Training on ECSS-Q-ST-60Crev2

Space Product Assurance Electrical, Electronic and Electromechanical (EEE)components

revision 18 May 2015

TEC-QE
Space Component Standardisation and Evaluation Division

European Space Agency

ECSS-Q-ST-60C Rev.2
What is it for ?

- This **top level** standard defines **requirements for the selection, control, procurement and use of EEE components in a space project**.

- The **customer** (e.g. Space Agency, Operator) of a given space project **defines** the **EEE component requirements** as part of the **project PA** requirements by calling ECSS-Q-ST-60C Rev.2 as an applicable document or by tailoring it. ECSS-Q-ST-60C is a pre-tailored document and further tailoring should be avoided.

- These project PA requirements are typically part of the project's phase C/D tender documentation. Q-60 has **contractual relevance** and its **requirements are verifiable.**

- The supplier responds with **a component control plan** to implement those requirements in a manner suitable to facilitate the management of all EEE parts related activities in accordance with the **project constraints,** such as **mission objectives and schedule, in a resource effective and efficient way**.

- The supplier must ensure to **pass these requirements down to lower level suppliers** and verify their compliance.

ECSS-Q-ST-60C Rev.2
Why is it already in revision 2 ?

- Yes, revision 1 contained quite a number of editorial flaws, even a whole paragraph is missing, but that's not a sufficient reason.

- Prior versions had two main weaknesses :
  - They were not suitable to address commercial EEE parts defined as not designed and intended for space applications and
  - They were inadequately treating Radiation Hardness Assurance aspects

- With the development of ECSS-Q-ST-60-13C we have now created a suitable standard for commercial EEE parts which needed an explicit recognition through Q-ST-60.

- This applies equally to ECSS-Q-ST-60-15 Radiation Hardness Assurance.
  However, please note that it became part of the list of ESA approved standards only through an adoption notice issued in 2014 which tailors a few requirements.

- As a 3rd reason we have the waiver for Post Programming Burn-In of heritage FPGA types which is incorporated in rev.2

- This opportunity was also used to make other corrections and clarifications in support of better practices, but it does not include the addition of new requirements proposed and to be considered for a future issue D.

Q-60: What are the basics?

The Q-60 applies to the component user and only indirectly to the manufacturer of EEE components, such as in instances where the user has to rely on the manufacturer's cooperation.

It has to be used in conjunction with the relatively extensive list of directly applicable and reference documents existing in ECSS and other Standardisation Systems such as ESCC (European Space Component Coordination), the US MIL system dealing with EEE components and other industrial standards relevant for and in use by the component manufacturer industry.

These other documents include a diverse range of specifications from qualification listings for space parts over test methods to component detail specifications for procurement.

ECSS-Q-ST-60 origin and support in ESA

The present ECSS-Q-ST-60C evolved out of the ESA PSS-01-60 (PSS was the ESA internal standard system, the pre-curser of ECSS) and has therefore a long standing heritage.

It is maintained by a standing Q-60 WG which is a subgroup of the ESCC Policy and Standards WG. This WG has a mandate for all standards in the Q-ST-60 series. It develops and updates these documents and submits them to the ECSS review and approval process.

For level 3 documents in the series e.g. ECSS-Q-ST-60-15C for Radiation Hardness Assurance (RHA) other WGs are formed to gather the necessary expertise.

Technical officers from TEC-QE and TEC-QEC routinely support ESA projects and other entities in the application of ECSS-Q-ST-60C and associated documents

ECSS-Q-ST-60C Rev.2: Highlights

The ECSS-Q-ST-60C Rev.2 is written from **the parts user perspective (= supplier in ECSS context).** Its requirements define the supplier obligations to demonstrate consistently that the components are fit for purpose in a space project.

The standard defines requirements for EEE Parts with respect to their:

- Selection (rules)
- Control (management approach)
- Procurement (purchasing practice)
- Usage (e.g. call-up of derating, storage, shelf-life, …)

The ECSS-Q-ST-60C Rev.2 **only addresses project approval** requirements and includes **requirements for the procurement of non-space qualified parts**.

The Requirements for **EEE Part Qualification and procurement are covered by the ESCC System of Specifications** (European Space Component Coordination).

The Pre-tailoring Approach

The ECSS-Q-ST-60C differentiates three classes [Class 1 highest to 3 lowest] of components

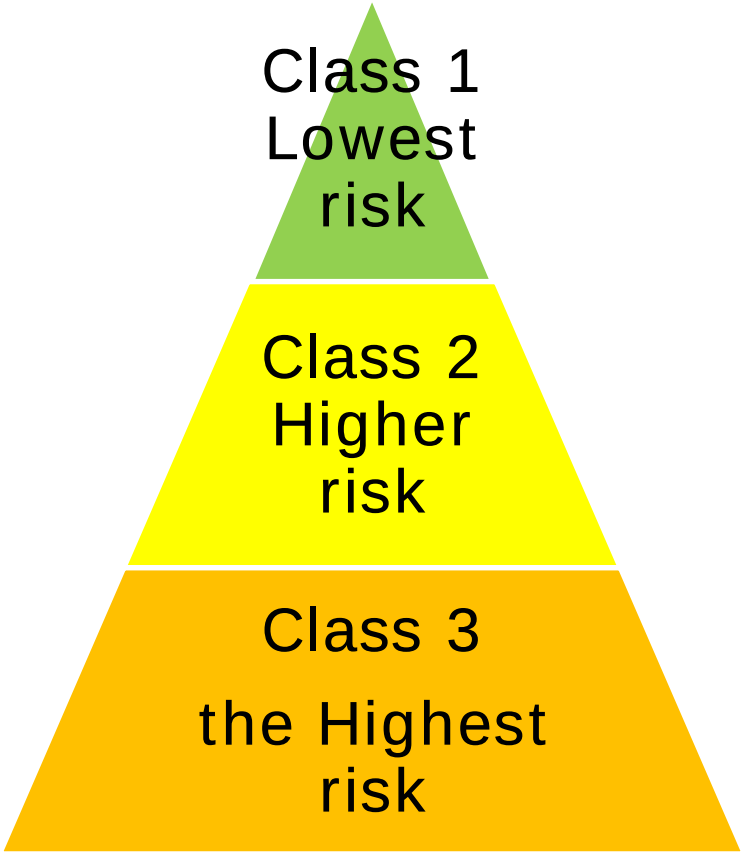
Each Class corresponds to a different level of Product Assurance and thereby the level of risk taken on reliability and quality.

