Passive Components: News, Activities and Trends

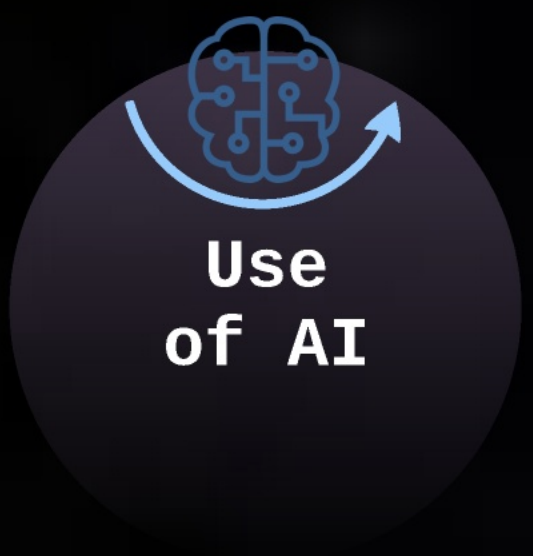
Dr. Léo Farhat & Mr. Joaquin Jimenez
ESA - European Space Agency

News & Challenges

#SpaceNext Era

The space market has evolved from the "New Space" era to what we now call **#SpaceNext**.

#SpaceNext is a fast-moving, adaptable phase where the push for better performance and lower costs continues to fuel innovation, driving the future of space exploration and technology.



Space Evolution

High/Long

- Reliability
- Cost
- Time to Market
- Lifetime

Traditional Space

For decades, space exploration was dominated by national agencies like NASA, ESA, JAXA, and ROSCOSMOS.

Missions such as Rosetta, Gaia and Herschel focused on scientific exploration, were government-funded, and involved lengthy planning cycles.

These programs prioritized high reliability and long mission lifetimes.

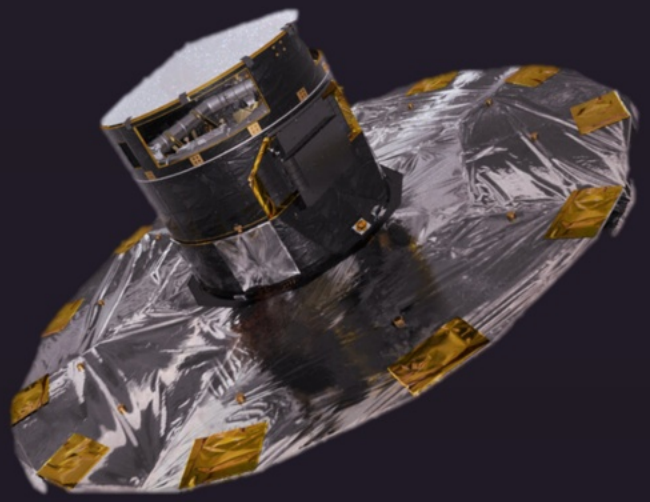
Due to the high costs and risks, rigorous testing, strict qualification, and full redundancy were essential to ensure mission success.

Time

Traditional Space

For decades, space exploration was dominated by national agencies like NASA, ESA, JAXA, and ROSCOSMOS.

Missions such as Rosetta, Gaia and Herschel focused on scientific exploration, were government-funded, and involved lengthy planning cycles.



These programs prioritized high reliability and long mission lifetimes.

Due to the high costs and risks, rigorous testing, strict qualification, and full redundancy were essential to ensure mission success.

Space Evolution

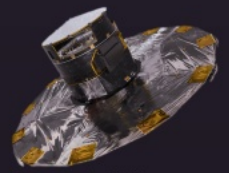
High/Long

- Reliability
- Cost
- Time to Market
- Lifetime

Traditional Space

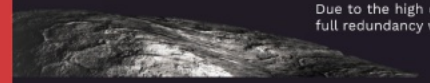
For decades, space exploration was dominated by national agencies like NASA, ESA, JAXA, and ROSCOSMOS.

Missions such as Rosetta, Gaia and Herschel focused on scientific exploration, were government-funded, and involved lengthy planning cycles.



These programs prioritized high reliability and long mission lifetimes.

Due to the high costs and risks, rigorous testing, strict qualification, and full redundancy were essential to ensure mission success.



Time

Space Evolution

High/Long

- Reliability
- Cost
- Time to Market
- Lifetime

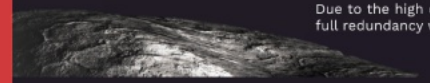
Traditional Space

For decades, space exploration was dominated by national agencies like NASA, ESA, JAXA, and ROSCOSMOS.

Missions such as Rosetta, Gaia and Herschel focused on scientific exploration, were government-funded, and involved lengthy planning cycles.

These programs prioritized high reliability and long mission lifetimes.

Due to the high costs and risks, rigorous testing, strict qualification, and full redundancy were essential to ensure mission success.



Reusable Launchers

#SpaceNext represents a major change from the traditional approach.

While safety and reliability remain "relatively" essential, there is a shift towards agility, cost-efficiency, and commercialization.

Private companies like SpaceX, Rocket Lab, and OneWeb are leading the way, introducing new business models and technological innovations.

Traditional Space

TELECOM+EO:

Constellations
SmallSats
Nano&CubeSats

Time

#SpaceNext represents a major change from the traditional approach.

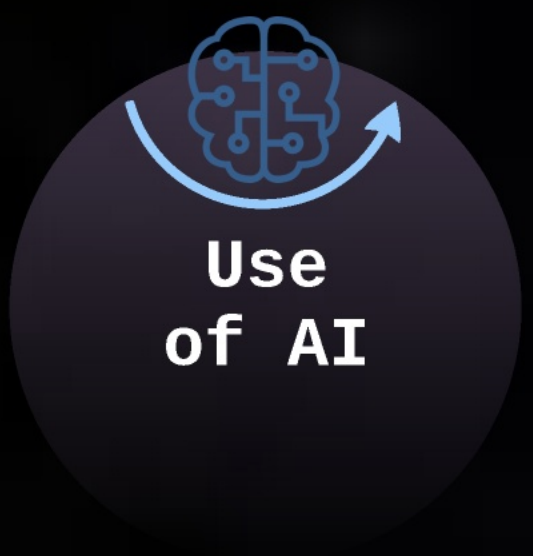
While safety and reliability remain "relatively" essential, there is a shift towards agility, cost-efficiency, and commercialization.

Private companies like SpaceX, Rocket Lab, and OneWeb are leading the way, introducing new business models and technological innovations.

#SpaceNext Era

The space market has evolved from the "New Space" era to what we now call **#SpaceNext**.

#SpaceNext is a fast-moving, adaptable phase where the push for better performance and lower costs continues to fuel innovation, driving the future of space exploration and technology.



Use of Artificial Intelligence (AI)

AI is expected to transform the entire lifecycle of EEE components in the space industry.

In the #SpaceNext era, AI will boost efficiency, and drive automation, making it increasingly vital for the future of space missions!

Generative Design

AI platform uses simulation results to assess the performance of a new design within minutes. AI optimization can reduce design time by over 50%!

Manufacturing and Assembly Automation

AI-controlled robots would assemble delicate EEE components with precision, reducing the risk of human error during the manufacturing and assembly processes!

Testing & Quality Assurance

AI algorithms can predict potential component failures by analysing historical data.
AI can also simulate component ageing to predict when a part would fail!

Procurement and Supply Chain

AI can assess supplier reliability by analyzing performance metrics and quality history.
AI can also predict the demand for components and monitor storage to avoid shortages.

Lifecycle Management

AI models can analyse historical performance data to predict when a component will require maintenance.
AI can also support LCA calculations!

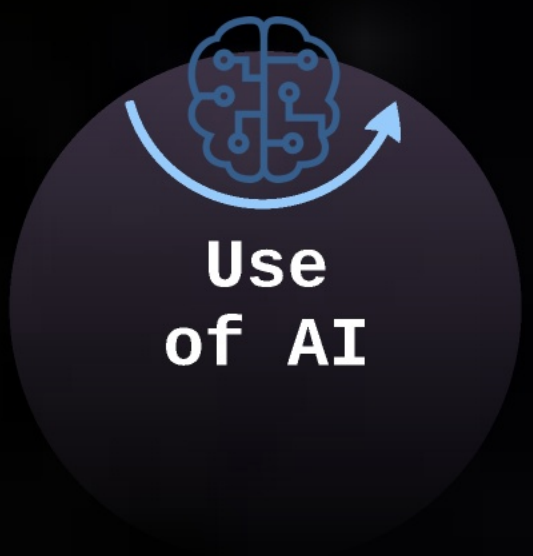
Do not miss the Interactive Panel Discussion on Thursday 17th @ 16h50 :

"Advancing Space Exploration: The Role of AI Across the Entire EEE Life Cycle"

#SpaceNext Era

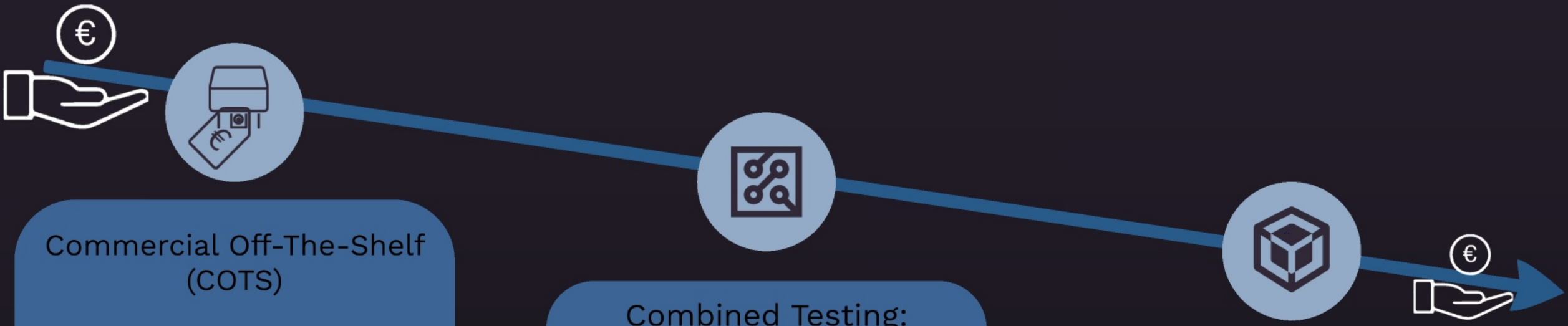
The space market has evolved from the "New Space" era to what we now call **#SpaceNext**.

#SpaceNext is a fast-moving, adaptable phase where the push for better performance and lower costs continues to fuel innovation, driving the future of space exploration and technology.



Cost Effective

Cost-effective approaches, including the use of COTS and integrated testing, are being used in the new space era to make missions more affordable and efficient.



Commercial Off-The-Shelf (COTS)

Cost-effective and commercially available automotive technologies

Conformal coating for pure tin parts, when needed!

Combined Testing:

EEE Components Qualification
&
Verification Assembly on the same PCB Boards!

Qualification and Acceptance Test @ Unit level

No Screening at Component Level

ACCEDE (Assessment of Commercial Components Enabling Disruptive Space Electronics)

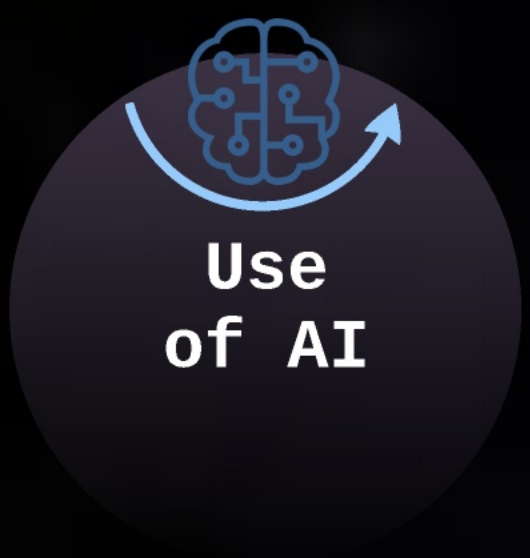
The two main European events devoted to the use of EEE components in space applications, ACCEDE and ESCCON,
will merge in Seville from March 25-27, 2025.

This conference will discuss trends in using and validating COTS for space with the evolution and activities being developed and implemented under the ESCC system.

#SpaceNext Era

The space market has evolved from the "New Space" era to what we now call **#SpaceNext**.

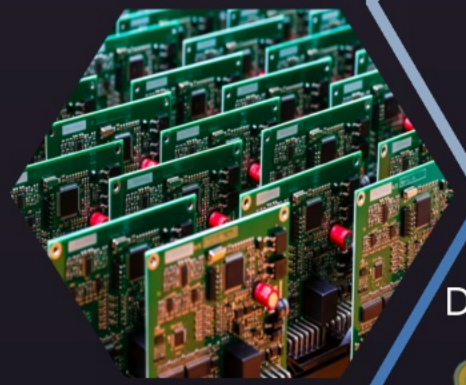
#SpaceNext is a fast-moving, adaptable phase where the push for better performance and lower costs continues to fuel innovation, driving the future of space exploration and technology.



Ease of Integration and Miniaturisation

The need for ease of integration drives the demand for cutting-edge miniaturised technologies, impacting the design and assembly of EEE components in the space industry.

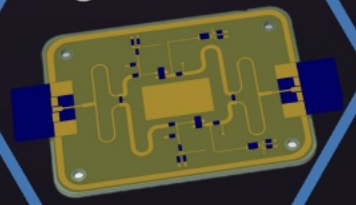
Compact Automotive Technologies



Modular Designs:

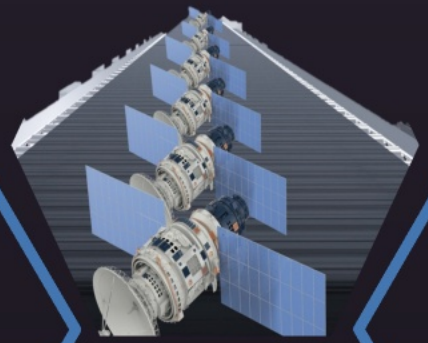
RF output flexibility

Digitalisation



Flexible & Interchangeable

Conductive Inks & 3D Printing



Automatic Assembly

Solderless Solutions

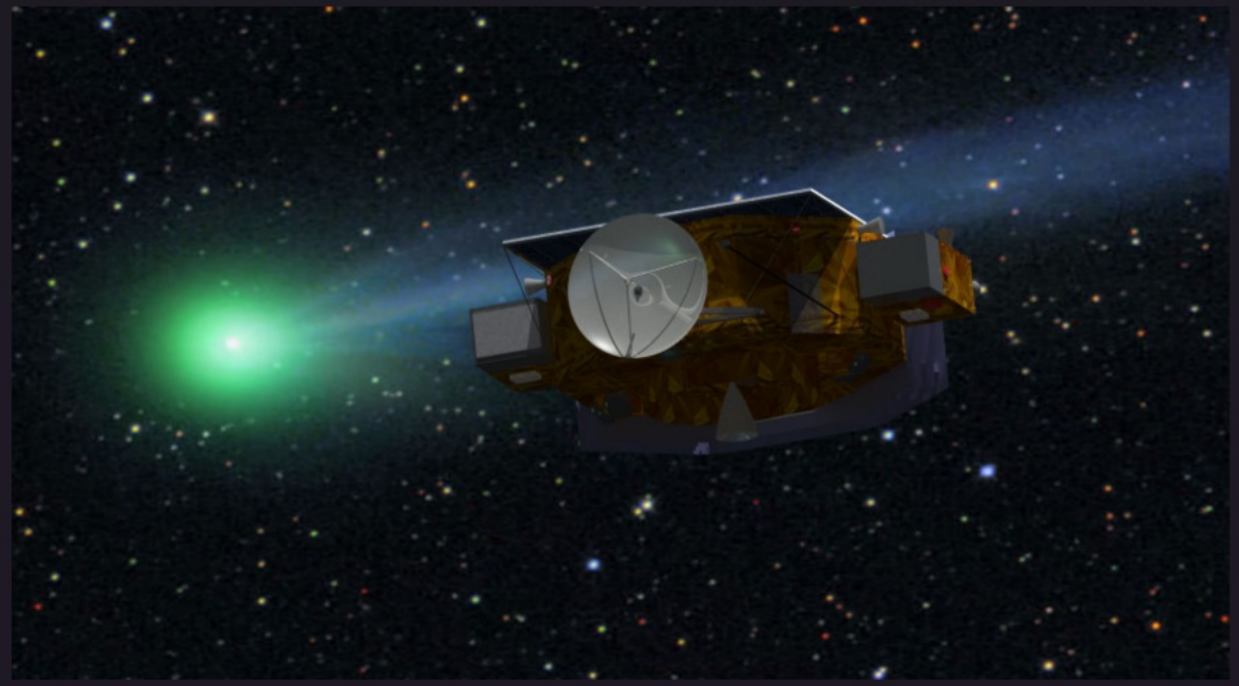
Efficient Thermal Management

Smart & Autonomous Units

Ease of Integration and Miniaturisation

For more information, join Florian Molière's presentation on Wednesday, 16th October at 17h40 :

"Selection of POGO-Pin based connector for ESA COMET-Interceptor Mission"



COMET-Interceptor Mission:

The first ESA close-up study of a dynamically "new" Comet!

News & Challenges

ECSS* Evolution

* **E**uropean **C**ooperation for **S**pace **S**tandardization

ESCC** Resilience

** **E**uropean **S**pace **C**omponents **C**oordination

Space Standards Resilience

How are the European space industry and Agencies coping with #SpaceNext era?

ECSS Evolution:Mission Classification Pending Approval

For all **new** ESA missions, a mandatory classification is conducted during Phase A:

ALPHA

Top Class Missions

Extremely Critical and strategic for ESA - Budget>400M€
Lifetime > 7 Years. Requirements are high, risk is very low.

BETA

High Class Missions

Highly critical - Budget 200 to 400M€, Lifetime 5 to 7 Years,
Requirements are relatively high, risk is low.

GAMMA

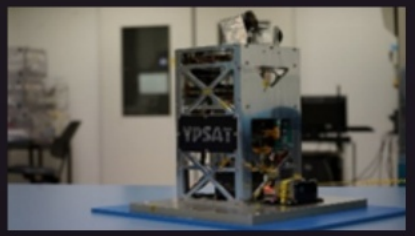
Medium Class Missions

Medium critical - Budget 25 to 200M€ Lifetime 2 to 5 Years,
Requirements are moderate with a non-negligible risk.

DELTA

Low Class Missions

Low critical - budget < 25M€, Lifetime <2 years.
Requirements are very limited with a significant risk.



The impact on ECSS Engineering, Management, and Quality (E/M/Q) standards is assessed and tailored accordingly when necessary.

ECSS Evolution: ECSS-Q-ST-60 Coming soon: Public Review

This ECSS-Q-ST-60 standard defines the requirements for selection, control, procurement and usage of EEE components for space projects.

Several key requirements have been updated, including the addition of standards from qualified JAXA-QTS parts (without additional conditions) and MIL-STD (with specific conditions) for the three component classes:

- Standards with specific conditions : MIL-PRF-49467 for capacitors, MIL-PRF-914 for resistors, MIL-PRF-23648 for thermistors, MIL-DTL-83513 and MIL-DTL-24308 for connectors, MIL-DTL-26482 and MIL-DTL-38999 for circular connectors, and MIL-PRF-39012 for RF connectors...

- Removals: MIL-DTL-28791 (circulators/isolators) and MIL-DTL-15370 (couplers) have been eliminated.

- Additional updates: 100% MIL-STD screening of all parts, Outgassing compliance with ECSS-Q-70-02C, and banning of CKR06 (1µF, 50V) capacitor.

