ElectroCap Pitch Deck

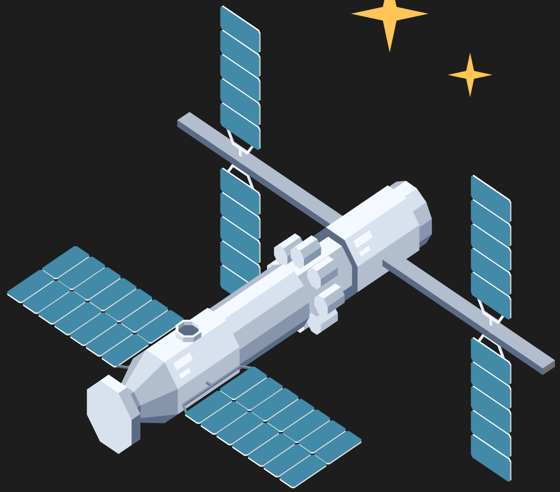
Low-cost Fine Sun Sensor

Francisco Jesus
Gonçalo Batalha
Guilherme Garcia
Miguel Silva
Mariana Cal
Rodrigo Caldeira

TÉCNICO LISBOA

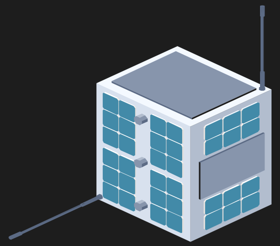
Problem

One of the key challenges in satellite development is attitude determination. To understand a satellite's orientation relative to a known reference frame, such as Earth-Centered Inertial (ECI), two non-collinear vectors are needed. For small-scale satellites, these vectors are typically the Earth's magnetic field and the Sun's position relative to the satellite. The latter, the Sun Vector, usually requires costly solutions, which can be prohibitive for some teams. Most market solutions today, despite being expensive, do not directly provide a Sun Vector, requiring additional computational power from the satellite's onboard computer. We believe a more affordable, less computationally demanding, and thus easier-to-implement solution is achievable.



Requirements

The purpose of developing a Sun Sensor from scratch has always also been to prove that it can be effectively and easily done with few resources while achieving the desired results. A solution cheaper than the generic and already commercially available had to be at the centre-point of the development. It had to be uncomplicated to set up since it was intended to be adopted by amateur satellite projects as well, so ease of installation is also key in the design. To compete with advanced solutions, cost is not the only key factor, but also sensitivity, power consumption and accuracy. Therefore, a solution that uses a minimal amount of hardware, with well-thought implementation had to be carefully chosen so that it would not ruin the premise of the whole project.



Requirements

Accuracy:

The sun sensor should accurately detect the position of the sun at all times under real-time conditions with a deviation of $\pm 1^{\circ}$. It should be trusted in harsh environments, lightweight and compact system resistant to temperature and vibrations.

Efficiency:

The solution will have to be efficient, reliable and have a low power consumption due to the importance of determining the satellite's position in relation to the sun's position.

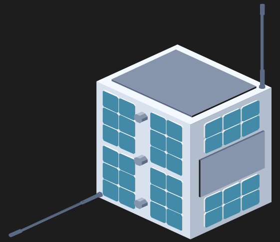
Testing and Validation Metrics

- Cost
- Ease of Installation
- Sensibility
- Field of View
- Power Consumption
- Accuracy
- Mass

Target Audience

- Individuals and groups who need to determine the Sun’s relative position, such as small organizations and hobbyists interested in building small satellites but who are limited by the high cost or lack of access to cutting-edge sun-sensing technologies.

- Individuals interested in building small dynamic solar panel arrays to maximize panel efficiency. In some cases, due to limited space, rather than installing more solar panels, we can increase the efficiency of existing ones through solar tracking.



Competitors and Previous Work

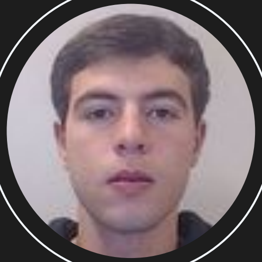
Competitors

- ★ NSS CubeSat Sun Sensor - €3300
- ★ Needronix Eagle - €1900
- ★ Maus - €3663

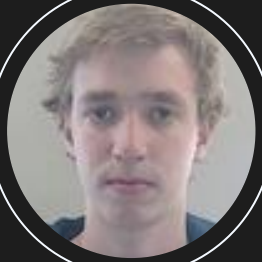
Previous Work

The market for CubeSat Sun Sensors is dominated by high-cost, high-precision products like the NSS CubeSat Sun Sensor (~0.5°) and Needronix Eagle (~0.15°). These prices limit accessibility for budget-constrained projects.

