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General Requirements for the Use of Commercial EEE Parts in Space Applications

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Centre National d'Etudes Spatiales
French Space Agency

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German Space Agency

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General Requirements for the Use of Commercial EEE Parts in Space Applications

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FOREWORD

This standard has been written in the framework of a partnership between the French and German National Space Agencies (CNES and DLR). One aim of this partnership is to encourage the production of common standards of benefit to the entire European space industry. This standard has been produced by a co-operative effort involving not just the two National Space Agencies but also representatives of both countries' space industries.

This standard deals with the general requirements for using commercial parts in space applications. These requirements are defined in terms of what must be accomplished, rather than in terms of how to organise and perform the necessary activities. This allows existing organisational structures and methods to be applied where they are effective, and for the structures and methods to evolve as necessary without rewriting the standard.

1 GENERAL

1.1 Scope

This standard defines requirements for all aspects of the selection, procurement and use of EEE commercial components in space applications.

1.2 Applicability

This standard is applicable to all commercial parts as defined in paragraph 1.6.1 of this document which are used in qualification hardware, flight hardware and flight spares.

This standard is applicable to all suppliers and actors working on space projects where commercial parts are applied.

1.3 Objective

The objective of this standard is to define part selection, procurement, control and use requirements which, when applied to a space project, will ensure that any commercial EEE components used are compatible with the project meeting its defined functionality, environmental conditions, quality, reliability, schedule and cost.

The defined requirements include:

- Component programme management,
- Component selection, justification and approval,
- Procurement, final acceptance,
- Handling and storage,
- Assembly and mounting,
- Quality assurance.

1.4 Normative References

The following applicable documents contain provisions which, through reference in this text, constitute provisions of this standard. When the reference is to a specific date or issue of the document then any subsequent amendments to, or revisions of, the document do not apply. When no specific date or issue is referenced then the latest edition of the document shall be used.

ECSS-P-001	ECSS: Glossary of Terms
ECSS-Q-20-09	Space Product Assurance / Non-conformance control system
ECSS-Q-60-11	Space Product Assurance / Derating and end-of-life parameter drifts - Electrical, electronic and electromechanical components, Draft 1, 15 July 2002
ECSS-Q-20	Space Product Assurance / Quality Assurance
ECSS-Q-70	Space Product Assurance / Materials, mechanical parts and processes

1.5 Informative References

The following documents are not referred to in this standard, and their contents do not constitute any part of this standard. They do, however, contain information which could be of use to anyone applying the general requirements given in this standard. The FMPS and DLR documents cited below can obtain a normative requirement status if so invoked in a specific programme's SOW.

FMPS Documents	RNC-CNES-Q-60-513 " Commercial components- General handbook "
	RNC-CNES-Q-60-514 " Selection procedure for EEE commercial components intended to be used in flight hardware "
	RNC-CNES-Q-60-515 " Formulation of component needs "
	RNC-CNES-Q-60-516 " Parts risk control "
	RNC-CNES-Q-60-517 " State of the art- commercial components "
	RNC-CNES-Q-60-511 " Guidelines on the use of parts out of manufacturer specified temperature range (uprating) "
	RNC-CNES-Q-60-518 " Justification Documents "
	RNC-CNES-Q-60-519 "Procurement"
	RNC-CNES-Q-60-520 " Commercial components- systematic tests "
	RNC-CNES-Q-60-521 " Commercial components- Incoming inspection "
	RNC-CNES-Q-70-506 " Recommendations on dry chain management when plastic encapsulated components are used "
	RNC-CNES-Q-70-508 " Capability approval rules for surface-mount technology on printed circuit (CNES/QFT/IN.0107-14) "
	RNC-CNES-Q-60-522 " Transformation of the environmental constraints into components requirements "
DLR-RF-PS-003	Assessment Procedure and Criteria for Determining Suitability of Commercial Components for Space Use
DLR-RF-PS-004	Risk Analysis and Control Procedures (for use when Assessing Commercial Components for Space Use)
DLR-RF-PS-005	Parts Procurement and Control Plan for Commercial EEE-Parts Suitable for Space Application in the <Project Name> Project (= a template for a PP&C Plan)
JESD22-112A	Moisture Induced Stress Sensitivity for Plastic Surface Mount Devices
JESD22-113A	Preconditioning of Plastic Surface Mount Devices Prior to Reliability Testing
JESD26-A	Plastic Packages for use in Rugged Applications
UTE80810	Reliability Data Handbook – A universal model for reliability prediction of – Electronics components, PCBs and equipments (ref. UTE C80-810) – original title: "Recueil de données de fiabilité: RDF 2000. Modèle universel pour le calcul de la fiabilité prévisionnelle des composants, cartes et équipements électroniques"