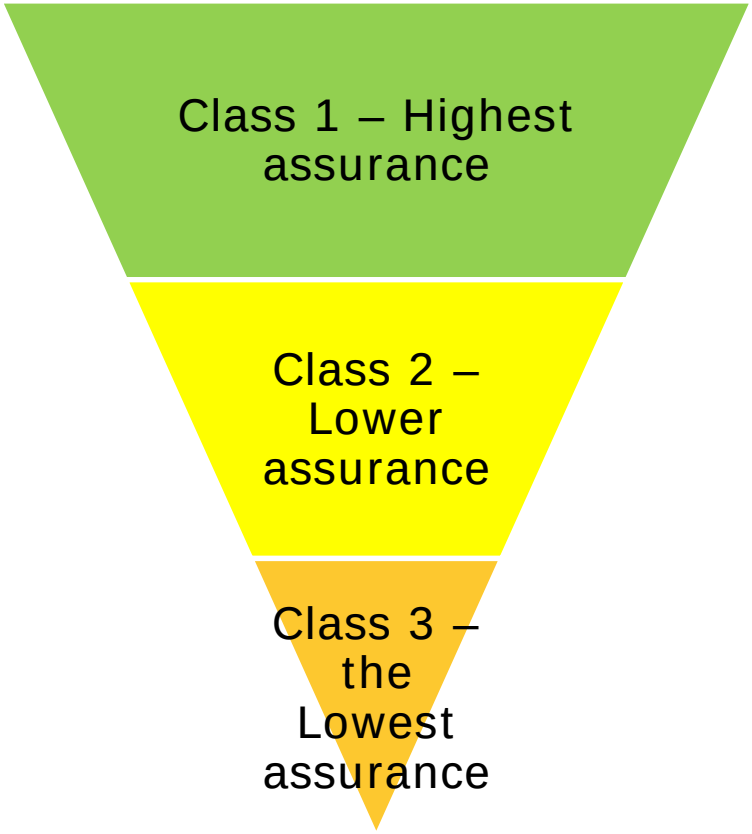
Class 1 components offer the lowest risk, while class 3 components reflect the highest advisable risk.

Note ! This is a qualitative, effort based PA approach. There is no absolute and no relative quantification of the risk difference between the defined classes !

At present there is a solid consensus that the assurance level for class 3 parts is the lowest permissible for flight.

Risk versus Assurance





Use and tailoring of ECSS-Q-ST-60C

The ECSS-Q-ST-60C rev2 is in the list of ESA approved standards and, as such, it is to be used by all ESA projects in accordance with ESA/ADMIN/IPOL(2007)11 (20 July 2007).

Projects will normally tailor the document to their constraints, add requirements – such as those related to RHA, for example. Most ESA satellite projects specify requirements which meet or exceed Q-60 Class 1; some projects specify Class 2 or some intermediate level between Class 2 and Class 1.

Outside ESA, most commercial telecommunication satellites use requirements that meet or exceed ECSS-Q-ST-60C rev2 Class 1; national government projects, typically for EO, may have requirements along ECSS-Q-ST-60C rev2 Class 2, and smaller platforms targeting new markets and some constellations may have parts requirements similar to Class 3

Document / Requirement Structure

1 Scope

2 Normative references

3 Terms, definitions and abbreviated terms

4 Requirements for Class 1 components

5 Requirements for Class 2 components

6 Requirements for Class 3 components

7 Quality Levels (in tabular form)

Annex A (norm.) Component Control Plan

Annex B (norm.) Declared Components List

Annex C (norm.) Procurement Specification

Annex D (norm.) Part Approval Document

Annex E (inform.) EEE documents delivery per review

Note : the sub-clause structure for Class 2 & 3 is identical to Class 1 but implemented in a tailoring manner

Class 1 : Component Progr. Mgmt.

Component Control Programme

The supplier must establish a **management organisation, define approaches/procedures** (incl. procurement) **compliant with ECSS-M-ST-10**

Note : Decision on central (recommended for more complex projects) or decentralised parts procurement

The supplier must establish a **Component Control Plan** (per Ax A, compulsory for Class 1);

Key elements :

Organisational structure, responsibilities, concurrent engineering;

Lower level supplier control; Procurement system;

Radiation control programme; Component selection and part type reduction;

Component data acquisition and assessment;

Evaluation, testing, approval, inspections, storage, milestone planning, problem management, reporting, compliance matrix

Class 1 : Component Progr. Mgmt. Parts Control Board

4.1.3 a. The approval of the selection and usage of EEE parts shall be implemented through Parts Control Boards (PCBs) held between the customer and the supplier (or lower tier subcontractor)

Chaired by a member of the suppliers PA team + parts engineer + customer representative + …

Review & approve EEE CCP and associated documents;

Part type reduction;

Part approval incl. evaluation results;

Problem assessments (Alerts, non-conformances, RFD, RFW, schedule)

Comparative assessments (initial approval vs. actual docs / sampling)

This means the PCB shall have the complete overview / visibility and approval responsibility incl. RHA, this may lead to the withdrawal of prior approvals.

Class 1 : Component Progr. Mgmt. Declared Components List

"4.1.4 a. For each equipment, its supplier shall issue a DCL in an editable and sortable electronic format, …, identifying all component types needed."

DCL content as per annex B

To be kept under configuration control,

Minimally issued at PDR and CDR (as designed) and TRR (as built)

After CDR all PAD changes require customer approval.

Changes during equipment manufacturing need RFW based customer approval before mounting.

DCLs are crucial for determining the impact of alerts

Class 1 : Component Progr. Mgmt. Electrical and Mechanical GSE

"4.1.5 a. EEE components used in GSE, which are physically and directly interfacing to flight hardware, shall be:

1. Fit, Form and Function compatible;
2. 2 manufactured from materials identical to the flight opposite part and
3. Ensured to be visibly clean before each connection to flight hardware.

b. Flight hardware connector interfaces to GSE shall interface to a flight compatible connector, as per 4.1.5.a.

Note : This connector can be installed on the test harness or can be a saver."

