



LAB IN A CUBE

PocketQube based on ESP32
for Lab activities



Yaqi Xu 103762

Sara Pereira 109311

Cristina Wang 109386

Lumi Pereira 109813

Lexin Weng 110627

Tiago Duanmu 111173

Website: <https://pic-1.vercel.app/>



ADVISORS AND MENTOR

- Scientific Advisor :
Professor Ayman Radwan

- Scientific Co-advisor :
Professor Mariana Santana

- Coordinator :
Professor Carlos Fernandes

- Mentor :
Professor João Felício

PROBLEM

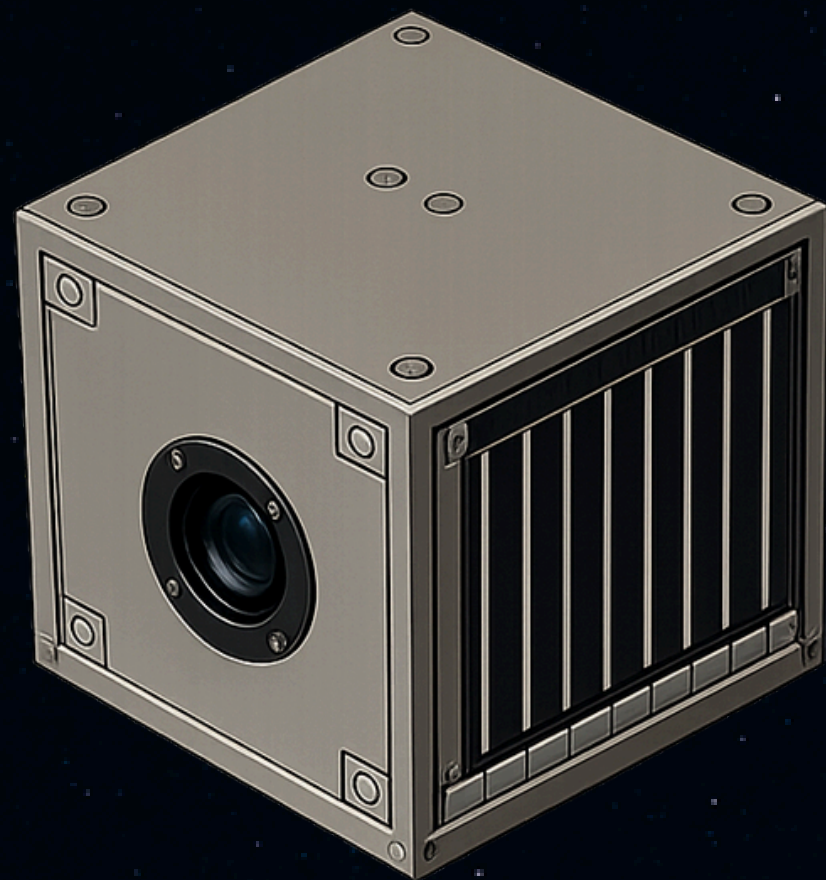
There is a **gap** between interest in space and practical educational tools that allow students to explore .



- **Lack** of practical exposure to real satellite systems
- **Don't understand** how the electronic components interact
- Have **limited** opportunities to experiment with system design