1.6 Definitions & Abbreviations

1.6.1 Definitions

For the purposes of this standard the definitions given in ECSS-P-001 apply. In addition the following terms are used in this standard with a specific meaning:

Advance batch procurement	A procurement of parts for a future need or needs for which there is not yet a firm contract, but where delaying the procurement could cause increased costs, problems due to long lead time or obsolescence, etc.
Commercial component/part	A part neither designed, nor manufactured with reference to military or space standards. That is, a part procured against a set of publicly available data put under configuration control by the supplier.
Component	A device that performs an electrical, electronic or electromechanical function and consists of one or more elements so joined together that they cannot normally be disassembled without destroying this capability. The term ‘Component’ may be used interchangeably with the term ’Part’.
Franchised distributor	A distributor officially recognised by the manufacturer
Manufacturing lot	A batch of components manufactured together on the same production line over a short time period such that they can be considered homogeneous in terms of the materials and processing parameters used.
Part	An electrical, electronic or electromechanical part, synonymous to component.
Parts’ procurer	A supplier who procures components for himself or a parts procurement agent who procures parts for the supplier.
Procurement document	A procurement document is any form of configuration controlled document, or a set of documents, which define(s) the components which have been, or are to be, procured or tested. It can be used as a contractual definition of which requirements have to be met by the parts which will be delivered by the manufacturer (through the distributor).
Single manufacturing lot procurement	A procurement of parts from a single manufacturing lot such that there are sufficient samples to validate that manufacturing lot for flight use, and also sufficient remaining parts to meet all the flight needs.
Supplier	An organisation that provides a product to a customer; in this document understood as an equipment manufacturer using commercial (and Hi-Rel) EEE parts (= parts “user”).

1.6.2 Abbreviations

The following abbreviations are defined and used in this standard:

AC	Alternating Current
CCP	Components Control Programme
CDR	Critical Design Review
CN	Change Notice
CNES	Centre National d'Études Spatiales = French National Space Agency
CoC	Certificate of Compliance
CPPA	Centralised or Co-ordinated Parts Procurement Agent
CR	Change Request
CSI	Customer Source Inspection
DC	Direct Current
DCL	Declared Component List
DDC	Dose Depth Curve
DLR	Deutsches Zentrum für Luft- und Raumfahrt e.V. = German National Space Agency
DPA	Destructive Physical Analysis
DRB	Delivery Review Board
ECSS	European Coordination for Space Standardization
EEE	Electrical, Electronic and Electromechanical (parts)
EIDP	End Item Data Package
ESCC	European Space Components Coordination
ESD	Electrostatic Discharge
FMPS	French multi-partnership (CNES / French industry co-operation)
Hi-Rel	High reliability
JD	Justification Document
NCR	Non-Conformance Report
P/O	Purchase Order
PA	Product Assurance
PCB	Parts Control Board (also used as abbreviation of Printed Circuit Board)
PDR	Preliminary Design Review
PED	Plastic Encapsulated Device
PIND	Particle Impact Noise Detection
PST	Part Selection Team
QA	Quality Assurance
RAMS	Reliability, Availability, Maintainability & Safety
RFD	Request For Deviation
RFW	Request For Waiver
RGA	Residual Gas Analysis

RVT	Radiation Verification Test
SEB	Single Event Burn-out
SEE	Single Event Effects
SEGR	Single Event Gate Rupture
SEL	Single Event Latch-up
SET	Single Event Transient
SEU	Single Event Upset
SOW	Statement of Work

2 COMPONENT PROGRAMME MANAGEMENT

2.1 General

The supplier shall establish and implement a system for component programme management which ensures full compliance with the requirements of the project as defined by his customer in line with this standard. The supplier shall also define any applicable needs and constraints for the use of the components in the project which are necessary to ensure full compliance with the customer requirements.

2.2 Planning

The supplier shall ensure that the component programme is thoroughly planned, documented and implemented in a timely manner, ensuring that all components will meet the appropriate requirements and be available within the project schedule. To achieve this the component programme shall include back-up plans which can be initiated if required.

2.3 Components Control Programme

2.3.1 Organisation

The supplier shall identify the organisation responsible for the management of the component programme, and describe the organisation's approaches and capability to efficiently implement, manage, and control the component requirements.

The supplier shall demonstrate to the customer his parts engineering expertise and experience with respect to commercial components.

The supplier shall put in place an internal multi-disciplinary Part Selection Team (PST).

This team, led by a EEE parts engineer, may be composed of parts specialists, circuit designers, system engineers, procurement specialists and any other relevant experts (radiation, technology, assembly, RAMS, …). It shall be convened as early as possible in the design phase of a programme to assure, by a concurrent engineering approach, a selection of only those EEE parts that are capable of meeting the programme requirements for the intended application. Its responsibility shall include the preparation of the JD and the performance of the risk analysis.

