COTS procurement for space missions

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NEW SPACE AND COTS

New Space activities are active in:

- launchers
- constellations

COTS components are mainly used in these applications.

COTS are, today, rarely used in other types of projects except Tselecom.

Why COTS?

There are 3 main reasons:

- better performances
- not existing in space QPL range

} reason why it is used in all types of space projects

- COST, with 1/10 of the cost of equivalent space QPL parts

} Launchers and constellations

These are two approaches based on different selection criteria

Space standards

Today, we have two types of space standardization systems addressing EEE parts

ESCC: European Procurement and qualification system (QPL and EPPL)

ECSS: Q60 series with guidelines for selection and procurement

Q30 and Q70 series for proper use of EEE parts

Several other E series

All these standards would be affected by the evolution of the New Space era.

Space standards

ECSS Q30 and Q70 series for proper use of EEE parts ,several other E series

ECSS-Q-ST-30-02C – Failure modes, effects (and criticality) analysis (FMEA/FMECA) – (6 March2009)
ECSS-Q-ST-30-09C – Availability analysis (31 July 2008)
ECSS-Q-ST-30-11C Rev.1 – Derating – EEE components (4 October 2011)
ECSS-Q-ST-30C Rev.1 – Dependability (15 February 2017)

ECSS-E-20-01A Rev.1 – Mulitipaction design and test (1 March 2013)
ECSS-E-AS-11C – Adoption Notice of ISO 16290, Space systems – Definition of the Technology Readiness Levels (TRLs) and their criteria of assessment (1 October 2014)
ECSS-E-ST-10-02C Rev.1 – Verification (1 February 2018)
ECSS-E-ST-10-03C – Testing (1 June 2012)
ECSS-E-ST-10-04C – Space environment (15 November 2008)
ECSS-E-ST-10-06C – Technical requirements specification (6 March 2009)
ECSS-E-ST-10-09C – Reference coordinate system (31 July 2008)
ECSS-E-ST-10-11C – Human factors engineering (31 July 2008)
ECSS-E-ST-10-12C – Methods for the calculation of radiation received and its effects, and a policy for design margins (15 November 2008) + "Identified typographical error"
ECSS-E-ST-10-24C – Interface management (1 June 2015)
ECSS-E-ST-10C Rev.1 – System engineering general requirements (15 February 2017)
ECSS-E-ST-20-06C Rev.1 – Spacecraft charging (15 May 2019)
ECSS-E-ST-20-07C Rev.1 – Electromagnetic compatibility (7 February 2012)
ECSS-E-ST-20-08C Rev.1 – Photovoltaic assemblies and components (18 July 2012)
ECSS-E-ST-20-20C – Electrical design and interface requirements for power supply (15 April 2016)
ECSS-E-ST-20-21C – Electrical design and interface requirements for actuators (15 May 2019)
ECSS-E-ST-20C – Electrical and electronic (31 July 2008)
ECSS-E-ST-31-02C Rev.1 – Two-phase heat transport equipment (15 March 2017)
ECSS-E-ST-31-04C – Exchange of thermal analysis data (1 February 2018)
ECSS-E-ST-31C – Thermal control (15 November 2008)
ECSS-E-ST-32-01C Rev.1 – Fracture control (6 March 2009)
ECSS-E-ST-32-02C Rev.1 – Structural design and verification of pressurized hardware (15 November 2008)
ECSS-E-ST-32-03C – Structural finite element models (31 July 2008)
ECSS-E-ST-32-08C Rev.1 – Space engineering – Materials (15 October 2014)
ECSS-E-ST-32-10C Rev.2 – Structural factors of safety for spaceflight hardware (15 May 2019)

