UNIVERSIDAD NACIONAL DE INGENIERÍA

POST-FLIGHT REPORT

Planete Sciences
une aventure pour les jeunes

CANSAT

Project Anemoi

Biomet LABORATORY Biomet research group

GEA Grupo Estudiantil Aeroespacial

FROM LIMA, PERÚ 2023

Team

The group is composed of students from the National Engineering University and the Biomet research group:

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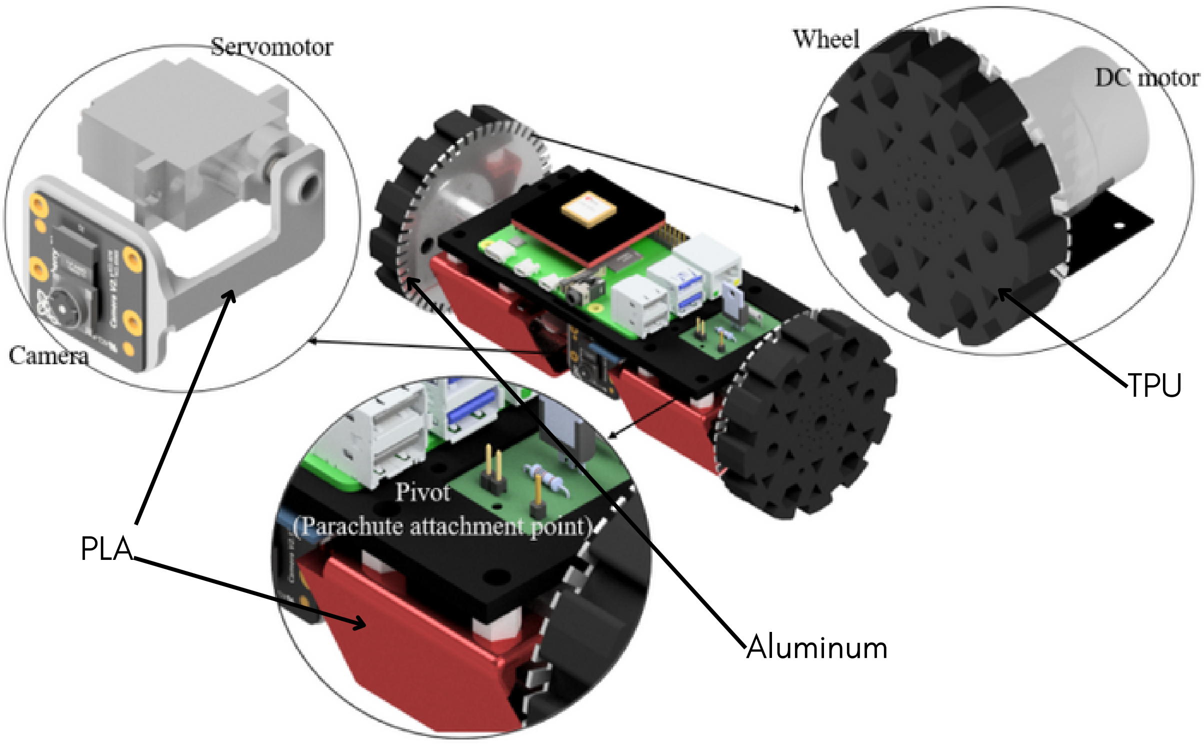
I. Introduction

The Anemoi project encompasses several technical, management and space science promotion aspects. On the technical side, we are building a CanSat picosatellite weighing no more than one kilogram to carry out the missions foreseen in the CanSat France 2023 competition rules (GPS positioning, QR detection, deployment of a ground structure). In addition, as an extra mission is to generate a precession movement of the picosatellite during the descent to ground. In the project management, we are evaluating step by step our work schedule, taking into account our university studies to avoid any discrepancy between them and the project, as well as evaluating any unforeseen events in the execution by justifying the importance of each component to be used. Finally, through the promotion of space science, the project is focused on disseminating space science among interested students, in line with the GEA objectives.

II. Mechanical Composition

The design of the CanSat Anemoi picosatellite was developed to be able to perform mainly the ground travel to reach a GPS location point, therefore it has a pair of wheels. In Fig I. You can see the composition of the most important parts to perform the missions and the material of which it is composed. For the bonus mission we will expose the CanSat to perform the precession movement during the descent in order to propose a future composite system with a camera in its center to monitor areas in their environment being a prototype design of a gimbal, it is important to note that there must be a difference of distances between the center of mass and pivot where the parachute hangs to increase the speed of precession.