ECSS Evolution: ECSS-Q-ST-20-30

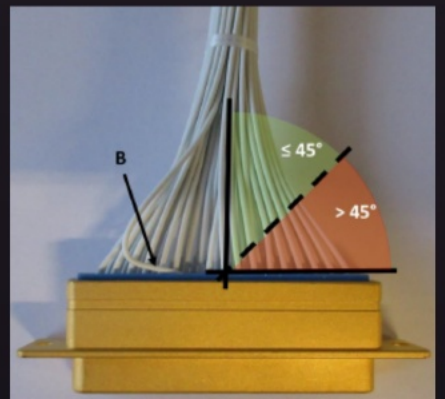
Public Review

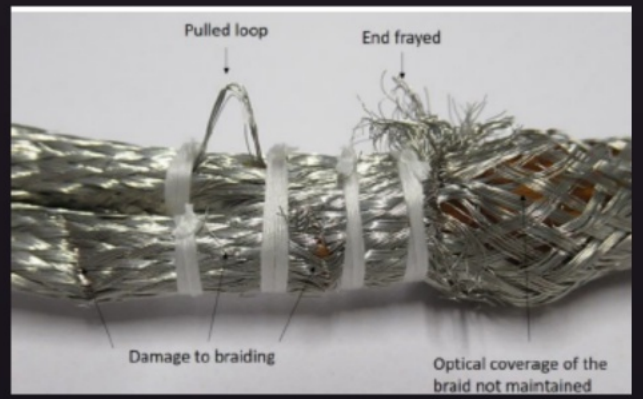
This ECSS-Q-ST-20-30 **NEW** standard specifies requirements for the manufacturing and control electrical harnesses.

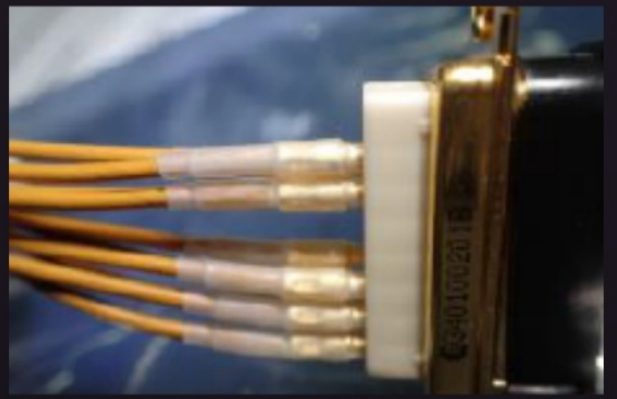
This standard largely applies the well-known IPC standard IPC/WHMA-A-620E ‘Requirements and Acceptance for Cable and Wire Harness Assemblies’ in conjunction with its addendum IPC/WHMA-A-620E-S ‘Space and Military Applications Electronic Hardware.

Within this standard, clauses and requirements from these IPC standards are made either applicable as is, applicable with modifications, applicable with amendments or not applicable.

In addition, new ECSS requirements are formulated to reflect the needs and best practices in the European Space Industry.







ECSS-Q-ST-20-30C DIR1
11 September 2024

EUROPEAN COOPERATION
ECSS
FOR SPACE STANDARDIZATION

Space product assurance

Manufacturing and control of electrical harness

This document is distributed to the ECSS community for Public Review.
(Duration: 8 weeks)
Start Public Review: 13 September 2024
End Public Review: 8 November 2024

DISCLAIMER (for drafts)
This document is an ECSS Draft Standard. It is subject to change without any notice and may not be referred to as an ECSS Standard until published as such.

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

ECSS Evolution: ECSS-Q-ST-70-61

Time for Change

This document defines the requirements for the verification assembly of high-reliability electronic circuits of surface mount, through hole, solderless assemblies, and soldering of harness and wire interconnection, for space applications.

This standard does **not include press-fit connectors** due to potential PCB damage, which is not evaluated in the test requirements.

Class 1 & 2 Missions: Press-fit connectors are not allowed unless no alternatives exist and approval is granted via an RFD with proper justification and testing.
Class 3 Missions: Already implemented in Class 3 missions, such as Proba-3 and Comet Interceptor.

Approval Process: An RFD requires validation from experts in components, M&P, and PCBs, including component qualification, modified assembly verification (adapted Q70-61 + electrical monitoring), and additional checks to assess the impact on the PCB.

NASA has recently removed the press-fit ban from NASA-STD-8739.11. With more evaluation data, this ban could eventually be lifted from ECSS as well.

ECSS* Evolution

* **E**uropean **C**ooperation for **S**pace **S**tandardization

ESCC** Resilience

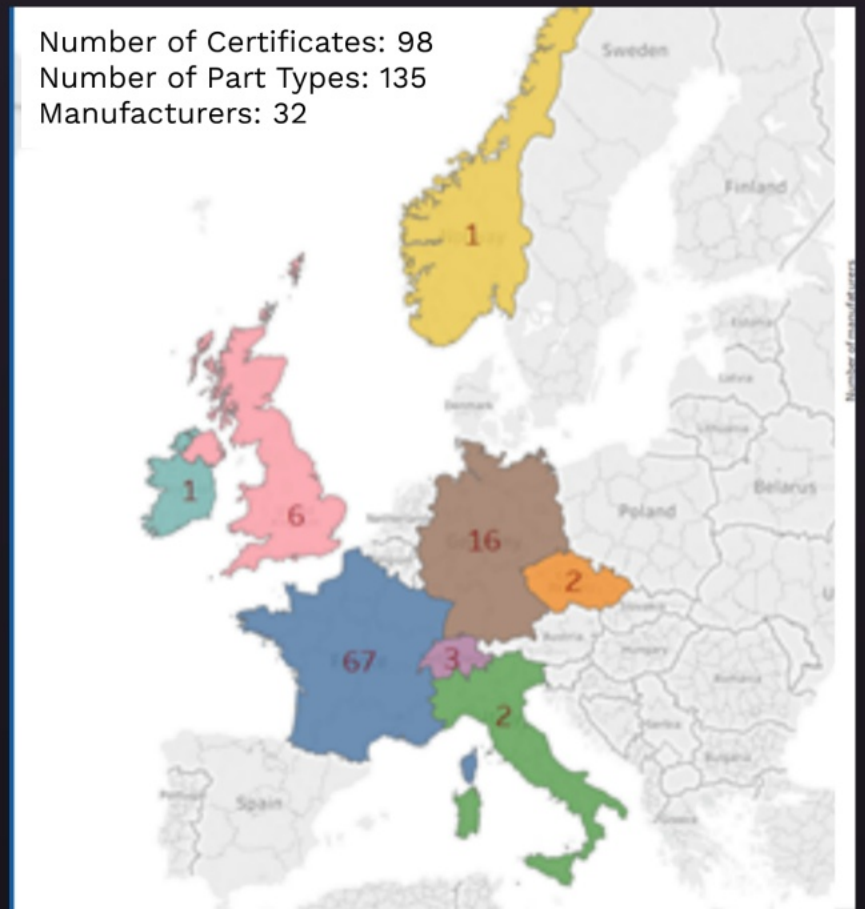
** **E**uropean **S**pace **C**omponents **C**oordination

Space Standards Resilience

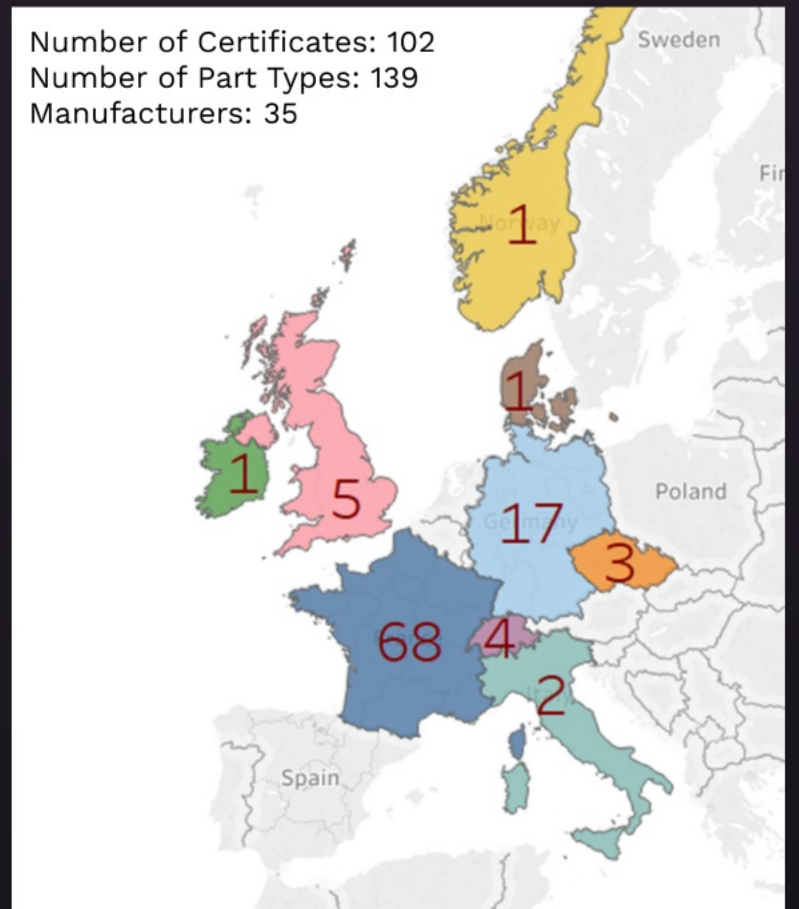
How are the European space industry and Agencies coping with #SpaceNext era?

ESCC Resilience for Passive Components

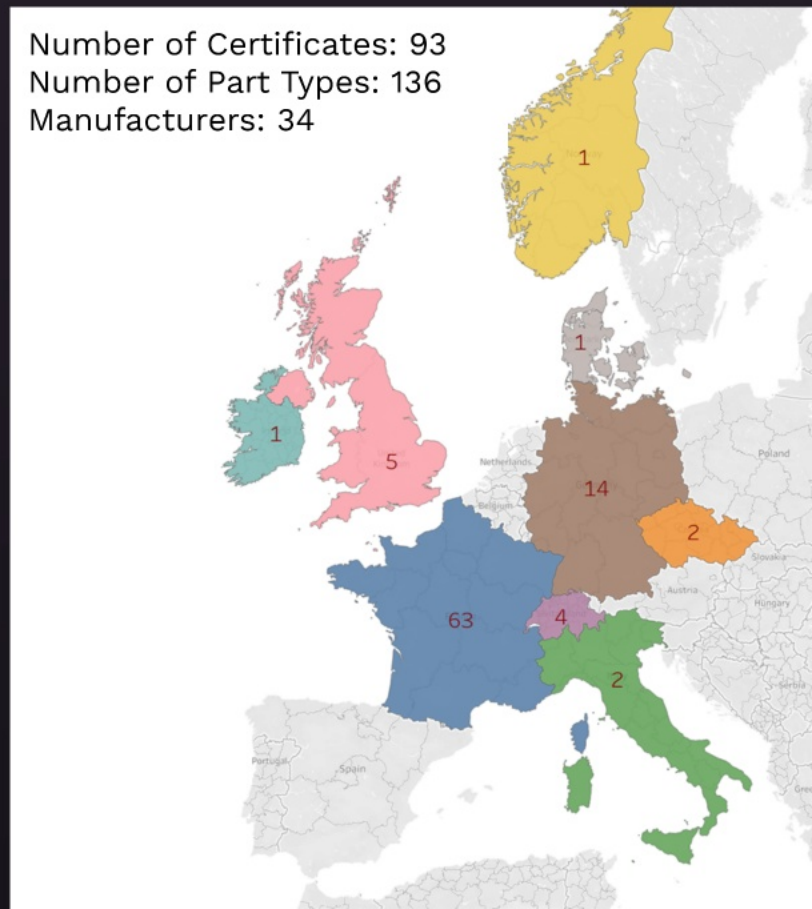
2018



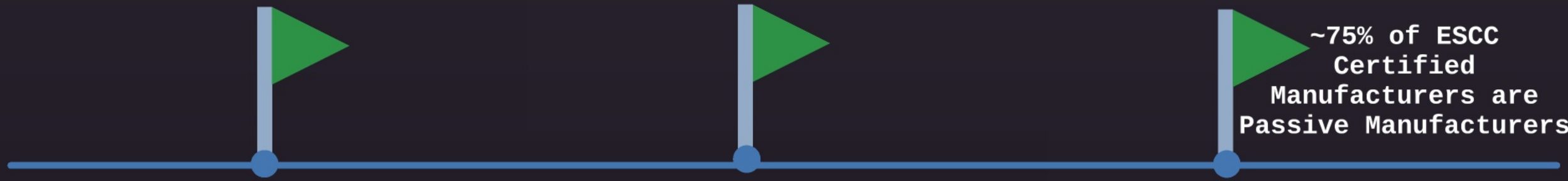
2022



2024



ESCC Resilience for Passive Components



- 3D plus
- Alter Technology
- Axon' Cable
- Bizlink
- C&K Components
- COMEPA
- Diamond SA
- Draka Fileca
- Exens Solutions
- Exxelia Magnetics
- Exxelia Technologies C
- Exxelia Technologies ..
- First Sensor Lewicki
- Flux A/S
- Infineon
- IRCA - RICA
- Isabellenhütte Heusler
- IST
- Kongsberg Norspace
- Kyocera AVX Cz
- Kyocera AVX Fr
- Kyocera AVX UK
- Leach (S)
- MICROCHIP
- NanoXplore
- Radiall
- RAKON France
- REL STPI
- Rosenberger
- Safran
- SCHURTER AG
- Smiths Interconnect
- Souriau
- Space IC
- STMicroelectr..
- STPI
- TE Connectivity D
- TE Connectivity ..
- Thales Alenia Space
- Tyco Electronics
- UMS
- Vishay fernice
- Vishay Selb
- W. L. Gore & Co
- W.L Gore
- IMST

34/46 ESCC Certified Manufacturers

How ESCC system can adapt to the #NextSpace Era?

Expanding Certification Scope

Should we consider allowing non-European entities to obtain ESCC certification?

What benefits or challenges (audits in non-European?) would this bring?

How could this impact the integrity and reputation of ESCC certification?

Sustainability and Environmental Impact

How can the ESCC standards incorporate sustainability and environmentally-friendly practices?

What new requirements or practices (i.e. LCA?) should be introduced to ensure components are produced and used sustainably?

Classifications and Standards

Should we introduce new classes within the ESCC system to address higher risk, lower price, or cost-effective components? Or new COTS Preffered List (CPL?) similary to existing QPL and EPPL?

What would be the basis of such CPL list?

Improving Qualification Processes

Should we revise the ESCC qualification framework to better accommodate new technologies and materials?

What changes are necessary to make the qualification process more dynamic, faster, cost-effective and responsive to innovation?

Adapting to COTS

Should the ESCC system evolve to specifically accommodate Commercial Off-The-Shelf (COTS) components, or should we create a new standard system to include COTS?

If creating a new system, what norms and guidelines should it follow?

Should we name it something like CSSC (COTS for Space Standards Coordination) to differentiate (or get more confused) from ESCC/ECSS?

Collaboration with Industry

How can we enhance collaboration between ESCC and industry to ensure standards evolve in line with technological advancements?

What mechanisms can be put in place to facilitate this collaboration (apart from CTB WGs)?

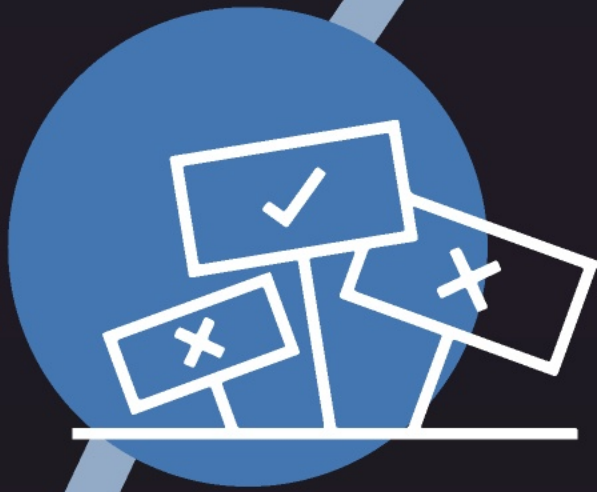
Adapting to COTS

Should the ESCC system evolve to specifically accommodate Commercial Off-The-Shelf (COTS) components, or should we create a new standard system to include COTS?

If creating a new system, what norms and guidelines should it follow?

Should we name it something like CSSC (COTS for Space Standards Coordination) to differentiate (or get more confused) from ESCC/ECSS?

Classifications and Standards



Should we introduce new classes within the ESCC system to address higher risk, lower price, or cost-effective components? Or new COTS Preffered List (CPL?) similary to existing QPL and EPPL?

What would be the basis of such CPL list?

How ESCC system can adapt to the #NextSpace Era?

Expanding Certification Scope

Should we consider allowing non-European entities to obtain ESCC certification?

What benefits or challenges (audits in non-European?) would this bring?

How could this impact the integrity and reputation of ESCC certification?

Sustainability and Environmental Impact

How can the ESCC standards incorporate sustainability and environmentally-friendly practices?

What new requirements or practices (i.e. LCA?) should be introduced to ensure components are produced and used sustainably?

Classifications and Standards

Should we introduce new classes within the ESCC system to address higher risk, lower price, or cost-effective components? Or new COTS Preffered List (CPL?) similary to existing QPL and EPPL?

What would be the basis of such CPL list?

Improving Qualification Processes

Should we revise the ESCC qualification framework to better accommodate new technologies and materials?

What changes are necessary to make the qualification process more dynamic, faster, cost-effective and responsive to innovation?

Adapting to COTS

Should the ESCC system evolve to specifically accommodate Commercial Off-The-Shelf (COTS) components, or should we create a new standard system to include COTS?

If creating a new system, what norms and guidelines should it follow?

Should we name it something like CSSC (COTS for Space Standards Coordination) to differentiate (or get more confused) from ESCC/ECSS?

Collaboration with Industry

How can we enhance collaboration between ESCC and industry to ensure standards evolve in line with technological advancements?

What mechanisms can be put in place to facilitate this collaboration (apart from CTB WGs)?

Collaboration with Industry

How can we enhance collaboration between ESCC and industry to ensure standards evolve in line with technological advancements?

What mechanisms can be put in place to facilitate this collaboration (apart from CTB WGs)?

News & Challenges

Long Lead Time

The market for EEE has been volatile in the last 5 years.

However, we are now seeing positive shifts as the market evolves in a more favorable direction!

Implemented Actions

Lead Time Overview

Long Lead Time

The market for EEE has been volatile in the last 5 years.

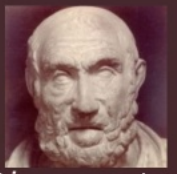
However, we are now seeing positive shifts as the market evolves in a more favorable direction!

Implemented Actions

Lead Time Overview

Implemented Actions

"Healing is a matter of time, but it is sometimes also a matter of opportunity."



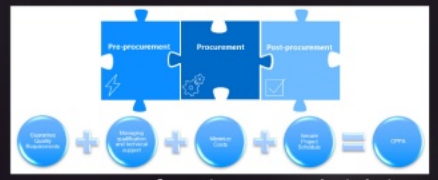
Hippocrates

Most of the proposed actions, proposed in SPCD 2022, have been implemented successfully.

These efforts have greatly reduced long lead times for component procurement.

End user/prime/customers are taking, when possible, the following actions:

- Contracting the service of CPPAs (Centralized Parts Procurement Agency) in order to better coordinate the mission's needs, facilitate the procurement (including qualification testing) and issue grouped POs (Procurement Orders),
- Anticipating the needs and issuing POs in advance,
- Looking for alternative solutions and/or new opportunities (Automotive, new companies).



