

Lessons learnt at ESA from failure with commercial product/process in space applications

PCNS Passive Components Networking Days 2017

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European Space Agency (ESA)

New era in the space market

! We are living in **an important milestone era** in the space industry !
For the first time, private actor are taking leading role in for shaping space industry community.

The first step is launchers, either in US or in Europe, launchers will be designed and manufactured by independent private companies.



New era in the space market

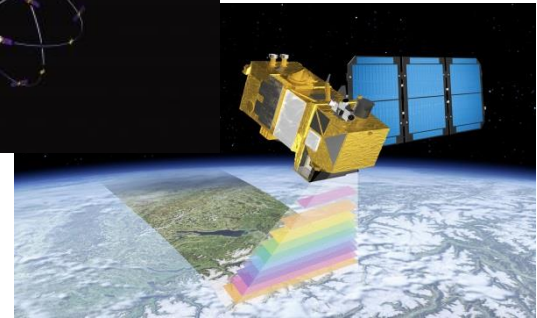
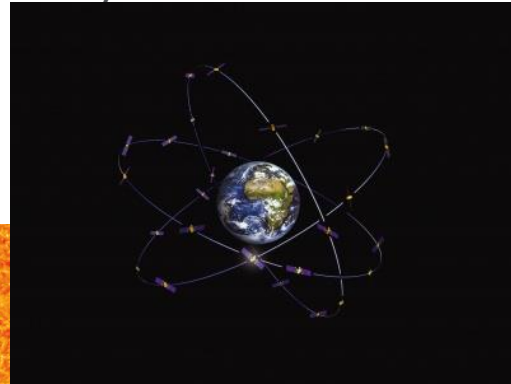
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For the first time, private actor are taking leading role in for shaping space industry community.

The second one is the arrival of new private actors, profit-oriented, that would like to challenge the current space market and want to drastically reduce the cost of satellites for mega- constellation.



New era in the space market

! We are living in **an important milestone era** in the space industry !
For the first time, private actor are taking leading role in for shaping space industry community.



The space market is opening up for **new commercial era**.

New commercial Era

What is a commercial part?

Why we use commercial parts in space?

When shall we use them in space?

Where are they used today in space?

How are they used today in space?

How shall we use them in space?



What is a commercial part?

How is defined a commercial part in EEE Parts Assurance space standards:

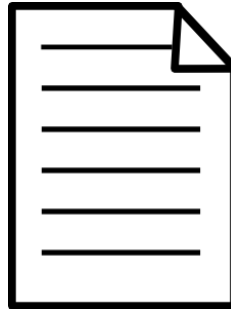
NASA-STD-8739.10

A classification for an assembly, part, or design for which the item manufacturer or vendor establishes performance, configuration and reliability, including design, materials, processes, and testing pursuant to market forces rather than by enforceable compliance to a government or industry standard.

ESA ECSS-Q-ST-60C

parts neither designed, nor manufactured with reference to military or space standards defined in this document.

Datasheet



Standard



What is a commercial part?

Each project specify which class shall be used:

NASA-STD-8739.10

Grade	Summary
1	Space quality class qualified parts or equivalent
2	Full Military quality class qualified parts or equivalent
3	Low Military quality class parts and Vendor Hi-Rel or equivalent. Screened automotive grade EEE parts
4	"Commercial" quality class parts.

Grade 4 EEE parts can be referred to as COTS.

Traceability to manufacturing lot or testing data may not be available.

Homogeneity cannot be assumed in terms of manufacturer facility, manufacturing lot, die origin, etc., when purchasing multiples of a specific part.

Most aspects of COTS part manufacturing are subject to change by the manufacturer without notice to the customer

What is a commercial part?

Each project specify which class shall be used:

ESA ECSS-Q-ST-60C

Class	Summary
1	Highest assurance and lowest risk
2	High assurance and low risk
3	Low assurance and High risk

ESA ECSS-Q-ST-60-13

Commercial electrical, electronic and electromechanical (EEE) components standard:

Standard covering active components only and it is not applicable to passive components!

Why we use commercial parts in space?



Commercial space-ready to use components bring the following benefits:

- Lower cost at purchase
- Availability
- Lead time efficiency
- Required performance

Nevertheless there is a high risk of infant failures, reliability, maverick lots or parts and procurement or traceability errors!



When shall we use commercial parts in space?