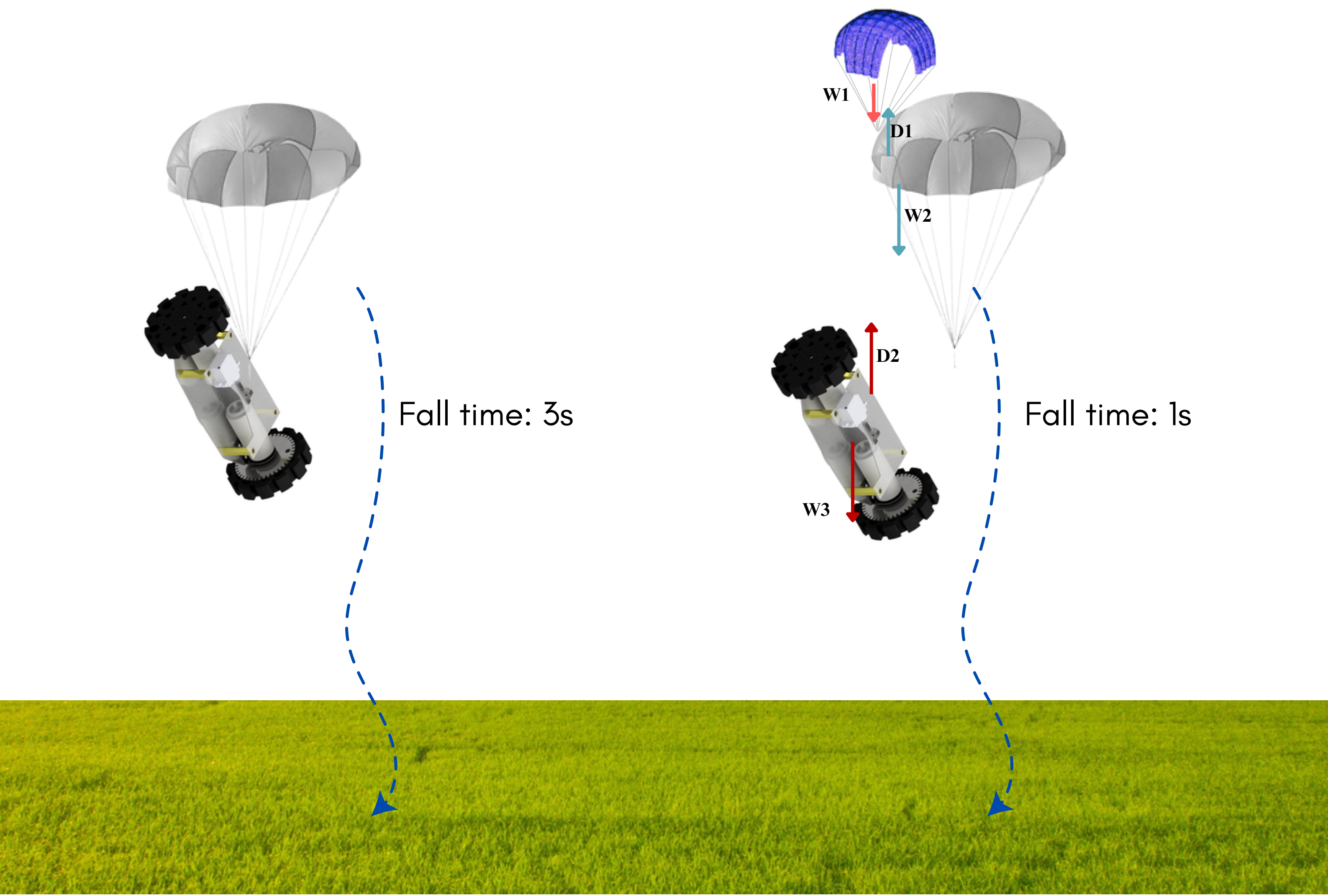
Fig1. Important parts of the CanSat Anemoi picosatellite structure design



The design is made in a first version to be able to adapt a small camera and perform a movement in azimuthal direction.

