Passive Components: News, Trends and Activities

News

Trends

Activities



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ESA - European Space Agency


#Strategic
Space Era
News &
Challenges
Space
Standards
Resilience
Anomalies

#STRATEGIC SPACE ERA

The **#Strategic** Space Era is a rapidly evolving phase where space has become critical infrastructure, driven by the growing importance of sovereignty, resilience, security and dual-use capabilities.

Resilience and defence needs are reshaping the space ecosystem while new tecnologies at lower costs are pushing the boundaries.



Space Evolution



Sovereignty



Cost Reduction



Pushing the Boundaries

SPACE EVOLUTION

FROM TRADITIONAL MISSIONS TO STRATEGIC INFRASTRUCTURE

TRADITIONAL MISSION:

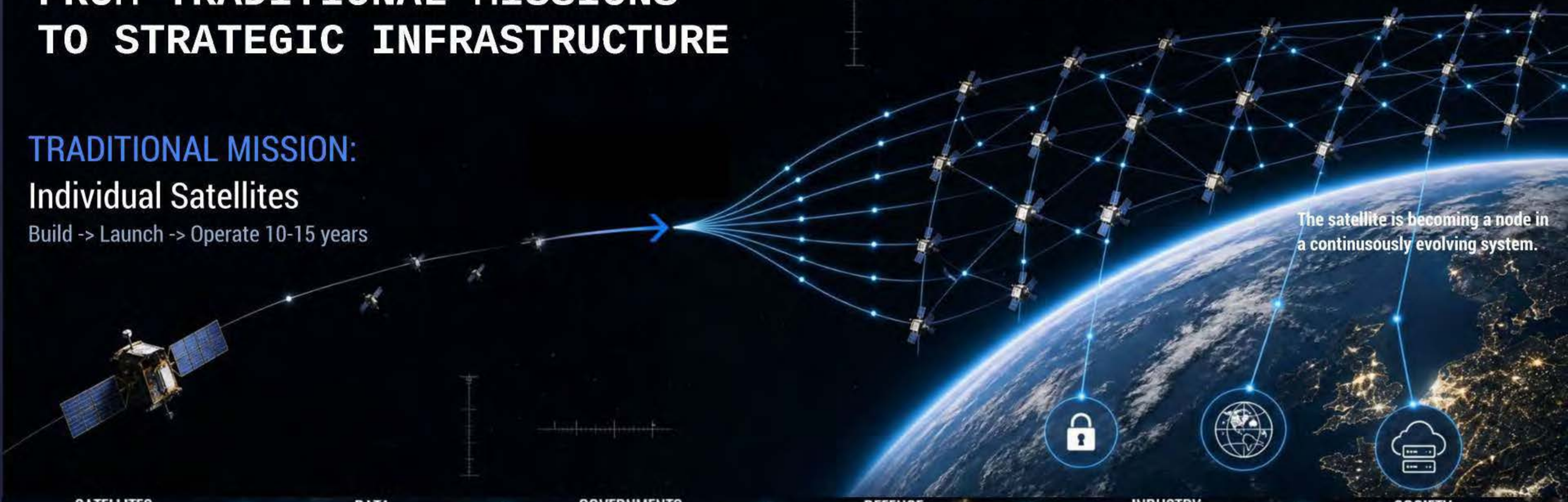
Individual Satellites

Build -> Launch -> Operate 10-15 years

STRATEGIC INFRASTRCTURE:

CONSTELLATIONS

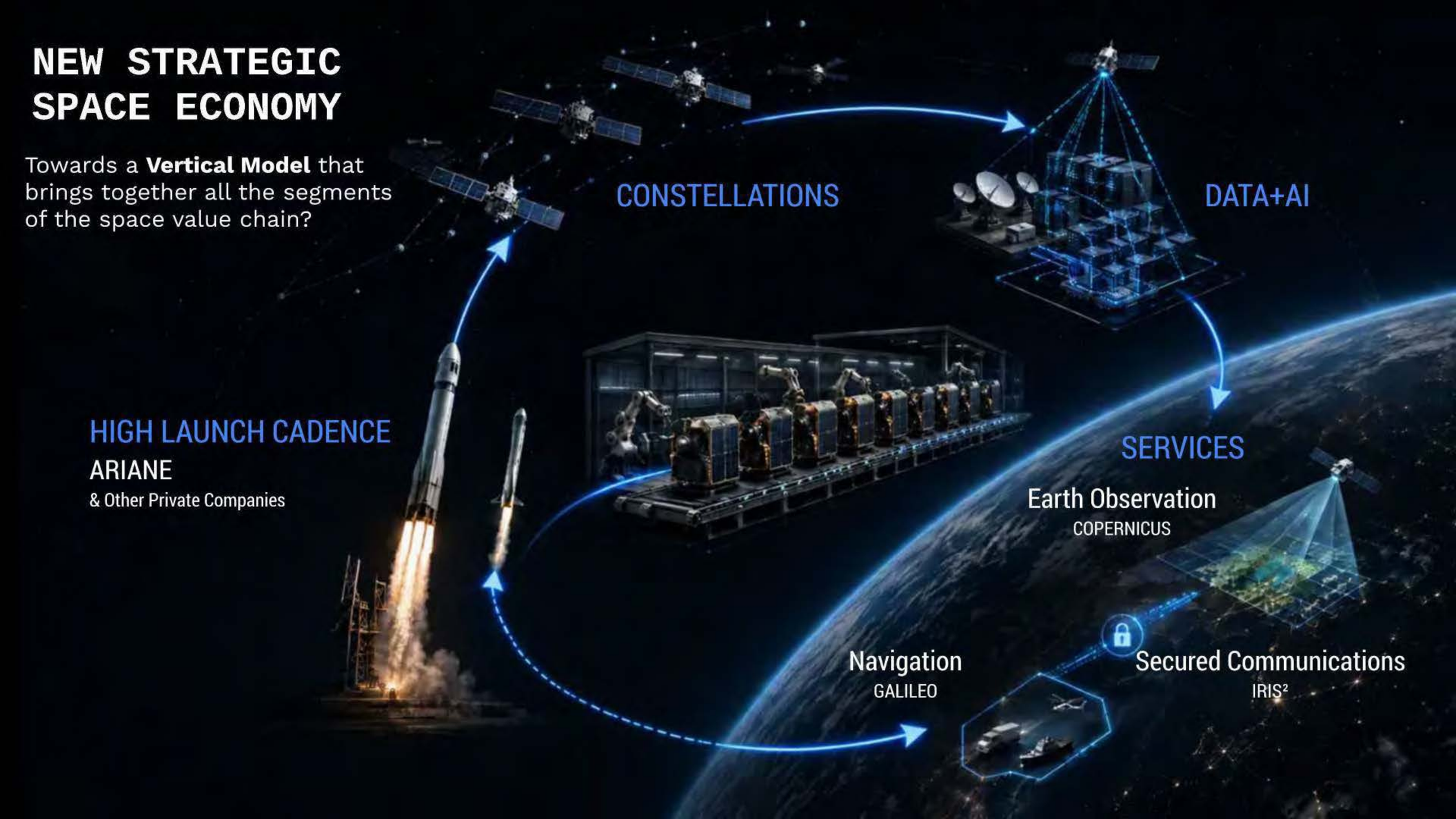
Build Fleets -> Launch Frequently-> Upgrade/Replace -> Deliver Services





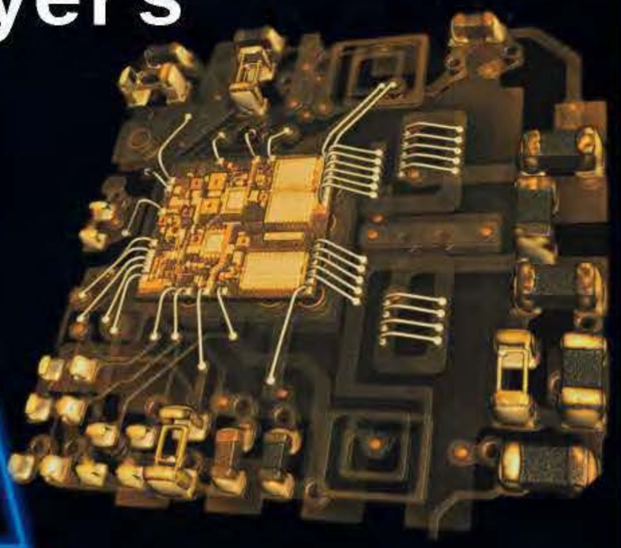
NEW STRATEGIC SPACE ECONOMY

Towards a **Vertical Model** that brings together all the segments of the space value chain?



Sovereignty:
Europe to Own the Critical Layers





EUROPEAN SERVICES
Secure connectivity - Earth observation - PNT
Safety, crisis response & defence

STRATEGIC INFRASTRUCTURE
EU - IRIS2 - Copernicus - Galileo - ARIANE

INDUSTRIAL CAPABILITY
System integration - Serial manufacturing - Cloud & AI - Cybersecurity

PAYLOAD and PLATFORMS
Secure data communications - Onboard processing -
Power, Optical, RF & sensing

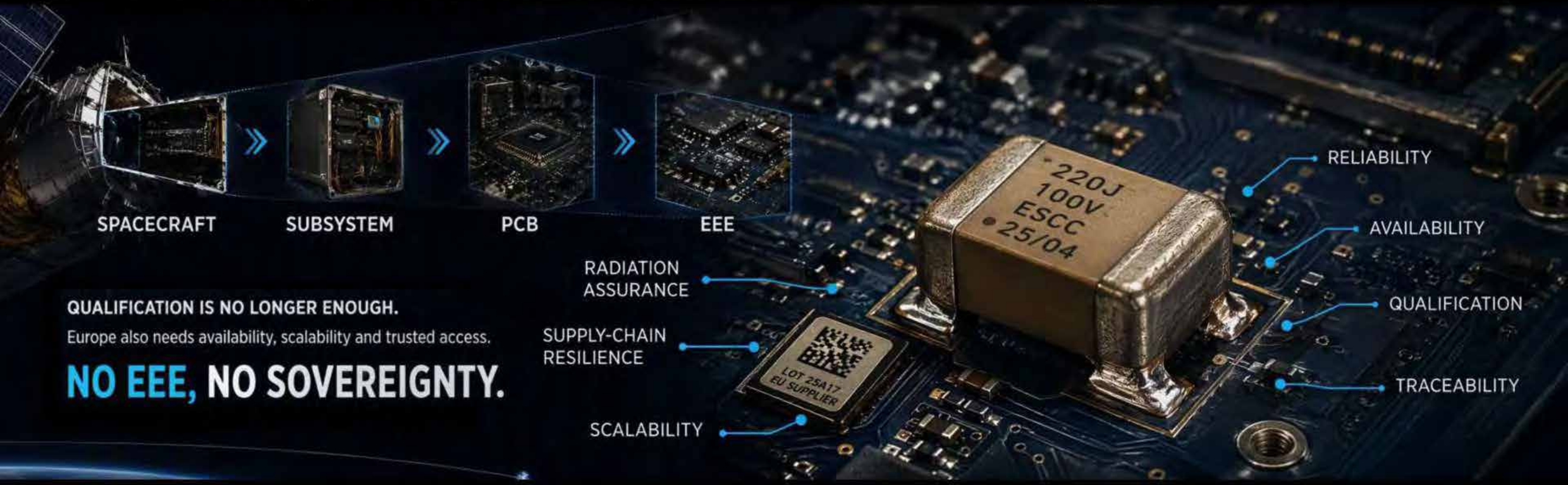
EEE COMPONENTS
ASICs - FPGAs - RF - Power electronics - Sensors -
Passive Components - Connectors & Cables - Electromechanical parts

NO RESILIENT SPACE INFRASTRUCTURE WITHOUT A RESILIENT COMPONENT BASE.

Sovereignty:
Europe to Secure a Robust Supply Chain

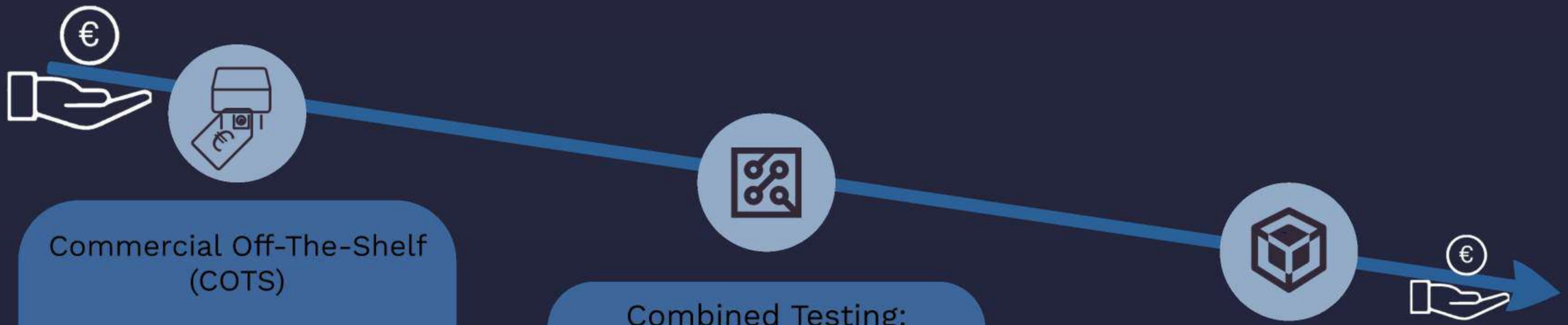
Europe cannot remain dependent on non-EU sources for critical space technologies:

No Resilient Space Infrastructure without a **Resilient Component Base!**



Cost Reduction

Cost-effective approaches, including the use of COTS and integrated testing, are being used in this strategic 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

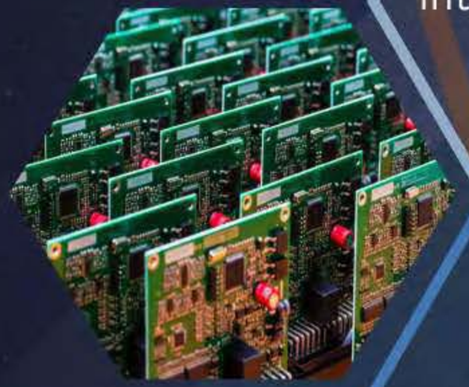
No Screening at Component Level



Pushing the Boundaries

The push for higher performance, harsher environments and lower costs drives innovation, impacting the design and qualification of EEE components in the space industry.

Automotive & COTS Technologies



Modular & Interchangeable Designs

Use of Artificial Intelligence



Flexible & Power



Conductive Inks & 3D Printing



Higher Mechanical Loads



Solderless Solutions

Thermal Management

Assembly and Packaging

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 take place in Seville from March 9-11, 2027.

This conference is the European reference congress on EEE components for space applications, bringing together the entire ecosystem — from qualified component manufacturers and distributors to system integrators, space agencies, and regulatory bodies.

EMPS – Electronics Manufacturing & Packaging Symposium

EMPS 2027

Connecting electronics manufacturing, packaging and reliability

28 JUNE – 1 JULY 2027

ESA/ESTEC - Noordwijk

Explore the latest innovations in electronics manufacturing, advanced packaging, PCB technologies, assembly processes, reliability and smart manufacturing for space and other high-reliability applications.

- ADVANCED PACKAGING
- MATERIALS AND PROCESSES
- ASSEMBLY AND LEAD-FREE
- RELIABILITY OF (U)HDI PCBs
- SMART MANUFACTURING
- SUPPLY-CHAIN RESILIENCE



CALL FOR ABSTRACTS

NOW OPEN

Scan for event information and abstract submission

For more information, join Alter's presentation on
Wednesday, 14th October at 11h30:

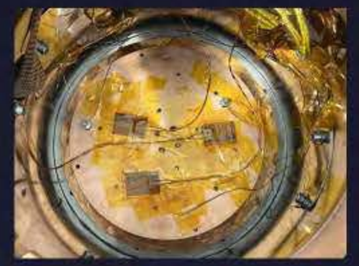
"Qualification Results for Cryogenic Temperature Testing of EEE Components in the ESA ARIEL Science Mission"

ESA ARIEL Mission :

The **world's first**
Exoplanet sniffer!