The outcomes of the PST shall be approved by the Parts Control Board (PCB).

This board is composed of a EEE parts engineer, a Quality Assurance representative and a customer representative as a minimum.

The main activities of the PCB are:

- The review and approval of the supplier's EEE components control plan (see § 2.3.2) and any associated document.
- The assessment and maintenance of the components' approval status, through DCL review, including evaluation activities (via Justification Documents).
- The resolution of problems (non-conformances, waivers, deviations, …).

The supplier is requested to issue a periodic progress report, giving information relative to selection, procurement and use of EEE parts, in the frame of his general periodic progress report addressed to the customer. The periodicity shall be in line with the programme requirements.

2.3.2 Component Control Plan

The supplier shall also prepare a Component Control Plan (which may be part of the overall Project PA plan) for customer's approval. The Component Control Plan will describe in detail the proposed approach, methods, procedures and organisation. This plan shall include, but not be limited to, a detailed description of the following items:

- Organisational structure, responsibility descriptions and management approach,
- Control of lower level suppliers, procurement agents (if any) and manufacturers,
- Programme for standardisation and control of component selection, including the organisation of any multi-disciplinary part selection team which is set up,
- Needs and constraints identification
- Component evaluation and related testing approach,
- Assessment of quality/reliability and performance of commercial parts,
- Radiation Hardness Assurance programme,
- Risk Analysis and control programme or action plan,
- Procurement schemes for parts procurement, including rationale for selection,
- Organisation and management of the selected procurement methods (direct procurement from manufacturer, use of distributors, use of procurement agent, etc.),
- Component testing and inspection,
- Component quality assurance activities,
- Assessment of problem notifications and alerts,
- Programme planning with schedule of tasks linked to programme milestones,
- Specific components control and back-up plans whenever there is evidence of possible schedule, quality or technical problems,
- Reporting and deliverables,
- A compliance matrix to the clauses of this standard taking into account applicable tailoring as defined in the contract,
- Examples of the Justification Document Summary and the Assessment Summary Sheets.

The Component Control Plan (and any overall Project PA Plan of which it is a part) shall be in line with the requirements of this document.

2.4 Declared Component List

For each equipment, the supplier shall issue a Declared Component List identifying all component types needed and this list shall be kept under configuration control (issue and identification of changes).

The Declared Component List shall be issued as a minimum at PDR and CDR (as designed) as well as a flight hardware delivery (as built).

After equipment CDR, all modifications (change of parts type or manufacturer, change of passive parts values, change of quality level…) shall be implemented, in the "as design" DCL, through the CN / CR process, submitted to customer for approval.

Any change of parts during equipment manufacturing (type, manufacturer, …) shall be handled through RFWs submitted to customer for approval.

The “as built” DCL reflecting the actual EEE parts assembled into the flight hardware and their date code, shall be provided to the customer for review at the delivery of the flight hardware.

The following information shall be included as a minimum:

- Component number (commercial equivalent designation)
- Family (ESCC group code)
- Package
- Value or range of values with tolerance (when applicable)
- Component manufacturer (name, country)
- Procurement document reference
- Franchised distributor (name, country) as applicable
- Additional tests if any (including RVT)
- Equipment name
- Quality level (if any)
- Allowable operating and storage temperature range
- When applicable, the Evaluation Plan reference
- The Justification Document reference
- Approval status
- Change identification between each DCL issue
- Date-code (only for “as built” DCL)

2.5 Component Materials

The supplier shall ensure that materials which are not hermetically sealed within components meet the requirements of ECSS-Q-70 regarding offgassing, outgassing, flammability, toxicity and/or other criteria defined by the intended use. The supplier shall also evaluate the robustness of selected EEE components to the stresses induced by his assembly techniques.

Any part or hazardous material listed below shall not be used without request for deviation approved by the customer during PCB. Such RFD shall include potential restrictions for handling and testing.

- Beryllium oxide
- Cadmium,
- Lithium,
- Magnesium,
- Mercury,
- Radioactive material,
- All other non-identified material causing a safety hazard.

3 COMPONENT SELECTION AND APPROVAL

3.1 Manufacturer & Component Selection

The supplier shall be responsible for the selection, procurement and use of components that will enable the performance, lifetime, environmental, material, safety, quality and reliability requirements of the product of which it forms a part, to be satisfied in all respects.

The supplier shall verify that the manufacturers have established assurance programmes or quality management systems to ensure that acceptable risk levels are met, i.e. he shall verify that:

- The manufacturer has introduced and maintains effective systems for process characterisation and process control.
- The manufacturer has introduced and maintains effective systems for qualifying processes and products.
- The manufacturer has a reliability test programme for generating reliability data for processes and products.
- The manufacturer has an effective policy installed for ensuring continuous process improvement.