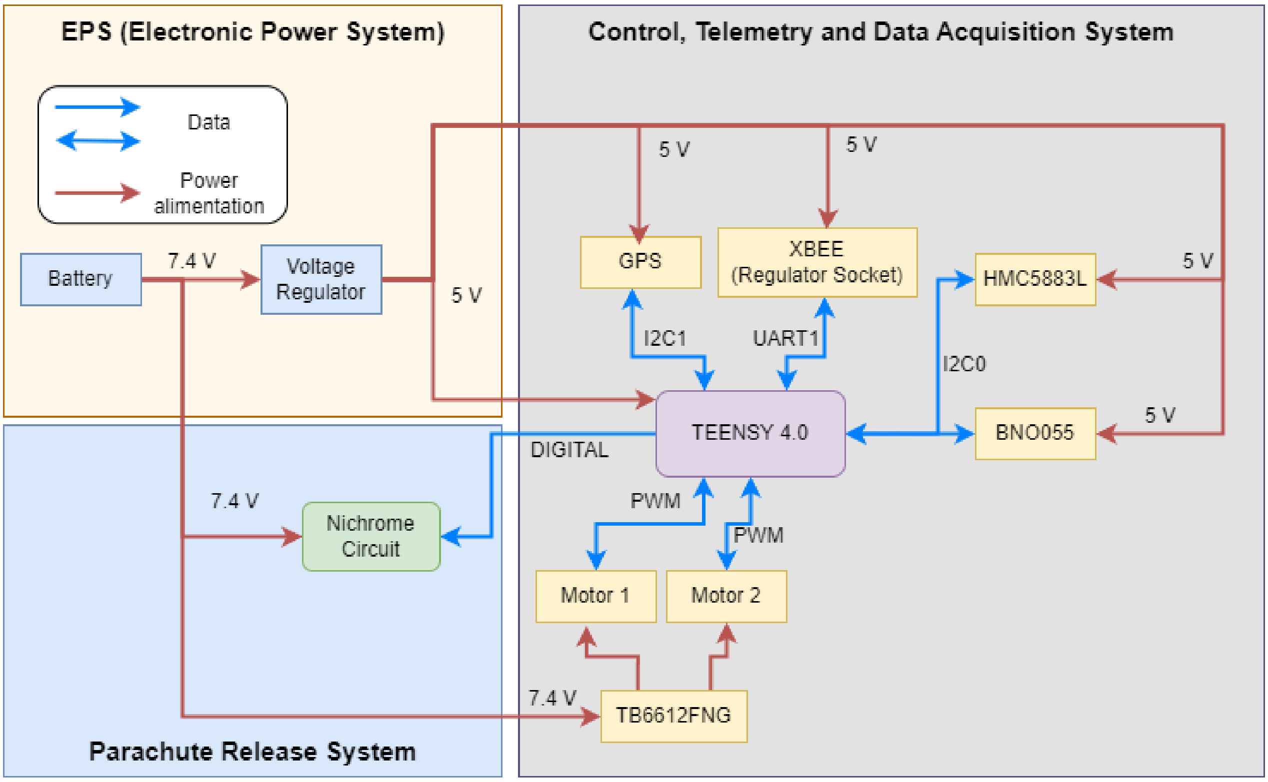
III. Descent System

The parachute was designed considering a slow enough descent to drive the wheels for the precession movement and considering that its area must be maximum to be the structure deployed on the ground as proposed in the secondary mission. For a slow and stable descent, a hexagonal parachute system with pilot was chosen.It consists of a hexagonal parachute so that its shape and symmetry provide stability, then the aerodynamic calculations were made to have the minimum allowed speed of 3 m/s that will give a longer fall. These parameters were also considered to calculate the maximum dimensions so that the structure is the largest possible.In pre-flights, only 3 to 4 seconds were obtained for the deployment of the hexagonal parachute. To reduce this deployment time, it was decided to implement a pilot, which is a miniature parachute to generate a drag force that only helps to open the parachute, but it does not interfere with the descent of the parachute.The design of the pilot is a crossed parachute, cubic in the air, this type of parachute has an immediate deployment.With this system the pilot opens immediately, generates additional drag force and opens the hexagonal parachute in a second. For the official flight, the dimensions were changed due to the change in height from 150 to 80 meters due to the change of drone, in the end the parachute was modified for a descent speed of 5 m/s.



IV. Electronical Composition

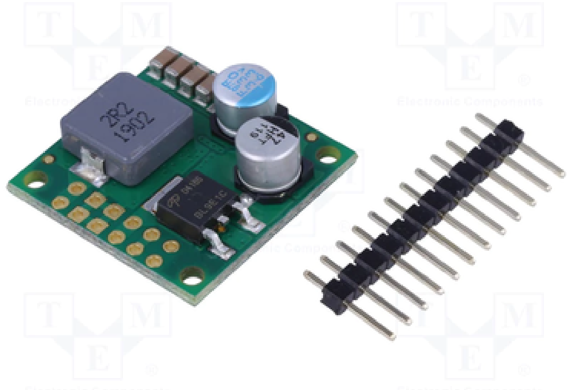
The electronic system is composed of three main systems. The first one is the electronic power system, followed by the control, telemetry, and data acquisition system in the second place. Finally, the parachute release system takes the third and last position in this comprehensive setup.



The first system is comprised of:

- Two 3.7V 2000mAh LiPo batteries.
- A 5V Step Down regulator (D36V50F5).

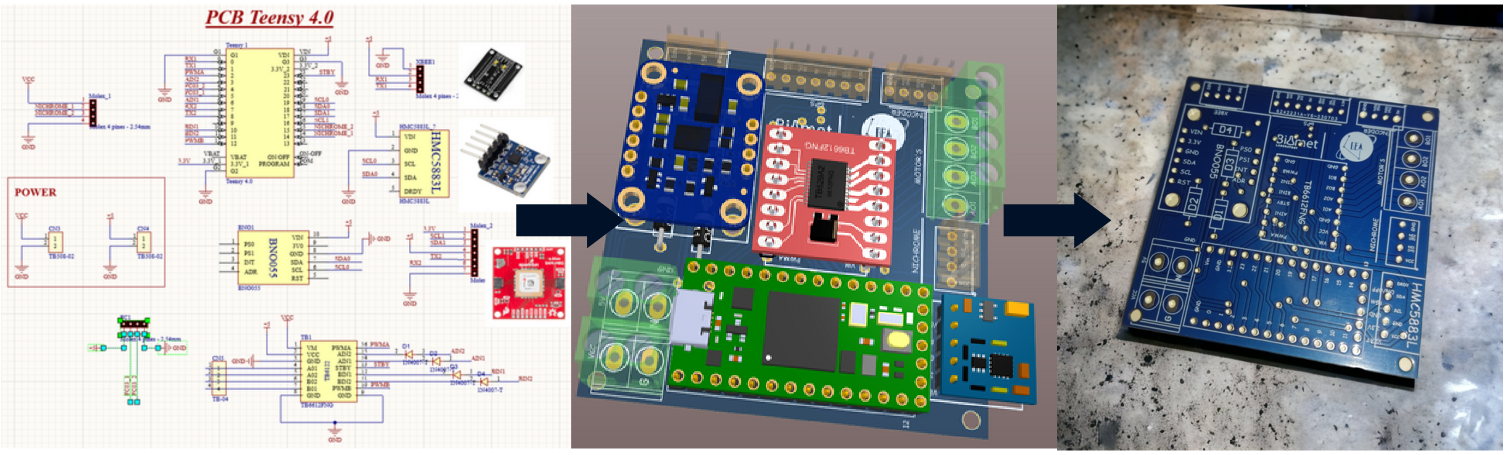
It's important to highlight that the batteries are connected in series to directly power both the parachute release system and the two motors.



