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DOCUMENT

Product Assurance Requirements For Instruments

Solar Orbiter

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CHANGE LOG

Date	issue	revision	pages	reason for change
2 March 2011	1	0	All	New issue
28 March 2011	2	0	2	Added ECSS-Q-ST-70-02C as applicable and updated the radiation hardness requirements reference (No change of content)
			3	Removed ECSS-Q-ST-70-02C as informative
			4	Added title of MIL-STD-975H
			13	Updated PAM-260
			14	Updated PAM-310 and PAM-320
			18	Added QAM-141
			19	Updated QAM-220
			20	Added QAM-281
			22	Updated QAM-350, clear typo QAM-360
			23	Added QAM-381
			24	Updated QAM-500
			30	Updated RAMS-020
			30 to 33	Replaced FMECA by FMEA
			37 to 42	Updated of Radiation Hardness Assurance (paragraph 10.3.2)
			45	Updated EEE-520
			50	Updated MMP-020
			53	Added MMP-190
			55	Added reference to SAP-090 and update
			56	Added reference to SAP-100 and update
			57	Updated CCC-020
			58	Added CCC-055 in replacement of informative paragraph
			58	Updated CCC-060
15 April 2011	2	1	Change log	Correct page 2 box content.
			Many	Spelling mistakes

TABLE OF CONTENTS

1 SCOPE

This document defines the product assurance requirements for all the Solar Orbiter Instruments.
The Instruments shall be designed, manufactured and tested in compliance with these requirements.
It is the responsibility of the Principal Investigator to reflect these requirements, to sub-contractors and suppliers to ensure their implementation.

2 APPLICABILITY

The Product Assurance Requirements are applicable to instruments for all phases of the Solar Orbiter project activities up to launch of the spacecraft
For SW the applicability is to the end of the maintenance phase.
The requirements are applicable to:

- Flight models and spares provided by the Principal Investigator
- Hardware and software subjected to or participating in design verification/qualification testing with respect to the properties relevant for those tests
- Portion of GSE which interface directly with flight hardware (e.g. connectors, cooling devices…) or which can have an impact on safety (e.g. lifting devices)

If specific rules or procedures are considered irrelevant, impracticable or inefficient for implementation, the Principal Investigator may propose alternative procedures to achieve the same objectives. These procedures are subject to agreement with ESA Project on a case-by-case basis.

3 NORMATIVE AND INFORMATIVE DOCUMENTS

3.1 Normative Standards and Regulations

The following ECSS standards are made here applicable to the Solar Orbiter Instruments in as much as they are referred in this requirement specification or referred in the ECSS standards called in this requirement specification.
For the purpose of this requirement specification ECSS-Q-xx and ECSS-Q-ST-xx standards reference (where xx is a generic place holder for the actual reference) shall be deemed equivalent.

Explicative Note:

- If the ECSS standard is called in this requirement specification it is applicable with the modification introduced in this requirement specification.
- If the ECSS standard or part of it is called in one of the ECSS standards **directly** called by this requirement specification this ECSS standard or part of it is applicable if the ECSS standard is in the list below.

- ECSS Standards not in the list below are not made applicable even if called in one of the above standards.
- Non ECSS standards called in the ECSS standard are part of them and are as such applicable.

NR-1	ECSS-Q-ST-10C	Product Assurance
NR-2	ECSS-Q-ST-10-09C	Nonconformance control system
NR-3	ECSS-Q-ST-20C	Quality Assurance
NR-4	ECSS-Q-20-07A	Quality Assurance for test Facilities
NR-5	ECSS-Q-ST-30C	Dependability
NR-6	ECSS-Q-ST-30-02C	Failure Modes, Effects (and Criticality) Analysis (FMEA/FMECA)
NR-7	ECSS-Q-ST-40C	Safety
NR-8	ECSS-Q-ST-40-02C	Hazard analysis
NR-9	ECSS-E-ST-32-01C rev1	Fracture Control
NR-10	ECSS-Q-ST-60Crev.1	EEE Components
NR-11	ECSS-Q-ST-30-11C	Derating and end of life parameter drifts - electronic, electrical and electro-mechanical components
NR-12	ECSS-Q-ST-60-02C	ASIC and FPGA Development
NR-13	ECSS-Q-ST-60-05C rev1	Generic requirements for hybrids
NR-14	ECSS-Q-ST-60-12C	Design, selection, procurement and use of die form monolithic microwave integrated circuits (MMICs)
NR-15	ECSS-Q-ST-60-14C	Relifing procedure EEE components
NR-16	ESSB-ST-Q-001 Issue 1	Radiation Hardness Assurance
NR-17	ECSS-Q-ST-70C	Materials, Mechanical Parts and Processes
NR-18	ECSS-Q-ST-70-01C	Cleanliness and contamination control
NR-19	ECSS-Q-ST-70-02C	Thermal vacuum outgassing test for the screening of space materials
NR-20	ECSS-Q-ST-70-07C	Verification and approval of automatic wave soldering
NR-21	ECSS-Q-ST-70-08C	Manual Soldering of High-Reliability Electrical Connections
NR-22	ECSS-Q-ST-70-11C	Procurement of printed circuit boards
NR-23	ECSS-Q-ST-70-26C	Crimping of high reliability electrical connections
NR-24	ECSS-Q-ST-70-28C	Repair and modification of printed circuit boards for space use
NR-25	ECSS-Q-ST-70-38C	High-reliability soldering for surface-mount and mixed-technology printed circuit boards
NR-26	ECSS-Q-ST-80C	Software Product Assurance
NR-27	ECSS-E-ST-40C	Software
NR-28	PSS-01-202	Preservation, storage, handling and transportation of ESA spacecraft hardware
NR-29	PSS-01-748	Requirements for ESA-approved skills training and certification (Electronic assembly techniques)

NR-30	Launch center safety regulation (ATLAS, Delta)
NR-31 NRP 8715.7	Expandable Launch Vehicle Payload Safety Program (NASA Procedural Requirements)
NR-32 TEC-EES-03-034/JS	Solar Orbiter Environmental Specification
NR-33 CSG-RS-10A-CN	CSG Safety regulations: General rules
NR-34 CSG-RS-21A-CN	CSG Safety regulations: Ground installations
NR-35 CSG-RS-22A-CN	CSG Safety regulations: Spacecraft

3.2 Informative documents

The following standards shall be used as reference document for the Solar Orbiter project. They will be used if a better interpretation of a requirement becomes necessary:

IR-1.	ECSS-Q-ST-10-04C	Critical item control
IR-2.	ECSS-Q-HB-30-01A	Worst case analysis
IR-3.	ECSS-Q-TM-30-12	End of Life Parameter drifts – EEE components
IR-4.	ECSS-Q-ST-70-03C	Black-anodizing of metals with inorganic dyes
IR-5.	ECSS-Q-ST-70-04C	Thermal testing for the evaluation of space materials, processes, mechanical parts and assemblies
IR-6.	ECSS-Q-ST-70-05C	Detection of organic contamination of surfaces by IR spectroscopy
IR-7.	ECSS-Q-ST-70-06C	Particle and UV radiation testing for space materials
IR-8.	ECSS-Q-ST-70-09C	Measurement of thermo-optical properties of thermal control materials
IR-9.	ECSS-Q-ST-70-10C	Qualification of printed circuit boards
IR-10.	ECSS-Q-ST-70-13C	Measurement of the peel and pull-off strength of coatings and finishes using pressure-sensitive tapes
IR-11.	ECSS-Q-ST-70-18C	Preparation, assembly and mounting of RF coaxial cables
IR-12.	ECSS-Q-ST-70-20C	Determination of the susceptibility of silver-plated copper wire and cable to “red plague” corrosion
IR-13.	ECSS-Q-ST-70-22C	Control of limited shelf-life material
IR-14.	ECSS-Q-ST-70-30C	Wire wrapping of high-reliability electrical connections
IR-15.	ECSS-Q-ST-70-31C	Application of paints and coating on space hardware
IR-16.	ECSS-Q-ST-70-36C	Material selection for controlling stress corrosion cracking
IR-17.	ECSS-Q-ST-70-37C	Determination of the susceptibility of metals to stress corrosion cracking
IR-18.	ECSS-Q-ST-70-45C	Standard methods for mechanical testing of metallic materials
IR-19.	ECSS-Q-ST-70-46C rev.1	Requirements for manufacturing and procurement of threaded fasteners
IR-20.	ECSS-Q-70-71A rev.1	Data for selection of space materials and processes
IR-21.	PSS-01-204	Particulate Contamination Control of clean Rooms by

		Particle Fall-out Measurement
IR-22.	ECSS-E-10-03Arev.1	Testing
IR-23.	ECSS-M-ST-40C rev.1	Configuration Management
IR-24.	ECSS-S-ST-00C	Description, implementation and general requirements
IR-25.	ECSS-P-01B	Glossary of terms
IR-26.	ECSS-E-10-03Arev.1	Testing
IR-27.	ESCC12300 iss.1	European Preferred Parts List (EPPL) and its management
IR-28.	MIL-STD-975H	NASA STANDARD ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL (EEE) PARTS LIST

4 TERM DEFINITIONS AND ABBREVIATED TERMS

4.1 Term Definitions

Refer to ECSS-S-ST-00C IR-24

4.2 Abbreviated terms

AIT	Assembly, Integration and testing
ASIC	Application Specific Integrated Circuit
CAM	Commercial, Aviation or Military (also Collision Avoidance Manoeuver)
CI	Configuration Item
CIDL	Configuration Item Data List
CIL	Critical Item List
CM	Configuration Management
DA	Derating Analysis
DCL	Declared Components List
DML	Declared Materials list
DMPL	Declared Mechanical Parts List
DPL	Declared Process List
DRB	Delivery Review Board
EEE	Electronic, Electrical and Electro-mechanical
EDAC	Error Detection And Correction
EIDP	End Item Data Package
EPPL	European Preferred Parts List
ESA	European Space Agency
FMEA	Failure Mode Effect Analysis
FPGA	Field Programmable Gate Array
HA	Hazard Analysis

HSIA	Hardware Software Interaction Analysis
ICD	Interface Control Document
KIP	Key Inspection Point
MIP	Mandatory Inspection Point
NCTS	Non-Conformance Tracking System
NDA	Non-Destructive Analysis
NDI	Non-Destructive Inspection
OTS	Off-The-Shelf
PA	Product Assurance
PAD	Part Approval Document
PA&S	Product Assurance and Safety
PCB	Printed Circuit Board
PTR	Post Test Review
QA	Quality assurance
RFA	Request For Approval
RFD	Request for Deviation
RFW	Request for Waiver
SCC	Stress Corrosion Cracking
SEL	Single Event Latch-up
SPF	Single Point Failure
SEU	Single Event Upset
TRB	Test Review Board
TRL	Technology Readiness Level
TRR	Test Readiness review
UV	Ultra-Violet
WCA	Worst Case Analysis

Heading

5 GENERAL

Informative

All space products procured in the frame of a programme of the European Space Agency are required to conform to the Agency's Product Assurance (PA) requirements as laid down in the ESA-ECSS series of documents.

The ECSS-Q standards define the Product Assurance (PA) policy, objectives, principles and rules for the establishment and implementation of PA programmes for projects covering the mission definition, design, development, production and operations of space products including disposal. They shall be considered **Normative documents to be tailored to the specific needs of the mission.**
Alternatively compliance to ECSS standard can be replaced by compliance to NASA equivalent standards for instruments under NASA responsibility.

Safety requirements imposed on ESA by the respective Launcher Authorities are applicable to Solar Orbiter project and hence the relevant requirements are applicable for all instruments.

Note: *Despite the fact that ESA and the selected Prime will act as formal interface to the Launcher Authorities this does not release the PI from the commitment to provide adequate inputs to ESA in order to comply with the applicable Launcher Authority Safety Requirements.*

The prime objectives of the PA requirements are:

- to establish confidence in the design;
- 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

While the first two topics intend to assure a successful functioning and performance of an instrument, the latter two aim to assure the safety and integrity of the interface of the instruments with the spacecraft, other instruments and the launcher.

