EEE COMPONENTS, COST AREAS AND THEIR RELEVANCE

Training course for SMEs

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INTRODUCTION

EEE components are a key contributor and driver to the cost of the system

The total ownership cost of those EEE components remains a non-negligible part of the cost of the system.

- ✓ The price of space EEE components cost remains high.
- ✓ The effort in engineering, quality and logistic which is required to procure those EEE is significant.

The EEE standards have a significant impact on the industrial processes which are used for design, manufacture and test of the hardware systems.

INTRODUCTION

In case of new developments, there will be costs that will be incurred once but will be non negligible and need to be well taken into account. They will represent an important portion of the overall costs.

For recurrent models, these costs will not impact as for the initial development/design.

A careful study needs to be carried out from the very beginning to ensure project will perform within agreed budget and schedule limits.

SATELLITES CLASSES

There are different factors to consider for satellite classification:

✓ **Size of the satellite**

Typical satellite classification:

- 500 tones: International Space Station.
- 5 tones and more: big GEO satellites (Eurostar platforms, Spacebus, Alphabus).
- From 3 to 5 tones: GEO telecom satellites, also MEO.
- From 1 to 3 tones Helio, GEO, MEO satellites
- 500 Kg: minisatellites (PROTEUS familiy)
- 100 Kg: microsatellites (MYRIADE, etc.)
- 10 kg: nanosatellites

Certain regions of space are not "preferred" for certain missions:

- Circular or slightly elliptical orbits which are incompatible with the altitude range between about 1,800 and 10,000 km, since radiation belts there deteriorate equipment more quickly.
- Any low orbit (< 400 km) where atmospheric drag is too strong, since the cost and frequency of station-keeping manoeuvres increases considerably and satellite lifetime diminishes.

SATELLITES CLASSES

✓ Space Environment/Orbit/Mission Duration

Orbit	LEO (low earth orbit)	GEO (geostationary orbit)	Planetary missions and Deep Space
Altitude	200 tot 800 km	36000 km	n.a.
Temperature	-100°C to +100 °C 16 cycles/day	-150 °C to +120 °C 1 cycle /day	-180 °C to +260 °C
Vacuum	10^{-4} to 10^{-9} mbar	10^{-9} to 10^{-10} mbar	to 10^{-14} mbar
Plasma	Dense cold plasma Aurora	Hot Plasma	Thin plasma
Radiation	hν [X-ray (V)UV, Vis, IR] Particles (98 % e^-, 2% p^+, Van Allen Belts) Solar particle events	Van Allen belts (partial) Cosmic Rays, Sun activity Solar particle events	Cosmic Rays Solar particle events
Impacts	Micrometeorites / Debris	Micrometeorites/ Debris	Comets Meteoroids
Atmosphere	Atomic Oxygen	n.a.	Planets (reactive gasses)

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SATELLITES CLASSES

✓ **Quality Requirements (Assurance/Risk)**

There are standards that define the requirements for selection, control, procurement and usage of EEE components for space projects. These standards differentiate between three classes of components through three different sets of standardization requirements (clauses) to be met.

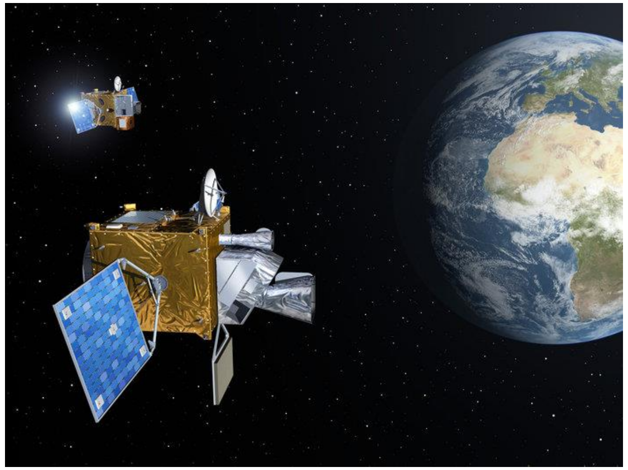
The three classes provide for three levels of trade-off between assurance and risk. Mitigation and other engineering measures may decrease the total cost of ownership differences between the three classes.

- Class/level 1: Parts shall be selected and processed to this level for missions requiring the highest reliability and lowest level of risk. Level 1 active parts shall be reviewed for radiation hardness, and radiation testing is required when information is not available. The typical mission duration for Level 1 programs is 5 years or greater.

- Class/level 2: Parts shall be selected and processed to this level for missions with low to moderate risk, balanced by cost constraints and mission objectives. Level 2 active parts shall be reviewed for radiation hardness, and radiation testing is required when information is not available. The typical mission duration for level 2 programs varies from 1 to 5 years.

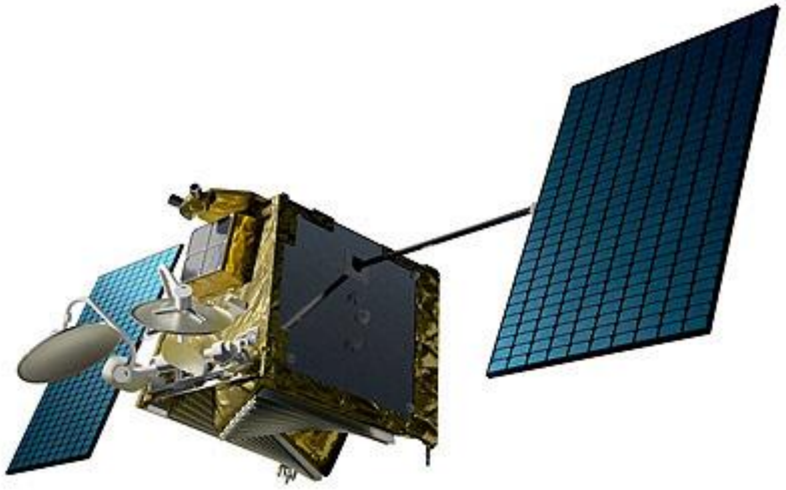
- Class/level 3: Level 3 parts are intended for mission applications where the use of high-risk parts is acceptable. Level 3 active parts shall be evaluated for radiation hardness, and radiation testing is required when information is not available. The typical mission duration for level 3 programs varies from less than 1 year to 2 years.

SATELLITES CLASSES



MTG – 800 kg, class 1, GEO.
15-20 years service

OneWeb constellation – New Space Class, lower than class 3, 175/200 kg, LEO. 7 years service



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SOME AREAS WITH IMPACT IN COST

Cost Driver	Rating ↑ Cost Up ↓ Cost Down
Altitude (larger launch vehicle, higher power, larger antennas and telescope apertures, orbit average downlink rate)	↑↑↑
Mass (launch vehicle)	↑↑
Size (drives structure stiffness, fairing size)	↑
Power (drives array design, spacecraft size, thermal design)	↑↑
Data rate (drives antenna size, altitude, onboard memory, necessity for relay satellites)	↑↑
Pointing accuracy (drives structure stiffness, mass, attitude determination and control system [ADCS] components required, ADCS software complexity)	↑↑
Number of telemetry points (drives harness mass, software size, testing, ease of anomaly resolution during integration and technology [I&T] and in orbit)	↑
Reliability (drives redundancy, testing complexity, mass)	↑↑
Radiation (high radiation tolerance drives redundancy, lifetime, shielding mass, more expensive hardened components)	↑
Lifetime (drives redundancy, array size, consumable mass)	↑
Number of payloads (increases number of interfaces, testing complexity)	↑↑
Number of organizations and people involved (level of oversight, documentation, potential for inefficiencies)	↑↑↑
Documentation (need appropriate amount for size of project; too little for a large project results in poor communication and rework; too much for a small project increases costs)	↑↑
Level of heritage (can increase reliability and lower costs; may increase complexity of component interfaces; costs per satellite lower for constellations)	↓
Continuity of team (high turnover creates errors and inefficiency)	↓
Maturity of design (drives number of late changes)	↓↓
Schedule (too long increases "standing army" costs; too short causes increased rework due to errors and inadequate testing)	↑↑

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PA REQUIREMENTS

The Product Assurance (PA) plan defines the requirements to be applied for the design, production, testing, storage, transport, delivery and operations of the for the project.

The Product Assurance requirements cover the following disciplines:

- ✓ PA Management;
- ✓ Quality Assurance;
- ✓ Dependability Assurance;
- ✓ Electrical, Electronic and Electromechanical (EEE) Components;
- ✓ Materials, Mechanical Parts and Processes;
- ✓ Software Product Assurance;
- ✓ Cleanliness and Contamination Control

The requirements are addressed to the supplying parties at all level of the project.

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PA REQUIREMENTS

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PLATO PA & Safety Requirement Document for the Payload
(P/L PARD)

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PARTS PROCUREMENT CONTROL PLAN

This document defines the programmatic Product Assurance requirements applicable to any specific space project.

This usually includes Quality Assurance, Software product Assurance, Safety assurance, Dependability, EEE parts quality, selection and Procurement, Materials Parts and process selection Control, Configuration management control and Acceptance activities.

All users and subcontractors have to meet the requirements of PA plan as applicable.

The Parts Procurement Control Plan will provide the basic guidelines for product selection based on project satellite radiation environment provided by the prime contractor.

These values are general ones and must be considered for product selection, but we must ensure we are customizing these requirements to our real values.

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PARTS REQUIREMENTS GUIDELINES

Quality Requirements for EEE parts to be used in each project are defined in standard documents.

ECSS-Q-ST-60 - Space product assurance Electrical, electronic and electromechanical (EEE) components.

NASA EEE-INST-002: Instructions for EEE Parts Selection, Screening, Qualification and Derating.

ECSS-Q-ST-60C Rev.3
Electrical, electronic and electromechanical (EEE) components

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DIFFERENCE CLASS 1, 2 AND 3 IN ECSS-ST-Q-60C

	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
-- Mfr assessment (evaluation)	required	not required	not required
- Approval process	DCL (qualified) PAD (not qualified)	DCL (qualified & EPPL/NSPL) PAD (others)	DCL (qualif & not qualif)
- Procurement spec	normative or project	normative -> datasheet	normative -> datasheet (for revie
- 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)

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PARTS PROCUREMENT CONTROL PLAN

The PPCP shall also implement an effective project control management to adequately verify proper configuration control, schedule control as well as cost control.

COST CONTROL

Establish and maintain an agreed cost and manpower basis for all the work

It is able to rapidly evaluate the actual expenditure and assess deviations.

Develop, evaluate and rapidly implement corrective actions.

Report a consistent set of cost data.

MODEL DEFINITION

BREADBOARD MODEL

Breadboard models are used to demonstrate that key aspects of a design are feasible and understood. They should be manufactured during the early stages of a project such that maximum benefit can be derived. They do not need to be flight representative with respect to the materials used but representative of the functionality which should be proven.

ENGINEERING MODEL

Limited differences to flight model design and manufacturing. The engineering model is representative of the intended flight design in all functional aspects and materials. Parts to be used: commercial.

ENGINEERING QUALIFICATION MODEL

Identical to flight model design and manufacturing. Prototype produced and tested in order to validate the functional qualification of the flight model. Parts to be used: reduced quality level compared to flight model. Tests on this model give confidence that the qualification programme using the QM is ready to proceed.

QUALIFICATION MODEL

Identical Flight Model design and manufacturing. Parts to be used: High-reliability parts as for FM.

FLIGHT MODEL/SPARE

Flight model that will be launched. Subject to requirements, spare model may be required.

PROTOFLIGHT MODEL

Flight Model tested with reduced levels/test durations. Acceptable for units with low complexity and/or similar to items qualified in different programs. Equal to the flight model that will be subjected to complete qualification.

STANDARD PROJECT REQUIREMENTS

PARTS SELECTION

Type	*FM*	*QM*	*EQM*	*EM/BB*
Integrated circuits	ESCC 9000 MIL-PRF-38535, Class V, S	ESCC 9000 MIL-PRF-38535, Class V, S	Specific EQM model MIL-PRF-38535, Class Q, 883B	Commercial
Trasistors/Diodes	ESCC 5000 MIL-PRF-38535, JANS	ESCC 5000 MIL-PRF-38535, JANS	Specific EQM model MIL-PRF-38535, JANTXV, JANTX	Commercial
Critical passive (crystals, relays, connector)	ESCC level B MIL Class S, Class K, ...	ESCC level B MIL Class S, Class K, ...	ESCC level C (connector FR022) MIL Class B, Class H, EM models, ...	Commercial
Passive	ESCC level C MIL FR S, R (Weibul B, C)	ESCC level C MIL FR S, R (Weibul B, C)	ESCC level C, specific EQM model MIL FR R (Weibul B)	Commercial
Hybrid	ESA-PSS-01-608 MIL-PRF-38534 Class K	ESA-PSS-01-608 MIL-PRF-38534 Class K	ESA-PSS-01-608, specific EQM model MIL-PRF-38534 Class H	Commercial

ALTER

EQM PHILOSOPHY

EQM MODEL (Cost and Schedule)

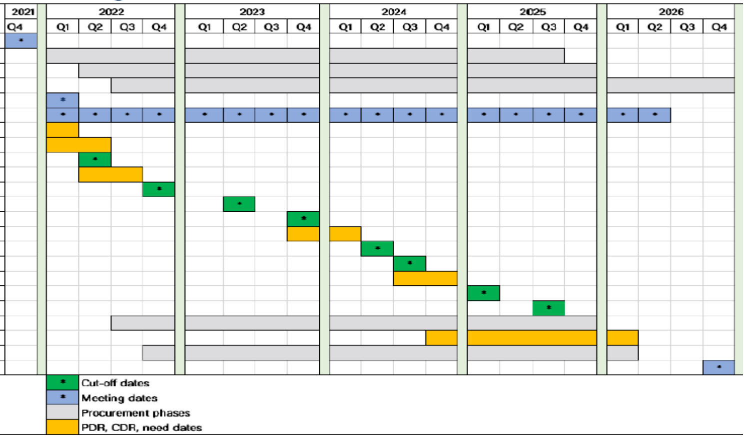
EQM types shall have in general the same form/ fit/ function, package type and temperature range as the ones for FM. However, relevant thermal and mechanical tests of EQM units may demand specific requirements. Hence, final responsibility for selection of parts lays on users.

In case users needed EQM parts with the same quality level as FM, solution was a combined procurement for both models.

ARIEL CPPA ITT

Ariel Payload Coordinated Parts Procurement
Volume 4, Annexe 1, "Planning Bar-Chart"

MS Nº	MILESTONE DESCRIPTION	Start	End
1	CPPA Contract Kick-off	21/11/2021	21/11/2021
2	Pre-procurement Phase	21/11/2021	31/09/2025
3	Procurement Phase	01/06/2022	31/12/2025
4	Post-procurement Phase	10/09/2022	21/11/2026
5	General Users meeting	20/01/2022	20/01/2022
6	Ariel-PCB meetings	15/03/2022	30/06/2026
7	PDR level DCL Q1 2022	01/01/2022	15/03/2022
8	Payload PDR	21/03/2022	10/06/2022
9	Cut-off#1 Items that need evaluation/qualification, LLLIs and EQM	01/06/2022	01/06/2022
10	Instrument PDRs	13/06/20202	02/09/20202
11	Cut-off#2 LLLIs and EQM (2nd batch) and first active parts	01/10/2022	01/10/2022
12	Cut-off#3 Active parts (2nd batch) and first passive parts	15/04/2023	15/04/2023
13	Cut-off#4 Active parts (3rd batch) and passive parts (2nd batch)	15/10/2023	15/10/2023
14	Instrument CDRs	06/11/2023	25/03/2024
15	Cut-off#5 Active parts (4th) passive parts (3rd) & very late orders for more advance users	15/04/2024	15/04/2024
16	Cut-off#6 Passive parts (4th batch) and very late orders (2nd batch)	01/09/2024	01/09/2024
17	Payload CDR	10/09/2024	02/12/2024
18	Cut-off#7 Very late orders (3nd batch) & back-up for unexpected parts	15/03/2025	15/03/2025
19	Cut-off#8 Back-up for unexpected required parts	15/09/2025	15/09/2025
20	Receipt of the parts	10/09/2022	31/12/2025
21	Users need dates	01/10/2024	31/03/2026
22	Delivery of the parts	10/10/2022	31/03/2026
23	End of Contract	21/11/2026	21/11/2026



EQM PHILOSOPHY

EQM MODEL (Cost and Schedule)

		Manufacturer	
		Vectron	Aeroflex
QUALITY LEVEL	QML Q/CLASS S/HIREL	40 w	16 w
	PROTO/EM	21 w	12 w

Class S parts for Vectron can reach 40 weeks, while EM parts are 21 weeks. Depending on the tests required for EQM, lead time may oscillate between these 2 values.

In the case of Aeroflex parts, usual lead time can reach 16 weeks. Nevertheless, as it occurs to some PROTO parts, some QML-Q parts may have longer lead times (around 20 w).

EQM PHILOSOPHY

EQM MODEL (Cost and Schedule) Cobham

In PLATO some Users such as Evoleo or Kayser have procured PROTO parts from Cobham.

Others such as CRISA, procured QML-Q

	PROTO		QML-Q	
Part Number	Cost (USD)	Lead Time (w)	Cost (USD)	Lead Time (w)
UT8SDMQ64M48-75ZPC	4700	12	5150	16
UT16MX111-XPC	775	10	1200	16
UT54LVDS031LVEUPC	765	10	1200	22
UT54LVDS032LVEUPC	840	10	1300	22
UT8R1M39-21XPC	3250	12	5200	17
UT8R2M39-22XPC	3066	12	4500	17
UT28F256LVQLEC-65UPC	2015	8	6000	17
UT28F256LVQLEC-65UWA	3434	12	5700	17
UT8SDMQ64M40-75ZPC	3320	12	8200	17
UT8MR8M8-50XPC	5179	30	7000	17
UT54BS16210-UPC	390	8	700	17
UT54ACS162245SLVUPC	551	10	750	17

Finally DLR and MSSL have procured EQM and FM combined→QMLV

ALTER

COSTS concepts

Manpower: People allocated (engineers, quality, testing,...)

Parts Manufacturers' Costs:

- ✓ Recurring Vendor Cost (RVC): This is the cost for each individual, single component multiplied by the quantity of flight units.
- ✓ Non Recurring Vendor Cost (NRVC): Are those costs which are charged by the manufacturer in order to ensure the quality of a procured lot (by means of additional tests, such as LAT, RVT, lot charges, test samples, MOQs), to compensate for minimum buy requirements, and to establish lot documentation (data package).

Testing Costs: Additional costs for testing not done at manufacturers' but required by the project to meet quality requirements.

Quality issues lead to cost increases (NRBs, extra testing, new procurement).

