

Lessons Learned on Electromechanical Relays for Earth Observation Applications

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Introduction to Copernicus



What is Copernicus?

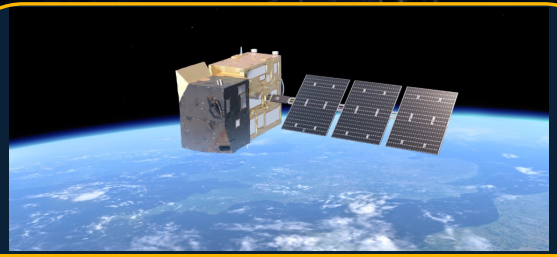
- Copernicus is Europe's Earth-observation programme
- Its Sentinel missions provide continuous data for six services:



Copernicus Evolution



Copernicus Expansion Missions



CO2M Copernicus Anthropogenic Carbon Dioxide Monitoring

Greenhouse gases and anthropogenic emissions



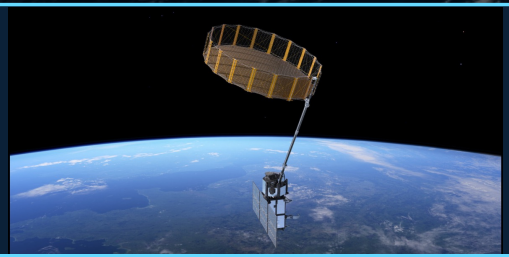
CHIME Copernicus Hyperspectral Imaging Mission for the Environment

Hyperspectral imaging for land, crops and minerals



ROSE-L Radar Observing System for Europe at L-band

L-band SAR for vegetation, soil and ground motion



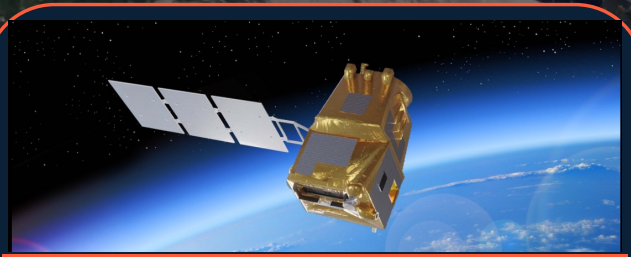
CIMR Copernicus Imaging Microwave Radiometer

Ocean and polar microwave radiometry



CRISTAL Copernicus Polar Ice and Snow Topography Altimeter

Ice thickness, snow depth and polar altimetry



LSTM Land Surface Temperature Monitoring

Land surface temperature and evapotranspiration

Why Expansion Missions?

The six missions expand the Copernicus Space Component to address user needs and observations not fully covered by the current Sentinels.

01 New variables

- Greenhouse gases
- Land surface temperature
- Hyperspectral imaging
- Microwave radiometry
- Polar altimetry
- L-band radar.

02 Observation Gaps

- More detailed observations of ice polar ocean
- Agriculture
- Natural resources
- Geohazards
- Emissions

03 Sentinel Complement

Improved continuity and synergies with Sentinel-1/2/3/5P/6 and Copernicus services.

Need for a higher mechanical environment



Why a higher mechanical environment had to be addressed?

Some Copernicus unit applications required mechanical robustness beyond what was already demonstrated for the selected relay families.

Where the higher environment comes from

- Evolution of European launchers changed the mechanical environment
- Higher unit-level qualification requirements
- Dependent on the mounting location inside the spacecraft.

Why this becomes a relay issue

- Relay relies on the position and contact force of moving mechanical parts to ensure their electrical state.
- The relay inside the unit must remain electrically and mechanically stable after exposure to the mechanical loads

Lack of qualification up to those levels

- Existing family qualification and heritage were not sufficient on its own.
- The selected relay lots need additional demonstration under the mission-relevant environment.

Need to prove functionality under all expected mechanical loads.