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

Additional to the “physical” interfaces:

- mechanical/dynamic:

elements that contribute to the mounting, fixation, position of an instrument, a

subassembly a device or part of them and which can by its failure or faulty operation damage or render the capabilities of other elements of the platform

- electrical

elements (harness or electronic equipment) which can be a source of any over voltage, under voltage, over current, under current (versus nominal design) or any unpredicted variation of an electrical signal of the interface circuit, capable to create any degradation to the electrical circuit characteristics or to the operational performance of the platform or any other instrument

- thermal

elements which can cause any unexpected change in temperature or heat flux capable to generate major disturbance in the thermal balance of the platform or other instruments

- radiative electromagnetic

elements which can cause any disturbance of the platform or other instruments by electromagnetic effect

- optical

elements which can cause disturbance of the platform or other instruments by generation of reflexion, absorption, biasing or modification (stray light) of the optical flux to a sensor, detector or from a source

- contamination

outgassing of materials that can contaminate other instruments or lead to degradation of surface coatings that can influence the thermal control of the instrument and the spacecraft

The following needs to be considered as interface relevant:

- control of materials and processes that can affect the structural integrity of the instrument and hence the spacecraft, and even the launch vehicle;
- outgassing of materials that can contaminate other instruments
- degradation of surface coatings that can influence the thermal control of the instrument and the spacecraft;
- qualification and acceptance testing of the instrument alone and after integration in the system;
- control of non-conformances to avoid effects on other instruments and schedule delays during integration;
- configuration control on documentation, hardware and software to assure reproducibility and traceability make possible to build, to qualify and to operate a complex integrated system.

The PA Requirements and Guidelines 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.

Heading

6 PRODUCT ASSURANCE MANAGEMENT ECSS-Q-ST-10C NR-1

Heading

6.1 Programme planning

PAM-010

The Principal Investigator (PI) shall establish and implement an effective PA programme tailored to the size and complexity of the deliverable in accordance with the ECSS-Q-ST-10C NR-1 to support the PA activities at programme level

Note: This requirement applies also to eventual supplier / contractors

Informative

The basic implementation principles are to:

- ensure the allocation and availability of adequate resources, personnel and facilities to carry out the required PA tasks, (see 6.1.1)
- define, in a Product Assurance Plan all PA activities consistent with the Project objectives, requirements, criticalities and constraints, (see 6.1.2)
- ensure that lower level contractors / suppliers perform proper PA monitoring and control,
- ensure proper progress monitoring, reporting and visibility of all PA matters, in particular those related to alerts, critical items, non-conformances, changes, deviations, waivers, actions and/or recommendations resulting from reviews, inspection and audits, qualification, verification and acceptance.

PAM-020

1. The PI shall report on a regular basis the status of the product assurance programme implementation as part of the regular progress reporting.

PAM-030

2. Reporting of PA progress shall address:
- risk management
- specific PA activities and actions
- critical items status
- non-conformance and waiver status

Heading

6.1.1 Organization

PAM-040

1. The PI shall assign an instrument PA manager (from the PA line organization if existing in the PI organization)
- reporting functionally to the instrument manager
- having unimpeded access the PI, and ESA,
- who will manage the PA activities within the instrument collaboration
- who will coordinate these activities with ESA and the designated Prime as requested by ESA

PAM-050

2. The appointed instrument PA manager shall have sufficient organizational authority and independence to propose and maintain a product assurance programme compliant to the Solar Orbiter product assurance requirements

PAM-060

3. The appointed instrument PA manager shall have no responsibilities others than PA in the frame of his instrument responsibilities.(e.g. he could do engineering on an other project but not on this project where he is PA manager)

PAM-070

4. The PI shall identify PA resource requirements and shall provide adequate resources to perform the required PA tasks. Trained personnel shall be assigned to the various PA activities.

PAM-080

5. In case the PI has no experienced personnel or suitable facilities, adequate measures shall be undertaken (including applying for additional funds) to obtain properly trained and experienced personnel and/or the use of adequate facilities.

information

The use of National Agency resources, consultants and contractors should be considered for specific tasks for which in-house expertise is not available and where the investment may not be possible.

Heading

6.1.2 Product Assurance Plan

PAM-090

1. The PI (or his PA manager) shall prepare and implement a project product assurance plan as part of the management documentation for ESA review.

PAM-100

2. The PI shall maintain the PA plan throughout the project life cycle. The PA plan may refer to clauses of the PI Organization Quality Manual and to in-house procedures.

Note: *The update rate of this document is related to the major review points as listed in EID-A*

PAM-110 3. The PA plan shall describe the PA responsibilities within the instrument collaboration and eventually be extended to outside facilities and external personnel used during the project lifetime.

PAM-120 4. The PA plan shall cover:

- Design assurance (e.g. reliability, safety, maintenability, selection of components/parts, material and process, software)
- Quality assurance including AIV quality control, procurement and control of components/parts, material and processes, contamination control (see7.1)
- Software quality assurance
- Configuration management and control (at least for the quality assurance part)

PAM-130 5. The PA plan shall describe in a structured manner the implementation phase addressing explicitly critical areas pertinent to the instrument development, such as magnetic, optical cleanliness, deployable items, safety items etc.

Heading

6.2 ESA/Prime Contractor Right of Access

PAM-140 For the purpose of product assurance and technical coordination ESA shall have the right to perform or participate to, together with the instrument team, audits, surveys, source inspections, test reviews, mandatory inspections, etc., at the facilities of the PI and his contractors and suppliers.

informative ESA or its Prime contractor's participation shall not in any way replace or relieve the PI of his responsibility; it will be rather aimed at contributing to the identification and resolution of problem areas and assessing satisfactory progress.

PAM-150 Arrangements shall be made to permit designated ESA free access to all technical and programmatic documentation, areas and operations within the facilities of the PI and his contractors and suppliers in which work related to the Solar Orbiter Programme is being performed.
Proprietary rights of the PI and third parties will be fully respected.

Heading

6.3 Identification and Control of Critical Items

Heading 1. The QA function shall contribute to the overall risk management activities by:

PAM-160

- Supporting the identification and risk evaluation of critical items for which major difficulties or uncertainties are expected in:
  - demonstration of design performances
  - development and qualification e.g. new product, processes and technologies
  - procurement, manufacturing, assembly, inspection, test or handling,
  - storage and transportation,
  - system incompatibilities
  - aspects, which could affect project requirements having major impacts on safety (including procedures that do not comply with the applicable safety requirements, or which cannot be verified as complying with those requirements (Safety Critical Items) and items whose structural failure may cause catastrophic or critical consequences (Fracture Critical Items)), mission success and the related cost and schedule consequences including single-point failures with a failure consequence severity classified as catastrophic, critical or major (Reliability Critical Items)

PAM-170

- Monitoring and documenting the achievement of the specified risk reduction implementation and the corresponding verification measures throughout all project phases.

PAM-180

- Identifying products that cannot be checked and tested after integration, limited-life products, products that do not meet - or can-not be verified as meeting – applicable maintainability requirements (Maintainability Critical Items)

PAM-190

2. A Critical Items List (CIL) shall be prepared as a summary of data from the different disciplines and with identical information, using the template included in ECSS-Q-ST-10-04C IR-1 as a guide line

PAM-200

3. The complete CIL shall be updated for the main reviews. The Critical Items of the category MAJOR shall be maintained permanently and changes shall be reported as part of the progress report and during the progress meetings.

Heading

6.4 PA Database

PAM-210

1. All PA-related data (such as NCR's, RFW's, EEE components list, DML, DPL, MIPs/KIPs) shall be stored in an electronic database. This shall allow to import and export data, electronically by email, from and to contractor, suppliers and the Agency.

PAM-220 2. The databases format and content shall be agreed with the Agency and imposed on all suppliers.

Heading

6.5 Non-Conformance Control ECSS-Q-ST-10-09C NR-2

Informative A non conformance is an observed condition of any item (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 non-conformances,

PAM-230 1. The PI shall ensure a system is established that provides for a disciplined approach to the identification and segregation of nonconforming items, the recording and reporting (Non-Conformance Report (NCR)), review, disposition and analysis of non-conformances, and the definition and implementation of corrective actions.

PAM-240 2. For the NCR database the Internet capable NCTS version of ESA shall be used for MAJOR NCRs.
It can also be used for MINOR NCRs
The NCR template is provided in ECSS-Q-ST-10-09C.

PAM-250 3. Non-conformances shall be reviewed and dispositioned by a formal Non-Conformance Review Board (NRB). The originator's PA shall ensure that:

- responsibilities and authorities for the disposition of non-conformances are properly defined
- the NRB includes at least representatives from the PA and Engineering organizations
- the Board to review non-conformances is chaired by the Product Assurance Management function;
- all relevant experts are involved in the review, investigation and disposition of non-conformances;
- all knowledge acquired from non-conformances results in preventive actions in all relevant engineering, manufacturing and Product Assurance fields.

Heading

6.5.1 Non-Conformance Classification

PAM-260 Non-conformances (NCRs) shall be classified as MAJOR or MINOR

1. MAJOR Non-conformances are those affecting flight or qualification models (FM, PFM, QM, EQM) which may have an impact on the next higher level requirements in the following areas:
   - safety of people or equipment;
   - operational, performance, functional or contractual requirements;
   - reliability, maintainability, availability;
   - lifetime;
   - functional or dimensional interchangeability;
   - interfaces with hardware and/or software of different contractual responsibility.
   - changes to or deviations from approved qualification or acceptance test procedures;
   - project specific items which are proposed to be scrapped;
   - for EEE components, in case of:
     - lot/batch rejection during manufacturing, screening or testing at the manufacturer's facilities, if the purchaser proposes:
     - use as-is of the rejected lot/batch, or
     - continue processing, rework or testing, although the lot/batch does not comply with the specified requirements
     - non-conformances detected after delivery from the manufacturer

PAM-270 2. **MINOR** non-conformances are those which by definition cannot be classified as major. The following EEE discrepancies after delivery from the manufacturer may be classified as Minor:
   - random failures, where no risk for a lot-related reliability or quality problem exists;
   - if the form, fit and function are not affected;
   - minor inconsistencies in the accompanying documentation.

PAM-280 **3. In case of doubt, non-conformances shall be classified as major.**

PAM-290 4. The consequences of several different minor non-conformances on the same item shall be evaluated for proper classification.

Heading **6.5.2 Non-Conformance Reporting**

PAM-300 1. ESA is to be informed of MAJOR NCRs within 48 hours of their detection, notified of the date of proposed NRB, progress towards closure and final closure. ESA reserves the right to participate as voting member on NRB for any major NCR and to invite experts to participate in failure analysis and NRBs.

PAM-310 2. Reports shall be documented as provided for in NCTS. The final report shall confirm that all actions are completed and that closure has been agreed by the relevant parties.

PAM-320 3. MINOR NCRs shall be reported to the next higher contractual level at least by means of a monthly report and shall be reviewed at the time of acceptance of hardware/software. They can also be reported using NCTS

Heading

6.6 Alert System

informative

ESA operates an Alert system to inform all affected ESA projects of technical problems of general nature concerning safety, parts, materials and processes (e.g. a serious deficiency discovered with the sealing of IC-packages by a specific manufacturer).

The notification of problems from any source will be screened by the Project Office for a first assessment of potential applicability to Solar Orbiter. If it is suspected or if it cannot be excluded that an instrument may be affected, the alert will be forwarded to the Principal Investigators with a request to evaluate the alert, to assess the relevance to the instrument and to take corrective actions as necessary to assure that the reported problem is avoided or eliminated on the instrument.

PAM-330 The PI shall assess incoming Alerts for applicability to the instrument and a response shall be provided to the ESA Project Office within 15 days after receipt of a formal Alert, either indicating its non-applicability or the appropriate actions (to be) taken.