These properties may be evaluated on the basis of documented evidence or by performing appropriate surveillance visits or audits at the parts manufacturer's facility.

For proper parts selection the supplier shall define:

- the need in terms of functionality, package, cost, schedule, risk level, assembly capability,
- the constraints in terms of environmental characteristics (e.g. thermal, mechanical, radiation, ON/OFF cycling, mission time, etc.).

The supplier shall also manage a part types reduction/standardisation programme.

For the assessment of commercial components the supplier shall collect the available data on the manufacturer and the component including:

- Technological and technical description related to the part (die technology, package technology, temperature range, manufacturing locations [wafer fabrication, assembly, final test], ESD class, moisture level, packing and conditioning, electrical and thermal model, etc.), performances and characteristics (e.g. electrical, thermal, mechanical, radiation, reliability),
- Information related to the manufacturer and distributor (quality assurance system, manufacturer's internal qualification results),
- Manufacturer's reliability data,
- Descriptions of manufacturer process control, final test and QA test and inspection on outgoing parts,
- Manufacturer's policy for process change notification,
- Manufacturer's policy for obsolescence notification,
- Component type availability and delivery time (e.g. export license limitation),
- Information about lot homogeneity, traceability, marking and coding,
- Identification of the data sheet issue and reference,
- Identification of any existing specification or procurement document.

3.2 Risk Assessment

Depending on any need identified during selection as defined in § 3.1, the supplier shall perform a risk assessment in line with the applicable procedures listed in § 1.5.

Depending on the results of this assessment, an action plan might have to be established as part of the Justification Document (see § 3.8) and submitted to the customer for approval.

This document may include (non exhaustive list):

- Mitigation at design level (design margins, electrical architecture, thermal control, multi-source design, etc. ...),
- Use of stock parts, single manufacturing lot procurement, advance batch procurement,
- Specific procurement conditions (packing, traceability, pre-cap CSI, etc. ...),
- Complementary tests,
- Further evaluation,
- Uprating process (that is the methodology to use the part outside of it's temperature range),
- Screening, sorting, incoming inspection,
- Lot testing,
- Radiation Hardening Assurance (evaluation, lot test, system protections, cold redundancy, shielding, etc.),
- Specific storage conditions, adaptation and validation of the assembly and packaging process,
- Trade-off (performance, cost, delivery) with other solutions,
- Initiation by the supplier of a deviation process in accordance with his Component Control Plan whenever this would be applicable.

3.3 Parts Restrictions

The use of components with the following characteristics is prohibited:

- Limited life,
- Known instability,
- Hazard potential,
- Low reliability.

Examples of such components are:

a) Hollow core components (with the risk of arcing under vacuum conditions),

b) Potentiometers,

c) Non-metallurgically bonded diodes,

d) Semiconductor dice without passivation or glassivation over exposed junctions,

e) Wet slug tantalum capacitors (except CLR 79 construction using double seals and a tantalum case),

f) Components whose internal construction uses solder material with a melting temperature incompatible with the end-application mounting or assembly conditions,

g) RNC90 > 100 kΩ,

h) TO5 relays,

i) TO3 & DO4/DO5 and similar packages,

j) Components using pure tin plating.

The use of some of the above parts may be authorised, on a case by case basis, through Requests For Deviations (RFW) submitted to the customer for approval in the frame of the PCB.

Further, the following families are not automatically authorised in commercial grade because special attention needs to be paid to their quality and workmanship. They may be used for space applications on condition that the properties and constraints identified in the following table are considered:

Table 1: Part families requiring special attention

Family	Properties and constraints to be considered
Connectors	• residual magnetism (requirements) • outgassing & forbidden materials (insulator, shell & finish) • mating / unmating requirements • contact insertion and extraction requirements • mounting compatibility / interchangeability • safety requirements
Wire fuses	• use of non-hollow core construction to prevent arcing under vacuum (e.g. with powder filling or SMD substrate versions) • vibration withstanding capability
Electromechanical Relays	• hermetically sealed package • appropriate contact materials • vibration withstanding capability • particle getter • no pure tin material (package, leads, other internal and external elements) • appropriate contact gap • appropriate internal gas
Crystals	• hermetically sealed packaging • exciting power shall not exceed the frequency/temperature power characteristic curve • radiation tolerance dependent on quartz material
Hybrids	• internal wiring (stress relief + mechanical fixation of cross-overs) • mechanical fixation of massive components (transformers, capacitor stacks, etc.) and clearance from package lid • criticality of the package size with respect to the vacuum conditions • thermal matching of interconnection substrate to base plate • internal bonding: mono-metallic or mixed • for internal dice, same rules as for discrete devices (selection, risk analysis, radiation, derating, procurement, etc.)