Beware : 'inter-mateability' between connectors from different manufacturers is often an issue !

Class 1 : Component Selection, Evaluation and Approval

To be considered already in the selection process :

Project Requirements (e.g. quality levels, component policy, delivery and manufacturing schedules, quantity, attrition)

Design requirements (e.g. component type, case, dimensions, materials)

Production requirements (e.g. packaging, thermal and storage constraints, component mounting process),

Operational requirements (e.g. electrical, mechanical, radiation, reliability, assembly, and lifetime).

“The selection, evaluation and approval of commercial EEE components for class 1 programmes shall be performed in conformance with clause 4.2 from ECSS-Q-ST-60-13”

Class 1 :
Manufacturer and Component Selection

Components shall be selected on the basis of 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.

Preference shall be given to components which necessitate the least evaluation or qualification effort.

Starting with the design phase of the project the supplier shall ensure **maximum use of preferred (see 4.2.2.3) and qualified components to achieve an effective component reduction** and standardization.

When selecting items, the supplier shall check the current data, applicability of the basis of qualification, problem notifications and alerts, and adequacy of specifications.

Class 1 :
Parts and Material Restrictions - 1

... non-hermetically sealed materials of components must meet the requirements of ECSS-Q-ST-70 regarding off-gassing, out-gassing, flammability, toxicity and any other criteria specified for the intended use.

... shall evaluate the **robustness** of selected EEE components against the **stresses induced by the assembly techniques to be employed**.

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 can cause safety hazards shall not be used.

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

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

Class 1 :
Parts and Material Restrictions - 2

For limited life duration, known instability, safety hazards or reliability risk reasons, the EEE components **listed below shall not be used**:

1. **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.**
2. Hollow core resistors,
3. Potentiometers (except for mechanism position monitoring),
4. **Non-metallurgically bonded diodes**,
5. **Semiconductor dice with unglassivated active area**,
6. Wet slug tantalum capacitors other than capacitor construction using double seals and a tantalum case,
7. **Any component whose internal construction uses metallurgic bonding with a melting temperature not compatible with the end-application mounting conditions**,
8. Wire link fuses < 5A,
9. TO5 relays without double welding of the mechanism to the header or with any type of integrated diodes inside,

Note : pure tin inside hermetically sealed packages can be approved but any pure tin approval is subject to a PAD entry and customer approval

Class 1 :
Preferred Sources

Parts shall be chosen from the EPPL part I (European Preferred Parts List) includes now all ESCC qualified parts and more

For parts not selected from the EPPL part I, the following sources shall be considered in the following order of precedence:

1. **EPPL part II (when compatible with the project requirements)**
2. **NPSL (NASA Parts Selection List) level 1 and level 2 or 3 (when compatible with the project requirements),**
3. **MIL QPL's and QML's.**

Parts subject to export restrictions or regulations shall not be preferred.

Class 1 :
Radiation Hardness - 1

The radiation requirements for EEE components are project specific.

The supplier responsible for the hardware design shall demonstrate the compliance of its components selection with the radiation constraints of the project in terms of cosmic radiation (Heavy Ions), electromagnetic, trapped (charged particles – electrons, protons – in radiation belts) and solar (flares) with due consideration to the mission orbit, trajectory, 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 damage and Single Events Effects (SEE).

Class 1 :
Radiation Hardness - 2

The supplier shall identify components which are not compliant with the radiation requirements as critical radiation sensitive components.

The supplier shall implement a Radiation Hardness Assurance Programme, in conformance with the requirements of ECSS-Q-ST-60-15, documented by a plan to be approved by the customer, for radiation sensitive components, covering the collection of all relevant information and specifying the necessary actions in terms of evaluation and procurement testing, planning and control.

The supplier shall issue an Equipment Radiation Analysis document identifying all sensitive components w.r.t. the relevant radiation effects, possibly their impact and giving an adequate engineering solution (e.g. local shielding, design solution, specific test, and RVT) for the relevant equipment.

The Equipment Radiation Analysis document shall be submitted to the customer for approval.

NOTE : More detailed environment information in ECSS-E-ST-10-12 and -Q-ST-60-15

ESA Adoption Notice ESSB-AS-Q-008 issue 1, for ECSS-Q-ST-60-15

Class 1 : Derating

Derating is the deliberate reduction of electrical parameters (maximum limits) used in an application circuit to reduce part stress levels and achieve a longer life time.

EEE component derating rules to be implemented in designs are defined in ECSS-Q-ST-30-11.

Note : the present version of ECSS-Q-ST-30-11 contains additional design recommendations which are not derating rules in the actual sense. They were included because the WG considered them to be of value but could not accommodate them in a more suitable document.

For wire link fuses, the current derating factor shall be 50 % with an additional derating of 0,2 % / °C for an increase in the temperature of fuse body above 25 °C.

Class 1 :
Component Evaluation - 1

The supplier shall perform a component evaluation in absence of an approved demonstration that a component has the ability to conform to the requirements for functional performance, quality, dependability, and environmental resistance as required for the project. So the evaluation test programmme shall reflect the needed characteristics of the intended application.

An evaluation plan shall be sent to the customer for approval, and include the following elements:

1. **Component Manufacturer Assessment (as per clause 4.2.3.2),**
2. **Constructional Analysis (as per clause 4.2.3.3),**
3. **Evaluation Testing (as per clause 4.2.3.4),**
4. **Radiation Hardness (as per clause 4.2.3.4b.5).**

In the definition of the evaluation programme any information including pertinent reliability, analysis and test data from the manufacturer of the component and previous use in comparable applications shall be considered.

Omission of any of these elements, or the introduction of alternative activities, shall be justified.

Class 1 :
Component Evaluation - 2

All tests and inspections shall be carried out on representative samples of the component type from the current production of the manufacturer selected for the component procurement for the flight hardware.

For programmable devices, the representativeness shall include the programming hardware tools and the compatibility of the software.

The supplier shall review the evaluation results to determine their impact on the content of the procurement specification which shall be amended as necessary.

The supplier shall summarize the evaluation results in the evaluation report and send it to the customer for approval.

NOTE For guidance for the assessment of the space environmental aspects refer to ECSS-E-ST-10-04 and ECSS-E-ST-10-12.