Heading

6.7 Contribution to configuration management

PAM-340 1. The QA function shall ensure that:

- the as designed status is defined prior to manufacturing
- the as-built documentation is properly defined, identified, traced to the as-designed baseline and maintained in order to reflect approved modifications;
- items to be delivered comply with the as-built documentation.

PAM-350 2. Each part, material or product shall be identified by a unique and permanent part or type number

Note: *To assure a full traceability the following controls shall be established*

- *Identification numbers are assigned in a systematic and consecutive manner.*
- *Identification numbers of scrapped or destroyed items are not used again.*
- *Identification numbers, once allocated, are not changed, unless the change is authorized by the ESA or the selected Prime.*
- *The logbooks shall contain historical and quality data and information which is significant for operation of the item, including non-conformances, deviations and open tasks*

PAM-360 3. All waivers shall be listed and described in the RFW section of the PA electronic database, including minors and supplier RFW's.

PAM-370 4. The waiver processing procedure and the waiver format shall be delivered to the Agency for review and approval.

Heading

7 QUALITY ASSURANCE MANAGEMENT ECSS-Q-ST-20C NR-3

Heading

7.1 General Requirements

QAM-010

The PI shall establish a detailed **Quality Assurance (QA) Programme Plan** as part of the PA plan following the generic guidelines given in ECSS-Q-ST-20C [NR10]. This document shall be considered an informative reference for the Solar Orbiter instruments. .Activities that have an impact on quality, dependability and safety shall be covered by written procedures. These shall be available to the Agency for review upon request.

QAM-020

1. If the PI institute/organization does not already provide a proven self-standing PA/QA organization, the PI shall establish (in collaboration with those responsible for PA/QA) a QA system covering the following tasks:

- Documentation and Data Control including Quality Records and Stamp Control;
- Traceability and Logbook (see7.2);
- Metrology and Calibration (see 7.3);
- Non-Conformance Control System (see 6.5);
- Alert System (see 6.6);
- Handling, Storage and Preservation (see 7.7)
- Statistical Quality Control and Analysis

Note: *Herewith related guidelines can be found in NR-3*

QAM-030

2. The PI shall ensure that QA personnel and other personnel, whose performance affects the instrument quality, have followed adequate training programs according to national or international standards. Especially those personnel performing critical processes or controlling critical processes shall be trained and certified according to the ESA accepted standards.

Heading

7.2 Traceability and Logbook

QAM-040

1. The PI shall prepare and maintain system, subsystem and equipment logbooks (in accordance with annex C of NR-3) for all operations and tests performed on the item during the period to be covered by the logbook.

QAM-050 2. The log books shall accompany the hardware whenever it is placed under the custody of another organization. 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.

Heading

7.3 Calibration of measuring, inspection and test equipments

QAM-060 Measuring, inspection and test equipments shall be calibrated against standard 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

QAM-070 The total error resulting from calibration and measurement process attributable to 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 shall be provided.

Heading

7.4 QA Requirements for Procurement

Heading

7.4.1 Contractor and Supplier Surveillance

QAM-080 1. In case the PI procures equipment or services from contractors or suppliers, he shall impose on them a set of product assurance requirements derived from the requirements listed herein, and tailored to the criticality of the products or services being provided.

QAM-090 2. The delegation of product assurance tasks by the PI to another lower tier supplier shall be done in a documented and controlled way. The PI retains the responsibility towards ESA.

Heading

7.4.2 Selection of Procurement Sources

QAM-100 1. For the procurement of equipment, components, parts, materials and services the PI shall evaluate and select manufacturers, suppliers or contractors who have a demonstrated capability of supplying the items with the required properties and the necessary quality levels.

QAM-110 2. The demonstration of capabilities shall be based on the successful supply of items or services similar to those to be procured.

Heading

7.4.3 Incoming Inspections

QAM-120 1. Incoming Inspections shall be performed on procured items to check their compliance with applicable requirements.

QAM-130 2. The visual inspection for completeness and freedom from obvious damage or deficiencies which might result from transportation shall always be performed.

Heading

7.5 QA Requirements for Manufacturing & Integration

Heading

7.5.1 Manufacturing and Inspection Flow Chart

QAM-140 1. Before the beginning of the actual manufacturing the PI shall review the manufacturing readiness in front of the following aspects:

- Status of product definition and requirements
- Status of manufacturing, assembly, inspection and test documentation
- Validation status of manufacturing processes, with particular emphasis on critical processes.
- Availability of required production, measuring and inspection equipment, and calibration status, when relevant.
- Cleanliness of facilities, with respect to the required cleanliness levels

QAM-141 2. ESA shall be informed and invited to the Manufacturing Readiness Review (MRR)

QAM-150 3. The manufacturing and assembly sequence together with associated inspections and used facilities shall be analyzed and the sequence of the various steps thoroughly planned and documented in a manufacturing and inspection flow chart.

QAM-160 4. 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.

QAM-170 5. The planning of inspections shall take into account the complexity of the operations and their potential effect on the properties and integrity of the end product.

Heading

7.5.2 Key and Mandatory Inspection Points (KIP/MIP)

QAM-180

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

QAM-190

2. 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.

QAM-200

3. A KIP shall require the same invitation, but the notified activity may be performed as scheduled if there is no reaction from ESA.

QAM-210

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

- when critical processes are performed
- formal qualification and acceptance tests
- when the manufacturing sequence is irreversible
- when the manufacturing sequence renders the location inaccessible for inspection (e.g. before conformal coating or before box closure)

QAM-220

5. The PI shall propose and identify in the instrument schedule a list of KIPs and MIPs to ESA together with the manufacturing and inspection flow chart at the ICDR and IPDR. The MIPs where ESA participation is required will be agreed with the PI.

Heading

7.6 Integration and Testing

Heading

7.6.1 Test Planning

QAM-230

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

- hardware configuration
- test objectives
- test parameters
- test sequences (incl. initial and final test conditions)
- acceptance/rejection criteria
- test equipment (incl. test software) and accuracy required
- test facilities involved
- hazards
- cleanliness of integration/test facilities

Heading **7.6.2 Test Procedures**

QAM-240

1. Test procedures are required for all tests on deliverable hardware.

QAM-250

2. Test procedures shall be derived from the project requirements of the project AIT plan and shall completely and precisely define the methods and steps by which the tests specified by the relevant test requirements shall be carried out.

QAM-260

3. The test procedures shall include:

- scope of the test, including the identification of the requirement being verified;
- identification of the test object;
- applicable documents, with their revision status;
- test flow;
- test organization
- test conditions;
- test equipment and set-up;
- step-by-step procedure, including definition of specific steps to be witnessed by QA personnel
- recording of data;
- pass/fail criteria and test data evaluation requirements;
- guidelines / criteria for deviation from test procedure and for retest (procedure deviation sheets).

Note: *Pass/Fail criteria shall be set allowing for test equipment accuracy and* measurem*ent uncertainty so that measured/indicated values can immediately be related to the required specification.*

QAM-270

4. All instrument level test procedures shall be submitted for review and approval by ESA for compliance with all related requirements 4 weeks prior to the Test Readiness Review and performance of the test concerned.

Heading **7.6.3 Test Facilities/Equipment**

QAM-280

1. Test facilities required to conduct the test programme shall be specified in the AIT (test) plan and shall comply with the requirements of ECSS-Q-20-07A NR-4.

QAM-281

2. The suitability of the test facility foreseen by the test plan shall be verified well in advance of testing

QAM-290 3. All test equipment including commercial test equipment shall be calibrated as required prior to use and shall remain within calibration during use.

QAM-300 4. Prior to unpacking and test of the equipment, the test facility shall have been set up in accordance with the applicable test procedure, and the facility cleared of all obstructions. The facility shall be inspected by QA who shall give approval for the unpacking and commencement of tests.

QAM-310 5. During testing all measurements and tests shall be made in conditions in accordance with the cleanliness and contamination control requirements. Actual ambient test conditions shall be recorded periodically during the test period.

QAM-320 6. During tests, only persons associated with the test shall be permitted into the facility.

Heading **7.6.4 Test Witnessing**

QAM-330 1. 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.

Note: *Test witnessing shall be considered when manual intervention is performed, at the setting-up, start and end of continuous fully auto-mated test sequences, or when no automatic recording of test parameters/results is available.*

QAM-340 2. The QA personnel shall document any variations to test procedures, deficiencies and non-conformances during the test, and monitor the implementation of dispositions and corrective actions.

Heading **7.6.5 Test Reviews**

QAM-350

1. A **Test Readiness Review** (TRR) shall be held prior to any formal instrument 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 (this shall include an inspection of the test item);
- status of existing non-conformances/failures, Requests for Waivers/, open work and assessment that open actions do not affect the test;
- availability and 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 and configuration of test facility, personnel and associated equipment (environment and cleanliness of test facility, calibration status and validity of all test equipment, including any software programme);
- identify recovery actions for the more probable contingencies in test (e.g. loss of pumping, cooling etc.)
- schedule and assignment of responsibilities during the test
- conclusion whether to release for testing.

QAM-360

2. After major portions of qualification and acceptance tests (e.g. at end of EMC tests and at end of vibration 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 authorized;
- 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 NRB;
- conclusion, whether the test article can be released to the next step or the test set-up can be dismantled.

QAM-370

3. After major portion of qualification and acceptance test and analysis of recorded data a Test Review Board (TRB) shall be held to:

- Review the analysis made of the test results
- Review NCR raised during the test and during the analysis
- Confirm conformance to test requirement specification

Note: PTR and TRB may be combined when analysis necessary for TRB are available at the time of the PTR.

QAM-380

4. Test Review Boards (TRR, PTR and TRB) shall include the following representatives of the PI:

- project management,
- AIT
- product assurance (chair person)

QAM-381

5. Test Review Boards (TRR, PTR and TRB) shall be explicitly included in the schedule.

QAM-390

6. ESA and its selected Prime shall be invited to attend instrument level Test-Readiness Reviews, Post Test Reviews and Test Review Boards, with a notification at least one week before the event.

Heading

7.6.6 Test Reports

QAM-400

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.

Heading

7.7 Handling, Storage and Preservation

QAM-410

1. Procedures and instructions shall be issued, made available and used to prevent deterioration and damage during handling, storage, packaging and transportation, by ensuring adequate environmental conditions(cleanliness, humidity,pressure, temperature, electrostatic discharge, shock) .

QAM-420 2. Effective implementation of applicable procedures and instructions shal be verified by the quality assurance activity

Heading

7.8 QA Requirements for Acceptance and Delivery

Heading

7.8.1 Acceptance process

QAM-430 All hardware and software deliverable items provided by the PI shall be submitted for acceptance to ESA following a formal acceptance process established by the PI. The hardware will be accepted on the basis of a mutually agreed acceptance test programme, most likely together with the Prime Contractor to avoid multiple handover meetings.

QAM-440 An acceptance review shall be held, supported by an End-Item Data Package (EIDP) to be provided by the PI

QAM-450 After consent to ship by ESA the deliverable items shall be shipped by the PI and after successful incoming inspection and closure of agreed action if any they are cleared for integration into the satellite or for operation with the satellite (or storage in the case of flight spares)

QAM-460 The responsibility for the transport lies with the PI. As a principle all flight hardware shall be accompanied by PI personnel during transport.

QAM-470 In support of the formal process of delivery to ESA, the PI shall establish a formal acceptance process for all items delivered to him by collaborating institutes/organizations as well as from contracted industries.

Heading

7.8.2 Acceptance data package

QAM-480 The End-Item Data Package (EIDP) shall contain all documentation which provides visibility over the configuration, fabrication, assembly and test operation performed on the equipment to be delivered to ESA. The content of this EIDP is described in ***annex A***.

