ECSS-Q-ST-60 Training Part 1

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

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

It is the standard that 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.

ECSS-Q-ST-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.

The objective of the standard is to define requirements for the **EEE component selection, control, procurement and use** in a space project and to enable the project to accomplish its mission.

The customer (e.g. Space Agency, Operator) of a given space project defines the EEE component requirements as part of the project PA requirements **mainly** based on the ECSS-Q-ST-60C Rev.1.

The supplier responds with **a component control plan** to implement those requirements into a system which enables the control of the selection, approval, procurement, handling of EEE parts in accordance with the project constraints such as mission objectives and schedule in a cost efficient way.

The supplier ensures that the applicable parts requirements are **passed down to lower level suppliers** and ensures that they are compliant to these parts requirements.

ECSS-Q-ST-60C rev 2 includes **433 requirements** (“shall”) and **30 permissions** (“may be used”)

www.ecss.nl

ECSS-Q-ST-60-02C	**196**
Permission	3
Recommendation	1
Requirement	192
ECSS-Q-ST-60-05C Rev. 1	**221**
Permission	23
Recommendation	1
Requirement	197
ECSS-Q-ST-60-12C	**218**
Permission	10
Recommendation	6
Requirement	202
ECSS-Q-ST-60-13C	**460**
Permission	19
Requirement	441
ECSS-Q-ST-60-14C Rev.1 Corr.1	**88**
Permission	2
Recommendation	1
Requirement	85
ECSS-Q-ST-60-15C	**105**
Permission	1
Recommendation	1
Requirement	103
ECSS-Q-ST-60C Rev. 2	**463**
Permission	30
Requirement	433

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:

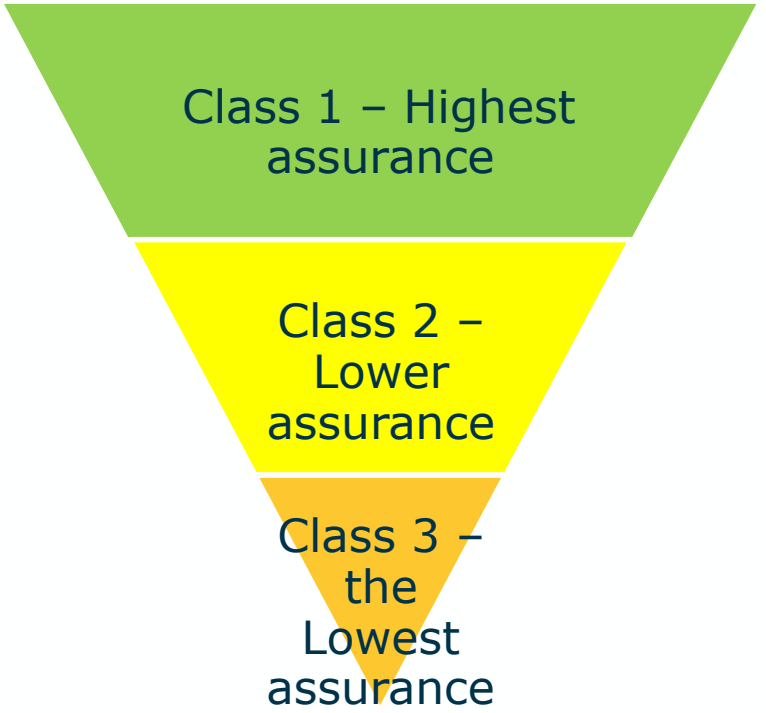
- Selection (rules)
- Control (management approach)
- Procurement (purchasing practice)
- Usage (e.g. call-up of derating, storage, shelf-life, …)

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)

Risk versus Assurance

- **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**



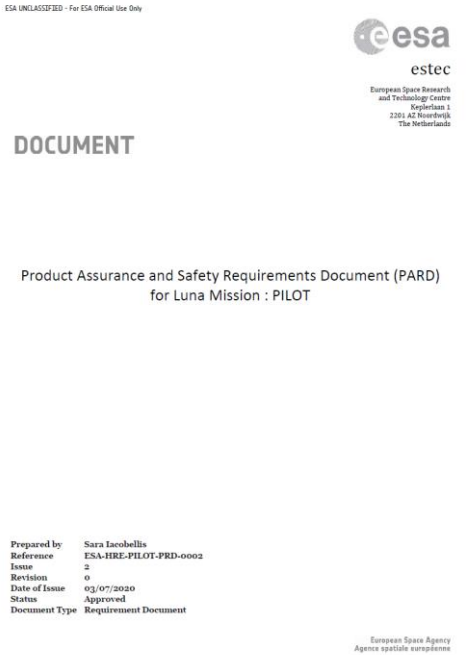
Use and tailoring of ECSS-Q-ST-60C

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.

This is done for ESA Project via the **ESA PARD (Product Assurance and Safety Requirement Document)**

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


ESA UNCLASSIFIED - For ESA Official Use Only

esa

estec

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DOCUMENT

Product Assurance and Safety Requirements Document (PARD)
for Luna Mission : PILOT

Prepared by	Sara Iacobellis
Reference	ESA-HRE-PILOT-PRD-0002
Issue	2
Revision	0
Date of Issue	03/07/2020
Status	Approved
Document Type	Requirement Document

European Space Agency
Agence spatiale européenne

Tailoring of ECSS-Q-ST-60 on PARD for PILOT Mission

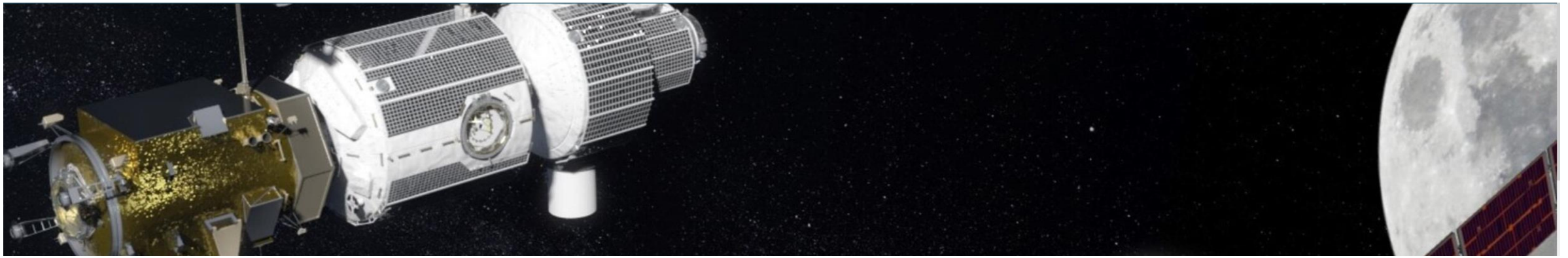
9 EEE COMPONENTS

9.1 General

ECSS-Q-ST-60C Rev.2 shall be applied with the following modifications:

Id	Type	Tailoring	Modified text / Comment
4	Requirement	Not applicable	ECSS-Q-ST-60C Rev2, Requirement for Class 1 components
5.1.3e	Requirement	New	The Contractor shall define a procurement policy that uses an attrition rate agreed by Customer representative within the PCB meeting.
5.1.3f	Requirement	New	For radiation sensitive components a Radiation Control Board (RCB) shall be established in order to assess compliance with ECSS-Q-ST-60-15C, ESSB-AS-Q-008 Issue 2 and the additional radiation hardness assurance requirements included in this PARD.
5.1.3g	Requirement	New	Approval of radiation sensitive components by the PCB shall be subject to prior approval by the RCB.
5.1.4a	Requirement	Modified	For each electronic equipment, an "as-design" DCL shall be issued in an editable and sortable electronic format, as a minimum compatible with CSV, identifying all component types needed. For the flight-standard products: - qualification model (EQM or QM) - flight model an "as-built" DCL shall be issued in an editable and sortable electronic format, as a minimum compatible with CSV, identifying all component part number used. *NOTE: CSV is a common file format that can be used to transfer data between database or spreadsheet tables (a spreadsheet program is for example Excel®).*

https://youtu.be/NgDX5LLkV14



Document / Requirement Structure

1 Scope

2 Normative references

3Terms, 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

Quality levels

Table 7-1: Quality levels for Class 1 components

EEE part family	Quality level			Supplementary Conditions
	ESCC	MIL	Other	
Capacitors, chip, ceramic	ESCC 3009 level C	MIL-PRF-55681 EFR level R min MIL-PRF-123		For ceramic capacitors procured through ESCC or MIL specifications but in an extended, non qualified, range of values or not belonging to ESCC QPL or MIL QML/QPL, the humidity, steady state, low voltage test (cf ESCC 3009, § 5.2.2) is mandatory if U rated < 50V and C > 1µF.
Capacitors, molded, ceramic	ESCC 3001 level C	MIL-PRF-39014 EFR level R min MIL-PRF-20 EFR level R min MIL-PRF-123 MIL-PRF-49470 EFR level T		For ceramic capacitors procured through ESCC or MIL specifications but in an extended, non qualified, range of values or not belonging to ESCC QPL or MIL QML/QPL, the humidity, steady state, low voltage test (cf ESCC 3009, § 5.2.2) is mandatory if U rated < 50V and C > 1µF.
Capacitors, glass (CYR type)	-	MIL-PRF-23269 EFR level R min		Lifetest 1000 h / 125 °C/ 1.5 Ur on each lot/date code. Not recommended for new designs
Capacitors, mica	ESCC 3007 level C	MIL-PRF-39001 EFR level R min		
Capacitors, chip, solid tantalum (e.g. TAJ, T495, CWR11)	ESCC 3011 level C ESCC 3012 level C	MIL-PRF-55365 WFR level C min		All capacitors shall be surge current tested.
Capacitors, non-solid tantalum, electrolytic (CLR79)	ESCC 3003 level C	MIL-PRF-39006 EFR level R min		39006 / 22, 25, 30, 31 and "H" dash number designated devices are recommended
Capacitors, solid tantalum, electrolytic (CSR type)	ESCC 3002 level C	MIL-PRF-39003 WFR level C min		Surge current test mandatory on low ESR capacitors (CSR21 and CSR33).