Family	Properties and constraints to be considered
Hybrids continued	• vibration withstanding capability • hermetically sealed packaging • outgassing before sealing (RGA) • solder control • cleanliness (particles and contamination) • rework capability • lot definition • special processes (flip-chip, chip stacking, etc.) should be extensively tested for compatibility with the space environment before use

In addition it is recommended to select standard passive parts (capacitors, inductors, resistors) in military (e.g. MIL, CECC) or space (e.g. MIL, ESCC) standards because of limited potential for cost savings and significant variability of commercial components' quality between manufacturers.

3.4 Radiation Hardness

The radiation requirements for EEE components are project specific and shall be determined for all components used in a particular piece of hardware by the supplier who is responsible for the design of this product. These requirements shall be established for all types of radiation including cosmic (heavy ions), electromagnetic, trapped (charged particles – electrons, protons - in radiation belts) and solar (flares). Due consideration shall be given to the mission orbit/trajectory, the duration, the associated spatial and temporal variations of the radiation environment as well as all protective factors such as shielding.

The supplier shall assess the actual radiation tolerance of the selected components for compliance with the radiation requirements in term of total dose, displacement damages and single events effects (e.g. SEB, SEGR, SEL, SET, SEU). Those components which are not fully or only conditionally compliant with the radiation requirements shall be treated as radiation sensitive components.

The supplier shall implement a Radiation Hardness Assurance Programme, documented by a Radiation Hardness Assurance Plan submitted to customer for approval, for radiation sensitive components, covering the collection of all relevant information and specifying the necessary actions in terms of preventive/corrective solutions (e.g. anti-latch-up system, error detection and correction, shielding, derating, etc.), evaluation and procurement testing (e.g. Radiation Verification Test), planning and control. The programme shall also define any special traceability or lot homogeneity constraints appropriate for commercial parts.

The supplier shall establish a radiation assessment report, sent to customer for review, identifying all sensitive parts with respect to the relevant radiation effects, their impact and giving the adequate solution (e.g. anti-latch-up system, error detection and correction, shielding, derating, etc.) for the relevant equipment.

3.5 Derating

Derating shall be applied as necessary to ensure that under space conditions the parts meet the appropriate electrical performance and reliability requirements. ECSS-Q-60-11 can be used as a basis for determining any necessary derating. The appropriate derating requirements shall be included in the supplier's Component Control Plan.

3.6 Electrical Design

The electrical circuit designer shall follow all recommendations given in the Component Data sheet and in the Manufacturer Part Application Notes.

3.7 Commercial Components Reliability Figures

For failure rate calculation in the frame of a reliability analysis the reliability handbook UTE C80-810 or any other appropriate documents may be used.

3.8 Approval Process

The supplier shall provide a Justification Document to the customer for approval. This document shall refer to the specific part type and manufacturer and shall include the following:

- A summary of the collected assessment data requested in § 3.1.
- An action plan when needed, based on risk assessment (see § 3.2), including evaluations or complementary tests.

If there is an action plan the customer has the option of giving conditional approval pending completion of the activities defined in the document.

3.9 Component Evaluation

When identified in §.3.2 as a result of the risk assessment, the evaluation programme, documented by an evaluation plan, records the manufacturing baseline in order to ensure that the flight parts have been built according to the same technology and manufacturing processes as the evaluated components.

This plan is based on the following elements :

- Constructional analysis,
- Manufacturer assessment,
- Evaluation testing,
- Radiation testing (if applicable, depending of the component sensitivity and the program requirements).

Reduction or complete omission of any element of the evaluation requirements may be done on the basis of documentary evidence provided by the responsible person or authority of the evaluation program.

The evaluation plan shall be submitted to the customer for approval, in the frame of PCB.

The evaluation results, documented by an evaluation report, shall be submitted to the customer for approval in the frame of the PCB.

Failure analysis shall be conducted on any part which fails during this evaluation programme, in order to determine the reason for failure and to react at procurement level or at part selection level.

