CASE STUDY:

DESIGN CONSIDERATIONS TO IMPROVE SMALL SATELLITE LAUNCH SUCCESS.

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2026 is set to be a “defining year” for the space sector, with global launch rates increasing, and spacecraft capabilities expanding. Indeed, a staggering number of scientific and commercial launches are due to take place this year, with California alone expected to send up more than six flights each and every month.

US companies such as SpaceX and Boeing (plus, of course, NASA) dominate this. But India and China are investing heavily, with Asia-Pacific being the fastest-growing region for space tech currently. And in Europe, there are a raft of start-up commercial launchers, with Isar Aerospace (Germany), Rocket Factory Augsburg (Germany), PLD Space (Spain), Skyrora (UK) and Orbex (UK) all predicting their first launch this year.

Indeed, the global space tech market broke through the half-trillion dollar mark last year, and is set to reach 1 trillion between 2032 and 2034. This is helping to drive down the cost of flights by a factor of 20, with SpaceX’s Falcon 9 advertising LEO launches as low as just $2,720 per kilo. As such, more and more companies are seeking to develop cube sats and other space tech.

In this article, we’ll examine the challenges of designing electronic equipment for this environment and examine how these are being addressed in the design of Protostar’s vision systems and data processing unit, which is due to complete testing in 2026 for a potential 2027 launch depending on the selected launch partner.

CORE DESIGN CHALLENGES FOR SPACE TECH

Designing high-reliability interconnects for 1U-form-factor satellites requires balancing extreme mass constraints against the high statistical risk of mission failure.

According to NASA, 42.6% of small satellites launched between 2009 and 2016 experienced partial or total failure, with a large proportion of failures linked to electrical power systems and communication subsystems. However, a more worrying correlation for those designing equipment for launch in 2026 might be NASA's observation that as launch rates increased, so too did the proportion of those launches that failed.

Space creates unique design challenges and the following outlines four of the key one's engineers need to overcome:

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1) RADIATION

LEO and MEO orbits can expose equipment to c.10 or even 20 krad of radiation per year, with this causing both cumulative degradation and instantaneous faults.

For example, in a silicon chip, the bombardment of high-energy protons and heavy ions can lead to a charge build up over time in its oxide layers. Additionally, single event effects can also occur, creating non-destructive bit-flips in memory and registers as well as single event latch-ups, which can permanently destroy a device. Mitigation requires a combination of radiation-hardened-by-design architectures and system-level strategies modular redundancy to ensure data integrity during transit and processing.