Class 1 :
Component Manufacturer Assessment

The purpose of the manufacturer assessment is to determine its capability, to ensure the adequacy of its organization, plant and facilities, and to ascertain its fitness to supply components to the appropriate specifications for space application.

The supplier shall perform an evaluation against the ESCC basic specification no. 20200 and the ancillary specifications for dedicated component families and shall include, but not necessarily be limited to, a survey of:

1. The overall manufacturing facility and its organization and management,

2. The manufacturer's system for inspection and manufacturing control including all relevant specifications, procedures, and internal documents,

3. The production line used for the component.

The complete manufacturer assessment, including the survey report and the associated corrective actions, shall be part of the evaluation report.

Class 1 :
Constructional Analysis

The primary aim is to provide an early indication of a component's constructional suitability for meeting the specified performances of the space project application.

Constructional analysis shall be carried out on representative components.

The Constructional Analysis shall comprise destructive and non-destructive inspections, analysis, and testing, to identify:

1. **Design and construction technology,**
2. **Materials used,**
3. **Inherent reliability aspects,**
4. **Quality of workmanship,**
5. **Potential hazards.**

The findings of the analysis shall be contained within a Constructional Analysis Report and shall be included in the Evaluation Report.

Class 1 :
Evaluation Testing

The evaluation shall determine which inspections or tests are required to provide the confidence that the component type under evaluation, when assembled and tested in accordance with the procurement specification, successfully meets the project requirements.

The supplier shall review the already existing data in order to adapt and minimize the content of the evaluation testing while ensuring that there are inputs and pertinent results covering the following topics:

1. Endurance test (operating at elevated temperature and electrical stress),

2. Mechanical stress (shock, vibration, constant acceleration),

3. Environmental stress (thermal shock, temperature cycling, high and low temperature storage, humidity),

4. Assembly capability testing,

5. Radiation testing, for total dose and single event effects sensitivity.

NOTE For guidance refer to ESCC basic specification no. 22600 and the ancillary specifications for dedicated component families.

Class 1 :
Parts Approval

Approval process must be fully traceable and includes :

1. A PAD in conformance with Annex D (or corresponding information included in the DCL) is required for space qualified parts when:

(a) additional controls are required (e.g. precap, buy-off, LAT or LVT, RVT, DPA),

(b) used outside the specified limits, (this is very risky and not recommended !)

(c) specific tests are required during procurement as per Table 7-1,

(d) pure tin is used inside or outside the part.

2. All other space qualified parts listed in the DCL are approved through the DCL review,

3. For any other part a PAD, in conformance with Annex D is required,

4. For any commercial part, a Justification Document, as per ECSS-Q-ST-60-13 (clause 4.2.4), is required, instead of a PAD.

In case the evaluation results are changing the procurement conditions documented in the PAD or the JD (as per clause 4.2.3.1), a new revision of PAD or the JD shall be submitted to the customer for approval.

Class 1 : Procurement

Class 1 components shall meet the quality levels ands supplementary conditions specified in Table 7-1.

The supplier shall be responsible for manufacturer surveillance and control throughout the procurement programme.

For non qualified parts, the supplier shall put in place a configuration control system to ensure that any change of the product (e.g. mask, manufacturing and assembly process) affecting evaluation, performance, quality, reliability and interchangeability is communicated to him by the manufacturer (e.g. PCN).

The supplier shall ensure the compatibility of the change with its application.

The change shall be submitted to the customer for approval.

To reduce the risk of procuring counterfeit components, when parts are not directly procured from the manufacturer, the supplier shall procure parts only from distributors duly franchised by the parts manufacturer.

The procurements of the commercial EEE components for class 1 programs shall be performed in conformance with the requirements of clause 4.3 of ECSS-Q-ST-60-13.

Class 1 : Screening

All components to be incorporated into flight standard hardware shall meet the quality level specified in Table 7-1, shall be procured as qualified (if available) and be subjected to screening.

The screening test requirements shall be defined such that accumulated stress does not jeopardize component reliability.

All screening tests shall be performed at the component manufacturer's premises or at a facility approved either by the qualification approval authority, where applicable (e.g. ESCC), or otherwise by the supplier.

For active parts (transistors, diodes) packaged in TO3, DO4 or DO5, the PIND test method shall be submitted to the customer's approval.

PIND – Particle Impact Noise Test : to detect lose (conductive) particles in the cavity

In case a component is not available in a qualified version according to quality level specified in Table 7-1, the screening of the component shall meet the screening flow defined by the generic specifications listed in Table 7-1.

In case of X-rays inspection, the total dose deposited shall be less than 1/10 of the product acceptable dose.

Class 1 :
Customer Source Inspection (Precap)

The procurement entity shall carry out, at the manufacturer's premises, a customer precap inspection for non-space qualified parts listed below:

1. Capacitors (ceramic, mica and plastic film)
2. Crystals
3. Oscillators
4. Discrete semiconductors (including diodes and transistors)
5. Filters
6. Fuses (cermet)
7. Inductors, coils and transformers (not applicable to in-house products)
8. Monolithic microcircuits (including MMICs)
9. Hybrid circuits
10. Relays
11. Resistors (high precision, fixed, metal foil – RNC90)
12. Switches (including mechanical and thermal)
13. Optoelectronic devices (e.g. opto-couplers, LEDs, CCDs and sensors).

A precap inspection is required on critical space qualified parts , including as a minimum relays, crystals, oscillators and hybrids.

Class 1 :
Lot Acceptance

The supplier shall ensure that any lot / date code of EEE parts is submitted to a lot acceptance procedure (in line with applied normative systems) according to the following rules:

1. Space qualified parts:

ESCC: not required due to periodic lot validation testing by the manufacturer

MIL: mfr. QCI or TCI i.a.w. the quality level of the MIL specification is OK

2. Non-space qualified parts:

(a) The content of the lot acceptance is ESCC level LAT1 or level LAT2 or LVT (subgroups 1, 2 and 3) or comparable QCI.

(b) In absence of any changes (design, construction, process) LAT may be replaced by the review of available data less than 2 years old.

(c) In case of partial available data, any complementary lot acceptance content is defined by the supplier subject to PCB agreement.

(d) The PCB documents and justifies any reduced lot acceptance based on available data for customer approval.