Relay Sensitivity to Mechanical Stress

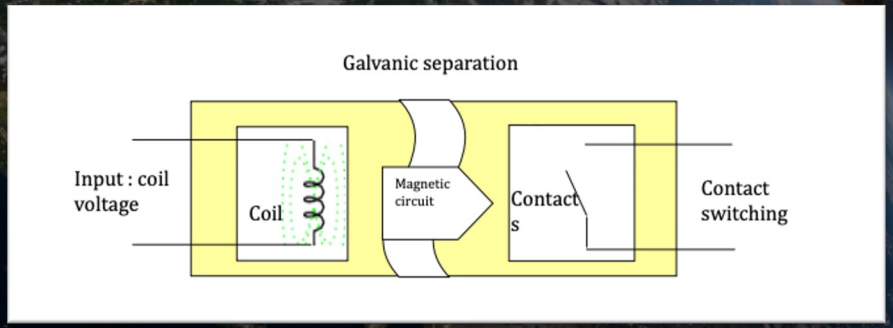
Why are relays critical on Spacecrafts?

1. **Switch essential loads**
   Instruments, heaters, mechanisms, avionics and power buses.

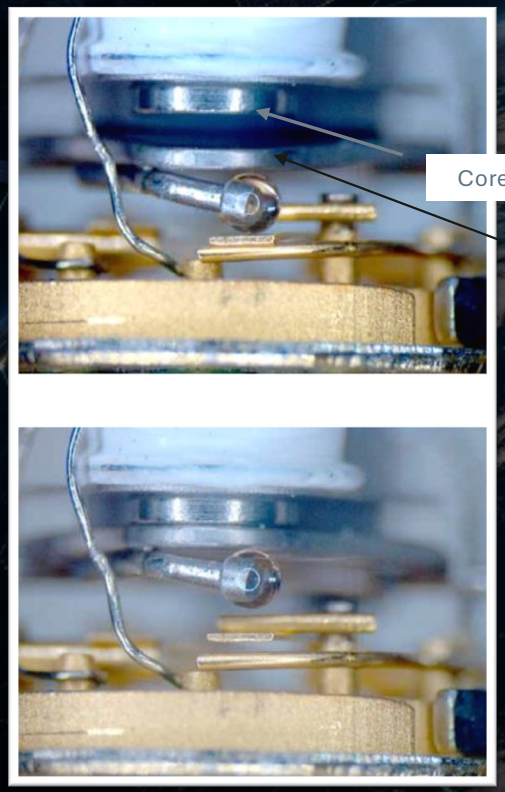
2. **Provide galvanic isolation**
   Separate control electronics from high-current or different-voltage domains.

3. **Enable recovery paths**
   Redundancy, fault isolation and electrical reconfiguration.



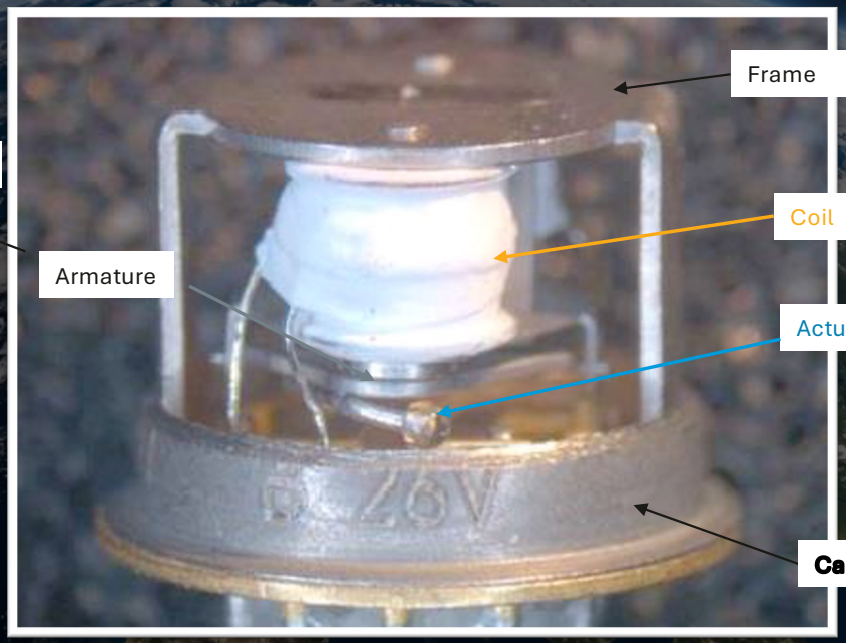


Why relays are sensitive to mechanical stress?