#Strategic
Space Era
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Anomalies

Space Standards Resilience

Are European Space Standards Ready for the #Strategic Space Era?

ECSS* Evolution

ESCC** Resilience

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

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

ECSS Evolution: ECSS-Q-ST-60

UPDATE PUBLISHED

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

ECSS-Q-ST-60C **Rev.4**, dated 30 April 2025, revises the Class 1, 2 and 3 quality-level tables to reflect the following changes:

- Expanded recognition of JAXA-QTS qualified parts across several EEE families across the component classes.
- Additional MIL specifications with ECSS supplementary conditions
- Several MIL specifications are explicitly recognised in the quality-level tables, and when needed with clearly defined ECSS additional conditions.
- Specific component restrictions, e.g. CKR06 1 µF / 50 V capacitors
- Removal of non-space-adequate MIL standards, e.g. MIL-DTL-28791 (circulators/isolators) and MIL-DTL-15370 (couplers).
- Additional screening conditions: 100% MIL screening is explicitly required for selected MIL component routes, replacing the sample-based approach.



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 >700M€
Lifetime > 7 Years. Requirements are high, risk is very low.



BETA

High Class Missions

Highly critical - Budget 350 to 700M€, Lifetime 5 to 7 Years,
Requirements are relatively high, risk is low.



GAMMA

Medium Class Missions

Medium critical - Budget 40 to 350M€ Lifetime 2 to 5 Years,
Requirements are moderate with a non-negligible risk.



DELTA

Low Class Missions

Low critical - budget <40M€, Lifetime <2 years.
Requirements are very limited with a significant risk.



Mission Classification vs ECSS EEE classes

PENDING APPROVAL

ALPHA	**Top Class Missions**	Class 1 EEE components according to ECSS-Q-ST-60
BETA	**High Class Missions**	Class 2, except for electro-mechanical parts (Class 1)
GAMMA	**Medium Class Missions**	Class 3, AEC-Q used as is without additional screening
DELTA	**Low Class Missions**	"Do Not Harm And Know What You Fly" Approach

ECSS Evolution: ECSS-Q-ST-60-13

TIME FOR CHANGE

This ECSS-Q-ST-60-13 standard defines the requirements for commercial EEE components.

ESA and European Primes are currently discussing the next evolution of ECSS-Q-ST-60-13.

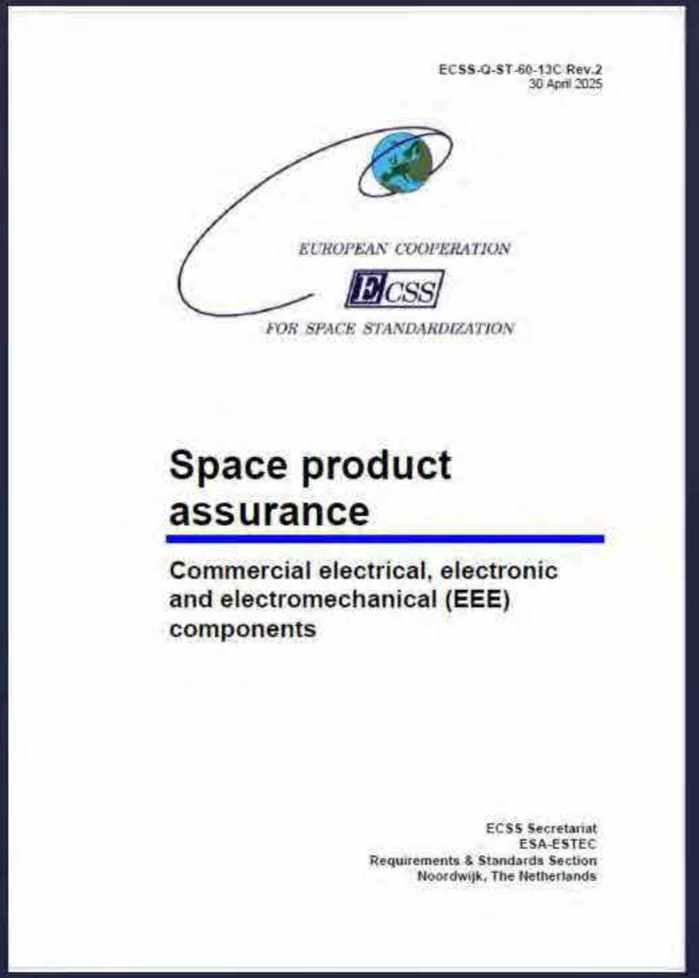
The ambition is to enable the **use of COTS** components for **Class Alpha** (eq. to class 1 for EEE) missions **WITHOUT*** additional screening!



From
"COTS + Screening"
towards →
"Trusted COTS + Evidence-based Assurance"

If implemented, this could fundamentally change how Europe qualifies and uses COTS for the most demanding space missions.

*provided that clearly defined conditions are fulfilled, potentially including trusted manufacturers, sufficient quality and reliability data, established production controls, traceability and demonstrated component performance (TBC).



ESCC Resilience for Passive Components



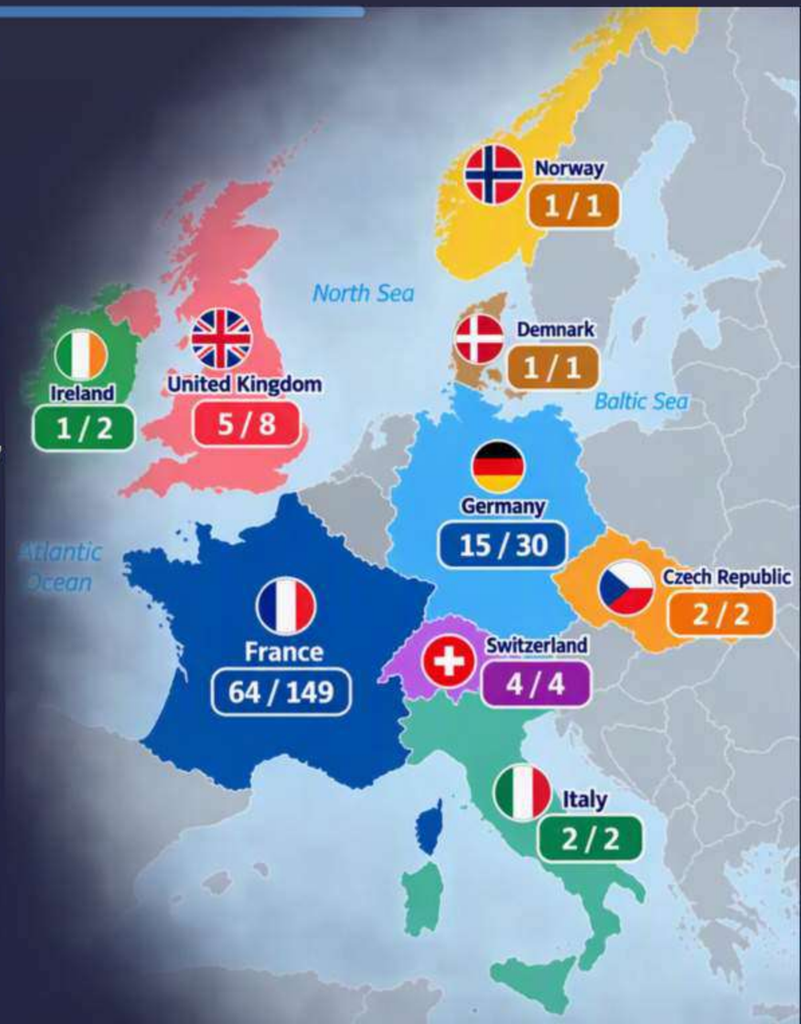
ESCC
European Space Components Coordination

34 out of 50 are ESCC Certified Passive Manufacturers

~66.6% of ESCC Certified Manufacturers are Passive Manufacturers

ESCC Resilience for Passive Components

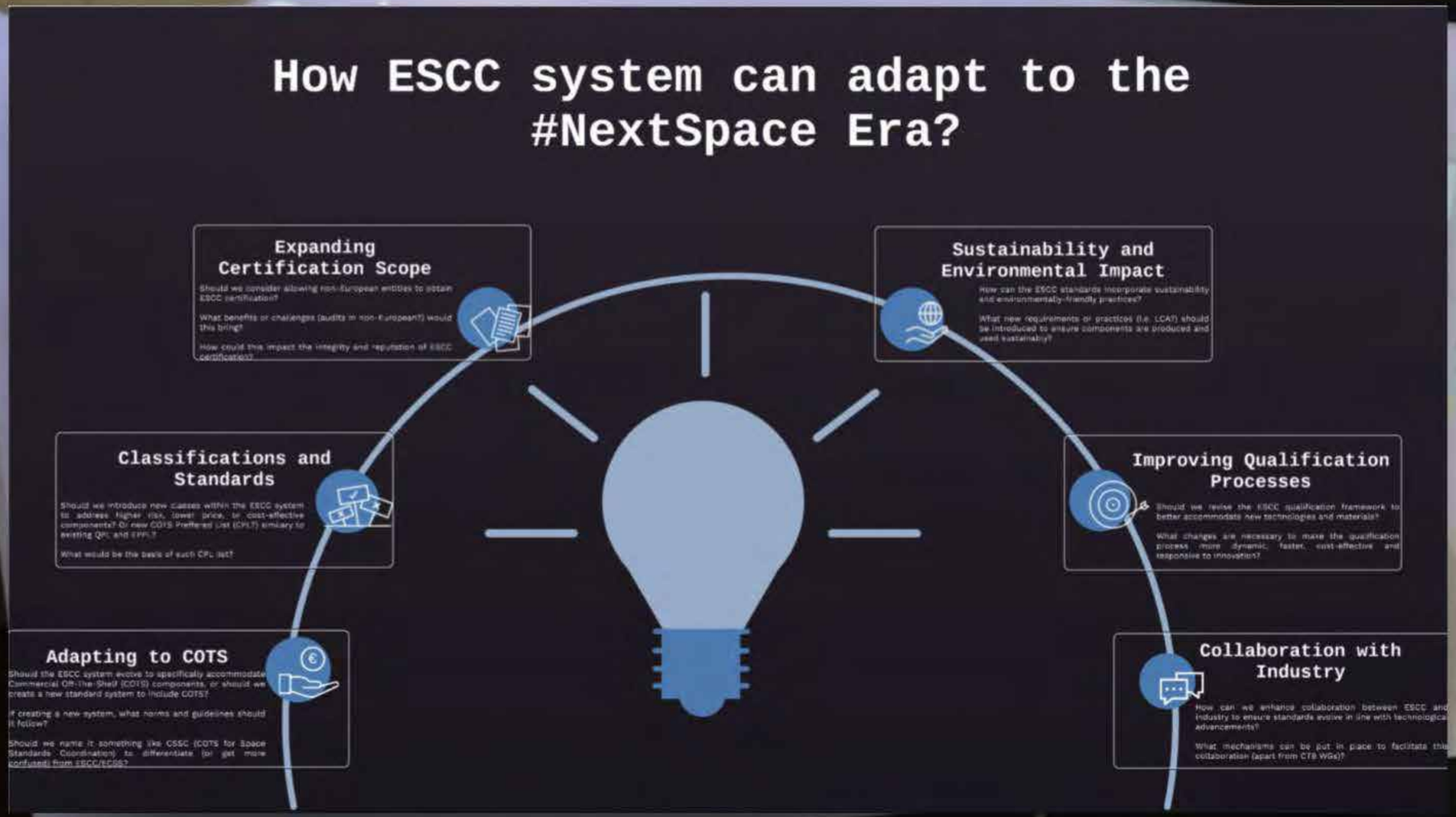
	2018	2022	2024	2026
Certificates	98	102	93	95
Part Types	135	139	136	197
Manufacturers	32	35	34	34



ESCC Resilience for Passive Components

Because the Space Industry is evolving, the ESCC standard system must evolve with it.




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 (CPLT) similary to existing QPL and CPPL?
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 evove 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)?

ESCC Resilience for Passive Components

Because the Space Industry is evolving, the ESCC standard system must evolve with it.



Introducing a new Quality Level :

ESCC Enhanced Grade

Objective: Improve the availability of cost-effective EEE parts in Europe, under ESCC oversight.

ESCC Enhanced Grade (EG)



Flexibility

Allows manufacturers to define their **own** procurement and validation **specifications**.

Quality

Maintains **a high level** of quality through a maintenance test plan, reliability data and continued oversight by the ESCC Executive.

Competitiveness

Helping **lower costs and lead times** by reducing qualification and testing burden for certified manufacturers.

Efficiency

Leverages existing manufacturer knowledge and reliability data, avoiding unnecessary duplication of testing while maintaining **appropriate assurance**.

Market Growth

Recognises Enhanced Grade products within the EPPL 2 framework, increasing their **visibility** and supporting broader market adoption.

Trust

Builds on the established relationship between the ESCC Executive and manufacturers, providing confidence through **ESCC review** and recognition.

Enhanced Grade (EG) ≠ ESCC Qualified

EG provides Enhanced Assurance under an ESCC controlled Framework
But the Component is NOT considered ESCC Qualified.

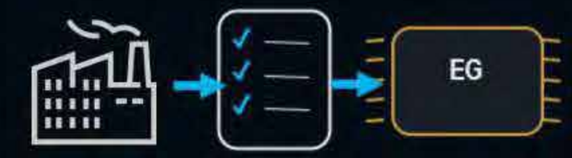
A Project Review and Approval remain necessary depending on the mission applications and classification.

ESCC Enhanced Grade (EG): Requirements

ESCC EXECUTIVE OVERSIGHT | CNES · DLR · ESA · UK Space Agency | Selection responsibility · Maintenance Test Plan · Available Reliability Data

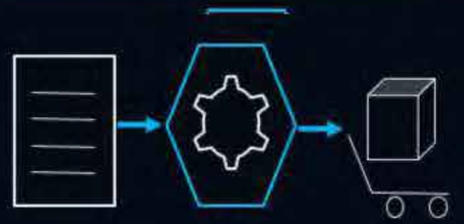
1 ESTABLISHED MANUFACTURER

- ESCC QML or PCAL
- Established Know-How & Capability



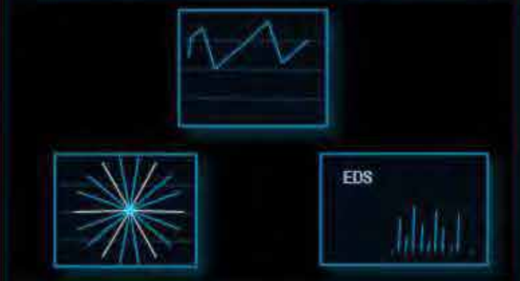
2 DEFINED EG APPROACH

- EG Definition
- Component Family
- Procurement Specification



3 RELIABILITY & TEST EVIDENCE

- Reliability and Radiation data
- Outgassing per ECSS
- Pure tin>97% as per JEDEC
- Maintenance Test plan





Manufacturer Driven & ESCC Oversight

ESCC Enhanced Grade provides a new pathway between commercial availability and full qualification.

ESCC Enhanced Grade
=
European Preferred Parts List EPPL-2

EPPL-1

- ESCC QPL
- ESCC QML
- JAXA QTS
- etc.

