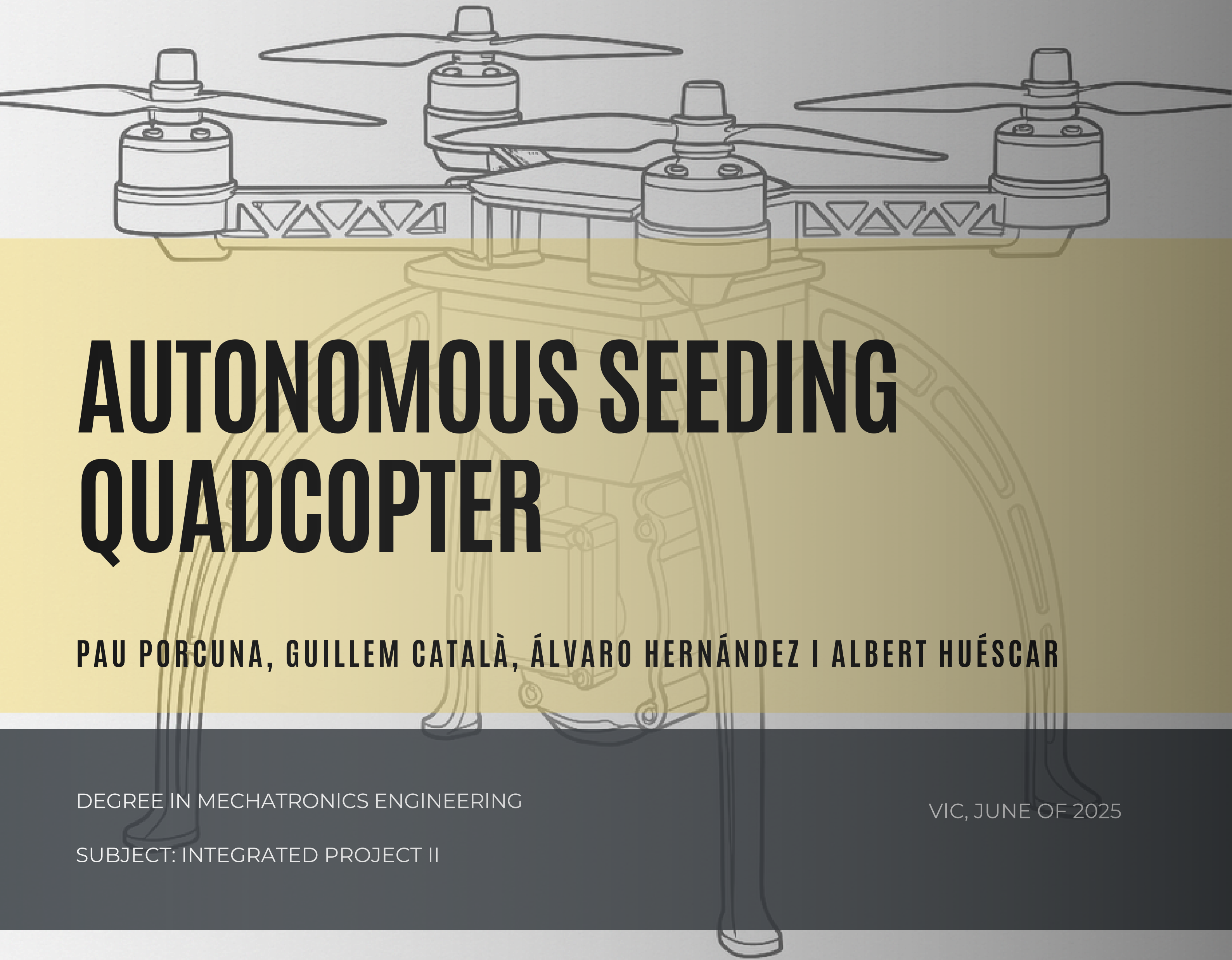
UNIVERSITAT DE VIC
UNIVERSITAT CENTRAL
DE CATALUNYA



AUTONOMOUS SEEDING QUADCOPTER

PAU PORCUNA, GUILLEM CATALÀ, ÁLVARO HERNÁNDEZ I ALBERT HUÉSCAR

DEGREE IN MECHATRONICS ENGINEERING

SUBJECT: INTEGRATED PROJECT II

VIC, JUNE OF 2025

SUMMARY

Title: Autonomous Seeding Quadcopter
Authors: Pau Porcuna, Guillem Català, Álvaro Hernández i Albert Huéscar
Subject: Integrated Project II
Date: 06/06/2025
Keywords: Autonomous system, agriculture, flight control.

This project presents the development of an autonomous seeding quadcopter designed to improve agricultural efficiency through automation. The drone is capable of independently performing seeding tasks without the need for human physical effort. Utilizing a specially designed hopper mechanism, the quadcopter accurately disperses lettuce seeds while maintaining controlled flight over the planting area.