QAM-490 The EIDP shall be initiated prior to and maintained during all stages of assembly, inspection and test for each of the equipment specified

QAM-500 The interface control documents/drawings (i.e. EID-B/MICD) to be provided with the EIDP shall reflect the latest design status for the item. Design modifications resulting from NCRs shall be covered by updated design documentation.

QAM-510 The original EIDP shall remain with the equipment at all times.
Five sets of the EIDP (electronic copies) shall be submitted to ESA at least 10 working days prior to the Delivery Review (final up-dates may be handed over at the review)

Heading **7.8.3 Delivery review board**

QAM-520 The PI is responsible to organize a formal Delivery Review Board for instrument models to be delivered to ESA.

QAM-530 The objective of this review shall be to establish that there is adequate documentary evidence to demonstrate that the instrument is:

- Conforming to its requirements,
- Conforming to its approved configuration
- Free from material and workmanship deficiencies (all NCR have an agreed disposition)
- Delivered with a complete and accurate EIDP
- All open works are identified

The conclusion shall state separately on the consent to ship and on the acceptance
Note: The formal acceptance of the instrument might be subject to closure of open actions, retests etc., in which case a delta DRB might be held

QAM-540 The DRB shall be composed of the following members (or their nominated representative) as a minimum:

- PI project manager
- PI PA responsible
- Instrument responsible engineer
- ESA PA representative
- ESA instrument responsible
- Satellite prime contractor representative

QAM-550

The instrument Delivery Review Board shall be chaired by ESA and shall cover the following subject:

1. Confirm list of deliverable items.
2. Review the Configuration Item Data List, CIDL (as-designed).
3. Review the actual build status for hardware and software ABCL (as-built).
    a. Review of relevant change proposals status and reconciliation of changes
    b. Establish potential deviations to the design qualification baseline or to different models.
4. Review the status of non-conformance (major + minor).
5. Review the status of waivers/deviations.
6. Evaluate inspection results including cleanliness status.
    a. Verify witness samples
    b. MIP/KIP reports
7. Review the status of the test programme/test flow and test reports.
    a. Review the verification status of requirements, VCD
    b. Qualification/Acceptance test successfully run
8. Establish acceptability of Residual Hazards, and verify that all safety issues were covered and well understood, including the dangerous goods declaration, when applicable.
9. Review all interfaces and critical items.
10. Evaluate Historical Records, Mate/demate log, Limited Life Item Records, Open Work Records, Temporary Installation Records, Red Flag Items, and other sections of ADP for content and completeness.
11. Evaluate Operational constraints, Operating and Maintenance Manuals.
12. Review the hardware status and procedure of packaging, handling shipping, and storage operations.
13. Visual inspection of HW
14. Authorise shipment.

Heading

7.9 QA Requirements for Support Equipment

Informative

Ground Support Equipment (GSE) is clarified as:
“Optical, mechanical, fluidic, electrical and software support equipment or systems used for calibration, measurements, testing, simulation, transportation, handling... of space segment or of space segment elements.”

QAM-560

For all above defined GSE items which will be directly mechanically or electrically connected to FM units the same acceptance requirements applies as for FM units with an EIDP commensurate with the quality activities required for these items

Heading

8 SAFETY ASSURANCE ECSS-Q-ST-40C NR-7

Heading

8.1 General

SAF-010

1. The PI shall implement a safety assurance programme comprising:
- the identification and control of all safety related risks with respect to the design, development and operations of the instrument
- the assessment of the risks based on qualitative and quantitative analysis as appropriate
- the application of a hazard reduction precedence and of control measures of the residual risks.

Informative

The hazard reduction process consists of the following sequence of activities, performed in sequence:

a) Hazard Elimination - Select design technology, architecture and operational characteristics to eliminate hazards and hazardous conditions from the design and operational concepts.

b) Hazard Minimization
- Select the least hazardous design architecture, technologies, and operational characteristics to minimize the severity of the associated hazardous events and consequences.
- Reduce the probability of occurrence of the hazardous condition.

c) Hazard control
- Safety devices – Control hazards through the use of automatic safety devices as part of the system, subsystem or equipment. Safety inhibits shall be independent and verifiable.
- Hazard control - Warning devices - Use devices for the timely detection of the condition and the generation of an appropriate warning signal. This shall be coupled with emergency controls of corrective action for operators to safe or shut down the affected subsystem.
- Hazard control - Special procedures – Only when it is not possible to reduce the magnitude of a hazard through the design, the use of safety devices or the use of warning devices, special procedures shall be developed to control the hazardous conditions for the enhancement of safety. Special procedures may include emergency and contingency procedures, procedural constraints, or the application of a controlled maintenance programme.

Note: *The objective of safety requirements is to establish methods to be followed during the design, development, manufacture, assembly, integration, testing, transportation, ground operations, launch and orbital operations. These methods will ensure that the risk of hazardous consequences to personnel, flight hardware and facilities are minimized.*

SAF-020 2. The PI shall identify the responsibility in his team and a contact person for safety related aspects. Description and planning of safety related activities shall be included in the Product Assurance Plan.

Heading

8.2 Requirements

Informative The requirements for safety assurance are governed by the requirements imposed on ESA by the launcher authority, complemented by requirements imposed by ESA itself and those of the applicable national safety standards and regulations in the country of origin or use.

SAF-030 The requirements for range safety for ATLAS V and for Delta 4 are applicable together with NPR 8715.7 NR-31

SAF-040 The requirements for CSG range safety specification CSG-RS-10A-CN NR-33, CSG-RS-21A-CN NR-34 and CSG-RS-22A-CN NR-35are applicable.

SAF-050 National safety standards of countries where the instrument will be assembled integrated or operated are applicable

SAF-060 No kind of hazardous events shall propagate across the interfaces.

Hardware or software failures shall not propagate to cause additional failures or the hazardous operation of interfacing hardware. The Contractor shall prove the capability of the design to sustain:

- a single failure or operator error without critical consequences, and
- any combination of two failures/ operator errors without catastrophic consequences.

Note:
a.CATASTROPHIC

- loss of life,
- life threatening or permanently disabling injury or occupational illness;
- loss of an element of an interfacing manned flight system;
- long term detrimental environmental effects;

b. CRITICAL

- temporary disabling, but not life-threatening injury, or temporary occupational illness;
- loss of major damage to flight systems, major flight system elements,

informative The ESA selected Prime will act on behalf of ESA as “Payload Authority” for the launcher Interface. It will assure that safety data resulting from the design

and operation of an instrument will be integrated into the safety considerations for the system and vice versa the Prime will identify and control the detailed safety requirements to be met by the payload.

Heading

9 DEPENDABILITY ASSURANCE ECSS-Q-ST-30C NR-5

Heading

9.1 General

Informative

This section is based on ECSS-Q-ST-30C [NR-5] and ECSS-Q-ST-30-02C [NR-6], which are tailored here to the instruments and their interfaces with other elements of the spacecraft.

Prime objectives of the reliability assurance activities are:

- to establish and list in a systematic way all possible modes of failure, in order to identify weak elements of the design for improvements, and to support the safety analyses by pinpointing potential hazards (FMEA, HSIA and SPF sections);
- to assist in the optimization of system reliability and redundancy concepts with comparative reliability assessments for alternative design options and trade off studies;
- to prevent the propagation of failures to other instruments or to the spacecraft (see section on Worst Case Analysis, 9.5).

RAMS-010

The PA Plan shall describe how compliance with the programme dependability requirements will be met and reliability assurance activities will be interrelated and coordinated with parallel engineering and safety activities. The various steps for the initiation, update and finalization of the reliability analyses shall be identified in the PA plan.

RAMS-020

Failure tolerance need not to be applied to: primary structures, load-carrying structures, load-carrying elements of mechanisms, and pressure vessels.
In these cases, the requirements of design for minimum risk shall be applied.
For structural fastener Single Point Failure shall be avoided.

Heading

9.2 Dependability Analysis: Failure Modes, Effects Analysis (FMEA)

RAMS-030

1. A comprehensive Failure Modes, Effects and Criticality Analysis (FMEA) shall be performed on the functional and physical design (functional FMEA and design FMEA) of the entire instrument and any GSE interfacing physically or functionally with the instrument. In all cases the FMEA shall identify how each failure mode is detected.

RAMS-040 2. The purpose of the FMEA shall be to identify all failure modes of the system and rank them in accordance with the severity of the effects of their occurrence. Furthermore, it shall be to:

- determine the effects of each failure on the performance of the function under analysis;
- identify all single point failures, classify them according to the severity of their effects, and propose actions to eliminate them from the design;
- establish how the detection, diagnosis, correction, and verification of each failure can be unambiguously implemented.

RAMS-050 3. FMEA shall be carried out in accordance with NR-6 clause 4.1 and 4.6, for all operational modes of the instrument during orbital phases, launch phases and also for ground testing, if not covered by analyses of the other phases.

RAMS-060 ***Note:*** *The FMEA shall be performed on the basis of the lowest level of design definition which is available at the successive steps in the design and development process, e.g. initially starting with assumed failure modes of basic functions, later at assembly level and finally at instrument level as necessary to cover potentially critical effects. Later, for mechanisms from part level upwards; else from functional blocks without redundancy upwards. The logical sequence of the FMEA shall include the following steps:*

- *to identify the item under consideration and its function;*
- *to identify the assumed failure modes for that item or function;*
- *to analyze and describe the effect of the assumed failure mode on the function of the assembly under consideration and the effects on related and higher level assemblies and functions;*
- *to identify observable symptoms for the assumed failure mode or its effects (e.g. automatic function monitoring or house-keeping data and telemetry; in orbit or during test).*
- *to establish what provisions are inherent in the design:*
- *to compensate the effect of the malfunction (e.g. switching to redundant unit, automatically or by telecommand),*
- *to isolate the fault, or*
- *to switch to contingency operational modes;*
- *to identify the criticality category of the failure effect according to the definition given below and, specifically, whether the item is a Single Point Failure (SPF).*
- *provide remarks and recommendations if applicable or necessary or desirable modifications for the design or operations (e.g. elimination of SPFs).*

RAMS-070 4. The following Failure Effect Severity Categories shall be used in the FMEA:

Catastrophic:
- Propagation of failure to other subsystems / assemblies / equipment

Critical:
- Loss of functionality

Major:
- Major Degradation of functionality

Negligible:
- Other effect.

RAMS-080 5. The following attributes shall be added to the criticality category as appropriate:
-the suffix “S” shall be used to indicate safety impacts.
-the suffix “R” shall be used to indicate redundancy

RAMS-090 6. The PI shall submit an updated FMEA at each instrument design review.

Heading

9.3 Hardware/Software Interaction Analysis (HSIA)

RAMS-100 1. A hardware / Software Interaction Analysis (HSIA) shall be performed in conjunction with the FMEA.

RAMS-110 2. The HSIA shall systematically address the hardware / software interface of a design to ensure that hardware failure modes are being taken into account in the software requirements and design. Detailed requirements are provided in [NR11].

RAMS-120 3. The HSIA shall be performed for flight H/W controlled by on-board S/W.

RAMS-130 4. The HSIA shall be performed for safety critical / elements of the GSE as identified in the FMEA and Hazard Analysis controlled by S/W.

RAMS-140 5. The HSIA shall be attached to the FMEA.

Heading

9.4 Single Point Failures

RAMS-150 1. On the basis of the FMEA, 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 in accordance with template in NR-6, to be a section of the FMEA, with a rational for retention.

RAMS-160 2. This rationale shall include an engineering assessment of the likelihood of occurrence, a discussion of the measures, if any, that might be taken to eliminate the SPF, and of special provisions to reduce the probability of occurrence or the potential failures effects.

RAMS-170 3. The PI shall take the necessary action to eliminate Single Point Failures (SPF) related to interface critical elements.

RAMS-180 4. Any remaining SPF shall be approved by ESA through the Request for Waiver procedure.