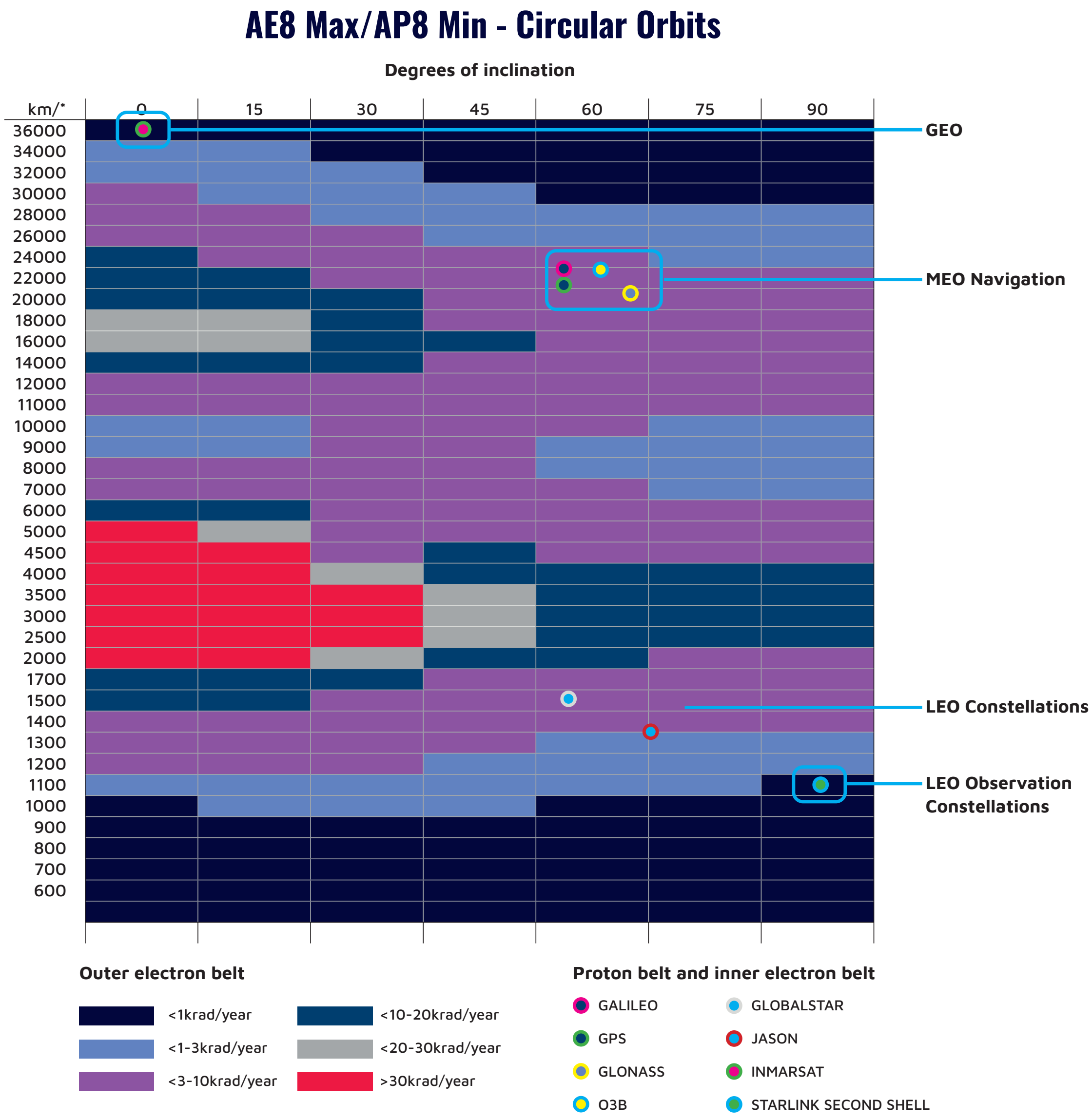


Fig 1 – radiation encountered by LEO, MEO and GEO satellites, adapted from ESA data.

2) VACUUM CONDITIONS

The absence of atmospheric pressure will allow volatile compounds within epoxies and polymers to be released. This allows microscopic particles to travel through the satellite, which can then condense on cooler surfaces, such as a camera lens or optical sensor.

Being a vacuum, convective cooling is also prevented, meaning thermal dissipation can only be managed through conduction to the satellite chassis itself, or via thermal radiation.

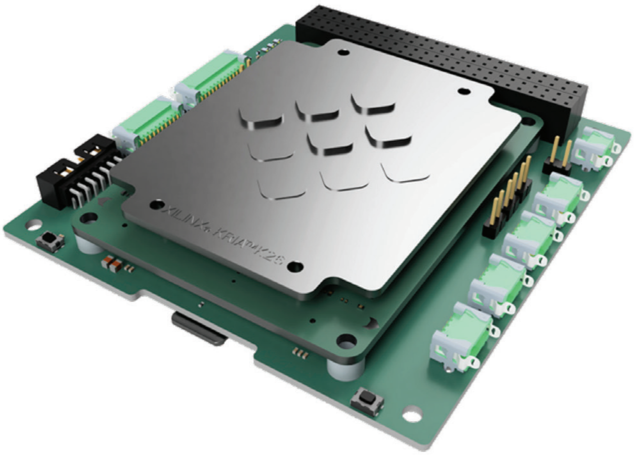
3) ECLIPSES

Satellites experience rapid temperature swing (from -65°C to +150°C) as they repeatedly switch between being in direct solar radiation to being in the Earth's shadow. This introduces significant mechanical stress, with (for example) the connector, the solder joints, and the PCB all expanding and contracting at different rates. The regular eclipses also imposes strict power limitations on equipment, with solar cells not only needing to power all on-board equipment between eclipses, but also fully recharge the secondary batteries, with efficiency at every stage of the design critical.

