ACCEDE Workshop: November 2019

Status of the Commercial Off The Shelf (COTS) Components in ESA Programmes

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Technology and Market Trends of Space 4.0

Strong increase of Low Earth Orbit missions (e.g. Constellations) driven by downstream applications

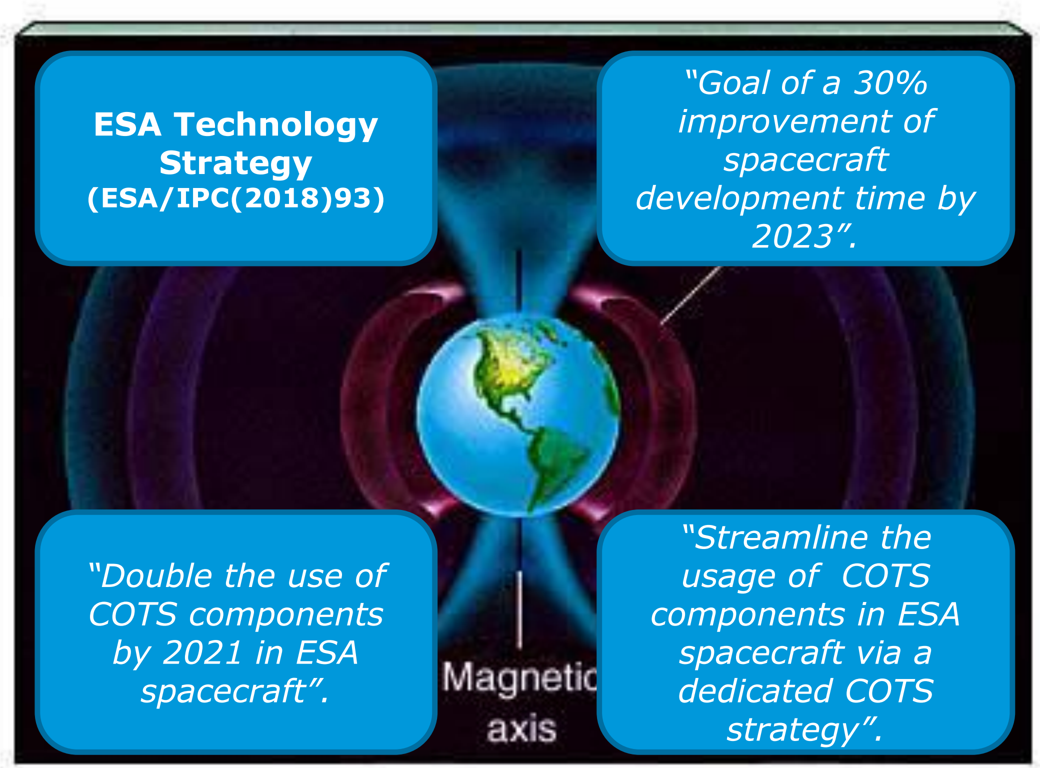
Competitive market with need of a fast access to new technologies with enhanced performances

Mature, diverse, industrial base with emerging mass production concepts and capabilities

New ways of assessing / taking risks with Venture Capital and Public-Private Partnerships

Ref: COTS in ESA Programmes (TEC-Q-HO-16)

ESA Technology Strategy (COTS)