Our team

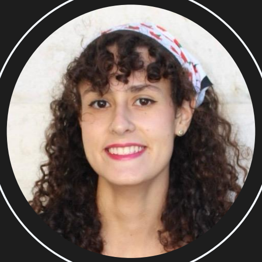


Francisco Jesus



Gonçalo Batalha

Guilherme Garcia



Mariana Cal

Miguel Silva

Rodrigo Caldeira

Advisors and Mentors

Scientific Advisor:	Professor João Paulo Monteiro
Eletrocap Coordinator:	Professor Duarte Mesquita
Mentor	Professor Fernando Gonçalves Miriam Demasi

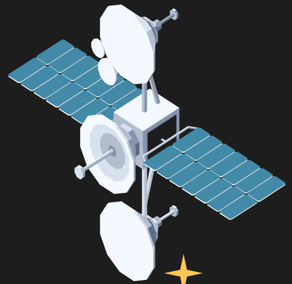
Partners

Nanosat Lab

This project is being developed in collaboration with the Nanosat Lab. We reached out to them to inquire if there was any technology we could develop for our project that would also be useful for them. They mentioned the sun sensor, so we will develop it with their assistance, and they will incorporate it into their future work.

Mentor:

We're also going to have the assistance of an IST professor, Fernando Gonçalves.