Class 1 : Component Progr. Mgmt.

Component Control Programme

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

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

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

Key elements :

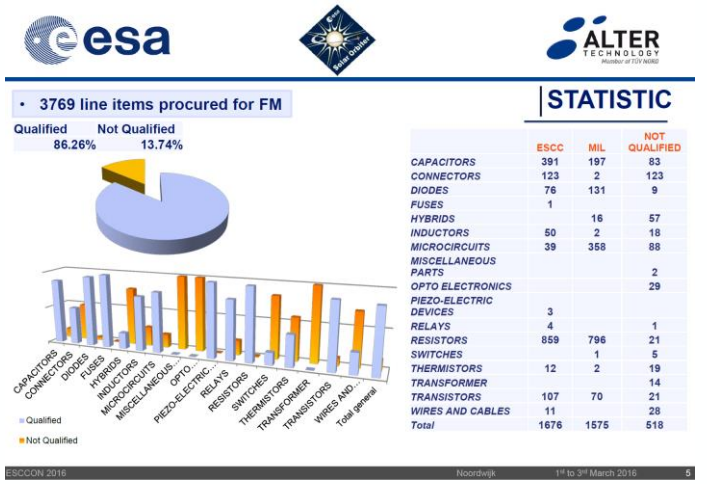
Organisational structure, responsibilities, concurrent engineering;

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



	ESCC	MIL	NOT QUALIFIED
CAPACITORS	391	197	83
CONNECTORS	123	2	123
DIODES	76	131	9
FUSES	1		
HYBRIDS		16	57
INDUCTORS	50	2	18
MICROCIRCUITS	39	358	88
MISCELLANEOUS PARTS			2
OPTO ELECTRONICS			29
PIEZO-ELECTRIC DEVICES	3		
RELAYS	4		1
RESISTORS	859	796	21
SWITCHES		1	5
THERMISTORS	12	2	19
TRANSFORMER			14
TRANSISTORS	107	70	21
WIRES AND CABLES	11		28
Total	1676	1575	518

Class 1: 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)**

Class 1: 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: 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."

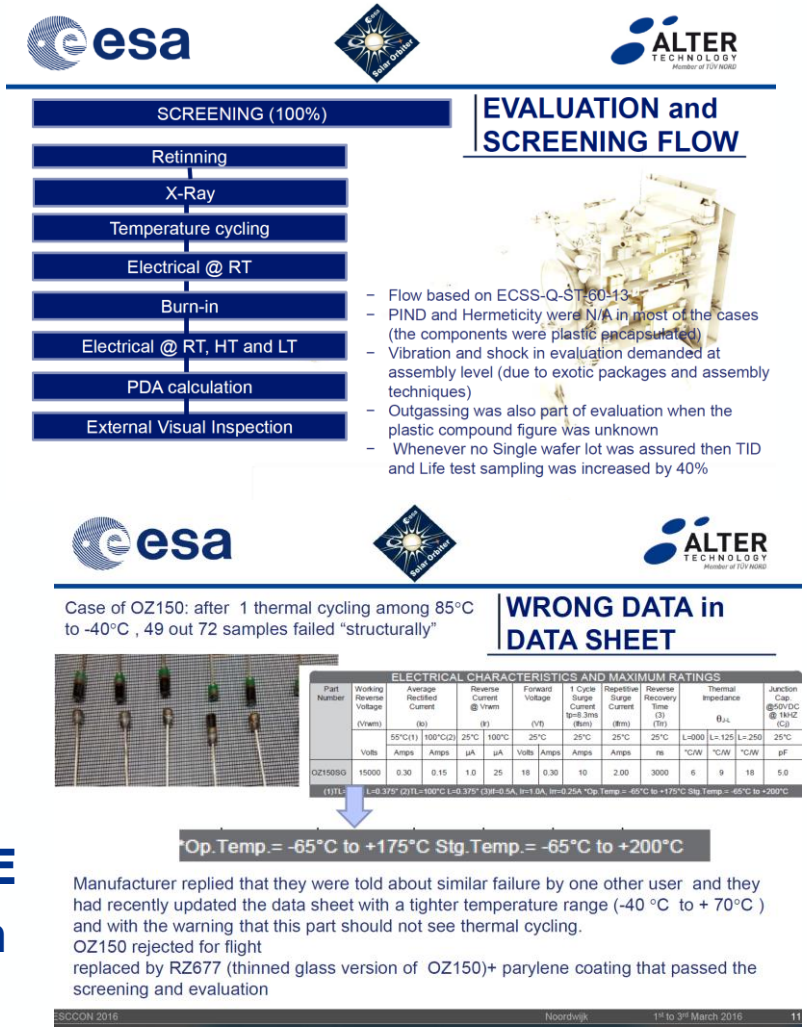
Beware : 'inter-mateability' between connectors from different manufacturers is often an issue

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.

ESCC QUALIFIED PARTS LIST (QPL)

ESCC/RP/QPL005-221 (REP 005)

September 2021

esa

Document Custodian: European Space Agency – see https://escies.org

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,Wire link fuses < 5A,

8.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

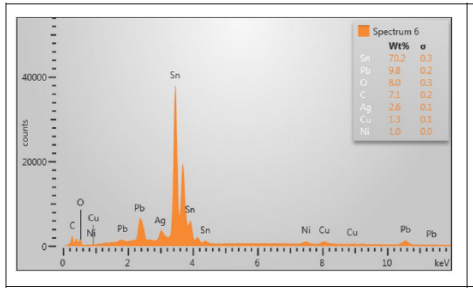


Figure 119

EDX spectrum No. 3: Lead plating (sample #1). EDX analysis was done before solderability test from top of the lead. According to manufacturer, standard solder coating should contain minimum 5% of Pb. Amount of Pb in this analysis is 9.8 %. According to applied specification (ESCC Detail Specification No. 3012/005 Iss. 1) finish shall be Tin-Lead plating, electro-deposited with Silver underplating which explains also the Silver peak.

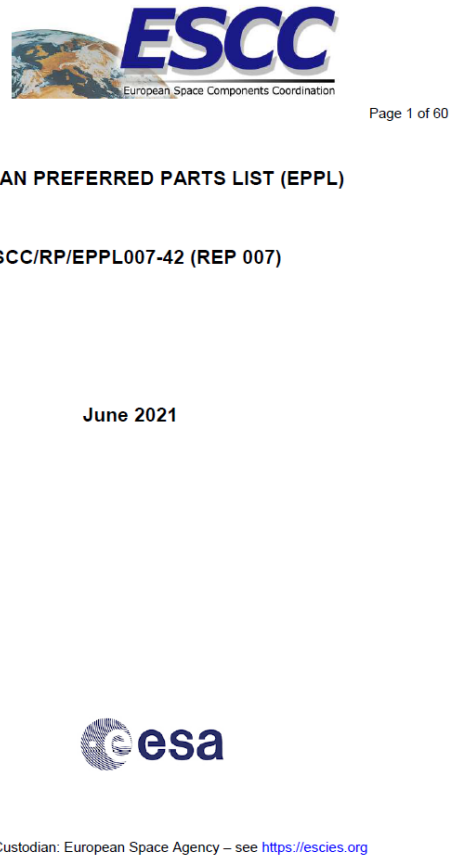
Class 1 : Preferred Sources

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.

