate documentary evidence to demonstrate tha t 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 Installatio n 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 subjec ted to and have satisfactorily passed all applicable inspections and tests. Emphasis shall be given to physical segregation of conforming equipments fro m those awaiting test results or final dispositions.

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.

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.