EPPL-2

ESCC Enhanced Grade



EPPL-3

- EU parts with ESCC Evaluation,
- Other Qualification systems

REDUCE
Cost & Lead time

STRENGTHEN
European component capabilities

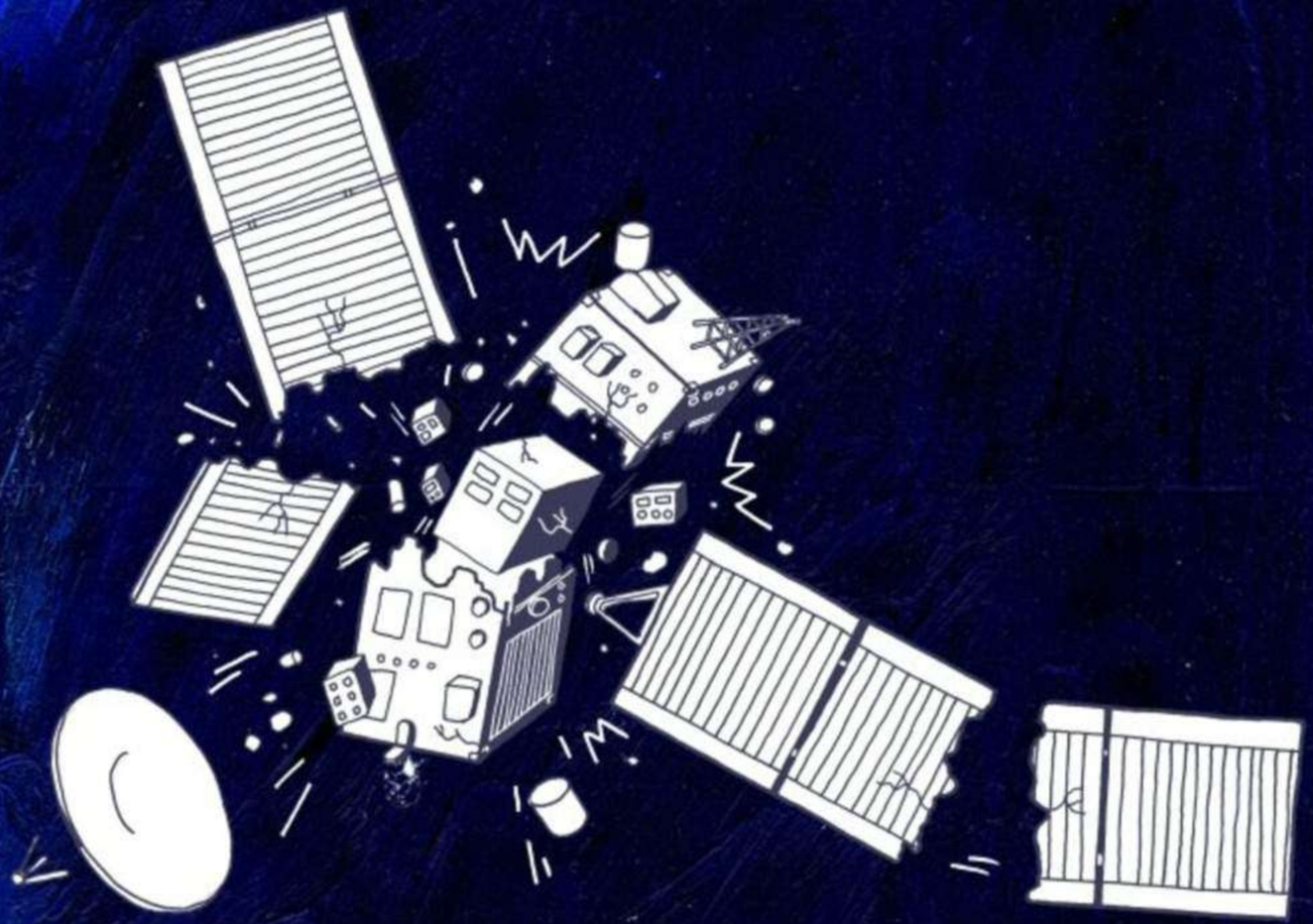
ENABLE
Faster adoption of new technologies


#Strategic
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Anomalies

Anomalies

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

In-Orbit Failures & Lessons Learnt



Non-Conformances

In-Orbit Failures & Lessons Learnt

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



BepiColombo

Mercury Magnetospheric Orbiter (**MMO**), aka **Mio**
JAXA

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



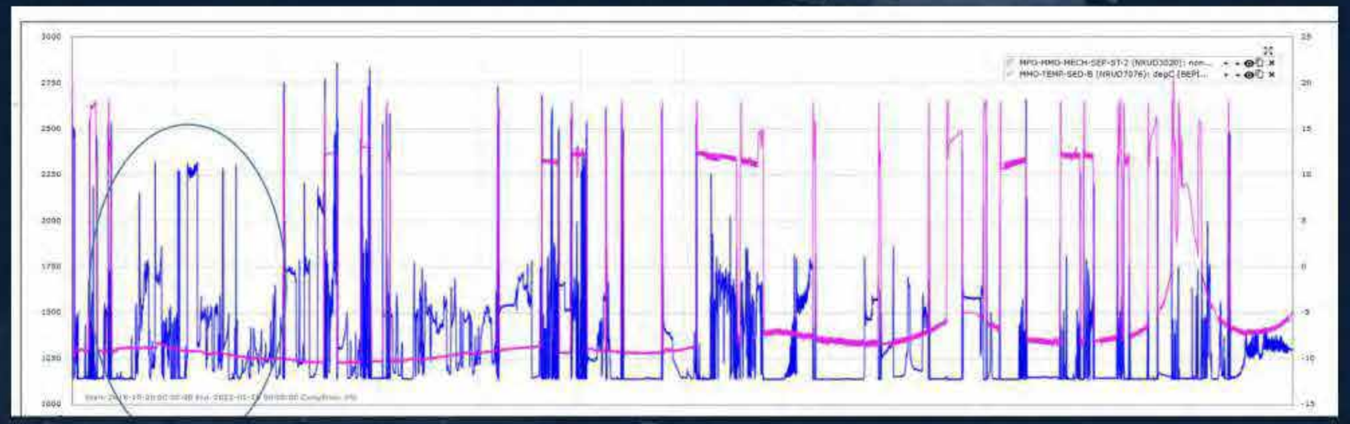
Mercury Planetary Orbiter (**MPO**)
ESA

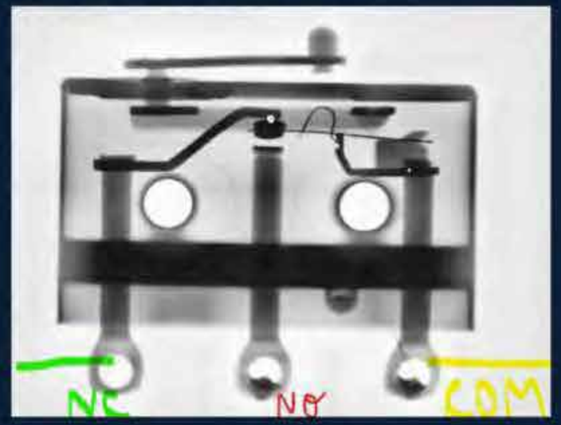
MPO - ESA is a spacecraft with 11 experiments and instruments.

BepiColombo: Lessons Learnt (LL) related to EEE

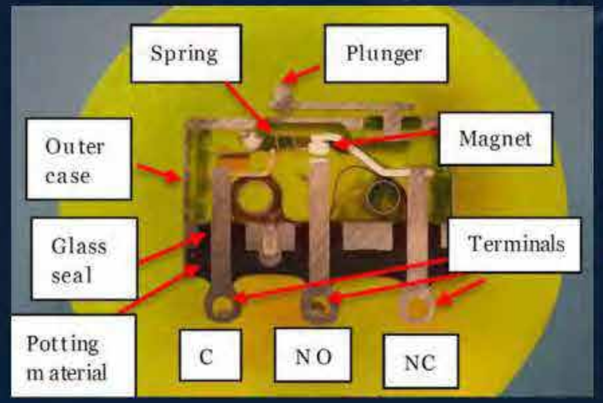
Mechanical separation **switches** started to **occasionally report separation**.

Several mechanical separation switches regularly toggles between separated and not separated status. Also the clamp band status toggles between states.





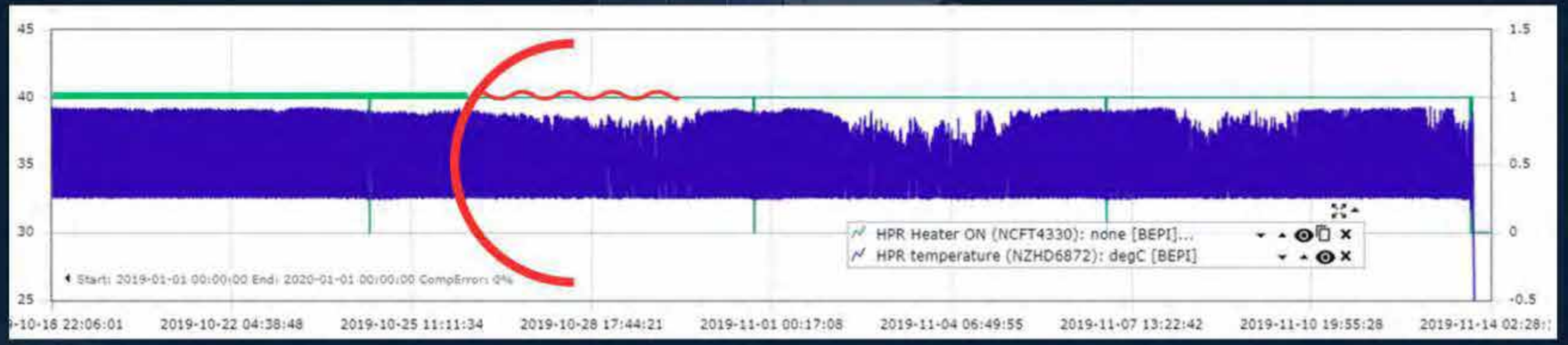
Investigation was performed and has shown a probable contamination in the swtich.

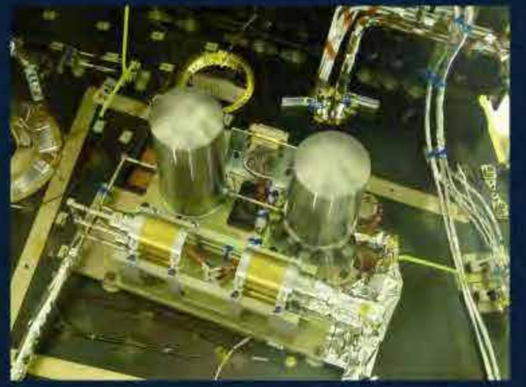


Lessons Learnt:
- Design (Hermetic vs non-hermtic)
- Choice of the switch (Space Grade vs Commercial)
- Screening including run-in
- **Application:** The Normally Open (NO) contact shall also be wired in addition to the Normally Closed (NC) contact.

BepiColombo: Lessons Learnt (LL) related to EEE

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.





Investigations identified the root cause of the issue related to the thermostat.

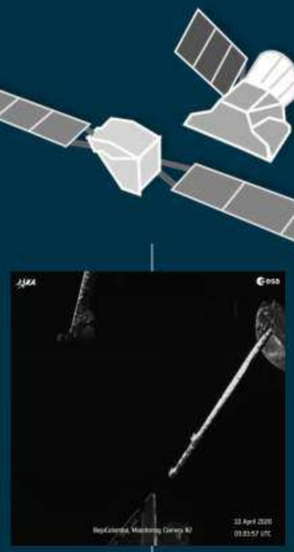


Lessons Learnt:
- Process Improvement and Inspection during manufacturing
- Additonal RGA test during Qualification
- **Application:** Operating the Thermostat only at temperatures where the contact stays always closed and controlling the temperature at the target by using the Telemetry Thermistor and the Power Distribution MOSFET

BepiColombo: Next Milestone!

VAL AT MERCURY

EUROPEAN SPACE AGENCY



3 September 2026

The Mercury Transfer Module (MTM) releases the Mercury Planetary Orbiter (MPO) and Mercury Magnetospheric Orbiter (Mio)

21 November 2026

MPO and Mio, still joined together, are captured by Mercury's gravity and orbit it at 674 x 178 000 km altitude