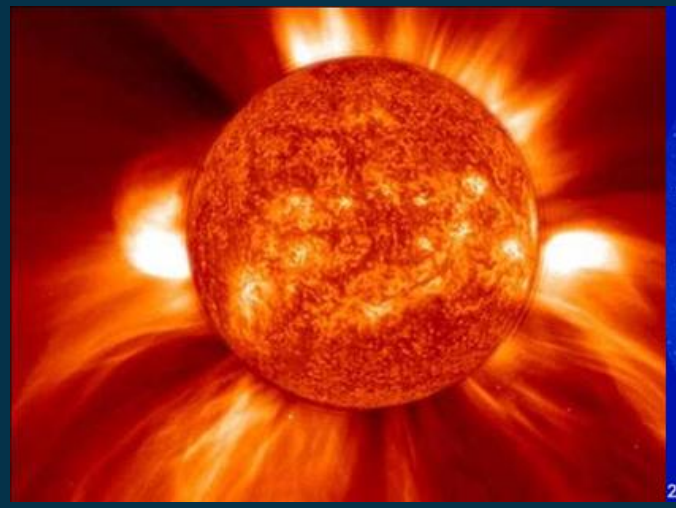
<u>Parts subject to export restrictions or regulations shall not be preferred</u>

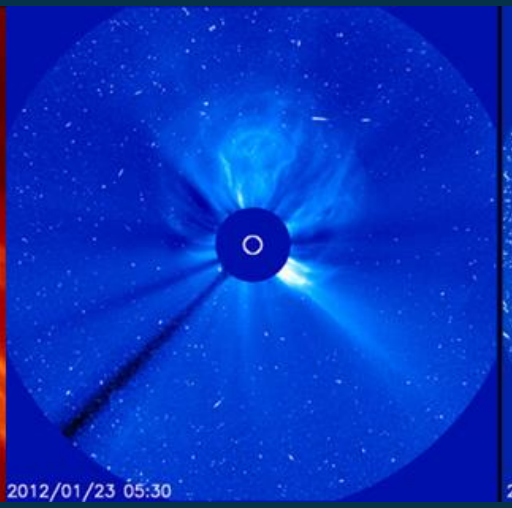


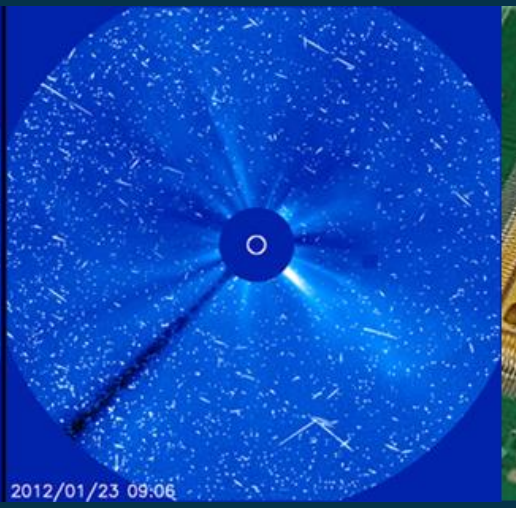
EEE Component Radiation Hardness Assurance (RHA)

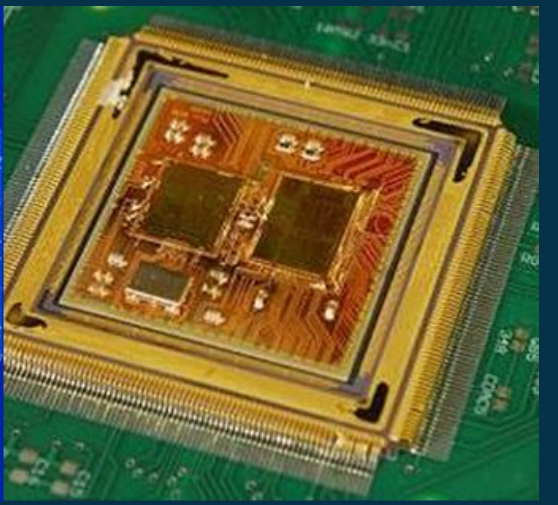
RHA consists of all activities undertaken to ensure that the electronics and materials of a space system perform to their design specifications after exposure to the space radiation environment.

Deals with environment definition, part selection, part testing, spacecraft layout, radiation tolerant design, and mission/system/subsystems requirements.