OUR SOLUTION

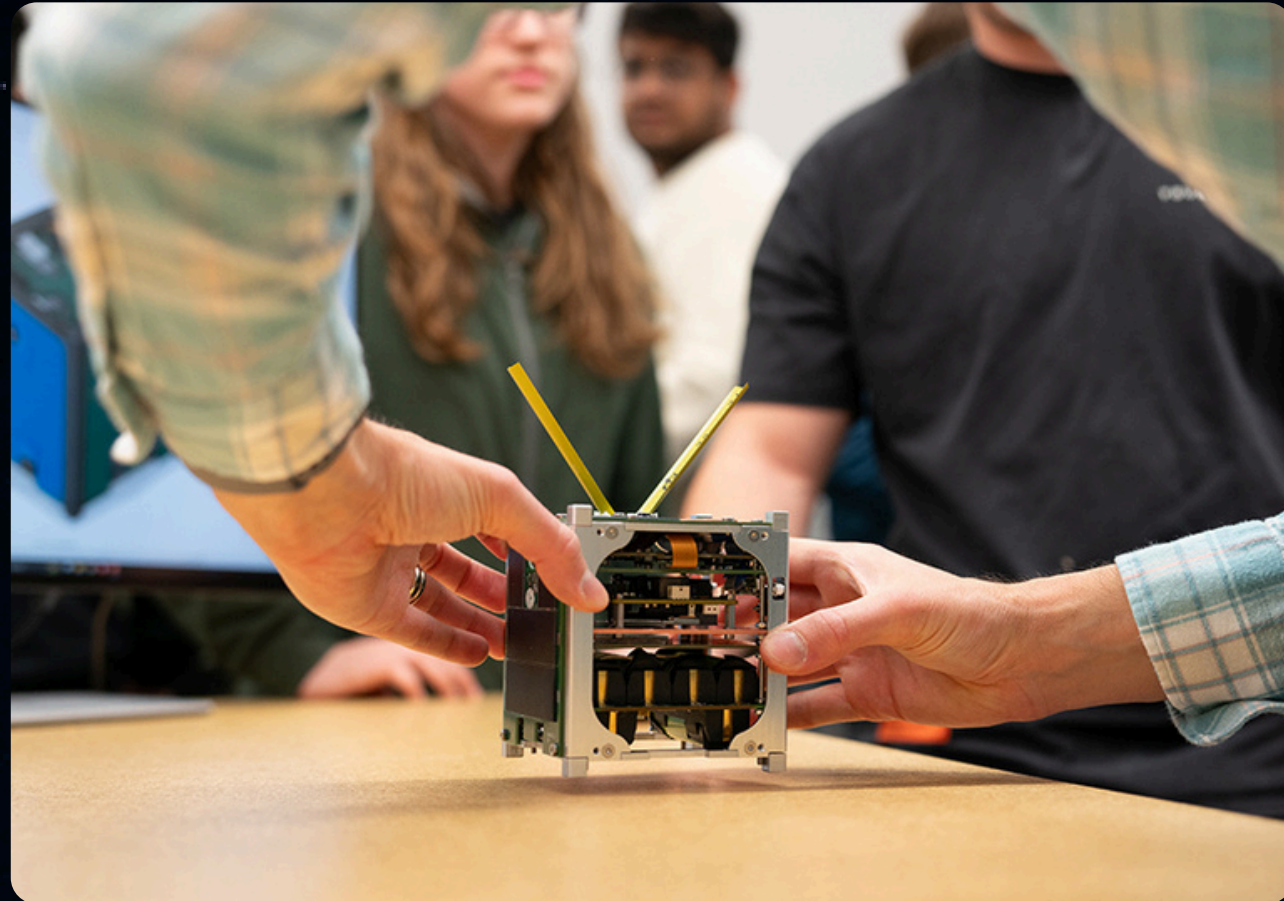
★ **"Do it yourself"** PocketQube for lab activities



★ This allows students to:

- Experiment with satellite electronics
- Understand system integration
- Observe the effects of design decisions
- Learn through practical experience

SOLUTION BENEFICIARIES



- Undergraduate & graduate students
- Children & teenagers



- Universities
- Secondary schools

COMPETITORS AND PREVIOUS WORK



CubeSat Kit for Microchip PIC24 MCUs
9 855,00 US\$ - 11 500,00 US\$

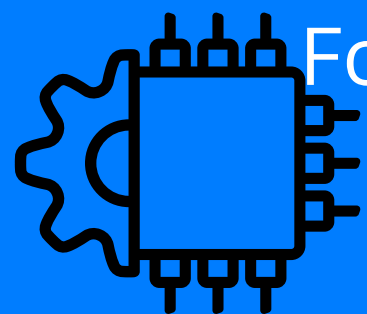
**Pumpkin Inc. -
CubeSat kit**



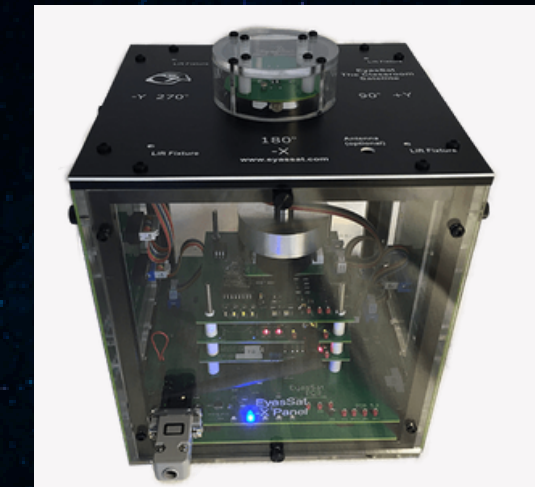
Not centered on
autonomous mission
execution



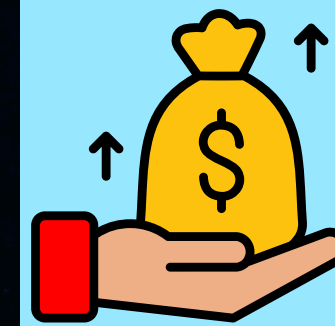
**Albaorbital -
PocketQube Kit v1.0 EM
£10,299.00**



Focused on hardware
integration and
communication



**EyasSat –
Educational Satellite
Kit (\$12350)**



Can be very
expensive

COST AND BENEFITS

Minimal Cost



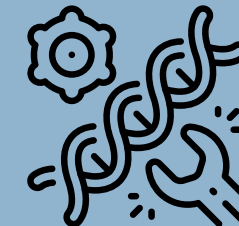
Designed to be as low-cost as possible for schools ≈85€.