ECSS-Q-ST-70-01C – Cleanliness and contamination control (15 November 2008)
ECSS-Q-ST-70-02C – Thermal vacuum outgassing test for the screening of space materials (15 November 2008)
ECSS-Q-ST-70-03C – Black-anodizing of metals with inorganic dyes (31 July 2008)
ECSS-Q-ST-70-04C – Thermal testing for the evaluation of space materials, processes, mechanical parts and assemblies (15 November 2008)
ECSS-Q-ST-70-05C – Detection of organic contamination surfaces by IR spectroscopy (6 March 2009)
ECSS-Q-ST-70-06C – Particle and UV radiation testing for space materials (31 July 2008)
ECSS-Q-ST-70-07C – Verification and approval of automatic machine wave soldering (16 April 2010)
ECSS-Q-ST-70-08C – Manual soldering of high-reliability electrical connections (6 March 2009)
ECSS-Q-ST-70-09C – Measurements of thermo-optical properties of thermal control materials (31 July 2008)
ECSS-Q-ST-70-12C – Design rules for printed circuit boards (14 July 2014)
ECSS-Q-ST-70-13C Rev.1: Measurement of the peel and pull-off strength of coatings and finishes using pressure-sensitive tapes (5 Oct 2011)
ECSS-Q-ST-70-14C – Corrosion (1 November 2016)
ECSS-Q-ST-70-17C – Durability testing of coatings (1 February 2018)
ECSS-Q-ST-70-18C – Preparation, assembly and mounting of RF coaxial cables (15 November 2008)
ECSS-Q-ST-70-20C – Determination of the susceptibility of silver-plated copper wire and cable to "red-plague" corrosion
ECSS-Q-ST-70-21C – Flammability testing for the screening of space materials (5 February 2010)
ECSS-Q-ST-70-22C – Control of limited shelf-life materials (31 July 2008)
ECSS-Q-ST-70-26C Rev.1 – Crimping of high-reliability electrical connections (15 March 2017) + Corr.1 (1June2017)
ECSS-Q-ST-70-28C – Repair and modification of printed circuit board assemblies for space use (31 July 2008)
ECSS-Q-ST-70-29C – Determination of offgassing products from materials and assembled articles to be used in a manned space vehicle crew compartment (15 November 2008)
ECSS-Q-ST-70-30C – Wire wrapping of high-reliability electrical connections
ECSS-Q-ST-70-31C – Application of paints on space hardware (15 November 2008)
ECSS-Q-ST-70-36C – Material selection for controlling stress-corrosion cracking (6 March 2009)
ECSS-Q-ST-70-37C – Determination of the susceptibility of metals to stress-corrosion cracking (15 November 2008)
ECSS-Q-ST-70-38C Rev.1 Corrigendum1 – High-reliability soldering for surface-mount and mixed technology (12 September 2018)
ECSS-Q-ST-70-39C – Welding of metallic materials for flight hardware (1 May 2015)
ECSS-Q-ST-70-45C – Mechanical testing of metallic materials (31 July 2008)
ECSS-Q-ST-70-46C Rev.1 – Requirements for manufacturing and procurement of threaded fasteners (6 March 2009)
ECSS-Q-ST-70-50C – Particles contamination monitoring for spacecraft systems and cleanrooms (4 October 2011)
ECSS-Q-ST-70-53C – Materials and hardware compatibility tests for sterilization processes (15 November 2008)

Space standards for procurement of commercial parts: ECSS-Q-ST-60-13 (today) applicable for active EEE

	Class 1	Class 2	Class 3
Evaluation	Complete	Complete	Partial
Justification	data collection	data collection	data collection
Screening	Complete	Partial	Light
Lot test	Complete	Complete	Partial

Space standards for procurement of commercial parts: ECSS-Q-ST-60-13 update

			<----------Informative area---------->		<---Normative area----->		<---Normative area----->
Mission reference	Type		"Low cost - experimental" mission,		"Robust" mission with high quality / reliability needs.		"Hi Rel certified" mission
	Cost		Low		Low/medium		Medium/High
	Lifetime		few weeks/months		> 1 year		> 3 Year
	Reliability		low to medium		High		high
	Radiation	SEE	negligible due to lifetime		Relevant		relevant
	Example		ESEO, Cubesat in LEO, R&D payloads, serviceable systems		SAT-AIS, Generic Constellation, Technology Demonstrators		MEX, GAIA, Bepi Colombo, Sentinel 1,2,3, METOP SG, EDRS, Electra, Galileo FOC, IOV…
Module, equipment or subsystem function	Type		Non Essential	Essential	Non Essential	Essential	all
	Radiation	TiD	Minor	Minor	Medium	Medium	medium to high
(Minimum) Risk class (quality standard, guidelines or procedures to be followed)			Q_4 (TBD)	Q_3 (TBD)	Q_2 (TBD)	Q_1 (TBD)	Q_0 According to ECSS-Q-ST-60-13C*, ECSS-Q-ST-60C '* extended to passives

Which part for which level?

	<----------Informative area---------->		<--Normative area-->
Mission reference	"Low cost - experimental" mission,	"Robust" mission with high quality / reliability needs.	"Hi Rel certified" mission
Reliabilty level	Commercial parts	Automotive parts →	Space parts
What does it mean?	no heritage no screening no lot homogeneity no evaluation	Existing evaluation lot homogeneity low heritage no screening	QPL parts Evaluation strong heritage lot homogeneity

Can we use AEC-Q200 parts in High Rel. space?

There are several questions to be answered:

- What are the designs of the parts certified according to AEC-Q200 vs space QPL designs?