NRVC: CONTRACTUAL CONTEXTS

EUCLID

Instrument Users covered their NRVC

PLATO

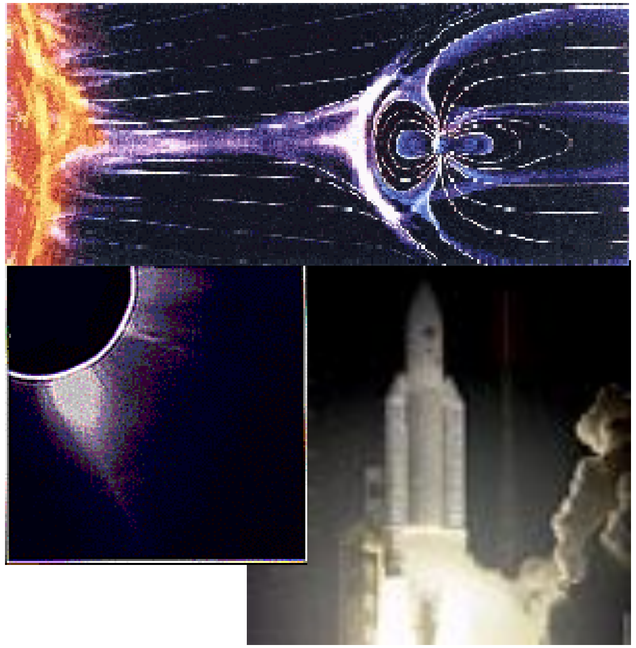
REALTRA is contractually under spacecraft´s coverage. However, it is a User with less experience and it was agreed to be included in the CPPA procurement.

REALTRA benefits for the CPPA service, but they cover the NRVC.

WHY HI-REL PARTS

The space environment is a hostile environment for satellites

- Temperature: Temperature extremes from -40 °C to +125 °C can be experienced by components open to the space environment. Typical temperature range for components is –55°C to +125°C. Almost entire lack of convection.
- Radiation: Ionizing and non ionizing effects.
- Mechanical Stresses: Vibration, acceleration, thermal shock. During launch and normal working life.
- Vacuum
- Lack of direct accessibility following launch



ASSESSMENT OF PPCP REQUIREMENTS

Different concepts with potential cost impact to be analysed:

- Engineering Tasks
- Procurement/parts ordering
- Tests plans/documentation generation
- Evaluations
- Lot screenings
- Inspections at MFRs'
- Incoming inspections
- Electrical Tests
- DPA
- Other Tests
- Radiations Tests
- LVT/LAT

ALTER

ENGINEERING TASKS

- Device selection requires a thorough study of design requirements and available devices.

- Types reduction. Standardization process can help in different aspects:

  - Fewer lines to be procured
  - Easier procurement handling and follow up
  - Lowest unit prices for higher quantities
  - Fewer components to be tested
  - Risks control

- Space heritage. Do we have any data from previous projects on non qualified components? Is there any data available?

- PAD and Justification Document if necessary.

ALTER

PAD EXAMPLE

- MSK496KRH
- Not qualified component by the time of this example PAD was discussed
- Activities included:
  - Precap.
  - Buyoff (replaced by Incoming Inspection by CPPA in this case).
  - DPA in 3 pcs.
  - QCI (Group A + Subgroup C2 on 5 pcs).
  - TID on 11 pcs.

PAD EXAMPLE

PROCUREMENT INSPECTIONS and TESTS

Precap (Y/N) [Y]

Lot

ESCC LAT/LVT LAT level or subgroup [ ]

Other LAT (Y/N) [Y] **MIL QCI/TCI group:** Group A + Subgroup C2 on 5pcs on the lot

Buy-off (Y/N) [N]

DPA (Y/N) [Y] **Sample size:** 0

Complementary tests: DPA ON 3 PCS COMING FROM GROUP C

Remark: RH6105 die from LTC is used

RADIATION HARDNESS DATA

Radiation hardness assurance plan applicable [N]

Doc. Ref.:

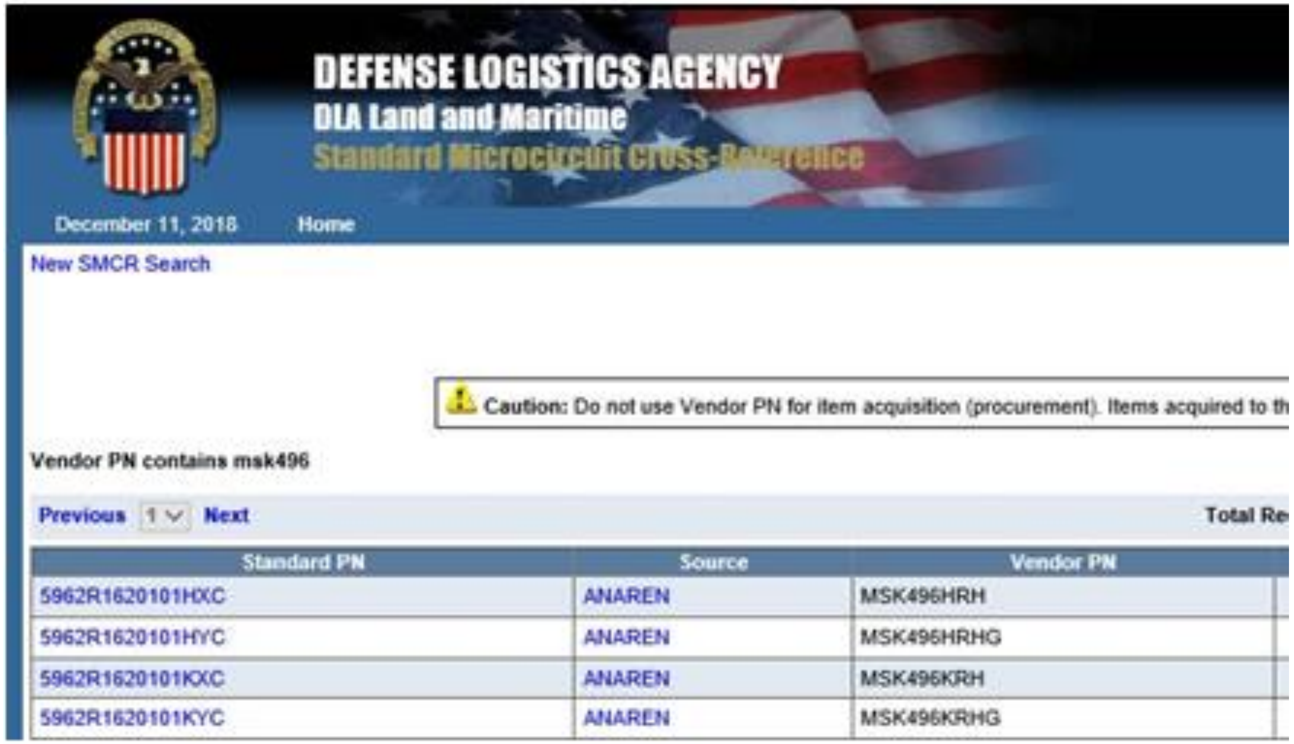
Total dose effects	[Y]	**Level**	100KRads(Si)	**Report ref:**	MFR DATA at HDR
SEL (Y/N)	[N]	**Level**		**Report ref:**	
SEU (Y/N)	[N]	**Level**		**Report ref:**	
SET (Y/N)	[Y]	**Level**		**Report ref:**	(*)
SEFI (Y/N)	[N]	**Level**		**Report ref:**	
SEB (Y/N)	[N]	**Level**		**Report ref:**	
SEGR (Y/N)	[N]	**Level**		**Report ref:**	
Others (Y/N)	[N]	**Level**		**Report ref:**	

RVT required (Y/N) [Y]

Remark: RVT TO BE PERFORMED AS PER SOL-ATN-RP--0076 AT 36RAD/H
(*) TO BE ANALIZED IN THE RADIATION ANALYSIS

PAD EXAMPLE

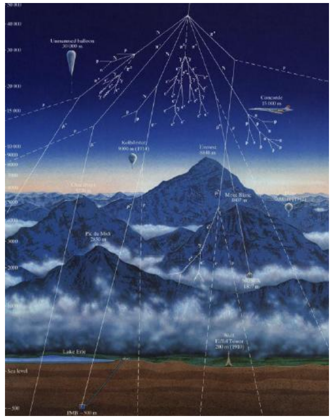
- Currently this component is QPL → MSK496KRH (5962R1620101KXC)
- Radiation guaranteed HDR 100 krad and ELDRS 50 krad



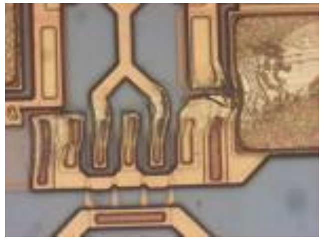
ALTER

PARTS SELECTION

- A proper product selection at a project early stage allows reducing cost and delivery problems while maintaining reliability and performance.
- EEE parts procurement must include:
  - EEE Parts definition and selection
  - Procurement
  - Quality control of procured parts
  - Non conformance management



- Risk mitigation strategies are needed, including:
  - Radiation analysis
  - Reliability analysis
  - Procurement scheme
  - Additional test required for validation



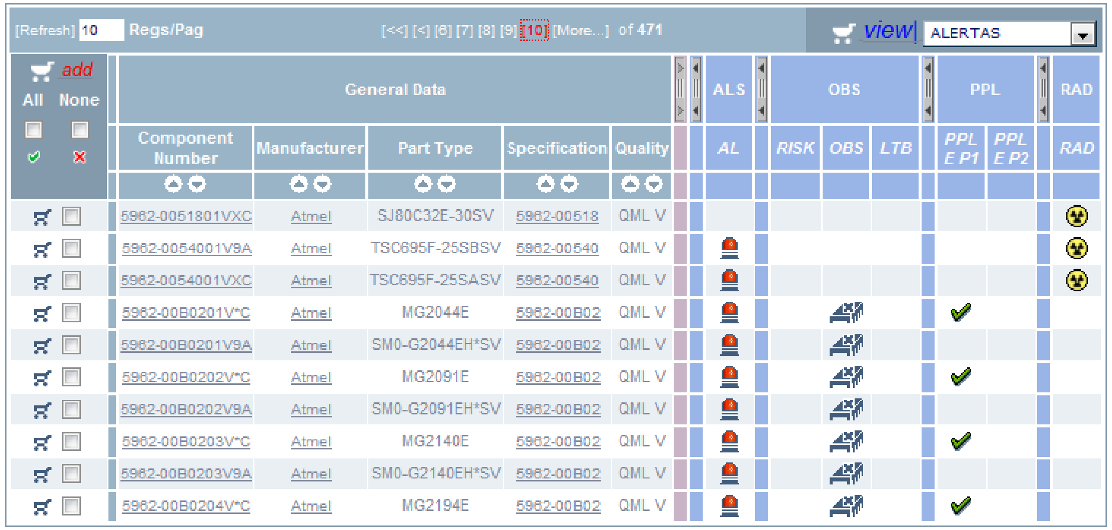
ALTER

PARTS SELECTION

- Once selected the most suitable parts for our application, we must define the additional requirements that allow ensuring the minimum risk for the mission.

- Risk mitigation analysis and plans must include actions for:

  - Obsolescence
  - Alerts monitoring
  - Export control needs
  - Long lead and critical schedule items
  - Manufacturers and products evaluation
  - Counterfeit detection



Component Number	Manufacturer	Part Type	Specification	Quality	AL	RISK	OBS	LTB	PPL E P1	PPL E P2	RAD
5962-0051801VXC	Atmel	SJ80C32E-30SV	5962-00518	QML V							
5962-0054001V9A	Atmel	TSC695F-25SBSV	5962-00540	QML V							
5962-0054001VXC	Atmel	TSC695F-25SASV	5962-00540	QML V							
5962-00B0201V*C	Atmel	MG2044E	5962-00B02	QML V					✓		
5962-00B0201V9A	Atmel	SM0-G2044EH*SV	5962-00B02	QML V							
5962-00B0202V*C	Atmel	MG2091E	5962-00B02	QML V					✓		
5962-00B0202V9A	Atmel	SM0-G2091EH*SV	5962-00B02	QML V							
5962-00B0203V*C	Atmel	MG2140E	5962-00B02	QML V					✓		
5962-00B0203V9A	Atmel	SM0-G2140EH*SV	5962-00B02	QML V							
5962-00B0204V*C	Atmel	MG2194E	5962-00B02	QML V					✓		

- Early detection and solution of these concerns will minimize impacts on the overall project schedule and cost.

ALTER

PARTS ENGINEERING

Identification of Critical Items:

- Safety, Reliability
- History of non-conformances
- Other critical items (alerts, PCN….)
- Limit life items (obsolescence)
- New industrial processes, technology (not qualified or not standard)
- New development versus qualified and flown
- Long lead/schedule critical items: propose alternative part types or sources to reduce lead time
- ITAR/EAR restricted items
- Procurement, manufacturing, assembly, inspection, test, handling, storage and transportation constraint
- Processes or activities subcontracted to lower tier sub-contractors involving two or more levels of subcontracting

ALTER

PARTS ENGINEERING

LONG LEAD ITEMS / SCHEDULE CRITICAL ITEMS

The LLI definition is based on the following added lead times:

Lead time associated to pre-procurement activities, such as: standardization, part type reduction, PAD preparation, specification preparation, request for quotation to manufacturers, etc...

Manufacturing lead time (including):

- Quoted lead time.
- Delivery time delinquency based on previous experience.
- Time required for export license approval.
- Transit time.

Lead time associated to post-procurement activities; amongst others: reception of parts, incoming inspection, destructive physical analysis (as applicable), electrical measurement (as applicable), packaging of parts, shipment of parts, etc...

PARTS ENGINEERING

LONG LEAD ITEMS / SCHEDULE CRITICAL ITEMS

The main risks associated to availability of schedule critical items are:

- Lack of space qualification.
- No previous space use.
- Need of component evaluation and/or additional testing.
- Failures during previous procurements.
- Single source availability.
- ITAR/EAR.
- Parts obsolescence or foreseen obsolescence.
- Alerts/problem notifications.
- In process of qualification, under development or affected by changes in the technology.

The total sum of these considerations can lead to determine the existence of a certain risk of project schedule constraints in case of any failure during the procurement, testing or qualification of these devices.

ALTER

PARTS ENGINEERING

LONG LEAD ITEMS / SCHEDULE CRITICAL ITEMS

The risk of delivery must be specially considered whenever the procurement activities are dealing with components holding:

- Immature technology.
- Short space manufacturing experience from the manufacturer.
- Custom defined part.

Any of these factors can lead to unexpected delays in the manufacturing of these items and put in a very critical situation the schedule of the whole project.

ALTER

PROCUREMENT / PARTS ORDERING

MFR LEAD TIMES FREQUENTLY DELAYED DUE TO THE GLOBAL SEMICONDUCTOR CRISIS

Due to the lack of supply of semiconductive materials derived from the Covid-19 situation, the number of unpredictable delays is increasing with multiple manufacturers – the lead times in the quotation compared to those confirmed often differ in several weeks, which could cause an impact on the Project Schedule.

Therefore, ATN strongly recommends to place the orders as soon as possible to avoid unforeseeable delays that could impact the Schedule, especially in late phases of the procurement process.

PROCUREMENT / PARTS ORDERING

MFR LEAD TIMES DELAYED

Microsemi diodes have an increased lead-time of 40 weeks.

Vectron oscillators lead-time have overpassed the 40 weeks.

Exxelia capacitors are quoted 30 weeks, but there are plenty of delays due to “high capacity”.

Texas Instrument LM124AWRLQMLV and LM139AWRLQMLV currently have lead-time of 70 weeks.

MSK5980 has a lead time of 72 weeks plus 10 weeks of qualification.

Cobham warns of lead-time for 50 weeks basically for all parts.

PROCUREMENT / PARTS ORDERING

COST OPTIMIZATION IN PLATO: DATA-PACKAGE

Even if testing is performed on the lot, it is not guaranteed the reception of a data-pack in all cases, as manufacturers apply a charge (often high) for its shipment. Therefore, when is a data-pack required and purchased? When specifically required by the User.

For non-qualified parts whose data is not shipped for free by manufacturer. For example: Analog Devices' space products not QPL.

Data-pack is not generally received when procuring QPL parts.

PLATO PCB based on a justified need. For example: FPGAs with a saving of **14 KUSD**.

PROCUREMENT / PARTS ORDERING

COST OPTIMIZATION IN PLATO: FPGAS

- RTAX2000S-CQ256E (E-FLOW) Unit Price= 18 KUSD

  Avoidance of 10% increase on UP (6 pcs) leads to a **saving of 10KUSD**

- RTAX2000SL-CQ352E (E-FLOW) Unit Price= 27 KUSD.

  Avoidance of unit price of 10% increase (35 pcs) leads to a **saving of 95KUSD**

A proactive procurement agent enables the avoidance of a potential increase of manufacturers´ unit prices.

ALTER

PROCUREMENT / PARTS ORDERING

COST OPTIMIZATION IN PLATO: FPGAS

- Users to inform of the yield of programming and the approval status of the programming to be implemented on the FPGA, as programming involve a risk of failure that can be critical for schedule.

- CPPA has procured for each FPGA batch a golden stock sample which is under ESA´s property. This samples replaces the DPA samples as PLATO PCB decided not to perform DPA on FPGAs.

PROCUREMENT / PARTS ORDERING

COST OPTIMIZATION IN PLATO: SKYWORKS OPTOCOUPLERS

- The main difference is that in **OLS249** the base of the transistor is accessible (not in the **OLS049** used by REALTRA), and this feature is required by ASP's design

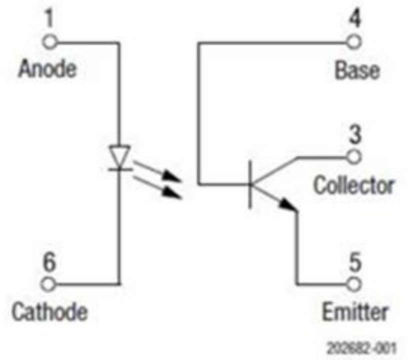


Figure 1. OLS249 Block Diagram

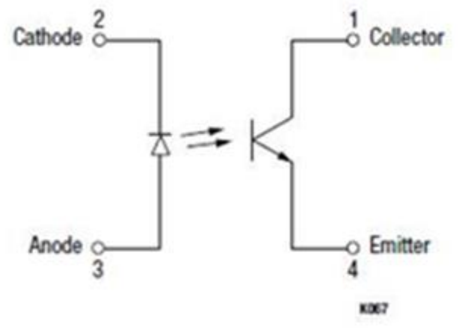


Figure 1. OLS049 Block Diagram

PROCUREMENT / PARTS ORDERING

COST OPTIMIZATION IN PLATO: SKYWORKS OPTOCOUPLERS

- OLS049 is in LCC4 package; OLS249 is in LCC6 package
- Emitter and Detector die for both OLS049 and OLS249 are the same.
- From radiation perspective, the performance should not be that different.