Educational Balance



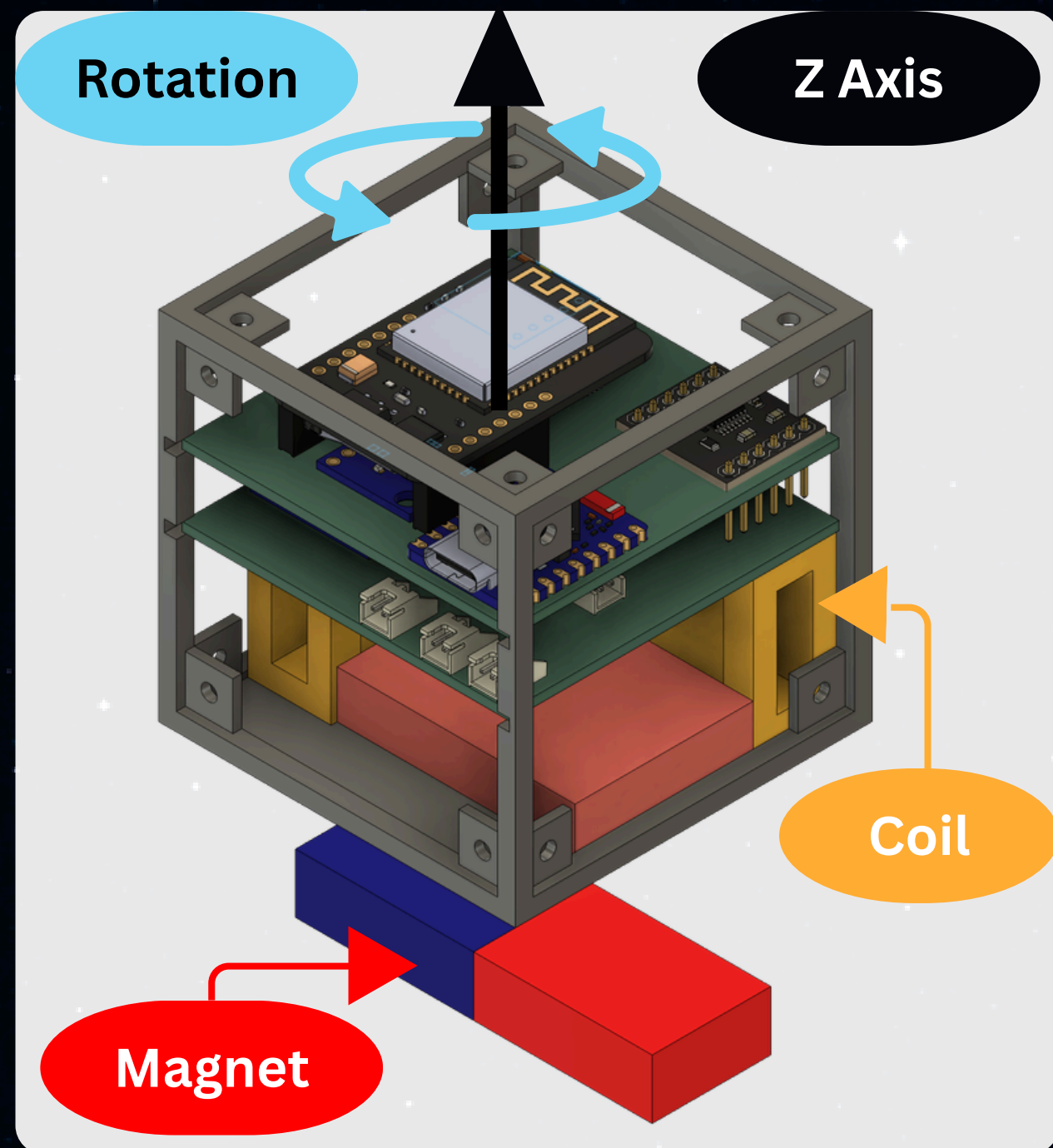
Beginner-friendly, yet challenging for students.

High Fidelity



Replicates the core functionalities of a real satellite

WHAT MAKES OUR PROJECT DIFFERENT



- The magnet simulates the earth's magnetic field;
- The electrical current that passes through the coils generates an electromagnetic field;
- The resulting magnetic attraction and repulsion generate the torque that rotates the satellite to the desired orientation on the Z axis.