- ❑ Class 1&2 missions

No available Qualified Parts (QPL) for the **required** performance



Greatest amount of evaluation, traceability, testing and procurement is provided. But it is expensive then rarely used for commercial parts. Up-screening of commercial parts is mandatory.

Commercial Part
+
Up-screening Tests



Qualified Part

When shall we use commercial parts in space?

- Class 3 missions

Low cost budget



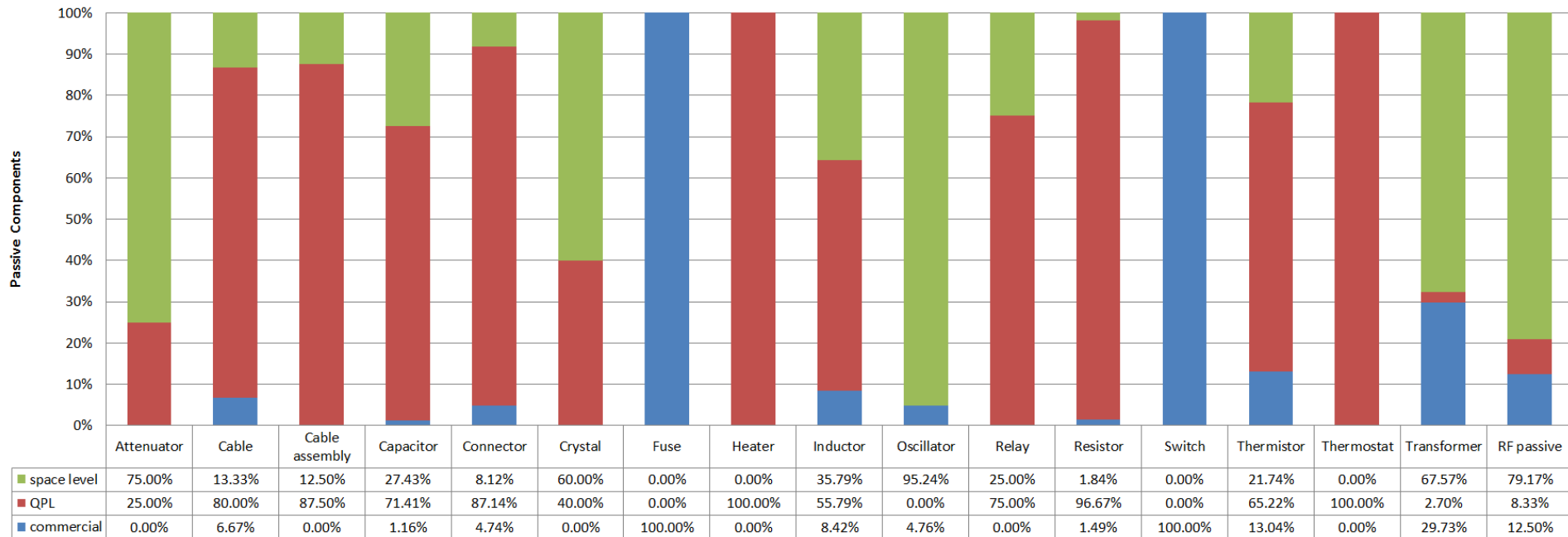
Component Type	Quality Level	Total Cost per Board [EUR]
PCB	ESCC	152
Integrated Circuits	QML-V	1 914
MOSFETs	JANS	872
Bipolar Transistors	ESCC Level B	1 028
Diodes	JANS	1 784
Capacitors	ESCC Level C + MIL FR R/S	725
Resistors	MIL FR R/S + standard	206
EUR		6 678

Component Type	Quality Level	Total Cost per Board [EUR]
PCB	IPC-3	71
Integrated Circuits	QML-Q	458
MOSFETs	AEC-Q101 + standard	213
Bipolar Transistors	AEC-Q101	276
Diodes	AEC-Q101 + standard	245
Capacitors	MIL FR R/S + AEC-Q200 + standard	230
Resistors	MIL FR R/S + standard	204
EUR		1 695

Commercial parts are used in low cost project but feedback on reliability (good or bad) are uncommon and investigation kept at a minimum.

Where are they used today in space?

Space Project Class 1: Earth Observation Application



Where are they used today in space?