Unfortunately, this comes at the expense of an increased risk in terms of quality, design, etc.

Manufacturers are trying to do their best to cope with the increased lead time issue by:

- improving their procedures, optimizing their production lines and increasing their capacities,
- hiring and training engineers/operators in order to increase their production capacity,
- adding working shifts,
- Looking for and qualifying alternative suppliers,
- purchasing a larger stock of raw materials, to be able to keep their production running.

Unfortunately, this comes at the expense of an increase in component costs!

While some risks related to quality, design, or costs still exist, they have been managed.

Overall, the positive results show how manufacturers and users have adapted and acted proactively to overcome Lead Time challenges.

EEE Compoenents Lead Time Overview

ESA has funded and is managing a contract with Alter Technology (SP) to track and analyse EEE procurement lead times for several upcoming science missions.

CABLES & WIRES

~22 Weeks

CAPACITORS

~36 Weeks

CONNECTORS

~20 Weeks

CRYSTALS & OSCILLATORS

~40 Weeks

FUSES

~16 Weeks

HEATERS

~14 Weeks

MAGNETICS

~24 Weeks

RELAYS

~30 Weeks

RESISTORS

~60 Weeks

RF PASSIVES

~16 Weeks

SWITCHES & THERMOSTATS

~28 Weeks

THERMISTORS

~30 Weeks

News & Challenges

Anomalies

Component failures happen due to mechanical, thermal, environmental, electrical, mounting, ageing factors, etc.

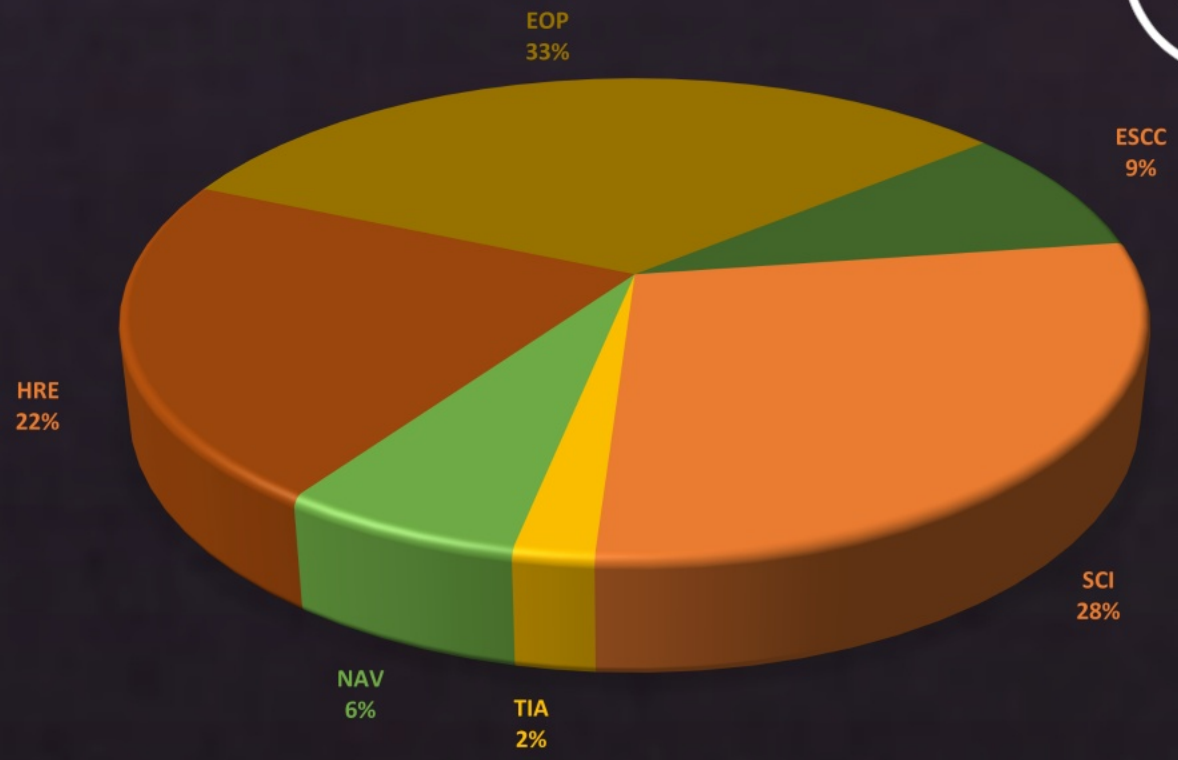
Non-Conformances

In-Orbit Anomalies

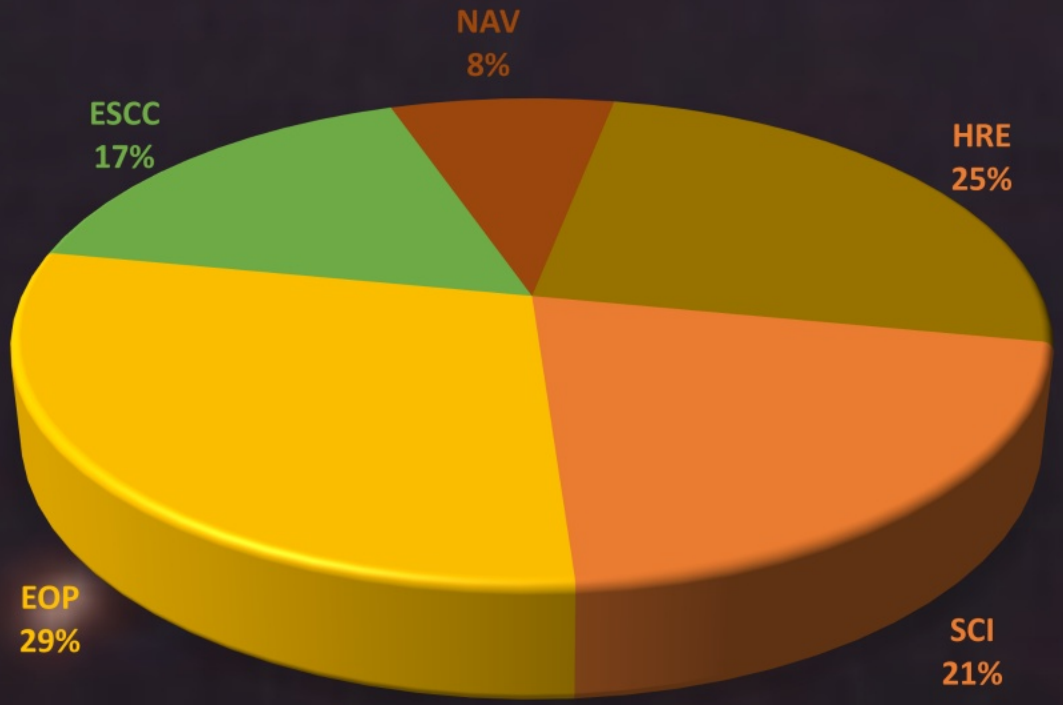
Non-Conformances: 2023 & 2024

NCs related to Passive and RF Passive components by **ESA Application Directorate**

2023 NCRS BY DIRECTORATE



2024 NCRS BY DIRECTORATE



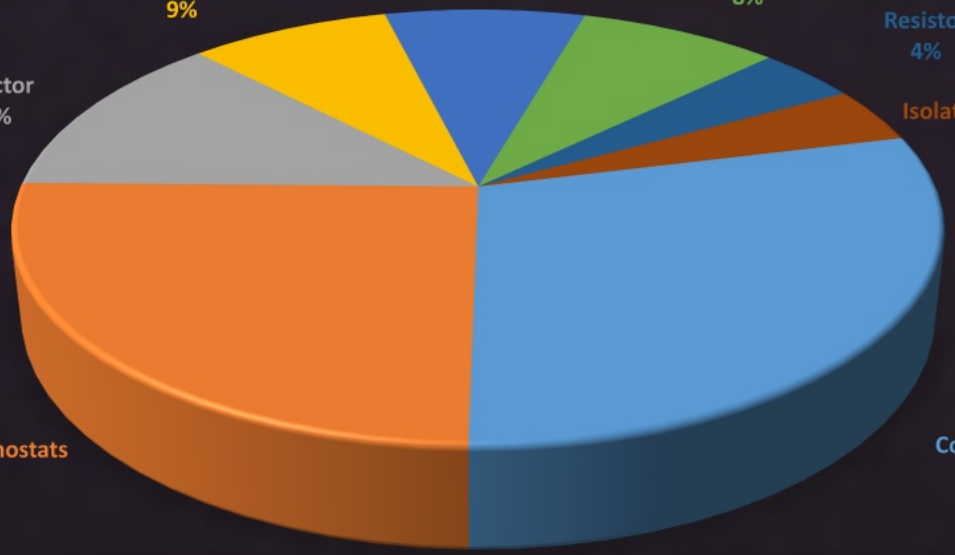
Very similar distribution of NCRs by application in both years

Non-Conformances: 2023 & 2024

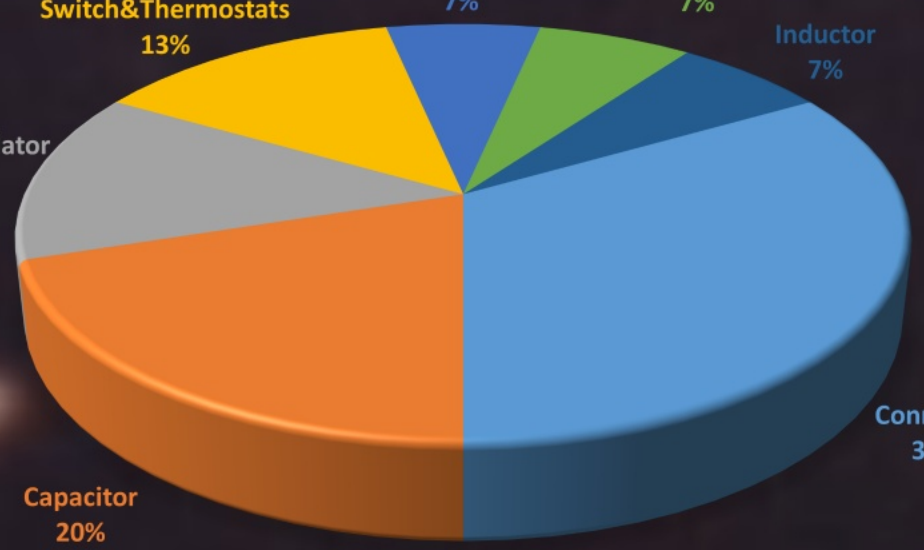
NCs related to Passive and RF Passive components by **component type**

NCs are proportional to the number/amount of passive parts that are mounted in spacecrafts.

2023 NCRS BY COMPONENT TYPE



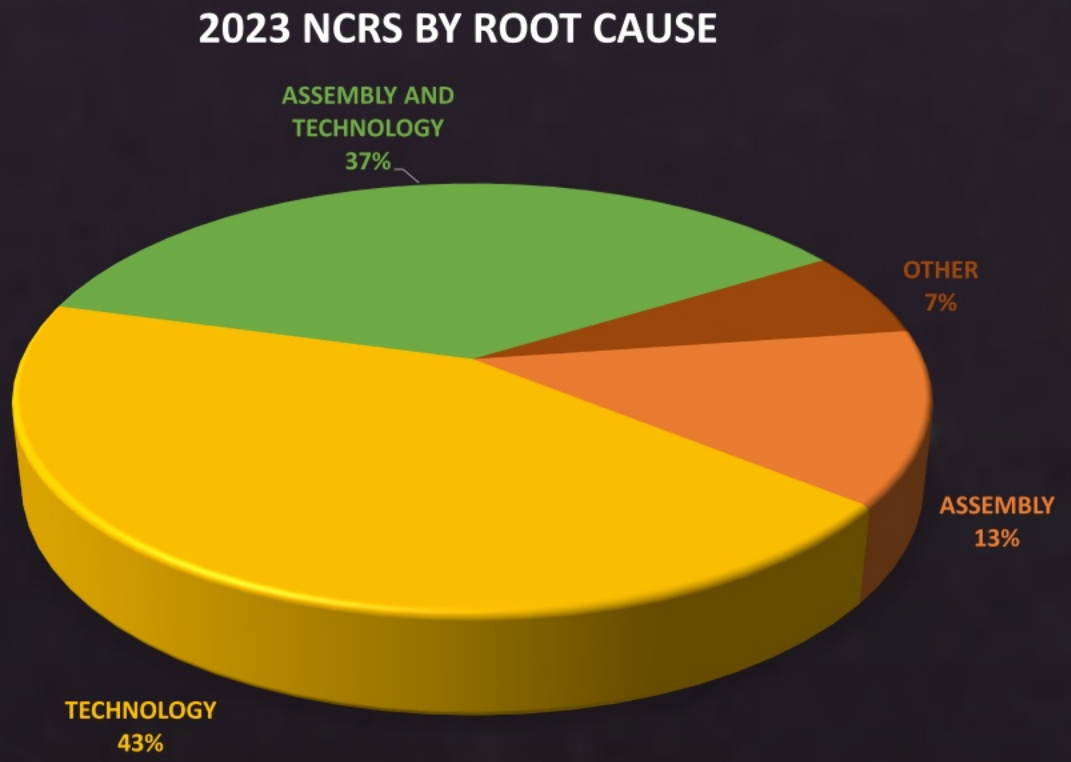
2024 NCRS BY COMPONENT TYPE

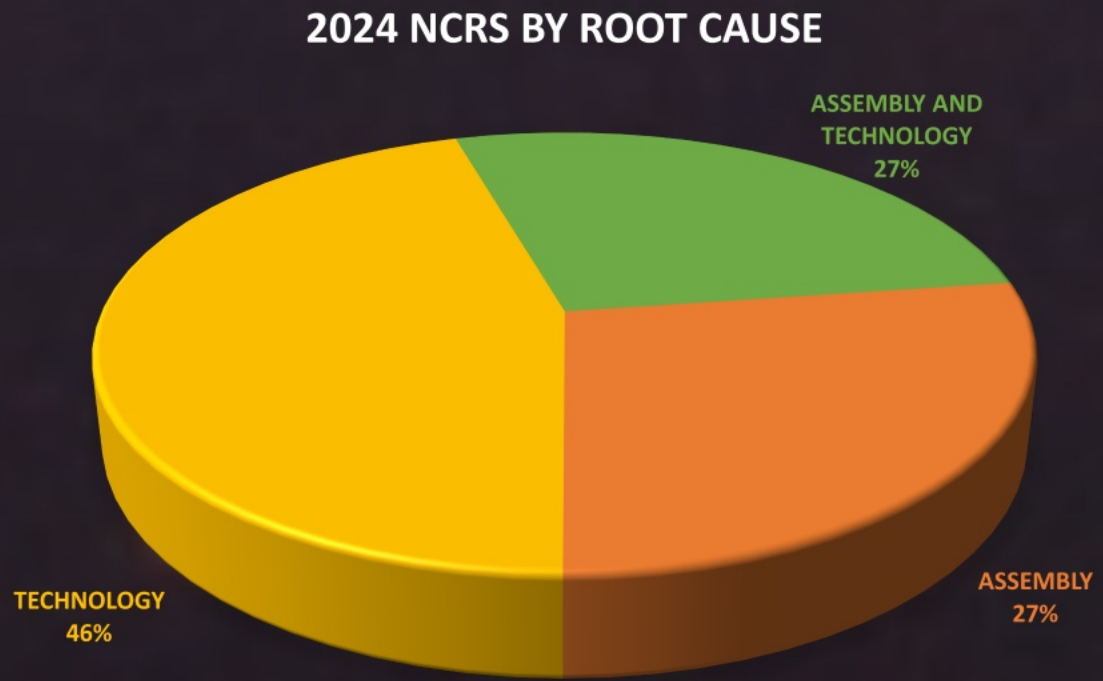


Non-Conformances: 2023 & 2024

NCs related to Passive and RF Passive components by root cause

Most of the issues are related to the technology.
Technology related issues were mainly detected in the case of non-QPL parts: mainly space-grade level, COTS and few ESCC QPL!





Non-Conformances: ESA Alert CKR06 capacitor

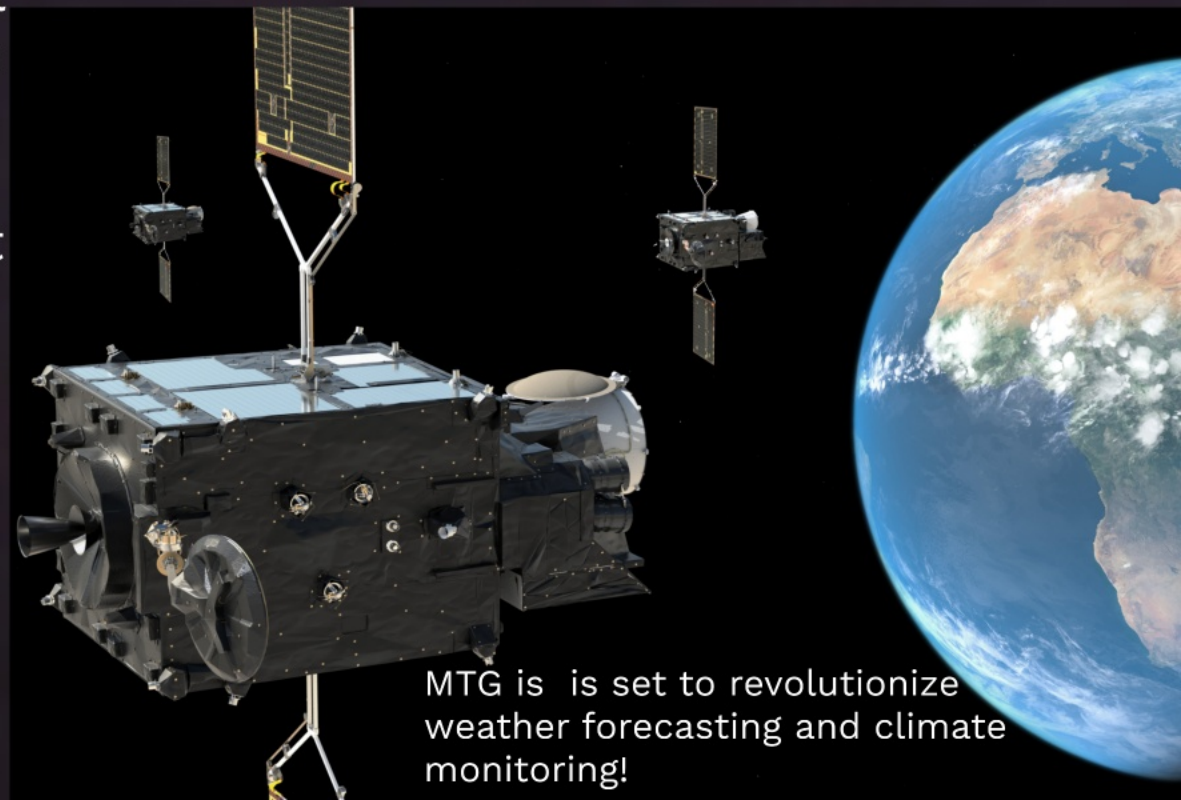
ESA Alert EA-2023-EEE-1-A was issued in 2023:
"Cracks in through-hole multilayer ceramic capacitors CKR06 MIL-PRF-39014/02 (1µF 50V) leading to short-circuit failures"

Several 1uF, 50V capacitors failed during equipment acceptance tests, primarily due to weak internal design (relatively numerous electrodes and very thin dielectric layers).

As a result, ECSS-Q-ST-60 was updated to prohibit the procurement and use of this capacitor type.