TECHNOLOGICAL SOLUTION



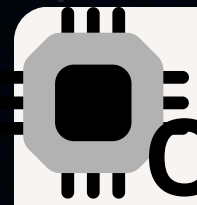
ESP-32 Microcontrollers

Low cost component.
It has low energy
consumption and
wireless communication



Power System

Solar panels and
rechargeable battery for
autonomous operation



Onboard Sensors

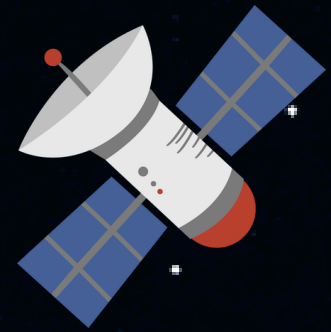
Gyroscope,
accelerometer,
magnetometer



Modular architecture

Easy to remove and
integrate subsystems

SYSTEM ARCHITECTURE



SPACE SEGMENT

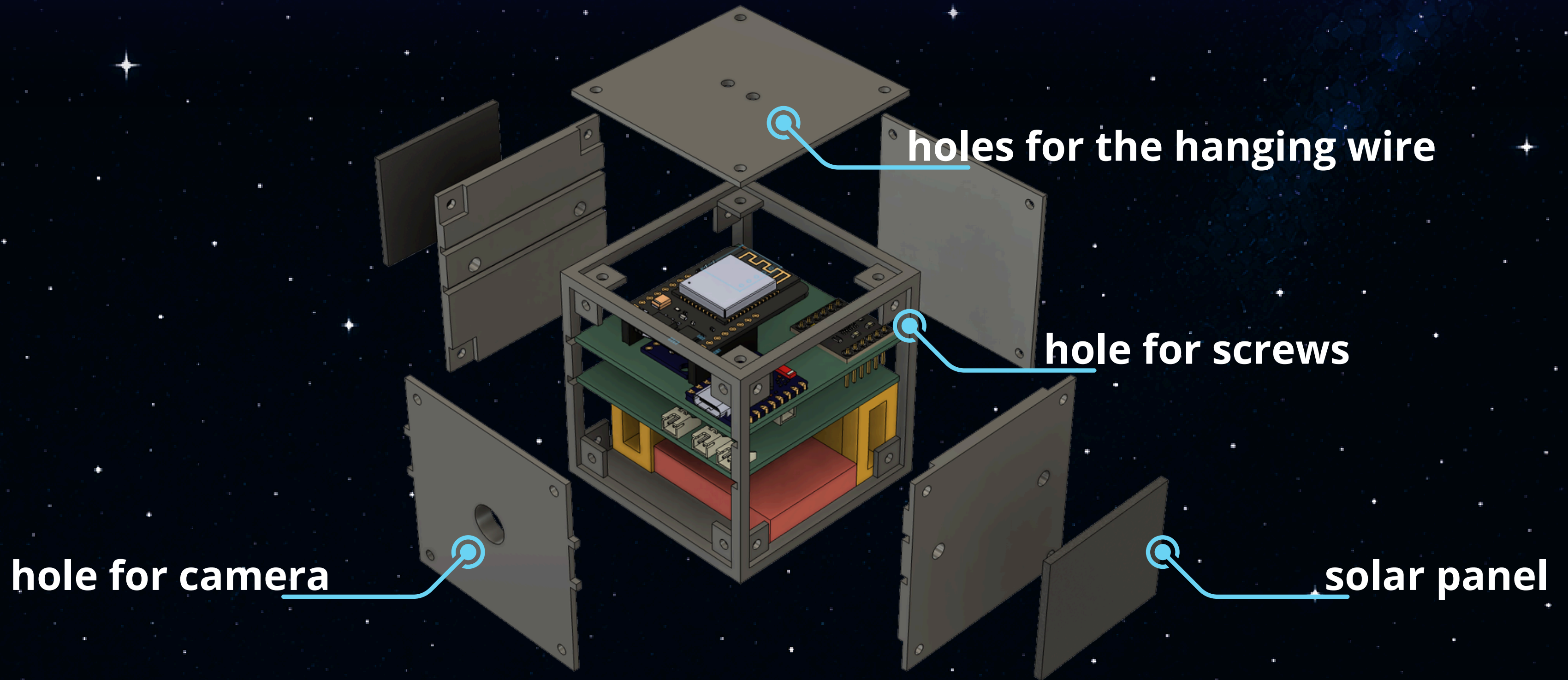
- Structures
- Power Systems
- Command and Data Handling (C&DH)
- Attitude Determination and Control (ADCS)
- Payload
- Communications