Components	QPL 81.80%	Space level 14.49%	Commercial 3.72%
Attenuator	25.00%	75.00%	0.00%
Cable	80.00%	13.33%	6.67%
Cable assembly	87.50%	12.50%	0.00%
Capacitor	71.41%	27.43%	1.16%
Connector	87.14%	8.12%	4.74%
Crystal	40.00%	60.00%	0.00%
Fuse	0.00%	0.00%	100.00%
Heater	100.00%	0.00%	0.00%
Inductor	55.79%	35.79%	8.42%
Oscillator	0.00%	95.24%	4.76%
Relay	75.00%	25.00%	0.00%
Resistor	96.67%	1.84%	1.49%
Switch	0.00%	0.00%	100.00%
Thermistor	65.22%	21.74%	13.04%
Thermostat	100.00%	0.00%	0.00%
Transformer	2.70%	67.57%	29.73%
RF passive	8.33%	79.17%	12.50%

For class 1 missions:

Average commercial parts ~5%

100% up-screened

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Most of High voltage and flexible cable assemblies.



Non critical equipment in need of special design of connectors:



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Unavailable Qualified parts with the required performances:

High capacitance values for capacitors (BME capacitors from Murata)

Low or high ohmic values for resistors

Thermistors for monitoring (non critical applications)

In-house transformer for low voltage

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Only export restricted license solutions existed at time of procurement.

European commercial part procured

MGA –Schurter now in QPL



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Non critical applications (monitoring, observation, etc.)

Reed switch



Mechanical switch



How are they used today in space?

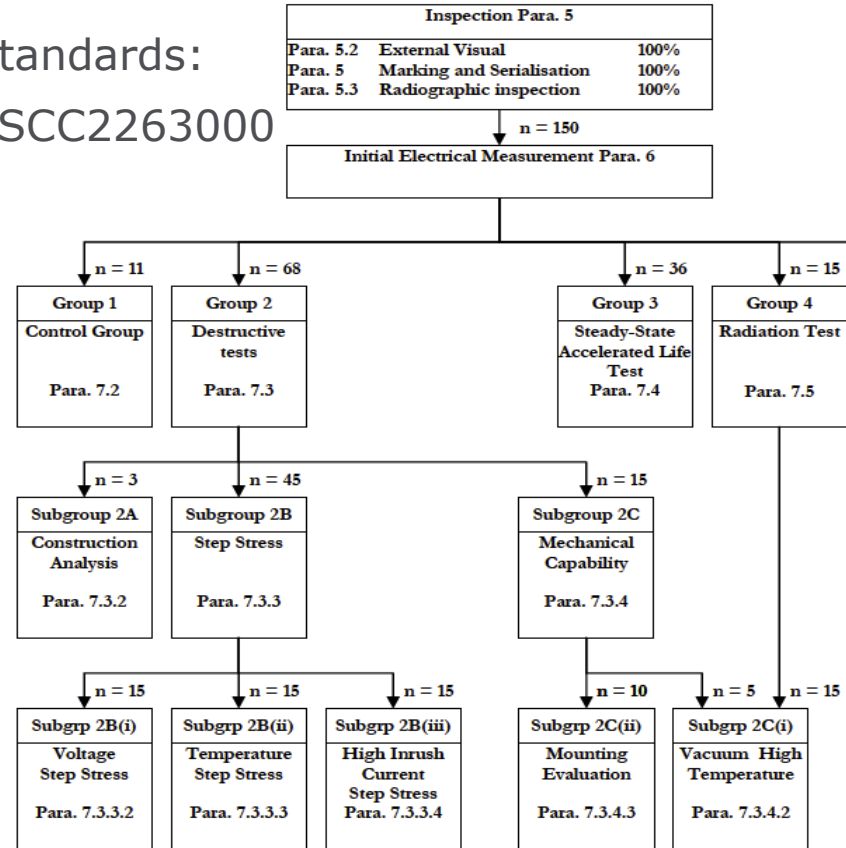
- Perform an Evaluation according to Space standards:

Ex: "Multi-anode polymer tantalum capacitor ESCC2263000"

- Construction Analysis
- Step stress tests
- Accelerated life Test
- Mounting evaluation
- Radiation and vacuum tests

- Procurement according to Space standards

- Screening
- Life test



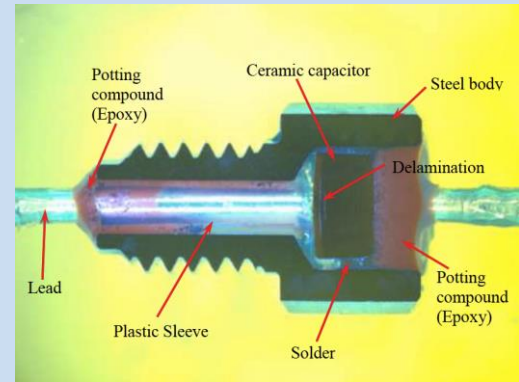
Otherwise...