The sample size for lot acceptance, which may be reduced in some cases, shall be submitted to the customer for approval through the PAD process (see clause 4.2.4).

Class 1 :
Final Customer Source Inspection (Buy-Off)

The procurement entity shall carry out, at the manufacturer's premises, a final customer source inspection for non-space qualified parts, based on inspections, tests and review activities to verify that the requirements of the purchase order are met prior to shipment of the flight parts.

The buy-off shall include:

1. **External visual inspection,**
2. **Witnessing electrical measurements,**
3. **Verifying mechanical dimensions,**
4. **Review and verification of the data-package.**

The buy-off may be replaced by an incoming inspection at the procurement entity's facilities.

If the buy-off is replaced by an incoming inspection at the procurement entity's facilities, it shall be declared in the PAD submitted to the customer for approval.

Class 1 : Incoming Inspection

The incoming inspection verifies conformance with the PO and includes :

All parts: (a) Marking control,

(b) Quantity verification,

(c) Packing checking,

(d) Review of the manufacturer delivered documentation,

(e) Additional tests based on the type of component, criticality and heritage with the manufacturer (e.g. solderability tests, electrical tests),

(f) for termination finish non-Au, lead finish check as per ESCC 25500.

For the non-space qualified parts, when the final customer source inspection has not been performed, the following additional items:

(a) External visual inspection by sampling (AQL 0,65% level II or 20 parts min)

(b) Electrical measurements at room temperature on 20 parts or 100% (if lot size < 20 parts), or a datapackage review.

If the parts have passed successfully a final CSI (or buy-off), the incoming inspection may be reduced to the following minimum: 1. Verification of the manufacturer's CoC,

2. Packing checking,

3. Quantity verification.

Class 1 :
Radiation Verification Testing (RVT)

Radiation sensitive components, as defined in clause 4.2.2.4, and for which applicable existing test data is insufficient shall be subjected to RVT.

RVT shall be performed in accordance with internationally recognized standards, such as ESCC Basic Specifications No. 22900 or per MIL-STD-750 Test Method 1019 (discretes), MIL-STD-883 Test Method 1019 (microcircuits).

If RVT is applicable a PAD in conformance with Annex D shall be issued and processed as per clause 4.2.4.

The results of RVT shall be documented by a report.

When RVT is performed in the frame of the project, the supplier shall send the related report to the customer for information.

Class 1 :
Destructive Physical Analysis (DPA)

e.g. as defined through MIL-STD-1580

"A DPA is a systematic, logical, detailed examination of parts during various stages of physical disassembly, conducted on a sample of completed parts from a given lot, wherein parts are examined for a wide variety of design, workmanship and processing problems that may not show up during normal screening tests. The purpose of theses analyses is to determine those lots of parts delivered by a vendor, which have anomalies or defects, such that they could at some later date, cause a degradation or catastrophic failure of a system."

MIL-STD-1580B is presently under revision

A DPA document for publication in the ESCC system is in final review (planned release in Q3/2015).

Class 1 :
Destructive Physical Analysis (DPA)

Non-space qualified parts : on 3 samples per lot / date code for :

1. Capacitors (glass, ceramic, tantalum and variable)
2. Crystals
3. Oscillators
4. Discrete semiconductors (including diodes and transistors)
5. Filters
6. Monolithic microcircuits (including MMICs)
7. Hybrid circuits
8. Relays
9. Switches (including mechanical and thermal)
10. Optoelectronic devices (e.g. opto-couplers, LED's, CCD's and sensors)
11. Passive microwave devices (e.g. mixers, couplers, isolators and switches)

Space qualified parts : on 3 samples per lot / date code on critical space qualified parts, including as a minimum relays and oscillators. For other space qualified parts families, DPA is not required.

If approved through the PAD process the sample size may be reduced.

Class 1 : Relifing

When components from a supplier's or parts procurement agent's stock are used, the following criteria shall be met:

1. The parts are stored according to the minimum conditions given in clause 4.4,
2. The minimum overall requirements (including screening) are in accordance with the project requirements,
3. The lot/date code homogeneity and traceability can be demonstrated,
4. The EEE parts documentation is available and the content is acceptable in accordance with the project requirements (including radiation data, if necessary),
5. There are no open NCR's and no unresolved alerts with respect to their date code.

For components meeting the above criteria, and which have a lot / date code exceeding the period defined in ECSS-Q-ST-60-14 clause 5, the relifing procedure ECSS-Q-ST-60-14 shall apply.

Relifing applies after 7 years of storage and, if successful, validates the parts usage for another 3 years. After 10 years of storage parts are deemed unfit for flight.

Yes, it is odd that we do not have maximum storage limits for equipments

Class 1 :
Handling and Storage

The supplier shall establish and implement procedures for handling and storage of components in order to prevent possible degradation.

The procedures shall be applicable at any facility dealing with components for flight application.

On request, handling and storage procedures shall be sent to the customer for review.

As a minimum, the following areas shall be covered:

1. Control of the environment in accordance with ESCC Basic Specification No. 24900.

2. Measures and facilities to segregate and protect components during receiving inspection, storage, and delivery to manufacturing.

3. Control measures to ensure that electrostatic discharge susceptible components are identified and handled only by trained personnel using anti static packaging and tools.

Class 1 :
QA – Non-Conformances and Failures

The supplier shall establish and maintain a non-conformance control system in accordance with the general requirements in ECSS-Q-ST-10-09.

Any observed deviation (failures, malfunctions, deficiencies and defects) of EEE components from requirements as laid down in applicable specifications, procedures and drawings shall be controlled by the nonconformance control system.

The nonconformance control system shall handle all non-conformances occurring on EEE components during:

1. **Manufacture (if available), screening and acceptance tests,**
2. **Incoming inspection,**
3. **Integration and test of equipment,**
4. **Storage and handling.**

For ESCC qualified components the supplier shall apply the ESCC basic specification no 22800.

Class 1 :
QA – Alerts

The supplier shall take into account all received alerts from international alert systems, from manufacturers or sent by the customer and shall validate that there are no alerts on the proposed parts with respect to the batch information (including date-code).

If alerts become available at a later stage, the supplier shall analyse the alerts, analyse the project risk and propose an action plan for customer approval.

The supplier shall initiate and distribute within the project notifications 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.

The major Alert Systems are the US GIDEP and ESA Alert both secure the detailed alert information in a private domain.