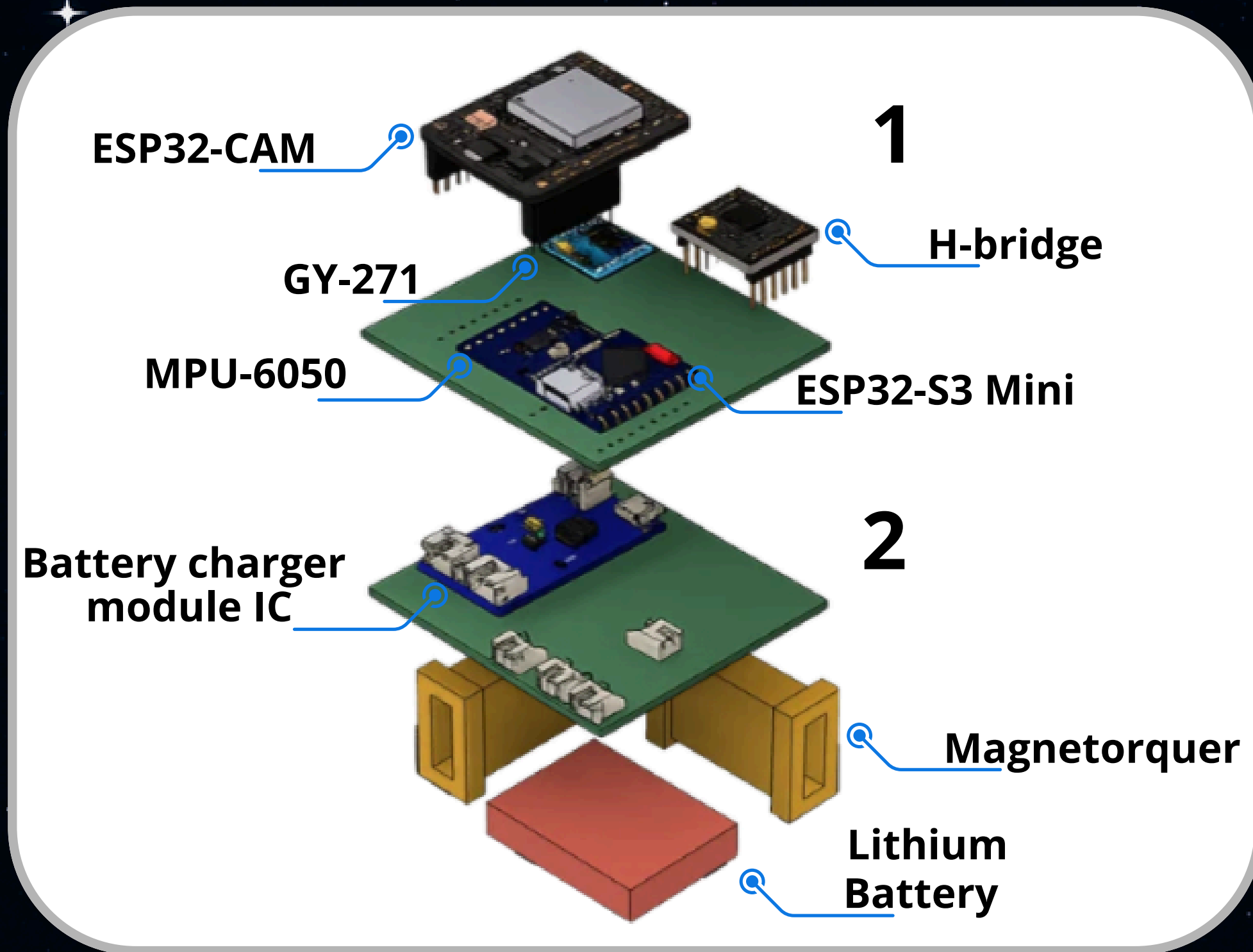
GROUND SEGMENT

- Ground Station
(on computer)

STRUCTURES

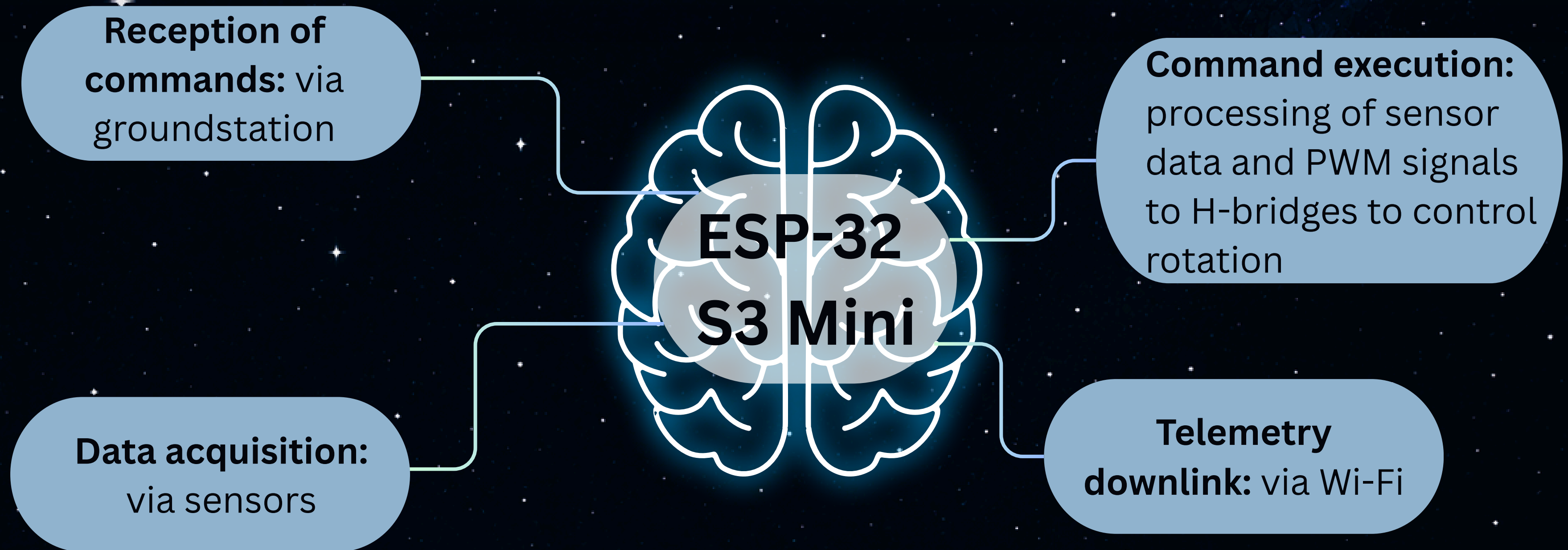


SPACE SEGMENT SUBSYSTEMS



- Board 1
(Control and sensors)
- Board 2
(Power system)

COMMAND & DATA HANDLING



ATTITUDE DETERMINATION AND CONTROL



Determination

MPU-6050 (6-axis): Functions as the Inertial Measurement Unit (IMU), measuring acceleration (Accelerometer) and angular velocity (gyroscope) to detect rotational movement.