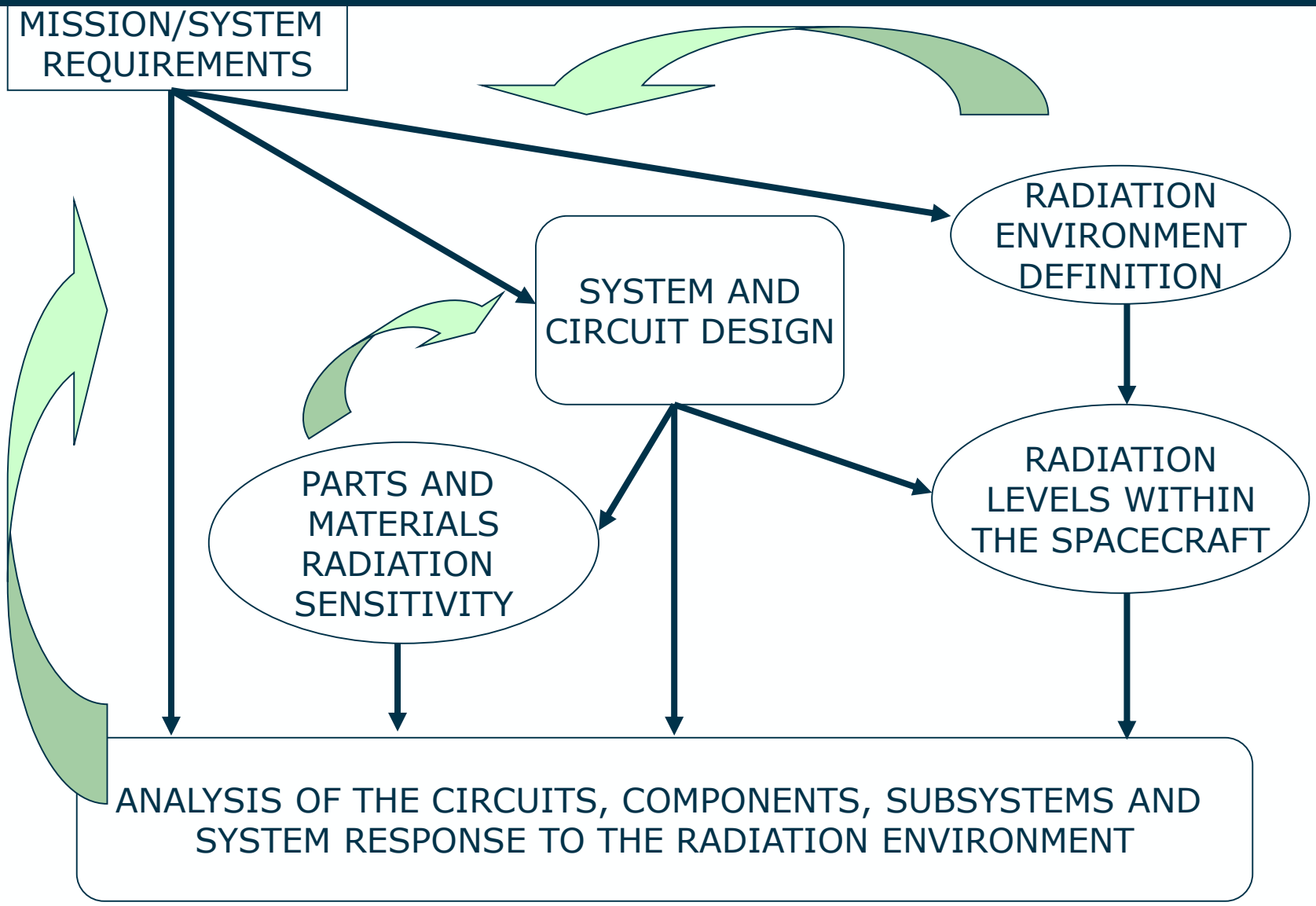




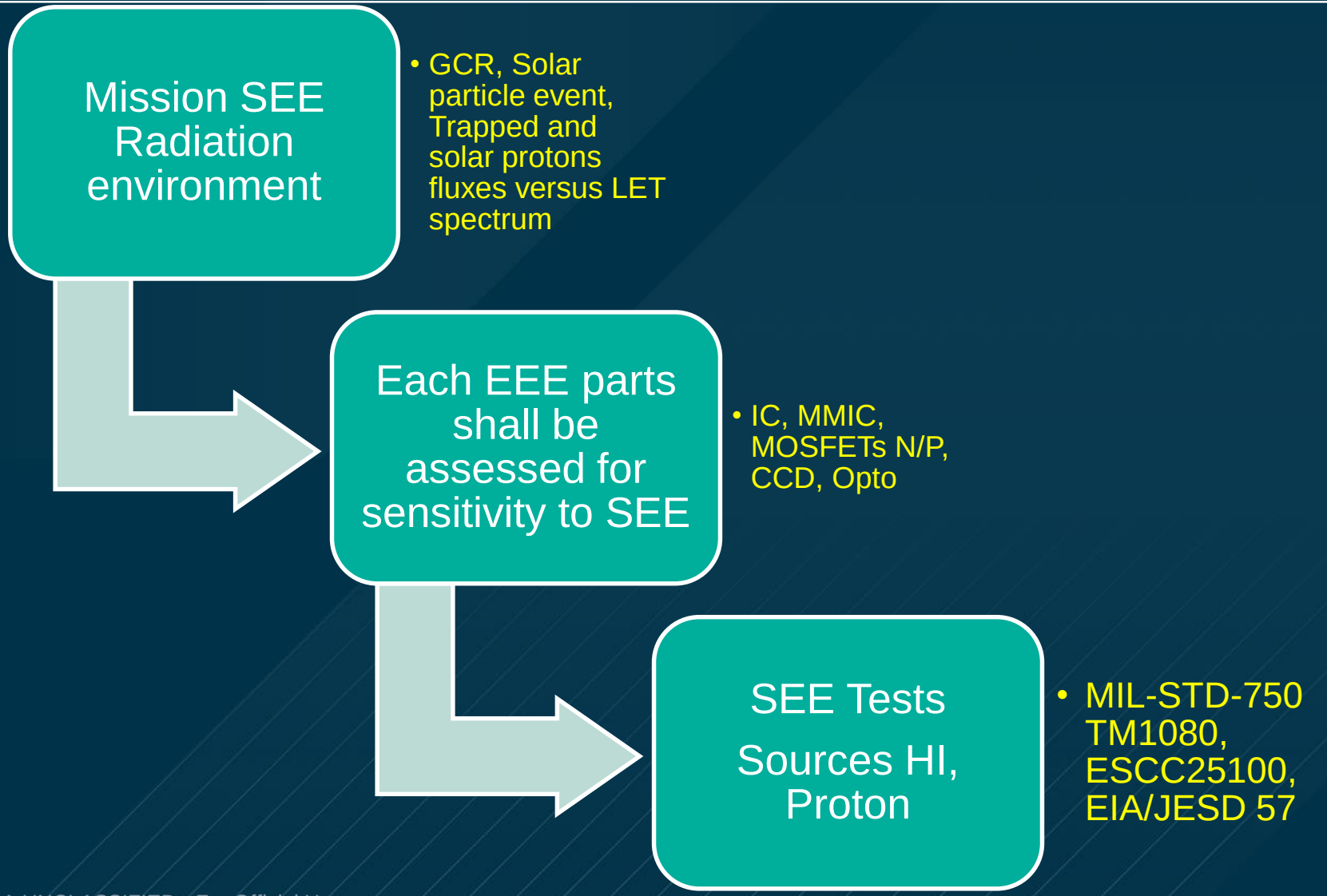




Radiation Hardness Assurance (RHA) process



Mission SEE RHA Process (ECSS-Q-ST-60-15C)



No SEE shall cause damage to a system or a subsystem or induce performance anomalies or outages not compliant with mission specifications

Alternative Sources: Cf-252, Focused Pulsed Laser, Neutron, Alpha sources

Alternative sources shall not be used for SEE qualification.
They can be used to check the test H/W and S/W and to investigate the device relative hardness or specific failure modes as a function of device operations

Class 1 : Radiation Hardness Assurance - 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).

11 RADIATION HARDNESS ASSURANCE

ECSS-Q-ST-60-15C and ESSB-AS-Q-008 Issue 2 (Adoption standard of the ECSS-Q-ST-60-15C document which tailors the ECSS-Q-ST-60-15C where needed), shall be applied.

For PILOT project, the following additional requirements shall be applied:

Id	Type	Tailoring	Modified text / Comment
RHA1	Requirement	New	The radiation environment as provided in the mission radiation specification: 1) Lunar Lander Space Radiation Environment Review, ESA Report, Issue 0 Revision 3, 22/02/2017 2) Luna-27 Interface Requirements Document for PILOT: Supporting Requirements on Environment ref. ESA-LEX-PIL-IRD-0002 iss 2.2 shall apply.
RHA2	Requirement	New	Components shall not be sensitive to destructive SEE. Whenever not feasible an analysis shall be performed in order to validate the use of sensitive components with following acceptance criterion: Destructive SEE rate < device failure rate / 10 *NOTE: Examples of destructive SEE are: SEL, SEB, SEGR and SEDR.*
RHA3	Requirement	New	Optocouplers and other optical semiconductors shall be selected also on the basis of their hardness against proton radiation, and displacement damage.
RHA4	Requirement	New	For Single Event Upset (SEU) sensitivity, components with an assured LETth > 60 MeVcm^2/mg shall be considered as SEE insensitive.
RHA5	Requirement	New	Components with a sensitivity of LETth < 60 MeVcm^2/mg shall be subjected to the appropriate Heavy Ion SEE. Proton induced SEE rate predictions are needed for parts sensitive to LETth < 15 MeVcm^2/mg.
RHA6	Requirement	New	Memory circuits shall have sufficient error detection and correction capability for protection against SEU such that the circuit performance goals are not affected by these errors.
RHA7	Requirement	New	Parts shall be proven to be insensitive to Latch-up, this meaning a SEL LETth > 60 MeVcm^2/mg

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 3, for ECSS-Q-ST-60-15

RHA During the Program Life

- Pre Phase A, Phase A
  - Draft environment definition
  - Draft hardness assurance requirements (top level)
  - Preliminary studies
- Phase B – PDRs
  - Final environment definition
  - Electronic design approach
  - Preliminary spacecraft layout for shielding analysis
  - Preliminary shielding analysis & hardness assurance requirements update
  - As-designed Radiation Control Board (RCB) starts
- Phase C –CDRs
  - Radiation test results
  - Final shielding analysis & final hardness assurance requirement
  - Circuit design analysis results
  - As-designed RCB completed
- Phase D
  - Radiation Lot Acceptance Tests (RLAT) also known as Radiation Verification Testing (RVT)
  - As-built RCB completed
- Phase E
  - Failure analysis

A Radiation Analysis Document is submitted at each phase. A decent RA document saves a lot of time in RIDS and discussions at each stage: Follow ECSS-Q-ST-60-15C; ensure all active parts are listed and match the Declared Components List

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 rev 2 (June 2021)

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.

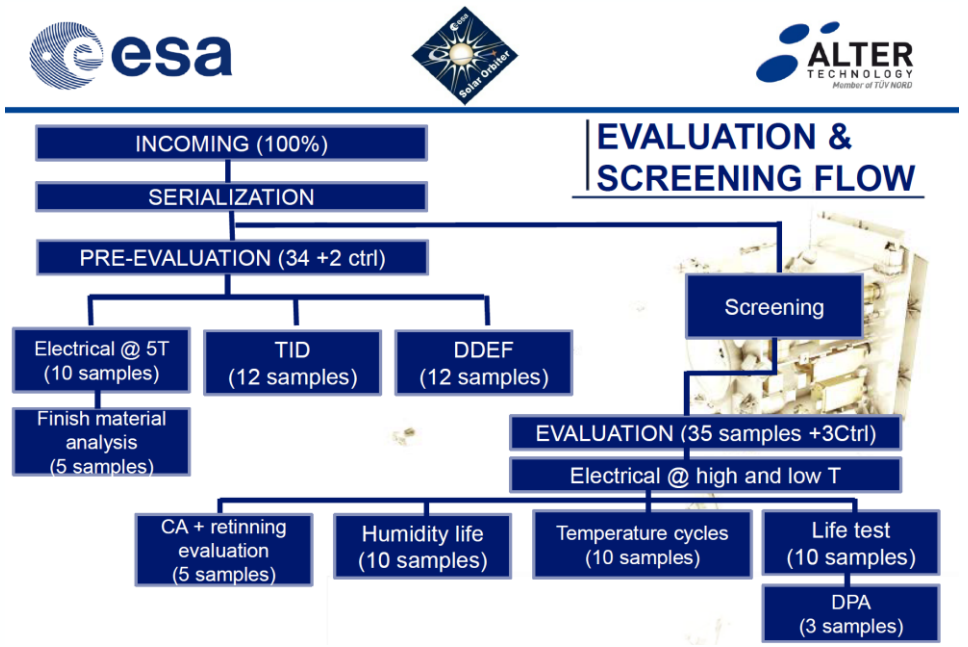
For wire link fuses, the current derating factor shall be 50 % with an additional derating of 0,2 %/°C for an increase in the temperature of fuse body above 25 °C

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

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.