4) VIBRATION AND GRAVITATIONAL FORCES ON LAUNCH

Of course, the most physically punishing phase of any mission is the launch, with payloads subjected to both significant levels (up to 2 kHz) of vibration and sustained G-forces, which will typically be between 10 and 15 G.

These forces can cause microscopic movement, for example between connector pins and pads, which risks intermittent signal loss or permanent plating damage.



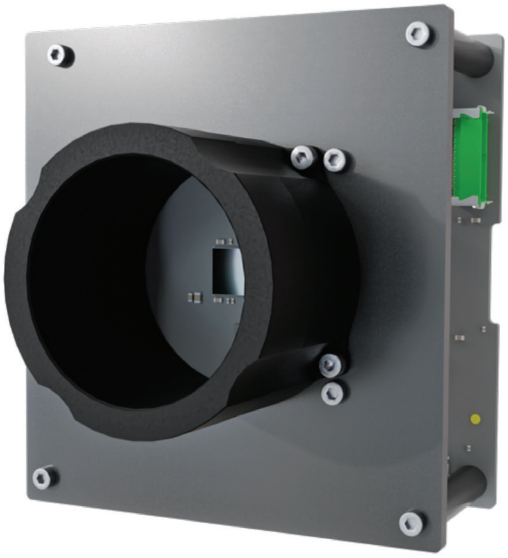


Fig 2 – The design of Protostar Labs' Helix-100 cubesat camera and DPU give a blueprint for creating equipment for LEO environments

A CASE STUDY IN DESIGN

A blueprint for overcoming these LEO challenges can be seen in the vision systems and data processing unit (DPU) developed by Croatian space-tech pioneer, Protostar Labs. Specifically, the company has developed an AI compute module based on AMD's Zynq UltraScale+ MPSoC and a flight-ready optical payload to be used onboard cubesats, for example to undertake environmental monitoring, maritime surveillance, or terrain mapping from LEO orbits.

In these we can see several features that typify good design in space tech: redundancy, material integrity, and mass efficiency.

For example, to counter the continual radiation exposure these systems will undergo, triple modular redundancy (TMR) has been implemented, with three parallel processing paths used for all critical data. Using a majority-vote algorithm, the system is able to constantly compare the outputs and check for errors caused by bit-flips before discarding them.

A CASE STUDY IN DESIGN (CONTINUED)

These features can also be seen if we look at Protostar's COTS component choices – especially its connectors. As stated, the use of COTS enables significant cost and time savings, but it's vital that high-reliability equipment is used.

Protostar has adopted Harwin's Gecko series and implemented redundancy at the pin level by assigning each power rail to multiple pins and backing this with dedicated power distribution logic. Taking this approach provided an increased inherent hardware resilience. In addition to this, the company is also developing re-routing software that enables the dynamic selection of I/O pins, allowing the system to adapt should a pin fail due to physical or radiation damage.

Beyond redundancy, these connectors implement features such as ultra-light, ultra-low outgassing thermoplastics (Polyamide 4T), which has a TML of 0.68% and a CVCM of 0.1%, plus a 1.25 mm pitch. This not only allows a [45%] space saving and [75%] weight reduction compared to traditional Micro-D components, and implements features such as 4-finger beryllium-copper contacts and jack screws that enables contact during vibrations of up to 20G for six hours or shocks of up to 100G.

That Protostar has been able to develop such technology in such a short time scale – it was founded in 2019 – only highlights how much the barriers to entry in space tech are falling, and not just in terms of launch costs.

2026 will see more launches than at any point in history and it's vital that the correlation between an increased rate of launches and the increased proportion of failures needs to end. This can be achieved through the use of well-trusted, proven standardized COTS components with and resilient software and hardware architectures, such as Protostar's triple modular redundancy, which together will maintain operational integrity in one of the most punishing environments known to engineering.

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