The onboard electronics and sensors allow the drone to adapt its altitude and speed according to terrain conditions, making it a versatile tool for small and medium scale farming operations.

By eliminating the need for manual labor in seeding, the project aims to reduce physical strain on workers and increase planting efficiency. Additionally, the drone's ability to operate autonomously contributes to sustainability by reducing time, energy, and resources typically required for planting.
This project showcases how modern technologies can be combined to create practical solutions for the farming sector. It serves as a proof of concept for future applications in smart agriculture.

All the sources and instructions to reproduce the project are uploaded in the next GitHub repository:

https://github.com/Integrated-Project-2-2025-UVic-UCC/Group-3

TABLE OF CONTENTS

1. Introduction / State of the art – Benchmarking _ _ _ _ _ _ _ _ _ 5

2. Objectives _ 6

3. Development of the project _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ 7

3.1. Analysis of the problem and possible solutions _ _ _ _ _ _ _ _ _ _ 9

3.2.Description of the design _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ 11

3.2.1 Mechanical design _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ 12

3.2.2 Electrical design _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ 13

3.2.3. Control and software _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ 14

3.3 Functional testing of the prototype _ _ _ _ _ _ _ _ _ _ _ _ _ 17

4. Cost of the project _ 20

5. Conclusions _ 23

6. Bibliography _ 24

Annexes _ 25

List of tables

Table 1 Work hours distribution. 19

Table 2 Materials and Components Cost 20

Table 3 Total cost of the project..21

List of figures

No specific content.

1. INTRODUCTION

Modern agriculture is facing serious challenges such as increasing food demand, reduced availability of labor, and the need to use resources more efficiently. According to the FAO, global food production must grow significantly to feed the expected population in 2050 [1]. These pressures are encouraging the use of new technologies to make farming more sustainable and productive.

In recent years, drones have become more common in agriculture, mainly for monitoring crops, spraying, or taking aerial images. These uses have proven useful, but most systems still require an operator and are not designed specifically for seeding tasks. Our project focuses on creating a drone capable of planting seeds autonomously, offering advantages like precision, low cost, and the ability to work in areas that are difficult for traditional machinery.

The drone is designed to include a seed storage unit, rotors for flight, a stable frame, and a controlled release system that allows accurate seed distribution. The idea is to reduce manual work, increase planting accuracy, and provide a scalable solution for small and medium-sized farms.

To develop this concept, we have reviewed existing applications of drones in agriculture, especially those related to precision tasks such as spraying and crop monitoring. While these systems have proven effective, there is still limited development in autonomous drones specifically designed for seeding. Most current solutions require manual operation or are intended for other purposes, which reveals a gap in the field. Our project aims to address this need by proposing a fully autonomous drone adapted to precision seeding [2][3].

2. OBJECTIVES

Given the increasing interest in drone-based agricultural automation and the lack of dedicated systems for autonomous seeding, this project aims to bridge that gap with a tailored solution. The following objectives define the technical and functional milestones required to design and implement a drone capable of efficient, precise, and fully autonomous seed planting.

Main Objective

- Develope a fully autonomous drone capable of accurately planting seeds in predefined areas, with a focus on improving planting efficiency and reducing manual labor.

Specific Objectives

- Integrate a seed dispensing mechanism capable of holding and evenly distributing 80 grams of lettuce seeds.
- Incorporate safety and stability systems, including tilt detection, obstacle awareness, and emergency shutdown protocols, to minimize the risk of crashes and enable safe autonomous operation.
- Ensure that the battery system provides at least 10 minutes of continuous flight time under full payload and operation conditions.
- Achieve a positioning accuracy of 2.5 meters, allowing precise route following and seeding at predefined GPS waypoints.
- Implement and test autonomous movement and seeding routines, enabling the drone to fly, stabilize, and dispense seeds automatically with minimal human intervention.

3. DEVELOPMENT OF THE PROJECT

This section describes the technical development of the autonomous seeding drone. It includes the evaluation of initial design options, the definition of the final configuration, and the detailed implementation of the mechanical, electronic, and software systems. The project was carried out following an iterative process, combining design, prototyping, and testing to achieve a functional and efficient prototype.

In the early stages, several structural and functional approaches were considered. Additive manufacturing using 3D printing was selected as the optimal method for building the drone due to its design flexibility, low cost, and suitability for rapid iteration. ASA filament was chosen as the primary material for its mechanical durability and resistance to UV exposure, essential for outdoor applications.

The final drone design has external dimensions of approximately 20 × 20 × 17 cm (measured from motor to motor), and a total weight of around 650 grams without payload. The structure is rigid, with no degrees of freedom beyond the control of the four rotors and the servo responsible for seed release. The drone is powered by a 3-cell (11.1V) LiPo battery, enabling an estimated 10 minutes of autonomous operation.

The onboard electronics include an MPU6050 inertial sensor, a BME280 barometer, a VL53L0X time-of-flight sensor, and a GPS module, which collectively enable stable flight, altitude estimation, and positional awareness. All code was written in C++, using the Arduino development environment and deployed on an ESP32 microcontroller, which manages sensor data, actuator control, and communication interfaces.