Multiple ESA projects were impacted:

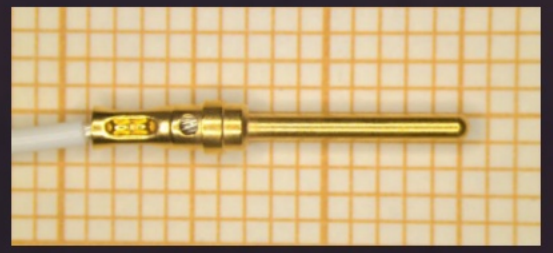
- Use-as-is when the application was not critical
- Replacement where necessary and possible.
- Use-as-is with additional lot testing.

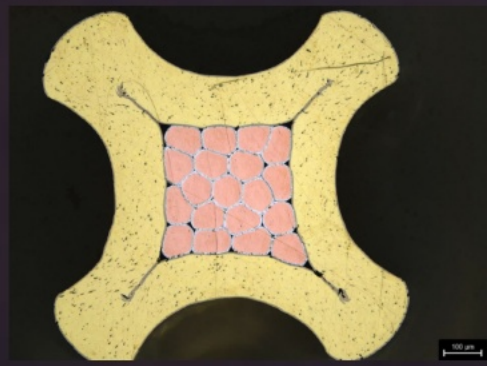


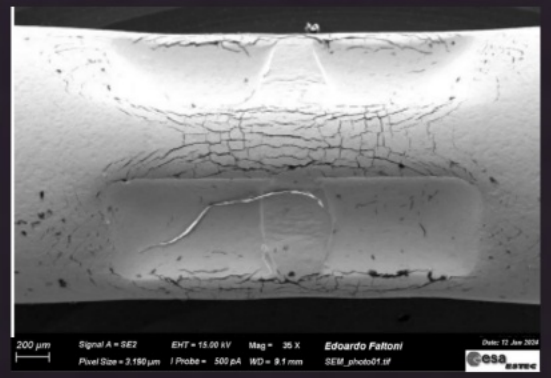
MTG is is set to revolutionize weather forecasting and climate monitoring!

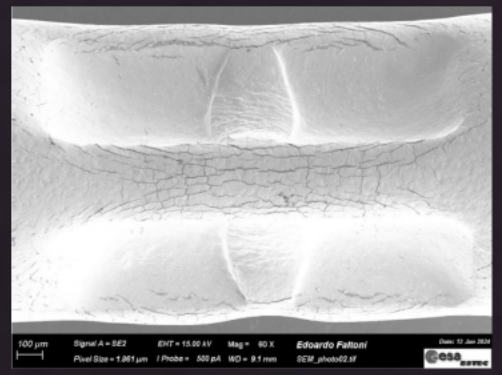
Non-Conformances: Cracks in Crimped Contacts (plating)

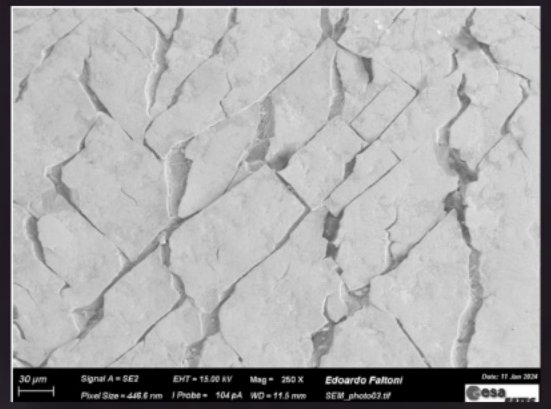
QPL contacts showing cracks in the plating after crimping due to the **underplating** layer composition.

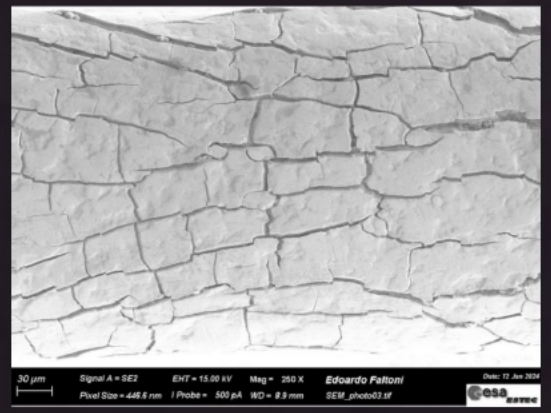




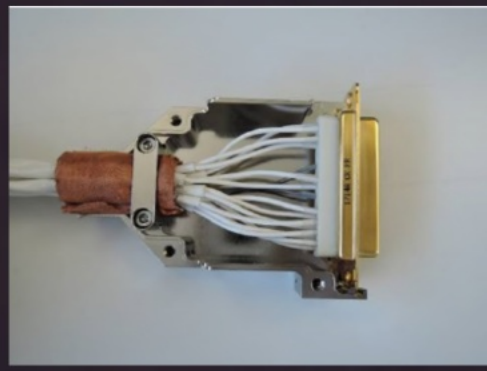






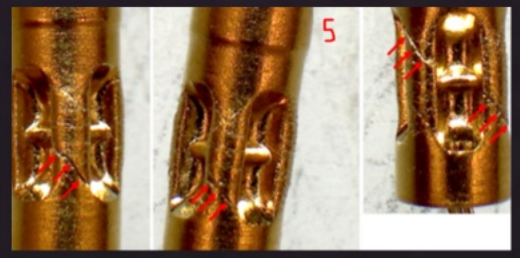


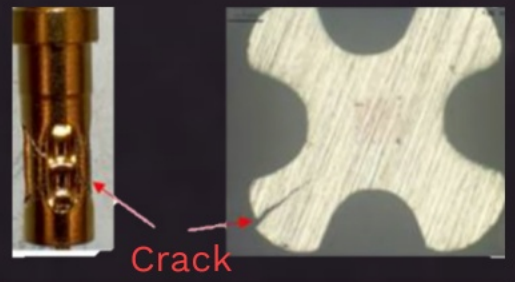
Non-Conformances: Cracks in Crimped Contacts (base material)

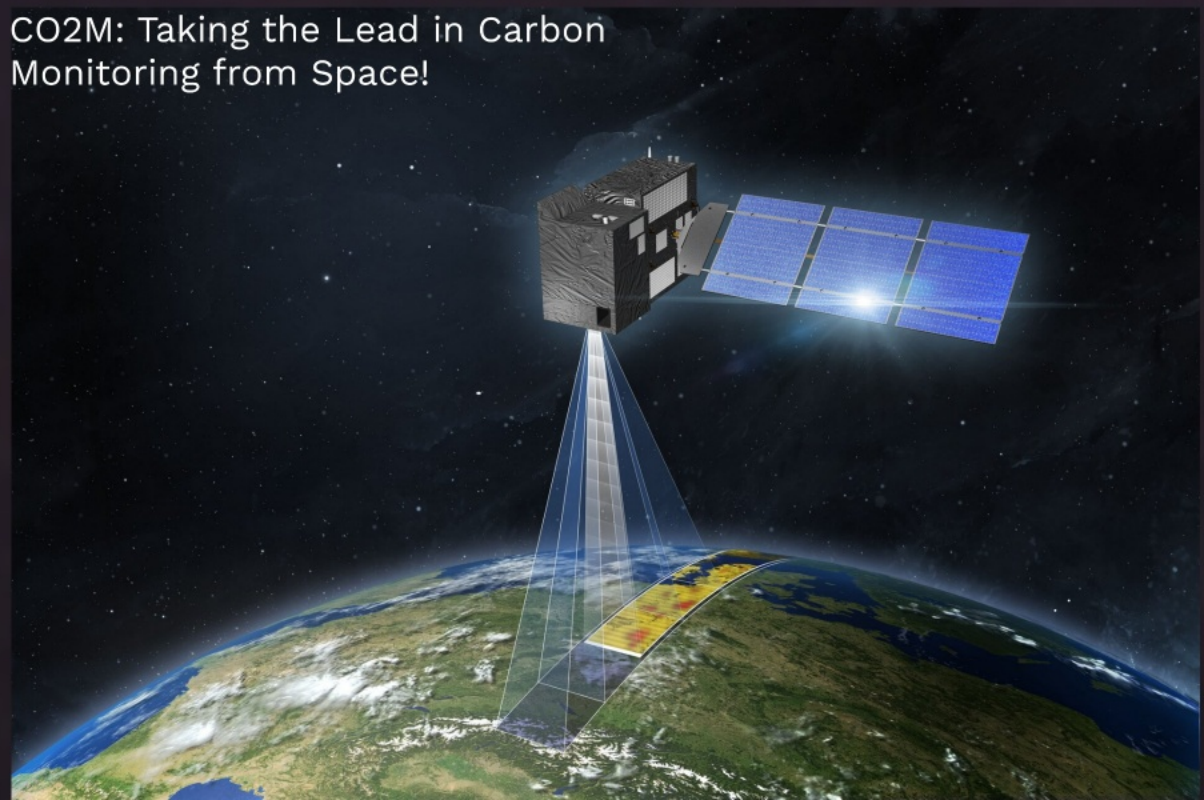


QPL contacts showing cracks in the **base material** after crimping.

Root cause identified:
The issue comes from two main factors:
- crimping process with a not recommended selector position
- base raw material with poor mechanical characteristics







Non-Conformances: Relays, here we go again!

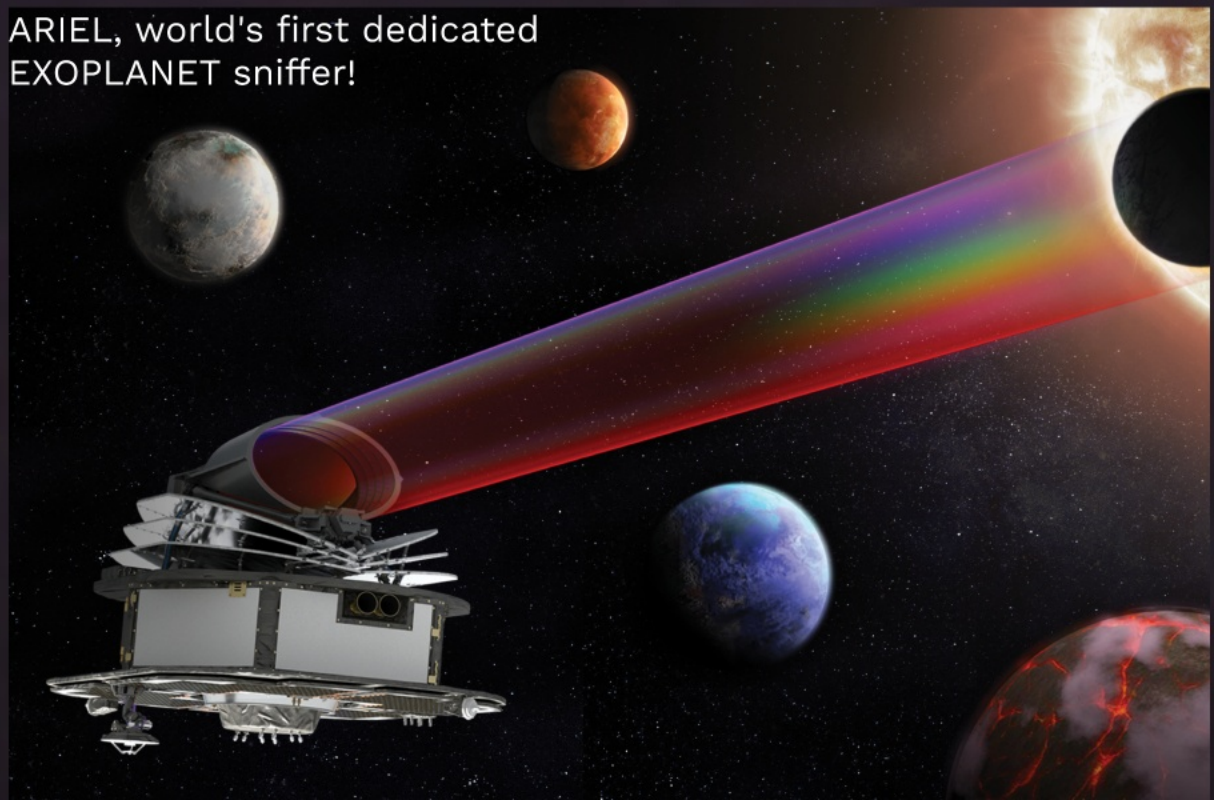
TO5 relays continue to be one of the most challenging passive components due to their sensitivity and mechanical subassemblies that require significant manual assembly.

New issue : low-level vibration Failures
Issues usually occur every two to three years, and now a new problem has emerged!

The root cause has not yet been identified, and current investigations are ongoing.

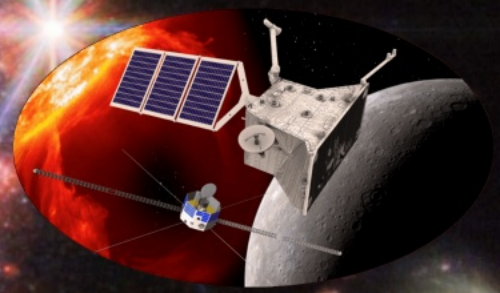
Customers have been informed by the manufacturer that ESA has placed a hold on the qualification status, so the part is no longer QPL.

Multiple ESA projects are impacted:
- Replacement with stock parts
- Use-as-is when the application was not critical.



In-Orbit Failures

When a "simple" component causes Satellite in-orbit failures!

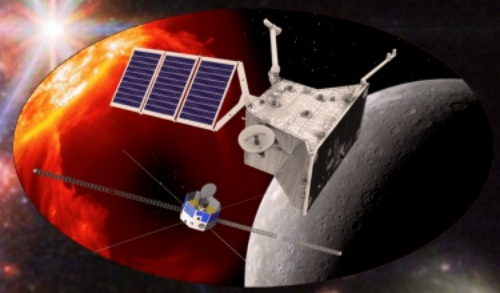


BepiColombo

Sentinel 1B

In-Orbit Failures

When a "simple" component causes Satellite in-orbit failures!

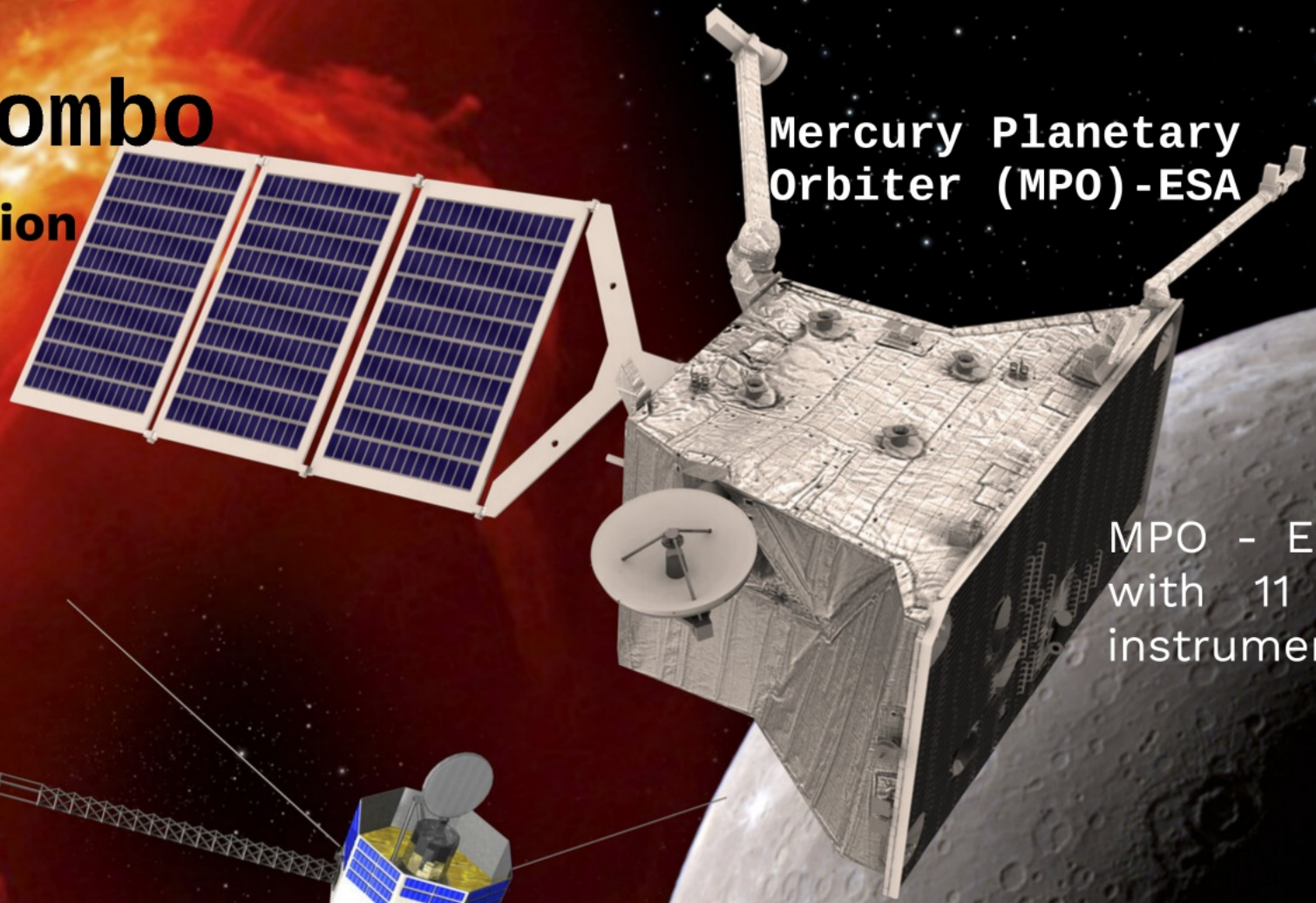


BepiColombo

Sentinel 1B

BepiColombo

ESA's first mission to Mercury!