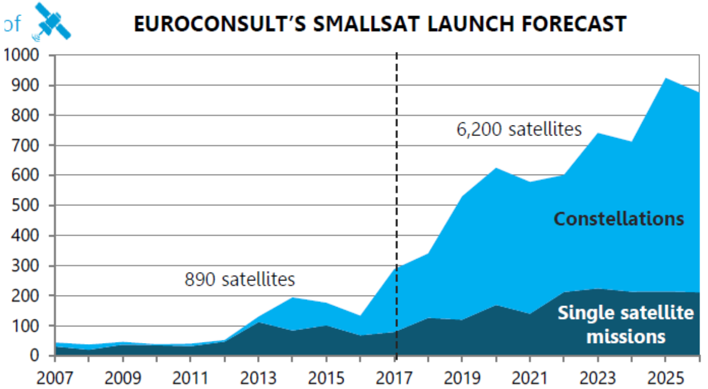


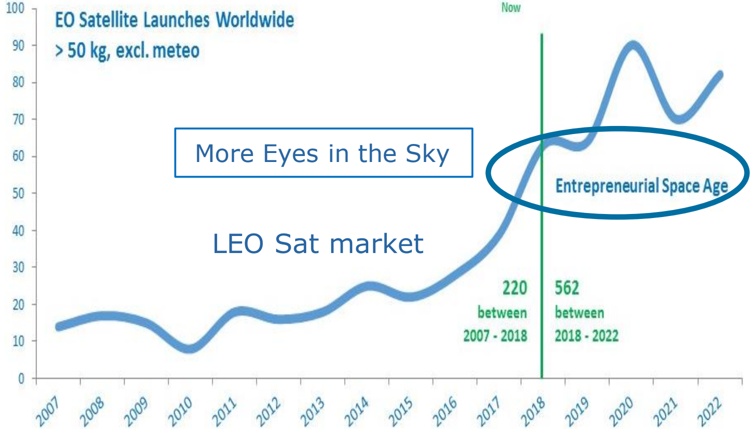
ESA Technology Strategy
(ESA/IPC(2018)93)

"Goal of a 30% improvement of spacecraft development time by 2023".

"Double the use of COTS components by 2021 in ESA spacecraft".

"Streamline the usage of COTS components in ESA spacecraft via a dedicated COTS strategy".





Ref: COTS in ESA Programmes (TEC-Q-HO-16)

What are the Arguments for COTS in a Space Project?

Better Performance	• Adoption of new technologies • Access to state of the art capabilities compared to more conservative Space Qualified components
Better Availability	• Multiple suppliers • Lack of Hi-Rel components • Short lead times • No/less export restriction constraints
Lower Cost	• Lower recurrent unit costs

Ref: COTS in ESA Programmes (TEC-Q-HO-16)

ESA COTS SC & WG 's (Established since Feb 2018)

All Programme Directorates

Steering Committee	
Britta Schade	TEC-Q
Philippe Armbruster	TEC-E
Frederic Teston	TEC-S
Jean-Loup Terraillon	TEC-S
Mikko Nikulainen	TEC-QE
Dietmar Schmitt	TIA-TT
Martin Born	TIA-PRQ
Anders Elfving	EOP-PA
Géraldine Naja	IPL-I
Michael Kasper	HRE-Q

COTS Secretariat	
Mikko Nikulainen	TEC-QE
Keith Miller	TEC-QE

Working Group 1	
Philippe Armbruster	TEC-E
Albert Crausaz	TIA-PP
Karin Lundmark	TEC-EDC
Olivier Mourra	EOP-PPE
Ralf de Marino	TEC-Q
Rok Dittrich	NAV-PFS
Karim Mellab	TEC-SP
Sam Rason	TEC-QEC
Silvia Massetti	TEC-EDC
Laurent Marchand	TEC-QQ

Combined WG 2/ 3			
Ferdinando Tonicello	TEC-EF	Rok Dittrich	NAV-PFS
Gianluca Furano	TEC-EDD	Stefano Santandrea	TEC-SPS
Josep Rosello	EOP-8MT	Sam Rason	TEC-QEC
Massimiliano Pastena	EOP-8MT	Eike Kircher	TEC-T
Anastasia Pesce	TEC-QES	Francois Deborgies	TEC-EF
Christophe Delepaut	TEC-EPM	Jorge Alves	HRE-X
Patrizia Secchi	NAV-Q	Karin Lundmark	TEC-EDC
Silvia Bayon	SCI-FMP	Valerie Dutto	TIA-TTS
Paul Robert Nugteren	TIA-TT		

Ref: COTS in ESA Programmes (TEC-Q-HO-16)

SWOT-analysis for ESA position with respect to COTS

Strengths

- Independent project procurement
- Technical authority & independent laboratories

Weaknesses

- Lack of accessibility to consolidated operational data
- Lack of an ESA quantified risk acceptance approach

Opportunities

- Better availability of critical technologies
- Decreased project costs
- Increased project diversity

Threats

- Higher uncertainty, reduced heritage
- Added complexity jeopardizing any cost advantages
- Lack of ESA visibility and Risk assessment
- Risks to the Hi-Rel Supply chain