- What are the reliability data available to space customers and agencies?

- How the manufacturing processes and materials are monitored to ensure that the reliability of AEC-Q200 parts are the same that during certification (PPAP)?

- Can we accept parts without screening? if yes, for what applications?

Is the design of AEC-Q200 parts compatible?

6	High Tempera-ture Operating Life	Appearance		No abnormal exterior appearance	1000hrs @ TA=125℃, 200% Rated Voltage, *2) Initial Measurement Perform the heat treatment at 150℃ +0/-10℃ for 1 hour and leave the capacitor in ambient condition for 24±2 hours before measurement. Then perform the measurement. Final Measurement Perform the heat treatment at 150℃ +0/-10℃ for 1 hour and leave the capacitor in ambient condition for 24±2 hours before measurement. Then perform the measurement.
		Capacitance Change	Class I	Within ±3.0% or ±0.3pF, (Whichever is larger)	
			Class II	Within ±12.5%	
		Q	Class I	Capacitance ≥ 30pF : Q≥ 350 ≥ 10pF : Q≥ 275 + (5/2) X C < 10pF : Q≥ 200 + 10 X C (C : Capacitance)	
		Tanδ	Class II	Rated Voltage ≥ 25V : 0.035 max ≥ 16V : 0.050 max ≥ 10V : 0.075 max *1)	
		IR		More than 1,000MΩ or 50MΩ X μF (Whichever is smaller) *1)	

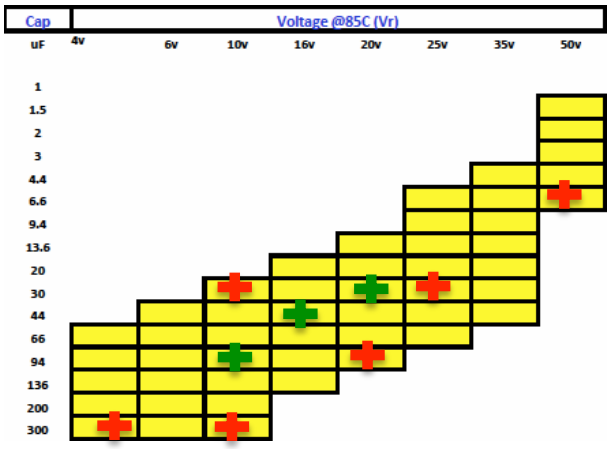
※ *1) : Indicates typical specification. Please refer to individual specifications.
*2) : Some of the parts are applicable in rated voltage X 150% or X 120%, Please refer to individual specifications.

SAMSUNG MLCC catalogue 2016

Available reliability data?

AEC-Q200 specifies clearly the tests to be performed and the methods to be used but:

- Reliability data package of AEC-Q200 are not freely available to space customers and agencies
- How the "four corners" defined in AEC-Q200 are chosen with regards to the range of certified products?



Is PPAP assuring a stable reliability level?

For space QPL parts, we have equivalent document that is called : PID.

It defines the design rules, the materials, the processes, tests and equipment used during manufacturing. BUT in addition to this, we request screening tests and a two years maintenance of qualification tests.

PPAP is generally not available for space actors. We expect that in addition to the information contained in space PID we will find some Statistical Process Control that would allow to discard regular reliability tests.

?

Can we accept parts without screening?

What is the usual screening?

- specific tests like surge current
- short accelerated life test

Is it relevant to remove early failure?

- early failure are not always the same types of failure that long term failure
- What are the types of rejects observed with usual screening?

Equipment manufacturer A	Equipment manufacturer B
1.10 millions of Hi-Rel parts for 50 launchers	2.34 millions of industrial parts for 50 launchers
7 PTE due to EEE parts	11 PTE due to EEE parts
6.4 ppm of PTE/component	4.7 ppm of PTE/component

Ariane 5 field return

Can we accept AEC-Q200 parts for space projects?

It depends on two main aspects:

- what are the needs and requirements?

  mission duration, criticality, constellation or not, cost

- how can we trust our suppliers?

  PPAP, reliability testing, audit, etc?

What can we learn space QPL parts?

Space QPL parts are reliable. (too much?)

For example: Ceramic capacitors lifetime

2000 hours life test at 2 times rated voltage at 125C is equivalent to more than 100 years of operational conditions.

What does it bring for a “3 years” mission? Do we still need a derating?

Screening is part of space heritage and is mandatory for flights models.

It may be now the time to analyse the types of rejects during screening. Is it still relevant as it is defined?

Thanks for your attention
and
see you next year

SPACE PASSIVE COMPONENT DAYS

4TH SPACE PASSIVE COMPONENT DAYS - SPCD 2020

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