Regarding the second design system, a PCB was created using Altium Designer. This 2-layer board features a modular design and is powered by the 5V output from the regulator. This PCB includes:

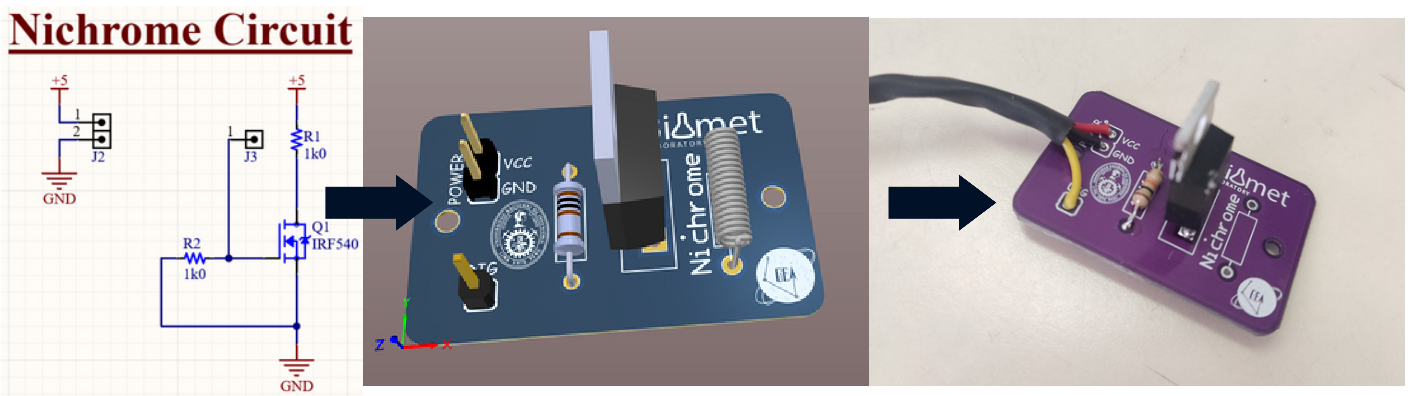
- Teensy 4.0 microcontroller.
- IMU (BNO055).
- GPS module (NEO SAM M8Q).
- XBEE module.
- H-bridge motor driver (TB6612FNG).

PCB design process :



In the third and final system, the mechanism of heating a nichrome wire was utilized to trigger the release of the parachute compartment. This process is activated through a MOSFET (IRF540), functioning as a switch. Initiation occurs by sending a digital signal from the microcontroller to the MOSFET Gate pin. To streamline the functioning of these elements, a dedicated PCB was meticulously crafted.

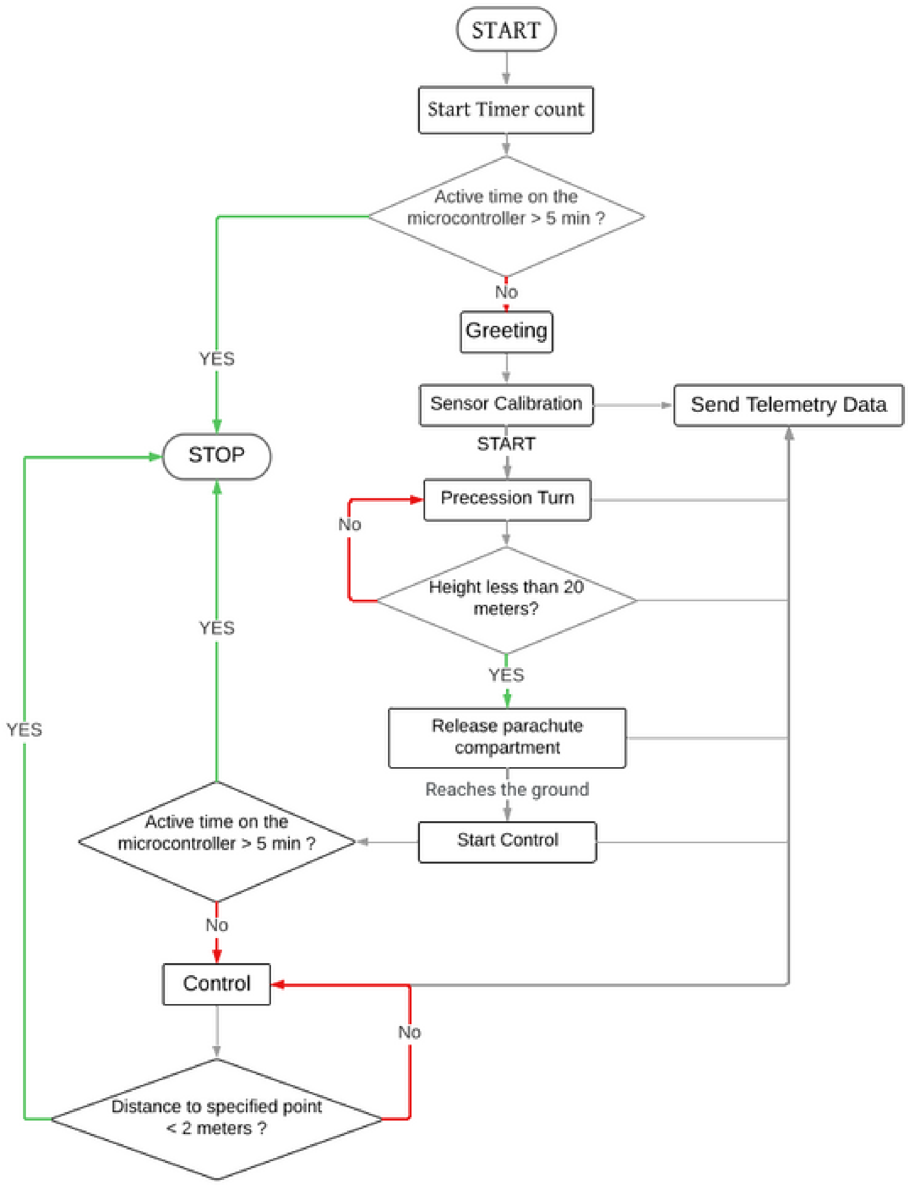
PCB design process :