Throughout the project, multiple mechanical and electrical calculations were performed to verify the feasibility and performance of the system. These include estimates of thrust-to-weight ratio, power consumption, voltage regulation, and mechanical load distribution. The full reasoning behind component selection and system configuration is detailed in the respective design sections.

The full set of 3D CAD drawings of the printed parts is provided in Annex 2, and an overview of the assembled system is shown in Annex 1. Professional electrical schematics, compliant with standard documentation practices, are included in Annex 3, and they illustrate the wiring logic and signal distribution of the prototype. Software design decisions, including the control logic, algorithms, and structure of the code, are explained in the software subsection, with full access to the source code through the project's GitHub repository.

Finally, this section also includes a report on functional testing, describing how the prototype was evaluated, the results obtained, and the performance achieved under realistic conditions. These tests validate the main objectives of the project and identify potential areas for improvement in future versions.

3.1 ANALYSIS OF THE PROBLEM AND POSSIBLE SOLUTIONS.

Throughout the development of our autonomous drone, we faced several technical challenges that affected our progress and forced us to adapt and find solutions.

The most serious problem occurred during one of our first flight tests while we were adjusting the PID controller. The motors reacted with much more force than expected, and while one of us was holding the drone, a propeller hit their glove. The impact caused the propeller to break and also damaged one of the drone’s arms. This incident stopped our testing completely for about two weeks, as we had to repair both the mechanical structure and check that everything was working safely before continuing. It was a major setback, but it made us more aware of the importance of safe testing procedures.

Another issue we encountered involved the ESP32 microcontroller. At the beginning, we were unable to upload any code to it. We tried several times and checked the connections, but nothing worked. Luckily, we had a second ESP32 available, although its USB connector was broken. We decided to try it anyway and soldered the connector manually. After doing that, it worked correctly and allowed us to continue with the software development.

The GPS module also gave us some trouble. While it was functional, the resolution was too low for our needs. The position data had a significant margin of error, which made precise autonomous navigation difficult. Since we could not change the hardware, we tried to reduce the impact through software by applying data filtering and adapting the logic to tolerate some positioning uncertainty.

Lastly, we had a problem with the ESCs when we were preparing to test the stabilization of the drone. One of the motors was spinning much faster than the others, which made us think there was a bug in the control system. After some time investigating, we realized that the ESCs had lost their configuration settings. We recalibrated them, and once that was done, all motors started working as expected.

All these problems delayed our progress at different moments, but we managed to solve them step by step. More importantly, they helped us understand the system better and improve the reliability of the final design.

3.2 DESCRIPTION OF THE DESIGN

The drone has been developed as an autonomous seeding quadcopter, designed to operate in agricultural environments with minimal human supervision. Its main purpose is to autonomously disperse seeds.

For the design, we opted for a structure that balances aesthetic appeal with lightness and functionality. The result is a drone that is visually clean and modern, but also engineered to be as lightweight as possible, optimizing each part to reduce mass without compromising strength.

Structurally, the drone uses a quadcopter configuration, with each motor positioned at the extremity of each arm. These arms are evenly distributed to ensure stability and equal force distribution during flight. The layout has been carefully planned to support the required lift and to maintain precise control, even when carrying seeding payloads.

The main structure of the drone is 3D printed using ASA (Acrylonitrile Styrene Acrylate). This material was chosen for its durability and its lightweight, making it ideal for outdoor use. 3D printing also enabled custom geometries and rapid prototyping, which helped in achieving an optimized and efficient design.

A key aspect of the internal design is the centralized placement of electronics and the battery. All major components, including the ESP32, power system, and sensors, are located at the center of the drone. This configuration helps maintain a low and stable center of gravity, fundamental for maintaining reliable autonomous navigation and smooth flight stability.

One of the project’s priorities was to make the drone easy to assemble and disassemble. Therefore, the drone was designed with a modular structure, allowing most parts such as the arms, landing gear, seed hopper, and the base of the central module, to be replaced independently and with minimal tools. Some aspects of the mechanical layout and modularity were inspired by similar drone concepts available online [1]

3.2.1. MECHANICAL DESIGN

The mechanical structure of the drone has been entirely designed for 3D printing using black ASA filament on a Bambu Lab A1 printer. All components have been optimized for printability, mechanical performance, and modular assembly.

The core of the structure is the Bottom Body (Annex 2.1), which acts as the main support for the PCB (discussed in a later section). It is connected to the Upper Body (Annex 2.2) via four Arms (Annex 2.3), which serve as motor mounts and structural spacers between both halves of the frame.

On top of the Upper Body sits the Battery Support Assembly, composed of the Bottom Battery Support (Annex 2.4) and the Upper Battery Support (Annex 2.5). These two parts ensure stable battery positioning and feature integrated cable management paths designed into the geometry.