Mercury Planetary Orbiter (MPO)-ESA

MPO - ESA is a spacecraft with 11 experiments and instruments

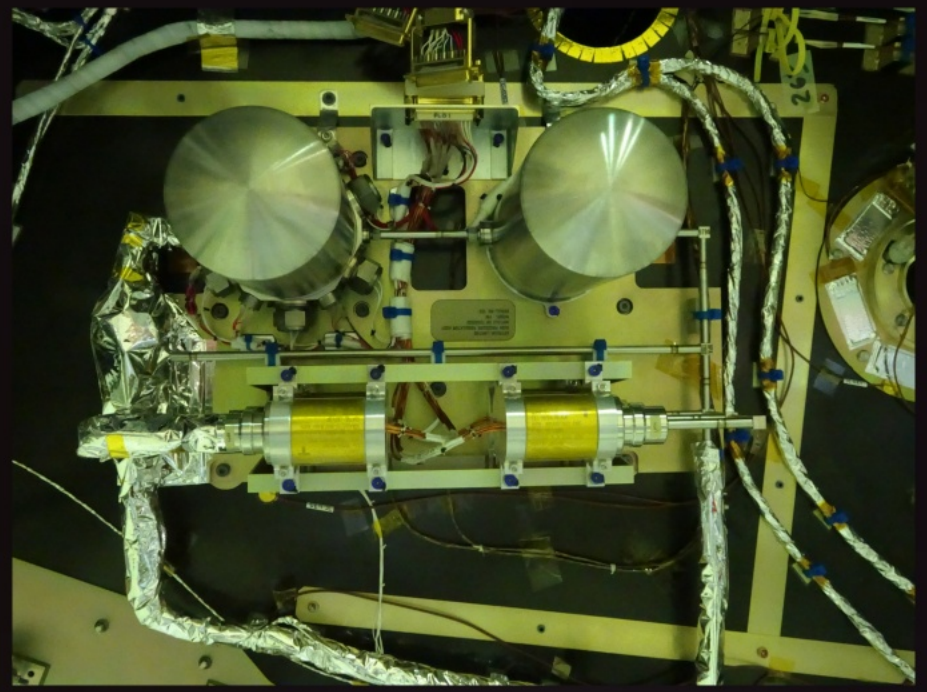
Mercury Magnetospheric Orbiter (MMO)- JAXA

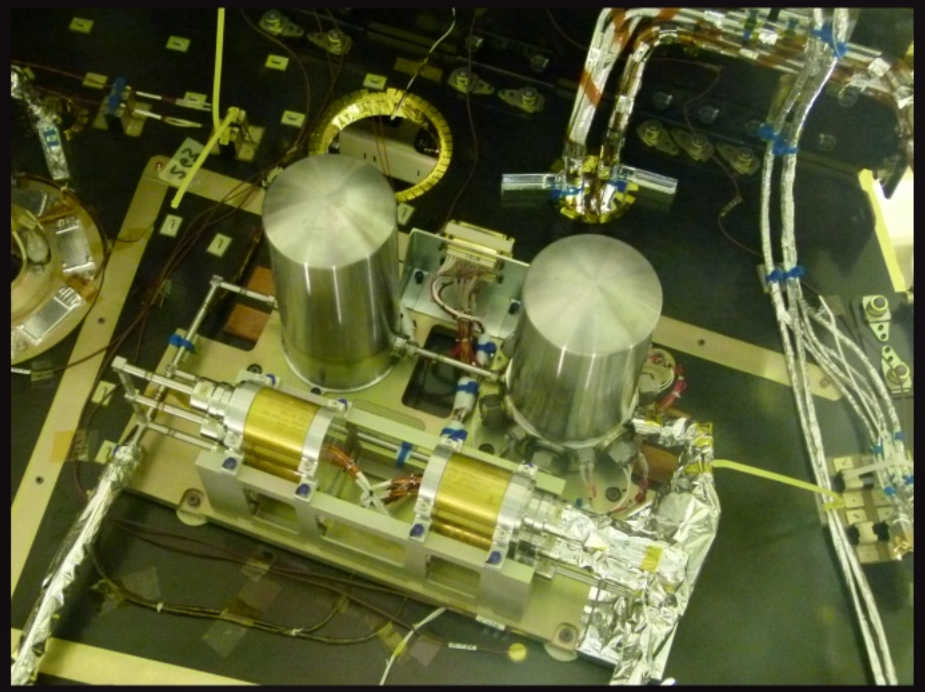
MMO - JAXA is a spinning spacecraft carrying a payload of five experiments and instruments.

BepiColombo: In-orbit Anomaly on Thermostat TH47

Telemetry data revealed an issue with the High Pressure Regulator (HPR) heating unit, part of the electrical propulsion system.

The HPR heating unit keeps Xenon in gas form, stopping it from turning into liquid.

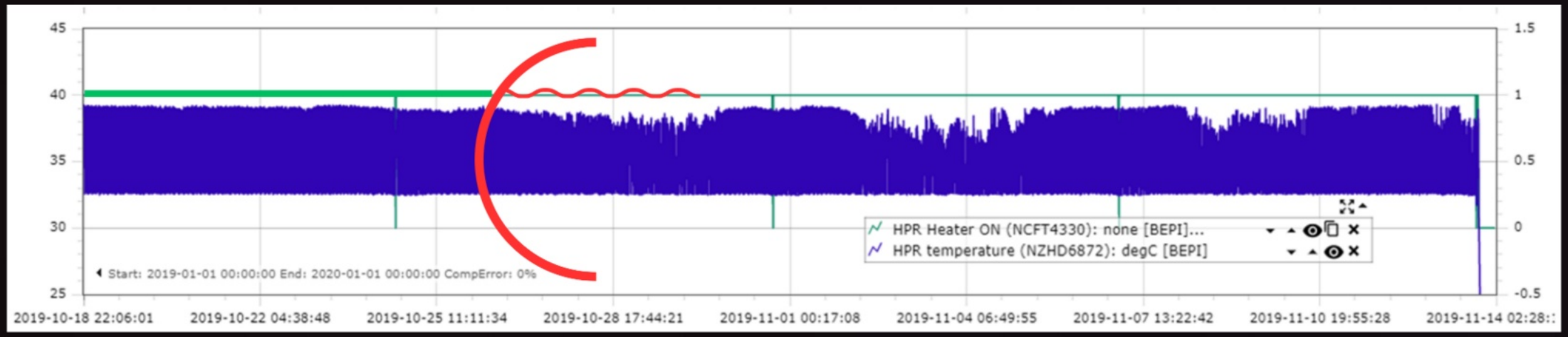


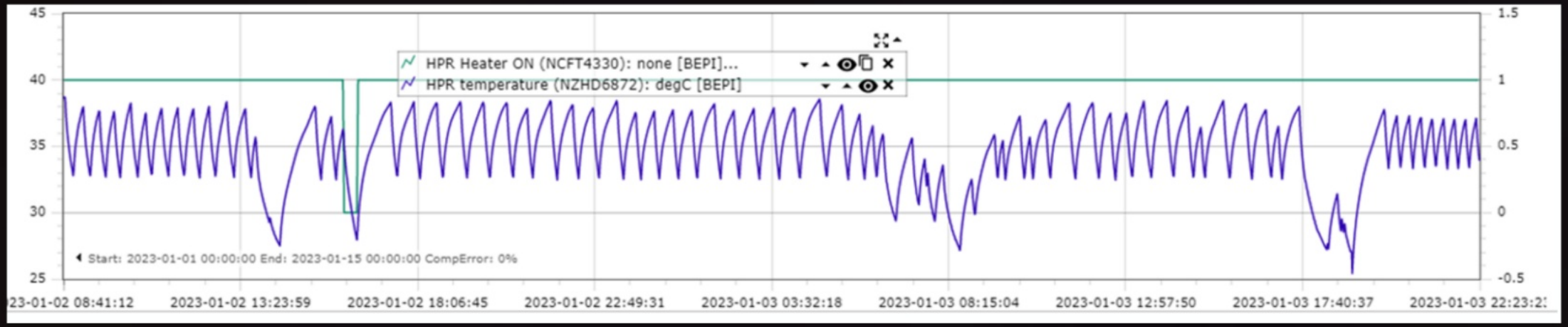


It is essential for the satellite's electrical propulsion system. Without it, control of the propulsion system is lost, putting the **entire satellite at risk.**

BepiColombo: In-orbit Anomaly on Thermostat TH47

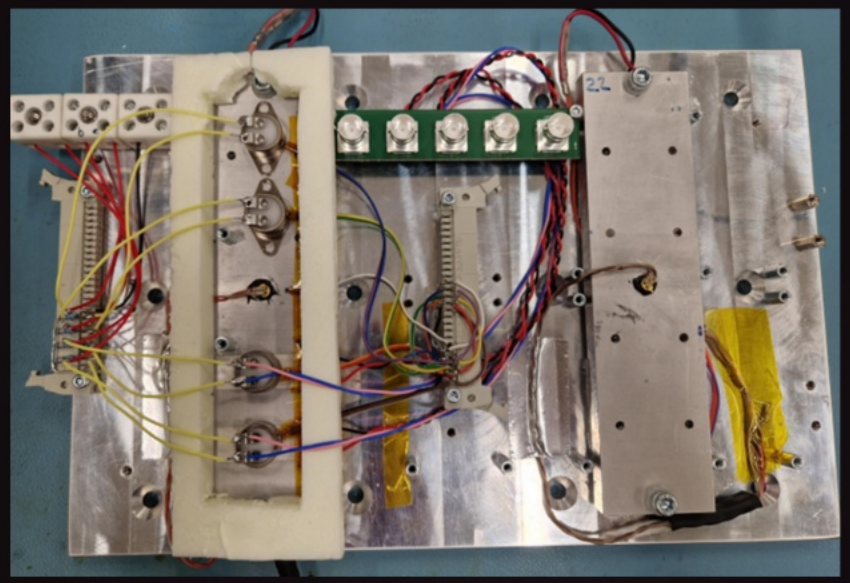
Telemetry data revealed an issue with the High Pressure Regulator (HPR) heating unit, part of the electrical propulsion system.

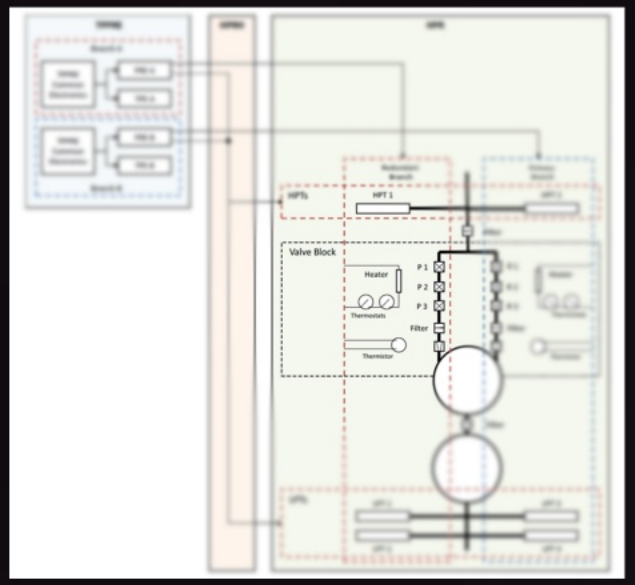




BepiColombo: In-orbit Anomaly on Thermostat TH47

The HPR includes a heater and two thermostats in series.





Extensive investigations by the ESA EEE Components Laboratory identified the root cause of the issue related to the thermostat.

Fortunately, a system solution was proposed by our colleague Florian Krimmel, who will present the details during his talk, on Friday 18th at 12:20h:

“Failure Analysis After In-Orbit Anomaly on COMEPA Bimetallic Thermostat TH47”

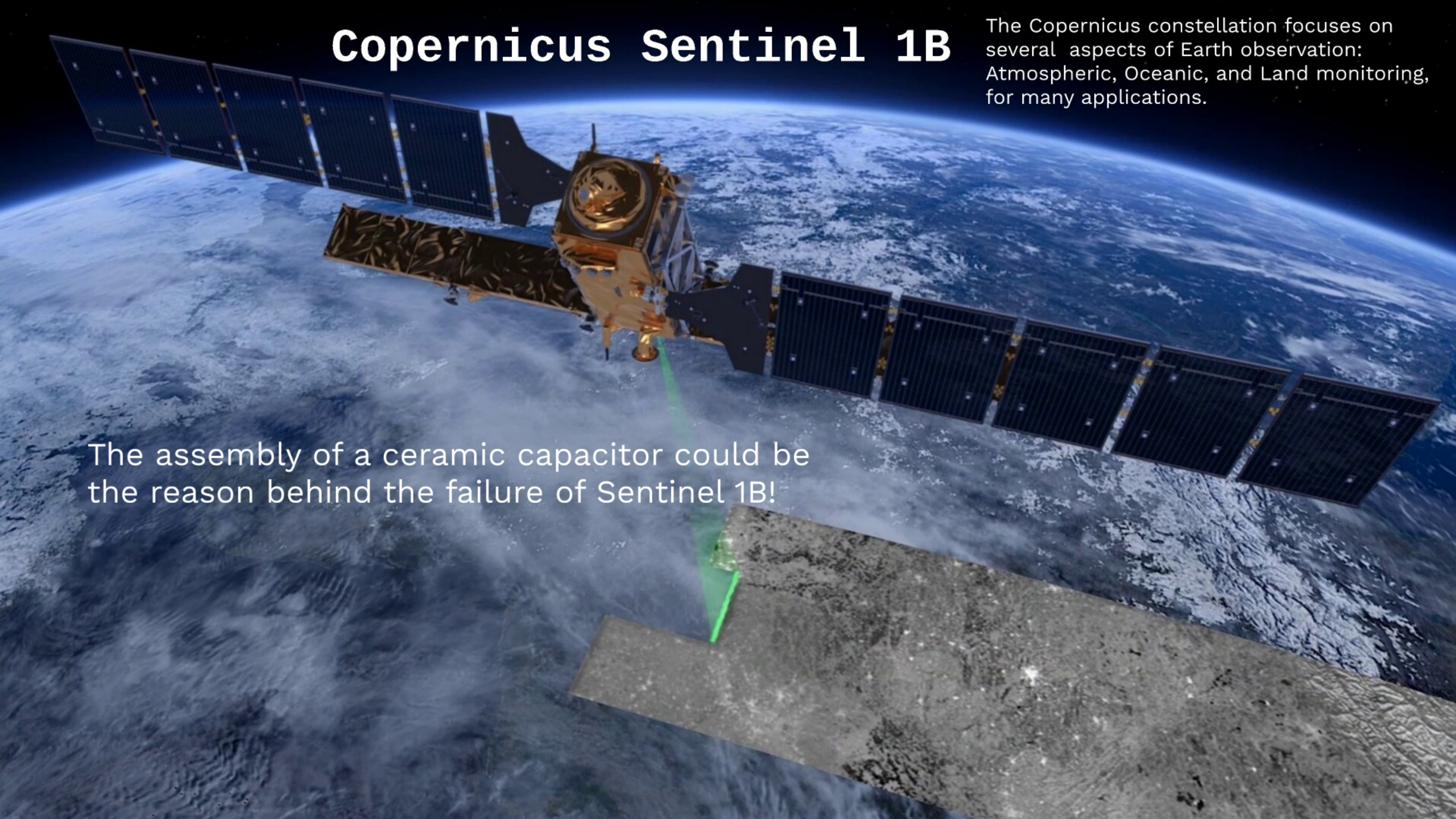
BepiColombo: In-orbit Anomaly on Thermostat TH47

Meanwhile, BepiColombo's fourth Mercury flyby is a cosmic dance—everything is **nominal**!

BepiColombo's fourth Mercury flyby!

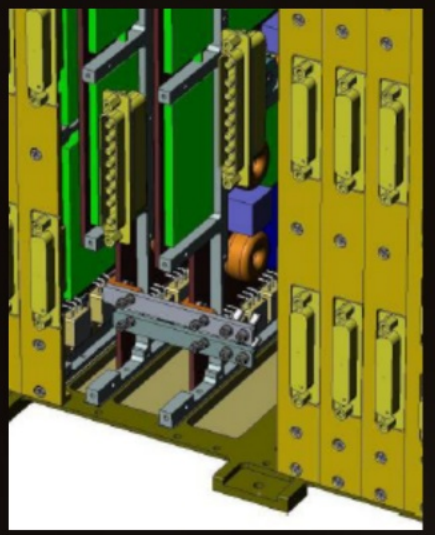
Copernicus Sentinel 1B

The Copernicus constellation focuses on several aspects of Earth observation: Atmospheric, Oceanic, and Land monitoring, for many applications.



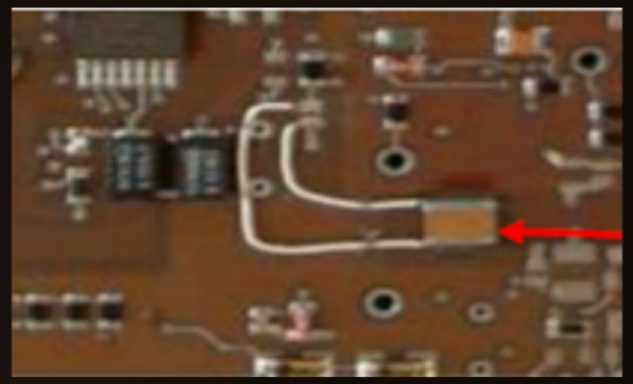
The assembly of a ceramic capacitor could be the reason behind the failure of Sentinel 1B!

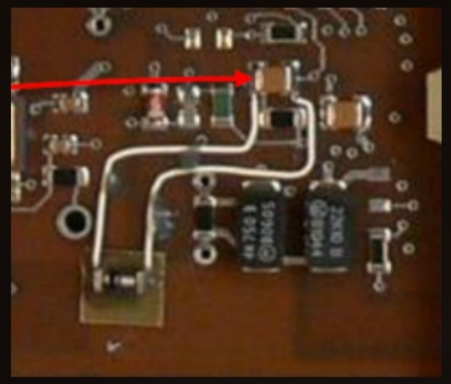
Copernicus Sentinel-1B: The root cause

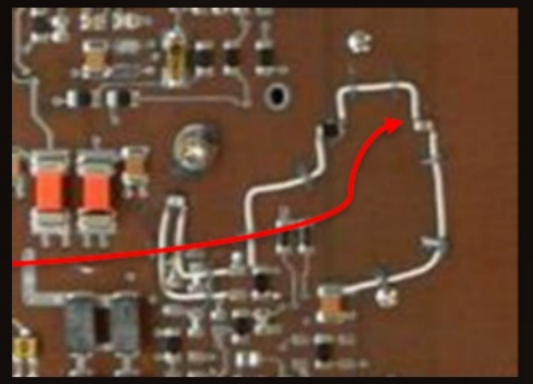


It was discovered that the main problem is related to the 28V regulated bus of the CAPS (C-SAR Antenna Power Supply).

The possible Root cause is the rework (direct wiring) of ceramic (Type II) capacitors!







Similar effects of crack problems detected in-orbit in other missions...

Copernicus Sentinel-1B: ECSS update

ECSS document update about the type 2 ceramic capacitors.

The rework is forbidden since 2017.

Type II chip ceramic capacitors shall not be reworked.

Reprocessing shall not damage the device.

NOTE Reprocessing of ceramic chip capacitors is advised to be avoided due to potential crack formation.

The direct wiring is not allowed and the use of PCB patch is recommended since 2019.

Wiring directly on the component termination (eg. Component bonded on PCB and wiring connection made) and wiring made on the same PCB pad than the capacitor (modification after component assembly) shall not be performed due to possible damage within the component such as crack in the ceramic.
It is recommended either to use a patch board with separate pads for the wiring (for addition of a capacitor) or to replace the capacitor during the wiring (modification applied after assembly)

Copernicus Sentinel-1B: ECSS update

At the same time, the ECSS also forbids the rework of flexible ceramic capacitors and the direct wiring of Ta capacitors.

ECSS-Q-ST-70-61_1510697

m. Ceramic chip capacitors with flexible terminations shall not be reworked.

ECSS-Q-ST-70-61_1510698

n. Ceramic chip capacitors with flexible terminations may be reworked providing the use of an appropriate procedure that avoids any thermal shock and is successfully verified according to clause 13 and approved by Approval Authority.