- 1/2 year investigation
- Thousands of engineering hours
- Repair or Redesign or manufacturing of new parts
- Review of the equipment design
- Measurements at equipment level

Otherwise... Lessons learnt

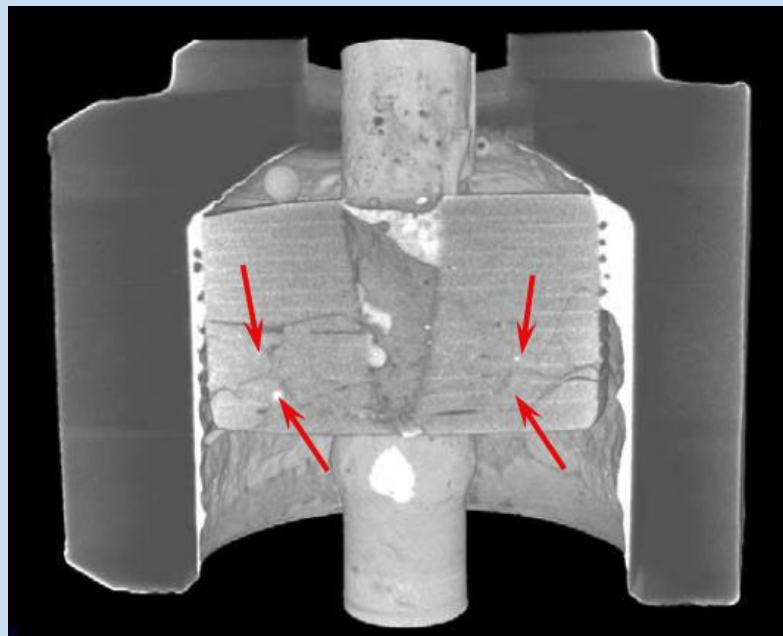
Mission:	Class 1
Part:	Commercial Feed-through filter capacitor
Application:	Filtering
Procurement:	According to the manufacturer's datasheet
Validation:	Functional measurement and equipment validation
Information:	<ul style="list-style-type: none">Reliability data: life test 2 times rated voltage 85C for 1000hoursManufactured in homogeneous batches of ceramic capacitor

Design :



Failure occurred In-orbit :
Short-circuit due to cracks in the ceramic capacitor

Failure:

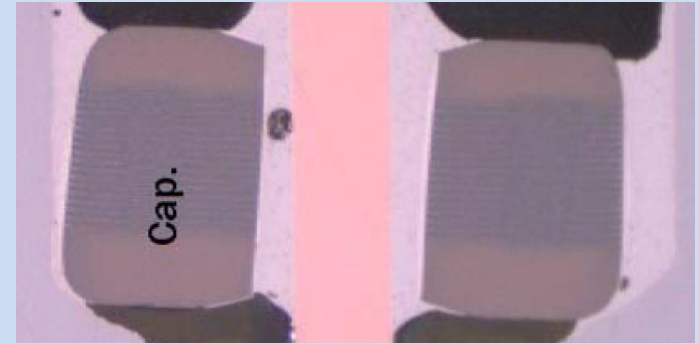
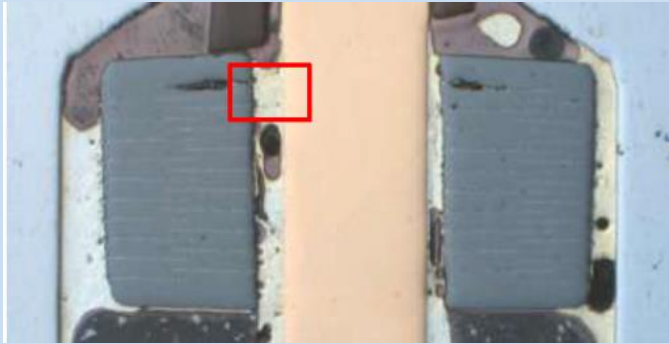