At the four bottom corners of the drone are the Legs (Annex 2.6), which feature a slightly organic design to enhance mechanical efficiency and impact absorption. Their height has been chosen to ensure ground clearance for the Hopper + Rotative Valve Enclosure (Annex 2.7), mounted underneath the Bottom Body.

This enclosure is attached using a 3D-printed hinge mechanism composed of the Hinge Joint (Annex 2.10), which allows it to pivot open for maintenance or seed refilling. The Rotative Valve (Annex 2.9), located inside the enclosure, is actuated by a 360° servo motor and protected by the Rotative Valve Cover (Annex 2.8).

On the opposite side of the servo, a Distance Sensor Support (Annex 2.11) is mounted to hold a vertically-oriented VL53L0 time-of-flight sensor, used for distance measurement to the ground.

A full render of the complete drone assembly is included in Annex 1.1.

3.2.2. ELECTRICAL DESIGN

The electrical system of the drone is powered by an 11.1V LiPo battery, which serves as the main power source. This voltage directly supplies the ESCs of the brushless motors, as they are designed to operate at this level. To power more sensitive electronic components, a voltage regulator (LM2595S-5) is used to step the voltage down to 5V. This 5V line powers the ESP32, which in turn provides a 3.3V supply used for all onboard sensors. Additionally, PWM signals generated by the ESP32 are passed through a logic level shifter to be compatible with 5V devices. This setup ensures a clear separation between power lines (motors and servo) and the low-voltage electronics used for control and sensing.

The control system is centered around an ESP32 microcontroller, which manages all core drone functions. It communicates via the I2C bus with several sensors: a module combining a BMP (for pressure and altitude estimation) and an MPU (for measuring angles and inertial movements), as well as five laser-based ToF distance sensors placed to detect obstacles in multiple directions. The system also includes a GPS module for navigation and positioning, and a servo motor responsible for rotating the hopper that dispenses seeds during flight. The ESP32 generates four PWM outputs for the ESCs controlling the brushless motors, and a fifth PWM signal for the seed-dispensing servo, enabling dynamic control of flight and seeding.

However, during the implementation of the prototype, several simplifications were identified. It was found that the 5V line was unnecessary, as both the ESCs and the servo functioned correctly with 3.3V signals directly from the ESP32, allowing the logic level shifter to be removed. Additionally, to simplify the initial prototype, only one downward-facing ToF sensor was included for altitude measurement, while the GPS and additional distance sensors were omitted. These adaptations helped streamline the build and testing of the system without compromising its basic functionality.

A full electronic schematics of the drone is included in Annex 3.1.

3.2.3. CONTROL AND SOFTWARE

For the control software, we decided to develop a Bluetooth command-based code to control all the parameters and actions of the testings. The Bluetooth allows us to have control over the testings with a proper security distance and avoiding control by USB. The main code is divided in different tabs that contain the functions of a certain technology or concept. These tabs are the main tab (including the setup and the loop), Bluetooth Low Energy, MPU (Gyroscope, Accelerometer and Barometer), PID, TOF (Distance sensors), motors and definitions.

One of the most important tabs is the **definitions** one. This tab contains all the definitions of the physical pins of the ESP32 connected to each of the components of the drone. This tab also includes libraries and global variable definitions that will be used in other tabs or in the main program.

The **TOF** tab, manages the initialization and reading of the distance sensors. Which take measures every 50ms. With the *getDistance* function, we can extract in milimeters the distance measured.

Then we have the **motors** tab, which sets the frequency and range of the 4 PWM pins attached to the ESC drivers and the hopper servomotor (as both components are set up in the same exact way). Then, with the *motorStart* funtion, we can set every motor power (with its name being ‘A’, ‘B’, ‘C’ or ‘D’) in a range between 0 and 100, being 0 completely stop and 100 the maximum thottle.

For the **MPU** tab, we have all the control related with the GY-88 module (MPU6050 and BMP085). This tab includes the setup of both MPU6050 [6] and BMP085 [7] sensors and their respective functions to extract their data. The main functions of this tab are *updateMPU* and *calcularKalman*. The first one reads and manages all the data related with gyros, accelerations and altitude (calculated based on the barometric pressure). The second one is a really sintetized Kalman filter with a constant value of conficende on the prediction (normally this constant is calculated dinamically).

The Kalman filter allows us to combine both acceleration and pressure to get a better estimation of real altitude, because the smooth but accumulative error of integrating the acceleration compensates with the accurate but noisy values of the barometer. We got a precision of about +-0.5m.

In the **PID** tab, there are two PID funtions with the exact same calculations but they are duplicated to manage the accumulative errors of each angle separately. This functions do the basic calculations of proportional, integral and derivative error with their respective constants to return the value expected fot the motors at each iteration of the main loop. Then with the two *Rollstabilize* and *Pitchstabilize* we use call the PID functions with the constants to get the error needed on the motors, Finally the *motorUpdate* function takes the values of power requiered for each Yaw, Pitch and Roll and asignates the corresponent error to the motors that compensate them. With this and correctly calibrating the Kp, Ki and Kd parameters we can teoretically stabilize perfectly the drone.