GY-271 (3-axis): Functions as a magnetometer (digital compass), measuring the direction and intensity of the surrounding magnetic field.



Control

Fixed magnet to generate a magnetic field that simulates the earth.

User sends the command from the ground station. The ESP32 processes the command and sends signal to the H-Bridge.

H-Bridge: controls the direction of the current that affects the direction of rotation.

PAYLOAD

Is the useful cargo, that performs the primary mission for which the satellite was designed.

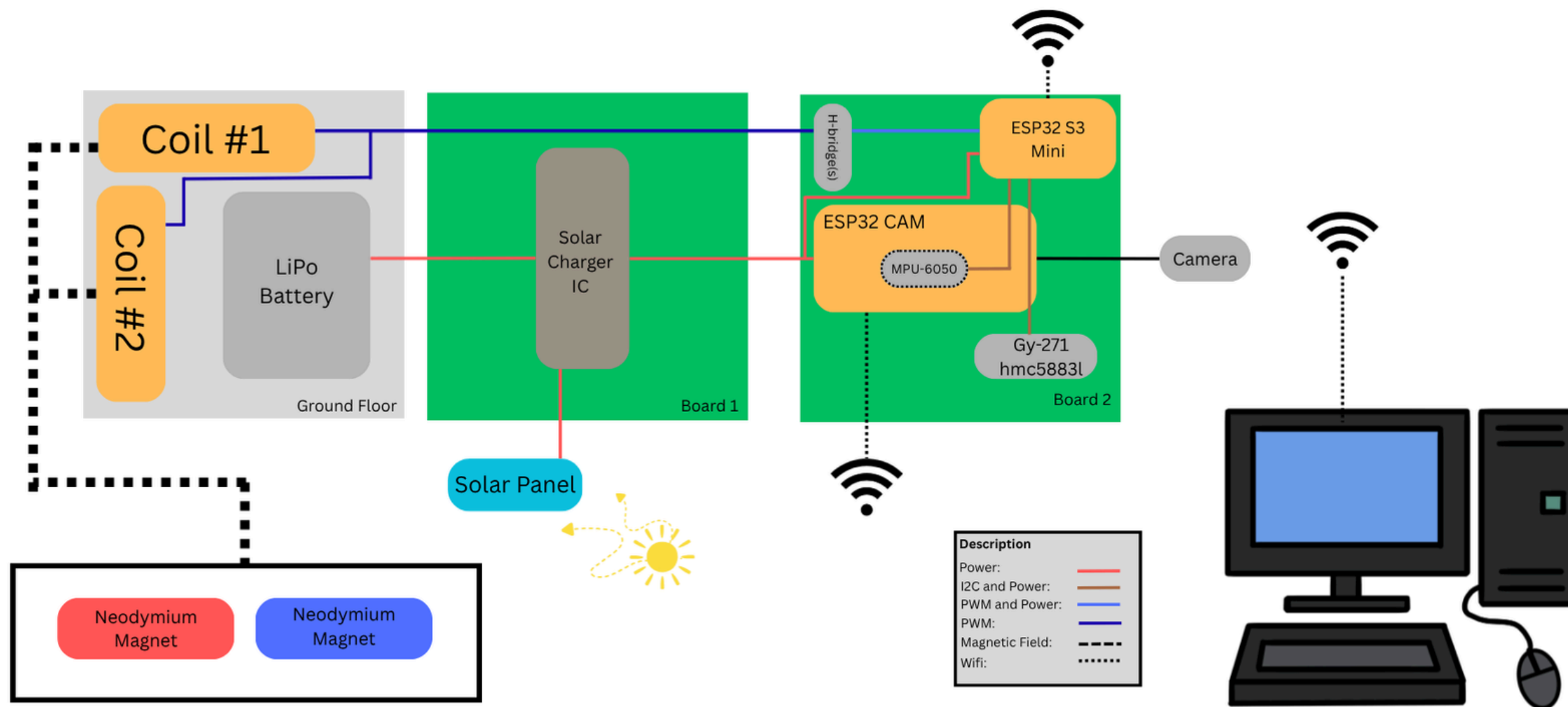


- An integrated camera managed by ESP32-CAM, which isolates video processing to prevent overloading the main MCU.
- Captures a continuous stream of video and images.