V. Programming

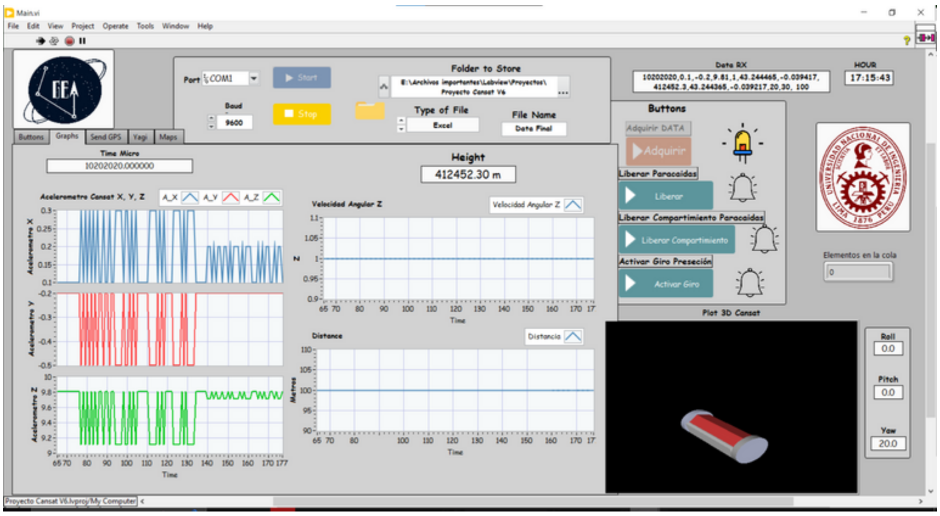
For the programming of the CanSat's microcontroller (Teensy 4.0), a design technique was employed: the state machine. This programming strategy was chosen for its significant advantages in terms of robustness, clarity, structuring, documentation, and optimization, all of which are crucial to ensure the optimal operation of the CanSat.

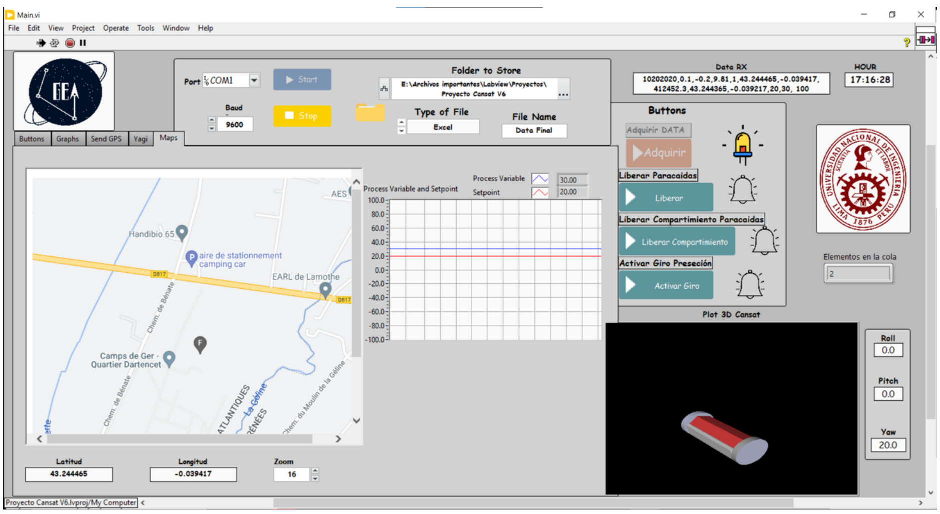
The state machine became the central axis of the control logic. Each state represented a specific stage of the CanSat's operation, clearly defining the associated conditions and actions. This can be visualized in the following flowchart.



The ground station telemetry software was developed using NI LabVIEW. It utilizes a QMH architecture, facilitating the management of a queue-based data structure. This architecture enables parallel communication and streamlined data processing. The software prompts the user to input the COM communication port for transmitting data frames.

It's worth noting that the communication network between the CanSat and the telemetry software is established through ZigBee. This connection is established using XBEE modules equipped with 2.4GHz antennas. The ground station antenna boasts a 12dBi gain, while the CanSat's antenna has a 3dBi gain. The data frame encompasses critical information: Micros (milliseconds from the microcontroller transmitted via the generated Zigbee network), X-axis Acceleration, Y-axis Acceleration, Z-axis Acceleration, Angular Velocity around the Z-axis, Current Latitude, Current Longitude, Altitude relative to the current field, Final Latitude, Final Longitude, Yaw angle, Desired Yaw value, and Distance measurement. Each of these components collectively contributes to the comprehensive transmission and understanding of data within the context of the serial protocol.