The **BLE** tab gestionates the communication with a connected BLE device. It creates a BLE server called “DRONE” to which external devices can connect to to comunicate with the ESP32, this implicates sending and recieving data. Avoiding all the setting up of the server, the two main functions that are important to consider are *enviarBLE* and *valorRebut.* The first one, allows us to send phrases (String) to the device connected to the server (Subscriber). The second one, which is the function that manages all the commands for control, recieves phrases from the BLE device and interpret them by the first letter of each command (i.e. V100, H15, P0.2). As the code is well commented, here we’ll explain only the possible commands. These commands are the next ones:

- Kp, Ki and Kd modification (P, I, D)
- Set a defined power to all motors (V)
- Set a base power for when the PIDs are active (H)
- Set the speed of the rotative valve (T)
- Enable the PID stabilization loop (S)
- Disable the PID stabilization loop and turn of all the motors (s)
- Kp, Ki and Kd reading from device (p, i, d)

Finally, the **main** tab (called *General_BT_Testing)* is where the code is executed. In the setup all the modules and GPIO are setted up while the Red LED is on. Once all is initializated, the Yellow LED turns on and that indicates that the drone is ready to fly and recieve commands. In the loop, we have a reiterative loop that sends some data to the BLE device every 500 ms. Also, with an if we control if the PID stabilization is running or its in standby.

To summarize, the main code initializates all the components and modules and enters in the main loop, which send real-time information to de BLE device (angle, power of each motor and sample time) and starts or stops the PID stabilization when is activated or desactivated by BLE commands.

All the code mentioned is available at the GitHub project repository: https://github.com/Integrated-Project-2-2025-UVic-UCC/Group-3

3.3. FUNCTIONAL TESTING OF THE PROTOTYPE

In this phase of the project, we focused on validating the functionality and stability of the drone by conducting a series of controlled tests. These tests helped us understand the performance of the motors, evaluate the PID tuning, and ensure safety during experimentation.

The first test we carried out was aimed at measuring the thrust generated by a single motor. We mounted the motor on a fixed structure and placed it on a scale (Annex 1.10). By slowly increasing the PWM signal, we were able to observe the variation in weight on the scale, which allowed us to estimate how much weight a single motor could lift. This helped us verify whether the motors selected were powerful enough to lift the total weight of the drone.

After that, we proceeded to mount all four motors onto the drone frame and built a custom testing rig to carry out further experiments safely. The structure was made using a wooden base and tabletop, two vertical aluminum profiles, and a cylindrical rod across the top (Annex 1.11). The drone was attached to the rod, which allowed it to rotate slightly and simulate hovering behavior, without the risk of flying away or injuring anyone.

This testing stand allowed us to run the motors safely at full speed and experiment with the PID parameters for stabilization. By observing the drone’s behavior while it was fixed in the rig, we were able to adjust the PID values gradually until we achieved a more stable response. It also gave us confidence to refine the control system before moving on to free-flight tests.

After tuning the system in the test rig, we carried out a more advanced test by attaching the drone to the legs of a table using four cords (Annex 1.12). This setup allowed much greater freedom of movement compared to the previous rig with the guide bar. With this configuration, we were able to lift the drone into the air and fine-tune the PID values to achieve better stability during hovering conditions, while still maintaining a safe environment for testing.

Thanks to this approach, we were able to iterate on the control logic while maintaining safety. It also helped us detect issues such as over-aggressive motor response or imbalance, and correct them before risking damage to the drone or harm to any team member.

As a result of these functional tests, we were able to draw several important conclusions regarding the capabilities and current limitations of the prototype. First, we confirmed that the mechanical structure of the drone is sufficiently stable and lightweight, capable of supporting all required components including an onboard payload of approximately 80 grams of seeds. The structural integrity held up well throughout the tests, which indicates that the design is mechanically sound and suitable for agricultural applications that demand consistent flight performance under load.

In terms of propulsion, the motors demonstrated that they could generate enough thrust to lift the total weight of the drone. This was verified through both individual motor tests and full assembly experiments. These results validate the adequacy of our motor selection and the distribution of power in the system. Furthermore, the seed dispensing mechanism functioned effectively and consistently during testing. The hopper system was able to release small seeds such as lettuce in a uniform manner without clogging. This outcome confirms that the core agricultural functionality of the drone, namely precision seeding, is viable even at this early stage of development.

Despite these successes, the testing process also revealed some significant limitations. One of the main issues encountered was the limited accuracy and stability of the GPS module. The positioning data provided by the module was not sufficiently precise to allow for waypoint-based navigation or reliable autonomous operation. This limitation directly impacted our ability to implement true autonomous behavior, especially in tasks that rely on accurate geolocation.