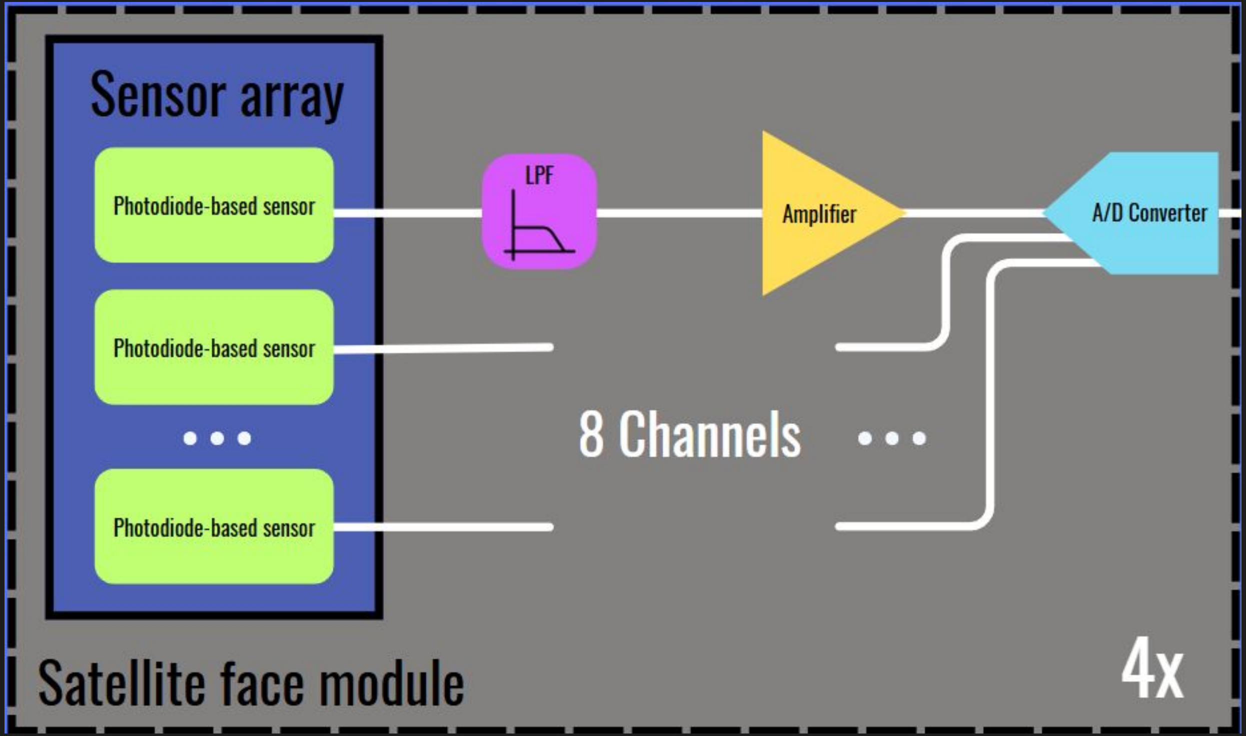


Technological Solution - BOM

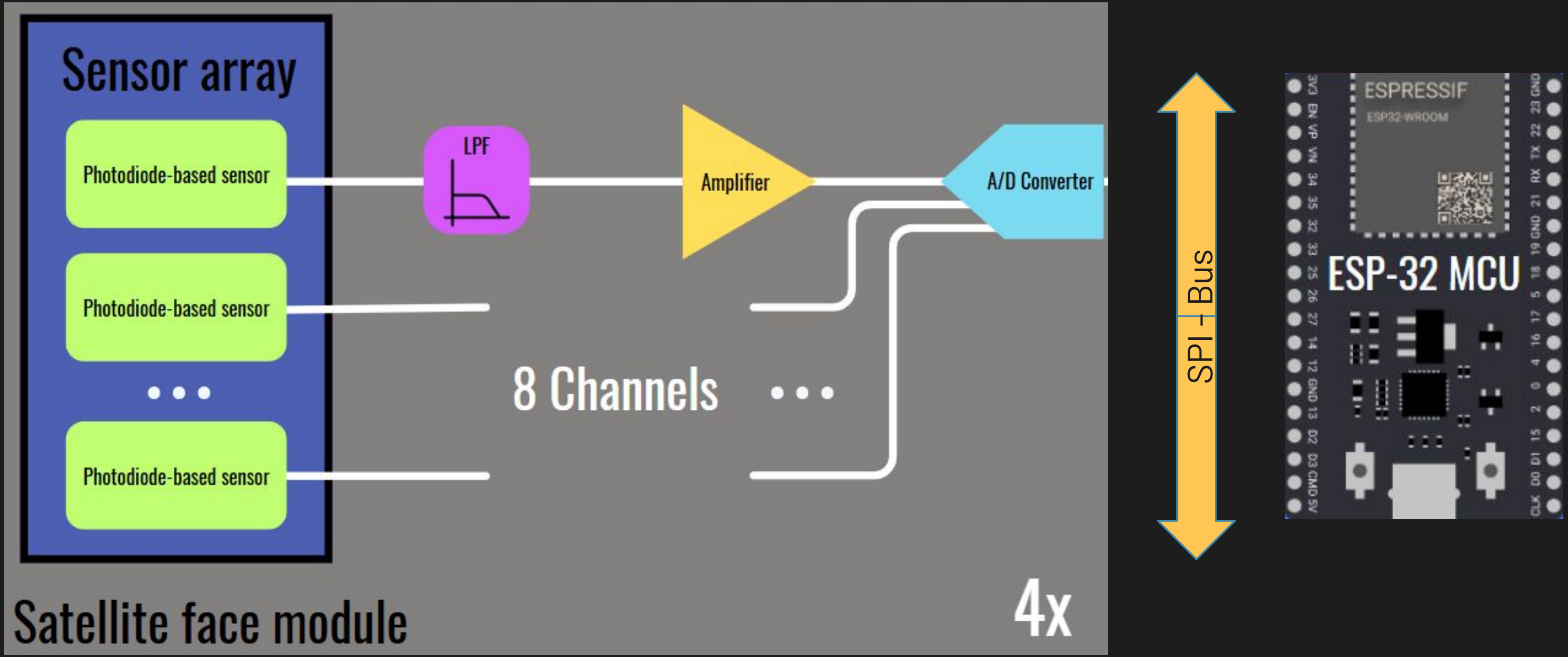
Components Used in the Prototype:

- ★ ADC -> MCP3208-CI/P
- ★ Op-Amp -> MCP604-I/P
- ★ ESP32
- ★ Photodiode BP104
- ★ Condensador Cerâmico 1nF
- ★ R 33K

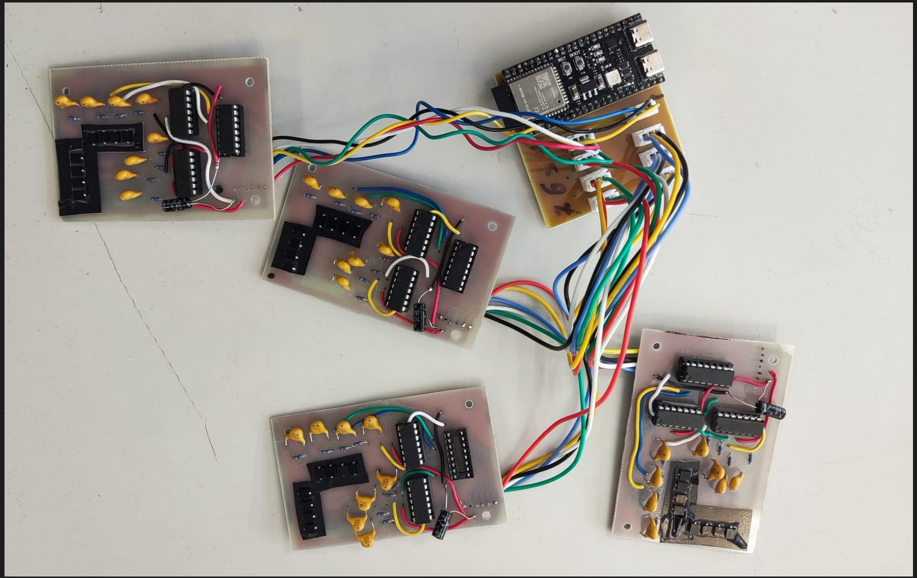
Technological Solution - Signal Conditioning