4 PROCUREMENT

4.1 General

- The procurement shall be fully in line with the risk assessment results (see § 3.2).
- When possible, commercial parts for space use shall be procured directly from the manufacturer. When not possible it is essential to select only authorised or franchised distributors who have close contact to the manufacturer and better access to any additional data and reliability information needed for the intended space use of such parts.
- The manufacturer's standard part shall be procured rather than specifying any additional processing or testing steps.
- The parts' procurer should try to order the parts from a single lot date code to minimise the variability of the performance characteristics of the components and the risk of jeopardising the mission success by marginal designs. The parts' procurer shall consider the possible implications if a delivered lot contains parts from more than one manufacturing lot / date code. This is primarily important for active components where the radiation tolerance or hardness characteristics can vary considerably from one lot to another.
- Further, commercial parts should be ordered in the manufacturer's standard packaging quantities or multiples thereof to avoid distributor re-packing and handling and to preserve the traceability information usually included on the original manufacturer packaging.
- When additional testing is required in accordance with the control programme or the action plan to confirm that the flight parts conform to the assessed parts, the supplier shall prioritise sampling tests or inspections over 100% screening to avoid unnecessary testing of the flight parts.
- The supplier is encouraged to make a single procurement for evaluation and flight parts in order to ensure that the evaluation results are representative of the flight parts.
- The supplier or procurer must ensure that the collected assessment data are representative of the flight lot (and sub-lots if any).
- The supplier is requested to ensure that the elements of the Justification Document, including any action plan, are fully applicable at the time of the procurement of flight parts.
- During procurement, when tests are performed by sampling, the sampled parts must be selected to assure that they are representative of the lot (sub-lots).

4.2 Procurement Document

Any EEE part intended for use into flight hardware shall be procured to a controlled document which may belong to a specification system, may be a procurer's in-house specification or may be a manufacturer's drawing or datasheet as a minimum.

For commercial components the procurement document normally takes the form of a manufacturer's data sheet, which could either be an individual data sheet or part of a data book. A data sheet might be specific for one component type, or cover a range of components from which the type specific data can be extracted. Any such procurement document shall be formally placed under configuration control by the supplier. This configuration process shall be designed to ensure that the supplier is notified of any product change affecting qualification, performance, quality, reliability and interchangeability, and this requirement shall also be addressed expressly in the supplier's purchase order.

The proposed data sheet shall be analysed in the frame of the risk assessment, alternatively, a specification or procurement document can be prepared by the supplier or the parts' procurer to cover as a minimum:

- Component marking,
- Mechanical requirements,
- Electrical and thermal requirements,
- Additional testing (if any),
- Manufacturer's documentation.

Any procurement document from the parts' procurer shall be referenced in the Justification Document and the corresponding data file, and any of the above referenced information which is not provided by the manufacturer shall be addressed in the risk assessment.

4.3 Incoming Inspection

Upon receipt of the parts at the parts' procurer a count and damage inspection shall be carried out by the receiving goods personnel – without opening the individual container or tray whenever possible – which shall include the following items:

- Part number or reference and marking,
- Parts quantity and quantity per packing unit or tray,
- Generic package type,
- Date code and any further traceability information (e.g. wafer lot no., assembly facility),
- Certificate of Conformity to the purchase order requirements and any other deliverable documents required by the purchase order,
- Suitability of packing with respect to the order requirements (mechanical protection, electrostatic discharges protection, humidity protection when applicable).

This process shall be described in a procedure submitted to the customer for approval, in the frame of the PCB (or addressed and described in the Component Control Plan).

Further, these items shall be verified for conformance with the ordering requirements as defined in the purchase order and the corresponding procurement documents. Appropriate records shall be made of these details and filed accordingly.

Any further treatment of the parts prior to kitting for the assembly process (e.g. unpacking, visual inspection, electrical testing, any other handling) shall be reduced to the minimum necessary to give confidence that the delivered parts will meet the project requirements.

4.4 Systematic Tests

When required by the Justification Document the supplier shall provide for systematic DPA on each lot to verify that the procured parts are the same as the assessed and that the materials, design, workmanship and construction meet the requirements of the relevant procurement document and are suitable for the intended application.

For active parts this verification DPA shall be mandatory.

Sample size, applicable tests and inspections, and acceptance criteria shall be individually defined for each component type based on engineering judgement. These requirements shall be defined in a DPA procedure called in the Component Control Plan. It shall be provided to the customer, for review, on request.

The DPA can be performed by the supplier or parts procurer, by an approved independent laboratory, or by the part manufacturer if witnessed by the parts' procurer or his nominated representative.

The DPA reports shall be provided to customer, for review, on request.

4.5 Complementary Tests

The complementary tests are identified and defined in the Justification Document as a result of the risk assessment.

These tests may be :

- Any lot validation (life test, thermal cycling) on a sampling basis,
- Additional 100% testing:
  - specific electrical tests,
  - PIND test for cavity devices and as applicable, etc),
- special storage and/or pre-assembly treatment steps for plastic packages (see § 5 and § 6),
- inspection.

These tests shall be performed by the parts procurer as defined in the Justification Document or action plan.