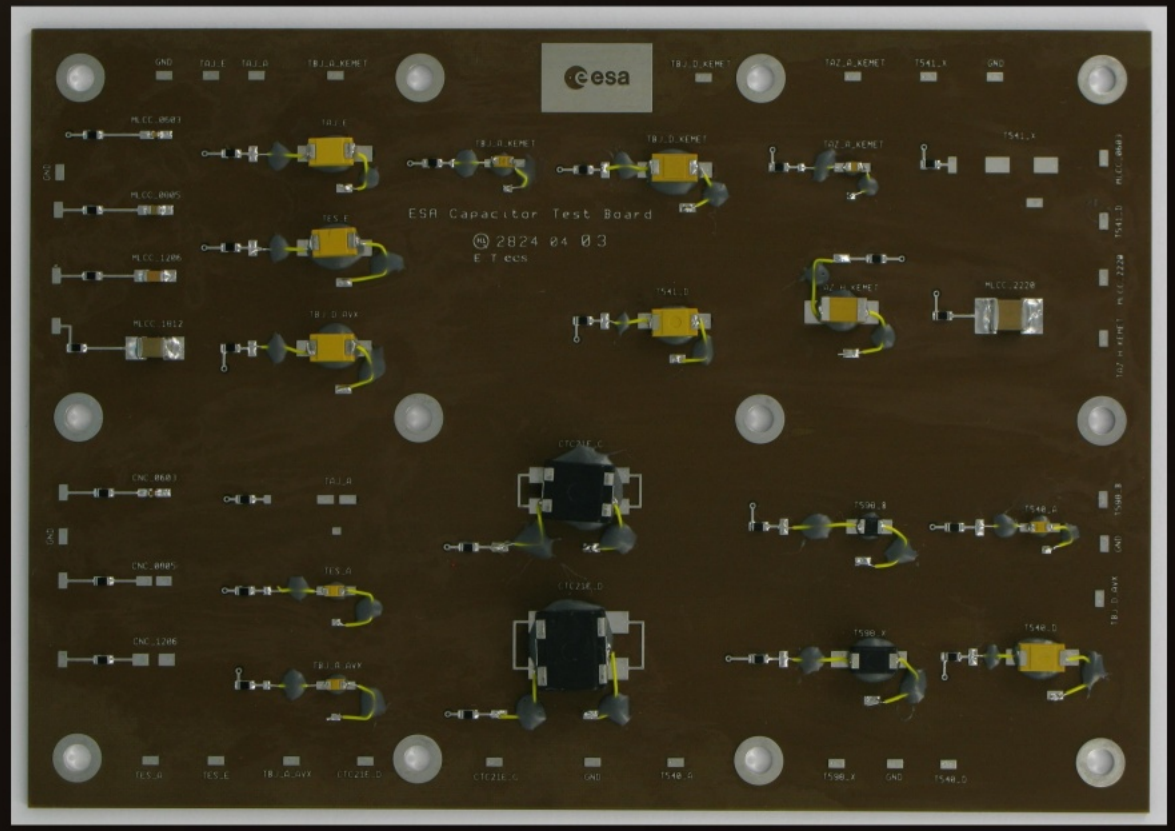
ECSS-Q-ST-70-61_1510699

o. Wiring a tantalum capacitor bonded on PCB as described in clause I.3.7 of ECSS-Q-ST-70-28 shall not be performed.

An ESA investigation is on going to determine if the ECSS has to be updated or not with respect to Tantalum and Ceramic Flexible capacitors.

Copernicus Sentinel-1B: Assembly verfication on capacitors

The investigation is done on a selection of flexible ceramic capacitors and Ta capacitors, in order to allow (or forbid) the rdirect wiring on Ta Capacitors and rework on Flexible Ceramic Capacitors.



No.	Manufacturer	Part Details	Qty	Capacitor Type
1	Kyocera AVX	301200405C337KA0035	20	Ta MnO2
2	Kemet	CWR09JC474KCA	20	Ta MnO2
3	Kemet	CWR09NC475KBB	20	Ta MnO2
4	Exxelia	301200301C156KN	20	Ta MnO2
5	Exxelia	301200301C566KK	21	Ta MnO2
6	Exxelia	300903901C103MX	20	Flexible MLCC
7	Kyocera AVX	06031C153KAR6-EM	20	Flexible MLCC
8	Kyocera AVX	08053C105KAR6-EM	20	Flexible MLCC
9	Kyocera AVX	1206YC273KAR6-EM	20	Flexible MLCC
10	Kyocera AVX	18123C685KAR6-EM	20	Flexible MLCC
11	Kyocera AVX	22205C685KAR6-EM	20	Flexible MLCC
12	Kemet	T598B107M006AHE045	20	Ta polymer
13	Kemet	T598X336M035AHE065	20	Ta polymer
14	Kemet	T540A226M010CH6710	20	Ta polymer
15	Kemet	T540D475M063AH6510	20	Ta polymer
16	Kemet	T541D157M010CH6720	20	Ta polymer
17	Kemet	T541X107M030CH6620	20	Ta polymer
18	Kyocera AVX	CWR11FC105KCA	20	Ta MnO2
19	Kemet	CWR11CH475MCB	20	Ta MnO2
20	Kemet	CWR11MC685KCB	14	Ta MnO2
21	Kyocera AVX	301200117C107KC	6	Ta MnO2
22	Kyocera AVX	301200117C227KJ	12	Ta MnO2
23	Kyocera AVX	301200401106KA1800	20	Ta MnO2

Copernicus Sentinel-1B: Assembly verfication on capacitors

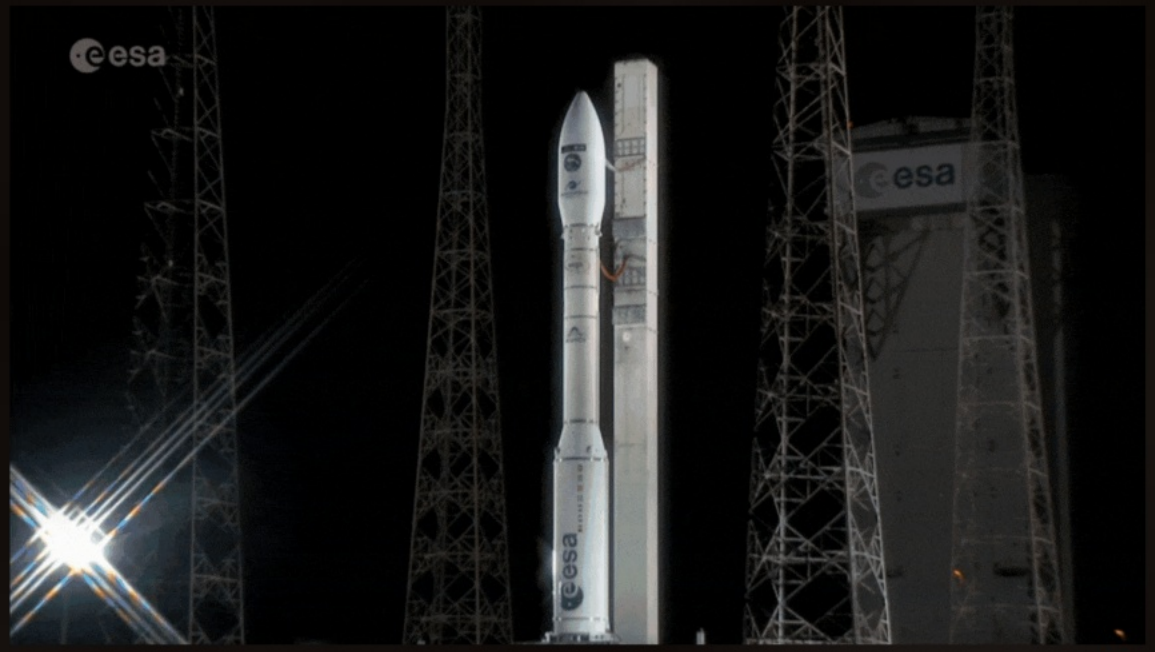
The capacitors are assembled on a space-qualified PCB. Then they are going through a verification assembly test campaign, according to ECSS-Q-ST-70-61 specification.

Right now, the humidity test is on going. Final results to be published soon.

The results will determine whether the ECSS-Q-ST-70-61C needs to be updated or not.

Copernicus Sentinel-2C: The Launch 05/09/2024

Sentinel-2C, developed in compliance with ECSS standards for capacitor assembly.



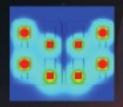
It was successfully launched in September 2024 on one of the final missions of the Vega rocket.

Passive Components: News, Activities and Trends

Dr. Léo Farhat & Mr. Joaquin Jimenez
ESA - European Space Agency

TRENDS

What is next?



THERMAL & MECHANICAL

HARNESS

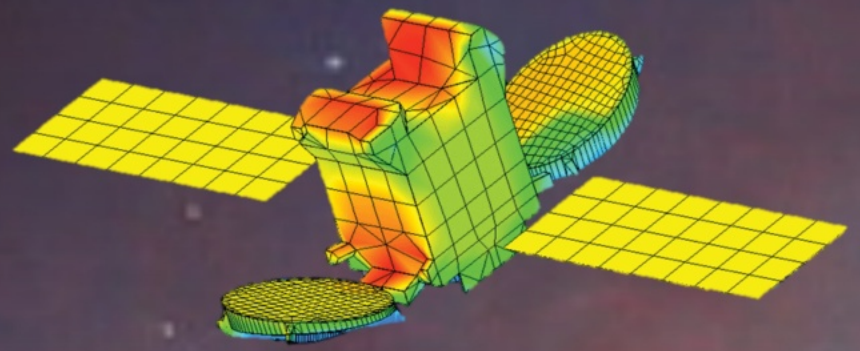
TIME & FREQUENCY

RF & POWER

ENERGY & POWER

THERMAL & MECHANICAL

Spacecraft systems tend to be designed with increasingly complex architecture management.



CRYOGENIC

HEATERS

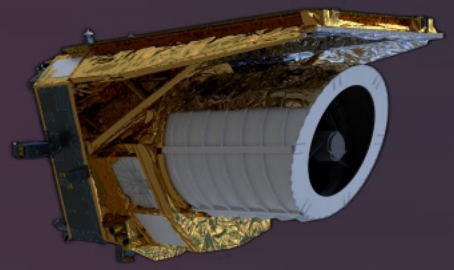
THERMO-ELECTRICAL MODULES

RELAYS

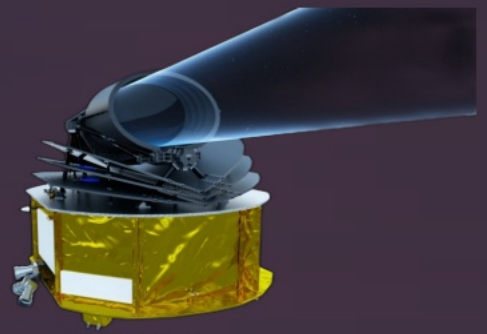
CRYOGENIC

- **European Technologies for Cryogenic Temperatures:**

Science missions are requiring instrument subsystems capable of withstanding and operating at cryogenic temperatures.



EUCLID
T~40K

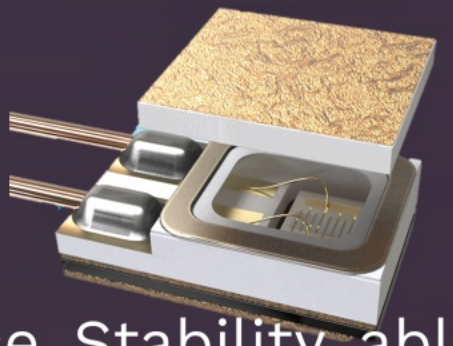


ARIEL
T~29K

ATHENA
T~0.5mK!

This demand is driving advancements in cryogenic technology for space applications, including improved thermal insulation, cryocoolers, materials and several components that should operate efficiently at extremely low temperatures.

CRYOGENIC



- **What´s next?**

- Thermal sensors with High Electrical-Resistance Stability able to withstand cryogenic temperature. (i.e. Sensing film composed of conducting zirconium).

- Thermal sensors pre-assembeled with wires, and integrated splices.

- Small gauge (AWG 36) wires, made from **phosphor bronze** or **manganin**, with extremely low thermal conductivity to minimize heat flow.

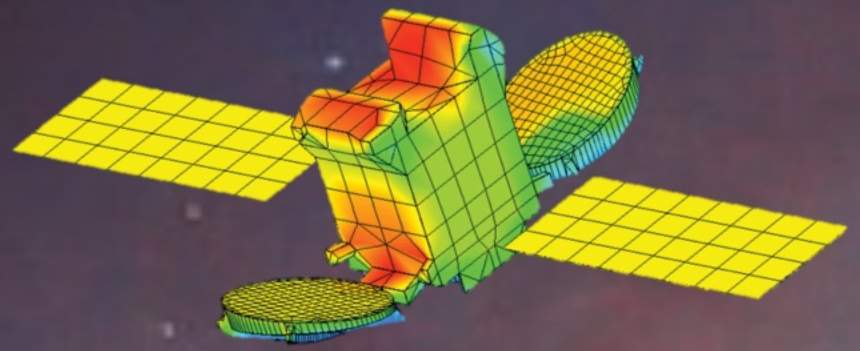
-Assessment of performance and evaluation of lifetime degradation and reliability for passive technologies (e.g., switches, capacitors, resistors, inductors, connectors, wires, heaters, sensors, etc.).

For more information, join ALTER's presentation on Thursday, 17th October at 9h40 :

"Qualification Challenges and Approaches for Cryogenic Temperature Testing of EEE Components in the ESA ARIEL Science Mission"

THERMAL & MECHANICAL

Spacecraft systems tend to be designed with increasingly complex architecture management.



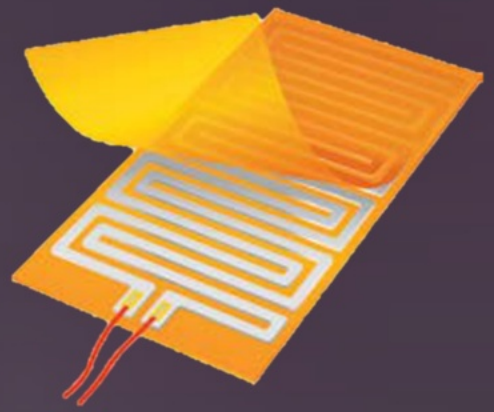
CRYOGENIC

HEATERS

THERMO-ELECTRICAL MODULES

RELAYS

HEATERS



- **High Temperature (up to 270°C) and Flexible heaters:**

These heaters should be pre-assembled with wires and a dediacted fast-locking connector (2/4 points).
They should also be easily assembled (i.e. integarted glue) without applying any pressure (i.e. PSA).

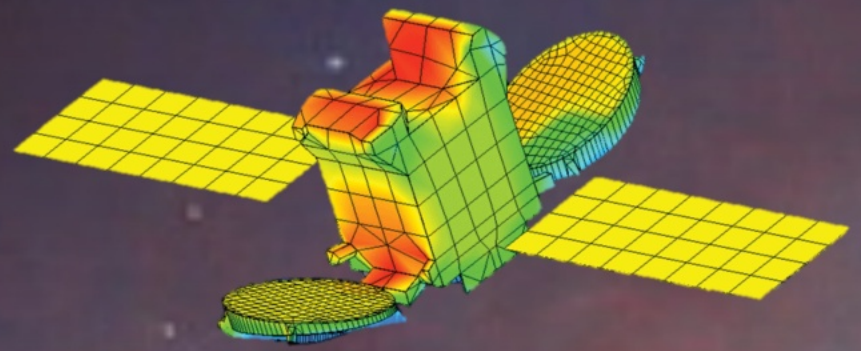
- Multi-function sensors for more efficient thermal management: **Self-regulating heaters embedded with thermal sensors** (e.g., PT sensors)

- Flexible Heaters based on **Advanced Manufacturing** technologies:

Novel 3D printing techniques, such as serigraphy and inkjet printing, offer a simpler, greener, and more cost-effective manufacturing process compared to the traditional photolithographic etching used in conventional heaters.

THERMAL & MECHANICAL

Spacecraft systems tend to be designed with increasingly complex architecture management.



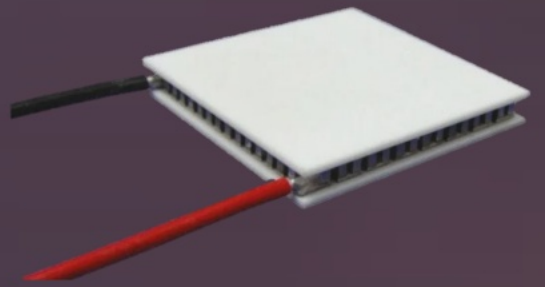
CRYOGENIC

HEATERS

THERMO-ELECTRICAL MODULES

RELAYS

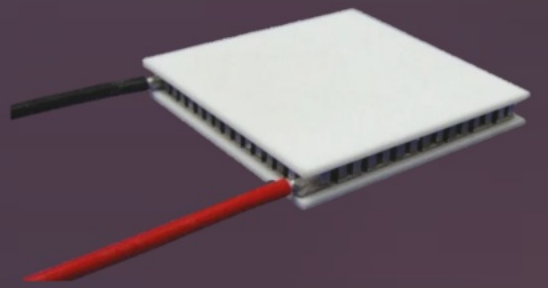
THERMO-ELECTRICAL MODULES



- **ThermoElectric cooler (TEC) based on Peltier effect:**

TECs are currently sourced from suppliers in Russia and Ukraine, emphasizing the need for European non-dependence.
To address this, **ESA is supporting two European manufacturers** in developing TECs capable of operating up to 125°C and delivering a maximum temperature differential of 60°C between the hot and cold sides.

THERMO-ELECTRICAL MODULES



- **ThermoElectric cooler (TEC) based on Peltier effect:**

TECs are currently sourced from suppliers in Russia and Ukraine, emphasizing the need for European non-dependence.
To address this, **ESA is supporting two European manufacturers** in developing TECs capable of operating up to 125°C and delivering a maximum temperature differential of 60°C between the hot and cold sides.

- **ThermoElectric Generators (TEG) based on Seebeck effect:**

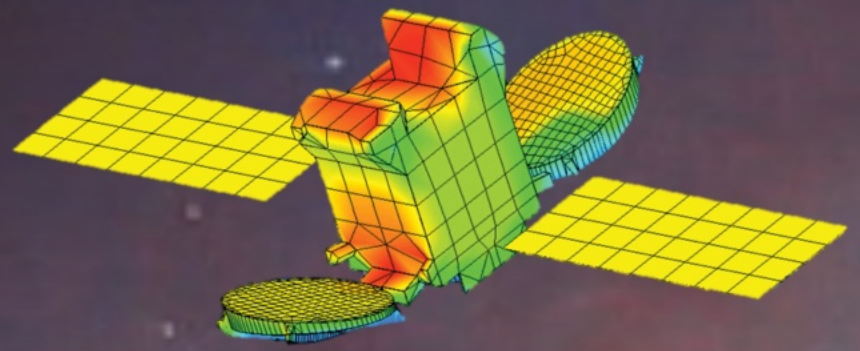
TEGs are needed for Radioisotope Thermoelectric Generators (RTG).
This would allow to launch and operate deep space and planetary missions in environments where use of solar power is not possible!

For more information, join Sven Wittig's presentation on Wednesday, 16th October at 10h40:

"L4: Moons of the Giant Planets: it will be cold, dark and far away from home"

THERMAL & MECHANICAL

Spacecraft systems tend to be designed with increasingly complex architecture management.



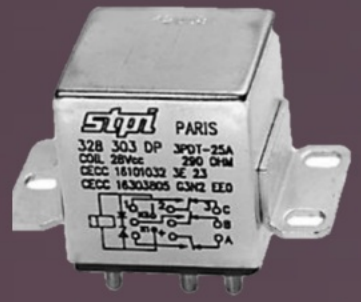
CRYOGENIC

HEATERS

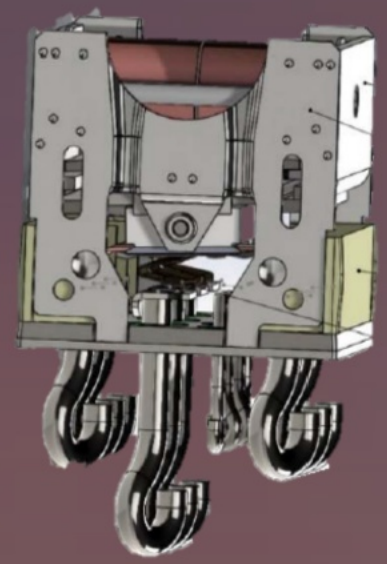
THERMO-ELECTRICAL MODULES

RELAYS

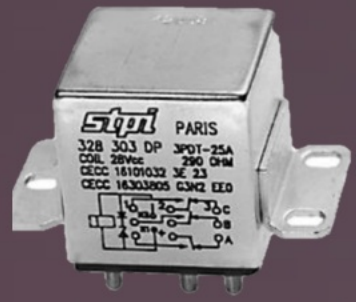
Relays



- **High level vibration/shock relays for new systems**
  Improved design exceeding the current ESCC3602 levels for shocks and vibration.