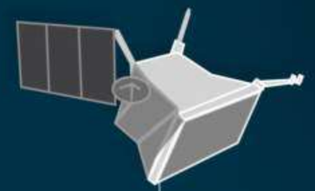


9–10 December 2026

MPO releases Mio onto its final 590 x 11 640 km orbit

16 December 2026

MPO ejects Mio's sunshield, and moves towards its final orbit



10 March 2027

MPO arrives in its final orbit at 480 x 1500 km altitude

6 April 2027

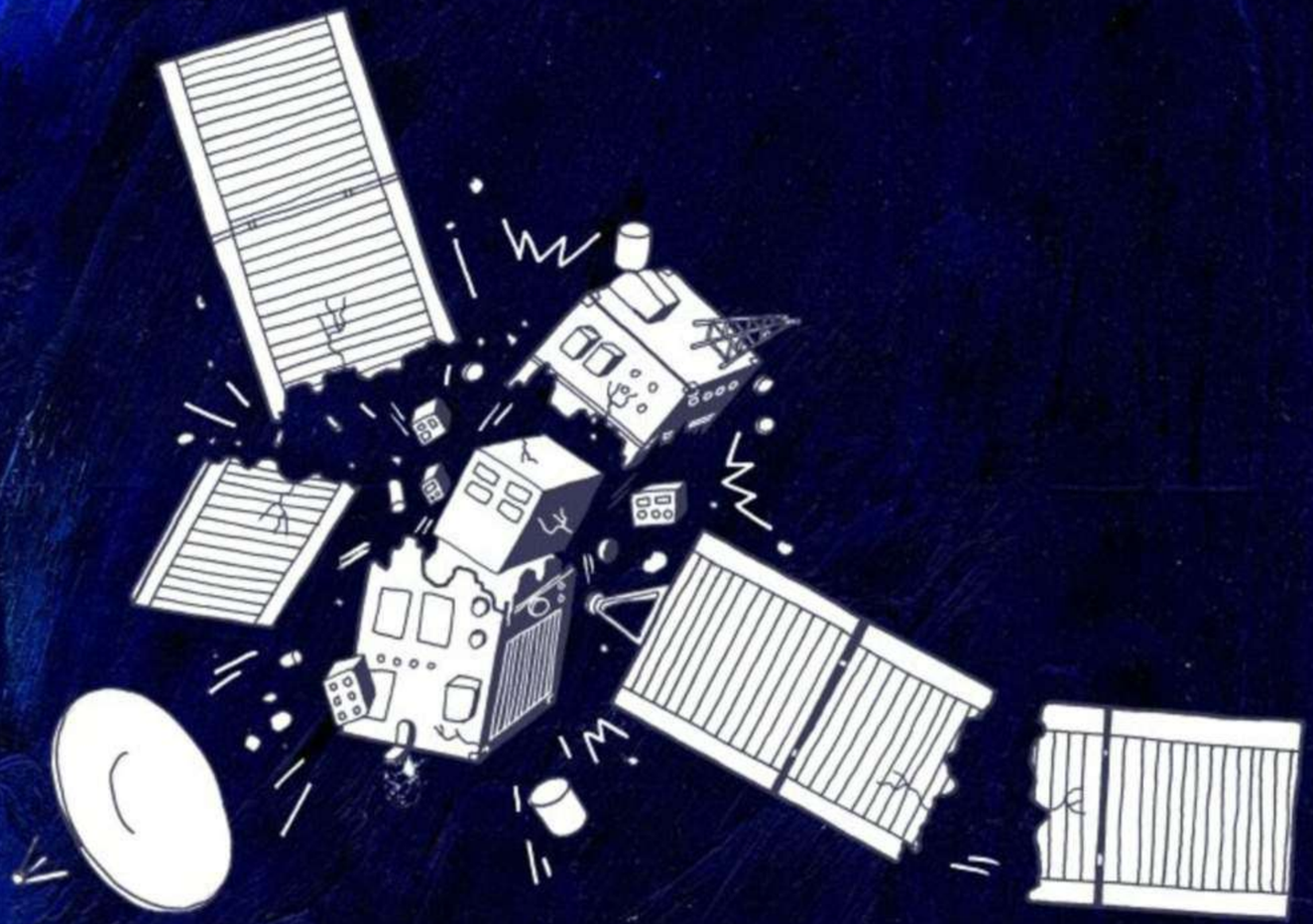
Science begins

THE DATES OF THESE EVENTS MAY CHANGE FOR OPERATIONAL REASONS

Anomalies

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

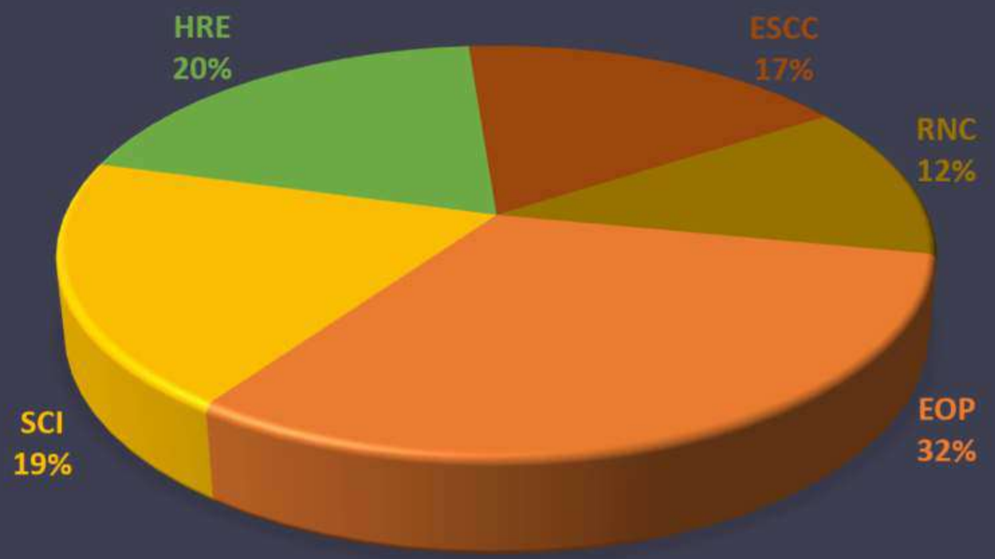
In-Orbit Failures & Lessons Learnt

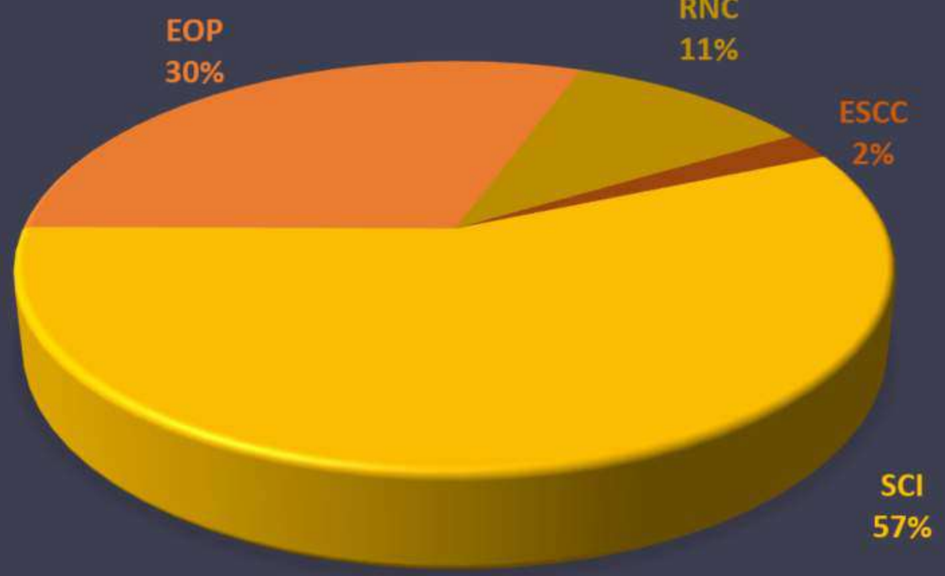


Non-Conformances

Non-Conformances: 2025 & 2026

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





Higher distribution of NCRs in Science than in Earth Observation in 2026 with respect to 2025

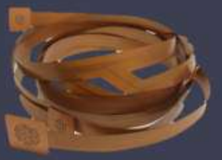
Non-Conformances: 2025 & 2026

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



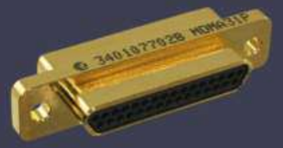






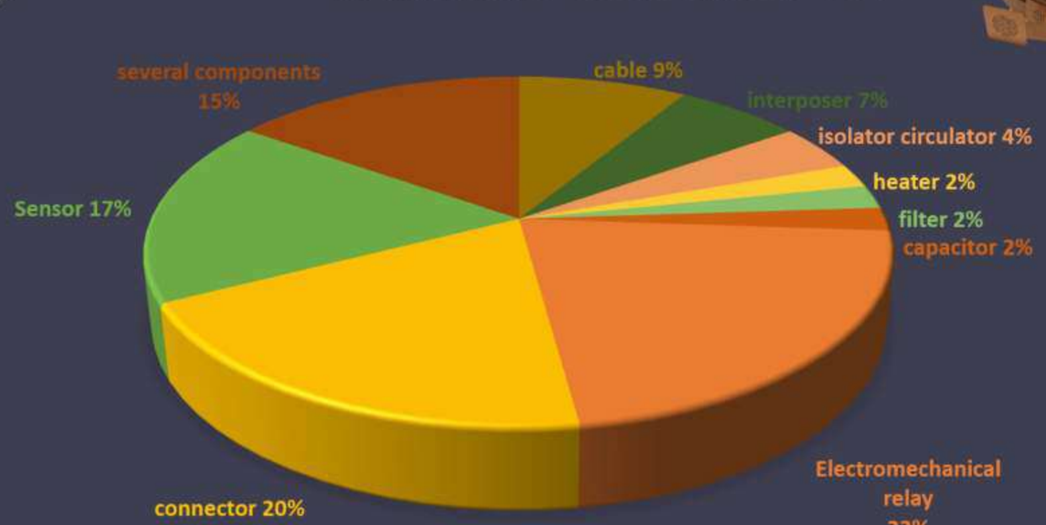










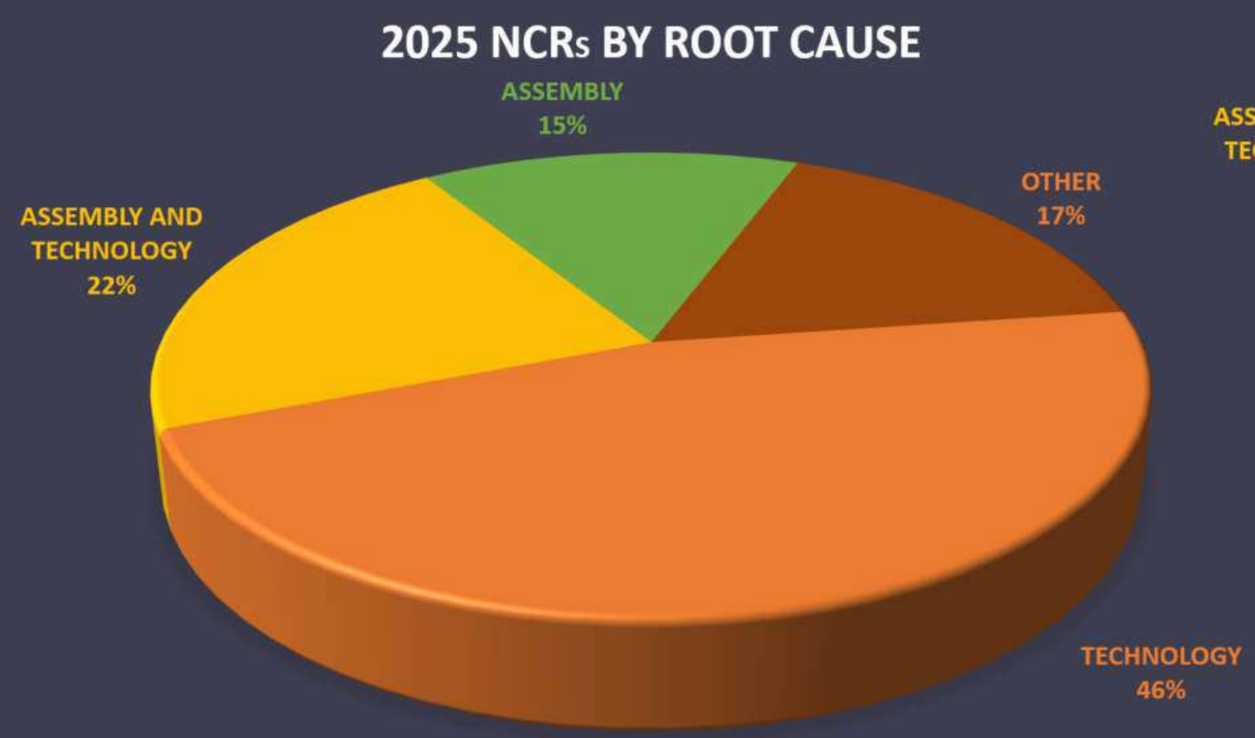


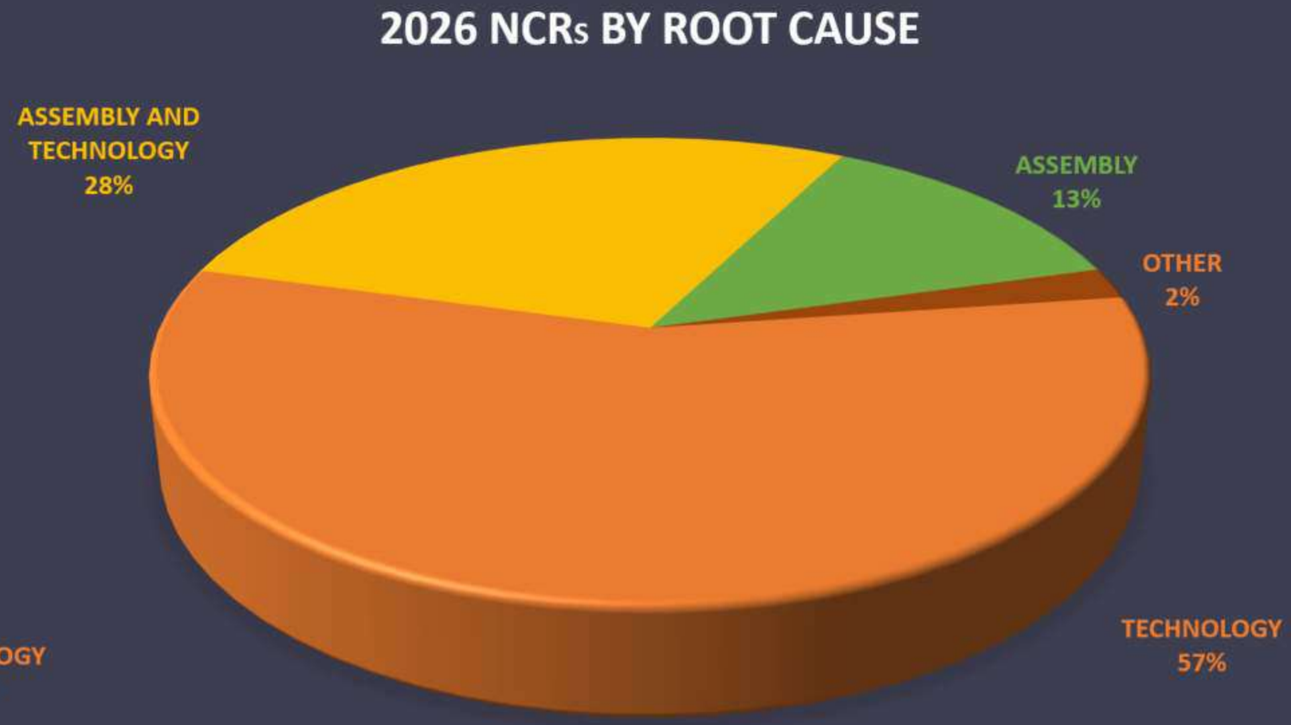
NCs are proportional to the number/amount of passive parts that are mounted in spacecrafts

Non-Conformances: 2025 & 2026

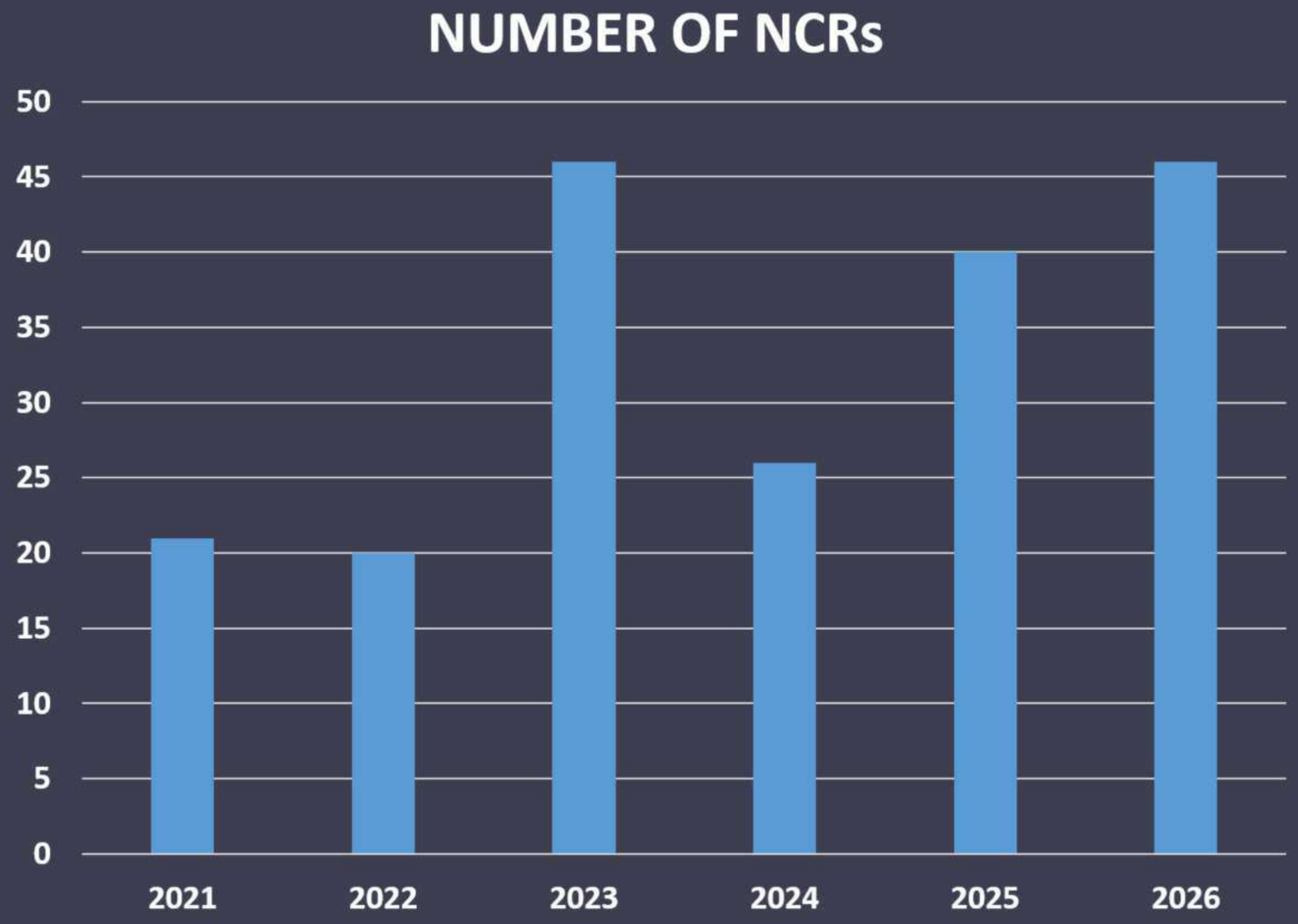
NCs related to Passive and RF Passive components by root cause

Most of the issues are related to the technology. There were mainly detected in the case of non-QPL parts: mainly space-grade level, COTS and few ESCC QPL (used outside their specification).





Non-Conformances: Since 2021 till today!