Normative Landscape Evolution

Today
Space Qualified / Up Screening

- ESCC / JAXA / MIL(NASA)
- Failure probability: Low

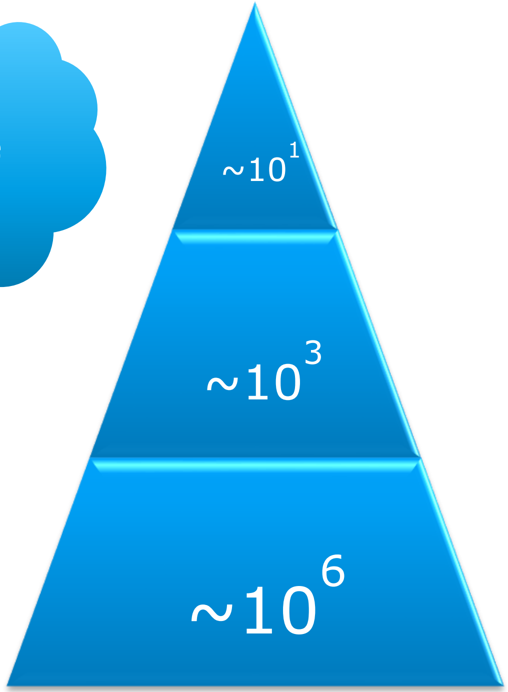
Present
COTS

- ECSS-Q-ST-60-13C
- Risk level: Class 1-3

Will also include some passive EEE Components

Future
COTS

- Automotive Qualified
- Terrestrial Hi-Rel
- Failure Probability level: To be Quantified



Typical Minimum Order

Ref: COTS in ESA Programmes (TEC-Q-HO-16)

ESA COTS Recommended Actions

Policy Issues

Mission Classification – Tailoring rules

Tailoring according to Equipment criticality levels

Normative Issues

Update of the ECSS standard on COTS

ESCC Specification on Plastic Encapsulated Devices

Review of the Automotive and JAXA/NASA Standards

Technical Issues

Guideline document for COTS utilization

Test Data Sharing with Stakeholders

Reference Designs for COTS and peripheral components

Lead (Pb) free control plan

Coordinated Testing activities – Radiation Hardness Assurance at components and board level

Tools and mitigation methodologies

Communication

ESA COTS Steering Committee+ Working Groups

HEPDT Workshop

ESA-JAXA-NASA trilaterals

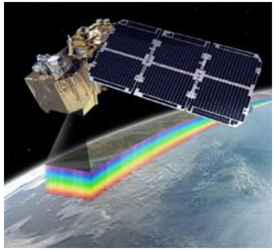
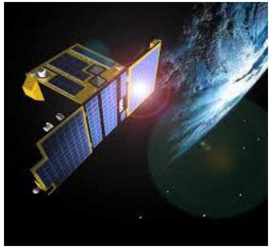
Industry bilaterals

ESCC Steering Board/Working Groups

Ref: COTS in ESA Programmes (TEC-Q-HO-16)

Mission Classification & Tailoring Rules

HIGH **Requirements** LOW


LOW **Probability of Failure** Increasing

- A mission classification with associated tailoring rules shall be defined according to ESA's stakeholders, acceptability of failure to be traded against mission implementation costs.

Example : NASA Mission Classification (Ref 8705.4)

HIGH **Requirements** LOW

NASA 8705.4	Class A	Class B	Class C	Class D	Ground System	7120.8 Class	DNH (Do No Harm)
	The lowest risk posture by design. **This would constitute a manned mission or a National Asset of exceptional priority, the failure of which would have extreme consequences to public safety or high priority national science objectives. Typically, these missions would be long duration, greater than 5 years.**	**Low risk posture.** This would represent a high priority National asset whose loss would constitute a high impact to public safety or national science objectives. While the guidance in NPR 8705.4 suggests a 2-5 year lifetime, the reality has been that 5-year and longer lifetimes are becoming common.	**Moderate risk posture**. This would represent an instrument or spacecraft whose loss would result in a loss or delay of some key national science objectives. While NPR 8705.4 suggests < 2 year lifetimes, recent examples have commonly had lifetime requirements up to 3 years for primary mission. New technologies may be employed that may not be fully compatible with some traditional requirements.	**Cost and schedule are on equal or greater considerations compared to mission success risks**. Technical risk is medium by design Many credible mission failure mechanisms may exist. New technologies may be employed that may not be fully compatible with some traditional requirements. A failure to meet Level 1 requirements prior to minimum lifetime would be treated as a mishap.	**Ground-based Equipment** Hardware, software, development processes, and ground operations associated with supporting a vehicle or instrument operating in space. Implementation practices differ significantly from the flight hardware, but are kept commensurate with the overall risk posture for the mission.	**Technical risk is high**. Some level of failure at the project level is expected but at a higher level (program level), there would normally be an acceptable failure rate of individual projects, such as 15%. Life expectancy is generally very short, although instances of opportunities in space with longer desired lifetimes are appearing. Failure of an individual project prior to mission lifetime is considered as an accepted risk.	**Technical risk is very high.** There are no requirements to last any amount of time, only not to harm the host platform (ISS, host spacecraft, etc.). No mishap would be declared if the payload doesn't function.
E.g.	Hubble Space Telescope (HST), **James Webb Space Telescope (JWST)**	**GOES-R**, TDRS-K/L/M, MAVEN, JPSS, OSIRIS-REX	LRO, MMS, ICESat-2, TESS, ICON, GEDI	LADEE, IRIS, NICER, DSCOVR	GOES-R GS, JPSS GS, SGSS	Sounding rocket, balloon, aircraft, cubesats, **(ISS) experiments**	CATS, RAVEN