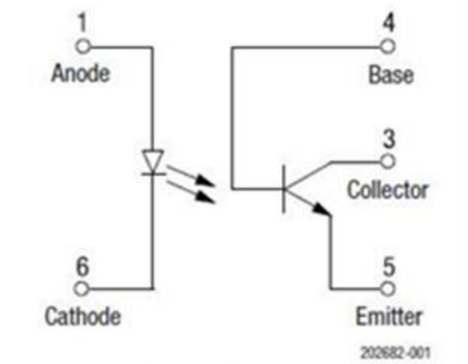


Figure 1. OLS249 Block Diagram

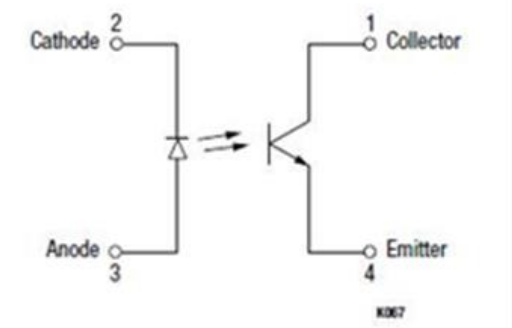


Figure 1. OLS049 Block Diagram

PROCUREMENT / PARTS ORDERING

COST OPTIMIZATION IN PLATO: SKYWORKS OPTOCOUPLERS

- **OLS049** and **OLS249** have both inside the same add-on parts (this is, diode and transistor). There was an ongoing lot of OLS049 being manufactured to include screening equivalent to JANS level iaw MIL-PRF-19500 plus additional groups.

- Skyworks have confirmed that there were enough overrun of the add-ons parts lots used to manufacture this OLS049 lot to manufacture the required parts of OLS249.

- Combined order for OLS049 and OLS249 to secure both parts come with add-ons parts from the same lot.

PROCUREMENT / PARTS ORDERING

COST OPTIMIZATION IN PLATO: SKYWORKS OPTOCOUPLERS

- RVT testing will be performed also on OLS049 optocoupler covering both lots, and QCI testing for OLS249 will also be covered by the one for OLS049.

- Groups A, B & C do not need to perform either to pay samples since CPPA joined to a OLS049 batch charging only $10.150.

- Combined procurement: TID and DD RVT only on OLS249. Saving of **around 50 KEU:** 11 pcs for TID at 250 EUR, 6 pcs for DD at 250 EUR, DD 20 KEU, SEE 30 KEU.

ALTER

PROCUREMENT / PARTS ORDERING

COST OPTIMIZATION IN PLATO: OSCILLATORS

- QCI Group C sampling is reduced from 8 pcs to 4 pcs and use 3 out of those 4 to later perform the DPA. DPA and QCI Quantity has been decreased from 11 pcs to 4 pcs:

✓ 1101R100M0000BS FP-12

UP= 1950 USD. Saving=1950*7= **13.650 USD**

✓ Hybrid VCXO 100MHz 3,3V Swept Quar FP-16

UP= 4000 USD. Saving=4000*7= **28.000 USD**

✓ 5219R100M0000BS FP-16

UP= 5000 USD. Saving=5000*7= **35.000 USD**

PROCUREMENT / PARTS ORDERING

COST OPTIMIZATION IN PLATO: DC-DC CONVERTERS

QCI Group C sampling is reduced from 5 pcs to 3 pcs which are used later perform the DPA.

SMRT2805S/EKL Flange Mount-12-5962L0622101EXC

UP= 18.000 USD. Saving=18.000*2= **36.000 USD**

PROCUREMENT / PARTS ORDERING

COST OPTIMIZATION IN PLATO: CDCM7005HFG/EM

- TID combined for 2 Users (MSSL & DLR)
- TID is not a standard radiation test:
- This is a clock synchronize which requires a complex bias circuit for electrical measurement and internal register programming through SPI protocol during the tests
- RF device: this microcircuit which operate up to 2GHz.
- Package: Flat-pack 52. It's not a standard package, so it will require procure 14 customized sockets or design a custom solution valid for RF devices.
- CPPA achieved samples for the same wafer procured for both Users. No need to repeat complex TID (**35KEU**) and extra 11 TID samples (**31 KEU**)

PROCUREMENT / PARTS ORDERING

COST OPTIMIZATION IN PLATO: 23 high precision resistors

- 3 DPA tests only using highest resistance value for each package. So it was skipped the cost for 20 DPA tests (average price is 500€). Average unit price is 25€ and DPA is performed on 3 pcs.

- Hence the saving breakdown is as follows:
  - (20*500)=10000EUR +
  - (25*20*3)=1500 EUR
  - **SAVING= 11.500€**

PRACTICAL SESSION

PART TYPE REDUCTION

ALTER

ENGINEERING TASKS – QUAD OPAMP REDUCTION

Component Number	Part Type	MFR	QTY.	Technology (kind of transistors, number of amplifiers, bandwidth)	Package	Detail Spec	Quality Level	Description
5962R9325801VDA	OP467AM/QMLR FP-14	AND U	19	**BJT, Quad, 28 MHz**	FP-14	5962-93258	QML V	Microcircuit, Linear, Radiation Hardened, Precision, High Speed, Quad Operational Amplifier. Only Radiation guaranteed at HDR .
RH1499MW	RH1499MW FP-14	LTC	6+13+32+47	**BJT, Quad, 10 MHz**	FP-15	MFR DATASHEET	MIL TEMP	10MHz, 6V/µs, Quad Rail-to-Rail Input and Output Precision C-Load Op Amp
5962R0051702VDA	OP484AM/QMLL FP-14	AND U	6 + 29 + 6 + 17	**BJT, Quad, 8 MHz.**	FP-14	5962-00517	QML V	Microcircuit, Linear, Quad, Rail-to-Rail, Precision, Operational Amplifier. User requested variant 01 but it is proposed and recommended to use variant 02. (guaranteed ELDRS at 50Krads). NOTE : for not guaranteed parts, radiation data shows parameters out of spec at 25KRAD (RHF484 proposed althout power compsumtion)
5962F0822201VXC	RHF484K01V	STM F	22 + 25 + 8	**BJT, Quad, 8 MHz.**	FP-14	5962-08222	QML V	Microcircuit, Linear, Precision, Quad Operational Amplifier. ELDRS free Power compsumtion
LT1014DMDWREP TBC	LT1014D-EP TBC	TEX U	8	**BJT, Quad, 1 MHz.**	soic-16	TBC	TBC	To be replaced by RH1014
TBD	LM124QML TBD	NSC U	10	**BJT, Quad, 1 MHz.**		TBD	TBD	LM124QML Low Power Quad Operational Amplifiers
5962R9950402VDA	LM124AWRLQMLV	NSC U	7 + 6	**BJT, Quad, 1 MHz.**	FP-14	5962-99504	QML V	Var 02 ELDRS guarantee
RH1014MW	RH1014MW FP-14	LTC	6+4+0+22	**BJT, Quad, 500 KHz**	FP-14	MFR DATASHEET	Class S Equiv	Quad Precision Operational Amplifier. Guaranteed at HDR
RH1014MJ	RH1014MJ DIL-14	LTC	7	**BJT, Quad, 500 KHz**	DIL-14	MFR DATASHEET	Class S Equiv	Quad Precision Operational Amplifier
5962-9452101M2A	OP497BRC/883 (TBC)	AND U	8	**BJT, Quad, 500 KHz**	QCC-20	5962-94521	QML Q	Picoampere Input Current,.NOTE: Radiation data shows that parameters are ot of spec at 5KRads
5962-8777101VKA	OP400AN/QMLV FP-24	AND U	3	**BJT, Quad, 500 KHz**	FP-24	5962-87771	QML V	Quad Low-Offset, Low-Power, Operational Amplifier. NOTE: Very radiation sensitive (parameters out of spec at 5KRAds)

ALTER

ENGINEERING TASKS – QUAD OPAMP REDUCTION

- 11 Quad Operational Amplifiers included on DCLs (class 1 Project).
- Standardization proposed to reduce to 4 types. Points to consider:
  - Quantities required.
  - Project requirements.
  - Quality-costs-risks trade off.
  - Standardization should not force to make important design changes.
- QMLV or JANS selected if posible according to Project requirement.
  - RHF484K01V (5962F0822201VXC) and OP484AM/QMLL FP-14 (5962R00517**02**VDA) are QML-V ELDRS guaranteed → OK for Project
  - RH1014MW FP-14 and RH1499MW FP-14 available for space as per MIL-PRF-38535 but not formally qualifed → QCI+DPA+RVT ELDRS

ALTER

ENGINEERING TASKS – QUAD OPAMP REDUCTION

- Class 1 Project:

    - Unit Price: 500 € → need quantity + 3 DPA + 11 RVT
    - Datapack: 2000 €
    - DPA on 3 pcs: 550 € (RH1014 y RH1499 **currently** qualified, no DPA needed).
    - TID on 11 pcs: 7500 €

- Class 2 Project:

    - QMLQ + PIND requested, no need to procure QMLV.
    - QMLQ versions not manufactured → no price reduction on unit Price.
    - Unit Price+ 11 RVT
    - Datapack: 2000 €: 500 € → need quantity
    - ~~DPA on 3 pcs: 550 €~~ → not requested on class 2
    - RVT on 11 pcs: 7500 €

ALTER

ENGINEERING TASKS – QUAD OPAMP REDUCTION

- What if any of the other items would had been used on the Project (OP497BRC/883) → Justification Document needed!

- Upscreening to class S or V equivalent should be performed plus radiation. Supposing 8 pcs needed, 52 would be necessary to perform tests on them

LABORATORY REMARKS

Screening from MIL-STD-883 class B to equivalent class level S (class V).
 	
Part Distribution:
 	
- TOTAL QTY: 52 pcs
    - SET-UP: 5 pcs
    - CONTROL: 1 sample
    - RVT (TID): 10 pcs + 1 control sample
    - SCREENING: 36 pcs + 1 control sample
        - FM: 8 pcs
        - CUSTOMER ATT: 3 pcs
        - LIFE TEST: 15 pcs
        - DPA: 3 pcs
        - ATN ATTRITION: 7 pcs
 	
Electrical Parameters: IIN, VOH, VOL, RO & IS.

- Unit Price 100 €.

ENGINEERING TASKS – QUAD OPAMP REDUCTION

- 52 pcs * 100 €: 5200 €
- Upscreening costs: 20000 €
- DPA on 3 pcs: 700 €
- RVT on 11 pcs: 6500 €
- TOTAL: 32400 €
- 32400 € VS QML-V option, **19050 €**
- Besides costs, this alternative has far more risks on technical side.
- However, it could be interesting for some projects (new-space), where volumen of components can be much higher (TRADE-OFFS!)

ENGINEERING TASKS – QUAL vs COTS (CLASS 1)

- OPA602 requested. Obsolete although stock from old DCs available.
- Component with heritage on previous projects.
- Risk leads to look for alternatives.
  - OP15AJ/QMLR. QML-V rad guaranteed HDR 100 krad (ELDRS needed)
  - OP16AJ/QMLR. QML-V rad guaranteed HDR 100 krad (ELDRS needed)
  - RH1056A as per SPEC NO. 05-08-5212 for space applications. Rad guranteed 200 krad HDR (ELDRS needed)
  - AD549SH/883B. Upscreening to class V or S equiv, DPA and RVT needed.

ENGINEERING TASKS – QUAL vs COTS (CLASS 1)

- Technical trade-off

		OPA602	OP15S	OPA627	OPA140	RH1056	OP16S	AD549S
Quality level		COTS (obsolete)	MIL-PRF-38535	COTS	COTS	COTS	MIL-PRF-38535	COTS
Part Designation		OPA602SM	5962R89542 03VGA	OPA627SM	OPA140AID	RH1016AMH	5962R89543 04VGA	AD549SH/8 83B
Input Bias Current max.	**@ 25°C**	±2pA	±50pA	±5pA	±10pA	±50pA	±50pA	±0,1pA
	@ 85°C	±200pA	±50pA	±1nA		±50pA	±50pA	
	@ Tmax	±2nA	±5nA	±50nA	±3nA	±3nA	±5nA	±420pA (typ)
Input Bias current @ 25°C	**@ 50Krad**	??	??	??	??	500pA	??	??
	@100Krad	??	3nA	??	??	1000pA	3nA	??
Input Resistance		10^13 Ohms	10^12 Ohms	10^13 Ohms	10^13 Ohms	10^12 Ohms	10^12 Ohms	10^13 Ohms
Input Capacitance		1pF	3pF	7pF	10pF	4pF	3pF	1pF
Input Noise Density	**@ 100Hz**		20nV/√(Hz)		5,8nV/√(Hz)		20nV/√(Hz)	60nV/√(Hz)
	@ 10Hz	23nV/√(Hz)		15nV/√(Hz)	8nV/√(Hz)	28nV/√(Hz)		90nV/√(Hz)
	@ 1KHz	13nV/√(Hz)	15nV/√(Hz)	5.2nV/√(Hz)	5,1nV/√(Hz)	14nV/√(Hz)	15nV/√(Hz)	35nV/√(Hz)
Unit gain bandwidth		4MHz min.	3,5MHz min.	16MHz typ.	11MHz typ.	6.5MHz typ.	5,5MHz min.	-
Supply Current	**@ 25°C**	4mA max.	4mA max.	7.5mA max.	2mA max.	6.5mA max.	7mA max.	0,7mA
	@Tmax	4,5mA max.	11mA max.	7,5mA max.	2,7mA max.	?	11mA max.	0,7mA
Output voltage offset	**@ 25°C**	±500µV	±500µV	±100µV	±120µV	±300µV	±500µV	±500µV
	@Tmax	-	-	-	±220µV	±900µV	-	-
Tj max. (rated value)		175°C	150°C	175°C	150°C			
Operating temperature		-55°C /	-55°C /	-55°C /	-55°C /	-55°C /	-55°C /	-55°C /

ALTER

ENGINEERING TASKS – QUAL vs COTS (CLASS 1)

- Facts:
  - Is it worth to perform activities in an obsolete part? → OPA602 rejected.
  - OPA140 (unit Price 2 €). COTS, full qualification + screening + RVT + DPA → 75k€ cost
  - OP15AC/QMLR. Unit Price 500 €.
    - 22 pcs requested: 11000 €
    - TID ELDRS: 7000 €.
    - TOTAL: 18000 €.
- Again, for projects with more relaxed technical requirements, it could be interesting to select a COTS component for high quantities.

DCL - PROCUREMENT Quantities

Attrition rules are defined in any project.

As supplier of any equipment, each company has full responsability on the attrition policy.

Different generic rules can be found and have been used in several projects

Table 23: *Attrition rules*

Needed Quantity	Additional quantity for attrition
1 to 5	3
6 to 10	4
11 to 30	6
31 to 50	8
51 to 100	12
>100	15%

Total quantity	Spare quantity
Q < 3	2
Q < 4	3
Q < 17	4
Q < 26	5
Q < 65	8
Q < 82	9
Q >81	10%

Proposed standard EEE parts attrition policy which could be tailored according to component criticality and price (except for FPGA: 2 spare for 3 and MRAM: 1 spare for 3)

These rules can be adapted to expensive parts, programmable parts, etc.

DCL - PROCUREMENT Quantities

Testing pieces should always be considered.

- DPA. Usually 3 pcs. For expensive pcs, DPA could be reduced to 1 pc, TBC with EEE expert working on the Project.
- TID. Usually 11 pcs (5 biased, 5 non-biased, 1 control).
- DD. Usually 6+1 pcs.
- SEE. Usually 6+1 pcs.
- Evaluation/Qualification on COTS. Follow ECSS-Q-60-13C.

- Other order cost: documentation, additional test, CSI,...

PRACTICAL SESSION

PARTS ORDERING: QUANTITIES

ALTER

DECLARED COMPONENT LIST

Component Number	Part Type	MFR	RVT	DPA	Qty required
300900806C332KE	3.3nF 100V 10%	AVX F			42
400102309R4702B2	47k 0.1% 10ppm	VSH U			78
520200106R	2N2907ARUBG LCC-4 (UB)	STM F			47
320100803C102K	MSCI 20K 1mH 10% Case C Chip	EXXE			8
1157R100M0000BF	1157R100M0000BF	VIN U			10
5962F9568902VXC	HS9-26CLV32RH-Q	HAR U			4
5962R1620101KYC	MSK496RH	MSK	Yes	Yes	38
JANSR2N7616UB	IRHLUB770Z4	IRF			8
340102901B9PFR112	MDM 9P FR112	C&K F			2
5962-0422107QUC	RTAX2000SL-CQ256E	ACT		Yes	4

- What are the final quantities to be procured (dismiss so far MOQs from MFR).
- Is there any way to reduce total quantities in any item?

ALTER

DECLARED COMPONENT LIST

Component Number	Part Type	MFR	RVT	DPA	Qty required	Qty to buy
CDR33BP272AJUR	CDR33 2,7nF 5% 50V TC:0±30ppm/°C 1210	KEM U			42	42
400102309R4702B2	47k 0.1% 10ppm	VSH U			78	78
520200106R	2N2907ARUBG LCC-4 (UB)	STM F			47	47
320100803C102K	MSCI 20K 1mH 10% Case C Chip	EXXE			8	8
1157R100M0000BF	1157R100M0000BF	VIN U			10	10
5962F9568902VXC	HS9-26CLV32RH-Q	HAR U			4	4
5962R1620101KYC	MSK496RH	MSK	Yes	Yes	38	38+11+3
JANSR2N7616UB	IRHLUB770Z4	IRF			8	8
340102901B9PFR112	MDM 9P FR112	C&K F			2	2
5962-0422107QUC	RTAX2000SL-CQ256E	ACT		Yes	4	4+1

- DPA on FPGA done in 1 pc due to their high cost and reliability/heritage.

DECLARED COMPONENT LIST

Component Number	Part Type	MFR	RVT	DPA	Qty required	Qty to buy
CDR33BP272AJUR	CDR33 2,7nF 5% 50V TC:0±30ppm/°C 1210	KEM U			42	42
400102309R4702B2	47k 0.1% 10ppm	VSH U			78	
520200106R	2N2907ARUBG LCC-4 (UB)	STM F			47	47
320100803C102K	MSCI 20K 1mH 10% Case C Chip	EXXE			8	8
1157R100M0000BF	1157R100M0000BF	VIN U			10	10
5962F9568902VXC	HS9-26CLV32RH-Q	HAR U			4	4
5962R1620101KYC	MSK496RH	MSK	Yes	Yes	38	38+11
JANSR2N7616UB	IRHLUB770Z4	IRF			8	8
340102901B9PFR112	MDM 9P FR112	C&K F			2	2
5962-0422107QUC	RTAX2000SL-CQ256E	ACT		Yes	4	4+1

- We can reduce quantity of MSK496RG if we use 3 pcs coming for RVT for DPA (destructive pcs in any case)

PRACTICAL SESSION

DOCUMENTATION PREPARATION

TESTS PLANS/DOCUMENTATION GENERATION

- Negotiation and edition of detail specifications
- PADs preparation
- Upscreening plans preparation
- Evaluation plans preparation
- Technical notes preparation
- Radiation hardness assurance programme
- Radiation Verification Test plan preparation

Manpower (engineering) + time : COST!!!