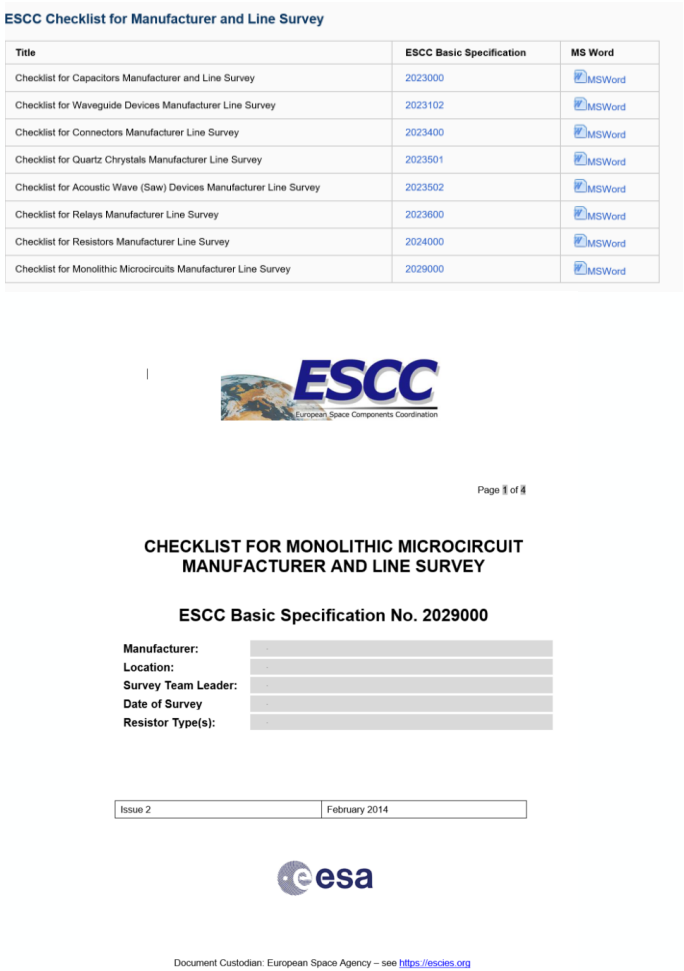
The supplier shall perform an evaluation against the ESCC basic specification no. 20200 and the ancillary specifications for dedicated component families and shall include, but not necessarily be limited to, a survey of:

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.



ESCC Checklist for Manufacturer and Line Survey

Title	ESCC Basic Specification	MS Word
Checklist for Capacitors Manufacturer and Line Survey	2023000	MSWord
Checklist for Waveguide Devices Manufacturer Line Survey	2023102	MSWord
Checklist for Connectors Manufacturer Line Survey	2023400	MSWord
Checklist for Quartz Chrystals Manufacturer Line Survey	2023501	MSWord
Checklist for Acoustic Wave (Saw) Devices Manufacturer Line Survey	2023502	MSWord
Checklist for Relays Manufacturer Line Survey	2023600	MSWord
Checklist for Resistors Manufacturer Line Survey	2024000	MSWord
Checklist for Monolithic Microcircuits Manufacturer Line Survey	2029000	MSWord

ESCC
European Space Components Coordination

Page 1 of 4

CHECKLIST FOR MONOLITHIC MICROCIRCUIT MANUFACTURER AND LINE SURVEY

ESCC Basic Specification No. 2029000

Manufacturer:	
Location:	
Survey Team Leader:	
Date of Survey	
Resistor Type(s):	

Issue 2	February 2014

esa

Document Custodian: European Space Agency – see https://escies.org

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

(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)

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."

ESCC 21001 DESTRUCTIVE PHYSICAL ANALYSIS OF EEE COMPONENTS

Destructive Physical Analysis (DPA) is a set of tests performed on samples randomly selected from each production lot to inspect and verify the design, materials, construction and workmanship of the component. It can also be used to monitor processes, to pre-assess lots, to compare suppliers or to suggest corrective actions. The information derived from the DPA may be used:

- **To preclude installation of components having patent or latent defects**
- **To assist in lot disposition**
- **To aid in defining improvements or changes in design, materials, or processes**
- **To evaluate supplier production trends**

When called up, the requirements of this specification shall apply for the particular component families specified in Chart 1.

DPA shall be performed subsequent to the completion of the EEE component manufacturing

ESCC Basic Specification PAGE 9
No. 21001 ISSUE 3

CHART 1 – DPA FLOW REQUIREMENTS VERSUS EEE COMPONENT FAMILIES

Family Type	Sub-Family Type	Minimum DPA Flow Requirement Appendix
Capacitors	Ceramic, Chip	A1.1
	Ceramic, Leaded	A1.2
	Tantalum, Solid, Hermetic	A1.3
	Tantalum, Solid, Surface Mount	A1.4
	Tantalum, Wet, Hermetic	A1.5
	Variable	A1.6
	Filter	A1.7
	Plastic Film	A1.8
Connectors	Contacts & Filtered Contacts	A2.1
	Multi-Pin	A2.2
	RF	A2.3
	RF Cable Assemblies	A2.4
Crystals	All	A3
Diodes	Axial Lead, Glass	A4.1
	Axial Lead, Metal Case	A4.2
	Chip & Wire, Hermetic	A4.3
	Axial Lead and Surface Mount, Plastic with Solder Assembly	A4.4
	Chip & Wire, Plastic	A4.5
Fuses	Wire, Axial Leaded And Surface Mount	A5.1
	Film, Surface Mount And Radial	A5.2
Heaters	All	A6
Hybrid Circuits And MCMs (including Hybrid Oscillators)	Hybrids, Hermetic, Chip And Wire And MCMs	A7.1
	Hybrids, Hermetic, Soldered Construction	A7.2
Inductive Components	Inductors, Axial Lead	A8.1
	Inductors, Surface Mount	A8.2
	Transformers	A8.3
Microcircuits	Monolithic, Hermetic	A9.1
	Monolithic, Moulded Plastic	A9.2
	MMICs	A9.1 or A9.2 (as applicable)
	MEMSs	A9.1 or A9.2 (as applicable)

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 4+4 years. After 15 years of storage parts are deemed unfit for flight

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.

ECSS-Q-ST-60 in Project

Anastasia Pesce
Head of the Radiation Hardness Assurance and Component Analysis Section
ESCC Executive Manager Deputy

26/10/2021

Outline

1. ESA Project life cycle
2. The ECSS-Q-ST-60C

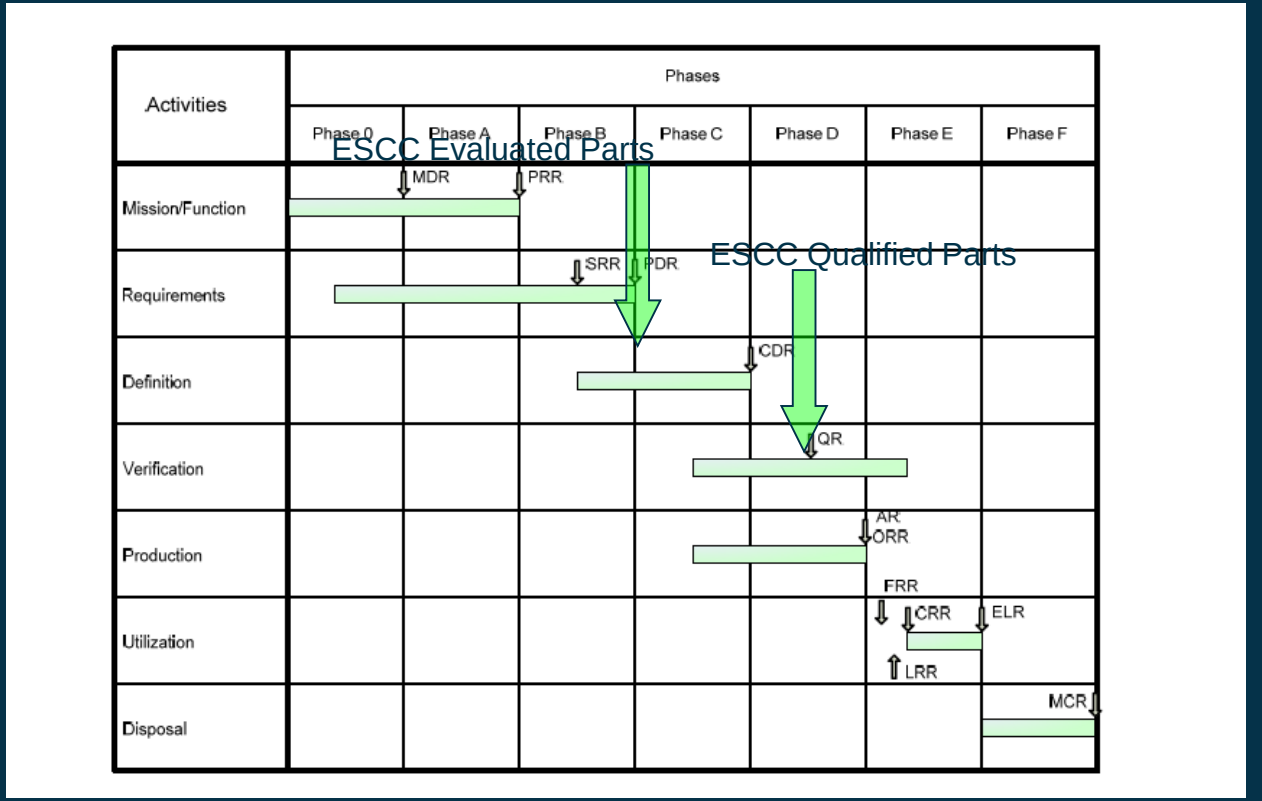
   The European standard for the selection and approval of EEE parts in ESA projects
3. The process of EEE parts approval in ESA projects
4. Lessons Learned
5. Conclusion
6. DCL and PAD Sheet Exercise

ESA Project life cycle

The life cycle of space projects is typically divided into 7 phases, as follows:

- Phase 0 - Mission analysis/needs identification
- Phase A - Feasibility
- Phase B - Preliminary Definition
- Phase C - Detailed Definition
- Phase D - Qualification and Production
- Phase E –Utilization
- Phase F – Disposal

ESA Project Life Cycle
ref ECSS-M-ST-10C rev1



Who deals with ECSS-Q-ST-60 in ESA?