LOW **Probability of Failure** Increasing

Agreed Way Forward & Next Steps

1) Establishing a **Mission Classification** scheme (*action driven by ESA Directors and Program Managers*).
2) Introducing a **Tailoring of Mission Classes down to Equipment Categorisation level** according to their criticality (*action to be driven by Project, ESA Technology Directorate, Sub-systems responsible and PA Managers*).
3) Establishing a **Coordinated COTS Components and Reference Design Evaluation Plan** (*action to be driven by ESA Technology Directorate, project representatives and Industry Suppliers*).
4) Promoting **Information sharing with internal and external Stakeholders** (*action to be implemented by All for the benefit of All*).

Annexes, backup Slides

Mouser Electronics (NL) , a commercial supplier of terrestrial pressure, temperature and load sensors, recently received a customer return of a sensor which was not functioning correctly.

Failure analysis concluded that its one-time programmable memory had been corrupted, due to it being irradiated.

Further investigation revealed that the end customer was Space X and the part was being used in their Starlink constellation satellites.

- You can be a manufacturer for space industry without knowing it,
- European COTS parts are in the big US constellations.

Annex A : COTS – Overall Approach w.r.t equipment criticality (2/2)

COTS EEE Components and modules

Subsystem criticality Category	Q2	Q1	Q0		
			Class 3	Class 2	Class 1
Trace code	•**Unclear Trace code homogeneity** •Lot homogeneity aimed but not certain		•**Expected Trace code homogeneity** (Expected lot homogeneity, including diffusion mask and wafer fab for radiation sensitive components		
Area	•**Informative** •Not yet covered by ECSS or ESA Requirements		•**Normative** •Covered by ECSS requirements		
Approach	•**Set of guidelines elaborated and agreed among experts**		•**Use ECSS Q-ST-60-13C for COTS EEE components** •Use ECSS-Q-ST-60C for Hi-Rel EEE Components		

- **Q1**, less risky and more expensive than Q2
- **Q2**, the most risky and economic;

- Homogeneity of procurement lot
- Evaluation, "qualification" and/or screening activities
- ECSS-Q-ST-60-13 and ECSS applicable standards.

Ref: COTS in ESA Programmes (TEC-Q-HO-16)

Annex B: COTS – Goal : Building up knowledge about COTS (1/2)