EVALUATIONS

CLASICAL TECHNOLOGY EVALUATIONS STRUCTURE

Work Package 0 - Design Assesment

- User to provide justification in a design and application reports

Work Package 1 - Component Manufacturer Assessment

- Data collection
- Evaluation Plan edition
- Evaluation Plan approval
- Evaluation samples purchasing

Work Package 2 - General Device analysis

- External visual /good receiving inspection
- Electrical measurements
- ESD
- Constructional Analysis,

ALTER

EVALUATIONS

Work Package 2 (cont) - General Device analysis

- Manufacturer assesment (visit/audit)
- Interim report
- Interim report approval

Work Package 3 - Radiation Hardness.

- Total Dose
- HIT (SEU, LU, B.O..)
- Protons
- Radiation Reports
- Radiation Reports Approval

EVALUATIONS

Work Package 4 - Evaluation Testing

- Screening/electrical measurements
- Environmental subgroup
- Mechanical subgroup
- Endurance subgroup (2000Hrs/125°C)
- DPA
- Evaluation testing reports
- Evaluation testing reports approval

Work Package 5 – Conclusions

- Evaluation report
- Evaluation report approval

ECSS-Q-ST-60-13C - Space product assurance - Commercial electrical, electronic and electromechanical (EEE) components (under public review)

ALTER

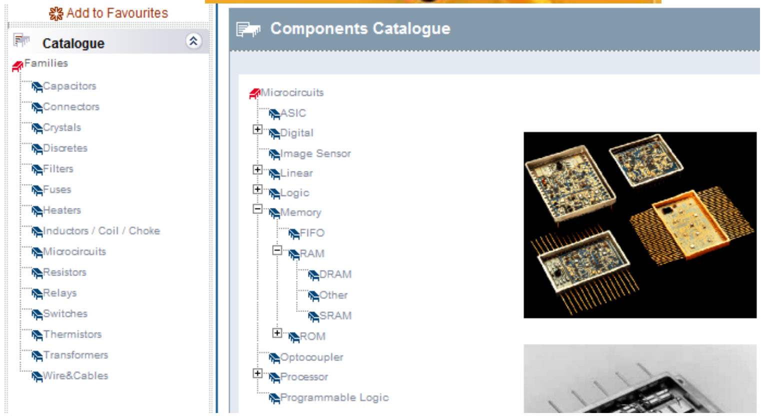
PARTS ENGINEERING

USE OF COTS AND NON SPACE PARTS

- A methodology for the selection and procurement of COTS is required, including:

    - Risk assessment (functionality risks, production risks and support risks).
    - Parts selection (obsolescence, environmental and design considerations and manufacturer production flow and know-how).
    - Component reliability assurance (characterization, screening and validation).

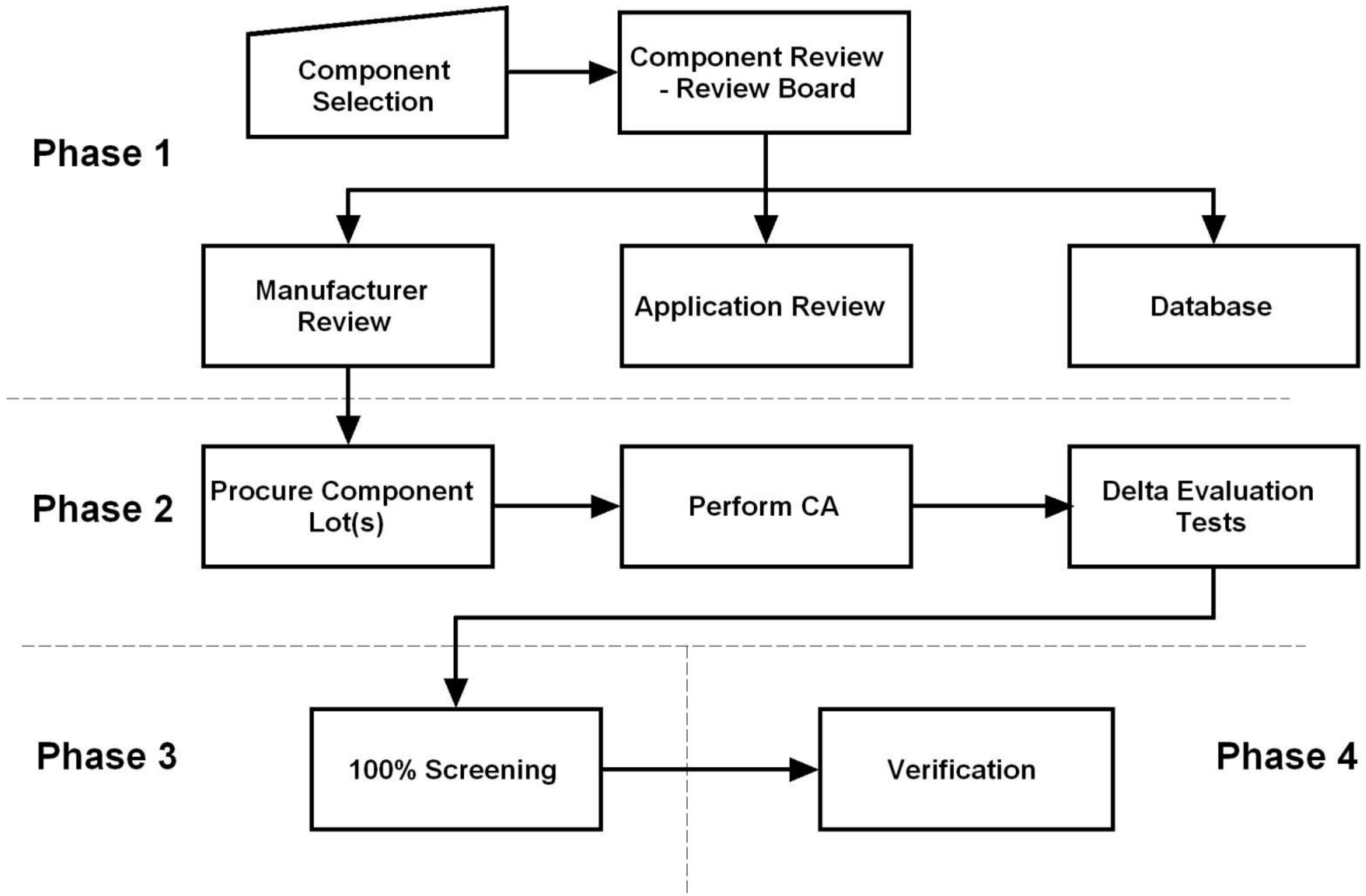
- All of these activities must be performed by experienced component specialists and test houses to ensure all possible concerns and risks are identified and alleviated.



ALTER

PARTS ENGINEERING

USE OF COTS AND NON SPACE PARTS



ALTER

SAVINGS WITH COTS AND NON SPACE PARTS IN PLATO

DG612DY: same wafer as the one used in Euclid

Outgassing test was performed in the frame of Euclid constructional analysis. The test is clearly successful: CVCM 0% and TML 0.053%. There was no change on raw materials so the test can therefore be waived.

Saving = 2,5 KEU

TID has been removed from the evaluation flow as PLATO procured batch comes from the same wafer as in Euclid.

Saving= 7 KEU

ATN laboratory has performed the LMV test on the DG612DY, being the results that lead finish is Sn/Pb 85/15. Therefore, retinning and the Retinning Process Verification could be skipped on this type based on this result. **Saving= 8 KEU**

PARTS ENGINEERING

SAVINGS WITH COTS AND NON SPACE PARTS IN PLATO

AD8021ARZ: OP-AMPS used by 2 Users (MSSL and DLR)

The major cost figure in a COTS qualification is the technical approach for electrical measurement, environmental and radiation tests bias conditions, based on device architecture and electrical parameters to be measured. This includes:

- Hardware development for electrical measurement.
- Design, manufacture and assembly of a hardware platform.
- High performance socket procurement.
- Electrical measurement software development.
- Electrical measurement setup validation including both hardware and software.
- Hardware development for environmental test and for radiation test.

In PLATO these activities were performed in paralell.

Saving= 30 KEU.

ALTER

PARTS ENGINEERING

SAVINGS WITH COTS AND NON SPACE PARTS IN PLATO

AD7961:

MSSL presented an RFD regarding the skip of retinning for AD7961BCPZ due to having only pure tin on the bottom of the lead. ATN performed a second LMV on PLATO lot showing same results as on previous test. Central pad material has shown to be Sn 100%. **Saving= 8 KEU**

SEE campaign for 3 types: DG612DY, AD7961 and EL7457

Saving= 15 KEU

PRACTICAL SESSION

EVALUATION/COTS

ALTER

USE OF COTS – TESTS ROM PRICES

EEE part	Test	Type part	ROM price
HMC361S8G	Constructional Analysis	SMT GaAs HBT MMIC	3000 €
MYX6M4424C8	Upscreening to QMLV	MOSFET driver	20000 €
C420	CA + Screening + Environmental/Mechanical + DPA	Resistance temperature detector	35000 €
C1206C102KGRAL7025	Screening (EM + Burn-in + EM) + DPA	Chip capacitor	3500 €

- Tests needed and complexity of device continue showing the different impact on prices!

ALTER

USE OF COTS – TESTS ROM PRICES

EEE part	Test	Type part	ROM price
OPA128	Qualification + Screening + TID	Op. Amplifier	78000 €
Fiberguides	Gamma and Electron RVT at low temperature (-230°)	Fiberguide	95000 €
HMC1060LP3E	Qualification + Screening + DPA + TID	Low noise voltaje regulator	130000 €

- Tests needed and complexity of device continue showing the different impact on prices!

USE OF COTS – TESTS ROM PRICES

SAVINGS WITH COTS AND NON SPACE PARTS IN PLATO

AD8021ARZ: OP-AMPS used by 2 Users (MSSL and DLR)

	LABOUR							
Direct Labour cost centres or categories Code	*/ Description*	*No. of FTE (calculated)* ***U = W / V***	*Sold Hours per ManYear* ***V***	*Manpower Effort No. of Hours* ***W***	*Gross Hourly Rate in NC*			
EEE	Engineer	0,15	1.760	269,74	82,09		22.143,21	22.143,21
EEE	Technician	0,28	1.760	486,76	58,02		28.241,81	28.241,81
EEE	Admin and Support	0,02	1.760	41,49	49,97		2.073,14	2.073,14
							0,00	0,00
							0,00	0,00
							0,00	0,00
							0,00	0,00
							0,00	0,00
							0,00	0,00
							0,00	0,00
							0,00	0,00
1	Total Direct Labour Hours and Cost	*0,5*		*798,0*		A	*52.458,16*	*52.458,16*

Labour hour is a key aspect in COTS qualification+ screening over other cost aspects

ALTER

Customized items

Users can also require procurement of customized ítems.

It is strongly recommended to **ensure that EM/EQM will be fully representative of the FM parts**.

- In the event that no standard specification or internal manufacturer production specification is available a customer specification may be released.
- This type of specifications must be minimized since the cost associated to these parts is typically much higher than standard procedure ones as well as a less control from the manufacture side.
- Require additional testing

ALTER

Customized Items: PLATO example

Coilcraft Inductor: AE522 RAS 161 with > 5A rating, air core preferred, SM preferred.

Available screened iaw ESCC 3201, iaw EEE-INST-002 level 1 and iaw MIL-STD-981 class S. Also, Group B is available.

Compliant to military temperature range and finish in tin/lead over copper.

Outgassing compliant.

There was concern on ESA and the CPPA related to the mounting of this part and its capacity to withstand vibration and mechanical shock.

Vibration and mechanical shock test= **8 KEU.**

CUSTOMIZED ITEMS

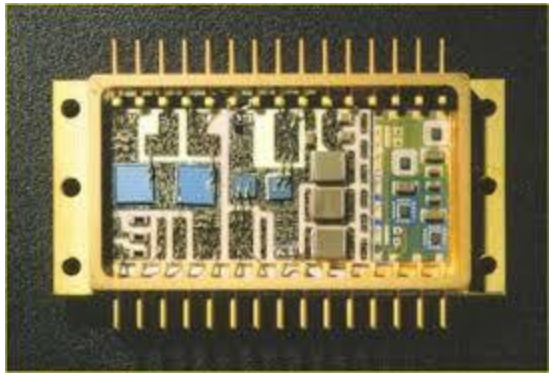
- Impact of Customized Items.

  ❑ Cost impact → Design, drawings.
  ❑ Schedule → Manufacturing of customized parts are usually longer.
  ❑ Quality → Probabilities of rejected lot increase.

- More complex devices (i.e. Hybrids) need more extense preparation.

  ❑ Are all devices inside the hybrid accepted in my Project?
    ❖ Yes. OK!
    ❖ No → tests needed on parts.

  ❑ Tests needed on the device



CUSTOMIZED ITEMS

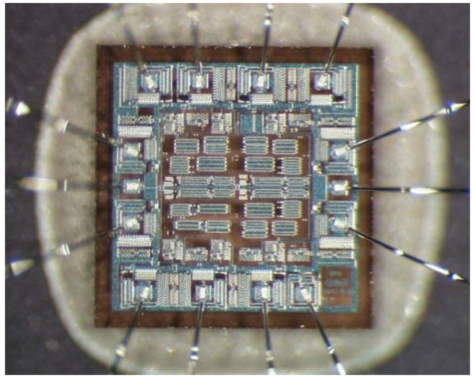
- Customized items testing can be similar to full evaluations on COTS seen in previous slides.
- Costs can vary significantly depending on complexity
    - Set up design may take several weeks and effort. Most occasions, custom part designers are the most appropriate personnel to develop set-up → close relationship between designers and test house.
    - Tests to be performed depend on technology, but will be always similar to any other part.

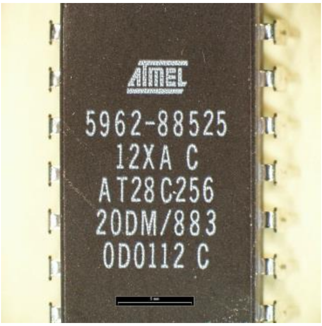
LOT SCREENINGS

SCREENING

TESTS, INSPECTIONS OR COMBINATION THEREOF, IMPOSED ON 100% OF PARTS TO REMOVE UNSATISFACTORY ITEMS OR THOSE LIKELY TO EXHIBIT EARLY FAILURES.

EUROPEAN AND INTERNATIONAL SPACE PROGRAMS USE PARTS WHICH ARE TYPICALLY SCREENED ACCORDING TO ESCC AND MIL SPECIFICATIONS.





LOT SCREENINGS

SCREENING

HIGH REL PARTS ARE 100% SCREENED

NON-HIGH REL PARTS HAVE TO BE SUBMITTED TO SCREENING → COSTS AND SCHEDULE DRIVERS

- Quantities will directly impact the cost of the screening (manpower for screening)
- Complexity of EEE part also directly impacts cost of screening (set-up design)

WHAT?

INSPECTIONS AT MFRs'

ECSS-Q-ST-60C Rev. 3 (12 May 2022)

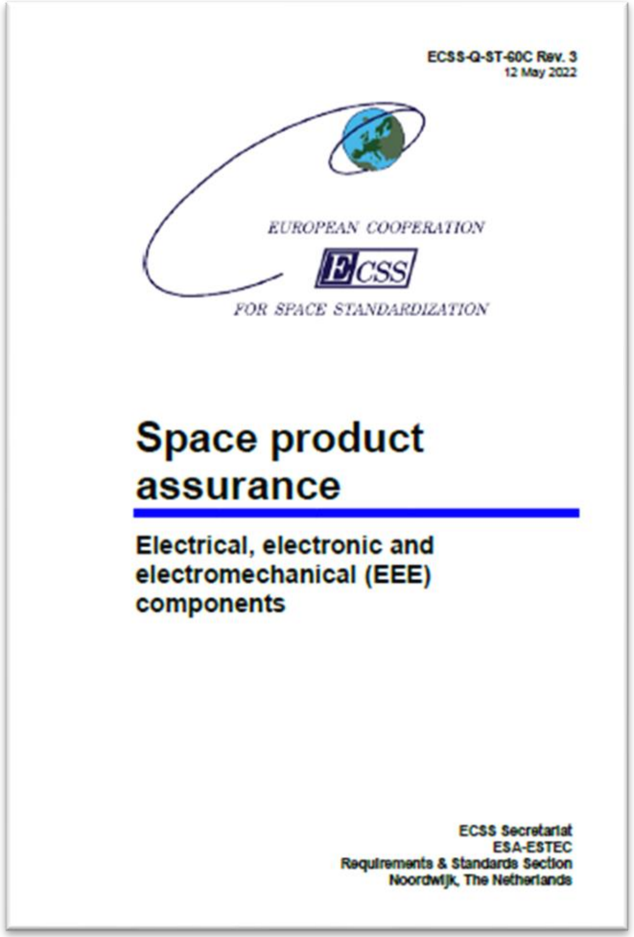
4.3.4 Initial customer source inspection (precap)

a. 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).

b. The procurement entity shall carry out, at the manufacturer´s premises, a customer precap inspection on critical space qualified parts, including as a minimum relays, crystals, oscillators and hybrids.

c. When not covered by MIL or ESCC specifications, methods and accept / reject criteria for customer´s precap inspection shall be documented by a procedure to be presented to the customer, on request, for review.