Heading

9.5 Worst Case Analysis

RAMS-190 1. The PI shall perform a Worst Case Analysis (WCA) in accordance with NR-5 requirements, in parallel to electronic design and development activities.

RAMS-200 2. The WCA shall cover at least 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.

RAMS-210 3. For electronic components the parameter variations defined in ECSS-Q-TM-30-12 IR-3 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).

RAMS-220 4. The replacement of sensitive parts or circuit redesign shall be considered if the WCA indicates a potential problem due to violation of de-rating requirements or marginal end-of life performance due to aging.

RAMS-230 5. The adequacy of margins in the design of electronic circuits, thermal and electromechanical systems shall be demonstrated by analysis or test.

RAMS-240 6. 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.

Heading

9.6 Part stress analysis

RAMS-250	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 de-rated values specified in ECSS-Q-ST-30-11C NR-11.
RAMS-260	Part stress analyses shall be performed at part level to verify that the derating rules have been implemented.

Heading

10 EEE PARTS SELECTION AND CONTROL ECSS-Q-ST-60C REV1 NR-10

Heading

10.1 General

Informative

Parts quality play an essential role for the overall chance of success of the mission, and therefore their selection and control shall be paid high attention.

In the following, ECSS-Q-ST-60 C Rev 1 NR-10 has been tailored for the definition of the component requirements to be applied for the instruments.

EEE-0010

These requirements apply to flight standard hardware and to components coming into direct contact with flight standard hardware such as the interfacing connectors from GSE cables. For Engineering Models, components shall be used which are equivalent in form, fit, function and materials (e.g. if thermal vacuum tests would be done on EM) but particular quality assurance provisions are not needed.

EEE-0020

The following items shall not be considered EEE components and will be controlled at unit or higher level by the relevant disciplines:
- intermediate products containing discrete components on substrates - PCBs but not including hybrids,
- solar cells,
- cells in batteries,
- HF sub-assemblies like coaxial cable assemblies or waveguide elements,
- TWTs,
- and RF switches, coaxial or waveguide.

EEE-0030

The PI shall prepare a Component Control Plan as part of the Product Assurance Plan. This plan shall describe how the component programme will be carried out with identification of 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.

Heading

10.2 Component Programme Management

Informative

Since a deficient identification of the needed components, the usually long delivery times, and the evaluation and tests can have serious impact on the overall schedule, the activities of the component procurement programme need to be planned thoroughly and progress must be closely monitored.

EEE-0040 1. The PI shall define the responsibility for the component engineering and procurement activities within this team and he shall nominate a contact person for coordination with ESA.

EEE-0050 2. The PI shall provide as part of the project management plan a EEE parts procurement plan, identifying possible long lead items and eventual re-qualification of parts requiring additional time and effort.

EEE-0060 3. The PI shall participate to Solar Orbiter Part Control Board (SO-PCB) established by the prime with the function of Component Advisory Board at programme level

Informative The SO-PCB tasks and objectives includes:

- To manage and control the part procurement programmes at all levels
- To implement the Parts Approval cycle through PAD approval including review of part/manufacturer evaluation/qualification plan and test reports (if applicable), status of qualification, approval of procurement specifications, quality and lot acceptance levels and procurement inspections, Destructive Physical Analysis (DPA), radiation sensitivity assessment.
- To review the procurement status and to identify risks like U.S. parts under Export license restrictions, ITAR, all Long Lead Time Items.

To assess parts technical issues such as Nonconformances, Waivers, Deviations and alerts.

Heading

10.3 Component Engineering

Heading

10.3.1 Parts and material restriction

EEE-0070 1. The PI shall ensure that non-hermetically sealed materials of components meet the requirements of ECSS-Q-ST-70 regarding off-gassing, out-gassing, flammability, toxicity and any other criteria specified for the intended use.

EEE-0080 2. The PI shall evaluate the robustness of selected EEE components against the stresses induced by the assembly techniques to be employed.

EEE-0090 3. With respect to health and safety, beryllium oxide (except if identified in the procurement specification), cadmium, lithium, magnesium, mercury, zinc, radioactive material and all material which may cause safety hazard shall not be used.

EEE-0100 4. For limited life duration, known instability, safety hazard or reliability risk reasons, the use of EEE components listed below shall not be used:
EEE components with pure tin (less than 3% Pb in case of SnPb alloy) used as a finish on the leads, terminations and external surfaces of components and packages.

- Hollow core resistors,
- Potentiometers (except for mechanism position monitoring),
- Non-metallurgically bonded diodes,
- Semiconductor dice with unglassivated on active area,
- Wet slug tantalum capacitors other than capacitor construction using double seals and a tantalum case,
- Any component whose internal construction uses metallurgic bonding with a melting temperature not compatible with the end-application mounting conditions,
- Wire link fuses < 5A,
- TO5 relays without double welding of the mechanism to the header or with any type of integrated diodes inside.

EEE-0110 5. For limited life duration, known instability, safety hazards or reliability risk reasons, EEE components listed below shall not be used for new designs:

- RNC90 > 100 kΩ,
- TO3 and DO4/DO5 packages.

EEE-0120 6. The use of pure tin in internal cavities may be authorized, on a case-by-case basis, based on the demonstration that there is no alternative product and there is no risk (supported by a technical justification).The justification of the use of pure tin shall be presented to SO-PCB for approval

EEE-0130 7. The justification of the use of pure tin shall be presented to SO-PCB for approval

EEE-0140 8. The use of pure tin (inside or outside the part) shall be declared in the PAD.

Heading **10.3.2 Radiation Hardness Assurance (EEE components)**

EEE-0150 1. The PI shall implement throughout the duration of the programme a Radiation Hardness Control plan in line with the requirements reported in ESSB-ST-Q-001 Issue 1 NR-16 as tailored in paragraph below

EEE-0160 2. The PI shall take into account the Radiation Environment [TEC-EES-03-034/JS] NR-32specified for the project in order to propose to ESA a classification of the EEE parts as insensitive or sensitive for the project environment. Total Ionising Dose (TID), displacement damage (TNID) and Single Event Effects (SEE) shall be assessed for this classification

EEE-0170 3. The PI shall perform a radiation analysis to evaluate single-event (SEE), displacement damage (DD) and total ionising dose (TID) effects on instrument operation for all components used in flight hardware that are exposed to radiation environment, including those components used in COTS units.
The radiation analysis on the electronic units shall include a sector analysis for all sensitive components that take into account the shielding provided by the spacecraft and by the unit material. The result of the shielding analysis is a list of calculated TID values per part. Additionally, for displacement damage sensitive parts a Total Non Ionising Dose (i.e. fluence of equivalent particle energy) value per part shall be calculated.
Note: Radiation analysis can be run considering only the shielding from the electronic box in first instance; If box shielding is not sufficient vs. acceptable TID then consider: a) extra shielding at box level; b) and/or spot shielding at component level; 3- and /or sector analysis including SC shielding

EEE-0180 4. The following replaces 5.1.h of ESSB-ST-Q-001 Issue 1.
Radiation Design Margin (RDM), defined as the ratio between component type TID sensitivity (TIDS) and expected TIDL during the mission, shall be greater than 2 (100%).
Sensitive parts or parts for which high lot to lot variability has been shown following RVT may require a higher margin.

EEE-0185 5. The following replaces 5.2.i of ESSB-ST-Q-001 Issue 1.
Radiation Design Margin (RDM), defined as the ratio between component type TNID sensitivity (TNIDS) and expected TNIDL during the mission, shall be greater than 2 (100%).
Sensitive parts or parts for which high lot to lot variability has been shown following RVT may require a higher margin.

EEE-0190 6. Radiation sensitive parts shall be classified as non-standard parts regardless of their qualification status. Therefore their approval for the project shall be negotiated via PAD submission.
The relevant Radiation Evaluation data shall supplement the PAD in these cases. Radiation Verification Test may be necessary as required by ECSS-Q-ST-60C Rev.1, Paragraph 5.3.8.

EEE-0200 7. As part of the SO-PCB (Solar Orbiter Parts Control Board) activities and as part of the radiation hardness control plan, the PI shall propose to ESA a classification of EEE parts proposed for application in the project w.r.t. their sensitivity to TID and TNID (TNID for displacement damage sensitive components).
Such classification shall be based on acceptable test data or, alternatively, be supported by radiation evaluation test conducted in accordance with applicable ESCC specifications

EEE-0210 8. Radiation hardened component that is components which are 100 Krad radiation tolerant shall be considered insensitive to TID for SO

EEE-0220 9. On components for which available data indicate sensitivity to the expected radiation environment, additional shielding and/or radiation verification testing to demonstrate that the batch of components (or wafers) intended for flight-application is acceptable shall be performed.

EEE-0230 10. If no radiation data are available on specific components, radiation testing will have to be performed for evaluation (as reported in ECSS-Q-ST-60C rev1 NR-10 para 5.2.3.1).

Informative Subject to personnel availability, 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

EEE-0240 11. Above a LETth of 60 MeVcm2/mg, the parts can be considered as immune to SEE in space and no further analysis is necessary

EEE-0250 12. Below a LETth level of 60 MeVcm2/mg , SEE analysis shall be performed.

EEE-0260 13. Parts showing a LETth < 3.7 MeV.cm2 /mg shall in principle not be used. Memory circuits shall have sufficient error detection and correction capability for protection against SEU such that the circuit performance goals are not affected by these errors.

EEE-0265 14. The following table defines the worst case SET model as noted in 5.3.c of ESSB-ST-Q-001 Issue 1.

Device type	SET nature at device output
OP-amps	$\Delta V_{max} = \pm V_{cc}$ & $\Delta t_{max} = 15\ \mu s$
Comparators	$\Delta V_{max} = \pm V_{cc}$ & $\Delta t_{max} = 10\ \mu s$
Voltage Regul.	$\Delta V_{max} = \pm V_{cc}$ & $\Delta t_{max} = 10\ \mu s$
Voltage Ref.	$\Delta V_{max} = \pm V_{cc}$ & $\Delta t_{max} = 10\ \mu s$
Optocouplers	Susceptible to SEU $\pm V_{cc}$ & $\Delta t_{max} = 100ns$

EEE-0270 15. Parts shall be proven to be insensitive to Latch-up, this meaning a SEL LETth >60 MeV.cm2/mg.

EEE-0280 16. The following table replaces table 5-7 of ESSB-ST-Q-001 Issue 1.