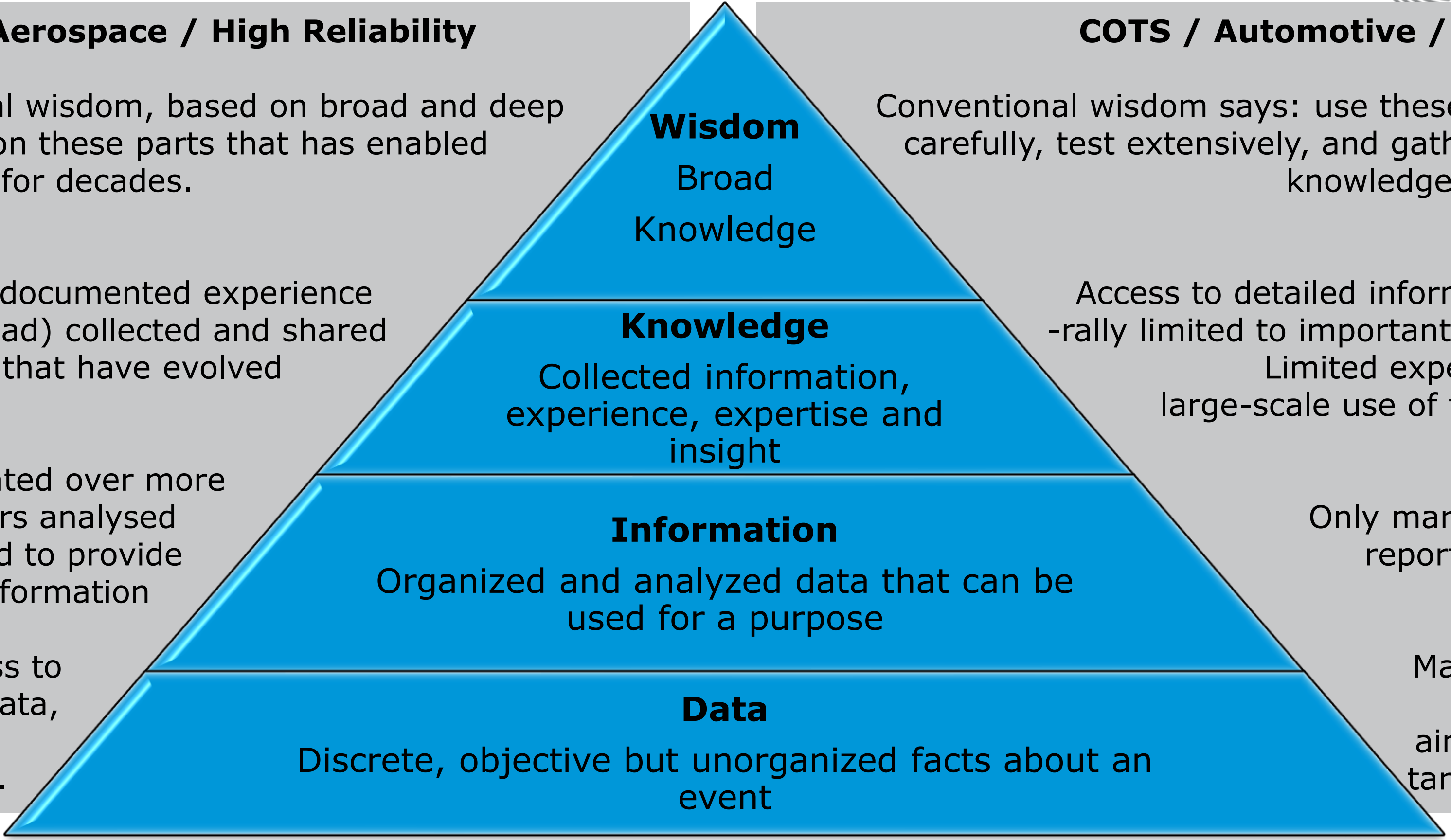
Military / Aerospace / High Reliability

Conventional wisdom, based on broad and deep knowledge on these parts that has enabled reliable use for decades.

Extensively documented experience (good and bad) collected and shared about parts that have evolved steadily.

Data generated over more than 40 years analysed and reported to provide extensive information

Ready access to mandated data, common to all suppliers.



COTS / Automotive / COTS Plus

Conventional wisdom says: use these parts very carefully, test extensively, and gather as much knowledge as possible

Access to detailed information gene -rally limited to important customers. Limited experience with large-scale use of these parts.

Only market-focused reports available.

Manufacturers supply data aimed at their target market.

Ref: COTS in ESA Programmes (TEC-Q-HO-16)

Adapted from NESC report “Understanding the risk”, 2014.

Annex B: COTS – How to support ESA Programs and Industry (2/2)

In practice, what is proposed is to setup a web-based platform allowing:

1. Companies interested in the usage of COTS Components to express their needs by describing the application profile and the type of components triggering their interest.
2. ESA will build-up statistics (histograms) based on these request and make them visible to the stake-holders.
3. If a specific type of components appears to be "popular", gathering many requests and hence witnessing a high level of interest, ESA could use this information to harmonise activities related to the characterisation of these components.
4. Outputs of 3 could be used as well to decide if a reference design should be made available to support the usage of the part in the conditions they have been tested.