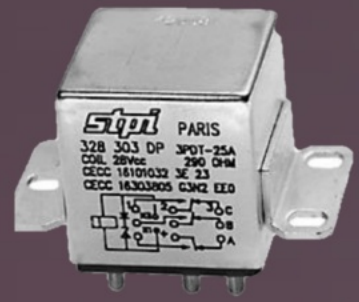


Relays



- **High level vibration/shock relays for new systems**
  Improved design exceeding the current ESCC3602 levels for shocks and vibration.

Relays



- **High level vibration/shock relays for new systems**
  Improved design exceeding the current ESCC3602 levels for shocks and vibration.

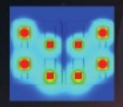
- Electro-mechanical relays operating under high voltage (up to 3kV) for electric propulsion

- **Contactors for Power platforms:**
  High-Voltage Electro-Mechanical Relays Capable of Switching 100-150V and 165A!

- Digital Architecture: Replacing Mechanical Relays with **Solid State Relays** for improved reliability and performance.

TRENDS

What is next?



THERMAL & MECHANICAL

HARNESS

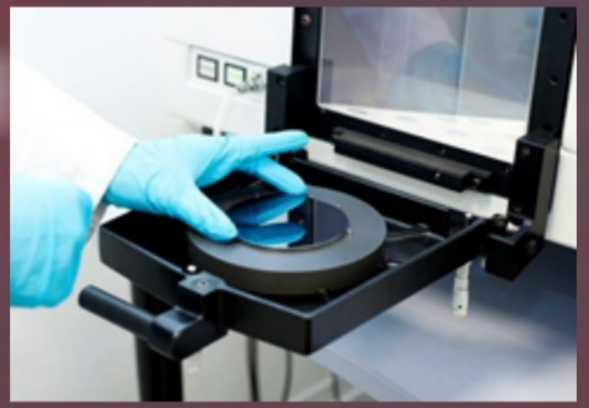
TIME & FREQUENCY

RF & POWER

ENERGY & POWER

TIME & FREQUENCY

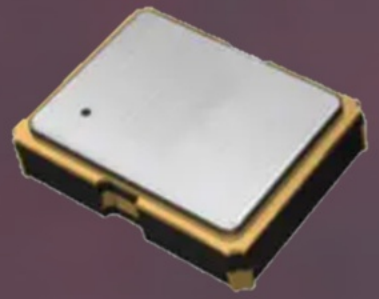
Low cost and rad-hard quartz oscillators are critical items for LEO mission applications like PNT (Positioning, Navigation and Timing), commercial telecommunication and any application requiring high spectral purity (e.g. Radar).



Quartz sweeping or pre-radiation are considered costly and time consuming processes. Those manufacturing processes are not compatible with low cost devices.

- Cost effective technologies for crystal growing and/or resonator process for reducing the sensitivity to radiation.

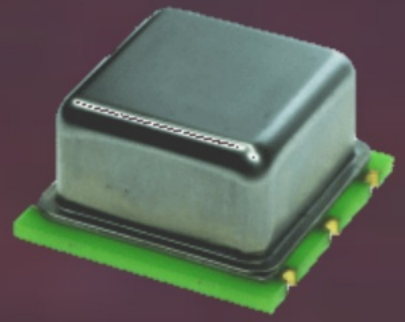
TIME & FREQUENCY



- **Frequency Flexible Oscillator:**

One of the drawback of hi-rel crystal oscillators is their long lead time, due to long-term stability test (i.e. frequency pre-ageing). ESA is supporting Rakon (FR) in order to develop a frequency-flexible oscillator.

This is possible by means of a one-time programmed (OTP) and an internal Phase-Locked Loop (PLL) frequency synthesizers. Pre-screened oscillators can be adjusted and delivered to the happy customer in few weeks!

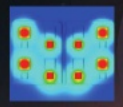


- **SMT resonators :**

Surface-mount technology (SMT) resonators are being space-qualified to enable greater miniaturization and simplify assembly processes, replacing traditional through-hole designs.

TRENDS

What is next?



THERMAL & MECHANICAL

HARNESS

TIME & FREQUENCY

RF & POWER

ENERGY & POWER

ENERGY & POWER

- **Global Trends**: Higher Power density & Better Integration

High Capacitance and voltage in SMT packages for capacitors with lead-free.

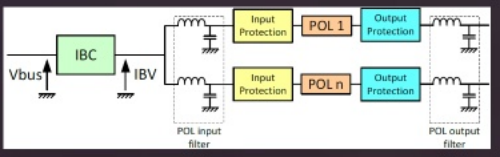
Planar transformers up to 8 kV for electronic power conditioning.

European solutions for ferrite beads for higher operating frequency in SMT packages.

Wet Tantalum Capacitor for high power applications requiring high energy/ voltage (i.e. RF GaN power transmitters) .

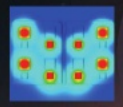
High-energy high-power supercapacitors for hybrid energy systems or power applications

High current SMT chip inductors for FPGA for Telecommunication satellites, or to be used at the input/output filters of Point Of Load (POL) and Distributed Power Architecture (DPA).



TRENDS

What is next?



THERMAL & MECHANICAL

HARNESS

TIME & FREQUENCY

RF & POWER

ENERGY & POWER

RF & POWER

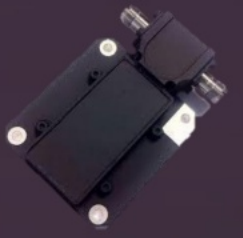
RF applications are driven by the increase of:

FREQUENCY

POWER

INTEGRATION

High Power Levels



- The trend toward increased power capacity continues to shape the development of RF payloads with Transponders up to 400W.

- **Power Handling** :

New materials and process for loads, gluying, etc. are needed for better dissipation at higher frequencies (Ku, Ka, Q, V & W bands)

- **Multipaction:**

A Major Challenge for High-Power RF Components and Equipment.
- Need to add Dielectric Shimming to mitigate its effects.
- Improve charachetrisation of SEY materials, needed for MP simulations.

- **European RF Diamond chip:**

Developement and Qualification of European solutions of RF Diamond chip and loads based on Chemical Vapor Deposition (CVD) in order to allow for better power dissipation and miniaturisation.

High Frequencies

- **Today:**

The frequencies needed for Telecom Satellites are:
Q, V and W bands.

This requires different technologies for RF Passive components:

- **S**ubstrate **I**ntegrated **W**aveguide (SIW)
- Microstrip LTCC/Hexaferrite

- **What is next?**

Development of new materials (e.g., hexaferrites) to enable operation at higher frequencies and improved integration.

RF Over Fiber: Transition to optical fiber channels for enhanced communication capabilities.

Faster & Better Integration

- **Today :**

Ka-band isolators and circulators based on SMT, Exens Solutions (France), are now available for several applications (successful ESCC Evaluation).

Several applications based on SIW have been identified, mainly for Telecom and New Space markets.
All RF chain parts will be increasingly based on SIW technology (no more connectors nor Waveguide adaptors are needed)!
- SIW circulator and isolator for W band, HARP (Finland), need further optimisation.

- **ESA On-Going Development:**

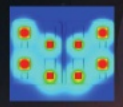
Integrated Ka band isolator and divider using SIW - Ecliptic DS (Cyprus)
Ultra-low loss combiners using SIW at Ka band - Ecliptic DS (Cyprus)
Ka-Band Compact Filter with integrated input isolator using SIW - Ecliptic DS (Cyprus)

- **What 's next?**

Intended ITT (TDE) about the development of Miniaturised self-biased (magnetless) circulators/isolators for GaN applications.

TRENDS

What is next?



THERMAL & MECHANICAL

HARNESS

TIME & FREQUENCY

RF & POWER

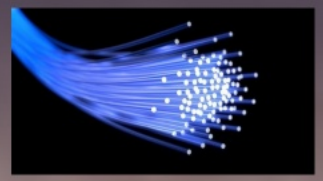
ENERGY & POWER


HARNESS
CABLE ASSEMBLIES
CONNECTORS
INTEGRATION

CABLE ASSEMBLIES

RF
ESCC 3408

Optical
ESCC 3420



High Data Rate
ESCC 3409

High Voltage
ESCC xxxx

RF Cable Assemblies

- **Today:** ESCC QPL qualification of RF cable assemblies:

SMA 2.2 mm up to 22 GHz
2.4 mm up to 45 GHz
VHP RF cables
2.92 mm up to 32 GHz

ESA TDE Activity (RADIALL & Axon FR) Development of a RF interface for connectors (1mm) and cable assemblies with a fast-locking mechanism, up to W band.

- **What is next?**

Qualifaction of RF cable assemblies 1.85 mm (up to 65 GHz) and 1mm (up to ~110 GHz)!

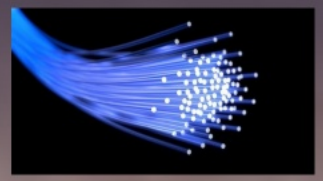
Phase stable Semi-flexible RF cable assemblies for phase sensitive equipment.

SiO_2 based temperature phase-stable semi-Rigid RF cable assemblies for phase sensitive equipment (e.g. SAR instruments, etc.)

CABLE ASSEMBLIES

RF
ESCC 3408

Optical
ESCC 3420



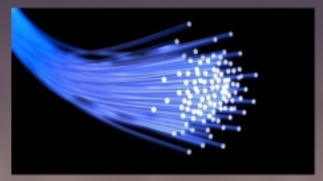
High Data Rate
ESCC 3409

High Voltage
ESCC xxxx

CABLE ASSEMBLIES

RF
ESCC 3408

Optical
ESCC 3420



High Data Rate
ESCC 3409

High Voltage
ESCC xxxx

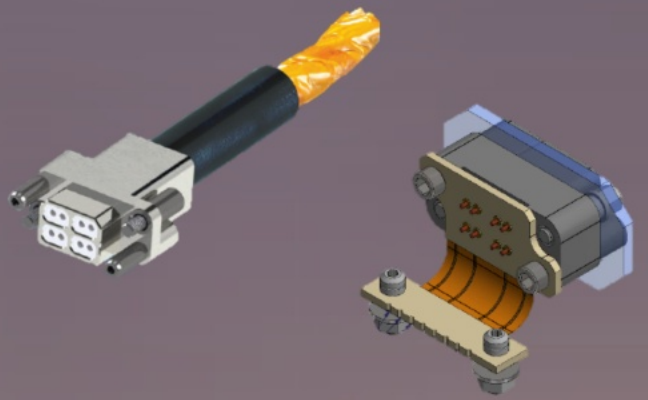
High Data Rate Cable Assemblies

Since ESCC3409 for HDR CA was published in 2018, the following solutions are available:

-AXON Cable **Axomach** and **Axomach Spacefibre** cable asssembly **up to 10Gbps.**

-AXON Cable **MicroMach** cable assembly **up to 3 Gbps**, with:

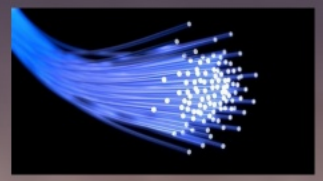
- Qualified Low Mass SpaceWire cables.
- EPPL-2 PCB MicroMach connectors



CABLE ASSEMBLIES

RF
ESCC 3408

Optical
ESCC 3420



High Data Rate
ESCC 3409

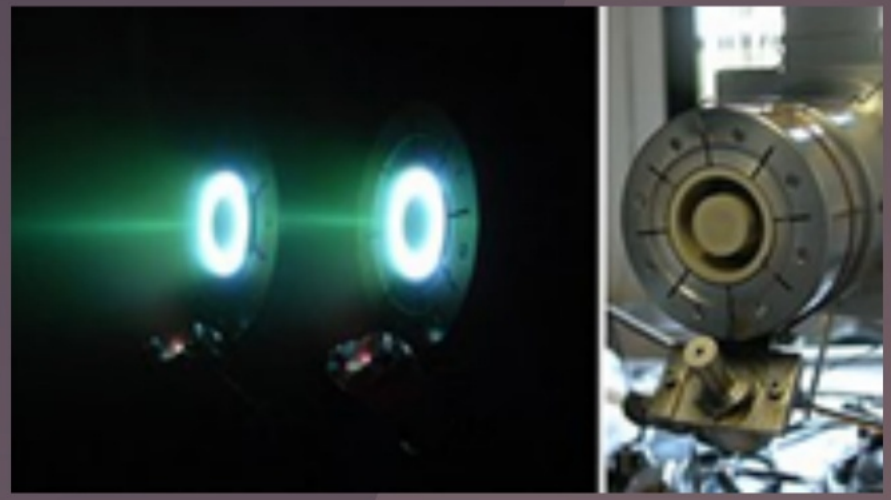
High Voltage
ESCC xxxx

High Voltage Cable Assemblies

- **What´s next?**

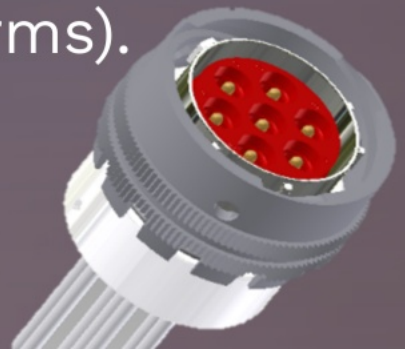
Evaluation and Qualification of High Voltage and High Temperature cable assemblies for electrical propulsion

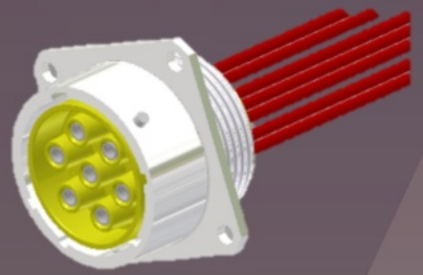
  - Operating voltage up to 20kV DC
  - Operating temperature above 200°C



- Radiation resistance up to 200 Mrad.

- Resistant to high temperatures:
  from min -55°C to max +170°C for dynamic applications (i.e. moving arms).



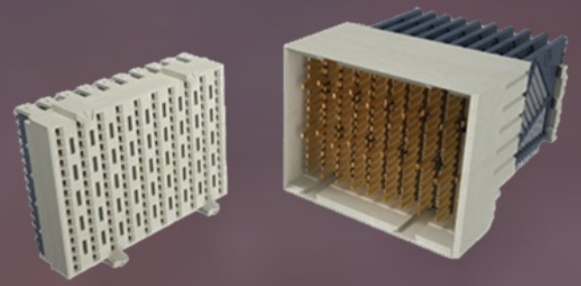



HARNESS
CABLE ASSEMBLIES
CONNECTORS
INTEGRATION

Connectors

- **Solderless Solutions:**

High Density, Mezzanine, Backplane, High Data Rate, etc.

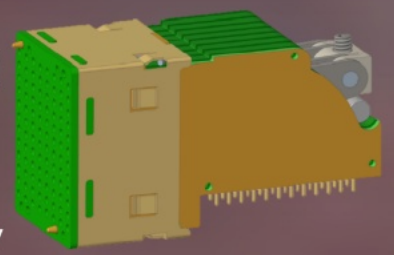


- **Today :**

- Ongoing QPL Qualification of **Positronic press-fit Connectors** (Currently EPPL 2)

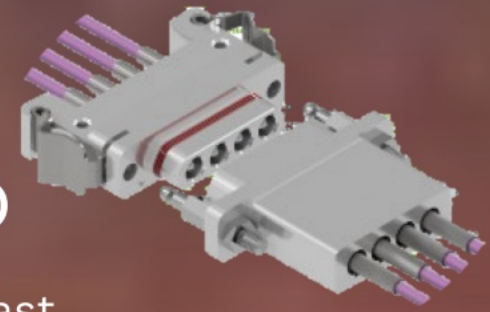
Solderless solutions for **Speed up to 56Gb/s:**

- NMS (Creotech/ITR PL): to perform Verification Assembly on COTS HDR and High Power press-fit connectors
- TDE (ALTER SP): Relaibaility Assesment of available COTS solution (AIRMAX) and Hyperbits (Performance Interconnect FR).



Solderless solutions for cPCI :

- ARTES AT (ALTER FR & Performance Interconect FR) : Development of High Density Modular Electrical Interconnections for High Data Rate Applications.
- TDE (AXON FR): Board to board interconnections for high data rate applications.



What is next?

- Development of HDR connectors for other standards (i.e. OpenVPX, etc.)

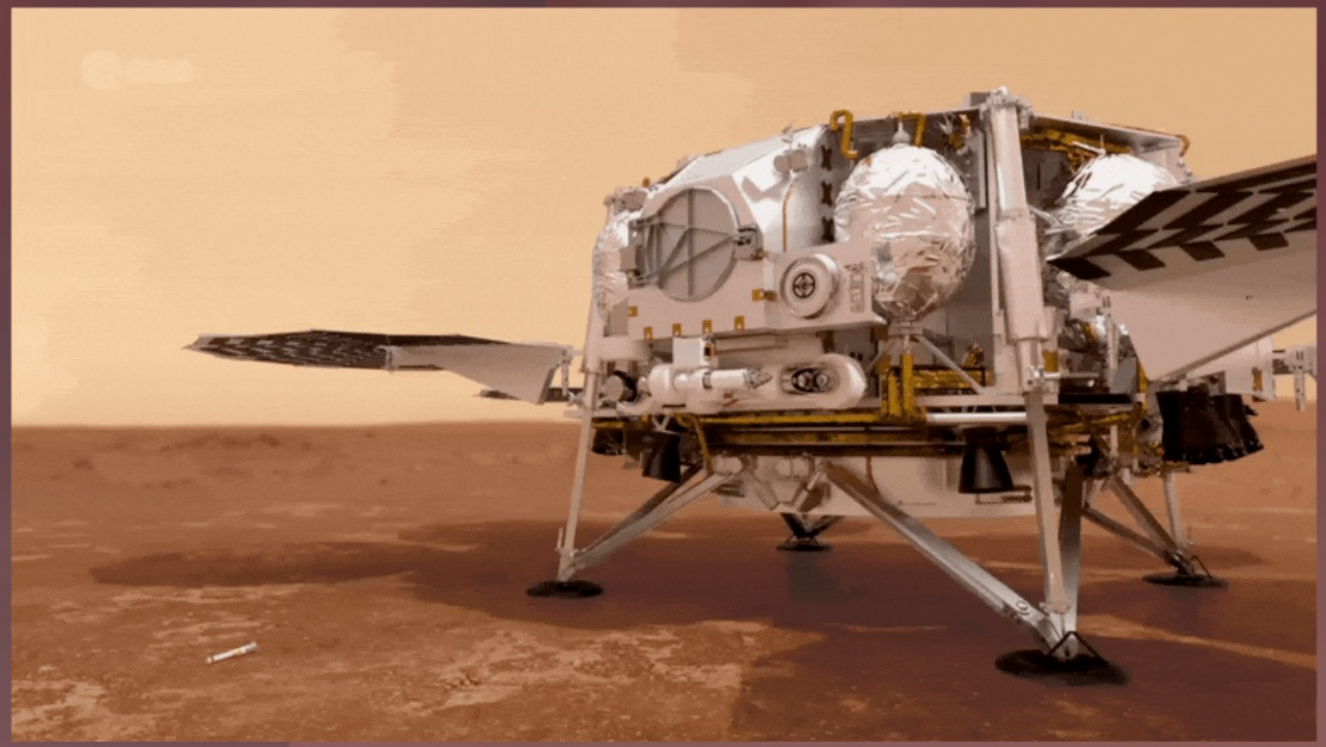
- Qualification of HDR connectors for space aplications **(i.e. cPCI, VITA, OpenVPX, etc.)**

- Standardisatioin of Optical fiber microD connectors (with FT ferrule), standard with fast lokcing, compatible with flat fiber optics!