Component LETth (MeVcm2/mg)	Environment to be assessed
LET <15	Heavy ions (GCR, Solar event ions) Protons (trapped, solar event protons)
LETth=15-60	Heavy ions (GCR, Solar event ions)
LETth > 60	No analysis required

EEE-0290 17. The calculated event rates shall be acceptable for the application

EEE-0291 18. The following table replaces table 5-2 of ESSB-ST-Q-001 Issue 1

Family	Sub-family	RHA qualification level	RDM	RVT Requirement
diode	Zener, voltage reference		>2	No testing required
			<2	RVT required if flight diffusion lot number different from data diffusion lot number and date code older than 4 years
integrated circuits	Silicon Monolithic CMOS	M or higher		No testing required
		-	> 2	RVT required if flight diffusion lot number different from data diffusion lot number and date code older than 4 years
			< 2	RVT required
	Silicon Monolithic bipolar, BiCMOS	M or higher	> 10	No testing required
			<10	RVT required if manufacturer test performed at HDR
		-	> 10	RVT required if flight diffusion lot number different from data diffusion lot number and date code older than 4 years
			<10	RVT required
transistors	Low power NPN Low power PNP High power NPN High power PNP	M or higher	-	No testing required
		-	> 2	RVT required if flight diffusion lot number different from data diffusion lot number and date code older than 4 years
			<2	RVT required
	FET N channel FET P channel	M or higher		No testing required
		-	> 2	RVT required if flight diffusion lot number different from data diffusion lot number and date code older than 4 years
			< 2	RVT required
optoelectronics	CCD, CMOS APS Opto discrete devices	M or higher		No testing required
		-	> 2	RVT required if flight diffusion lot number different from data diffusion lot number and date code older than 4 years
			< 2	RVT required

EEE-0292 19. The following table replaces table 5-4 of ESSB-ST-Q-001 Issue 1

Family	Sub-family	RDM	RVT Requirement
Diodes	voltage regulator, Zener	> 2	no testing required
		< 2	RVT required if flight diffusion lot number different from data diffusion lot number and date code older than 4 years
integrated circuits	Silicon Monolithic bipolar	> 2	No testing required
		< 2	RVT required if flight diffusion lot number different from data diffusion lot number and date code older than 4 years
transistors	Low power NPN, Low power PNP High power NPN, High power PNP	> 2	No testing required
		< 2	RVT required if flight diffusion lot number different from data diffusion lot number and date code older than 4 years
Optoelectronics	CCD, CMOS APS		RVT required
	Opto discrete devices	> 2	No testing required
		<2	RVT required if flight diffusion lot number different from data diffusion lot number and date code older than 4 years

Heading

10.4 Component Selection and Approval

Heading

10.4.1 Preferred Components

EEE-0300 1. The European Preferred Parts List (EPPL) and the ESA/SCC Qualified Parts List shall be used as the primary basis for component selection.
The following additional selection sources shall be considered in the following order of precedence:
EPPL part II, ESCC QPL/QML, NPSL level 1 and 2 (with disposition of the associated application notes), MIL QPLs/QMLs

EEE-0310 2. All components used in flight hardware shall comply with the following standards as a minimum: see annex B Quality level for class 2 components

EEE-0320 3. Components interfacing the spacecraft (power bus interface, MIL-BUS-1553 bus interface, etc..) shall be Class 1 component as per ECSS-Q-ST-60C rev.1 NR-10Table 7-1

Heading

10.4.2 Non PPL Listed Components

EEE-0330 1. The selection of components which are not in the list mentioned in para. 10.4.1 shall be based on proven qualification, characterization, and previous space experience and data, relevant with regard to the requirements for the programme, from manufacturers or sources (preferably European) employing effective Product Assurance Programmes in manufacturing and test.

EEE-0340 2. Preference shall be given to components from sources which would necessitate the least evaluation/qualification effort.

Heading **10.4.3 Component Approval**

EEE-0350 1. Components used in flight standard hardware of an instrument will be reviewed and approved by the Solar Orbiter Parts Control Board (SO-PCB) though PADs submission.

EEE-0360 2. Approval via DCL can be proposed limited to those space qualified items (see definition in ECSS-Q-ST-60C rev.1 NR-10 para. 3.2.8) that are not radiation sensitive and for which no pre or post procurement inspection or lot acceptance test or additional test are required.

EEE-0370 3. Type approval will be given if equivalence to ESCC/MIL qualification requirements can be demonstrated via existing data or by similarity to qualified components. This information shall be provided on or attached to the Part Approval Document. The actual qualification status of the selected manufacturer shall be checked prior to procurement.

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 program, if applicable. Copies of procurement specifications which are not readily available SO-PCB, shall be provided with the Part Approval Document.

Approval by ESA is given by the signature on the Part Approval Document (PAD) (see 10.4.5) An approval reference shall be entered on the DCL to maintain traceability of ongoing work.

EEE-0380 4. All the requirements specified in this document are applicable also for OTS. Therefore, the previous use or approval of a part (via PAD or otherwise) in any other project shall not be considered in any case as an approval for Solar Orbiter. The project explicit approval remains applicable.

Heading **10.4.4 Component Evaluation and Qualification**

EEE-0390 1. In absence of a valid demonstration that the component has the ability to conform to the SO requirements for functional performance, quality, dependability and environmental resistance, the PI shall perform a component evaluation test program.

EEE-0400 2. This program shall cover the following elements:

- Design assessment for the parameters of the component which are essential for the intended application and which justify the use of a non-preferred part.
- Constructional analysis of the selected part (minimum three components) to assess the standards of manufacturing and assembly, potential failure modes, materials and processes which may lead to deterioration or malfunction.
- Manufacturer assessment to assure that the organization, facilities, production control and inspection system are adequate.
- Evaluation and qualification tests corresponding to those defined in the ESCC specifications for similar technologies.

Further details for an evaluation/qualification program are outlined in ECSS-Q-ST-60C rev.1 NR-10 para 5.2.3
Experienced consultants or procurement agents may have to be used by the PI to perform these tasks.

EEE-0410 3. If applicable, the evaluation plan and report for a specific component for use on Solar Orbiter shall be provided with the Parts Approval Document (see 10.4.5 below).

Heading **10.4.5 Application for Part Approval**

EEE-0420 1. A Part Approval Document (PAD) shall be prepared and submitted for approval for all parts intended to be used for the instruments, after performing type reduction as described in 10.4.6

EEE-0430 2. The PAD shall be in accordance with [NR-10 Annex]. A minimum of 20 (TBC) working days shall be included in the schedules to allow for the ESA review of the PAD.

EEE-0440 3. The PI is responsible for the flow down of requirements from ESA and for the implementation of an effective Component approval cycle such that all PADs shall be approved prior to each experiment CDR close out. The PI shall be considered fully responsible of selection, procurement and use of EEE parts, and this responsibility remains with the PI once parts approval for the project has been granted

EEE-0450 4. The PI shall ensure that initiated PADs shall be provided to ESA prior to actually starting the evaluation and/or procurement of the relevant EEE component for Solar Orbiter
ESA may decline responsibility if the PI fails to comply with this requirement.

EEE-0460 5. User-programmable devices shall be considered non standard in all cases and need to be approved via PAD cycle

EEE-0470 6. Specific components (Hybrid Circuits, ASIC's etc) of which the technology is qualified by Capability Approval (or similarity), but which are newly developed and for which a Detail specification is not listed in the EPPL, ESCC QPL and NPSL, shall be covered by an individual PAD.

Heading **10.4.6 Declared Components List (DCL)**

EEE-0480 1. The PI shall be in charge of establishing and updating, a consolidated DCL at experiment level.

Informative The DCL is intended to be completed stepwise as the selection of the components and the approval process progresses. The document will be used for comments and advice by component experts from ESA and by the SO-PCB for type reduction or substitution and for recommendation on procurement details

EEE-0490 2. The DCL shall be compatible with electronic transmission and be also provided in an unlocked pdf format with meta data filled in as well as in an editable format (excel compatible)

EEE-0500 3. The DCL shall identify the instrument / instrument unit and the design status to which it is applicable.

EEE-0510 4. The parts shall be grouped according to the families identified in the ESA PPL and the list shall be in accordance with NR-10

EEE-0520 5. The Investigator shall prepare and submit issues of the DCL in-line with the components procurement need including time for efforts on standardization and coordination.

EEE-0530 6. The DCL shall be issued as required for the instruments reviews (as designed) and at flight hardware delivery (as built).

Heading ## 10.5 Procurement Requirements

Heading **10.5.1 Procurement Specifications**

EEE-0540 1. Each type of component used by the PI shall be controlled by a procurement specification, or series of specifications, which must be approved by SO-PCB.

EEE-0550 2. The PI shall make maximum use of approved specifications issued under existing European component specification systems, either CECC or ESCC as appropriate.

Heading **10.5.2 Component Screening and Burn-In**

EEE-0560 1. All components to be incorporated into flight-standard hardware shall be subjected to screening test in accordance with Class 2 standard (Annex B).

EEE-0570 2. In any case lot traceability shall be assured by the component manufacturer, starting from the wafer to the final product.

EEE-0580 3. All screening test shall be performed at the component manufacturer's premises or at an approved source

Heading **10.5.3 Lot Acceptance Test (LAT)**

EEE-0590 1. LAT test shall be performed at the component manufacturer's premises or at an approved source.

EEE-0600 2. It shall be ensured that any lot or datecode of EEE part shall be subjected to Lot Acceptance Testing (LAT) as defined in the ESCC specifications or QCI (Quality Conformance Inspection) as defined in the United States Military specifications. The applicable LAT group policy is defined in NR-10 para 5.3.5 modified as follow:
OTS hybrids shall be submitted to LAT or group C as per MIL-PRF-38534 independently from the qualification status

Heading **10.5.4 Destructive Parts Analysis (DPA)**

EEE-0610 1. The DPA shall be performed on 3 samples per lot for the following non-space qualified parts types: as a minimum relays, oscillators, thermostat, hybrids, optocouplers, capacitors, ICs and semiconductor and commercial parts

EEE-0620 2. The DPA shall be performed on 3 samples per lot on critical space qualified parts, including as a minimum relays, thermal switches, OTS hybrids, optocouplers and oscillators. For other space qualified parts families, DPA is not required

Heading **10.5.5 Specific components**

EEE-0630 Devices such as custom hybrids, ASIC, detectors, MCMs shall be subject to parts control via PAD.
If a new design is planned for the mission, ESA reserves the right to request / attend the necessary design reviews as appropriate for the relevant technology.

Heading **10.5.5.1 Hybrids**

EEE-0640 For hybrid the ECSS-Q-ST-60-05 (NR-13) applies
For each hybrid circuit a PAD shall be established, including all add-on components, and submitted to SO-PCB for approval

Heading **10.5.5.2 Monolithic Microwave Integrated Circuit (MMIC)**

EEE-0650 For MMIC, ECSS-Q-ST-60-12 applies.
For each MMIC a PAD shall be established and submitted to SO-PCB approval

Heading **10.5.5.3 Application Specific Integrated Circuit (ASIC) and Field Programmable Gate Array (FPGA)**

EEE-0660 1. All ASICs and FPGA shall be considered as non-standard parts and therefore controlled via PAD agreement.

EEE-0670 2. ECSS-Q-60-02 shall apply for the design development.

EEE-0680 3. The user of FPGAs shall design and implement test interface boards, test software and test procedures for appropriate test equipment, which allows all functional and parametric tests to be performed on every programmed part independent from the actual unit where it is intended to be used, for acceptance test and if needed for failure analysis.

EEE-0690 4. All Programmed FPGA's shall receive a burn-in and testing sequence according to manufacturer's specifications. The procedure shall address as a minimum the following elements**:**

- Method of calibration, i.e. verify that the programmer equipment passes all the diagnostic checks
- Verification of status of the program of the programming equipment
- Method of configuration, i.e. by using data from computer mass memory and use of reference devices
- Method of identification of each program configuration, i.e. the part number to be assigned to each device
- Use of 100% serialization to maintain traceability
- Programming procedure, i.e. current / voltage waveform to be applied. Only 1 programming cycle is allowed
- Method of verification of the contents of the programmed device
- Corrective actions in case of a programming failure. An analysis shall be carried out if the number of failures for each lot/date code that are programmed relying on the same programmer calibration exceeds 15%
- Electrical measurements, in accordance with the part specification (read and record optional)
- Burn-in test, according chart III of ESCC9000 with the configuration for burn-in in accordance with the component procurement specification
- Electrical verification of correct programming and electrical measurements pre- and post-burn-in.
- The maximum PDA shall be 5% for each lot/date code. If the PDA is higher than 5% the lot shall be rejected and submitted to Non conformance Review Board disposition.

EEE-0700 5. The FPGAs used in Engineering models shall be guaranteed to be fit, form and function representative of the parts intended for Flight, and shall be procured from the same manufacturer. It shall in addition be designed with the same libraries and adopting the same design rules (e.g. radiation hardness mitigation techniques) as the FM FPGA. All the analysis provided should refer to performances of the relevant FM part

Heading

10.6 Documentation

EEE-0710 1. All documentation will be retained and made available for ESA. Individual manufacturer's documentation shall be as per the agreed procurement specifications.