Other organisations maintain also proprietary alert systems with strict access control (e.g. CNES, NASA GSFC, ...)

The rules for the ESA Alert system are in the public domain https://alerts.esa.int

Use of the ESA Alert system is compulsory for ESA projects.

Class 1 :
QA – Traceability and Lot Homogeneity

The traceability of all components shall be maintained during manufacturing, testing, through incoming, storage, and installation at the procurer and user 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 allow managing the adequacy of the tests performed by the supplier (i.e. evaluation, lot validation, any additional test or inspection).

The traceability of EEE parts during installation in equipment, shall be ensured by the supplier through maintaining the traceability to the manufacturer's lot/date code number of the EEE parts actually mounted.

If the as built DCL has not yet been delivered, the supplier shall be able to provide this information (part type actually installed with its relevant lot/date code number) within one week.

Lot homogeneity is a key requirement and applies also for sampling tests.

Class 1 :
One time programmable devices

For FPGA, ECSS-Q-ST-60-02 shall apply.

The PAD shall allow traceability to the information related to the procurement of blank parts, the programming process and the acceptance of the programmed parts.

One time programmable components shall be submitted to a post-programming sequence.

For FPGA types without a clear and defined heritage, a post-programming burn-in shall be applied, in conformance with ESCC9000 subclause 8.21, for a minimum duration of 160 h.

NOTE: FPGA types with defined heritage are documented in the report: ESCC REP 010 SCSB Decisions Regarding OTP FPGA PPBI, available on https://escies.org.

The supplier shall prepare a post-programming procedure for customer's approval, depending on part types (including when necessary electrical tests, programming conditions and equipment, programming software version qualified by the supplier, burn-in conditions, additional screening tests and specific marking after programming) as applicable per 4.6.4d.

The lot acceptance procedure, as defined in clause 4.3.5, shall be performed on devices coming from the flight lot/date code and programmed on the same kind of hardware tools and compatible software.

In case of several designs based on the same lot of blank parts, the lot acceptance procedure, as defined in clause, 4.3.5, may be limited to one representative flight programmed design.

Documentation and Quality Levels

1. Refer to actual document

ECSS-Q-ST-60C rev2 Classes / EEE parts Quality Levels

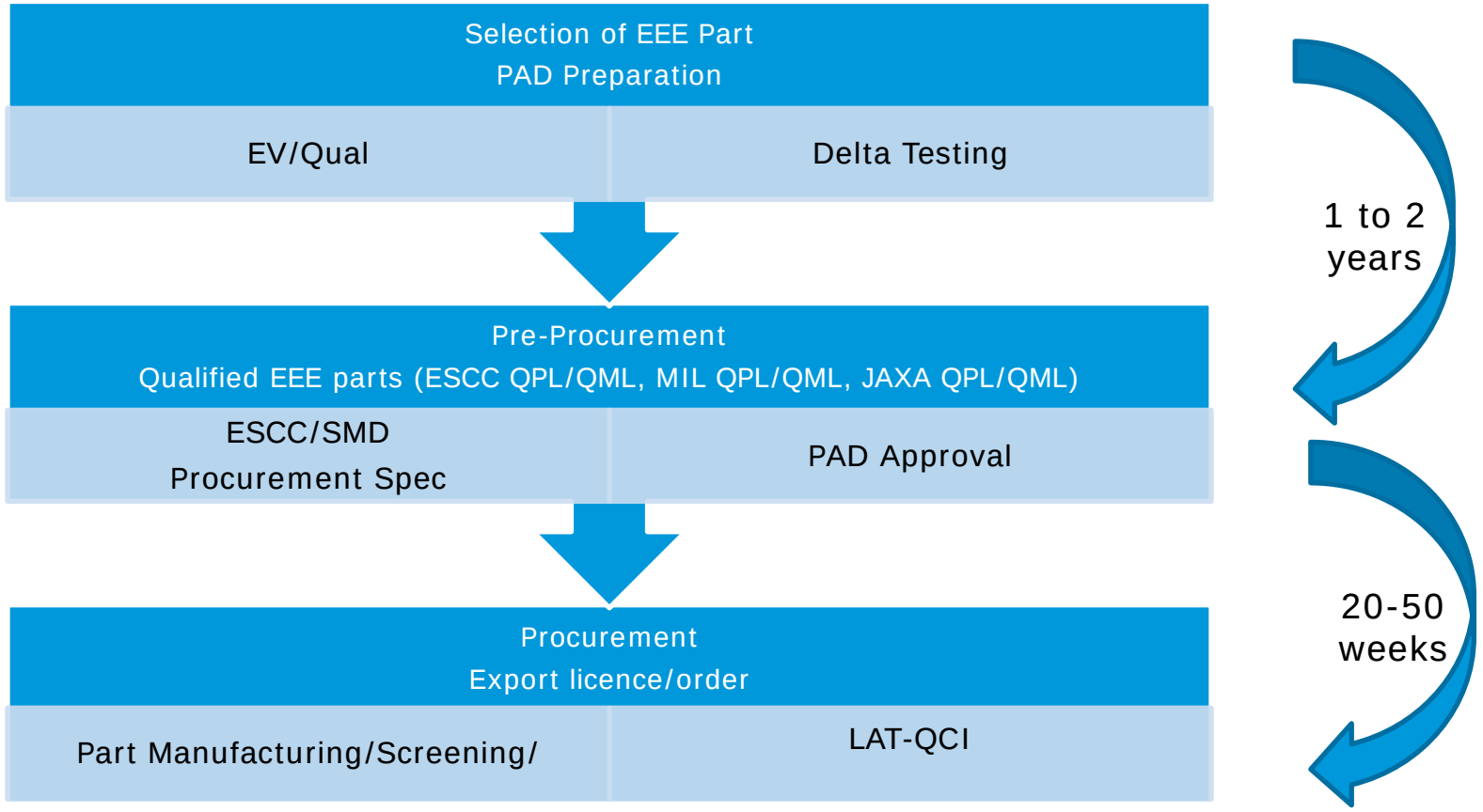
For Microcircuits:

Class	Quality Level
1	ESCC / QMLV *
2	ESCC /QMLQ /COTS+
3	ESCC / MIL/COTS+

Some facts for consideration

- The ‘catalogue’ of space qualified components is not (and can not reasonably expected to be) aligned with project / innovation needs
- Space qualification of components is consuming resources and time
- It is therefore necessary to provide for systematic and pragmatic rules to increase the available space component portfolio and accommodate short project schedules and limited budgets.
- The type and number of requirements have an influence on effort and schedule
- Necessarily this leads to the risk conscious reduction of requirements w.r.t. qualification pedigree (e.g. terrestrial MIL vs. Space), reduction of Product Assurance practices such as reduced testing, screening, inspection and documentation and reviews. All of which are to some degree reflected in the class definitions.
- Q-60Crev1 did not provide a clear cut approach to the use of commercial components. This gap is now closed by the dedicated Q-ST-60-13 document.
- The use of commercial components is not intended to replace space qualified pats but to close gaps in the qualified parts range.