The standard is part of the ECSS series maintained by ESA, TEC-Q Department, TEC-QES Section.

The Product Assurance Section (TEC-QQM) refers to the standard in their daily support to projects

The RAMS Section (TEC-QQD) refers to the standard as well and contributes to maintain the ECSS-Q-ST-30 standards which address the application details of components

The Requirement and Standard Section (TEC-QES) supports the preparation of the Q-ST-60 standard and its Level 2 ancillary documents

The Components Technology Section (TEC-EDC) also supports the preparation of the standards and provides service to ESA projects w.r.t. the implementation of the requirements

The Radiation Hardness Assurance and Component Analysis section (TEC-QEC) develops and maintains standards for RHA and retains tests capability necessary to conduct tests and inspections as required by Q-60

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

The ECSS-Q-ST-60C Rev.2 is written from **the parts user perspective.** 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
- Control
- Procurement
- Usage

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 Parts Qualifications are covered by the ESCC System of Specifications**.

Parts Investigation at ESA

http://multimedia.esa.int/Videos/2012/09/Crystal-Oscilator-Investigation-Stories-from-the-Materials-and-Electrical-Components-Lab

Three Classes of Component

The ECSS-Q-ST-60C differentiates three classes of components Class 1 trough 3, defined in clauses 4 through 6 following an identical requirement structure and corresponding Quality Level Tables in clause 7.

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, while class 3 components reflect the highest advisable risk.

The choice between these 3 classes reflects already a requirement tailoring

There is no quantification of the risk difference between the defined classes – it is a qualitative approach

For Microcircuits:

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

ECSS Q-ST-60C
EEE Components simplified class comparison

	CLASS 1	CLASS 2	CLASS 3
- Compliance to ECSS-M-00	required	not required	not required
- EEE parts control plan	required	compliance matrix	compliance matrix
- PCB	required	required	not required
- “as built” DCLs	required	required	not required
- Type red. & pref. process	required	not required	not required
- Commercial parts -	allowed (some families)	allowed (some families)	
-- Mfr assessment (evaluation)	required	not required	not required
- Approval process	DCL (qualified)	DCL (qualified & EPPL/NSPL)	DCL (qualif & not qualif)
	PAD (not qualified)	PAD (others)	
- Procurement spec	normative or project	normative -> datasheet	normative -> datasheet (for review)
- Quality levels			
+ integrated circuits	ESCC or QML/V	ESCC or QML/Q-M + PIND	ESCC or 883B screening
+ discrete active	ESCC or JANS	ESCC or JANTXV + PIND	ESCC or JANTXV
+ standard passive	ESCC/C, EFR-R	ESCC/C, EFR-R, CECC qual + BI	ESCC/C, EFR-R, CECC qual + BI
+ relays	ESCC/B	ESCC/B or MIL/R + ESCC screen	ESCC/B, MIL/R + ESCC screen
+ hybrids	ECSS-Q60-05 level 1 or QML/K	ECSS-Q60-05 level 2 or QML/K	ECSS-Q60-05 level 2 or QML/H + PIND
- Customer precap	required (non qual & few qual)	required (some non qual types)	not required
- Lot acceptance test	required (data < 2 years)	required	required –
- Customer buy-off	required (non qualified)	required (some non qual types)	not required
- DPA	required (non qualified)	required (some non qual types)	required (non qual. relays)
- Alerts	required	only handle alerts received	only handle alerts received
- Lot homogeneity	required	not required (except for rad)	not required (except for rad)

Common Principles across classes

The EEE Components Selection and Approval Process is class dependent defined through the following key elements:

- A component control plan.
- A Parts Control Board: for review and approval of parts selection and part type reduction, monitor running evaluation programmes and procurement activities, to address problems/Alerts [not required for Class 3].
- The approval of a Declared Components List that is established and updated through the project timeline, from PDR up to FAR; from as-designed to as-built status.
- A parts approval exercise, through the DCL and Part Approval Document mechanisms.

Common Principles across (most) classes

- the ECSS-Q-ST-60C Rev.2 sets preferences for selection through the EPPL (European Preferred Parts List), only class 1.
- the ECSS-Q-ST-60C Rev.2 requires procurement specifications (if not existing to be written) to be used for procurement.
- the ECSS-Q-ST-60C Rev.2 requires 100% screening of parts for Flight.
- the ECSS-Q-ST-60C Rev.2 requires sampling tests (Lot Acceptance tests).
- the ECSS-Q-ST-60C Rev.2 requires additional inspections (precap, buy-off, incoming, DPA, relifing) and controls for handling and storage.
- the ECSS-Q-ST-60C Rev.2 includes data documentation requirements; it defines a what documents are to be prepared, review and approved for each class of components.

Common Principles across (most) classes

Parts and Materials restrictions: prohibited components, forbidden ranges of some technologies, approach for pure tin.

New technology insertion through requirements for the Evaluation of components

Component application requirements: Radiation Hardness (ECSS-ST-Q-60-15), Derating (ECSS-ST-Q-30-11), Relifing (ECSS-ST-Q-60-14)

Device-specific sets of requirements: ECSS-ST-Q-60-02: ASICs and FPGA, ECSS-ST-Q-60-05: Procurement of Hybrid Microcircuits, ECSS-ST-Q-60-12 MMIC dies.

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+

What are the differences among classes?

- The type and number of requirements have an influence on schedule and cost
- Space qualification of components is time consuming and costly
- The ‘catalogue’ of space qualified components is not (and can not reasonably be expected to be) aligned with project / innovation needs
- 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.
- 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-60Crev2 does not provide a clear cut approach to the use of commercial components. This gap will soon be closed by the dedicated Q-ST-60-13 document soon to be put into public review.

Examples of class 3 savings

•For Class 3:

- the Parts Control Board requirement can be waived (Class 3)

- The additional inspection requirements, additional to the screening (quality) levels also change. Precap and buy-off are not required for example.

- The documentation requirements also requires a lighter paperwork approach.

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 and military ‘classic’ telecommunication satellites have 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 ECSS-Q-ST-60C rev2 Class 3

Parts Control Board – class 1 & 2

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

Depending on the progress of the program, the main PCB activities are:

1. Review and approval of the suppliers EEE component control plan and any associated documents,
2. Part type reduction and standardization,
3. Parts approval including evaluation activities to be performed on non standard parts,
4. Problem assessment (e.g. handling of alerts,

non-conformances, RFD (request for Deviation), RFW (Request for Waiver) and delivery delays).

Component Selection - Class 1

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 and qualified components to achieve an effective component reduction and standardization.

Preferred sources
Parts shall be chosen from the EPPL (European Preferred Part List) part I

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

Declared Components List (DCL)

For each equipment, its supplier issues a DCL identifying all component types needed.

The DCL is issued as a minimum at PDR and CDR (as designed) and at flight hardware delivery (as built).

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.