Passive Component Anomalies

4 case studies:

Observation → Failure mechanism → Potential impact

ESA Materials and Electrical Components Laboratory

01 RELIABILITY TESTING



PIND
Particle impact noise detection



Environmental
Temperature cycling ; humidity



Vibration
Mechanical vibration

Shock
Mechanical shock testing



Hermeticity
Fine and gross leak testing



Wire bonding / die shear
Mechanical assembly evaluation

02 IMAGING & MATERIAL ANALYSIS



3D CT
High-resolution 2D & 3D radiography



SEM / EDX
Surface imaging + elemental analysis



FIB
Dual-beam + plasma targeted sections



C-SAM
C-Mode scanning acoustic microscopy

03 LOCALIZE THE FAILURE



Optical microscope
External / internal inspection



OBIRCh / PhotoEmission
Electrical failure localization

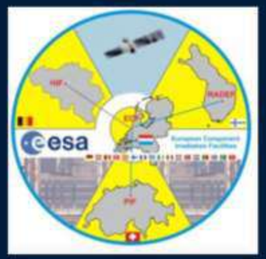


Lock-in Thermography
Thermal failure localization

04 RADIATION EFFECTS

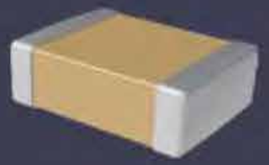


TID
Total ionizing dose:
Co-60 Gamma source

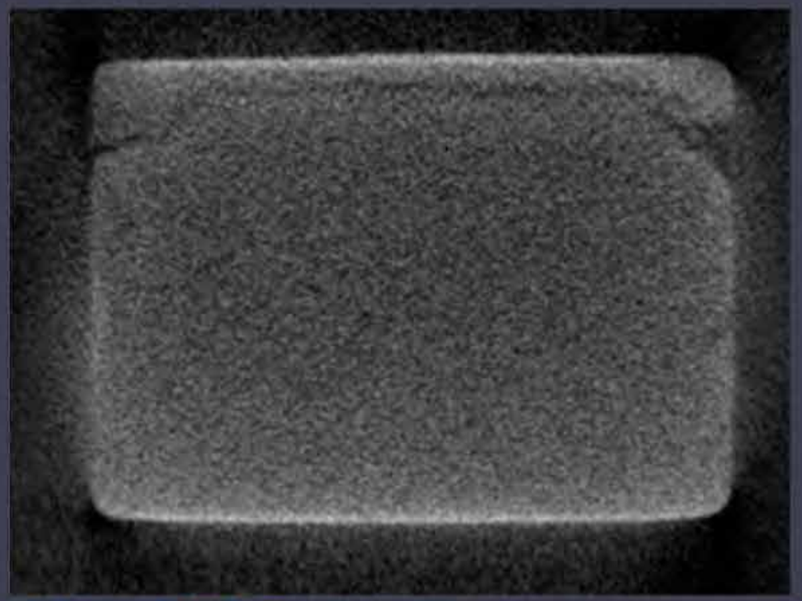


SEE
Single-event effects ; heavy-ion and proton testing

Ceramic Capacitor



Failure description: Mechanical crack in the ceramic body causing electrical functional failure







01 OBSERVED ANOMALY

Crack observed in the capacitor body and electrodes.

02 FAILURE MECHANISM

The crack appears to be the final result of a previous process; potential root causes might be related to assembly, thermo-mechanical and electrical stresses.

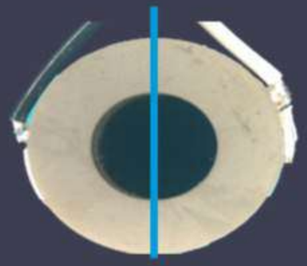
03 CONSEQUENCE

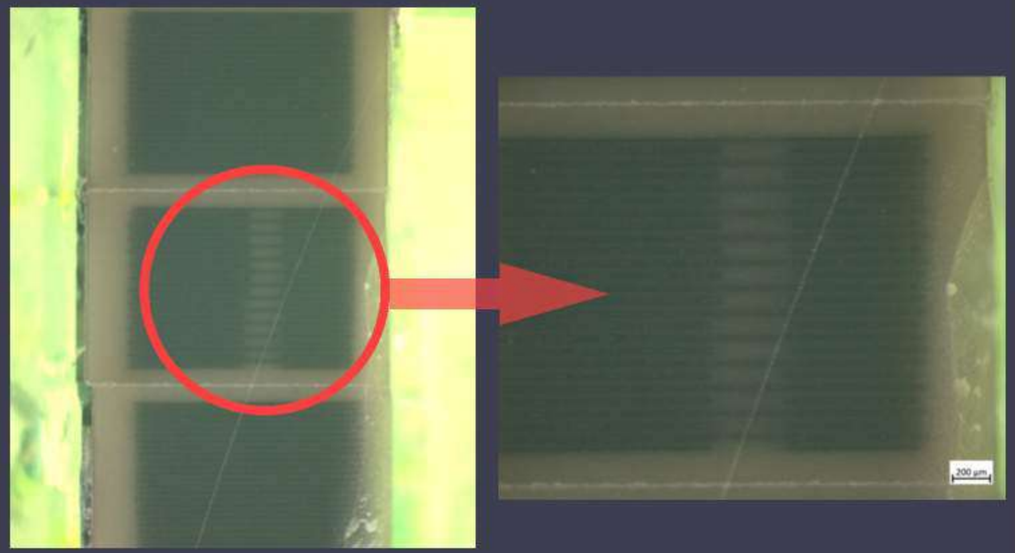
Insulation resistance drastically diminished to few miliohms.

Piezo Actuator



Failure description: Missing internal electrode in the ceramic body





01 OBSERVED ANOMALY

A discontinuity or missing layer is visible in the internal electrode stack.

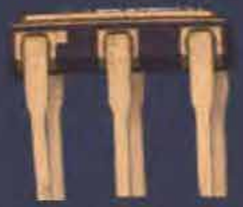
02 FAILURE MECHANISM

Non-uniform electric field → local electrical overstress.

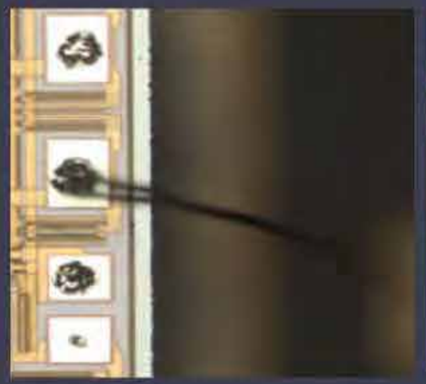
03 CONSEQUENCE

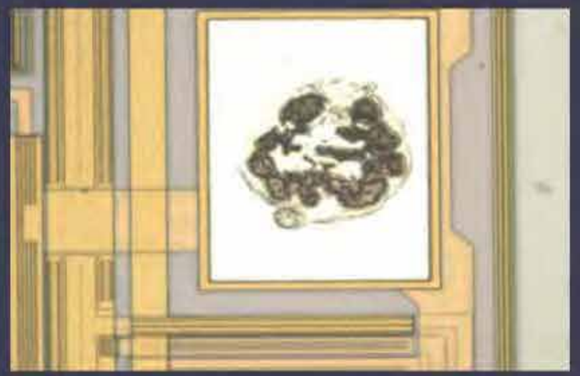
Reduced active area → loss of actuator performance → potential electrical failure.

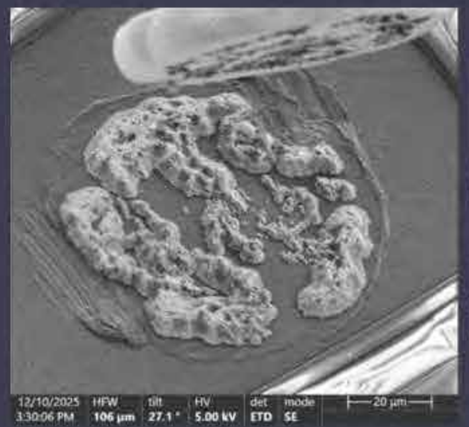
Crystal Oscillator

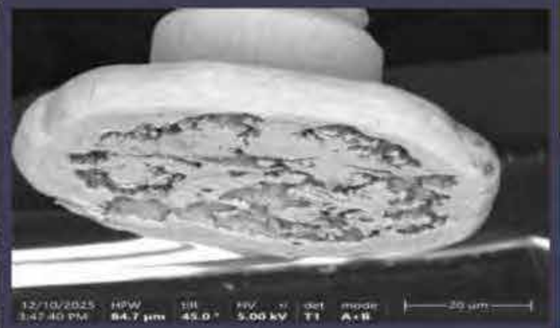


Failure description: Diminished wire bond attachment force due to Kirkendall voids under the bond









01 OBSERVED ANOMALY

Bond-wire pull testing and SEM examination show poorly formed Au–Al bonds and voiding beneath a lifted ball bond.

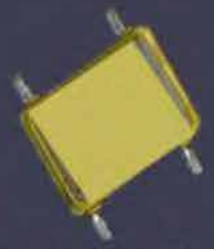
02 FAILURE MECHANISM

Kirkendall void formation can reduce the effective bonded area and weaken the intermetallic interface.

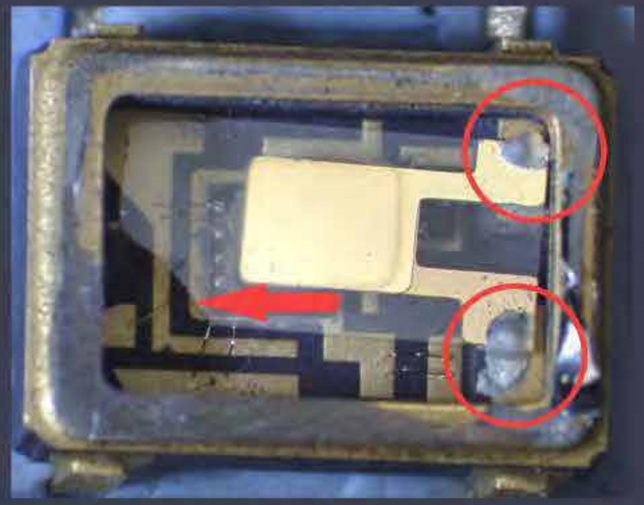
03 CONSEQUENCE

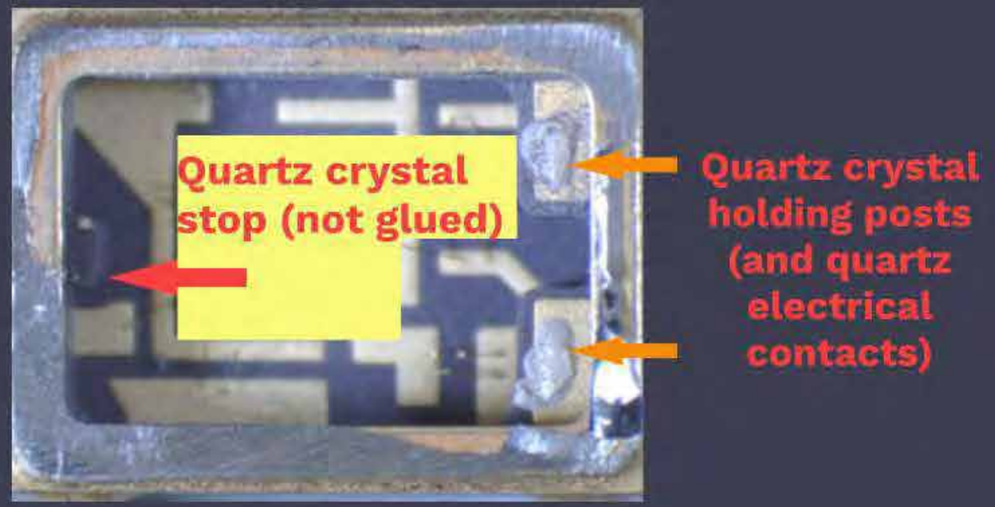
Temperature cycling or vibration can make the damage worse and may cause an open circuit.

Crystal Oscillator



Failure description: Detachment of the quartz crystal from its contacts due to an inadequate joint assembly





01 OBSERVED ANOMALY

The quartz crystal is detached from its assembly points on the component's package.

02 FAILURE MECHANISM

- Only two joints secure the quartz crystal and carry both electrical and mechanical loads;
- The assembly does not provide a reliable attachment.

03 CONSEQUENCE

Electrical continuity and mechanical stability are compromised, leading to unreliable operation and device failure.

TRENDS

What is next?



THERMAL & MECHANICAL



HARNESS



ENERGY & POWER



RF & POWER

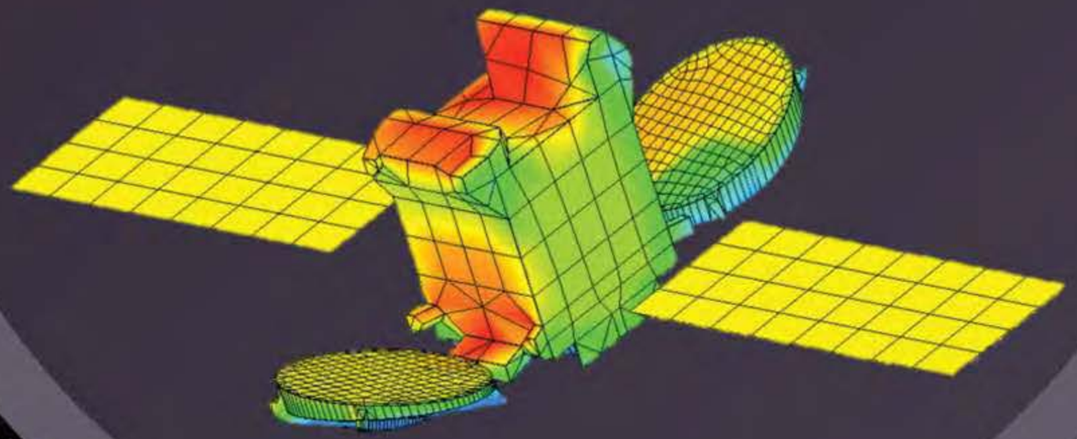


TIME & FREQUENCY



THERMAL & MECHANICAL

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



CRYOGENIC

HEATERS

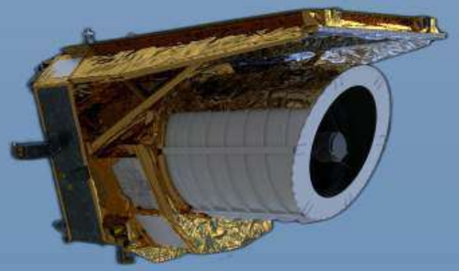
THERMO-ELECTRICAL MODULES

RELAYS

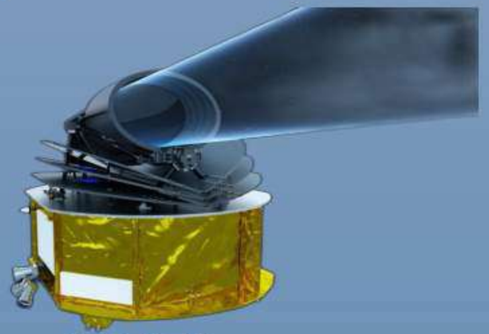
CRYOGENIC

- **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



NewAthena
T~50mK!

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

CRYOGENIC



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



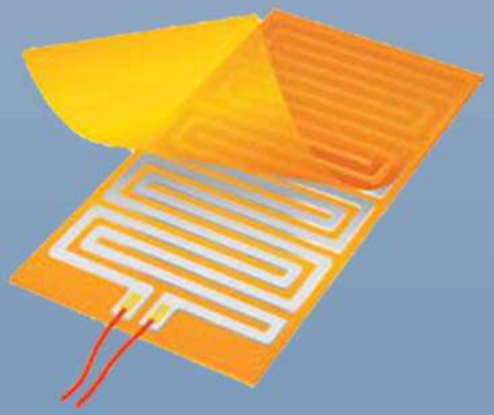
- Thermal sensors pre-assembeled with wires, and integrated splices.