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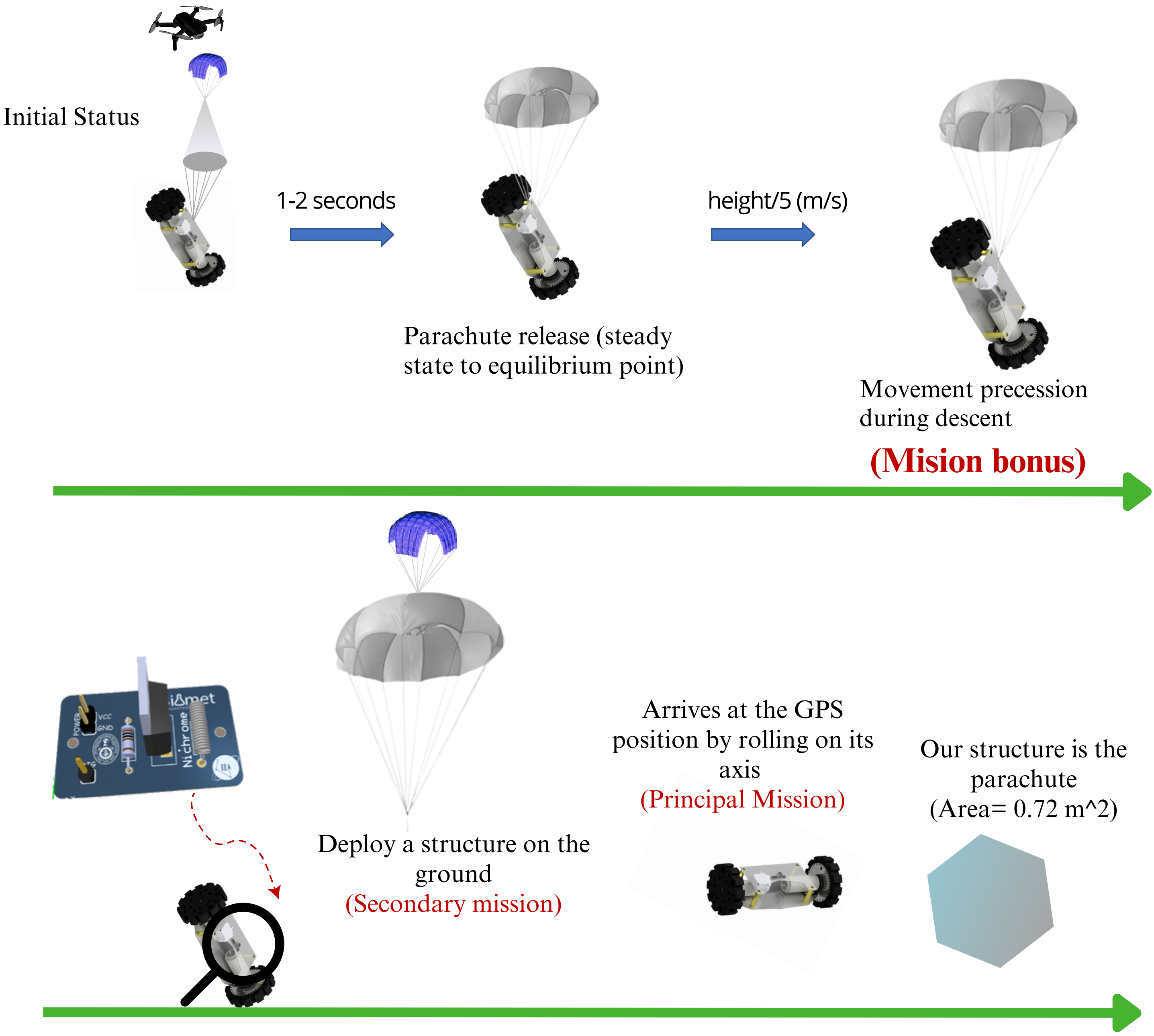
VI . Results

A) Missions overview



Flight Operation Complications

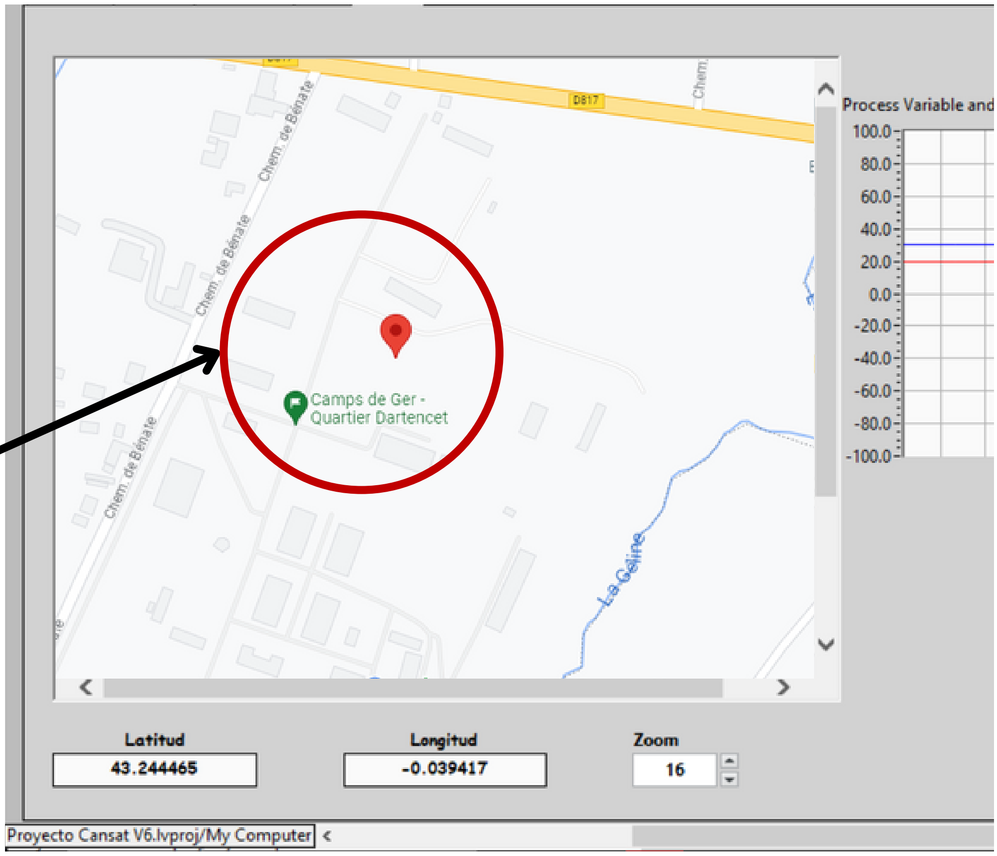
The complications presented by our design was the consideration of a driver that was incapable of withstanding the peak currents of 2. 5A for the descent to ground with collision to the wheels (protective diodes were included but were not much help), so for other opportunities to consider a much more robust driver, another important point is that our CanSat weighed approximately 800 g and the drone was unable to raise it to a desired height, in a first attempt it hit and bent the wheels of the CanSat and overloading the current burning the H bridge that supported 2A maximum and damaging the development board teensy 4.0.