In addition to the GPS-related challenges, the stabilization system based on PID control required further refinement. While it provided some level of control under constrained test conditions, it was not robust enough to ensure safe and stable untethered flight. During free-flight attempts, the drone exhibited instability that could have led to crashes or damage. To address this, we implemented a test setup using four cords to secure the drone to a table structure. This allowed for greater movement freedom than the initial test rig but still ensured safety for both the hardware and the operators. With this setup, we were able to fine-tune the PID parameters and observe partial stabilization in a safer environment.

In conclusion, the project allowed us to validate key components of the drone and gather valuable data to guide further development. The structure, motors and seeding mechanism were all tested successfully and proved to meet their design objectives. However, the system did not reach the level of full autonomous and stable flight due to GPS inaccuracies and an insufficiently tuned stabilization system. These challenges, while limiting, also helped us identify critical areas for improvement. The current progress provides a solid foundation upon which more advanced iterations of the drone can be built. With future enhancements in control algorithms, positioning systems and flight software, we believe that a fully autonomous seeding drone is an achievable goal.

4. COST OF THE PROJECT

For this project, we worked with a maximum budget of 300€, which was allocated for materials and necessary components. In addition to direct expenses, we also estimated the effort contributed by each team member. Below is a detailed breakdown of both labor and material costs.

Work Hours Distribution

Table 1 Work hours distribution.

Team member	Total hours
Albert Huescar	98h
Guillem Català	98h
Alvaro Hernández	96h
Pau Porcuna	93h
TOTAL	**385h**

The total work time invested in the project was approximately 385 hours. Based on an hourly labor rate of 20€, the estimated value of the team's work is 7700€. This cost is not part of the actual budget but reflects the effort required to develop the system.

Materials and Components Cost

Table 2 Materials and Components Cost.

Component	Quantity	Price Unity [€]	Subtotal [€]
Motor Servo dispenser	1	5,00 €	5,00 €
Lipo Battery 3S 3200mAh	1	25,50 €	25,50 €
ESP-32	1	11,99 €	11,99 €
MPU 6050	1	12,99 €	12,99 €
Distance Sensor	1	5,00 €	5,00 €
GPS Module	1	8,59 €	8,59 €
Motor/Propeller/Driver Pack	1	90,66 €	90,66 €
11.1V to 5V Regulator	1	3,00 €	3,00 €
Barometer BME280	1	7,99 €	7,99 €
Propellers	2	3,00 €	6,00 €
Filament	1	21,45€	21,45€
Screws and Threaded Inserts	1	5€	5€
TOTAL	**11**		**203.17€**

Total cost of the project

Table 3 Total cost of the project.

CATEGORY	COST (€)
Material and components cost	203.17€
Labor cost per hour	7700€
TOTAL VALUE	**7903.17 €**

Despite the high theoretical value, the actual expense was limited to 203.17€, staying well below the €300 budget. This demonstrates a cost-effective design and smart resource management by the team.

5. CONCLUSIONS

Throughout the development of this project, we were able to make significant progress in the design and construction of an autonomous seeding drone, even though not all of the initial objectives were fully achieved. We successfully built a lightweight and stable mechanical structure capable of supporting all necessary components along with an 80 gram seed payload. One of the most successful aspects of the prototype was the seed dispensing mechanism. The hopper system worked reliably and was able to release small seeds such as lettuce evenly and without clogging, which confirms the viability of this part of the design.

Regarding flight performance, we were not able to achieve a fully autonomous or stable free flight. The GPS module lacked the required accuracy and stability, which limited our ability to implement reliable positioning or waypoint-based navigation. Additionally, the drone’s PID-based stabilization system was not robust enough to allow for safe untethered flight.

To continue testing safely, we created a setup using four cords to hold the drone in place. This allowed us to lift the drone off the ground and perform basic motor and control system tests without risking injury or hardware damage. In this controlled environment, we managed to observe partial stabilization and adjust PID parameters, although the system remained sensitive and unstable for full flight.

Despite these limitations, the project allowed us to gain hands-on experience in embedded systems, control theory, mechanical assembly, and testing procedures. The successful operation of the seed delivery system was a major achievement and proves that the core agricultural function of the drone is feasible. For future versions, improvements should include a more precise GPS module, a more refined stabilization algorithm, and further motor tuning to ensure safe and autonomous operation.

In summary, although the drone did not reach full autonomous flight, we demonstrated that the structure can lift off, the seeding mechanism functions well, and a solid foundation has been built for further development in future iterations.

6. BIBLIOGRAPHY

[1] Carbon Aeronautics. Autonomous Seeding Drone Prototype [Video]. YouTube, 2022. Available: https://www.youtube.com/CarbonAeronautics

[2] Food and Agriculture Organization (FAO). (2017). The future of food and agriculture. Rome: FAO.