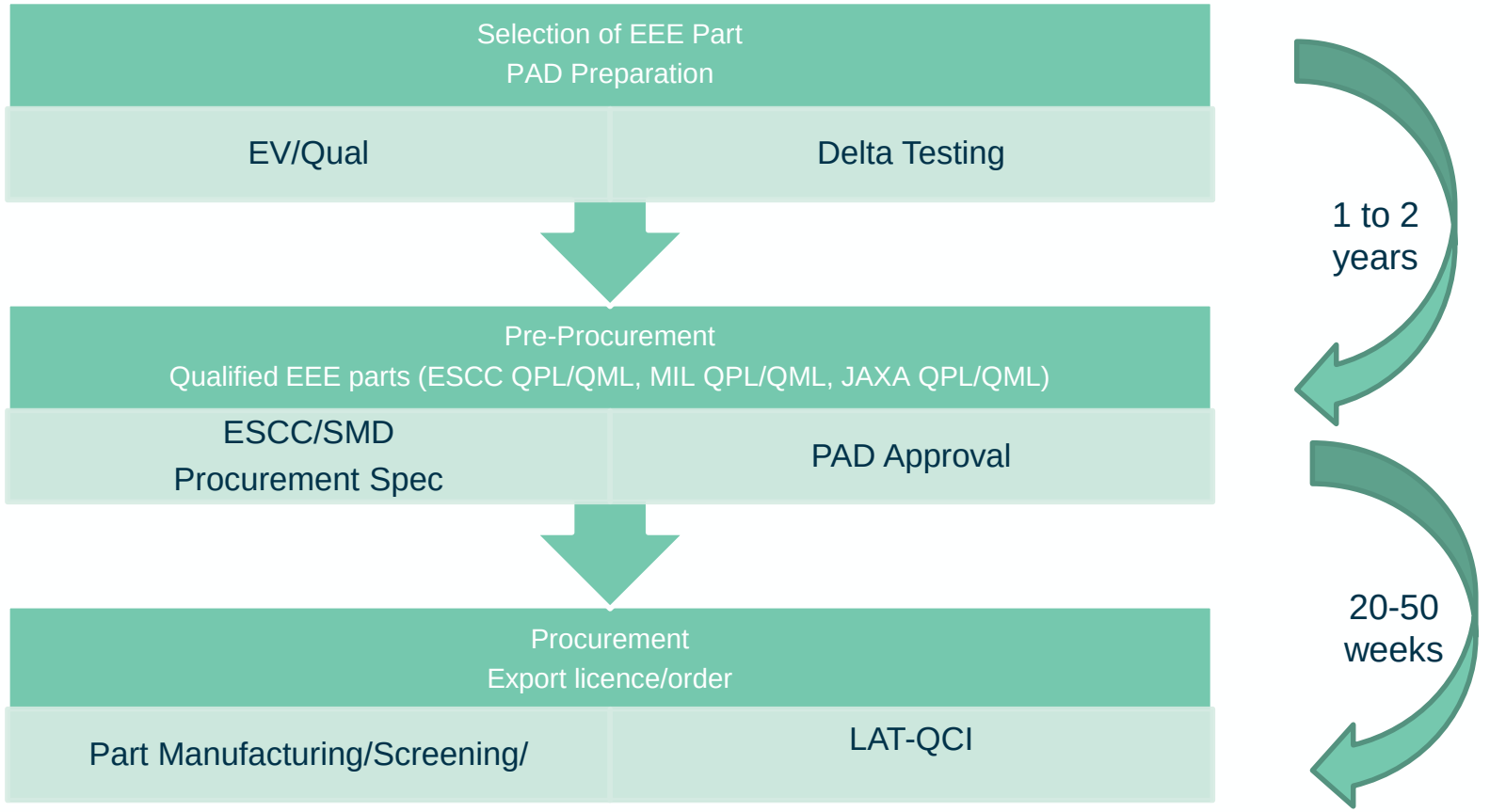
Note : the DCL may be rather dynamic; small changes like changing the part manufacturer may seem insignificant but may have major consequences e.g. in terms of Radiation tolerance levels or in terms of detail specification parameters.

Parts Approval - class 1

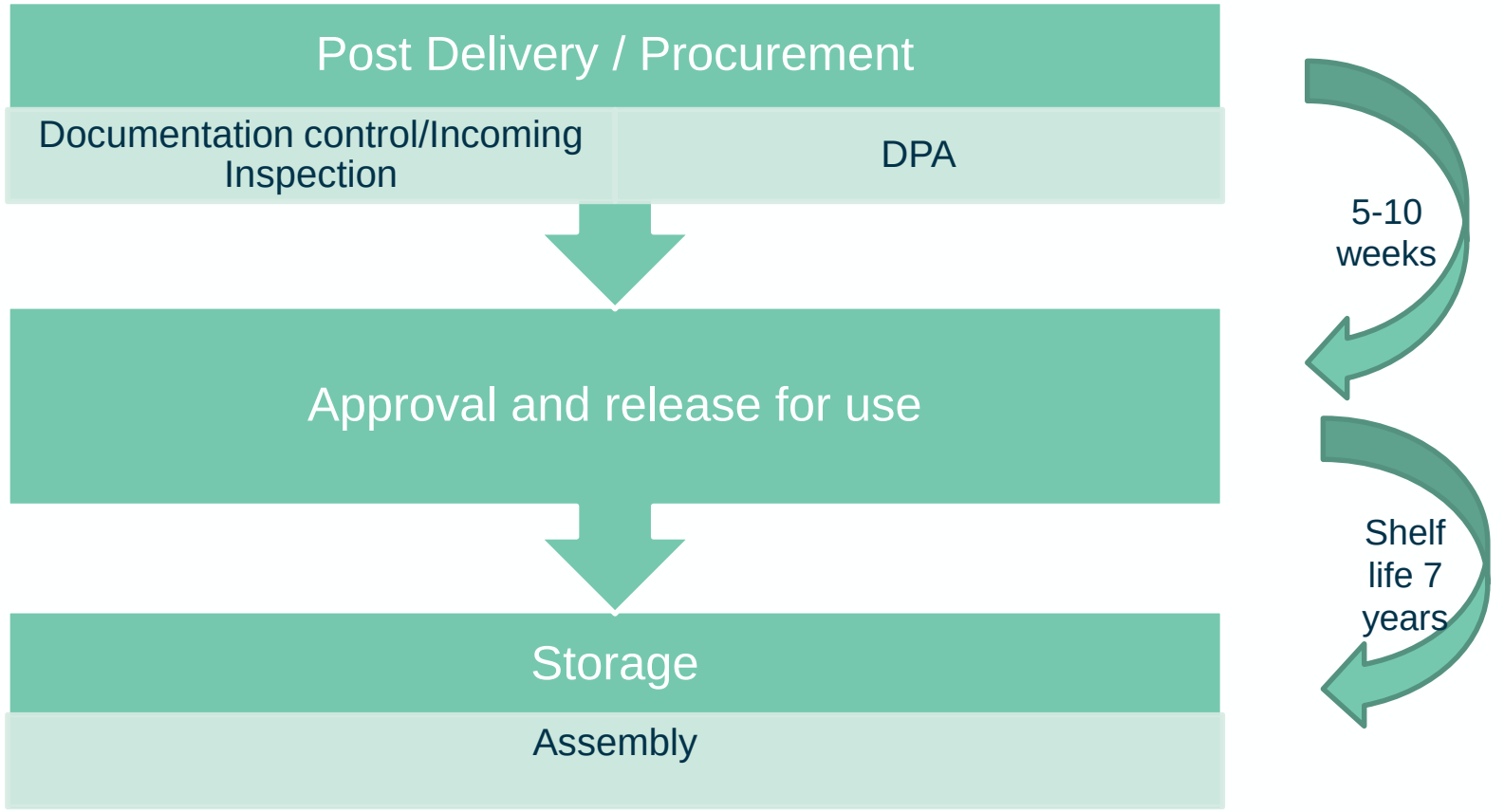
The approval process by the customer shall be organized as follows:
All space qualified parts by listing them in the DCL,
A PAD generated for any other part,
A PAD is required for space qualified parts when:
(a) additional controls are required (e.g. precap, buy-off, LAT or LVT, RVT, DPA),
(b) used outside the specified limits,
(c) specific tests are required during procurement,
(d) pure tin is used inside or outside the part.

When a PAD is required, the customer's approval process shall include 2 steps:
Step 1: approval of the part type and attached action plan, through the PAD process for the PDR.
Step 2: approval of the results of the action plan defined during step 1 through the final approval of the PAD

ECSS-Q-ST-60C rev 2
EEE Parts requirements and their implementation



On receipt …


Post Delivery / Procurement
Documentation control/Incoming Inspection
DPA
Approval and release for use
Storage
Assembly
5-10 weeks
Shelf life 7 years

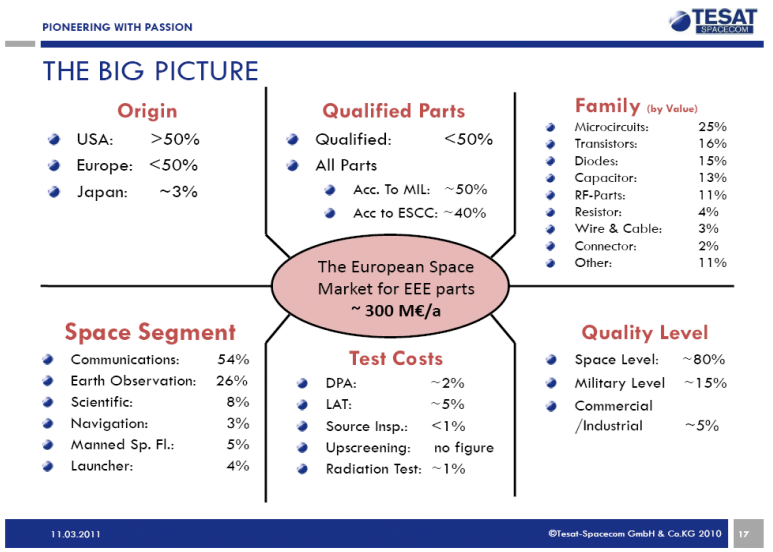
Procurement situations

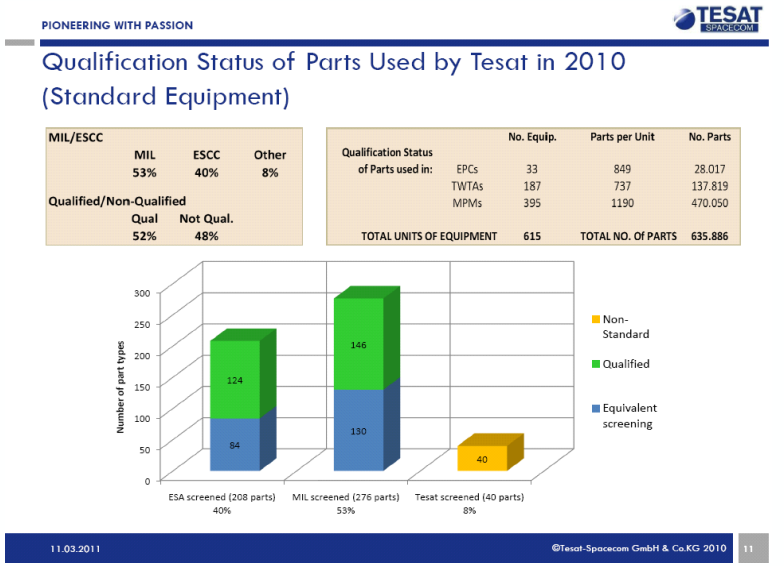
Cost can matter a lot with EEE parts:

In a mission / satellite context, parts add to 10%,

BUT, for an equipment manufacturer, 30-50% of the internal costs to make a unit may be parts

Parts procurement may encounter difficulties: lack of communication, poor response, questionable commercial practices, obsolescence of product, export control limitations, counterfeit parts,…





Commercial Component

A commercial Component is difficult to define precisely ! Even in such a limited context as Space applications.