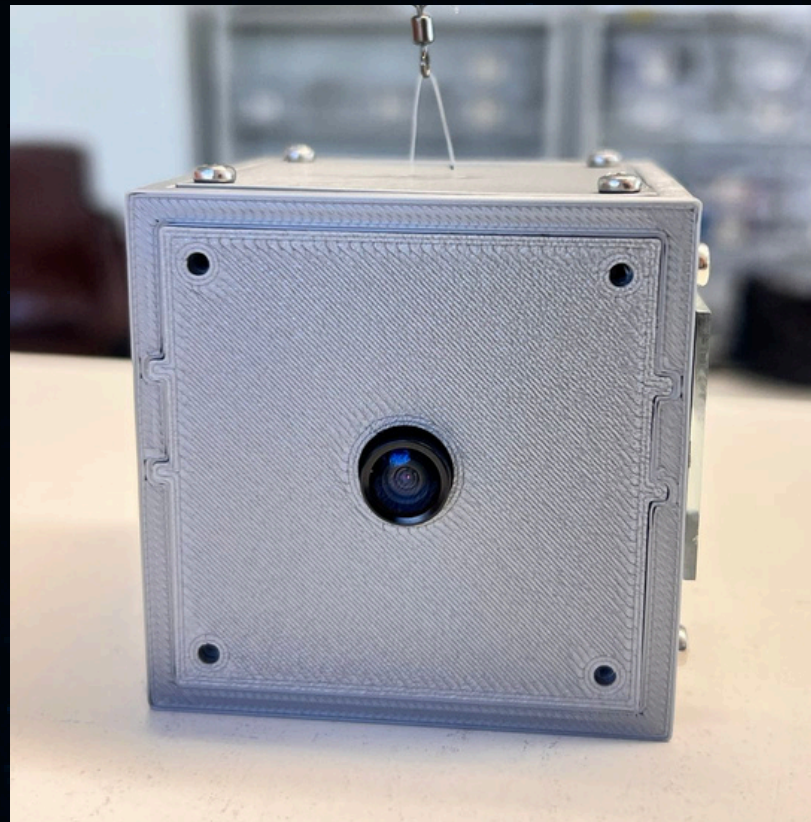


- When the user sends a command from the Ground Station, the main microcontroller (ESP32 S3 Mini) alters the electrical current flowing through the coils.

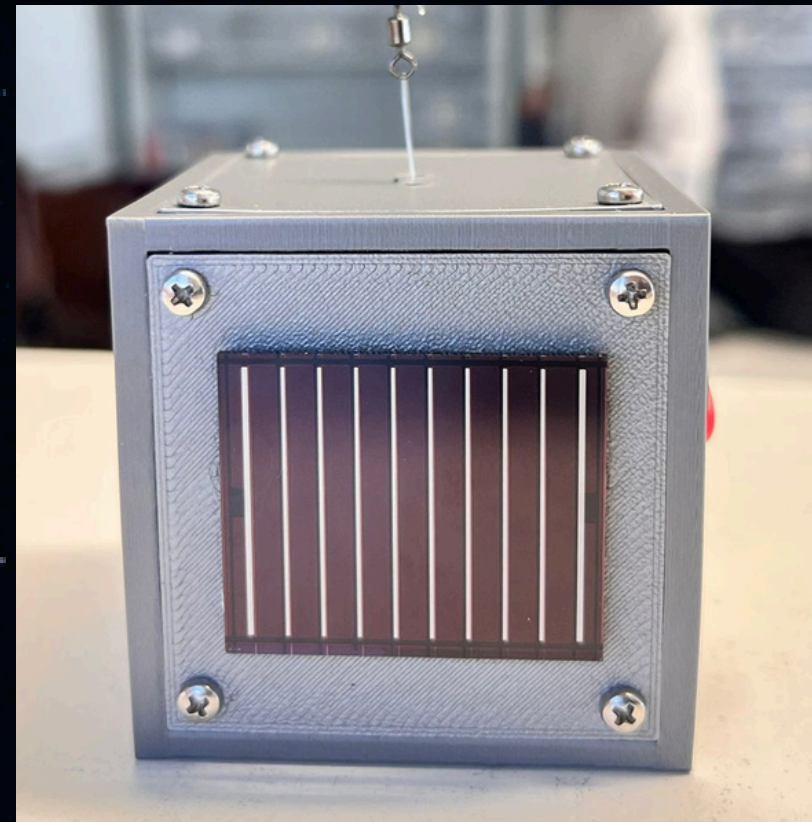
DIAGRAM OF THE UPDATED SOLUTION ARCHITECTURE



FINAL PRODUCT



Front-view



Right-view



Back-view



Left-view

FINAL PRODUCT



FINAL PRODUCT

☰ Toggle OV2640 settings

- XCLK MHz: 20
- Resolution: QVGA(320x240)
- Quality: 4 63
- Brightness: -2 2
- Contrast: -2 2
- Saturation: -2 2
- Special Effect: No Effect
- AWB:
- AWB Gain:
- WB Mode: Auto
- AEC SENSOR:
- AEC DSP:
- AE Level: -2 2
- AGC:
- Gain Ceiling: 2x 128x
- BPC:
- WPC:
- Raw GMA:
- Lens Correction:
- H-Mirror:
- V-Flip:
- DCW (Downsize EN):
- Color Bar:
- LED Intensity: 0 255