Core

Armature

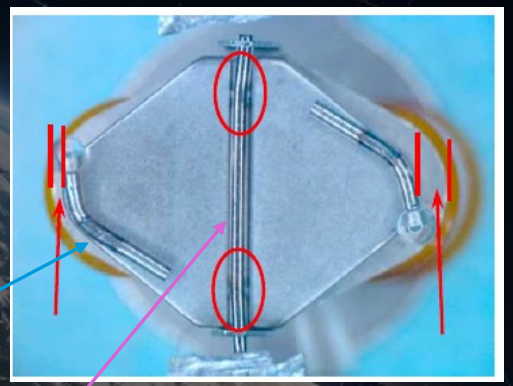


Frame

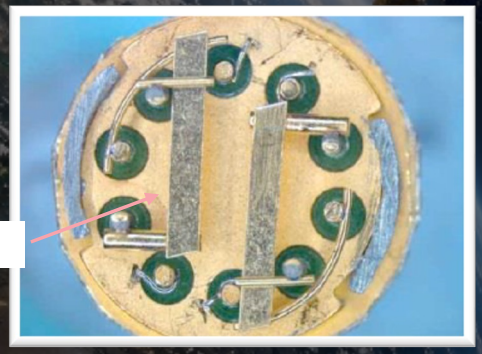
Coil

Actuator

Cap



Hinge Pin



Contacts

Why relays are sensitive to mechanical stress?

Manufacturing process is critical

Relays are process-sensitive assemblies. Several operations are highly dependent on workmanship, precision adjustment and stable manufacturing control.

1 Precision coil winding

- Ultrafine wire (µm) is easily damaged or broken.
- Incorrect turns or winding tension can change coil resistance and magnetic force
- Insulation damage can cause short circuits between turns

2 Manual contact alignment

- Poor contacts alignment can increase contact resistance and lead to unstable switching, contact bounce, or intermittent operation.
- Micron-level gaps and parallelism errors can change the contact force

3 Armature and spring assembly

- The armature, spring, and frame must be positioned and assembled with tightly controlled geometry

4 Welding / hermetic sealing of metal can

- Metal can is welded
- Heat input and alignment must be tightly controlled

Micron-level tolerances | **Delicate, small parts** | **Interdependent steps** | **Aerospace environment**

Key message



1

Manufacturing tolerances define the margin

Clearances, preload, contact gap and armature travel are established during build.

2

Mechanical loads consume or shift that margin

Shock and vibration add inertial forces, relative motion and possible permanent geometry shift.

3

Functional failure can occur without gross structural damage

Contact bounce, no-switch conditions or unstable contact resistance can occur before visible damage.



Qualification gap and testing

Mechanical Requirements

RANDOM VIBRATION — gRMS

Relay	Original qualified level	Copernicus requirement	Testing levels and number of samples
TL12	23.9 gRMS	37.8 gRMS - (Out of plane) 32 gRMS	On 6 parts – 1 date code tested Successfully passed
TL26	23.9 gRMS	46 gRMS – out of plane 37.3 gRMS ---------- 45.06gRMS out of plana	On 6 parts – 1 date code tested ---------- On 3 parts – 1 date code tested Successfully passed
GP250	23.9 gRMS	54 gRMS – out of plane 37.3 gMRS	6 parts – 1 date code tested Successfully passed

Qualification Gap & Testing

Mechanical Shock — g

Relay	Original qualified level	Highest Copernicus requirement	Testing levels and number of samples
TL26	750 g	2000g – 10.000Hz	6 parts – 1 date code tested Successfully passed
GP250	750 g	2000g – 10.000Hz	6 parts – 1 date code tested Successfully passed

Conclusions

1. **Space applications evolve**

   Higher launcher and mission mechanical performance is increasingly demanded.

2. **Relays sit in critical switching paths**

   They can control power distribution, cross-strapping and control lines.

3. **Precision mechanical assembly during manufacturing**

   Manufacturing defines geometry, spring force, alignment and contact behaviour.

4. **Dedicated lot-level testing to demonstrate acceptability**

   Due to lot-to-lot variability, and until a more statistically representative number of samples has been tested, dedicated testing remains the appropriate way to demonstrate acceptability.

Why this is a real risk

A process-sensitive electromechanical part can behave differently from lot to lot. Therefore, “generic family heritage” is not always enough for a demanding application.

Recommendations

Obtain evidence on the actual relay lots intended for use and expose them to the relevant mechanical conditions.

Way forward

As higher mechanical environments are required, and available test results indicate additional performance margin, an extension of the ESCC qualification envelope shall be pursued.

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THANK YOU!

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