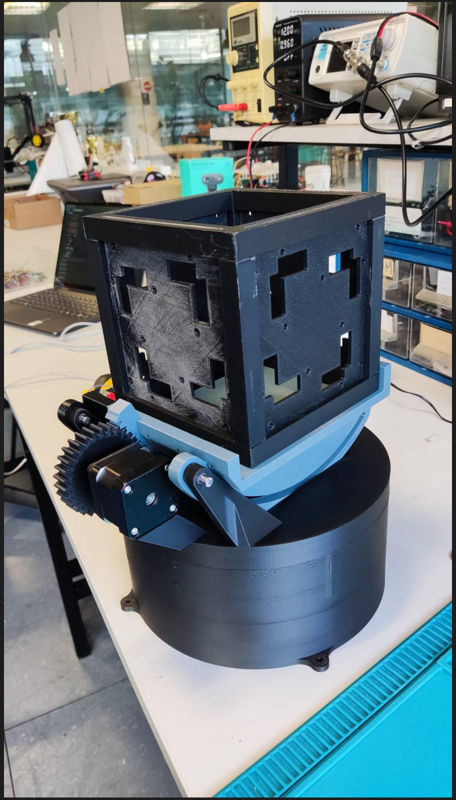
Technological Solution - Final scheme

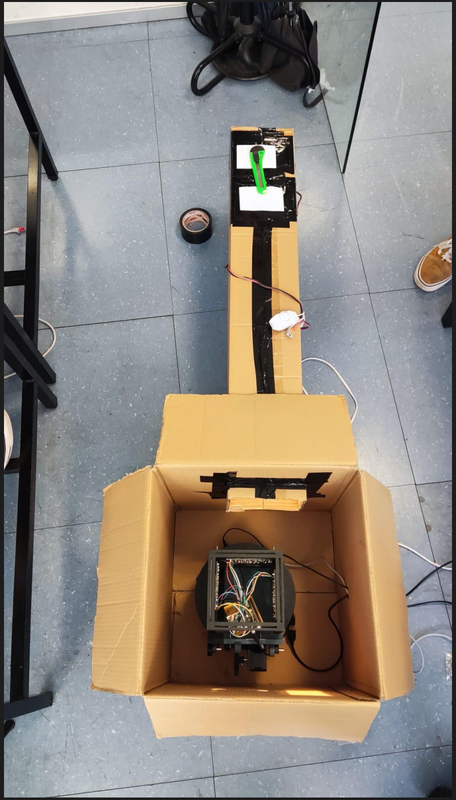


Technological Solution - PCBs

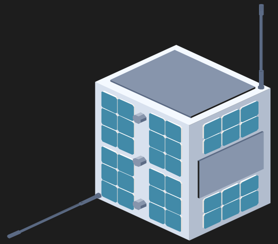


Technological Solution - Testbench





Results



Tests	Requirements	Results
Orientation Test	Test if the sensor can produce a valid orientation	The test was successful with an accuracy of about 5º.
Power Test	Test the power requirements for the system	Successful test with power draw of about 0.2W.
FOV Test	Test the actual Field of View of the sensor	Successful test with 75º FOV and blind spots measured.

Contributions of each team member (1)

Miguel Liñan da Silva	Rodrigo Caldeira	Francisco Jesus
Software Engineer	**Team Leader/Hardware Engineer**	**Hardware Engineer**
ESP32 programming	System Design & Programming	Component selection
Documentation	Circuit Design & Simulation	PCB Design
CAD - 3D Modeling	PCB fabrication	CAD - 3D Modeling

Contributions of each team member (2)

Gonçalo Batalha	Guilherme Garcia	Mariana Cal
Soft Engineer	**Hardware Engineer**	**Graphic Designer**
System Design	Hardware assembly	Blog managing & design
Interviews	PCB design & fabrication	PCB fabrication
Prototype testing	Prototype testing	Interviews

Thank you!
We are willing to answer any questions!

Our project's website is

https://web.tecnico.ulisboa.pt/ist1102792