Advanced Settings

☰ Register Get/Set



ESP32 CONTROL PANEL

MOTOR CONTROL

LEFT

FRONT

RIGHT

SEQUENCE

STOP

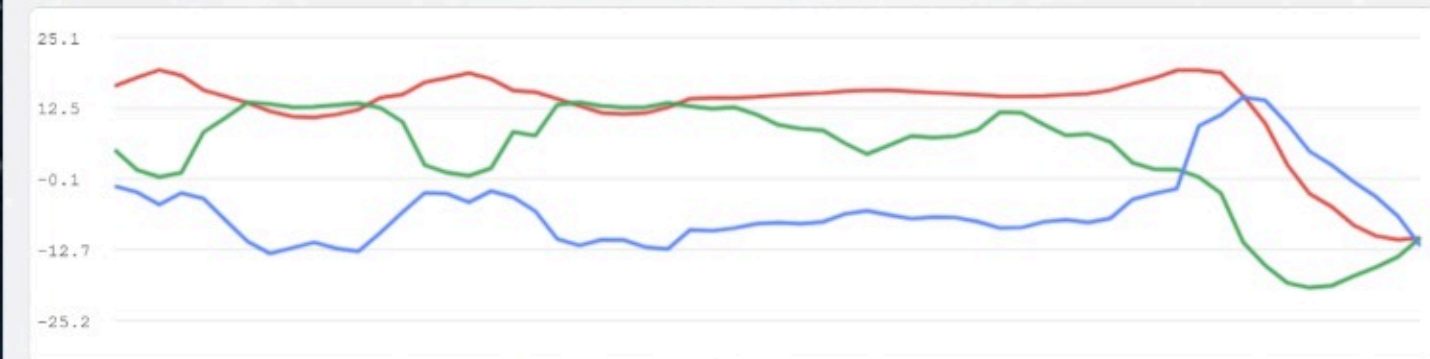
Motor status: Left | Motor A: + | Motor B: 0

3D ORIENTATION (YAW / PITCH / ROLL)



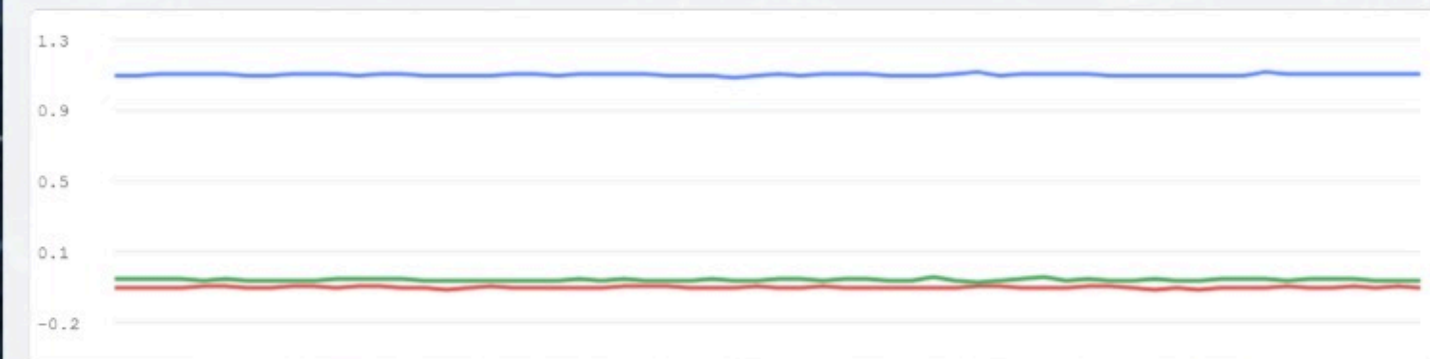
Yaw: 603.64° | Pitch: 2.14° | Roll: -0.51°

MAGNETOMETER



X = red | Y = green | Z = blue

ACCELERATION



X = red | Y = green | Z = blue

OUR RESULTS

The PocketQube is fully functional!
MISSION SUCCESS

- Fully autonomous operation.
- Capable of recording video successfully.
- Simulates common satellite telemetry, including magnetic field measurements, acceleration, and RPY (Roll, Pitch, and Yaw) data.
- It receives energy from solar panels.
- Transmits telemetry data via Wi-Fi and provides real-time data visualization.
- Successfully controls attitude using improvised magnetorquers.

TEAM MEMBERS' CONTRIBUTIONS

Cristina	Lexin	Lumi	Tiago	Sara	Yaqi
Boards & Eletronics	Box Structure	Web developer	Power	Ground station & Serial communication	Analisy & Graphic Designer
Make prototype board	Make 3D exterior model	Website and blog	Power Budget	Research	Results analysis
Research/Choose necessary components	General internal layout (where to put everything)	Create graphic interface	Research on batteries and panels	Program ESP32	Design + Poster
Create the electrical schematic	Modular interior		Energetic connection	Communication between sensors and ESP32	Video + video editing
H-Bridge coding	Magnetorquer		Magnetorquer	Program the sensors	Magnetorquer

LEARN MORE



**Our
Website**



**Our
Blog**



**Our
Video**