ECSS-Q-ST-60C Rev. 3
12 May 2022

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ECSS
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Space product assurance

Electrical, electronic and electromechanical (EEE) components

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

ALTER

Precap INSPECTION STAGES

1 - Special In-Process Controls

2 - Documentation Review

3 - Optical Inspection

4 - Wire Bond Strength

5 - Die Shear

6 - Accept / Reject

7 - Reporting

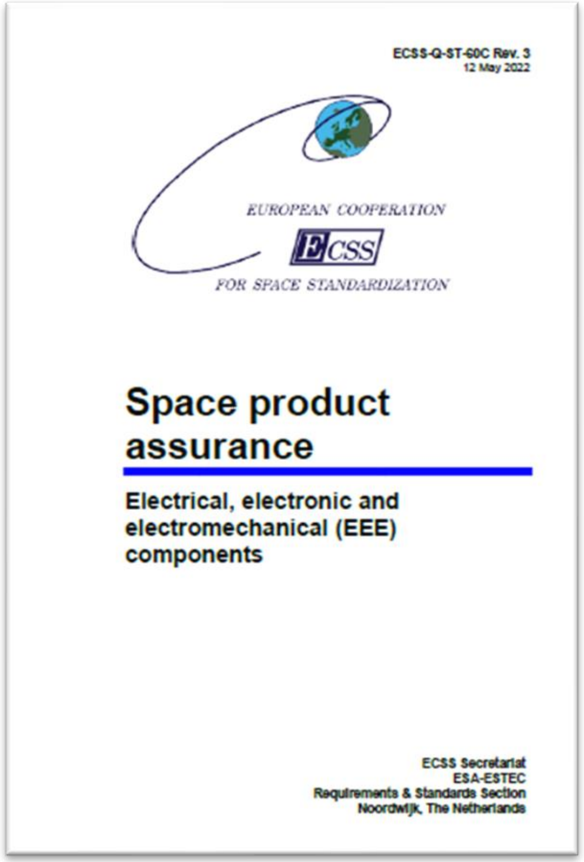
INSPECTIONS AT MFRs’

ECSS-Q-ST-60
Electrical, electronic and electromechanical (EEE) components

4.3.6 Final customer source inspection (buy-off)

a. 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.

b. 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.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Final Inspection Stages

1.- Documentation Review (Compulsory)

2.- External Visual Inspection (Compulsory)

3.- Other Test. To be agreed Customer and MFR

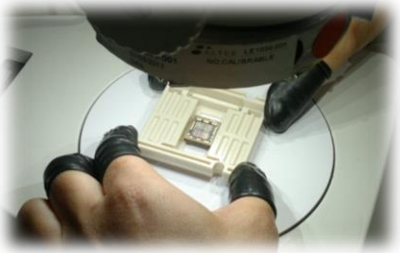
- Dimension and weight check
- Electrical Measurements
- QCI / LAT-LVT witnessing
- Lead finish verification
- Check packaging material

4.- Accept/Reject and Lot Disposition

5.- Reporting (Compulsory)

INSPECTIONS AT MFRs’

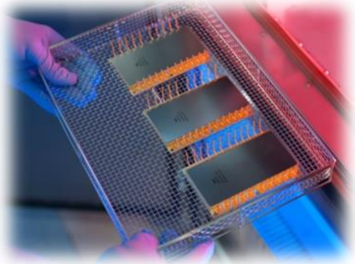
Customer Source Inspection



Initial Assembly

Pre-Cap (Initial CSI)

Final Assembly (Sealing Process)



Final Production Testing & Screening

Buy-Off (Final CSI)

CUSTOMER SOURCE INSPECTIONS - COSTS

Different costs apply to Customer Source Inspections (Precap and Buyoff).

- Manufacturers charges. They apply a single charge for each inspection, in order to provide support during the length of the inspection.
  - Charges may vary from 500 €/USD to 1500 €/USD.

- Inspection cost. Inspection can be performed by the company procuring EEE components or a trustable inspection company (inspections to be performed usually in Europe or USA).
  - Travel expenses + personnel time have to be considered.
  - Pricing for inspection services vary significantly on the location of the Manufacturer. Ranges from 500 €/USD to 4000 €/USD (most expensive pricing typically in USA).

INCOMING INSPECTIONS

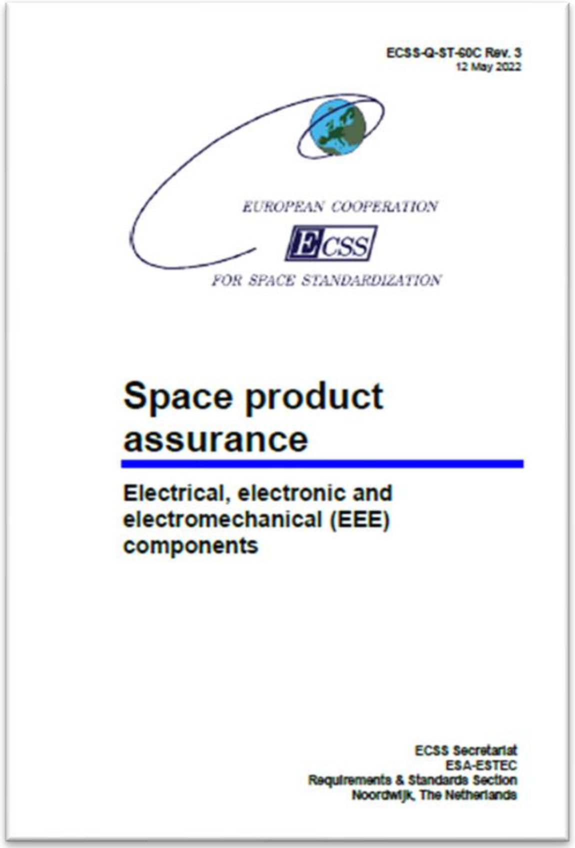
ECSS-Q-ST-60
Electrical, electronic and electromechanical (EEE) components

<u>4.3.7 Incoming inspections (I/IV)</u>

a. The procurement entity shall perform incoming inspection at his premises on all components to verify conformance with the purchase order requirements.

b. The incoming inspection shall include the following items:

1. For any part:
   - (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) In case of not golden termination finish, check the lead finish as per ESCC 25500 basic specification.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ALTER

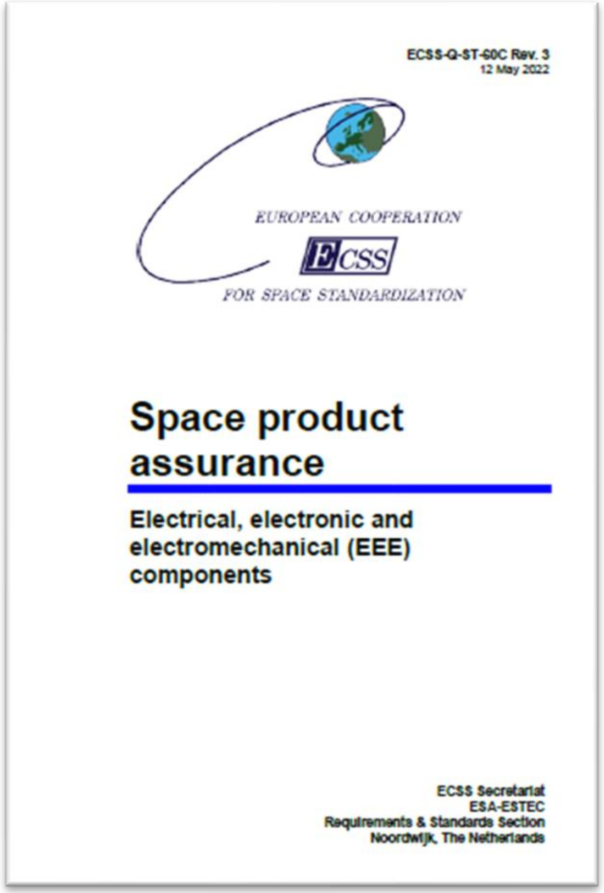
INCOMING INSPECTIONS

4.3.7 Incoming inspections (II/IV)

2. 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 data package review.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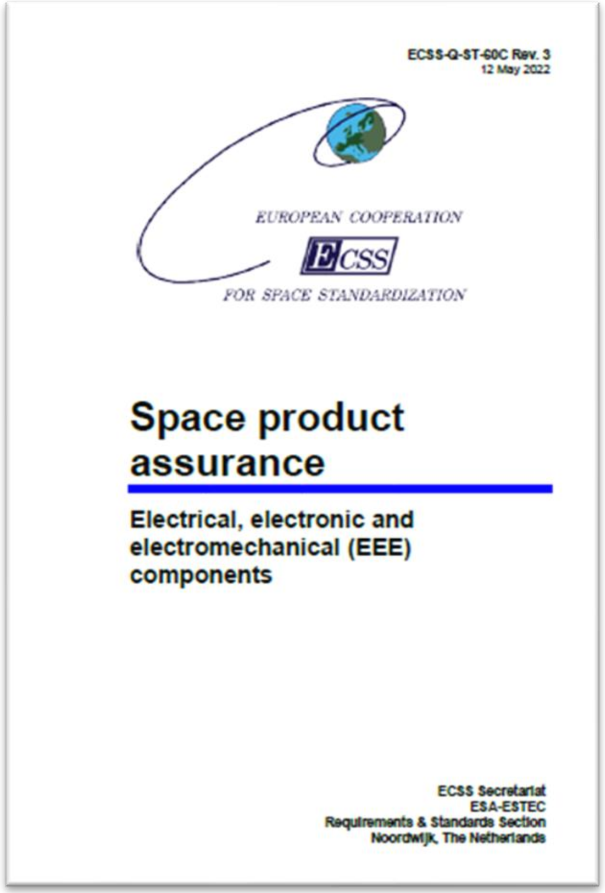
INCOMING INSPECTIONS

4.3.7 Incoming inspections (III/IV)

c. The incoming inspection shall be documented by a procedure to be presented, on request, to the customer for review.

d. 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.



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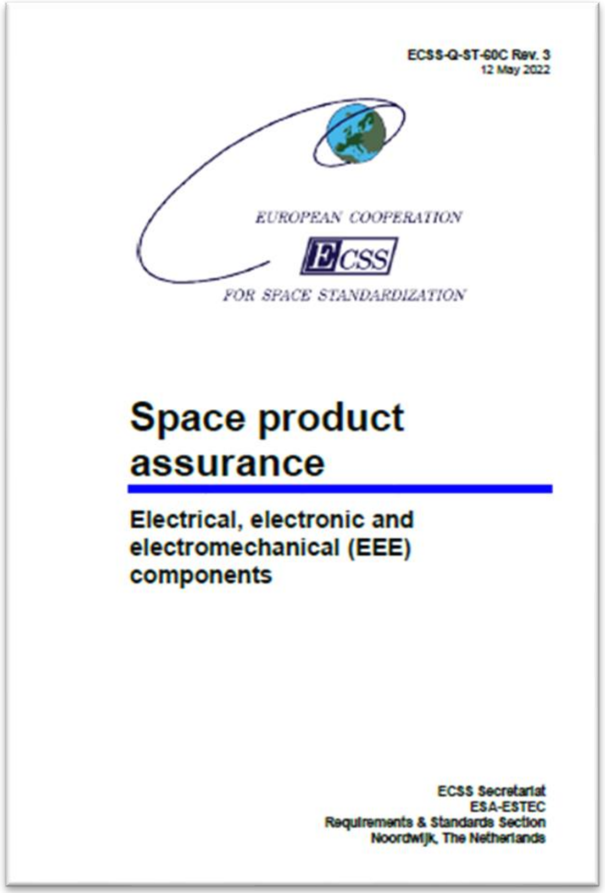
INCOMING INSPECTIONS

4.3.7 Incoming inspections (IV/IV)

e. In case the incoming inspection has been performed by a procurement agent, the incoming inspection performed by the end-user, may be reduced to the following minimum:

1. Packing checking,
2. Quantity verification.

Equivalent paragraphs: 5.3.7 and 6.3.7 can be found for device classes II and III.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INCOMING INSPECTIONS

Inspection Stages

1.- Travel Visual Inspection (Compulsory)

2.- External Visual Inspection

3.- (Dimension and weight Check)

4.- Lead Finish Verification (Compulsory)

5.- Electrical measurements

6.- Lot Data Review (Compulsory)

7.- Other Inspections

8.- Reporting (Compulsory)

Compulsory requirements based on ESCC Basic Spec N° 21004

ALTER

INCOMING INSPECTION - COSTS

Packing checking and Quantity verification shall be performed on every lot by end-user. Costs will depend mainly on the quantity requested.

Electrical measurements for non-qualified components can be the driver for a higher cost on the Incoming Inspection.

In any case, Incoming Inspection cost is the lowest one compared to any other tests.

On the other hand, it is mandatory on every procured item.

Range of costs can vary from 200 to 500 €.

ELECTRICAL TESTS

Subject to device complexity, costs for development of needed electrical test programmes may be non negligible

When do these tests need to be carried out?

- Incoming Inspection
- Before and after thermal cycling
- Before and after each radiation steps
- ...

Potential extra costs to be considered in Electrical Measurement:

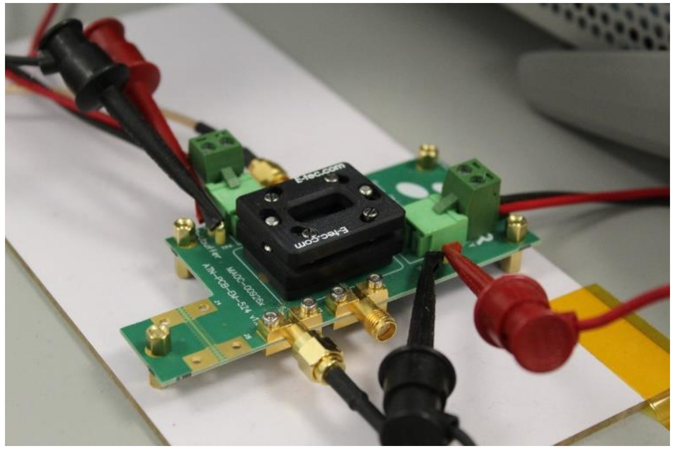
- Set up development → directly related to part complexity
- Manpower + availability of equipment

ALTER

ELECTRICAL TESTS

What parameters will be measured on electrical tests?

- Full datasheet?
- **Driving parameters for Unit design**



Selecting parameters to be measured can drastically change the set-up cost on complex devices (ASICs, RF...) not only on design but also in material costs (i.e. sockets adapted to RF)

Prices ranges typically from hundred € to a few thousands. On complex devices, set-up design and manufacture can lead to expensive costs (above 10 k€)

DPA Introduction and motivation.

Wide range of DPA requirements

- S-311-M-70 GFSC Specification for the Performance of DPA
- SSQ 25000 DPA Testing Specification for the SSP
- MIL-STD-1580 DPA for EEE Parts
- MIL-STD-883 Test Method 5009, DPA
- MIL-STD-750 Test Method 2101, DPA Procedure for Diodes
- MIL -STD-750 Test Method 2101, DPA for Wire Bonded Devices
- NASA-PEM-INST-001 Section 5 DPA for PEMS
- Etc.

Project DPA test matrices

- Defined and discussed on a project basis

ALTER

DPA applicability I.

- In accordance with current ECSS-Q-ST-60, DPA shall be performed on non-space qualified components duly tailored by the class mission.

	Class 1	Class 2	Class 3
DPA families (non-space qualified parts)	Capacitors Crystals Oscillators Discretes (diodes and transistors) Filters MMICs Hybrid Circuits Relays Switches Optical devices Passive Microwave devices	Relays Oscillators Commercial parts	Relays Commercial parts
DPA families (space qualified parts)	Relays Oscillators	-	-

- DPA may not be applicable to ESCC Qualified Components unless specified by ECSS-Q-ST-60 or by the customer.

- DPA may be performed on non-catastrophic failures or out of family devices from the following tests:
  - Post burn in /life test electrical testing at 168 hours / 1000 hours,
  - Temperature cycling per MIL-STD-883, Method 1010, or similar test method,
  - Post temperature cycling electrical measurements (3 temperatures)

DPA applicability II.

- For all other qualified components per ECSS-Q-ST-60 DPA is not required unless the supplier identifies that:

  - the EEE component has a known history of problems, e.g. alerts or NCR's, and previously good DPA results are not available within a two year period.
  - the EEE component has not been in continuous production for at least two years,
  - the EEE component manufacturer has not produced and tested the product in the same facilities for at least two years.
  - there have been changes to the component over the previous two years.

- For components meeting any of the above criteria a DPA shall be performed.

ALTER

DPA Flow for Capacitors, Ceramic, Chip

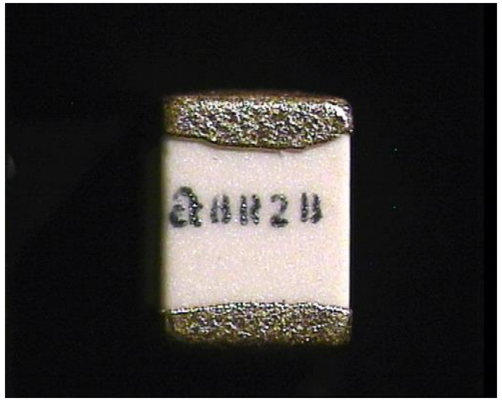
TEST SEQ.	TEST DESCRIPTION	TEST METHOD	SAMPLE
1	**EXTERNAL OPTICAL INSPECTION**	ESCC Basic Specification No.20500	3 PARTS
2	**PHOTOGRAPHIC RECORD**	See next page	1 PART
3	**ELECTRICAL MEASUREMENT**	DETAIL and GENERIC SPECIFICATIONS	3 PARTS
4	**VERIFICATION OF LEAD MATERIAL FINISH**	MIL-STD-1580 Requirement 9	1 PART
5	**MARKING PERMANENCE**	ESCC Basic Specification No.24800	3 PARTS
6	**SOLDERABILITY**	MIL-STD-202 Method 208	3 PARTS
7	**MICROSECTIONAL ANALYSIS**	ESCC Basic Specification No.23400	3 PARTS
8	**PHOTOGRAPHIC RECORD**	See next page	1 PART
9	**DPA REPORT**		3 PARTS
10	**DPA REPORT REVIEW**	DPA Facility Q.A. Dept.	3 PARTS

Note:

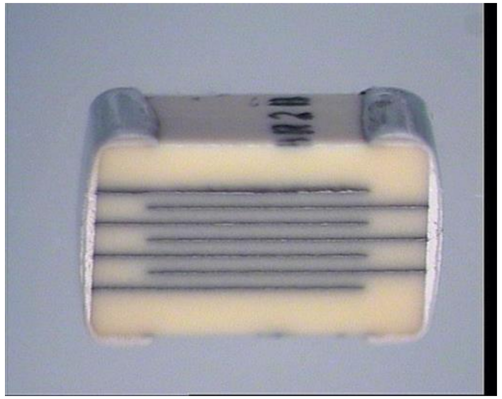
1. Ceramic capacitors rated <100V and used in <10V applications shall be subjected to DPA. The dielectric thickness shall be verified to be a minimum of 0.8 mils (ref. JPL-D-20348).

ALTER

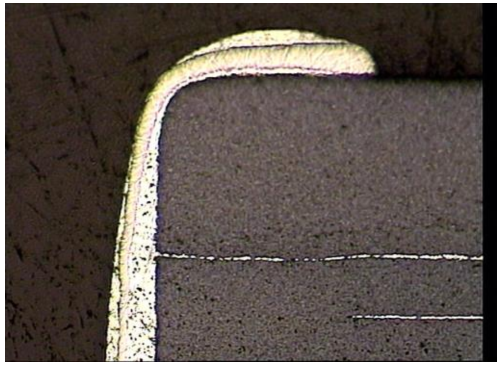
Minimum Images Required for Capacitors, Ceramic, Chip DPA.