[3] DJI Agriculture. Product documentation and drone use cases. Retrieved from www.dji.com/agriculture

[4] XAG. Agricultural drone technology overview. Retrieved from www.xa.com

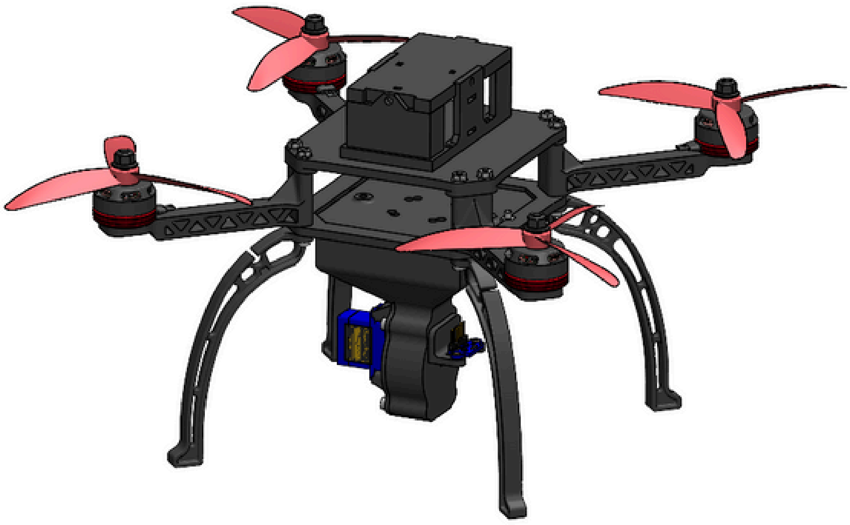
[5] OpenAI. ChatGPT (GPT-4) [Large language model]. Used for general knowledge acquisition and assistance with overall structure and composition. Available: https://chat.openai.com

[6] Determinar la orientación con Arduino y el IMU MPU-6050. Overview of MPU6060 sensor https://www.luisllamas.es/arduino-orientacion-imu-mpu-6050/

[7] Medir presión del aire y altitud con Arduino y barómetro BMP180. Overview of BMP085 and BMP180 sensors. https://www.luisllamas.es/medir-presion-del-aire-y-altitud-con-arduino-y-barometro-bmp180/