EEE-0720 2. Other documents related to EEE parts, like component manufacturer's data relevant to procurement, or lot-specific results, will remain available for review by ESA for the duration specified in the contract**.**

EEE-0730 3. ESA reserves the right to request at any time a Data Package Review to verify that all activities and specifications, as agreed in the relevant PADs, have been effectively put in place in the procurement of components intended for Flight application prior to the actual integration of the components into Flight hardware**.**

EEE-0740 4. Additionally, upon request, the PI is responsible for the delivery to ESA of the following documentation relevant to EEE components used in the project, in electronic, unlocked, .pdf format with meta-data filled in: Part Approval Documents (signed), Component procurement specification, Component Evaluations, Radiation Test data, Construction Analysis and DPA**s.**

Heading

10.7 Component Quality Assurance

EEE-0750 Para. 5.5 of NR-10 applies with the following amendment.
EEE parts related NCR and Alert assessment shall be provided as well to SO-PCB

Heading

10.8 Off-The-Shelf equipment

EEE-0760 1. Any Off-The-Shelf (OTS) equipments that the PI is expecting to use shall be pre-agreed with the ESA Project office.

EEE-0770 2. The PI shall review the components used in OTS equipment to verify compliance with the requirements of this document. The review shall consider the used parts' list, radiation hardness, the derating rules, Worst Case Analysis and the equipment design. COTS components shall be treated as non standard parts.

Heading

11 MATERIALS AND PROCESS SELECTION AND CONTROL ECSS-Q-ST-70C NR-17

Heading

11.1 General

Informative

In the following, NR-17 has been tailored and summarized here for the definition of the materials, mechanical parts and processes requirements to be applied for selected payload instruments.

Heading

11.2 Materials and Process Selection and Approval

MMP-010

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

MMP-020

2. To this end, the PI shall plan and enforce an effective material control and standardization program. Materials and processes shall be selected in accordance with the criteria summarized below; full details are given in ECSS-Q-ST-70 C NR-17

MMP-030

3. 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 instructions are provided in NR-17

MMP-040

4. The PI shall submit to ESA for approval a Declared Material List (DML) (see NR-17]), a Declared Mechanical Parts List (DMPL) (see NR-17]) and a Declared Process List (DPL) (see NR-17Materials and process used by Co-Investigators and/or contractors shall be consolidated in the lists produced by the PI. This shall be preferably achieved using the ESA DMPL tool available at http://esmat.esa.int/ESA_TOOL/esa_tool.html

Informative

5. Material and processes for which experience has been gathered in previous space project are listed in the European Space Material DataBase at http://www.esmdb.esa.int/ (ask ESA project for password). The use of ESA-known materials and processes is highly recommended: however their suitability for the use on the programme shall be evaluated for each application

MMP-050

6. For materials or mechanical parts with limited or no test data available, the PI shall submit a Material or Mechanical Part Request for Approval in accordance with [NR15], proposing an evaluation program. ESA will provide advice on and approve the evaluation program and its results. ESA may request material samples for additional evaluation and comparative testing. These samples shall be provided with a Material Identification Card in accordance with NR-17

MMP-060 7. Typical elements of an evaluation programme are:
Thermal vacuum: Materials shall have their outgassing properties assessed by thermal vacuum tests. ECSS-Q-ST-70-02 NR-19 temperature range shall be extended if required by the mission environment.
Thermal cycling: Materials or material combinations subjected to thermal cycling in orbit shall be assessed to determine their suitability for the intended application. ECSS standard ECSS-Q-ST-70-04 temperature range shall be extended if required by the mission environment.
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 with margins.
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 stresses (frequently present in welded constructions) in the terrestrial atmosphere shall not be used. This requirement shall also apply to GSE lifting devices
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.

MMP-070 8. Material which may constitute a safety hazard or can cause contamination are prohibited from being used without prior approval by ESA. Examples of these materials are:

- beryllium-Oxide
- Cadmium
- Zinc
- Mercury
- Radioactive materials
- Polyvinylchloride (PVC)

Note: this is applicable to flight hardware as well as to GSE to be installed in the vacuum chambers and to GSE in contact with flight hardware

MMP-080 9. As far as practicable materials and mechanical parts shall be non magnetic. In case magnetic materials must be used for a particular function (e.g. a motor or a relay) the magnetic characteristics will have to be determined and depending on the effect on system level, magnetic compensation methods mat have to be applied

MMP-090 10. A first issue of the DML, DMPL and DPL shall be submitted in the conceptual design phase for ESA comments and guidance for replacement of unacceptable materials and processes with suitable ones.

MMP-100 11. DML, DMPL and DPL shall be updated to reflect the degree of

definition of the design in the following phases of the program and revisions shall be provided for each of the project design reviews.

Heading

11.3 Materials Control

MMP-110

1. Each type of material to be used shall be covered by a procurement specification or standard. The contractor is encouraged to use existing international and national standards at the maximum extent, in order to expedite the approval process of the DML. When developed by the PI, procurement specifications shall be made available upon request to ESA for review; proprietary rights will be respected.

MMP-120

2. Lot/batch acceptance test reports shall be kept at the investigator's or contractor's plant for at least 10 years together with other historical manufacturing/production records for the assemblies.

MMP-130

3. ESA reserves the right to require samples of raw or processed materials for evaluation and testing in its own or other laboratories.

MMP-140

4. Mechanical parts (for bolts/nuts at least for size M4 and larger) shall be covered by procurement specifications including all technical requirements and adequate quality assurance provisions.

MMP-150

5. The name of the source/manufacturer shall be entered in the DML together with the name of a back-up source for critical procurement. Printed Circuit Boards should preferably be procured from ESA qualified sources.

MMP-160

6. Material design allowable used in mechanical stress analyses shall correspond to "A values" as defined in MIL-HDBK-5 [NR25] or equivalent documents. Strength values for mechanical parts shall not be assumed to be higher than the values specified for the relevant qualification and acceptance tests.

Heading

11.4 Process Control

MMP-170

1. Each process used by the PI and listed in the DPL shall be covered by a process specification or standard.

informative

The PI is encouraged to make maximum use of existing ESA specifications or ESA approved specifications/standards produced by international organizations and national agencies, because they reflect a consolidated experience and in order to expedite the approval process of the DPL. The complete list of approved documents and standards is contained in [NR26] and [NR27].

MMP-180 2. 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.

MMP-190 3. For materials that require curing, in-process witness samples shall be prepared under representative conditions from the same materials batch as used on hardware. The witness samples shall be stored until launch (QM) and end of mission (FM).

Heading

12 SOFTWARE PRODUCT ASSURANCE ECSS-Q-ST-80C NR-26

Heading

12.1 General

SPA-010

1. An effective Software Product Assurance (SPA) program shall be implemented. 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.

SPA-020

2. The SPA requirements shall be applicable to:

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

Heading

12.2 Software Product Assurance Activities

SPA-030

The following fundamental tasks of SPA activities shall be performed:

- establishment of standards and quality assurance procedures. Examples of ESA software engineering standards are listed in ECSS-Q-ST-80C NR-26; in-house software standards shall be approved by ESA.
- participation in writing coherent development, analysis, production and test plans for PA related issues;
- participation in reviews, audits and meetings;
- ensuring adherence to standards and procedures;
- liaison with configuration management;
- involvement in problem reporting and resolution;
- control of supplies/contractors;
- validation and acceptance test follow-up including non-conformance control

***Note**: The SPA can be part of the overall Product Assurance Plan. As such the verification of this requirement can be assessed in combination of that Plan.*

Heading

12.3 Software Product Reviews and Inspections

SAP-040

1. The Software Development shall be done in accordance with ECSS-E-ST-40C NR-27 and ECSS-Q-ST-80C NR-26. During the software development process the following key reviews and inspections shall be performed:

- System Requirements Review (SRR);
- Preliminary Design Review (PDR);
- Critical Design Review (CDR);
- Qualification Review (QR);
- Acceptance Review (AR);
- Operations Readiness Review (ORR)
- Software Inspection on Source Listing;
- Review of Test procedures and test plans;
- Witnessing of tests;

SAP-050

2. 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.

Heading

12.4 Hardware/Software Interaction Analysis (HSIA)

informative

This subject is covered by section 9.3.

Heading

12.5 Software Configuration Management

SAP-060

1. Software and software related documents shall be placed under configuration control not later than the start of integration of the individual software modules.

SAP-070

2. Configuration management and change control activities shall be performed in accordance to the configuration management requirements

Heading

12.6 Software Problem Reporting

SAP-080

Software non-conformance shall be treated as defined in the Non-Conformance Control section 6.5, but the terminology used may be different.

SAP-090

- In ECSS-Q-ST-80C replace “ECSS-Q-ST-20 clause 7” with “ECSS-Q-ST-20C clause 5.4” in paragraph 7.4.1

SAP-100

In ECSS-Q-ST-80C modify table D-2 as follow:

- Entry 5.4.1: replace “Y” with “-”
- Entry 6.2.3.7: for software criticality category C, replace “Y” with “N”
- Entry 6.2.3.8: for software criticality category C, replace “N” with “Y”

Heading

13 CLEANLINESS AND CONTAMINATION CONTROL ECSS-Q-ST-70-01C NR-18

CCC-010

1. The PI shall define in the PA plan the criteria and tasks for the contamination control, taking into account the guidelines provided in ECSS-Q-ST-70-01C NR-18

CCC-020

2. After establishing the cleanliness requirements for his instrument up to EOL (End of life), the PI shall identify the provisions, activities and verification methods necessary to achieve the cleanliness levels through all stages of manufacturing, handling, transportation and testing. The precautions and provisions to be taken during the integration, transportation and launch preparations of the spacecraft as well as the launch and the flight to EOLshall be defined by the PI in collaboration with ESA so that the necessary arrangements can be made in due time.

CCC-030

3. The following potential contamination sources shall be considered:

- choice of materials;
- molecular and particulate contamination transported by air
- 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.

CCC-040

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

CCC-050

5. 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 (usually class 8) is not of the same high cleanliness standard which 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.

CCC-055	6. Bake-out in vacuum at elevated temperatures of contamination sensitive items before integration into the instrument shall be performed as an effective method to reduce the molecular contamination accumulated and the potential for cross contamination when in orbit.
CCC-060	7. At delivery instruments are required to be at a minimum “visibly clean” (level 300/A/5) (see ECSS-Q-ST-70-01C NR-18 para 5.4.2.2) and to meet the allocations as will be agreed in the Cleanliness Working Group.
CCC-070	8. Material and parts shall meet outgassing requirements of RML<1% and CVCM<0.1%
Informative	9. In the vicinity of sensitive items material and parts should meet outgassing requirements of RML<0.1% and CVCM<0.01%

14 ANNEX A

14.1 EIDP ToC

Section	
1	Title Page
2	Table of Contents
3	Shipping Docs
4	Certificate of Conformance
	Hardware
	Cleanliness
5	Configuration Item Data List (CIDL)
6	Serialised Item List (SIL) (ABCL)
7	Historical record Sheets
8	Limited Life/Age Sensitive Item Records
9	Connector mating records
10	Problem Reports (PRs); -Problem Failure Reports (PFRs); Non Conformance Reports(NCRs)
11	List & copies of all Request for Waivers/Deviations (RFW/RFD)
12	Record of temporary removals and installations (e.g. Red Tag/Green Tag Items)
13	Packaging/Unpacking, Storing, Transport and Handling procedures
14	Record of open and deferred work or installations.
15	Installation Procedures
16	Drawings (as necessary to use the item, Can be part of user manual)
17	User's manual (including Flight Software User's Guide) (can be in one part for installation and one part for operation).
18	Qualification Status List with reference to applicable Qualification Reports and with identification of differences/modifications between the item used for qualification and the item being offered for acceptance.
19	Test procedures
20	Test Reports and Analyses (All including also contamination and calibration, inspections..)
21	Verification Matrix
22	Overall Test Flow Chart and copies of all Inspection and Test Reports
23	Calibration Data Record, Instrument Data Base
24	Residual Hazard Sheets with applicable safety procedures
25	Proof Load Certificate for Handling/Lifting Equipment, Safety Certificates for GSE
26	Software
27	Preship Review and Delivery Review Board : Minutes of Meetings