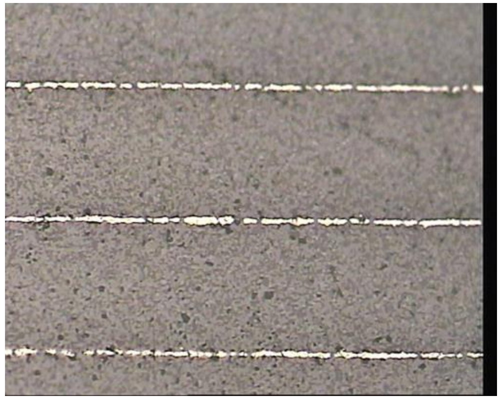
1. Capacitor marking



2. Capacitor in microsection.



3. Capacitor termination in microsection



4. Capacitor plates in microsection

ALTER

DPA Flow for IC's Plastic

TEST SEQ.	TEST DESCRIPTION	TEST METHOD	SAMPLE
1	EXTERNAL OPTICAL INSPECTION	ESCC No.2059000	3 PARTS
2	PHOTOGRAPHIC RECORD		1 PART
3	ELECTRICAL MEASUREMENT	DETAIL and GENERIC SPECIFICATIONS	3 PARTS
4	VERIFICATION OF LEAD MATERIAL FINISH	MIL-STD-1580 Requirement 9*5	1 PART
5	SCANNING ACOUSTIC MICROSCOPY	ESCC No. 25200*5	3 PARTS
6	MARKING PERMANENCE TEST	ESCC Basic Specification No.24800*5	3 PARTS
7	SOLDERABILITY TEST	MIL-STD-883 Method 2003	3 PARTS
8	TERMINAL STRENGTH TEST	DETAIL SPECIFICATION	3 PARTS
9	DE-ENCAPSULATION*2	ESCC No.25300*1	3 PARTS

1. De-encapsulation involves a mixture acids and shall be handled with appropriate care.

2. Every care shall be taken to prevent damage to the internal elements during de-encapsulation.

3. Most plastic encapsulated microcircuits have silver plating on the bonding area, and rapidly degraded by the acid.

4. Some plastic encapsulated microcircuits have copper bond wires which will be rapidly degraded by the acid.

Note 5. These tests are not required by ECSS-E-ST-Q-60-13 and shall be omitted if they are performed as part of a previous test flow performed on the component lot e.g. Constructional Analysis.

7. Scanning Electron Microscopy (SEM) shall be used to support wire bonding Internal Optical Inspection.

8. Special care on AL-AU interfaces

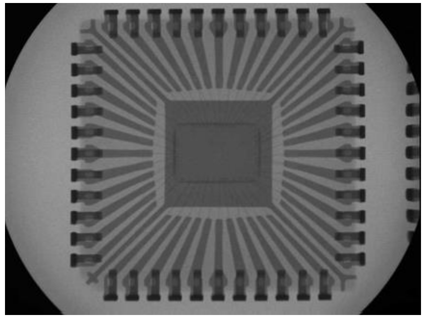
9. Plastic encapsulated microcircuits have an epoxy or polymer die attach which may degraded.

TEST SEQ.	TEST DESCRIPTION	TEST METHOD	SAMPLE
10	INTERNAL OPTICAL INSPECTION*7	ESCC No. 2049000	3 PARTS
11	SEM INSPECTION*7	ESCC Basic Specification No. 21400	1 PART
12	PHOTOGRAPHIC RECORD		1 PARTS
13	WIRE BOND STRENGTH TEST	MIL-STD-883 Method 2011	3 PARTS
14	METALLISATION QUALITY ASSESSMENT	ESCC No. 21400*4	1 PART
15	PHOTOGRAPHIC RECORD		1 PART
16	DIE SHEAR STRENGTH TEST*3	MIL-STD-883 Method 2019	3 PARTS
17	DPA REPORT		3 PARTS
18	DPA REPORT REVIEW	DPA Facility Q.A. Dept.	3 PARTS

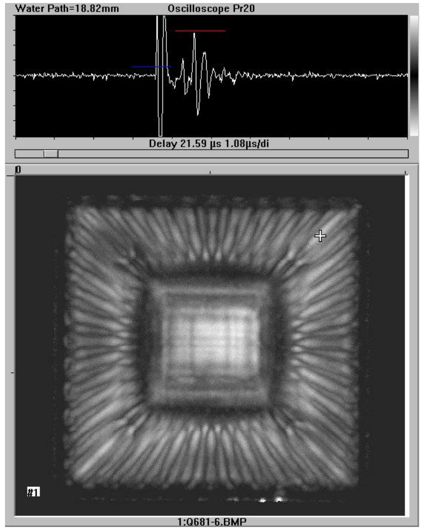
ALTER

Minimum Images Required for IC's Plastic I.

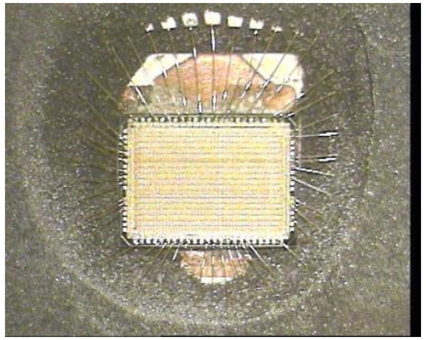
Example of a plastic encapsulated microcircuit.



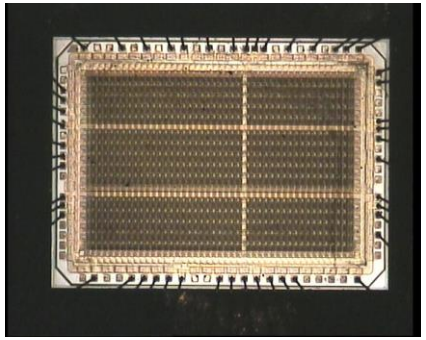
Radiographic image of a plastic encapsulated microcircuit.



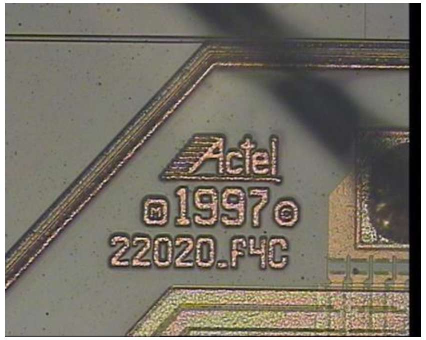
Acoustic microscope image of a plastic encapsulated microcircuit



De-encapsulated microcircuit.



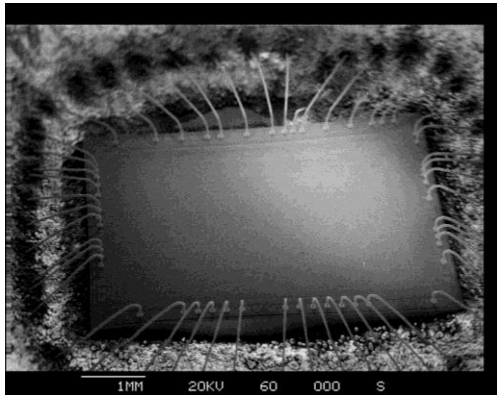
De-encapsulated die



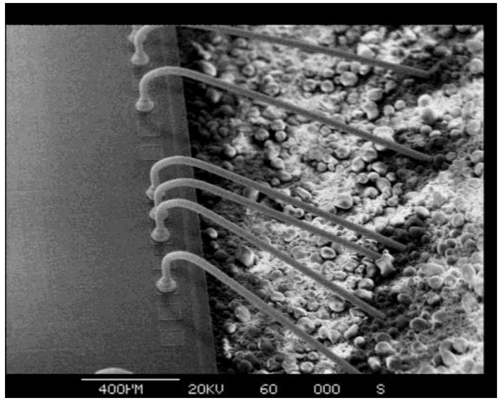
Die identification

ALTER

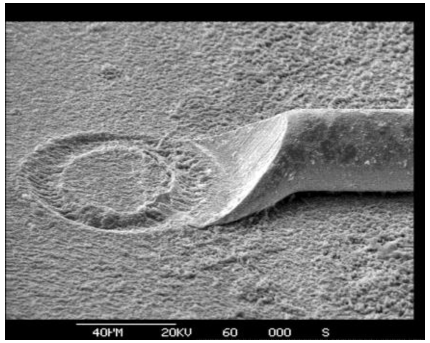
Minimum Images Required for IC's Plastic II.

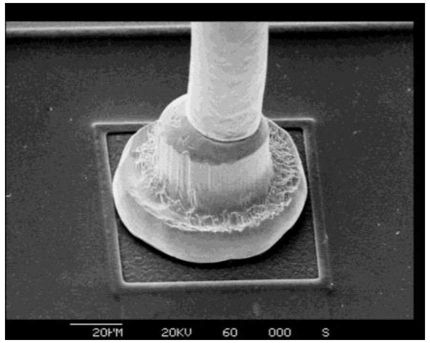


SEM Image of the de-encapsulated microcircuit.

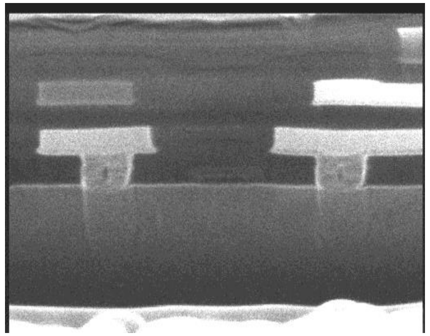


SEM Image of the bond wire dressing.





SEM Image of a ball and wedge bonds.



FIB Image of planarised metallisation with vias, see images required for an hermetic microcircuit for alternatives.

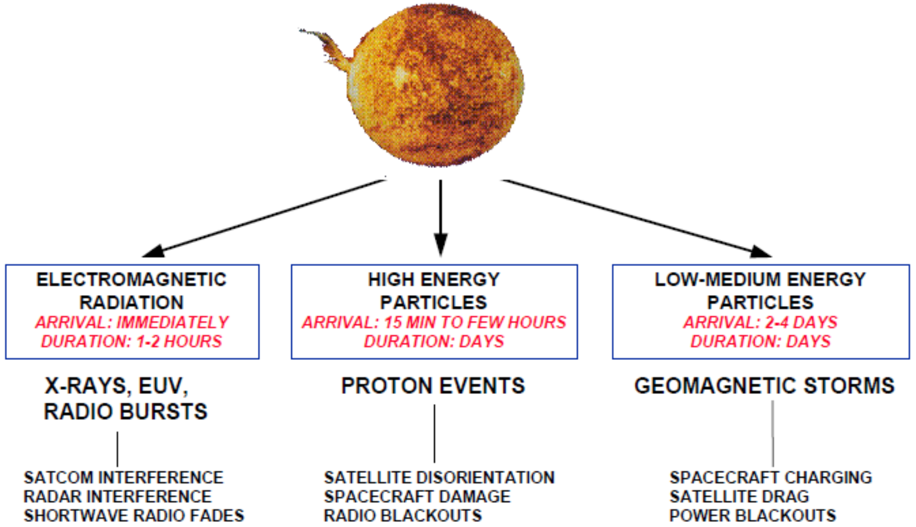
ALTER

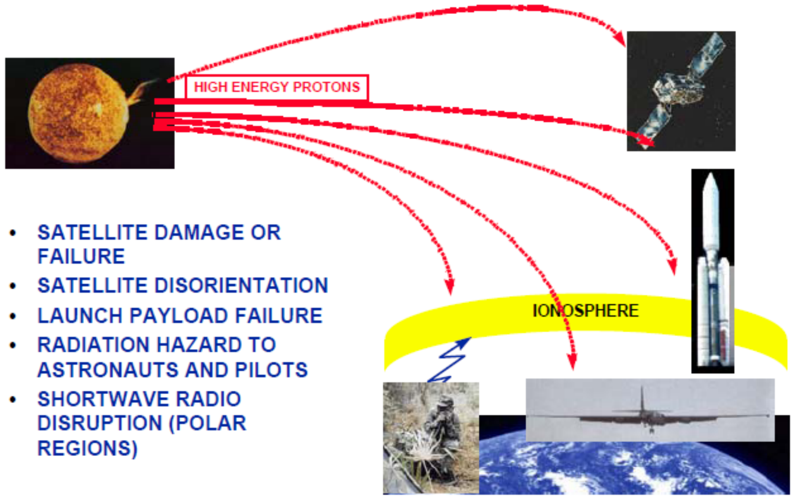
DPA ESTIMATED COSTS

EEE family (3 pcs)	From (EUR)	To (EUR)
Ceramic capacitor	450	550
Tantalum capacitor	500	600
Crystals	550	700
Diodes	550	650
Connectors	600	700
Relays	450	600
Transistors	650	700
Switches	500	650
Optoelectronic	600	750
Fuses	500	650

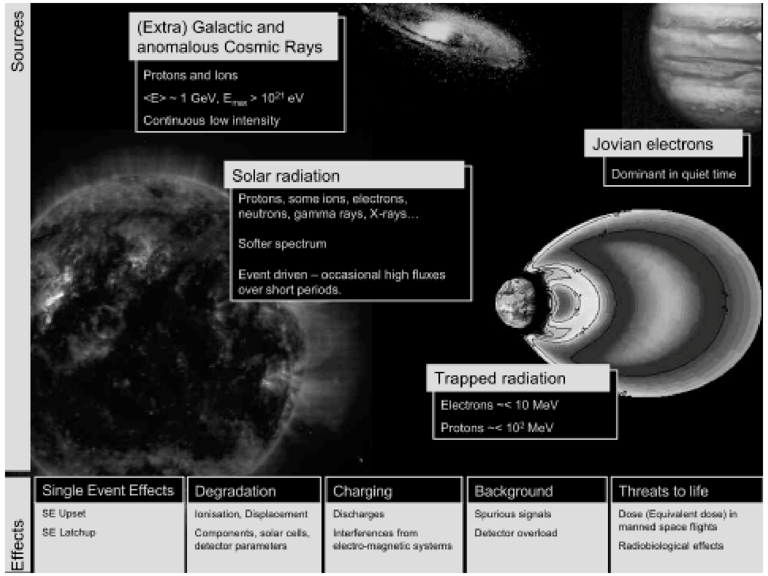
ALTER

RADIATION TESTS – WHY HI-REL PARTS



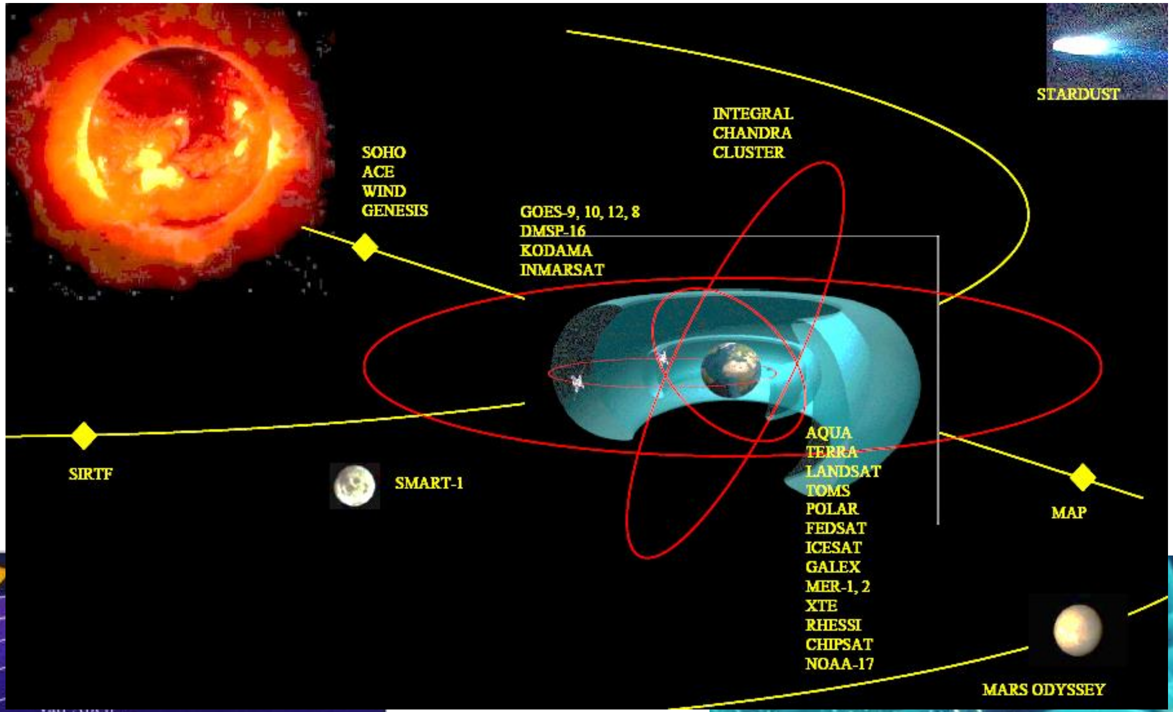


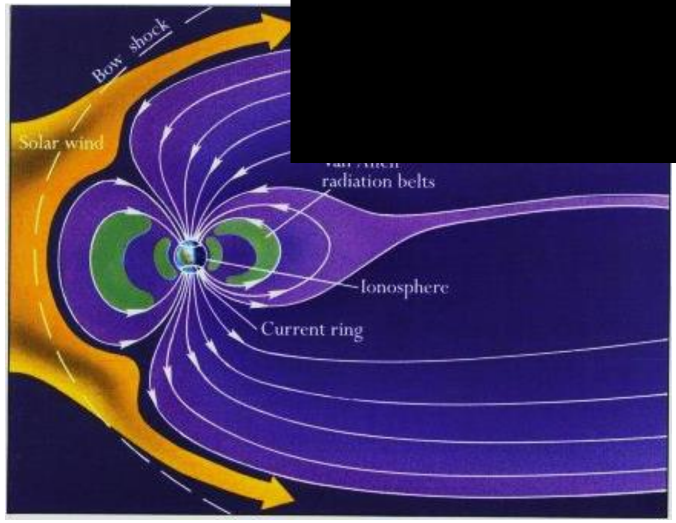
- SATELLITE DAMAGE OR FAILURE
- SATELLITE DISORIENTATION
- LAUNCH PAYLOAD FAILURE
- RADIATION HAZARD TO ASTRONAUTS AND PILOTS
- SHORTWAVE RADIO DISRUPTION (POLAR REGIONS)

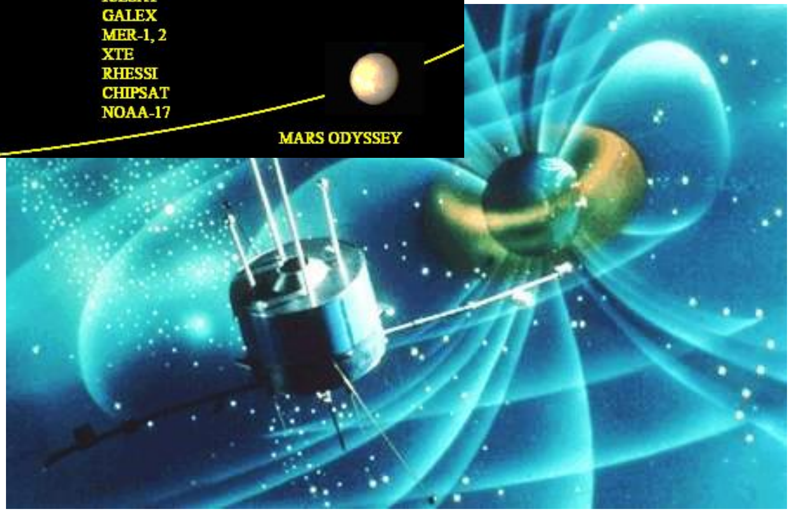


ALTER

RADIATION







ALTER

RADIATION

Exposure to radiation from a space mission is determined by its orbit: latitude and altitude, along with the duration of the mission.