Main Mission

For the main mission of being able to navigate and reach a GPS position as much as possible, a system of wheels is used so that the CanSat can roll around its axis on the ground, from the landing point towards the goal, which is the proposed position.

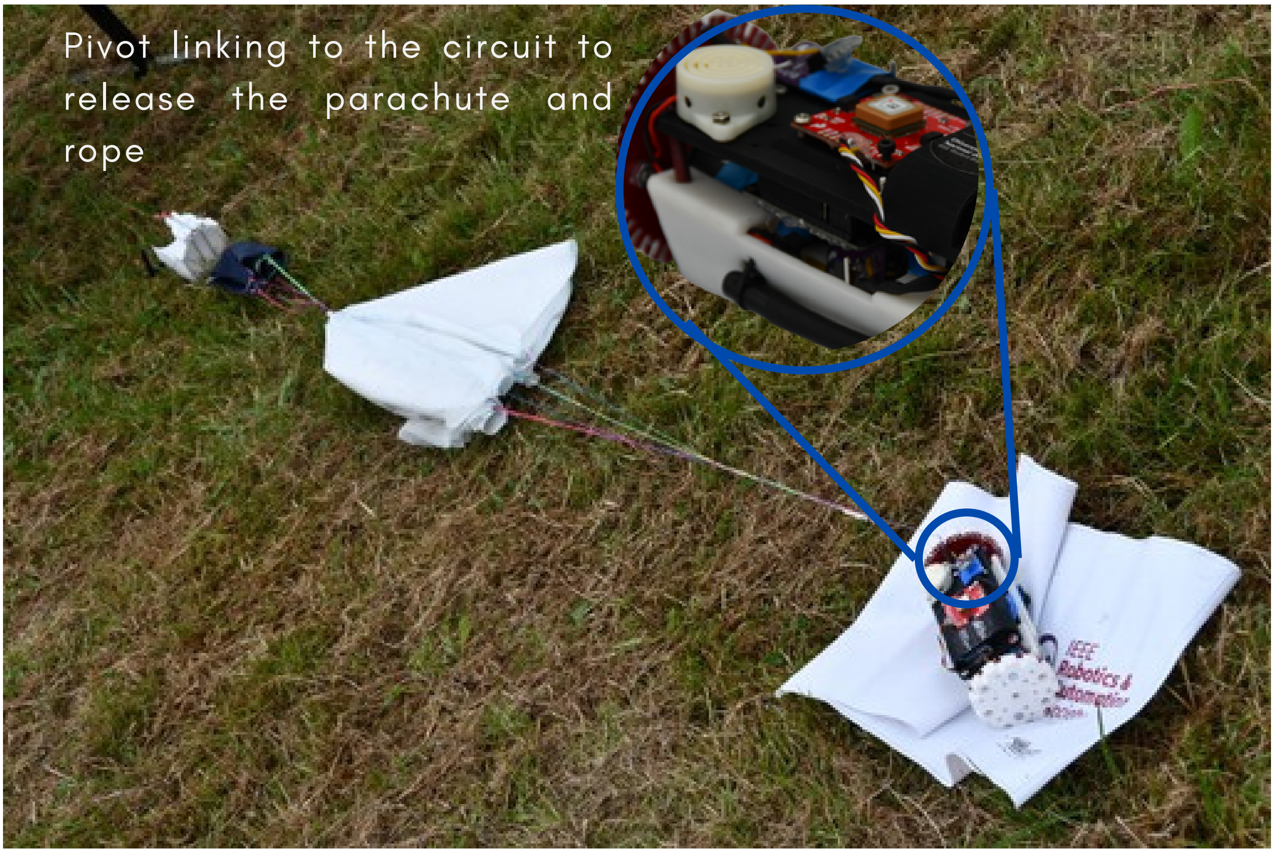
given the complications exposed during the flight, according to the data acquired during its operation, the location of its geographic location can be appreciated in real time by means of NI Labview.

Launch location



Secondary mission

For the mission of deploying an object, we thought of the parachute itself, since when making a movement on the ground it is necessary that there is no obstruction, so for this purpose we use nicrom to release the parachute. Then it is necessary the emission of a serial command for it to receive and see that it fulfills it.



Bonus mission

For the generation of the oscillatory motion, four rotations with change of angular velocity and direction of the wheels are taken. Table I indicates the series of stages to generate the change of direction of the precession motion, the change of stage is programmed to be executed in a time of 2 s.

Stills of the CanSat Rover-Back precession motion.