Space Qualified Small gauge (AWG 32-36) wires, made from **phosphor bronze** or **manganin**, with extremely low thermal conductivity to minimize heat flow, and qualified assembly process (crimping, soldering, etc.)

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

HEATERS



- Qualification of **All-Polymide 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).



- Qualification of Multi-function sensors for more efficient thermal management:

Self-regulating heaters embedded with thermal sensors (e.g., PT sensors)

- Qualification of Flexible Heaters based on **Advanced Manufacturing:**

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.

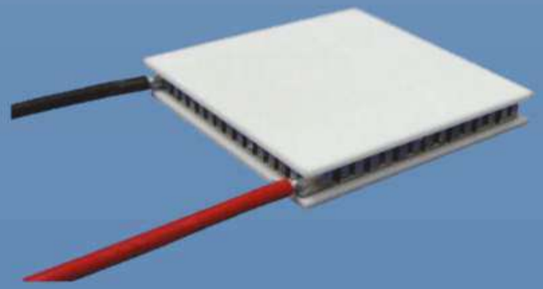
THERMO-ELECTRICAL MODULES

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



TECs were mainly sourced from suppliers in Russia and Ukraine, emphasizing the need for European non-dependence.

TECs are used mainly for precise local cooling/temperature stabilisation of sensitive systems, such as Star trackers / optical sensors, IR and optical detectors / focal-plane arrays, including CCD/ CMOS detectors.

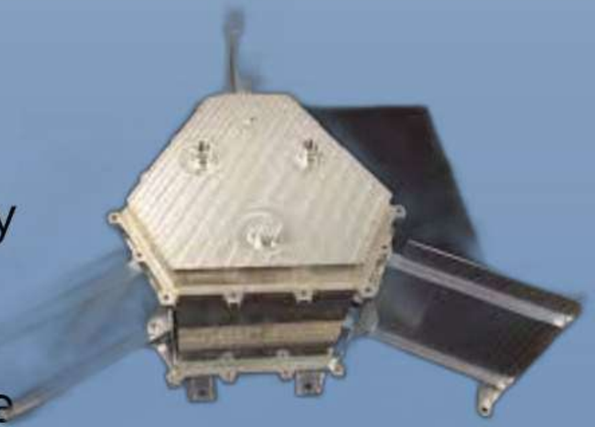


To address this, ESA has supported two European manufacturers in developing TECs capable of operating up to 125°C and delivering a maximum temperature differential of 60°C between the hot and cold sides.

Optimisation and qualification of European technologies, including fully European materials such as bismuth telluride, should follow.

THERMO-ELECTRICAL MODULES

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



TEGs convert a temperature difference into electrical power.
However, no space-qualified or space-developed solution currently exists.

TEGs are mainly used for power generation from temperature gradients, most notably in radioisotope thermoelectric generators (RTGs).



This would allow to launch and operate deep space and planetary missions in environments where use of solar power is not possible!
In particular, it would enable the **Voyage 2050 L4 mission** to operate in the extreme outer Solar System.

For more information, please join Martin Haag's presentation on Wednesday, 14th October at 10h40:
"**Evolving the Enceladus L4 Mission Under New Launcher Conditions**"

Relays







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



Copernicus Constellation:

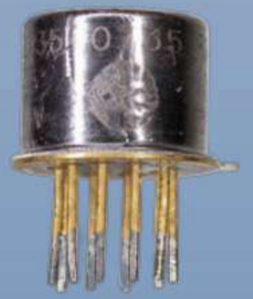
The **world's largest** Earth Observation programme!

For more information, join ESA's presentation, Lorena Capitán - EEE Engineer,
on Friday, 16th October at 10h50 :

"Lessons Learned on Electromechanical Relays for Earth Observation Applications"

Relays

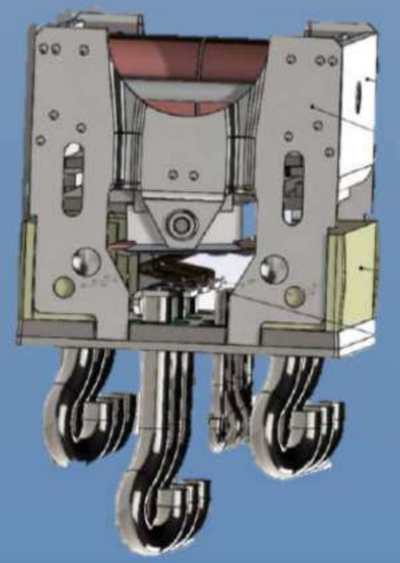






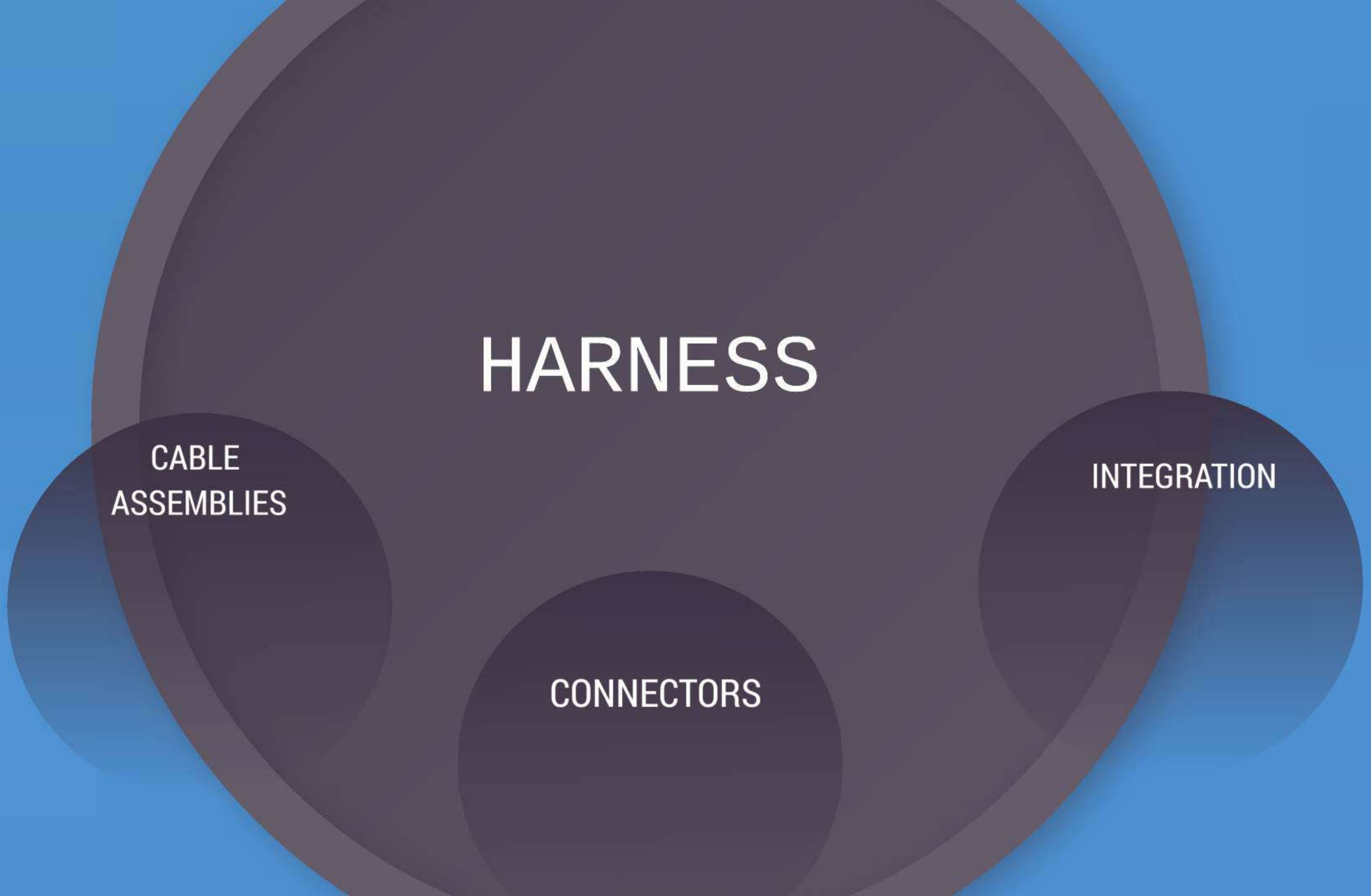
- **High level vibration/shock relays for new systems**
  Improved design exceeding the current ESCC3602 levels for shocks and vibration.

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



- **Relays 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.

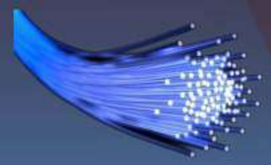

HARNESS
CABLE ASSEMBLIES
CONNECTORS
INTEGRATION

CABLE ASSEMBLIES

RF
ESCC 3408



Optical
ESCC 3420



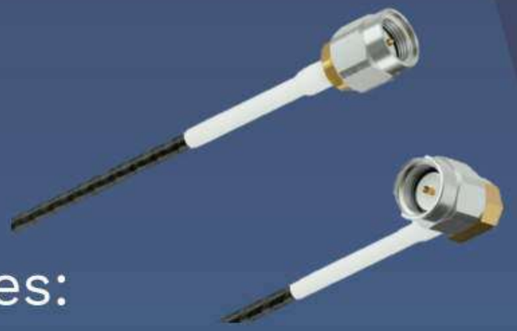
High Data Rate
ESCC 3409



Wires &
Cables



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

What is next?

Extending space-qualified RF interconnections towards 65 GHz with 1.85 mm interfaces and 110 GHz with 1.0 mm interfaces, building on European connector and cable-assembly developments.



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

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

Wires & Cables

- **Time for a Change?**

ESCC specifications to be updated to allow copper wires with minimum 1 µm silver plating thickness, as compared to the current 2 µm requirement, subject to implementation of a Red Plague Control Plan.

- **High Voltage Cable Assembly**

Development and Qualification of dedicated 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.
- AC signal (i.e. few MHz)
- Dynamic (i.e. moving arms)



CONNECTORS

Connectors are moving towards smaller footprints, higher data rates, modular interfaces and faster integration.

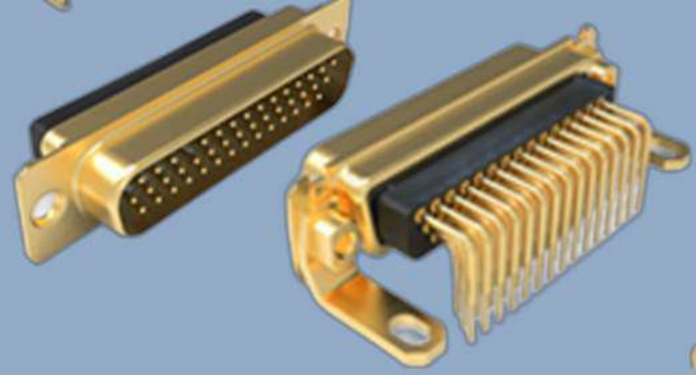
Miniaturisation & Easier Integration

Solderless Board Connections

Modular Interfaces

Higher Data Rates

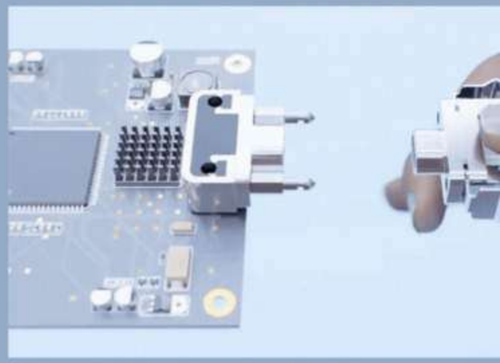
Miniaturisation & Higher Density

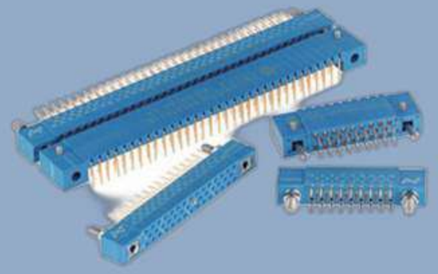


D-Sub and Micro-D connectors remain established solutions for spacecraft equipment, while Nano-D connectors offer further mass and volume savings for tightly constrained applications, mainly scientific instruments.



Qualification of Micro-D with **Removable crimp contacts and fast-locking mechanisms** are valuable improvements for assembly and rework.



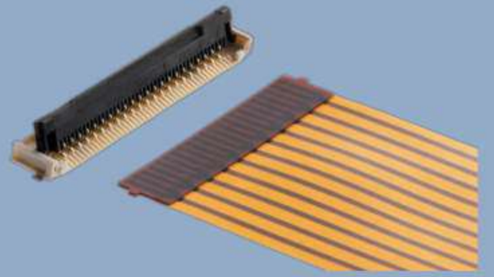


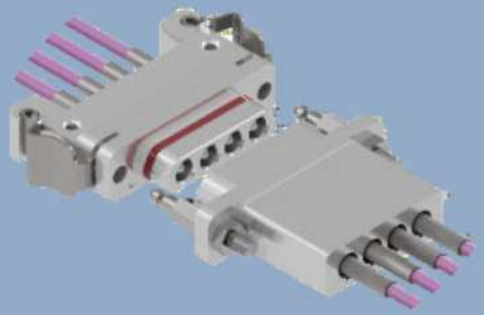
High-density board interconnections accommodate several hundred contacts within a compact footprint.

Modular Interfaces

Configurable interfaces combine **signal, power, RF and optical** connections within a common connector housing, reducing the number of separate interfaces and simplifying equipment integration.

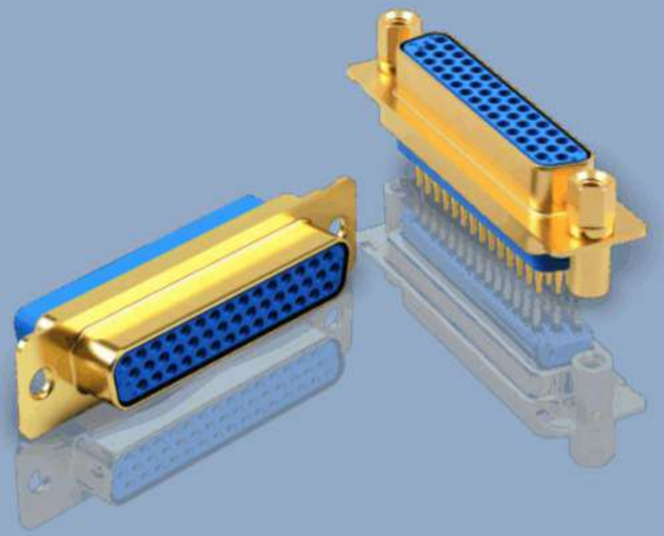
Zero Insertion Force (ZIF) and Low Insertion Force (LIF) interfaces reduce mating effort for flat cables. Development of space-grade equipment-side connectors to be developed to enable easy and reliable integration.





Standardisatioin for multi-fibre and multi-cavity optical interfaces, building upon the existing work on single-fibre connectors.

Solderless Board Connections

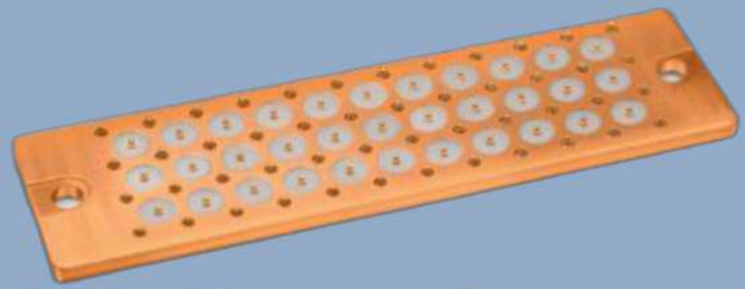


Press-fit and compression-contact technologies enable electrical connections to PCBs without soldering.

FACT: Amphenol Positronic became the first EU manufacturer to achieve ESCC qualification for press-fit connectors.