A) LEO (Low Earth Orbit). Orbiting the Earth at a distance <1000 km.

1. (200 to 500 km) and inclination (<28°) produce low exposures <1 krad / year. Very low TID degradations TID and occasionally by SEU.
2. Orbits of low altitude (200 to 1000 km) and high inclination (> 28°) exposures occur typically <10Krad/year. (IRIDIUM)

C) MEO (1000 - 4000Km)

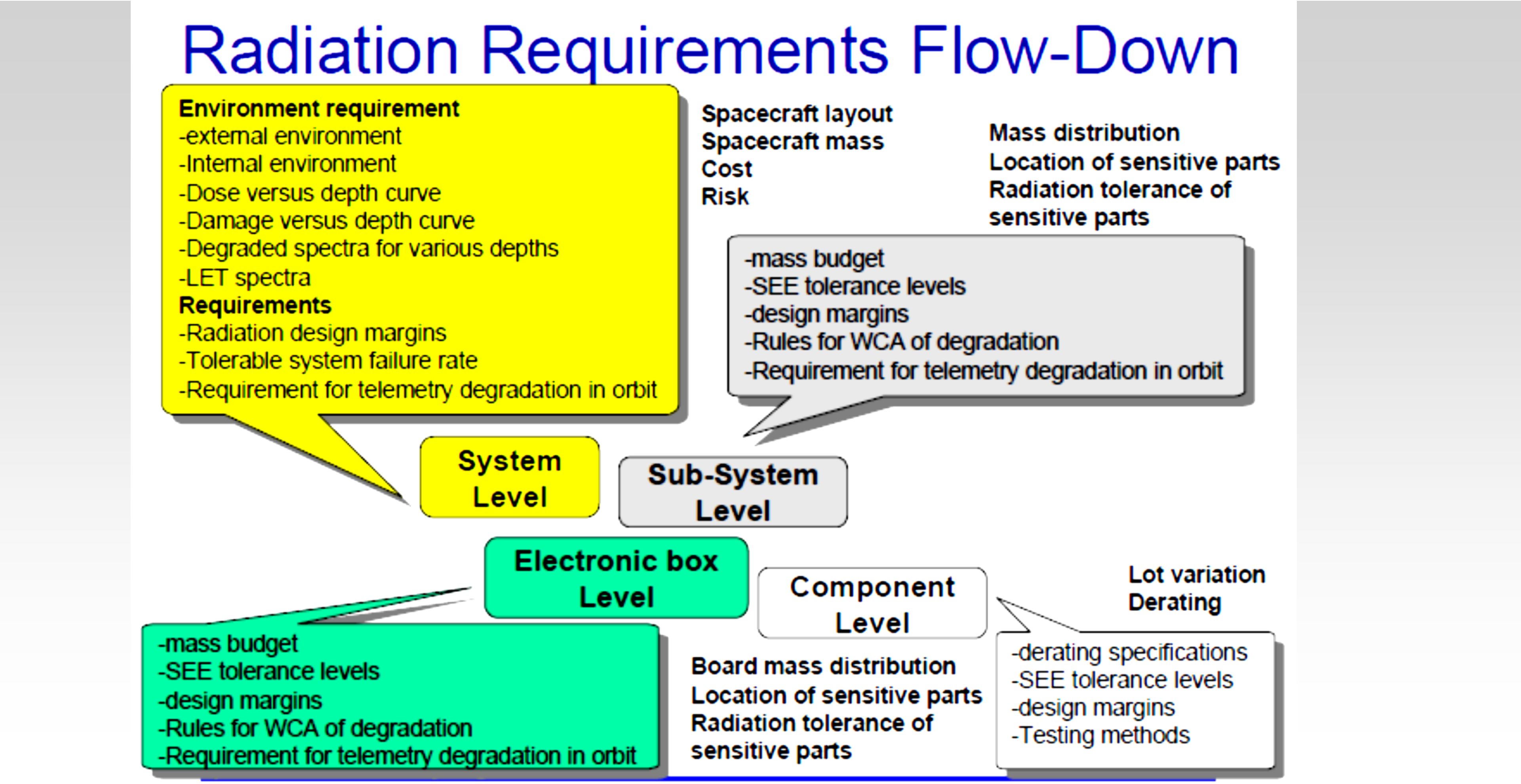
TID from 100 krad to Mrad per year. The geomagnetic shielding is reduced and the satellites are within Van Allen belts. SEU is likely.

Typical MEO with high altitude (20.000km aprox.) are Glonass, GPS and Galileo)

D) Geo Orbit (35.800Km) They are exposed to less than 10Krad per year but is very prone to SEU by not having the protection of the magnetosphere environment. It is used by some commercial and military satellite communications, etc. (METEOSAT)

F) Others: (elliptical orbits in general quite far from the Earth at perigee), solar orbits, interplanetary missions, etc.

RADIATION


Radiation Requirements Flow-Down
Environment requirement
-external environment
-Internal environment
-Dose versus depth curve
-Damage versus depth curve
-Degraded spectra for various depths
-LET spectra
Requirements
-Radiation design margins
-Tolerable system failure rate
-Requirement for telemetry degradation in orbit
Spacecraft layout
Spacecraft mass
Cost
Risk
Mass distribution
Location of sensitive parts
Radiation tolerance of sensitive parts
-mass budget
-SEE tolerance levels
-design margins
-Rules for WCA of degradation
-Requirement for telemetry degradation in orbit
System Level
Sub-System Level
Electronic box Level
Component Level
Lot variation
Derating
-mass budget
-SEE tolerance levels
-design margins
-Rules for WCA of degradation
-Requirement for telemetry degradation in orbit
Board mass distribution
Location of sensitive parts
Radiation tolerance of sensitive parts
-derating specifications
-SEE tolerance levels
-design margins
-Testing methods

RADIATION

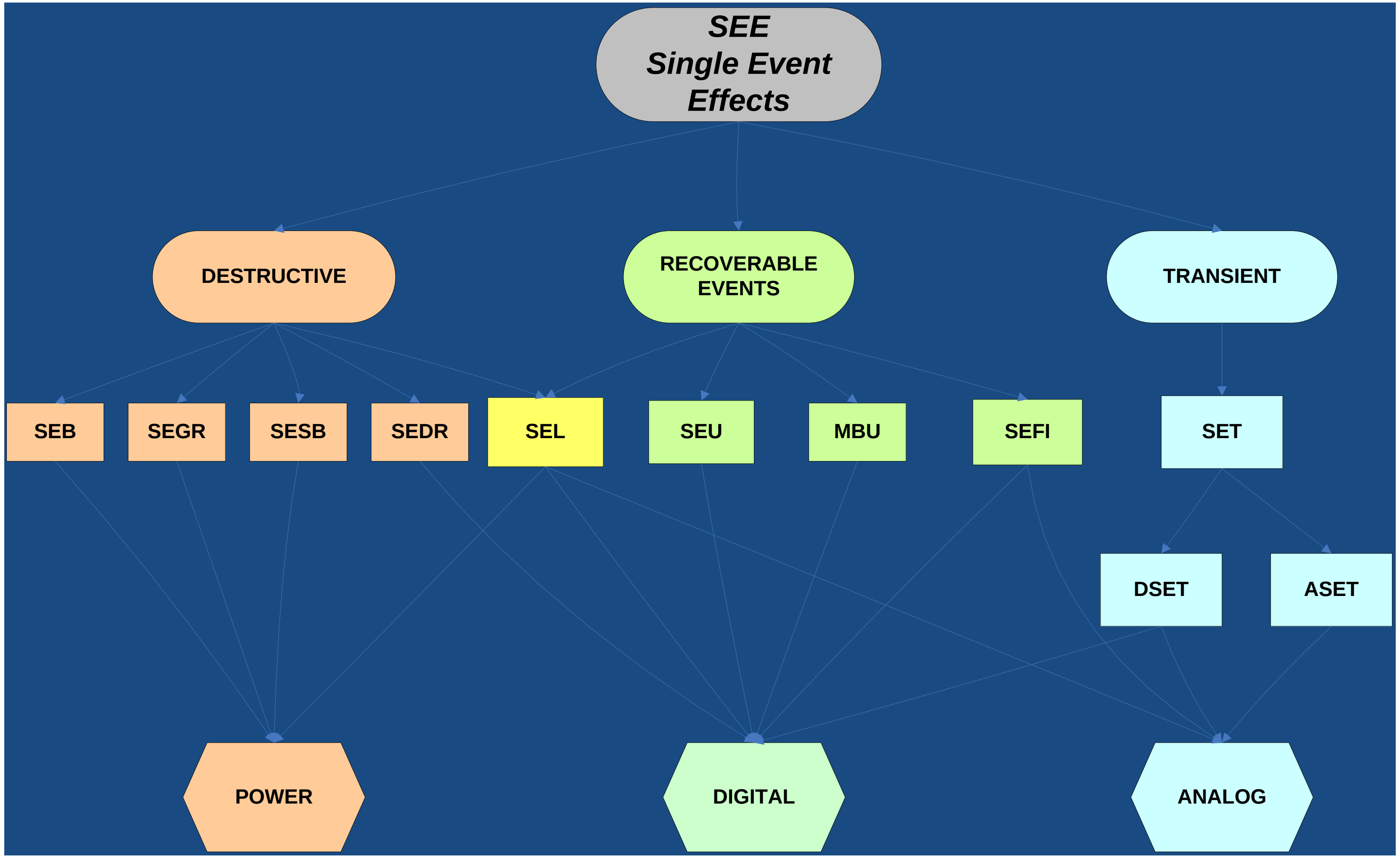
TECHNOLOGY	MAIN RADIATION SENSITIVITY EFFECTS		
	TID (Total Ionising Dose)	SEE (Single Event Effects)	NIEL (Non-ionising Energy Loss)
CMOS	X	X	
BIPOLAR	X	X	X
GaAs		X	X
SiGe/InP			X
CCD, CID	X	X	X
Solar Cells			X
Power devices		X	
LEDs and Laser Diodes			X
Optocouplers	X	X	X
Fibre-optics	X		
MEMS	X		
Insulation materials	X		
Optical materials	X		
Cryogenics systems	X		

ALTER

RADIATION

		Dest.	Brief Description	Affected devices
SEU	Single Event Upset	N	Corruption of the information stored in a memory element.	Memories, latches in logic devices.
MBU	Multiple Bit Upset	N	Several memory elements corrupted by a single strike	Memories, latches in logic devices.
SEFI	Single Event Functional Interrupt	N	Loss of normal operation.	Complex devices with built-in state/control sections.
SET	Single Event Transient	N	Pulse response of certain amplitude and duration.	Analog, mixed signal devices
SED	Single Event Disturb	N	Momentary corruption of the information stored in a bit.	combinational logic, latches in logic devices
SHE	Hard Error Event	N	Unalterable change of state in a memory cell.	Memories, latches in logic devices.
SEL	Single Event Latch-up	Y	Unexpected high current generation.	CMOS, BiCMOS
SESB	Single Event Snapback	Y	Unexpected high current generation.	N-Channel Power MOSFET, SOI
SEB	Single Event Burnout	Y	Destructive burn-out.	BJT,
SEGR	Single Event Gate Rupture	Y	Rupture of the gate dielectric.	Power MOSFETs
SEDR	Single Event Dielectric Rupture	Y	Rupture of the dielectric layer	Non-volatile NMOS, FPGA, linear devices, ..

RADIATION


SEE
Single Event
Effects
DESTRUCTIVE
RECOVERABLE
EVENTS
TRANSIENT
SEB
SEGR
SESB
SEDR
SEL
SEU
MBU
SEFI
SET
DSET
ASET
POWER
DIGITAL
ANALOG

PROCUREMENT OF RAD TOLERANT PARTS

FIRST QUESTION: Which information should I take into account?

General information provided by the **PA plan** will give us the required starting point

Taking into account the **orbit** (LEO, GEO, polar) and **mission duration** we can generate a first approach to radiation tolerance by requirements in addition to PA requirements.

In order to better ensure we are not over or underestimating the radiation requirements, we must perform a **sectorial analysis** for our equipment

This sectorial analysis does not modify the general requirements but allows us a fine tune whenever we are analyzing the existing data and the required verification testing

We must analyze and take into account all potential effects depending on technologies of our components:

- Total ionizing dose
- Enhanced low dose rate
- Non ionizing effects
  - Displacement damage
- Single Event Effects
  - Single Event Latch-up
  - Single Event Upset
  - Multiple Bit Upset
  - Single Event Transient
  - Single Event Disturb
  - Single Event Functional Interrupt
  - Single Event Burn-out
  - Single Event Gate Rupture
  - Single Event Snapback
  - Single Event Dielectric Rupture

ALTER

PROCUREMENT OF RAD TOLERANT PARTS

Selection criteria

When constructing the declared component list, special attention must be paid to:

- Project requirements
- Products sensitivity
- Design requirements
- Schedule and budget for radiation validation

Once analyzed the previous criteria we will make our product selection giving priority to:

- Radiation hardness products
- Radiation tolerant products, requiring additional validation efforts by:
  - Previous data
  - Testing of actual procured lot
- Design requirements

No list of radiation tolerant parts is available although some guides can be found either in MIL QPL/QML, EPPL, ESA QPL/QML, company internal tools.

Types covered by similarity:		Remarks: These devices have a TID tested capability of 70kRADs (Si).		
Procurement Specifications	Manufacturer	Nature of Approval	Supervising Authority	Date
Generic ESCC 5000 Detail ESCC 5205/021	ST Microelectronics Rennes France	Qualification	CNES	Oct 2010
Characteristics: Variants 01 and 02 are qualified Maximum Ratings: I_{DS} (A): 48, T_{case} (°C)= $^{+}25$ V_{DS} (V_{dc}): 100 over T_{op}, V_{GS}= 0 V V_{GS} (V_{dc}): ± 20 $r_{DS(on)}$ (m Ω): 35, V_{GS}=12V, I_D=24A P_{TOT}: 170 W at $T_{case} \leq ^{+}25$ C Package Type: TO-254AA Operating Temperature Range (°C): $^{-}55$ to $^{+}150$				
ESCC QPL	TRANSISTORS, MOSFET, N-CHANNEL, POWER, TYPE STRH100N10FSY3	Current validity of Qualification Certificate: 303 Valid Until: October 2012		Page 12-05 003-1

CATALOGUE: *Microcircuits*

8108 Matches

[Refresh] 10 Regs/Pag [<<] [<] [6] [7] [8] [9] [10] [More...] of 811 view| ALERTAS

add (All / None)	General Data					Qualification Status	Application	Mechanical Data	Functional & Electrical	RAD
	Component Number	Manufacturer	Part Type	Specification	Quality	Qualified Part	Rad. Level	Package	Finish	RAD
	5962-0151507QYC	Actel	RTSX72SU-CQ208E (E-FLOW)	5962-01515	QML Q	Y	Not Available	CQFP-208	Gold Plate	
	5962-0151508QXC	Actel	RTSX72SU-1CQ256E (E-FLOW)	5962-01515	QML Q	Y	Not Available	CQFP-256	Gold Plate	
	5962-0151508QYC	Actel	RTSX72SU-1CQ208E (E-FLOW)	5962-01515	QML Q	Y	Not Available	CQFP-208	Gold Plate	
	5962-0152001QPA	Texas Instruments	UC1710J883B	5962-01520	QML Q	Y	Not Available	DIL-8	Hot Solder Dip	
	5962-0152001VPA	Texas Instruments	UC1710JQMLV	5962-01520	QML V	Y	Not Available	DIL-8	Hot Solder Dip	
	5962-0152001VXA	Texas Instruments	UC1710JQMLV	5962-01520	QML V	Y	Not Available	DIL-8	Hot Solder Dip	
	5962-0250101QXC	Atmel	MMDJ-65609EV-40MQ	5962-02501	QML Q	Y	Not Available	FP-32	Gold Plate	
	5962-0250101VXC	Atmel	SMDJ-65609EV-40SV	5962-02501	QML V	Y	Not Available	FP-32	Gold Plate	
	5962-0253801VXA	Analog Devices	AD9042SD/QMLV	5962-02538	QML V	Y	Not Available	DIL-28	Hot Solder Dip	
	5962-0253801VZA	Analog Devices	AD9042SF/QMLV	5962-02538	QML V	Y	Not Available	FP-28	Hot Solder Dip	

ALTER

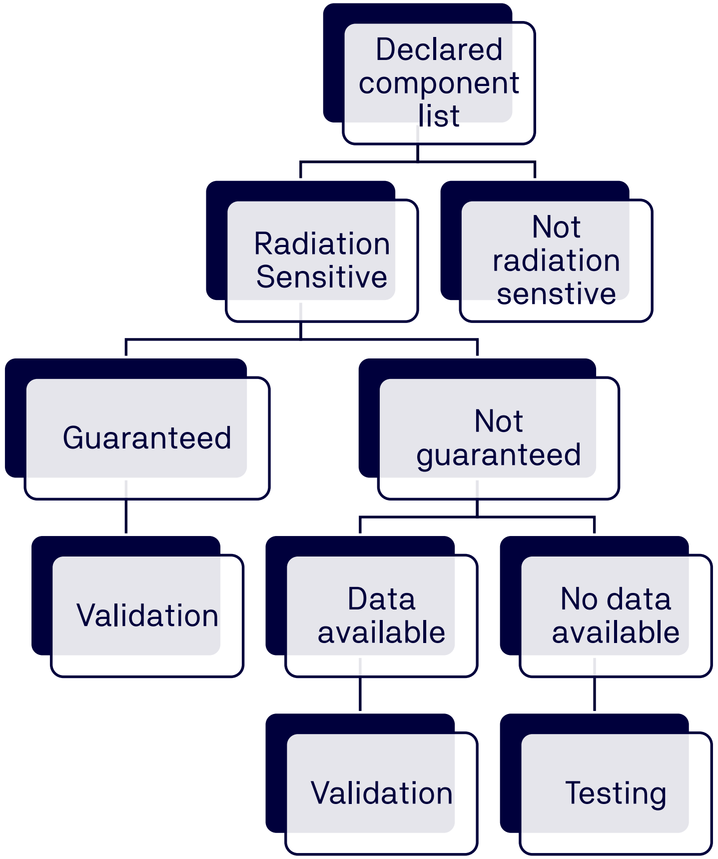
PROCUREMENT OF RAD TOLERANT PARTS

Critical review

For each selected parts, following questions must be answered:

- Is this part sensitive to radiation effects?
- Does the manufacturer provide guarantee up to the required level for each part they deliver?
- Is there enough information available to provide confidence that parts will survive in the forecasted environment?
- Which design margin for product replacement can be considered?
- Level of confidence to pass the required radiation evaluation
- Which is the dominant ionizing particles in the orbit?