28	Pictures (can be part of user manual)
29	Declared material and process list (including PL)
30	Trending data reports (part of test reports and analysis)
31	Elec. Assembly Procedures (part of user manual)
32	Flight SW Project Reference Database (PRD) Document
33	Document covering Scripts, TLM Pages, Equations
34	Special Tools List
35	Loose Items List
36	Residual Risk List
37	Lower level EIDP

14.2 EIDP DRD

Description: The Flight Unit EIDP is required prior to submittal of the flight unit release for shipment to next higher level of assembly. The EIDP shall constitute the basis for formal acceptance of the flight article and shall provide the set of documents and records for further integration, testing, and operation in higher-level assemblies. Lower level EIDPs shall be maintained and integrated into higher-level EIDPs during subsystem/instrument I&T.
Content: The EIDPs shall contain a complete history of the deliverable item with any certification required by either the program or local safety laws.
EIDPs shall include:

1. Title page
2. Table of Contents
3. Shipping Documents
4. Certificate of Conformance (CoC)
5. Copy of the full "As-Designed/As-Built Configuration Item Data List" (CIDL)
   CIDL shall **identify all documents with** the n**ame, number, issue number/date which define the configuration status** of an item starting with the applicable Requirement and ICDs and including (following a hardware/drawing tree) all documents identifying the design/build standard of the item (assembly and detail drawings, major manufacturing procedures, circuit diagrams, PLs, software version release lists, etc.).
6. Serialized Items List (replaceable subassemblies) with reference to lower level EIDPs
7. Historical Record Sheets ("logbook") [chronologically list all major events & activities carried out on the item starting at the latest from the end of the manufacturing phase and with the beginning of all formal inspections and tests).
   list shall contain:
   * Start/end date of the activity or event
   * Activity or Event (e.g., vibration test, transport from A to B, repair per PR-xxx, removal/temporary replacement of a subassembly)
   * Reference Document identifying the procedure and/or the test- or activity-report established for the particular activity or event
   * Name and signature of the person responsible for the activity
8. Operating Time or Operating Cycle Records for limited life or age sensitive items (if applicable)

9. Connector mating records (if applicable)
10. List all PR/PFRs and copies of major and interface PR/PFRs
11. List and copies of all Request for Waivers/Deviations (RFW/D)
12. Record of temporary removals and installations (e.g. Red Tag/Green Tag Items)
13. Record of open and deferred work or installations
14. Packaging, Storing, Transport and Handling procedures
15. Installation Procedures (including alignment)
16. Drawing Delivery Package (DWG-01)
17. Operation and Maintenance Manuals
18. User Manual
19. Qualification Status List (refer applicable Qual Reports & with identification of diff/mod's between qual item & acceptance item)
20. Test Reports, including as-run procedures (in electronic format only)
21. Verification Matrix
22. Overall Test Flow Chart and copies of all Inspection and Test Reports
23. Calibration Data Record, Instrument Data Base
24. Residual Hazard Sheets with applicable safety procedures
25. Proof Load Certificate for Handling/Lifting Equipment, Safety Certificates for GSE

15 ANNEX B

EEE part family	quality level			Supplementary Conditions
	ESCC	MIL	Other	
Capacitors, chip, ceramic	ESCC 3009 level C	MIL-PRF-55681 EFR level R min MIL-PRF-123	CECC 32101 (qualified parts) + burn-in	For ceramic capacitors procured through ESCC or MIL specifications but in an extended, non qualified, range of values or not belonging to ESCC QPL or MIL QML/QPL, the humidity, steady state, low voltage test (cf ESCC 3009, § 5.2.2) is mandatory if U rated < 50V and C > 1µF.
Capacitors, molded, ceramic	ESCC 3001 level C	MIL-PRF-39014 EFR level R min MIL-PRF-20 EFR level R min MIL-PRF-123 MIL-PRF-49470 EFR level T	CECC 30601 (type 1) CECC 30602 (type 2) (qualified parts) + burn-in	For ceramic capacitors procured through ESCC or MIL specifications but in an extended, non qualified, range of values or not belonging to ESCC QPL or MIL QML/QPL, the humidity, steady state, low voltage test (cf ESCC 3009, § 5.2.2) is mandatory if U rated < 50V and C > 1µF.
Capacitors, glass (CYR type)	-	MIL-PRF-23269 EFR level R min		Not recommended for new designs
Capacitors, mica	ESCC 3007 level C	MIL-PRF-39001 EFR level R min		
Capacitors, chip, solid tantalum (e.g. TAJ, T495, CWR11)	ESCC 3011 level C ESCC 3012 level C	MIL-PRF-55365 WFR level C min		All capacitors shall be surge current tested.
Capacitors, non-solid tantalum, electrolytic (CLR79)	ESCC 3003 level C	MIL-PRF-39006 EFR level R min		39006 / 22, 25, 30, 31 and "H" designated devices are recommended

EEE part family	quality level			Supplementary Conditions
	ESCC	MIL	Other	
Capacitors, solid tantalum, electrolytic (CSR type)	ESCC 3002 level C	MIL-PRF-39003 WFR level C min		Surge current test mandatory on low ESR capacitors (CSR21 and CSR33).
Capacitors, super metallized plastic film, (CRH type)	ESCC 3006 level C	MIL-PRF-83421 EFR level R min		
Capacitors, metallized film, (HTP86, KM94S, PM94S, PM90SR2, MKT, …)	ESCC 3006 level C	-		
Capacitors, variable	ESCC 3010 level C	-		
Connectors, non filtered, D-sub rectangular	ESCC 3401 level B	-		
Connectors, filtered, D-sub rectangular	ESCC 3405 level B	-		Lifetest 1000h / 125°C / 1,5Ur on each tubular ceramic lot. By default, assured for ESCC products.
Connectors, printed circuit board	ESCC 3401 level B	-		
Connectors, RF coaxial	ESCC 3402 level B	-		
Connectors, microminiature rectangular	ESCC 3401 level B	-		
Connectors, non filtered, circular	ESCC 3401 level B	-		
Connectors, filtered, circular	ESCC 3405 level B	-		Lifetest 1000h / 125°C / 1,5Ur on each tubular ceramic lot. By default, assured for ESCC products.
Crystals	ESCC 3501 level B	-		

EEE part family	quality level			Supplementary Conditions
	ESCC	MIL	Other	
Diodes	ESCC 5000	MIL-PRF-19500 JANTXV + PIND test	commercial parts according to JD	PIND test (see note).
Diodes microwave	ESCC 5010 level C + PIND test	MIL-PRF-19500 JANTXV + PIND test	commercial parts according to JD	PIND test (see note).
Filters	ESCC 3008 level C	MIL-PRF-28861 acc. to class S		
Fuses (wire link ≥ 5A)	-	MIL-PRF-23419		Burn-in (168h – 85°C – 50% rated current) is mandatory on each lot
Fuses (CERMET)	-	MIL-PRF-23419		
Heaters flexible	ESCC 4009 level C	-	GSFC S-311-P-079	
Inductors, coils, (molded)	ESCC 3201 level C	MIL-STD-981 class S MIL-PRF-39010 EFR level R min		
Inductors, coils (non molded)	ESCC 3201 level C	MIL-STD-981 class S		
Integrated circuits	ESCC 9000	MIL-PRF-38535 class Q or M + PIND test	commercial parts according to JD	PIND test (see note).
Integrated circuits microwave (MMIC)	ESCC 9010 level C + PIND test	MIL-PRF-38535 class Q or M + PIND test	commercial parts according to JD	PIND test (see note).
Microwave passive parts (circulators, isolators)	ESCC 3202 level B	-		

EEE part family	quality level			Supplementary Conditions
	ESCC	MIL	Other	
Microwave passive parts (coupler, power dividers)	ESCC 3404 level B	MIL-DTL-23971 (dividers) "space flight"		
Microwave passive parts (attenuators, loads)	ESCC 3403 level C	MIL-DTL-39030 (loads) S letter (screened parts) MIL-DTL-3933 (attenuators) S letter (screened parts)		
Oscillators (hybrids)	ECSS Q-ST-60-05 level 1	MIL-PRF-55310 (class 2) level S		
Relays, electromagnetic, latching and non-latching	ESCC 3601 level B ESCC 3602 level B	MIL-PRF-39016 EFR level R min + ESCC screening according to chart 3		
Resistors, fixed, film, (RNC, MB x xxxx type, except RNC90)	ESCC 4001 level C	MIL-PRF-55182 EFR level R min MIL-PRF-39017 EFR level R min	CECC 40401 + burn-in (qualified parts)	
Resistors, high precision, fixed, metal foil (RNC90)	ESCC 4001 level C	MIL-PRF-55182/9 EFR level R min		100 kΩ max allowed.
Resistors, network, thick film	ESCC 4005 level C	MIL-PRF-83401 level M		
Resistors, current sensing (RLV type)	-	MIL-PRF-49465		
Resistors, power, fixed, wirewound (RWR type)	ESCC 4002 level C	MIL-PRF-39007 EFR level R min	CECC 40201 + burn-in (qualified parts)	
Resistors, power, fixed, wirewound, chassis mounted (RER type)	ESCC 4003 level C	MIL-PRF-39009 EFR level R min	CECC 40201 + burn-in (qualified parts)	
Resistors, precision, fixed, wire wound (RBR type)	-	MIL-PRF-39005 EFR level R min		Diameter of wire shall be greater than 0,03 mm.

EEE part family	quality level			Supplementary Conditions
	ESCC	MIL	Other	
Resistors, fixed, film, high voltage (RHV type)	ESCC 4001 level C	-		
Resistors, fixed, thick and thin film chip	ESCC 4001 level C	MIL-PRF-55342 EFR level R min	CECC 40401 + burn-in (qualified parts)	
Switches, electromechanical	ESCC 3701 level B	MIL-PRF-8805		
Switches, thermostatic	ESCC 3702 level C	-		
Thermistors	ESCC 4006 level C	MIL-PRF-23648	GSFC S-311-P-018	
Transformers	ESCC 3201 level C	MIL-STD-981 class S		
Transistors	ESCC 5000	MIL-PRF-19500, JANTXV + PIND test	commercial parts according to JD	PIND test (see note).
Transistors microwave	ESCC 5010 level C + PIND test	MIL-PRF-19500, JANTXV + PIND test	Commercial parts according to JD	PIND test (see note).
Cables & wires, low frequency	ESCC 3901 level B	MIL-W-22759		
Cables, coaxial, radio frequency	ESCC 3902 level B	MIL-C-17		
Hybrids	ECSS-Q-ST-60-05 level 2	MIL-PRF-38534 class K		
Surface Acoustic Waves (SAW)	ESCC 3502 level C	MIL-PRF-38534 class K		
Charge coupled devices (CCD)	ESCC 9020 level B	-		
Opto discrete devices Photodiodes, LED	ESCC 5000	MIL-PRF-19500 JANTXV + PIND test	Commercial parts according to	PIND test (see note).

EEE part family	quality level			Supplementary Conditions
	ESCC	MIL	Other	
Phototransistors Opto-couplers			JD	

NOTE 1 Particle Inducted Noise Detection (PIND) test is applicable to all cavity packages of active components.

NOTE 2 By default, assured for ESCC products.

NOTE 3 For semiconductor devices the JANS criteria is applicable per MIL-PRF-19500.
The lot is submitted to 100 % PIND testing according to test condition A (per test method 2052 of MIL-STD-750).

NOTE 4 For integrated circuits the Class V criteria is applicable per MIL-PRF-38535.
The lot is submitted to 100 % PIND testing according to test condition A (per test method 2020 of MIL-STD-883)

NOTE 5 For active parts (transistors, diodes) packaged in TO3, DO4 or DO5, the PIND test method is submitted to customer's approval, in order to ensure the efficiency of the operating mode.