Failure:

In-orbit Short-circuit

Different internal designs : different ceramic parts
although same capacitor values

Root cause:



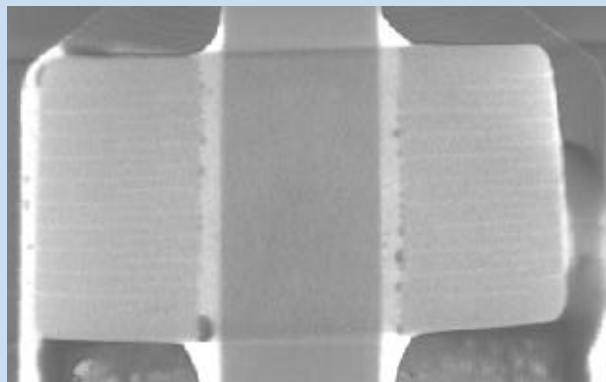
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In-orbit Short-circuit

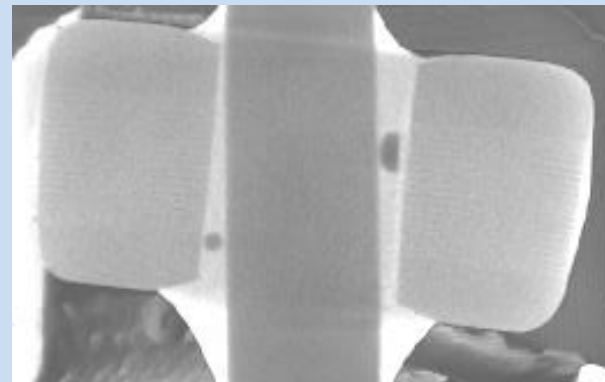
Root cause:

Different ceramic parts

Investigation:



- 10 cap layup structure
- Thicker dielectric
- Smaller area



- 17 cap layup structure
- Thinner dielectric
- Larger area
- Much thicker ceramic top & bottom of capacitor structure

Failure:

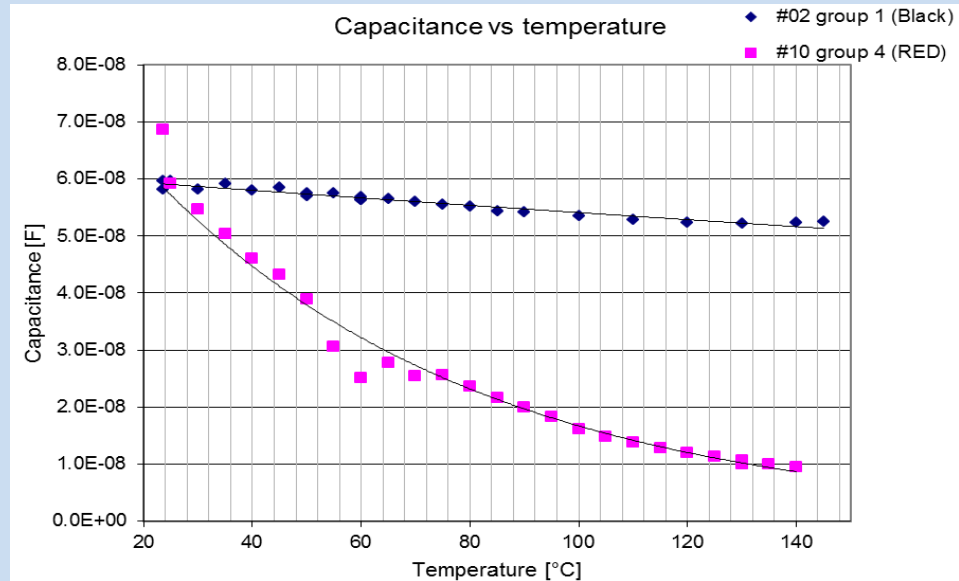
In-orbit Short-circuit

Root cause:

Different ceramic parts

Investigation:

Two Types of ceramic capacitors



Otherwise... Lessons learnt

Failure:

In-orbit Short-circuit

Root cause:

Different ceramic parts

Investigation:



First failure after 200H

One batch no failure after 4500h

Two batches 100% failure after 1700h

How shall we use commercial parts in space?