Parts must be categorized by:



ALTER

PROCUREMENT OF RAD TOLERANT PARTS

RVT need identification

- Project requirements definition
- Data compilation
- List of parts requiring characterization and effects
- PAD generation
- RVT plan generation

RVT plan generation

- Definition of required conditions
  - TID
  - SEE
- User's validation
- Prime contractor validation
- Final implementation

RVT testing

- Samples validation
- Wafer lot validation (no previous test performed)
- Implementation
- Testing reporting
- Non conformance management (if any)

PROCUREMENT OF RAD TOLERANT PARTS

- RADIATION COSTS

  - Radiation facilities have to be reserved for testing.
  - Dose rate (HDR-LDR-ELDRS) and total dose have a direct impact on lenght of TID tests
  - Number of parts to be submitted to the test (reduction for expensive components)
  - TID test steps have a clear impact on manpower costs (electrical measurement to be performed on each step).
  - Set-up for measurements again has a significant impact on cost of these tests.

- Variability of RVT test costs makes critical an early definition of their need.

PRACTICAL
SESSION
RADIATION

ALTER

RADIATION TESTS - COSTS

Family	Dose Rate	Total Dose	From	To
Transistors	LDR	50 krad	3800 €	5500 €
Transistors	LDR	100 krad	4200 €	7000 €
Microcircuits	LDR	50 krad	5000 €	11000 €
Optoelectro	LDR	50 krad	5500 €	13000 €

- DD and SEE tests are shorter tests (usually performed within the same day).
- Their prices are directly related to facilities and set up design.
- TID test also depend on Dose Rate, Total Dose and Measurement Steps.

ALTER

RADIATION TESTS – COSTS EXAMPLES

Part Type	MFR	Test	ROM price
SOC2920	STM	TID 100 krad	4200 €
2N3810	MICORP	TID 100 krad	5500 €
AD565ASD	AND	TID 100 krad	7000 €
61082-300	MII U	DD	16500 €
VS-703	VIN U	SEE	37000 €

LOT VERIFICATION TEST/LVT/QCI

Objective:

To provide greater reliability assurance with respect to environmental, mechanical assembly and endurance of the devices.

Many manufacturers include this tests on their procedures, or at least offer it with separate charges on procurement.

OTHER EXPENSES

Other sources for additional expenses :

- General management
- Ordering follow-up
- Customs clearances
- Quality assurance and failure management
- ..., etc.

OTHER EXPENSES – GENERAL MANAGEMENT

All tasks mentioned above (from engineering to final tests on EEE parts) need to be coordinated.

Management can anticipate and mitigate important risks leading to an appropriate cost control.

This management shall be considered before any other tasks, and will last until the project closure.

OTHER EXPENSES – ORDERING FOLLOW-UP

Procurement of EEE parts needs a proper follow-up to assure project lead-times will be respected and also anticipate delays.

Lead-times for EEE from MFRs can vary from a few weeks to almost a year.

Not all MFRs/procurement agencies send a periodic backlog with estimated delivery dates → variability in manpower needed to have updated information.

Personnel has to be assigned to these tasks during the whole procurement process.

OTHER EXPENSES – LICENSE MANAGEMENT

Parts subject to ITAR (International Traffic in Arms Regulations) or EAR (Export Administration Regulation) restrictions (export licenses) are considered as critical, and require specific management on a case by case basis.

- In the frame of the a procurement programme, the following activities of the export license management should be performed.
- Identification of items subject to export licenses. Identification of jurisdiction (ITAR, EAR).
- Back up solutions. Risk assessment.
- Preparation of documents for review/approval of all parties directly concerned, with the inputs from other parties, as applicable.
- Coordination/integration of documentation.
- Documentation delivery to manufacturers.
- Export license follow up and control.
- Data base reporting.

OTHER EXPENSES – LICENSE MANAGEMENT

The amount of paperwork required will be based on whether the product is controlled by the US Department of State or the US Department of Commerce - Bureau of Industry and Security. This categorisation is not always obvious from the type of product ordered.

US Department of State:

In general the following paperwork will have to be generated:

- Parts Control Plan.
- Accountability Plan.
- User Letter of Approval of Parts Control Plan.
- End Use Certificate.
- Non Transfer and Use Certificate (DSP-83).

OTHER EXPENSES – LICENSE MANAGEMENT

The US Department of Commerce classifies the items as:

- EAR 99: No licence required but End Use Certificate / Statement or BIS-711 (Statement by Ultimate Consignee and Purchaser) will be required.
- EAR: Licence required. Components with a specific ECCN number in the CCL.

The applicability of a license and the paperwork will depend on:

- Final destination of the parts, end use and user.
- Characteristics of the device.
- The paper work may range from a single End Use Statement to a special Parts Control Plan, Accountability Plan, as well as a BIS-711 (Statement by Ultimate Consignee and Purchaser).

OTHER EXPENSES – LICENSE MANAGEMENT

Average lead-time for approval/denegation is:

- EAR (DoC) 4-6 weeks
- ITAR (DoS) 5-8 weeks

Export control is a critical area where expertise is required.

Incorrect application could lead to delays, extra costs or even sanctions (typing, missing

documents, incomplete information shall be double check each set of documents before each

application)

In case of changes after an export license is granted, General Correspondence (DoS)

or Re-tranfers (DoC) is required.

OTHER EXPENSES – CUSTOMS CLEARANCE

To import goods from foreign countries (as US), a declaration must be lodged at local

Customs of the importer country.

As part of this declaration the following information should be presented:

- Packing list
- Commercial Invoice
- Air Waybill

During the Customs import clearance 3 ways can be resolved: green lane (ok), yellow lane (documentary check) or red lane (documentary check and physical assessment).

OTHER EXPENSES – CUSTOMS CLEARANCE

During the Customs Clearance three costs should be considered:

- Agent fee. The Customs broker will charge a percentage of goods value for administrative tasks. This cost starts usually in a minimum value between 50-100€ plus percentage of invoice amount (round 0,04%) i.e: invoice value: 1.000€ ->75€, 10.000€-> 400€

- VAT. European TAXes should be considered during Customs Clearance process. VAT is the percentage of invoice value to "nationalise the merchandise". It means, in order to introduce the goods in EC. This amount will be returned to the importer between 3-5 months after the import, but the financial cost of this amount should be considered.

- Tariff code (or HS Code, harmonized code) must be shown and declared. Some of these tariff numbers require Administrative Fees Tariff, it means an extra payment. (typical value for most electronic devices 0%, fuses and thermistors up to 5%).

If not properly anticipated, the import could lead to extra delays and costs could be faced.

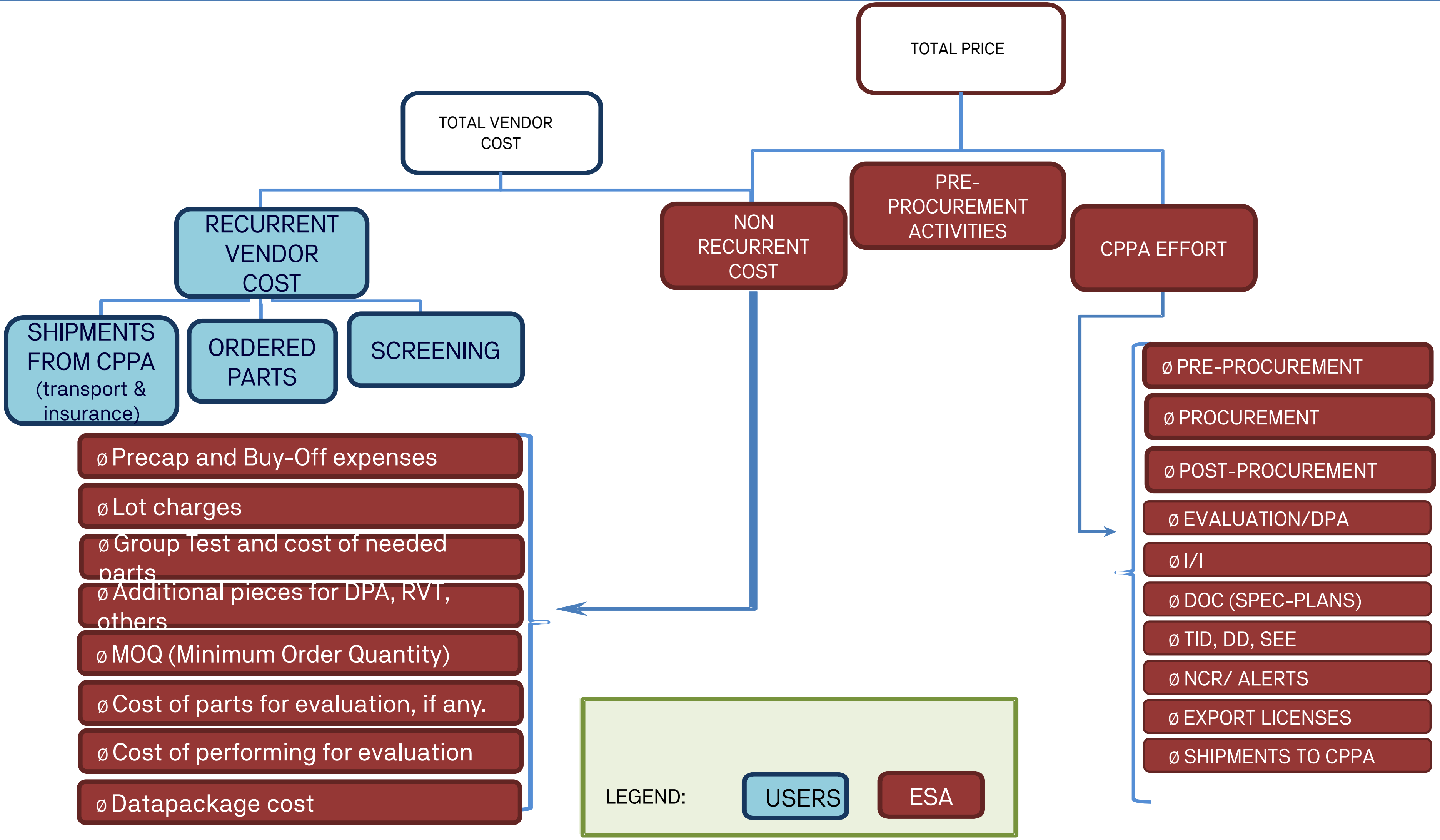
OTHER EXPENSES – QUALITY ASSURANCE

One person shall be assigned as quality responsible for every project.

Different tasks request an important amount of time and technical expertise:

- Discussion with MFRs regarding failures.
- NCRs.
- NRBs assistance and discussion.

COST AREAS – COORDINATED PROCUREMEI



ALTER

COST SAVINGS AND BENEFITS OF COORDINATED PROCUREMENT

- Unit cost reduction through increased volume
- Reduced minumum buys
- Reduced NRC (lot cost, LAT/QCI cost)
- Reduced number of lot acceptance test: DPA, LVT, radiation tests, etc.
- Consistent and homogeneous application of quality requirements.
- Obsolescence management.
- Source selection – Project PPL and DCL.
- Technical support.

- Standardisation and part type reduction
- PRoject based export control for ITAR via US subsidiary
- Single management function
- Single interface for prime and manufacturers
- Single unified reporting channel
- Procurement visibility and control
- Less experienced users support – Instruments and new European States
- Reduced prime management cost

PRACTICAL
SESSION
COSTS EXERCISE

COST EXAMPLES

Component Number	Part Type	MFR	RVT	DPA	Qty required	Unit price	MOQ	MFR charges
CDR33BP272AJUR	CDR33 2,7nF 5% 50V TC:0±30ppm/°C 1210	KEM U			42	4,2	250	
400102309R4702B2	47k 0.1% 10ppm	VSH U			78	7,7	50	
520200106R	2N2907ARUBG LCC-4 (UB)	STM F			47	45	50	
320100803C102K	MSCI 20K 1mH 10% Case C Chip	EXXE			8	375	8	
1157R100M0000BF	1157R100M0000BF	VIN U			10	1400	10	Group C in 4 pcs: 5860
5962F9568902VXC	HS9-26CLV32RH-Q	HAR U			4	520	5	
5962R1620101KYC	MSK496RH	MSK	Yes	Yes	38	1000		Life Test 5 pcs: 5750 €, Datapack: 1900 €; MFR precap: 700 €.
JANSR2N7616UB	IRHLUB770Z4	IRF			8	670	8	
340102901B9PFR112	MDM 9P FR112	C&K F			2	115	5	
5962-0422107QUC	RTAX2000SL-CQ256E	ACT		Yes	4	20000	4	

- Can you estimate total cost for CPPA and non-CPPA Project?
- Is there any cost missing?

COST EXAMPLES

Part Type	MFR	RVT	DPA	Qty required	Unit price	MOQ	MFR charges	Total cost
CDR33 2,7nF 5% 50V TC:0±30ppm/°C 1210	KEM U			42	4,2	250		250*4,2
47k 0.1% 10ppm	VSH U			78	7,7	50		78*7,70
2N2907ARUBG LCC-4 (UB)	STM F			47	45	50		50*45
MSCI 20K 1mH 10% Case C Chip	EXXE			8	375	8		8*375
1157R100M0000BF	VIN U			10	1400	10	Group C in 4 pcs: 5860	10*1400+5860+4*1400
HS9-26CLV32RH-Q	HAR U			4	520	5		5*520
MSK496RH	MSK	Yes	Yes	38	1000		Life Test 5 pcs: 5750 €, Datapack: 1900 €; MFR precap: 700 €.	38*1000+5750+5*1000+1900+700+PRECAP+RVT+11*1000+DPA+3*1000
IRHLUB770Z4	IRF			8	670	8		8*670
MDM 9P FR112	C&K F			2	115	5		5*115
RTAX2000SL-CQ256E	ACT		Yes	4	20000	4		4*20000+DPA+1*20000

- Buyoff could also be included for MSK496RH- We considered it covered by an I/I for a typical ESA mission.
- DPA in FPGAs considered in 1 pc due to their high cost and reliability.

COST trade offs

- Even though technical requirements on each Project are obviously mandatory, trade offs between technical requirements, lead-times and costs are recommended on critical ítems

- Risks on the use of some EEE parts (usually COTS) are not finally worth, saving an important budget to the Project in case a standard qualified component is used.

- Even 2 different COTS alternatives can have significant differences on the risks-costs

EEE part	Lead-time	Cost (Class 1)	Risks
SW-303	4+48	150000 €	COTS
MLP-024	72 weeks	300000 €	Only die available

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Redesign costs

- Back-ups shall always be defined for all critical components (i.e. components to be submitted to qualification, foreseen end-of-life...).

  - ❑ Is footprint the same?
  - ❑ Is alternative qualified?
  - ❑ Alternative tests?
  - ❑ Heritage?

- A thorough comparison of technical requirements, costs and risks at early stages can drastically reduce cost deviations.

BUDGET CONSTRAINTS

- Cost savings (always within PPCP boundaries).

    - ❑ Heritage/info from previous projects → tests can be skipped.
    - ❑ Reducing pcs on tests.
    - ❑ Simultaneous tests (i.e. RVT).
    - ❑ Combined procurement → NRVC sharing (i.e. CPPA).

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NEW-SPACE

- Same name for multiple approach to requirements
- Multidisciplinar approach (EEE, equipment system…).
- Dedicated documentation released for each project.
- Duration: from 6 months to 3-5 years

Risk Classification for NASA Payloads (GPR 8705.4)	
EEE parts	Class A
	Class B
	Class C
	Class D
	Ground Systems (GS)
	7120.8 class
	Do No Harm
	Hosted payload Class

ECSS Component classes	
EEE parts	Class 1
	Class 2
	Class 3
	COTS
	COTS +
	EP

			<-----------------------Informative 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

NEW-SPACE

- ECSS-Q-ST-60 has been updated, but New Space projects are genereally not following standard requirements.

- New issue of ECSS-Q-ST-60-13 under public review
  - Distinction between AECQ and – non-AECQ parts
  - New families (passives) included in this stantard
  - Justification document

- Technical note ESA-TEC-TN-021473 “Guidelines for the utilization of COTS components and modules in ESA”

- Maximization of automotive qualified parts and/or commercial parts with space heritage.

NEW-SPACE

Parts family	Automotive grade	Class 1	Class 2	Class 3	Category	Test type	Sample size	Test Procedure	Specific Test condition
Discretes	AEC-Q	X			Evaluation	Radiation evaluation		i.a.w. ECSS-Q-ST-60-15	
Discretes	AEC-Q	X	X	X	Evaluation	Construction Analysis	5	i.a.w. Annex H + outgassing	
Discretes	AEC-Q	X			Evaluation	Life Test 2000h	15	test methods i.a.w. ECSS-Q-ST-60-13 Rev C	Life test duration 2000h
Discretes	AEC-Q	X			Screening	Hermiticity	all	test methods i.a.w. ECSS-Q-ST-60-13 Rev C	
Discretes	AEC-Q	X	X	X	Screening	Pind test	all	test methods i.a.w. ECSS-Q-ST-60-13 Rev C	
Discretes	AEC-Q	X			Screening	Complete screening	all	test methods i.a.w. ECSS-Q-ST-60-13 Rev C	burn-in duration 240h
Discretes	AEC-Q	X	X		LAT	RVT		i.a.w. ECSS-Q-ST-60-15	
Discretes	AEC-Q	X	X	X	LAT	DPA	5	i.a.w. Annex H	
Discretes	AEC-Q	X	X		LAT	Life test	15	test methods i.a.w. ECSS-Q-ST-60-13 Rev C	Life test duration 1000h
Discretes	No	X	X		Evaluation	Radiation evaluation		i.a.w. ECSS-Q-ST-60-15	
Discretes	No	X	X	X	Evaluation	Construction Analysis	5	i.a.w. Annex H + outgassing	
Discretes	No	X	X		Evaluation	Complete Evaluation	55	test methods i.a.w. ECSS-Q-ST-60-13 Rev C	
Discretes	No	X	X		Screening	Hermiticity	all	test methods i.a.w. ECSS-Q-ST-60-13 Rev C	
Discretes	No	X	X	X	Screening	Pind test	all	test methods i.a.w. ECSS-Q-ST-60-13 Rev C	
Discretes	No	X	X		Screening	Complete screening	all	test methods i.a.w. ECSS-Q-ST-60-13 Rev C	240/168h duration in class 1/2
Discretes	No	X	X	X	LAT	RVT		i.a.w. ECSS-Q-ST-60-15	
Discretes	No	X	X	X	LAT	Construction Analysis	5	i.a.w. Annex H	
Discretes	No	X	X	x	LAT	LAT i.a.w. ECSS-Q-ST-60-13 Rev C	45	test methods i.a.w. ECSS-Q-ST-60-13 Rev C	Life test duration 1000h

Example of new issue of ECSS-Q-ST-60-13 for discretes as reference for new Space:

- Class 3: Life test not required for AEC-Q parts, covered by AEC-Q data
- Class 2&3: Screening not required for AEC-Q parts, covered by AEC-Q data

For class 3 missions, AEC-Q parts with significant reliability data require minimum/null processing

Important effort to define and harmonize criteria for testing at PCB level

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Thank you

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