HARNESS
CABLE ASSEMBLIES
CONNECTORS
INTEGRATION

BETTER INTEGRATION & ROUTING

Sample Transfer Arm (STA), will play a crucial role in the success of the Mars Sample Return (MSR) mission (NASA & ESA collaboration).



Designed to be autonomous, highly reliable, and robust, the STA requires flexibility, seamless integration, and multi-layered structural harness:

- Published ESA ITT: "European Flat Flexible Harness for Mars Exploration Phase 1 & 2"

BETTER INTEGRATION & ROUTING

- **Flexible Harness:**
  - -Mass savings target up to 30%
  - -Reduction of cost by reduction of the number of devices
  - -Better shielding and impedance characteristics
  - -Drastic reduction of AIT integration time

- Two Main Technologies: **FFC vs FPC**

Flexible Flat Cable (FFC):s a type of electrical cable that is both flat and flexible and it has straight conductors.

Flexible Printed Circuit (FPC): offers more flexibility with various pinouts, multi-layered structures, and the ability to cross conductors.

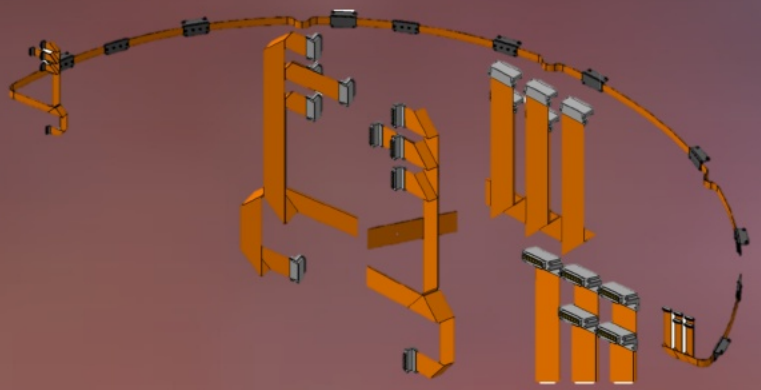
BETTER INTEGRATION & ROUTING

- **Today:**

ESA TDE Activity (ARIANE GROUP & AXON): "**Improved design of harness for launchers"**

- Objective is to design, develop, manufacture and test an optimized harness: FFC, fast-locking connectors, optimized harness support for Ariane 6 (bloc 2)

- Mass savings expected at 30% (internal harness) and 75% (external raceways), overall volume saving of 90%!



For more information, join ARIANE's presentation on Wednesday, 16th October at 11h50 :

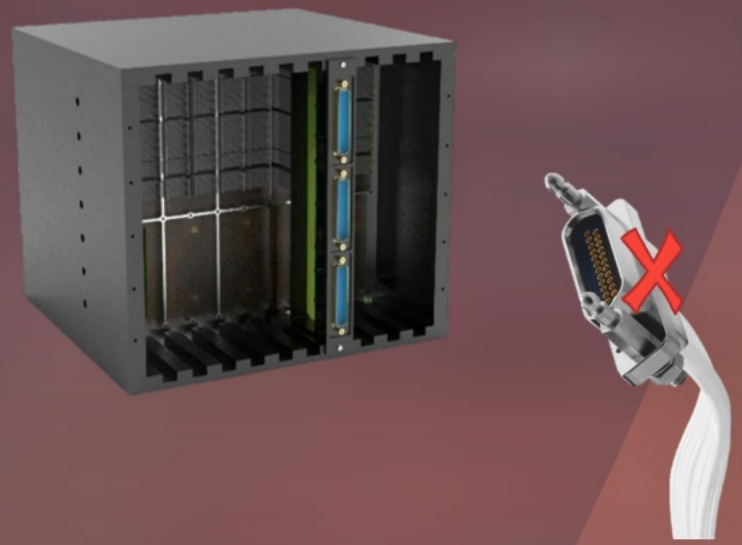
"Flat Cable Harness for Space Launcher Applications"

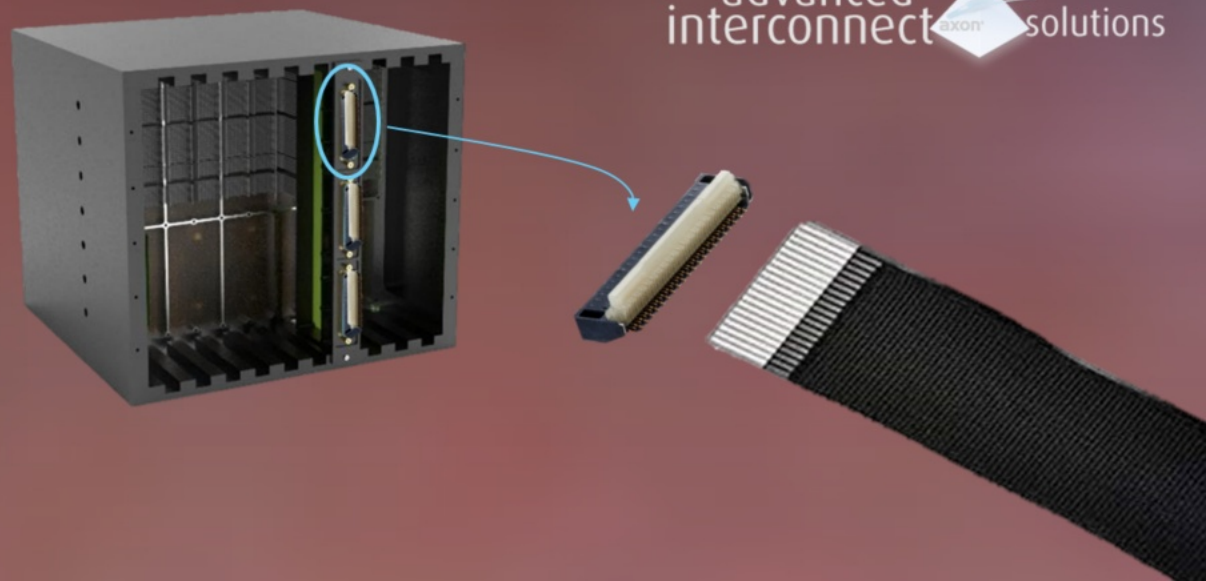
BETTER INTEGRATION & ROUTING

- **What is next?**

ESA ARTES AT Activity (AXON): "Fast-lock interconnections and connectorless flat cables for satcoms"

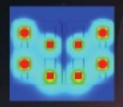
- Objective is to design, manufacture and test dedicated connectors with a fast-locking mechanism for satellite electronic units and PCB boards. The developed connectors will allow direct mating with **connectorless** flat cables.





TRENDS

What is next?



THERMAL & MECHANICAL

HARNESS

TIME & FREQUENCY

RF & POWER

ENERGY & POWER

Passive Components: News, Activities and Trends

Dr. Léo Farhat & Mr. Joaquin Jimenez
ESA - European Space Agency

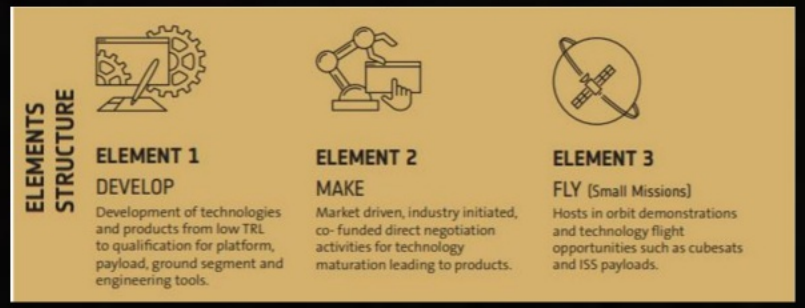
Activities

How is ESA supporting the European Passive Industry?

ESA: Funding types

The Technology Development Element (**TDE**) is a **mandatory** programme. The TDE is the only ESA technology programme supporting all of ESA's fields of activity across the entire spectrum of technical disciplines

The General Support Technology Programme (**GSTP**) is an **optional** programme. GSTP performs its activities under three distinct elements: Develop, Make and Fly.



Several other optional programmes, where support from national delegations is needed, cover areas such as Earth observation (FutureEO), telecommunications (ARTES), satellite navigation (NAVISP) and space transportation (BEST!, Boost!), Plan for European Cooperating States (PECS), New Members States (NMS).

esa-star Publication

esastar-publication-ext.sso.esa.int

OSIP platform: ideas.esa.int

ESA: Expanding GSTP EEE Sovereignty for Passives

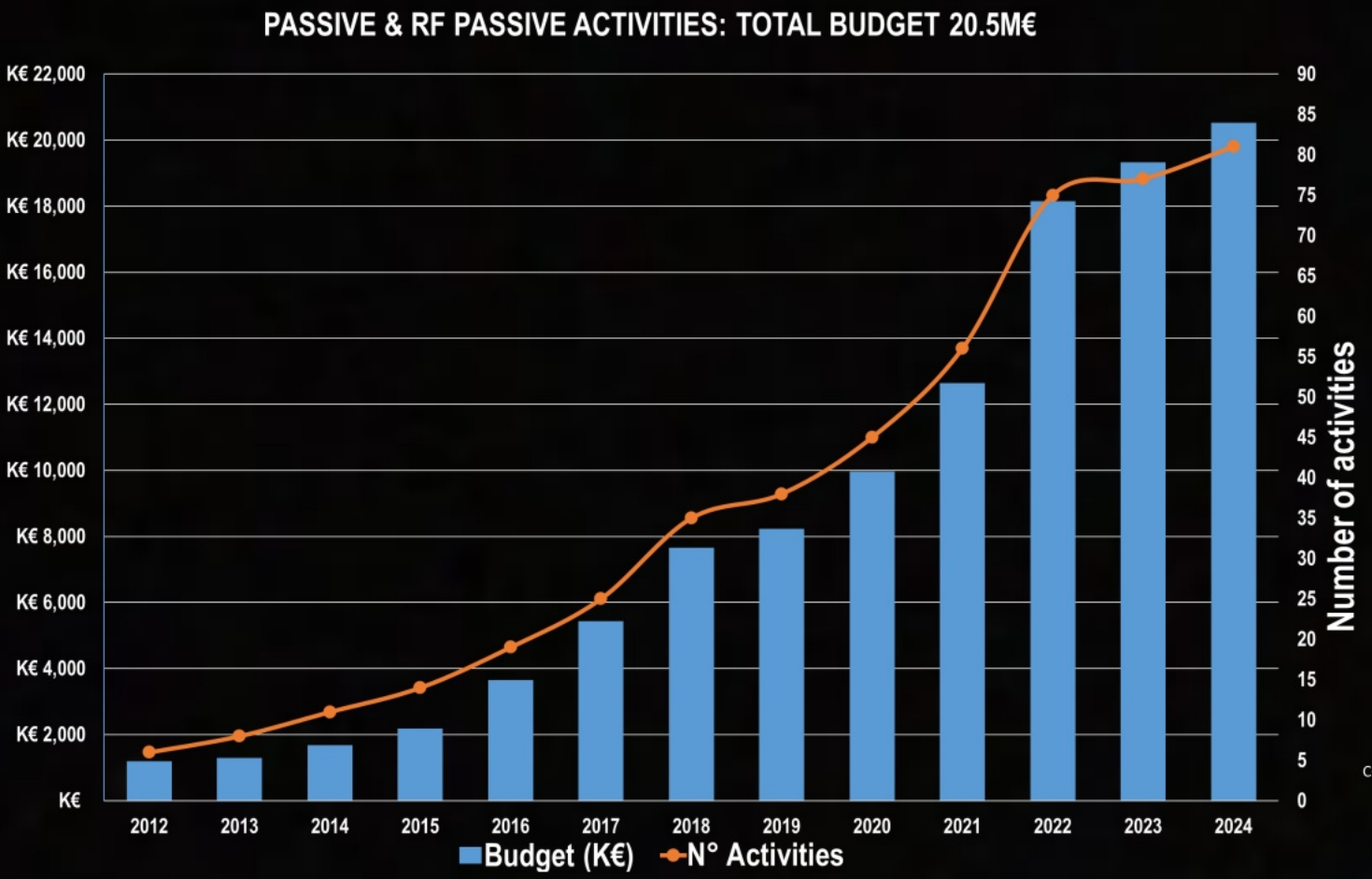
GSTP EEE Sovereignty supports European technology advances, autonomy and secure the supply chain of space Electrical, Electronic, and Electromechanical (EEE) components, considered as fundamental building blocks of all spacecraft.

The Passive component industry is relatively mature, with established EU suppliers compared to cutting-edge sectors like semiconductors, GaN, SiC, photonics and FPGA. However, there has recently been a growing demand for high-reliability and specialized designs that are **not yet available within Europe.**

In reponse, in 2025, **a copendium for GSTP EEE Sovregnity focused on passive components** will be issued, addressing critical EEE passive components that are not currently produced in Europe.

ESA R&D Passive & RF Passive Activities

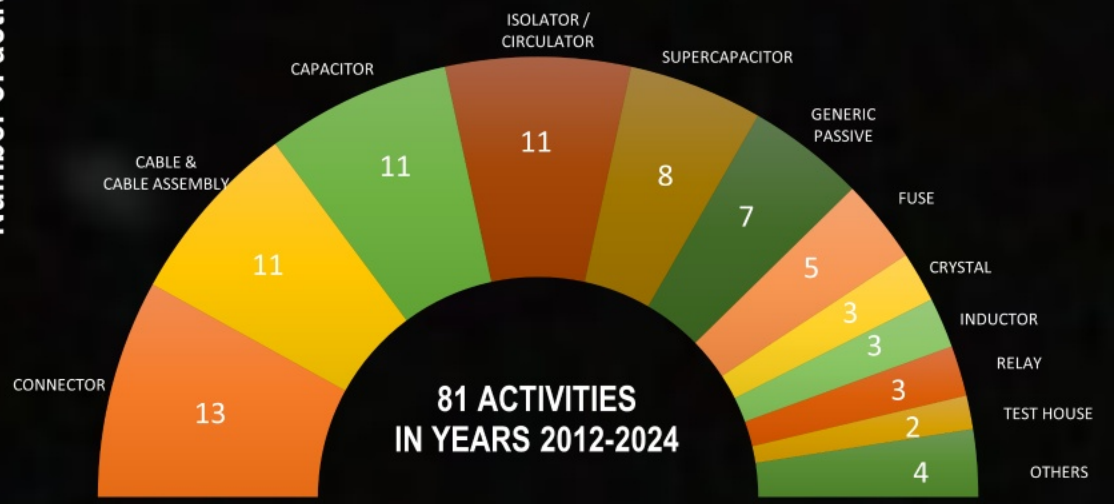
ESA has funded 81 activities for Passive & RF Passive components since 2012 with a total budget of 20.5 M€.



Total budget
20.5 M€

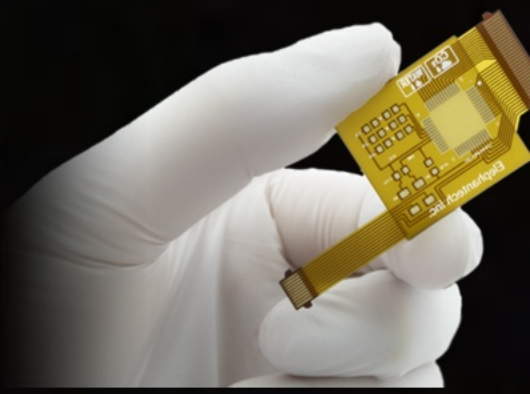
~6 new activities per year

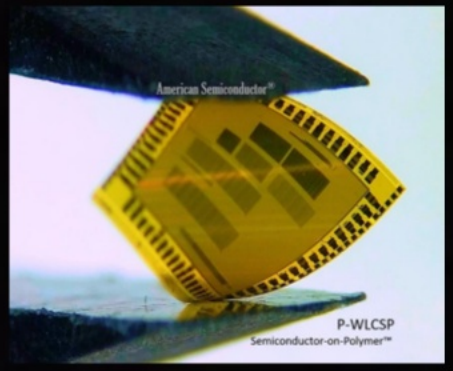
~253k€ per activity

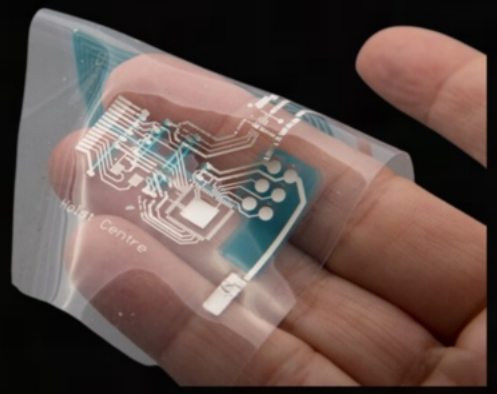


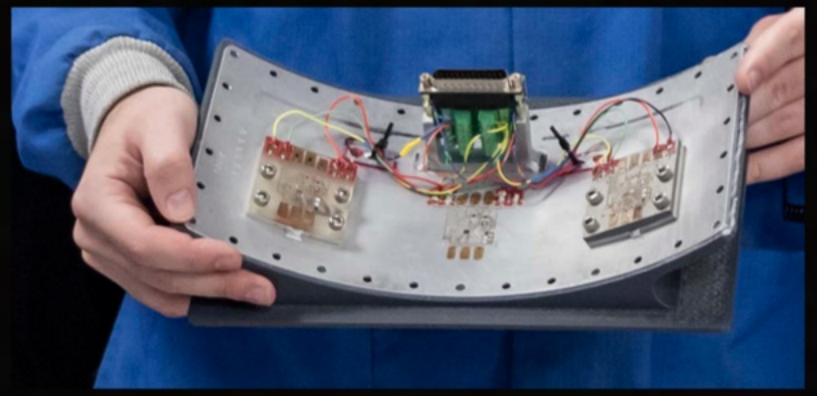
ESA: Advanced Manufacturing of Electronics (AME)

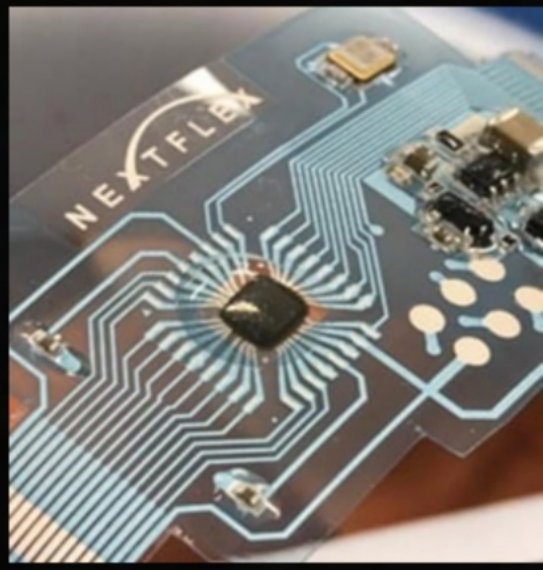
- **Advanced Manufacturing of Electronics** (AME) refers to cutting-edge processes and technologies used to design, produce, and assemble electronic components and systems.
- It often integrates electronics design and production through additive manufacturing, often using 3D printing techniques.
- Main targeted applications: small sats for Telecommunications and Earth Observation.











For more information, join Rita Palumbo's presentation on **Thursday** 17th October 11:30-11:50:

"Unlocking the Future of Space Electronics with the Advanced Manufacturing Revolution"

Passive Components: News, Activities and Trends

Dr. Léo Farhat & Mr. Joaquin Jimenez
ESA - European Space Agency

ESA Passive Components: News, Activities and Trends

Dr. Léo Farhat & Mr. Joaquin Jimenez
ESA - European Space Agency

#SPCD

Thank You For Your Attention!

Passive Components: News, Activities and Trends

Dr. Léo Farhat & Mr. Joaquin Jimenez
ESA - European Space Agency