Excerpt from Steering Committee/WG1 Report : ESA-TEC-TN-106038

Normative Landscape Evolution

Today Space Parts

Including COTS per ECSS-Q-ST-60-13

- ECSS-Q-ST-60 Class 1
- Risk level: Lowest

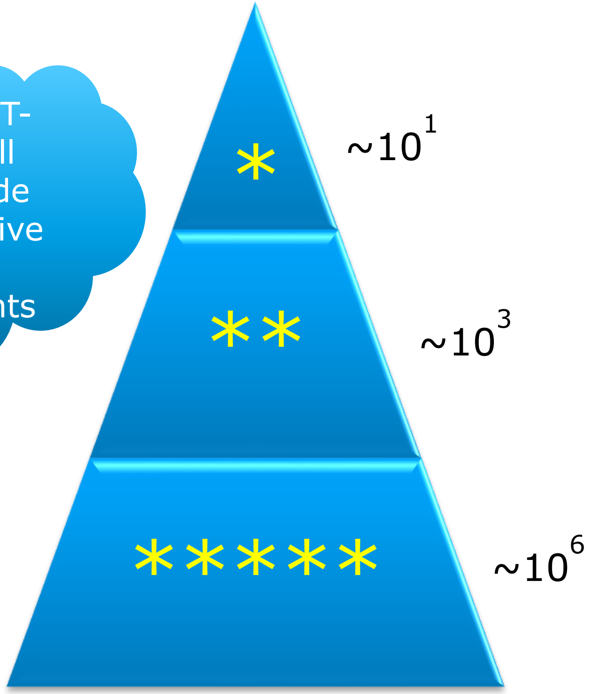
- ECSS-Q-ST-60 Class 2
- Risk level: Low

- ECSS-Q-ST-60 Class 3
- Risk level: Medium/Low

Future COTS

- Automotive/Commercial/ Ruggedized used without justification/tests
- Risk level: Unknown

ECSS-Q-ST-60-13 will also include some passive EEE Components



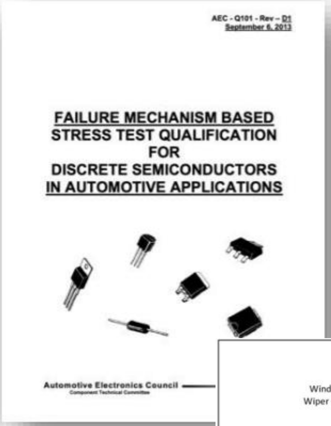
Typical Minimum Order

Ref: COTS in ESA Programmes (TEC-Q-HO-16)

Automotive Electronic Council Standards

AEC-Q100

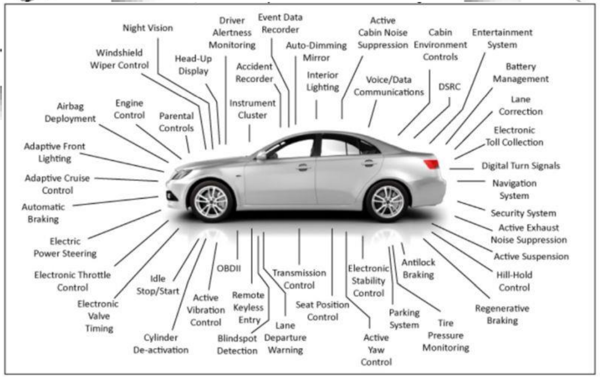
AEC-Q101



AEC-Q102

AEC-Q200

AEC-Q104 (New)



Ref: COTS in ESA Programmes (TEC-Q-HO-16)

Normative Landscapes

In ESA, the **ECSS-Q-ST-60-13C** “Commercial electrical, electronic and electromechanical (EEE) components” is the normative reference for the use of COTS parts.

This standard is applicable to commercial encapsulated active monolithic parts (integrated circuits and discrete) but is currently **NOT applicable for the use of COTS passive parts.**

Based upon the discussions at the PSWG/SCSB and with Industry, this document at the next revision will be updated and extended to include passive parts.


ECSS-Q-ST-60-13C
21 October 2013

EUROPEAN COOPERATION
ECSS
FOR SPACE STANDARDIZATION

Space product assurance

Commercial electrical, electronic and electromechanical (EEE) components

ECSS Secretariat
ESA-ESTEC
Requirements & Standards Division
Noordwijk, The Netherlands

General consensus from the WGs is any new standard/guideline should go further by broadening the definition of COTS from EEE parts to also include EEE assemblies/modules.