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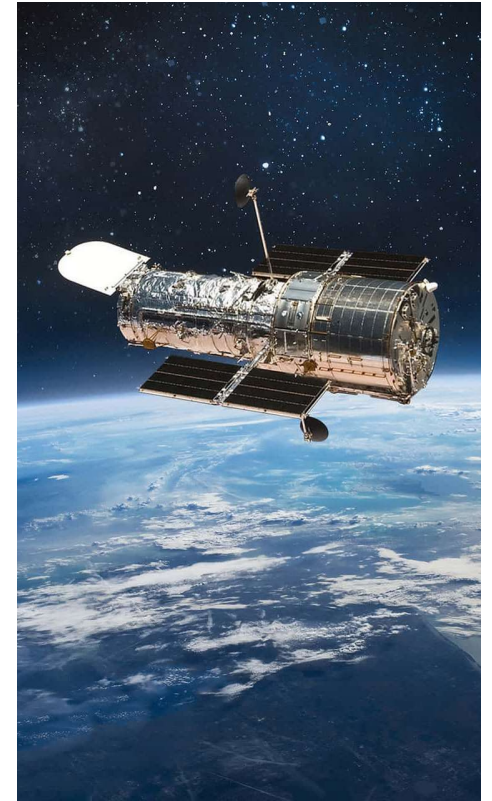
ADVANCED THERMAL AND VIBRATION TESTING FOR OPTICAL PACKAGING SYSTEMS



GROUND, SPACE: WHAT IS THE DIFFERENCE?

- Launch
- Vacuum
- Radiation
- Thermal extremes
- No repair (or ?)

➤ ***An optical system can fail in orbit within hours not because it performs poorly, but because it was never designed to survive space***



DESIGN FOR SPACE



Harsh environment: vacuum, thermal extremes/cycling, radiation, launch vibrations, no repair



ECSS / ESA approach:

Design (D), Qualification (Q), Acceptance (A)
Full traceability: requirements → verification → compliance



Thermal design:

Operational range (performance guaranteed)
Non-operational range (survival)



Margins & derating:

Thermal margins $\approx \pm 5-10^{\circ}\text{C}$ (D/A/Q levels)
Mechanical margins $> 1.25-2$
Operate below limits to ensure reliability



Reliability principles:

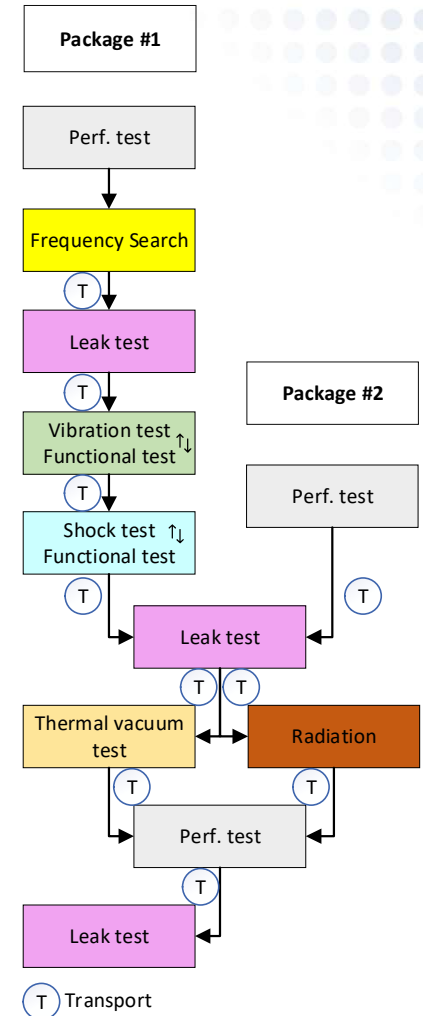
Space-qualified, low-outgassing materials
Robust design, controlled interfaces
Minimise failure modes



Verification:

TVAC, vibration/shock, radiation testing ...
Demonstrate compliance under worst-case conditions

Design for space = ECSS-driven design + margins + rigorous testing



VIBRATION AND SHOCK TESTING

- Launch generates vibrations (thrust, aerodynamic loads, acoustic pressure...)
- Pyrotechnic events (stage separation, fairing release, deployment...) generate shocks
- This is an input to the system design and shall be considered right from the start!

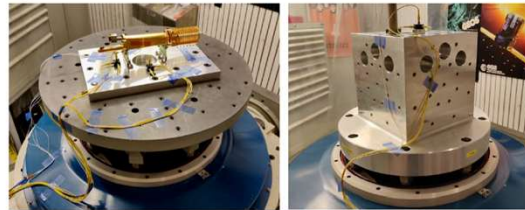
➤ Hardware must be tested, and sometimes it is bad