4.6 Radiation Verification Test (RVT)

4.6.1 General

Components sensitive to Total Dose shall be submitted to a Radiation Verification Test (RVT) if the space application suitability assessment revealed marginal results of the analysed component type.

Components sensitive to Total Dose are those whose intrinsic total dose resistance is between 1 and 2 times the dose received. The dose received is calculated from the dose depth curve (DDC) defined in the customer environmental specification for a dedicated project.

The parts related safety margin required is typically project dependent and will be defined differently by various customers and also various programmes.

Further, when the orbit of the satellite or spacecraft is such that Single Event Effects (SEE) must also be taken into consideration it may be required to carry out some kind of verification testing for these effects. This will be considered when sufficient SEE tolerance cannot be guaranteed on the basis of technology, manufacturer, production line, process, design, etc. Finally, when the spacecraft or satellite orbit is exposed to a proton environment, displacement damage degradation effects must also be considered and accounted for and thus, appropriate characterisation or verification testing may be required in the absence of suitable characterisation data. Any RVTs carried out and the relevant results shall be referenced in the Justification Document.

4.6.2 RVT Test Methods & Sample Size

The supplier shall establish a procedure for RVT (sampling size, bias, dose rate, acceptance criteria, etc. ...) in line with the programme requirements which shall be appropriately addressed in the Component Control Plan and made available for review.

4.7 Components from Stock & Relifing

Commercial components from a supplier's or parts procurement agent's stock may be used provided the following requirements are met:

- The parts are stored according to the minimum conditions given in § 5,
- The minimum overall requirements (including screening) are in accordance with the present document,
- The lot homogeneity and traceability can be demonstrated,
- The EEE parts documentation is available and the content is acceptable in accordance with the project requirements (including radiation data, if necessary),
- There are no open NCRs and no alerts exist with respect to their date code.

For components from stocks meeting the above criteria, and which have a lot / date code exceeding a period proposed by the supplier, a relifing shall be performed by the supplier according to a procedure which shall be submitted to the customer for approval. This procedure shall detail the maximum storage period, the testing and control sequence applied (electrical, visual, hermeticity, solderability, etc. ...), depending on the technology considered, as well as the acceptance/rejection criteria (sample size, aging sensitive parameters, etc. …).

4.8 Post Programming Screening

Programmable components shall be submitted to a post-programming sequence. The supplier has to prepare a post-programming procedure, depending on part types (including when necessary electrical tests, programming conditions and equipment, burn-in conditions, additional screening tests and specific marking after programming). This procedure shall be submitted to the customer for approval, in the frame of the PCB.

Due to this post-programming operation, the procurement of virgin parts may be tailored, provided that their final status after incoming, programming, and post-programming activities is in accordance with the programme requirements.

4.9 Manufacturer's Documentation Deliveries

The manufacturer's CoC shall be delivered to the parts' procurer.

Any other data, defined in the applicable procurement documents, shall be available at the manufacturer's facilities or delivered to the parts' procurer in line with the purchase order.

The documentation minimum storage period shall be as defined in the customer's statement of work (SOW) or the contract.

5 HANDLING & STORAGE

The supplier shall establish and implement procedures for handling and storage of EEE parts in order to prevent any degradation, taking into account the possible use of plastic packages.

These procedures shall be available for review by the customer.

As a minimum the following areas shall be covered:

- control of storage environment such as temperature (22°C ± 5°C), humidity (RH 65% max), cleanliness,
- appropriate measures and facilities for segregating and protecting components during incoming inspection, storage and delivery to manufacturing,
- control measures to ensure that components susceptible to electrostatic discharge (ESD) are identified and handled only by properly trained personnel using anti-static packaging, tools and other means, including procedures.

6 ASSEMBLY & MOUNTING

The supplier shall be able to demonstrate the adequacy of his mounting and assembly rules with respect to the use of various package technologies and materials.

As a minimum, the relevant procedures shall address:

- The design of printed circuit boards or any support receiving EEE parts (thermal requirements, lay-out rules of EEE parts, etc.),
- The storage and handling on the assembly line,
- The preparation of EEE parts before mounting,
- The mounting process,
- The criteria for visual inspection after mounting,
- Storage conditions for printed circuit boards.

These procedures shall be available for review by the customer.

Plastic Encapsulated Devices (PED) require special treatment prior to assembly, e.g. baking for a certain period of time prior to mounting to avoid the destructive “Pop corn” effect. Further, to avoid penetration of moisture into the PED, the mounting process must be completed within a defined period of time after the end of any baking process. Therefore, the supplier must have established appropriate procedures to ensure that the parts are not pre-damaged during the assembly process. Guidelines for the proper definition of the preconditioning of PEDs can be found in the JEDEC standards [JESD22_112A] ,[JESD22-113A] and [JESD26_A], respectively.