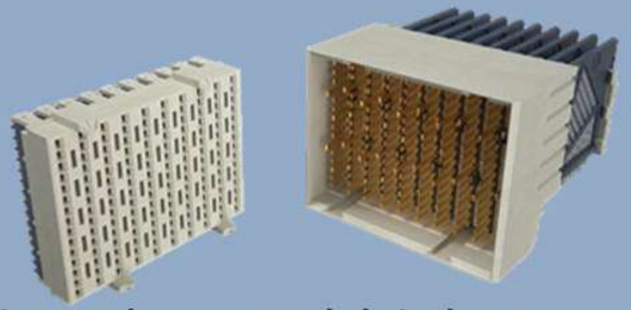
Other solderless technologies:

- Interposers,
- Spring-loaded, or Pogo contacts
- S-FECT interfaces,



should be developped for connections **with reduced height <5mm, and increased power (up to 100V and 2A)**

Higher Data Rates

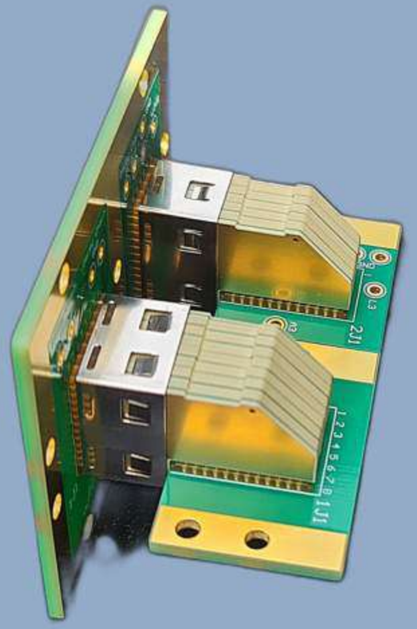


Faster FPGA transceivers and increasing onboard processing demand higher-performance connectors and board interconnections.

From ~12 Gb/s towards **56 Gb/s**

Low insertion loss, low crosstalk and effective shielding become essential as data rates increase.

Evaluation and Optimisation of high-density, HDR, backplane board-to-board Connecotrs: COTS and space-grade solutions for several standards cPCI, VITA, OpenVPX.



Development of HDR, mezzanine board to board connectors + modular (Power + RF).

BETTER INTEGRATION & ROUTING

Space applications such as robotic arms, deployable antennas, solar arrays and compact payload electronics require lightweight, compact electrical interconnections.





BETTER INTEGRATION & ROUTING



- **Flexible Harness:**
  - Mass savings target up to 30%
  - Volume saving up to 75%
  - Reduction of cost by reduction of the number of devices
  - Better shielding and impedance characteristics
  - Drastic reduction of AIT integration time

FFC vs FPC



Flexible Flat Cable (FFC): A flat, flexible cable consisting of parallel metallic conductors laminated between insulating films.

ESCC Generic Specification Needed!

Flexible Printed Circuit (FPC): A flexible circuit consisting of patterned conductive tracks, allowing multi-layered structures, and complex routing.



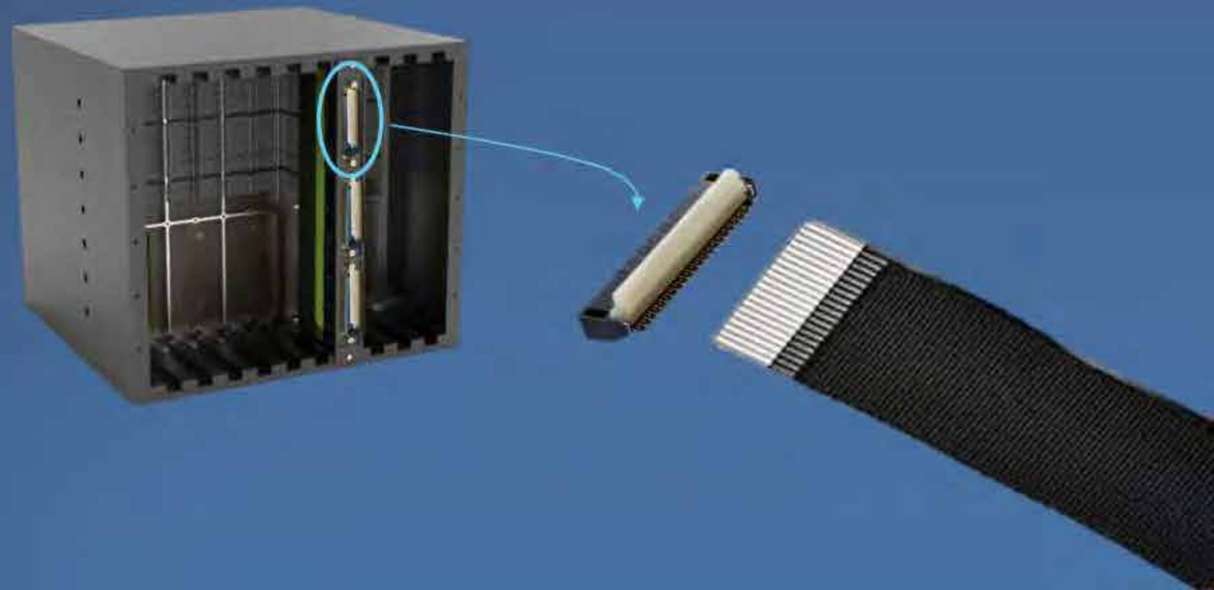
BETTER INTEGRATION & ROUTING

- **What is the long-term trend?**

Develop and Qualify flat cables for space and develop dedicated LIF/ZIF connectors with a fast-locking mechanism for satellite electronic units and PCB boards.

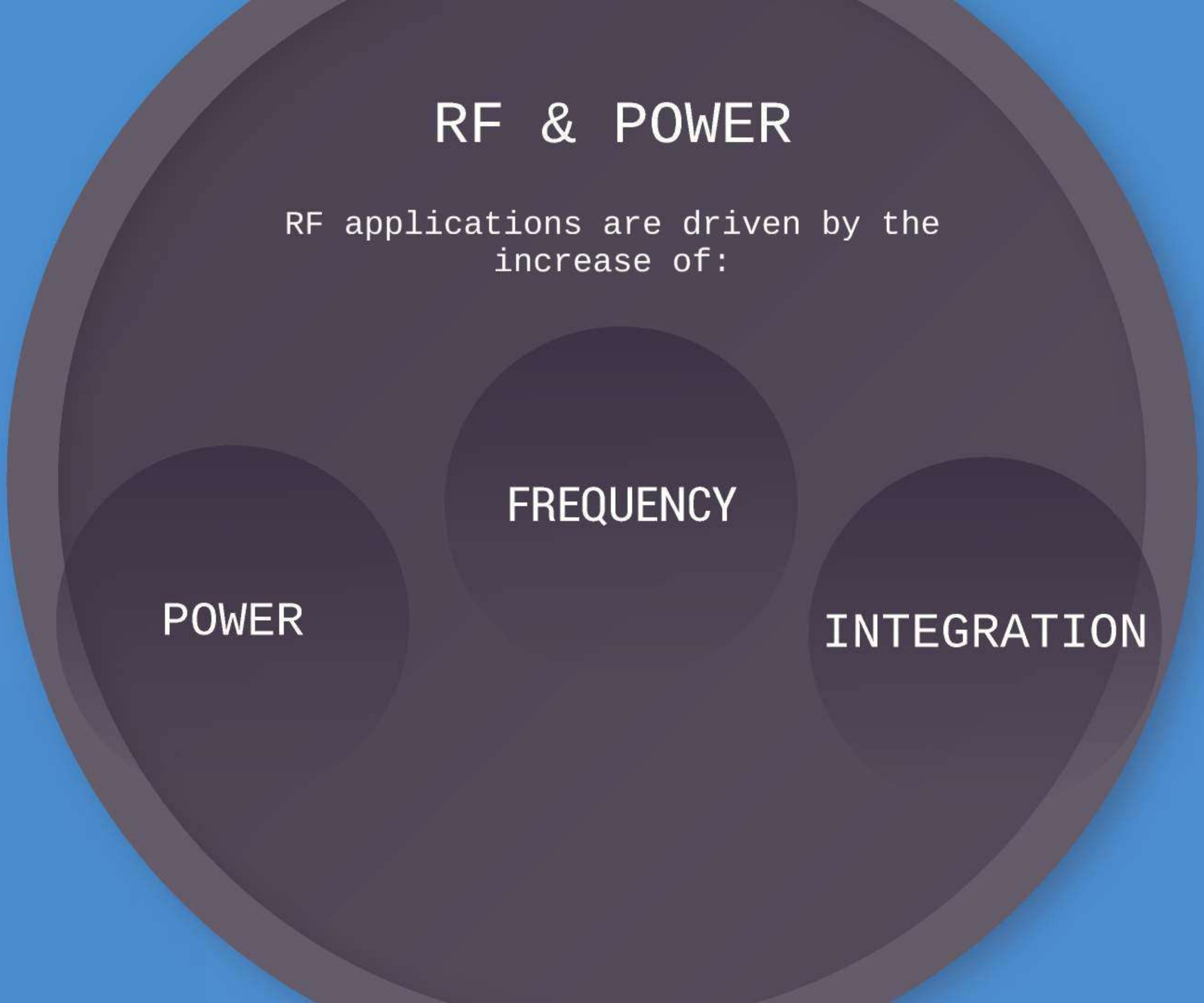
These connectors allow direct mating with **connectorless** flat cables.





RF & POWER

RF applications are driven by the increase of:



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 processes 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 - Technical Note added to ESCC 3402.

  - Improve charachetrisation of SEY materials, needed for MP simulations.

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.

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)!
Further optimisation of SIW circulator and isolator for W band



- **ESA On-Going Development:**

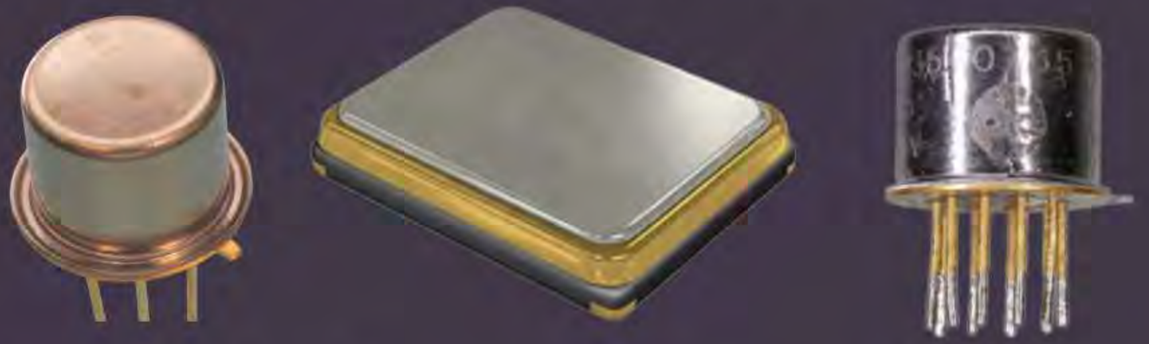
Integrated Ka band isolator and divider using SIW
Ultra-low loss combiners using SIW at Ku and Ka bands
Ka-Band Compact Filter with integrated input isolator using SIW at Ka band

- **What 's next?**

Development and Qualification of Miniaturised self-biased (magnetless) circulators/isolators for GaN applications.

TIME & FREQUENCY

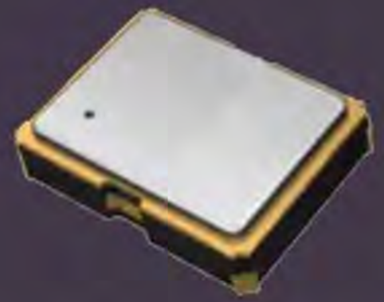
Quartz crystal oscillators are designed to minimize their sensitivity to ionizing radiation, which can cause frequency drift.
Selecting the appropriate crystal quality for the intended application and cost range is essential.



ESA is supporting Rakon (FR) in evaluating oscillators using crystals of different quality grades—standard, high, and very high quality—under Total Ionizing Dose (TID) irradiation, at both low and high dose rates.
The objective is to assess the trade-off between crystal quality, radiation sensitivity, and cost

RAKON's presentation of the TDE activity
"Minimisation of Crystal Oscillator Cosmic Radiation Effects"
Friday, 16th October at 10:10h

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), with SAPHYRION (CH), 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!

RAKON presentation on this activty

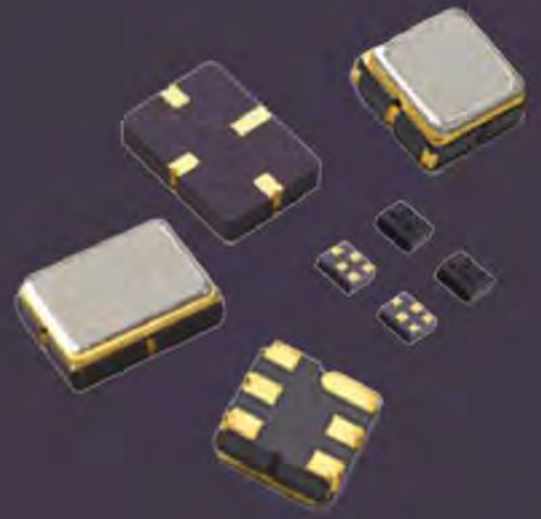
"**Radiation Mitigation in ASIC-Based Oscillators: Comparative Analysis of Design for Resilience and COTS Foundation Approaches**"
Friday, 16th October at 12:00

TIME & FREQUENCY

- **SAW devices:**

  Development of SAW oscillators for high frequencies (>250MHz for CMOS).

  Evaluation of radiation of SAW resonators.





- **SMT resonators:**

  Qualification of surface-mount technology (SMT) resonators to enable greater miniaturization and simplify assembly processes, replacing traditional through-hole designs.

ENERGY & POWER

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

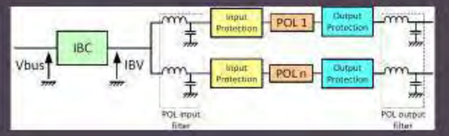
Increasing capacitance density and extending voltage ratings in compact SMT packages. Materials and manufacturing processes must evolve to address **REACH** requirements while preserving space reliability and long-term availability.

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).



European solutions for ferrite beads for filtering or GaN power applicaitons in SMT packages.