➤ ***The rocket will shake it, shock it, and test it ... once!***



Ling 2016 shaker, 89 kN, vertical orientation

TGT 7100 30H slip table for horizontal orientation

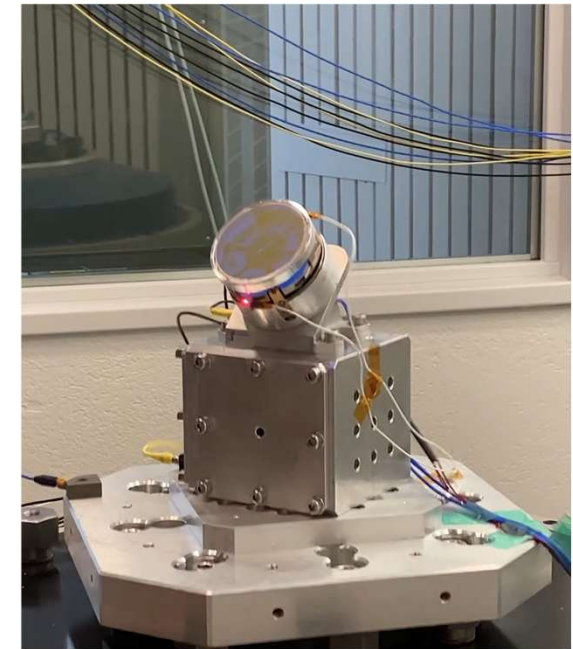


Ling head expander

3-axis cube for small footprint items

Specification summary

Vertical configuration			System limits	Horizontal configuration		
Sine	Random	Shock		Sine	Random	Shock
89	71	178	Force vector (kN)	89	71	178
135	45 _(RMS)	180	Acceleration (g)	55	20 _(RMS)	110
	1.78		Velocity (m/s)	1.78		
38	51		Displacement, p-p (mm)	38	51	
57			Armature weight (kg)	149		



THERMAL ENVIRONMENT

Solar flux:

- Direct radiation
- Strong heating

Deep space cold:

- Radiative cooling
- No convection

Earth IR / albedo:

- Secondary heating

Typical thermal environment is defined as:

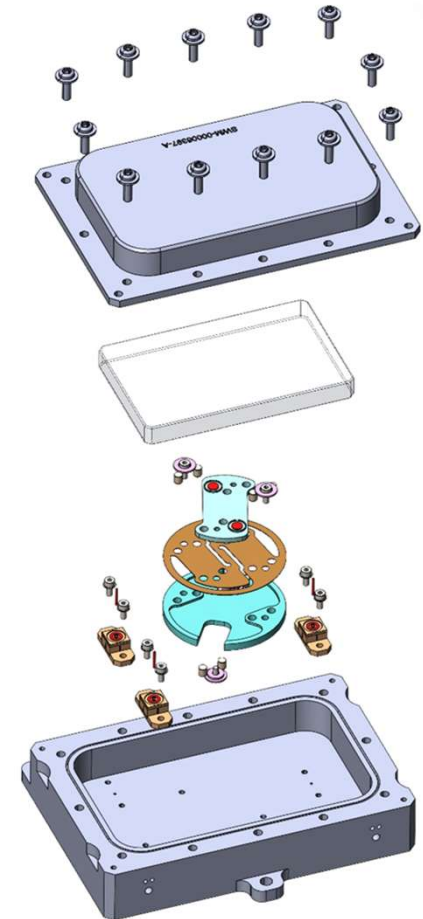
- Non-operational temperature range on board a satellite -55°C to $+85^{\circ}\text{C}$
- Operational temperature range 30°C to $+50^{\circ}\text{C}$, but can be stabilized for sensitive hardware

➤ ***In space, temperature is not controlled, it is engineered***



SPARCOM: RUGGEDIZATION OF A GHZ FREQUENCY COMB BY MENHIR PHOTONICS

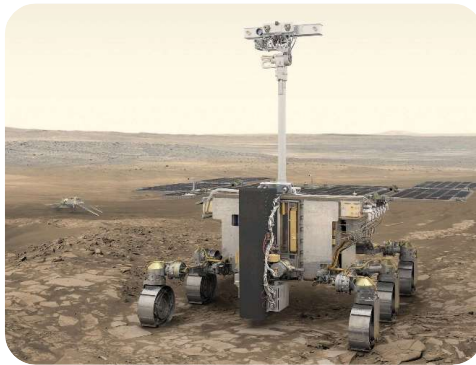
- Designed for LEO constraints following ESA ECSS
 - Space constraints addressed by design:
 - hermetic sealed package and feedthroughs,
 - controlled internal atmosphere,
 - Thermomechanical decoupling
 - Margins backed by analysis
 - Full test campaign: outcome end of 2026
- **TRL 6 space-mature optical module, scalable platform toward 10 GHz and future in-orbit demonstration**



CSEM: SPACE HERITAGE

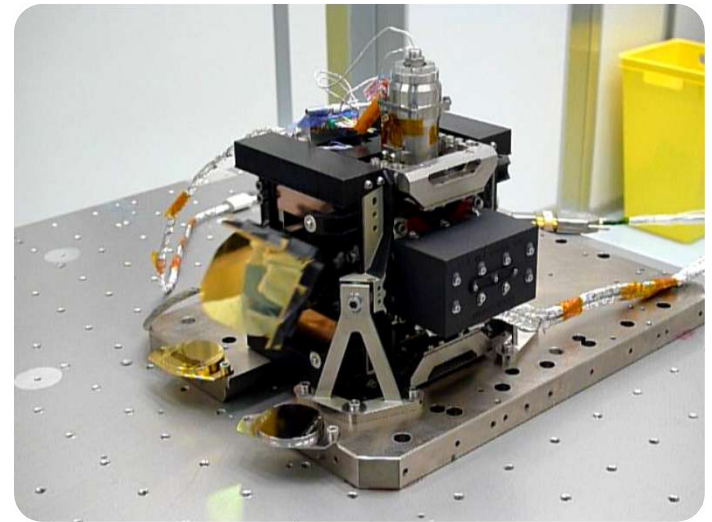
CLUPI Focus Mechanism

Image of core samples from the Martian soil in search of traces of life



MTG Corner Cube Mechanism

Linear scan mechanism which is a critical assembly of the MTG Infrared Sounder Instrument.





FACING THE CHALLENGES OF OUR TIME