Recommendation:

- Always use Qualified parts

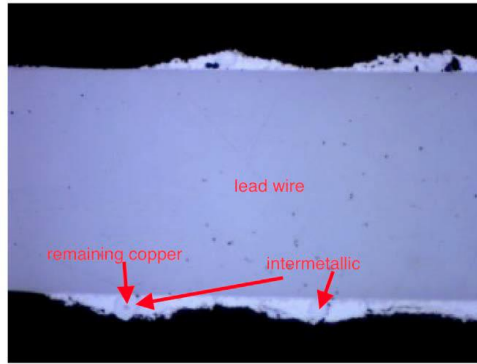
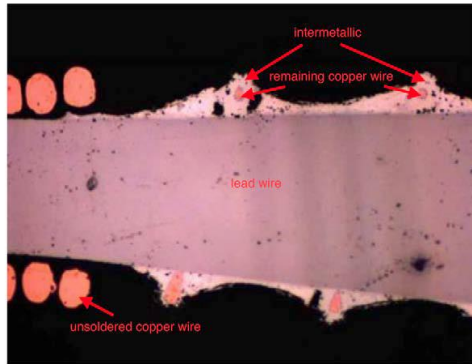


How shall we use commercial parts in space?

Recommendation:

- Always use Qualified parts

Even QPL can have **failures**: ESA alert on Qualified (ESCC) relay



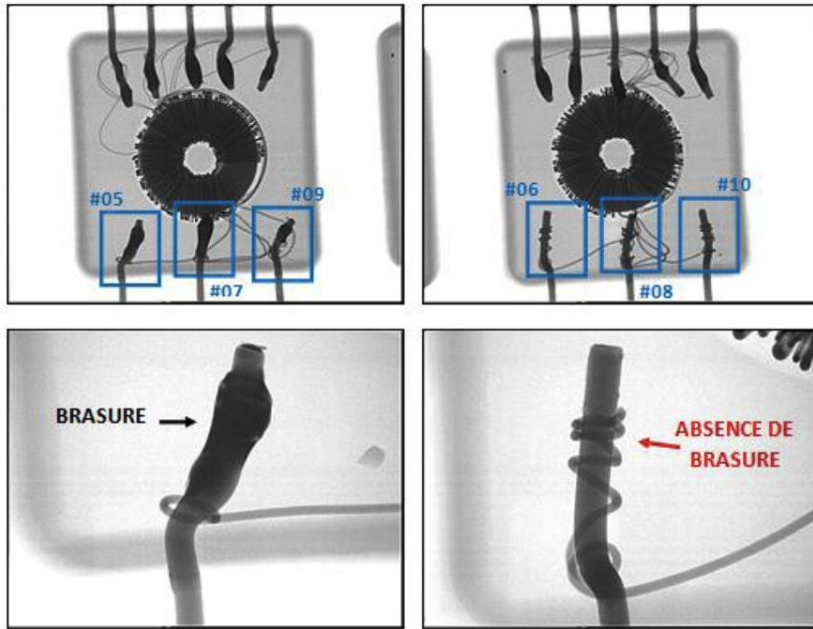
- Failure :
Open circuit occurred during AIT for class 1 mission
- Root Cause:
Dissolution of the copper wire of the coil
- Reason:
Not controlled subcontracted process

How shall we use commercial parts in space?

Recommendation:

- Always use Qualified parts

Even QPL can have **failures**: Problem Notification on Qualified (MIL) transformer



- Failure :
Open circuit occurred during AIT for class 1 mission
- Root Cause:
Missing Soldering on lead wire
- Reason:
Bad incoming inspection after subassembly process

How shall we use commercial parts in space?

Recommendation:

- Always use Qualified parts
- Otherwise **Know** what are you doing?

It is the responsibility of the user to assess the part manufacturer's quality capability to produce space quality parts and perform additional screening and qualification tests.



- And keep in mind :
 - Derating,
 - Design margins,
 - Traceabilityneed **careful** control

How shall we use commercial parts in space? Recommendation:



Conventional wisdom says:

" Test what you fly,



How shall we use commercial parts in space? Recommendation:



Conventional wisdom says:

" Test what you fly, test like you fly



How shall we use commercial parts in space? Recommendation:



Conventional wisdom says:

" Test what you fly, test like you fly ... and eventually fly what you can"



How shall we use commercial parts in space? Recommendation:



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Thank you for your attention !

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