ECSS-Q-ST-60C rev 1
EEE Parts requirements and their implementation



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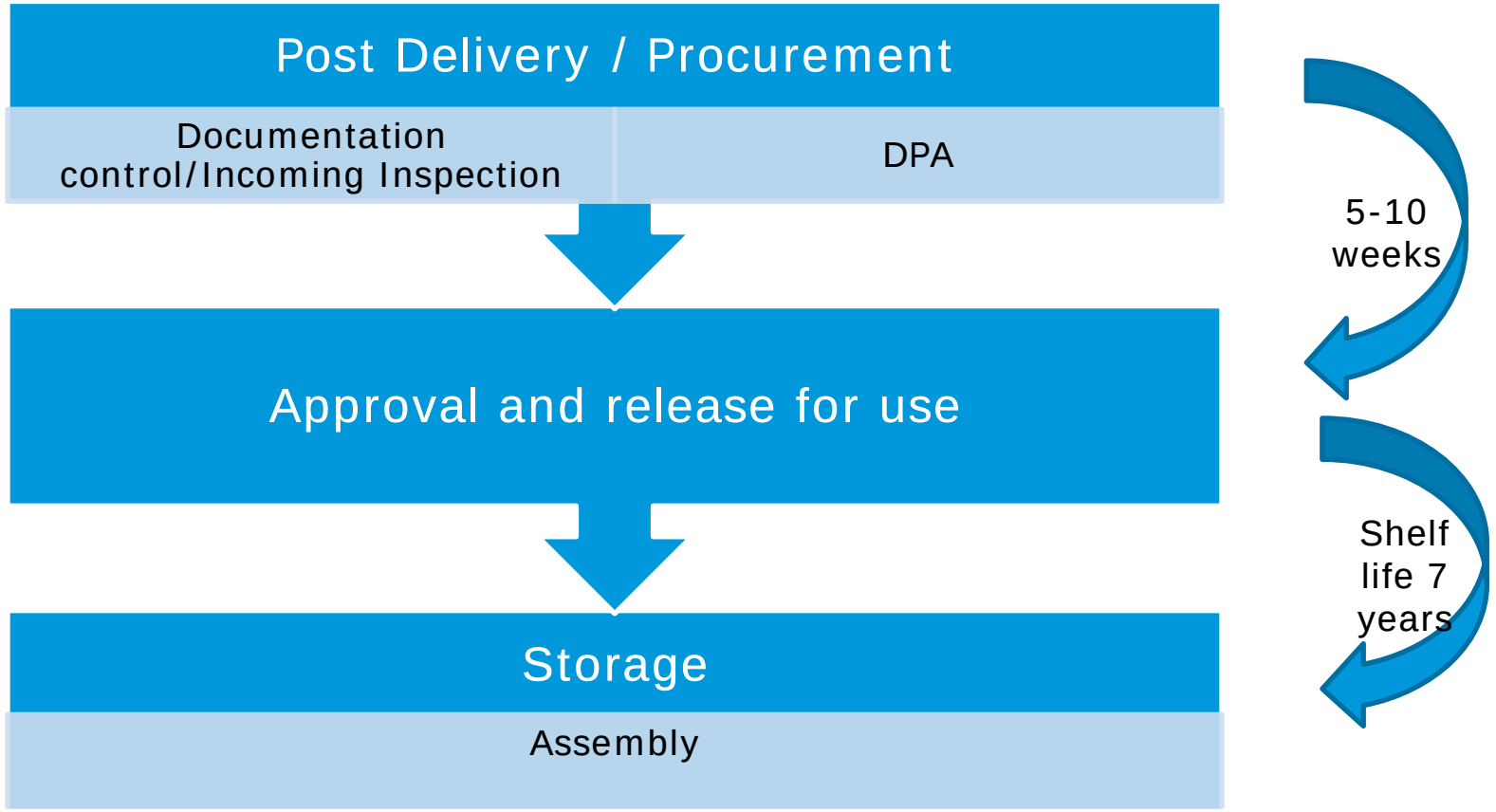
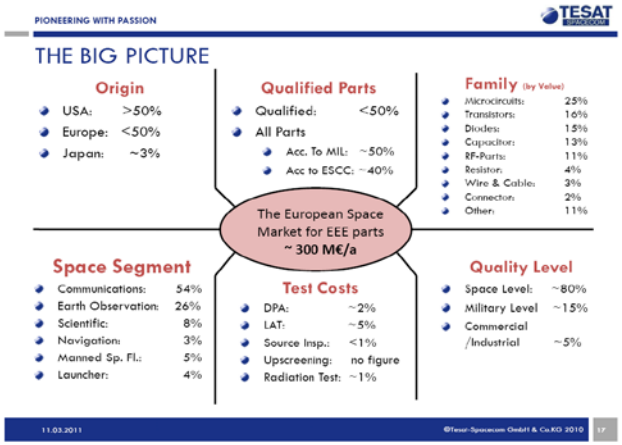
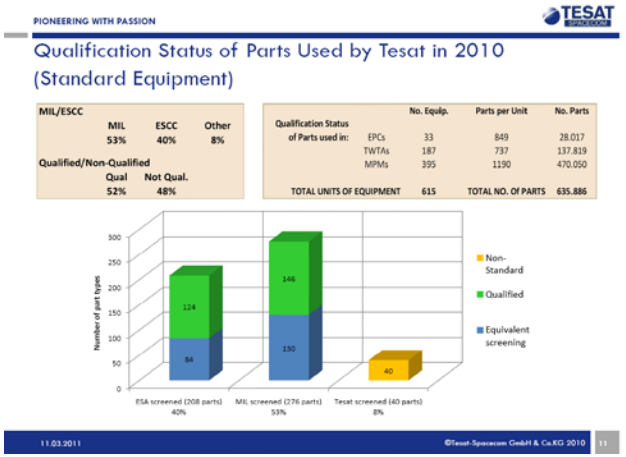


Procurement situations

1. **Cost** can matter a lot with EEE parts:
   a. In a mission / satellite level EEE parts represent +/- 10%,
   b. On equipment level they may amount to (30-50)% of the total cost
2. **Parts procurement** may encounter difficulties: lack of communication, poor response, questionable commercial practices, obsolescence of product, export control limitations, counterfeit parts,...