Passive Components: News, Trends and Activities

News

Trends

Activities



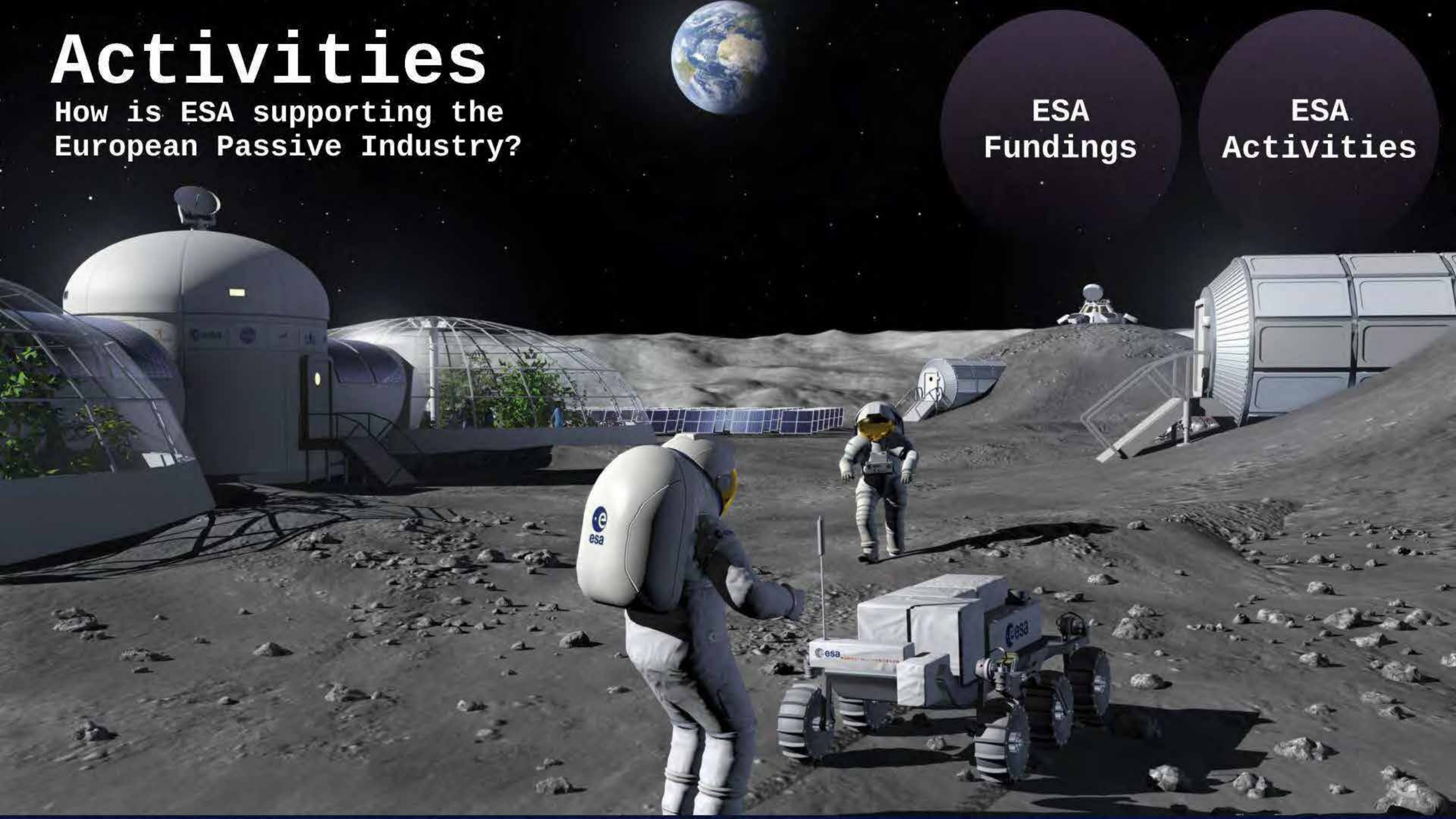
Dr. Hussain Alaaeddine, Mr. Joaquín Jiménez, Dr. Léo Farhat
ESA - European Space Agency

Activities

How is ESA supporting the European Passive Industry?

ESA Fundings

ESA Activities



HOW TO WORK WITH ESA TEC

INDUSTRY DRIVEN

"I have an idea / capability"

CHANNELS: OSIP and ESA Star

First steps for unsolicited proposals are always through OSIP. Followed by ESA Star, where we have requests for proposals (RFPs), open calls and requests for information (RFI) on dedicated subjects.

ESA DRIVEN

"I have a need / challenge"

CHANNEL: ESA Star

In ESA Star you can find the compendia, workplans, ITTs, RFIs and roadmaps. We also have targeted industry consultations, thematic workshops.

ROLE OF ESA TECHNOLOGY DIRECTORATE

Understand the idea and fit to need - Assess objectives and maturity - Connect to expertise and facilities - Match to programme


DISCOVERY


PREPARATION


TDE


GSTP E1


GSTP E1 Frameworks: BB


GSTP E1 Frameworks: De-risk


GSTP EEE components


GSTP Resilience & Security


GSTP E2


GSTP E3

Programme choice depends on strategic fit, funding route, Member State support and initiative use.

EARLY IDEAS (TRL 1-3)

Concepts, proof-of-principle, new approaches

TECHNOLOGY DEVELOPMENT (TRL 4-6)

Breadboards, validation, relevant environment

DEMONSTRATION+ADOPTION (TRL7-9)

Flight qualification, IOD/IOV, mission use

VALUE: De-risked technology - Stronger European industry - Mission readiness - Competitiveness - Faster route from idea to impact

esa EUROPEAN SPACE AGENCY

Scan me!

TDE

GSTP

Space Journey

TDE

1975 → TODAY

More than 50 years of
European technology development!

TECHNOLOGY DEVELOPMENT ELEMENT

- Formely TRP (Technology Research Programme)
- Turning emerging concepts to demonstrated technology.

MANDATORY BASIC PROGRAMME

- Funded by All ESA Member States!
- No National Delegation support is needed.

TECHNOLOGY MATURITY

Starting TRL: 1–3
→ Target TRL: 4

HOW IT WORKS?

Work Plans :
Regular 2-year work plans, aligned with ESA Technology Strategy.

Open Procurement:
Activities and Contracts are awarded on a competitive basis

All Disciplines:
TDE supports technology development across the full spectrum of space engineering.

HOW TO WORK WITH ESA TEC

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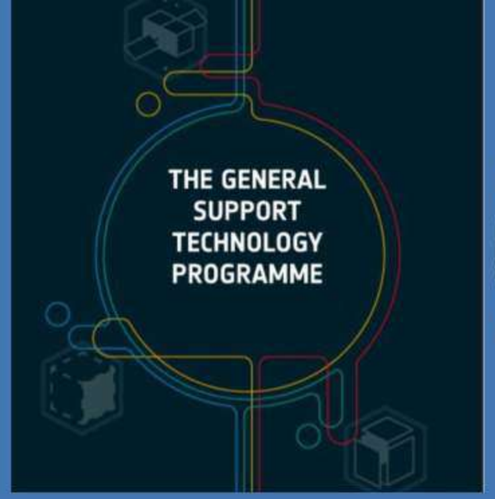
esa EUROPEAN SPACE AGENCY

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GSTP

1993 → TODAY

More than 30 years of
European technology maturation!

GENERAL SUPPORT TECHNOLOGY PROGRAMME

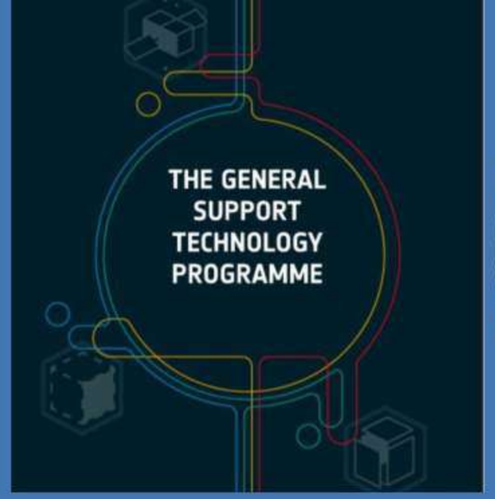
- From proven innovation to flight ready technology

OPTIONAL PROGRAMME

- Funded by Participating Member States according to their national priorities
- National Delegation support is needed.

TECHNOLOGY MATURITY

Starting TRL: 3+
→ Target TRL: 8



GSTP

GENERAL SUPPORT TECHNOLOGY PROGRAMME

Introduced at ESA Ministerial Council meetings

ELEMENT 1 DEVELOP

Develop:

Technologies & Applications for the Future

ELEMENT 2 MAKE

Make:

Commercial Development

ELEMENT 3 FLY

Fly:

In-Orbit Demonstration

EEE

EEE Sovereignty:

European Supply-chain for Critical EEE

+ PASSIVES

Resilience & Security

Resilience & Security:

Resilient Supply for Key Technologies

Expanding GSTP EEE Sovereignty for PASSIVE & RF PASSIVE Components

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.**







During "EEE sovereignity workshop" (ESTEC, March 2026) users, agencies and manufacturers came together to discuss critical Passive and RF Passive components.

ESA proposed potential activities that were discussed, prioritised and consolidated.

ESA proposed potential activities that were discussed, prioritised and consolidated.

The European passive components supply chain is resilient and strategically well-established.

However, several technologies have been identified for development, targeting niche markets and specific performance requirements:

Need is confirmed for:

1.- High Current, Low Voltage Planar Transformers 

2.- High Data Rate board to board interconnection VITA 

3.- Thermal Sensors for Cryogenic Applications 

4.- RF embedded SMD filters 

Already funded:

5.- Flexible Heaters for High Temperature (ASI, ZOPPAS RICA, IT) 

6.- RF phase-stable cable assemblies (TDE, THERMOCOAX, FR) 

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esa EUROPEAN SPACE AGENCY

Scan me!

TDE

GSTP

Space Journey

Space Journey: From Idea to Beyond the Sky

TRL 2-3 ~1 year

TRL 4-5 ~2-3 years

TRL 6-7 ~2-3 years

TRL9 ~2 years

IDEA SELECTION

CTB WORKING GROUPS

Passive WG

RF Passive WG

ESA MISSION NEEDS

Recurrent Quality Issues

Design Challenges

Sovereignty/Critical

New Applications

Technology Gaps

ITT & DEVELOPMENT

ITT & CONTRACT

ESA funding Programmes: TDE, ARTES, etc.

esa-star Publication

Tendering Period: 8 Weeks

Negotiation & Contract

DEVELOPMENT

Design & Prototyping

Manufacturing & Optimisation

Preliminary Characterisation

INDUSTRIALISATION & QUALIFICATION

INDUSTRIALISATION

GSTP Funding or Self Funding

Process Maturity

Supply Chain Validation

Flight Hardware Preparation

QUALIFICATION & EVALUATION

Evaluation & Reliability Testing

Qualification Testing

Assembly Verification

PROCUREMENT & INTEGRATION

PROCUREMENT

Flight Production

Space Craft Integration

System Testing

FLIGHT PROVEN



Space Journey: From Idea to Beyond the Sky

Success Story: an example of building up the space passive component supply chain in Europe:



Versatys® MMC
Micro Modular Connector

ESA-funded TDE activity

POWER • COAXIAL • MINIATURISED



Versatility
Fast-locking
Removable
Double Insulation



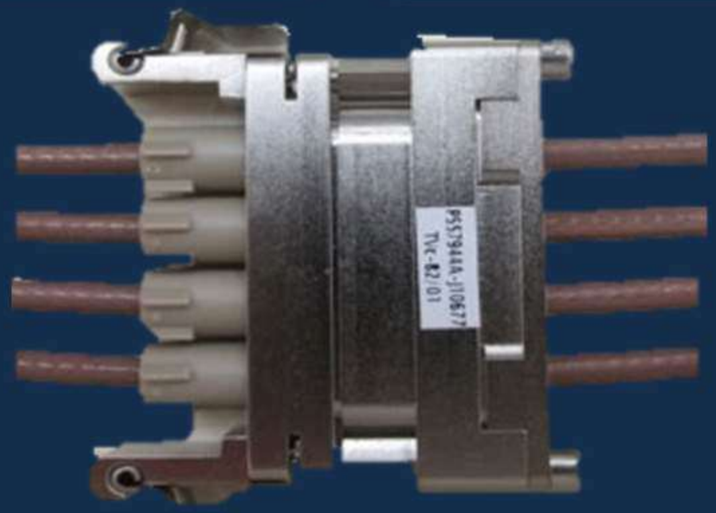
What was achieved?

A qualified, flight-proven European solution

250k€
TDE budget

ESCC
Qualified

10+
Years in orbit



In orbit:

ONEWEB
ONESAT
ARROW 450
and more ...

A Miniaturised and Versatile Connector for Power and Coaxial Applications: Enabling Fast, Reliable Integration in High-Density Spacecraft Architectures

ESA-STAR

ESA's Platform for procurement and proposal submission.

- Published ITTs on esastar-publication-ext.sso.esa.int



OSIP

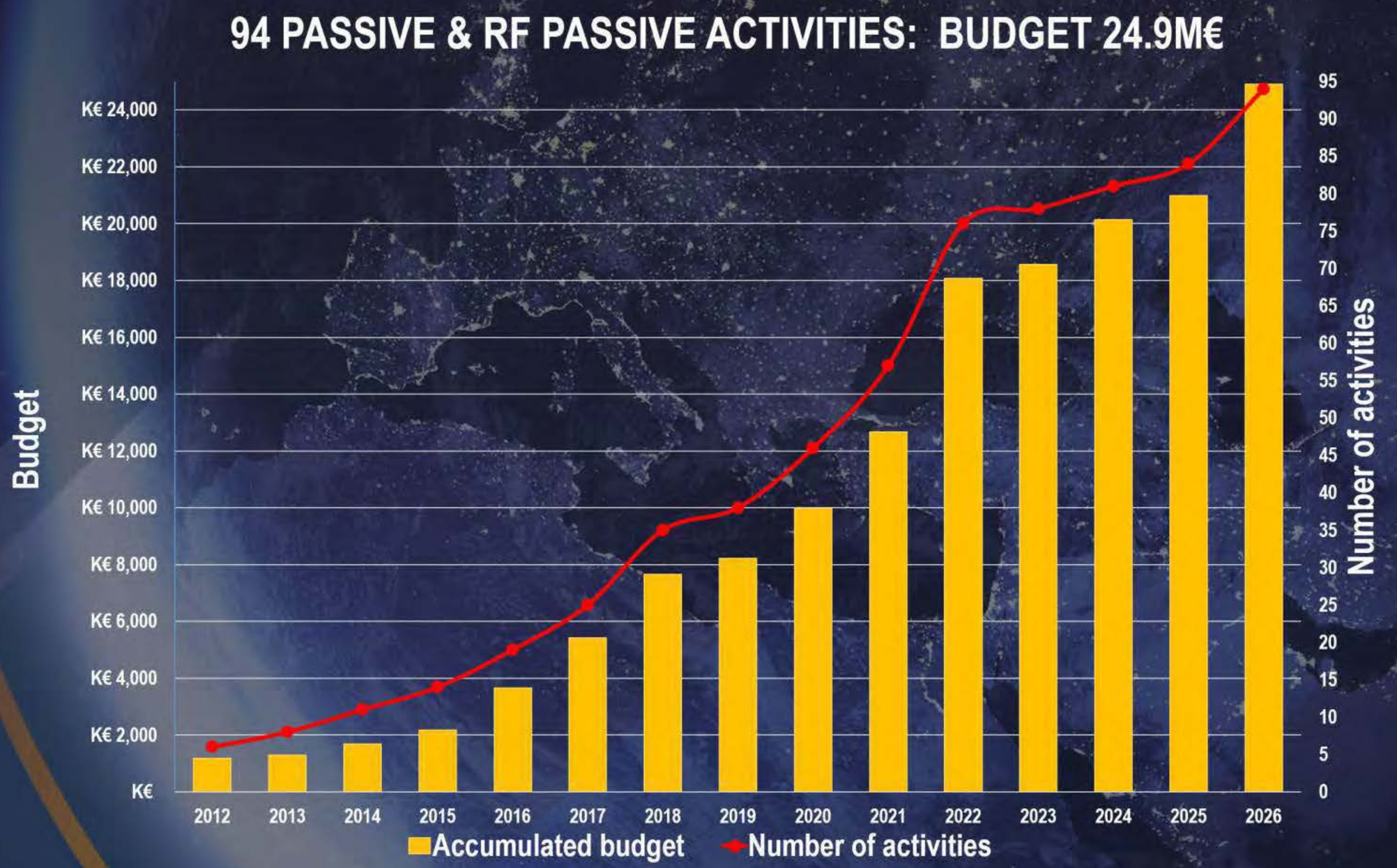
ESA's Open Space Innovation Platform for ideas submission.

- Submit your ideas on ideas.esa.int

~25M€ since 2012

~6 new activities per year

~265k€ per Activity



ESA R&D Passive & RF Passive Activities



Total Budget:
4.4M€

TDE Workplan 2026-2028:
8 activities

300K-500K€
per activity



Electromechanical MicroSwitch Qualification - Astronika

ESCC qualifications for flexible heaters - RICA



Board to board interconnections for HDR applications - Axon



Hexaferrite development for Ka-Band SMT isolator - TKI Ferrit



High Temp Metalized PET Film Capacitors - EXXELIA



High Temp Metalized PET Film Capacitors - Cidetec



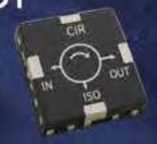


Space Flexible heaters (SAFER) - Azimut Sapce



Very high phase-stable Rigid RF Cable Assembly - Thermocoax

Miniaturised self-biased Circulators for GaN Applications - EXENS Solutions



Passive Components: News,Trends and Activities

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ESA - European Space Agency

Thank You For Your Attention!