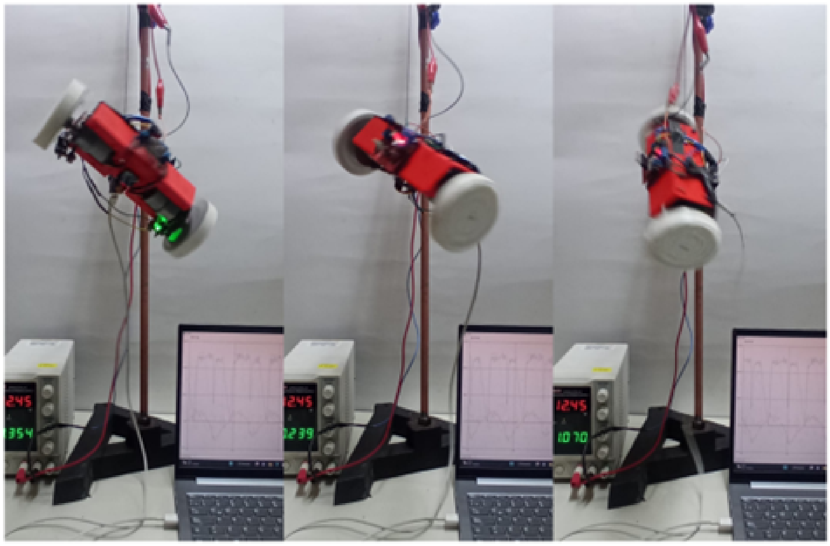


TABLE I. STAGES OF THE DIRECTION OF ROTATION FOR THE GENERATION OF OSCILLATORY MOTION IN PRECESSION

Wheel	**(1)**	**(2)**	**(3)**	**(4)**
A-Wheel	Clockwise rotation	Counterclockwise rotation	No rotation	Clockwise rotation
B-Wheel	No rotation	Counterclockwise rotation	Counterclockwise rotation	Clockwise rotation

VII. Conclusion

The results of the experiment were carried out in an interval of 60 s, it was evidenced that the signals generated by the sensors are periodic in nature. A time interval of 16 s was taken for the data acquisition. Fig. xA shows the oscillatory precession movement of the experiment with a maximum amplitude of 200 RPM, and an oscillation period of approximately 8 s per cycle, generated by the four stages of change in the rotation of the wheels. Fig. xB represents the angular velocity changes in RPM for each wheel.

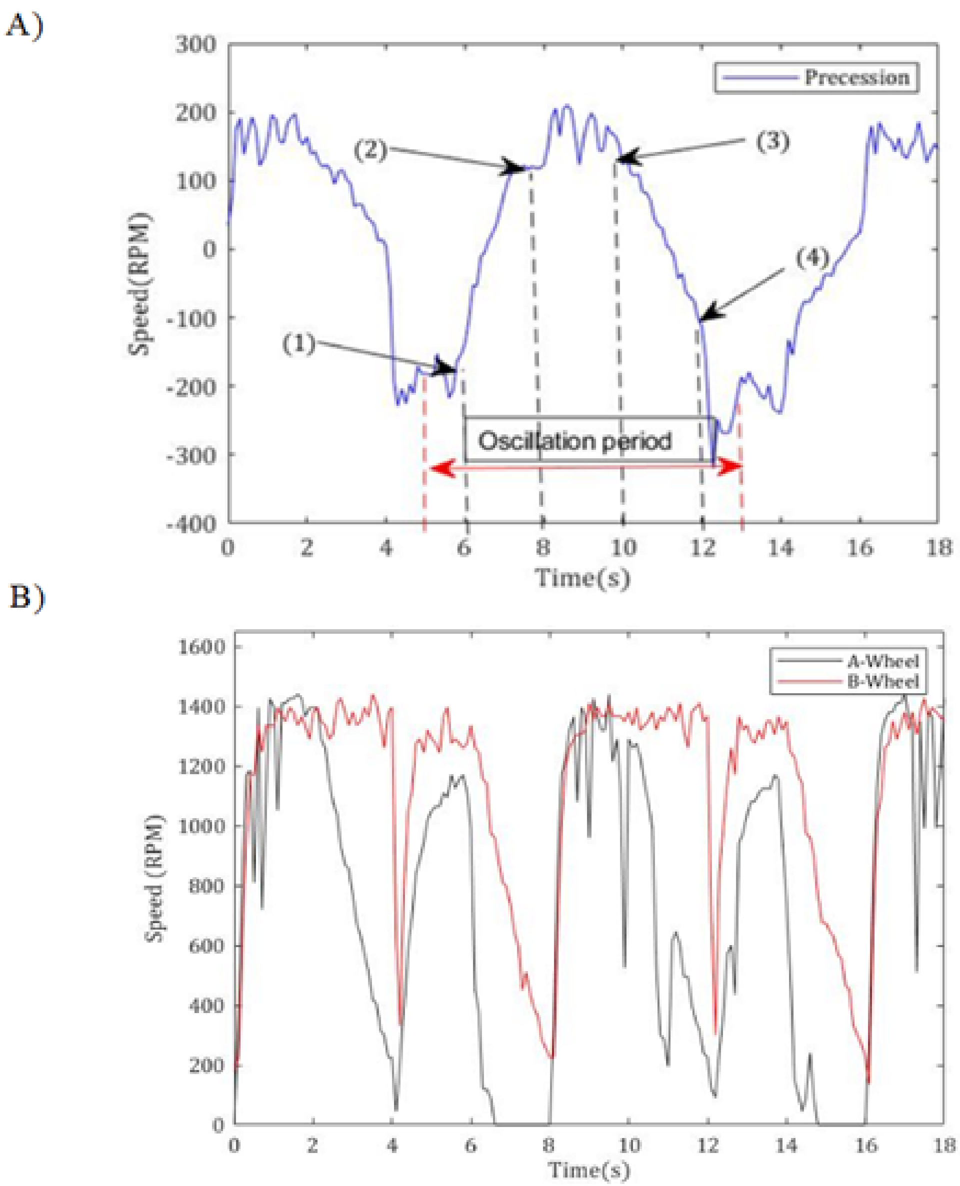


Fig. 1. Plots A) of the precession motion B) of the angular velocity of wheels A and B.

The results of these experimental tests were published in IEEE LAEDC 2023, for more information please read https://ieeexplore.ieee.org/document/10209111.