The ECSS and ESCC definition of choice is : A commercial component is a EEE part neither designed, nor manufactured with reference to military or space standards.

Commercial Components essentially limited to Microcircuits and Discrete Devices and definitely excluding Passive components are being addressed systematically in the new ECSS-Q-ST-60-13 standard, soon to be released for public review .

Commercial components are parts procured against a set of publicly available data put under configuration control by the supplier. They are a sub-set of non qualified parts which are approved through justification documents (including data collection, risk mitigation plan and its final results).

Example of Justification Dossier 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

Tailoring of ECSS-Q-ST-60= Project PA (Product Assurance) requirement, Class 1/2/3

RHA (Radiation Hardness Assurance) = policy on ELDRS (Enhanced Low Dose Rate Sensitivity) testing/acceptance of data < 4 year date code

PPBI (Post Programming Burn-In) = Policy for PPBI of FPGA

PADs= Policy for PADs for qualified parts, hybrids add-on, dies

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:

Only preliminary DCL is available for a limited set of equipment depending on the design maturity

Little space for changes in case of recurrent unit

Time for changes and recommendations for use “alternative”, newly build, under evaluation parts, ESA supported development

Typically the parts are still at low TRL (TRL3, 4, 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

DCL are in principle frozen and all the procurement activities concluded. All PADs are approved

Little space for replacements/recommendation

Only case by case based on NCR/RFW/RFD/Anomalies a replacement of parts is implemented

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 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 exceeding relife requirement of parts.

-PPBI not done on FPGAs.

-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.

Q-60: What is the basics?

The **Q-60** is written from the point of view of the **users** of the parts.

Therefore, Q-60 is not the place-holder for requirements on actual devices, nor for general approaches to test, qualification…

It is however the place for requirements of projects and users in order to build assurance (by design, inspection-control and test) on the reliability of EEE parts used in a specific mission context.

The ideal set of requirements would make the components just fit for purpose in a project: performance, reliability, availability, cost…

Small letter: the focus on the ECSS standard differs from ESCC. **ESCC is more manufacturer-centric** and component technology oriented (process and design). It provides requirements for performance and test of actual specific devices / families of devices, with a general satellite application in mind and hence irrespective of specific mission considerations or non-technical constraints.

CONCLUSION

The ECSS-Q-ST-60 standard defines well 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

References

www.esa.int

www.ECSS.nl

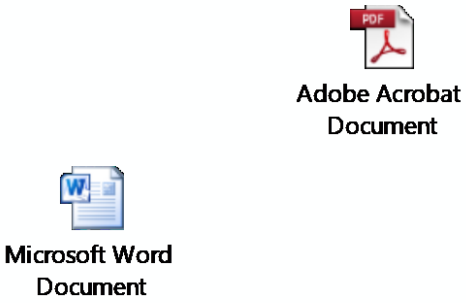
www.escies.org

- EPPL
- EQPL/EQML
- ESCC specification
- ECSS standards (Component Related)
- ESA Radiation Data

Exercise on DCL

Typical DCL List (Working Document)

Exercise on PAD



ECSS-Q-ST-60-14C

RELIFING

ECSS-Q-ST-60-14CRev. 1 Corrigendum 1
2 March 2020

ECSS-Q-ST-60-14C , 15 November 2008 , First issue

ECSS-Q-ST-60-14C Rev.1, 1 August 2019

The major changes between ECSS-Q-ST-60-14C (15 November 2008) and First issue Revision 1:

- Creation of two relifing flows: one covering Class 1 and Class 2 components and the other covering Class 3
- Harmonization with the latest version ECSS-Q-ST-60
- Introduction of the applicability of the relifing requirements to commercial components
- **Change of timing requirements for relifing (from 7+3 to 7+4+4 years)**

increasing the maximum elapsed time between date code and time of mounting from 10 to 15 years

- Transformation of normative Annex A "Relifing report - DRD" by into informative Annex C "Guidelines for a Relifing report"
- Deletion of informative Annex B "ESD"

Why Relifing ?

EEE components are subject to technology specific ageing effects with some type of influence on their residual reliability and life time.

Even under optimum storage conditions there may be some degradation occurring, e.g. loss of hermeticity and ingress of humidity, material instabilities through process residue etc..

Unfortunately there is only limited data available and in total it is insufficient to support more than the present conservative approach.

Parts with more than 10 years of storage on their record are deemed to be no longer suitable for flight.

This is still deemed to be a sensible rule although in some cases (e.g. even for ATV) by means of extra screening on top of Q-ST-60-14 requirements certain part types have been proven to be stable and reliable for more than 10 years.

Also, **for obsolete parts this may be a less risky approach than procurement from questionable sources (counterfeit parts).**

Environmental parameters for storage

ECSS-Q-ST-60-14C defines the rules for the proper storage of EEE parts to be used on space programs. Those rules are in line with the requirements defined in ESCC Basic Specification 24900 which addresses :

Storage area and storage zone

Cleanliness

ESD protection

Packing and Packaging

Handling

Quality assurance

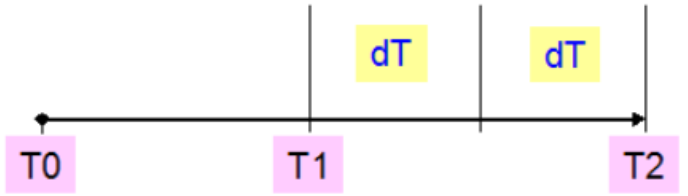
Relife Timing Parameters

When used, relifing shall be performed anywhere between T1 and T2

ECSS-Q-ST-60-14_0470055

Table 5-1: Timing parameters

T1	T2	dT
7 years	15 years	4 years



T0	Original date code
T1	Maximum allowed storage period from T0 with no relifing control
T2	Maximum duration between the original date code of part and its mounting
dT	Maximum allowed storage period after a relifing control which can be repeated once

Relifing test requirements

General requirements per EEE parts family:

For relifing, the tests, as specified in Table 6-1 of ECSS-Q-ST-60-14 shall be performed:

- External Visual Inspection
- Electrical measurements
- Seal test
- Specific test

Relifing Report- DRD Objectives

DRD identification

This DRD is called from ECSS-Q-ST-60-14C clause 6.4a. The purpose of this document is:

to give the detailed references of the lot tested

to describe the relifing tests performed

to give the results obtained

to give the date of tests

Relifing Report - Contents

Expected Information

The relifing report shall give the following generic information:

- part style
- detailed specification (with issue and variant)
- item identification by the supplier
- quantity stored
- original date-code
- date of storage

For each test, the relifing report shall indicate:

- operator
- date of test
- quantity tested
- quantity rejected
- comments

The relifing report shall include a conclusion (accepted / rejected).

The relifing report shall indicate the new date-code (after relifing).

Example of a Relife traveller Sheet

Part Style:	
Detailed specification: Issue: Var:	
Item identification at User:	
Quantity Stored: Date code: Date of Storage:	
TESTS	**RELIFING**
1. External visual	
Operator	
Date	
Quantity tested	
Quantity rejected	
Comments	
2. Electrical tests	
Operator	
Date	
Quantity tested	
Quantity rejected	
Comments	
3. Hermeticity	
Operator	
Date	
Quantity tested	
Quantity rejected	
Comments	
4. DPA (if any)	
Operator	
Date	
Quantity tested	
Results	
DPA Report number	
5. Other tests	
nclusion: cepted / Rejected	
New date code	

New Date Code

Note :
New (Relifing) Date Code does not replace the original manufacturing DC; it provides additional traceability information

ECSS-Q-ST-60-13C

COTs

ECSS-Q-ST-60-13 Commercial Components

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.
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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.

References

www.esa.int

www.ECSS.nl

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

https://esarad.esa.int

https://landandmaritimeapps.dla.mil/programs/milspec/DocSearch.aspx

US-MIL specs and Qualifications

https://nepp.nasa.gov/ NASA Electronic Parts and Packaging website

http://radhome.gsfc.nasa.gov/top.htm NASA Radiation home page

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