7 COMPONENT QUALITY ASSURANCE

7.1 General

The supplier or the parts' procurer, as applicable, shall establish and implement all of the requirements of this document including methods, organisations and documents used to control the selection and procurement of commercial EEE parts foreseen for space application. The supplier's or procurer's quality assurance (QA) shall assume a monitoring and surveillance responsibility for the parts engineering and parts procurement activities.

7.2 Non-Conformance & Failures

The supplier, and the procurement agent if applicable, shall establish and maintain a non-conformance control system in accordance with the requirements of ECSS-Q-20-09.

Non-conformances and failures observed on commercial components with respect to the requirements defined in the applicable procurement documents and any referenced documents and drawings shall be controlled by the non-conformance control system and classified accordingly.

This system shall handle all non-conformances (including failures, malfunctions, deficiencies and defects) occurring on commercial EEE components during:

- Procurement and any additional screening, testing or inspections, or
- Incoming inspection, or
- Handling and storage, or
- Assembly, integration and test of equipment.

7.3 Alerts

The supplier shall confirm that there are no known alerts on the proposed parts with the applicable date code. If alerts or problem notifications become available at a later stage, the supplier shall review them, analyse the project risk and propose an action plan for approval within one week.

The supplier shall initiate and distribute any notification for all major problems arising on EEE parts during procurement, incoming inspection or during all levels of equipment manufacturing or testing, which are of general concern.

All these requirements related to alerts shall equally apply to any parts procurement agents who are used.

7.4 Traceability

The manufacturing date code is required as an element of traceability and shall be maintained as required by the procurement documents.

This traceability shall be maintained through incoming, storage, and installation at the procurer and supplier of the component in accordance with programme PA Requirements.

In any case, the traceability requirements imposed by the supplier on the EEE parts manufacturer or distributor shall be sufficient to ensure the validity of the tests performed by the supplier (i.e. additional test or inspection).

Traceability of EEE parts during installation in equipment, shall be ensured by the supplier to allow the traceability of the manufacturer lot/date code number of the EEE parts actually mounted.

7.5 Final Acceptance

Final acceptance of the parts for flight application will be established upon successful completion of the incoming inspection and any corresponding data review, systematic DPA and RVT as well as any additional or supplementary screening, testing or inspection as required by a risk analysis and the defined action plan from the risk analysis.

8 EXPERIENCE SUMMARY REPORT

On completion of the programme the supplier shall establish an experience summary report to improve the efficiency and possible cost savings for future programmes, demonstrate the viability of the procurement approach as defined in this document and also make recommendations based on the experience gained and the lessons learned during the procurement of commercial parts.

This report shall include:

- Special requirements and conditions and policies applied for the particular programme (an abridged extract from the Component Control Plan),
- Experience gained with the parts and the corresponding manufacturers and/or distributors during the space application suitability assessment,
- Experience gained with the parts and the corresponding manufacturers and/or distributors during the actual procurement and delivery of flight parts,
- An evaluation of the actual procurement including statistics on quantities, controls, schedule and performances as applicable to both, commercial components and to traditional standard space level or Hi-Rel parts (a certain share of which will always be required in a space programme),
- Presentation of non-conformance and problem areas,
- Recommendations from lessons learned for future procurements and any related proposals to modify and adapt the approach described in this document and the corresponding evaluation and/or assessment specifications.

9 DELIVERABLE DOCUMENTS

The supplier shall establish all documents and plans as defined in the below table for delivery and/or presentation to the customer as applicable and unless otherwise defined by the programme requirements or statement of work (SOW):

Table 2: Deliverable documents

DOCUMENT	REFERENCE	CUSTOMER
Periodic progress report	2.3.1	Review
Components Control Plan	2.3.2	Approval
RFD, RFW	2.4 2.5 3.3	Approval
“as design” DCL	2.4	Approval
“as built” DCL	2.4	Review
Radiation Hardness Assurance plan	3.4	Approval
Radiation Assessment report	3.4	Review
Supplier’s derating rules	3.5	Approval (through CCP)
Justification Documents	3.8	Approval
Evaluation plans	3.9	Approval
Evaluation reports	3.9	Approval
Procurement documents	4.2	Approval (through JD)
Supplier’s incoming procedure	4.3	Approval (through PCB)
Supplier’s DPA procedure	4.4	Review (through CCP)
DPA reports	4.4	Review (on request)
RVT procedure	4.6.2	Review (through CCP)
Supplier’s relifing procedure	4.7	Approval
Supplier’s post-programming procedure	4.8	Approval (through PCB)
Procedures for handling & storage of EEE parts	5	Review
Procedures to handle EEE parts during assembly & mounting	6	Review
Experience Summary Report	8	Review