European Space Agency

Extras / Back-up slides

1. Refer to actual document

Commercial Component

There are numerous definitions and interpretations for the term ‘commercial component’.

The ECSS and ESCC definition is :

A commercial component is a EEE part neither designed, nor manufactured with reference to military and space standards and not intended for use in space applications.

Commercial Components are addressed in ECSS-Q-ST-60-13C (released Oct. 2013) are limited to Discrete and Integrated Semiconductors – exceptions apply - and definitely exclude Passive Components .

Note : this is not done to save cost but to satisfy technical requirements which can not be fulfilled with existing space qualified or components otherwise known to have the demonstrated capability to meet high reliability requirements.

Commercial components are parts procured against a set of publicly available data put under configuration control by the supplier/user. They are a sub-set of non qualified parts and are approved via a Justification Document (not a PAD!) which includes reliability test data, a risk mitigation plan and procurement details.

Justification Document for Commercial Components

- Risk analysis and mitigation actions.
- Summary gathering general information on product and manufacturer sheet.
- Supporting data on previous lot including radiation data and quality & reliability data from tests of previous lots. In addition RVT and reliability test on the Flight lot is performed.
- Validation lot data and test flow diagram. Activities to be performed and the flow that shall be followed during the execution of the activities.
- Handling and Testing requirements: precautions to be taken when handling and testing the COTS components
- Storage of the parts
- Elements of the Device technology
- Application conditions based on the Evaluation/Radiation test results

ECSS-Q-ST-60 in ESA Projects: An Example

1. Tailoring of ECSS-Q-ST-60= Project PA (Product Assurance) requirement, Class 1/2/3
2. RHA (Radiation Hardness Assurance) = policy on ELDRS (Enhanced Low Dose Rate Sensitivity) testing/acceptance of data < 4 year date code
3. PPBI (Post Programming Burn-In) = Policy for PPBI of FPGA
4. PADs= Policy for PADs for qualified parts, hybrids add-on, dies
5. Policy for DPA, attrition rule

Project Reviews and EEE Parts Acceptance- PDR

The standard requires a preliminary DCL for each equipment at PDR and all the evaluation and qualification activities are defined and approved.

In practice:

1. Only preliminary DCL is available for a limited set of equipment depending on the design maturity
2. Little space for changes in case of recurrent unit
3. Time for changes and recommendations for use “alternative”, newly build, under evaluation parts, ESA supported development
4. Typically the parts are still at low TRL (TRL3, 4, 5)
5. Parts are typically only ESCC evaluated or qualification tests are not completed

To manage the associated risks:

- Contingency plan needs to be put in place to take into account the risk associated to the need to replace the part (same package/footprint as available qualified parts, secure order for the alternative parts, design margins, etc
- Critical development milestones have to be periodically reported to the project

Project Reviews and EEE Parts Acceptance - CDR

Conditions for a successful CDR

1. DCL are in principle frozen and all the procurement activities concluded. All PADs are approved
2. Little space for replacements/recommendation
3. Only case by case based on NCR/RFW/RFD/Anomalies a replacement of parts is implemented
4. Qualification tests are completed

In practice many qualification activity for Non-Standard parts are still running, some PADs are still opened, some RVT tests are not performed, PPBI (if applicable) not done yet, Qualification failures could happen

Typically depending on the status, CDR actions stay opened but CDR major progress/payment milestones are met

Typical Findings at CDR

- Parts with different quality requirements are already fitted.
- Parts violating relifing requirements.
- PPBI not done on FPGAs but for a large range of non-volatile types no longer needed since rev2.
- Unexpected lot qualification failures due to e.g. loss of hermeticity.
- No ELDRS test done on Linear Devices (PAD approved as RVT: Yes)
- Last minute parts replacement due to anomalies detected at board qualification level

Corrective actions are then coordinated between ESA, Primes and subcontractors.

Some additonal remarks

- The ECSS-Q-ST-60 standard comprehensively defines the requirements for the selection, control, procurement and use of EEE parts in ESA projects.
- EEE parts that are yet not available are identified and selected for dedicated development, ESCC evaluation and qualification. This is the beginning of a long journey for EEE parts which are needed by the space users but that are still far to be procurable according to this standard.
- Having timely and precise information on the mission requirements is fundamental to define new activities either with low TRL or in case of spin-in of commercial technologies into space market. These activities are typically funded at ESA under the ECI, TRP, GSTP and ARTES.

- Considering the always limited budget available compared to the activities proposed to be developed, the cooperation with national space agencies such as JAXA, CNES, ASI and DLR and with the EC has been fostered during the last years and has resulted in a larger portfolio of technologies and components.
- The harmonization and recognition of EEE parts requirements across all ESCC participants (manufacturers, users, National Space Agencies and ESA) is fundamental to the availability of EEE parts for space programmes, the sustainability of their supply chain and the maintenance of an enlarged list of qualified parts.

References

1. www.esa.int
2. www.ECSS.nl
3. https://escies.org contains among others

   European Preferred Parts List, ESCC QPL/QML

   ESCC specifications, Radiation Effects Database, ESCCON Proceedings, Technology and EEE components information, links
4. http://www.landandmaritime.dla.mil/ US-MIL specs and Qualifications
5. https://nepp.nasa.gov/ NASA Electronic Parts and Packaging website
6. https://assist.dla.mil best quick search facility for US MIL-System docs
7. http://radhome.gsfc.nasa.gov/top.htm NASA Radiation home page

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