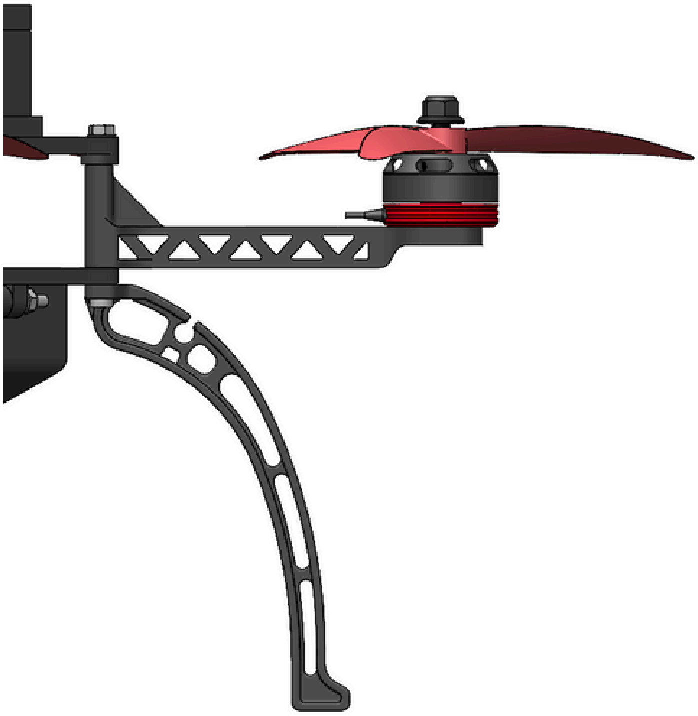
ANNEXES

Annex 1 – Project renders and photographs

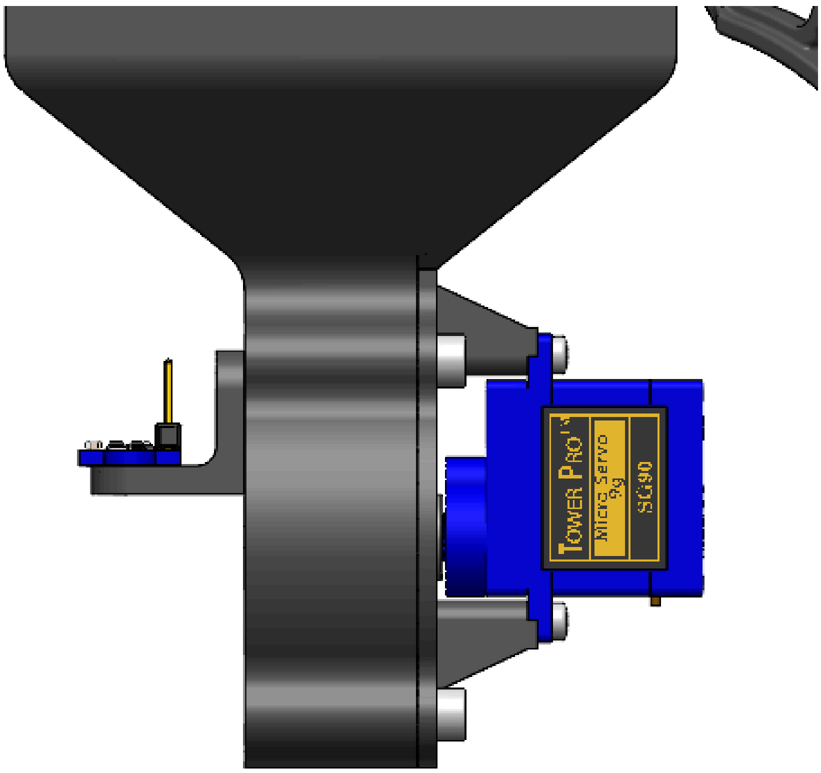


Annex 1.1 Overall view of the drone

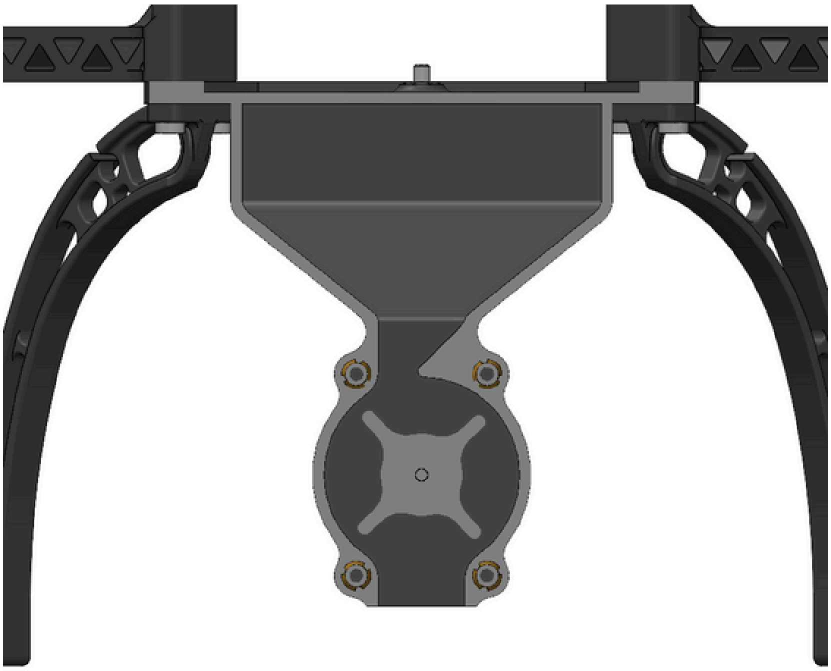
Annex 1.2 Loading Status



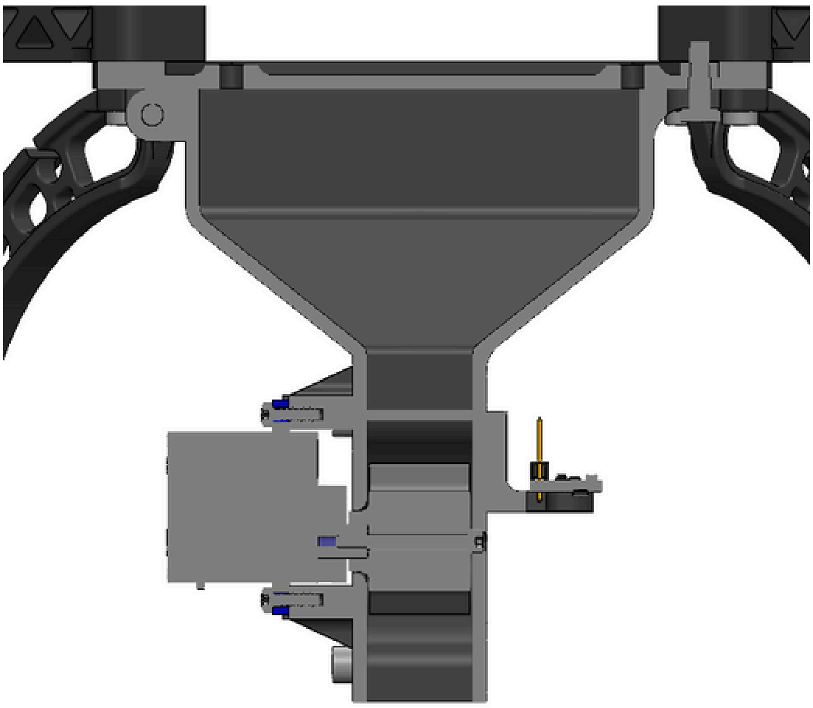
Annex 1.3 Drone arm with motor, propeller and landing leg



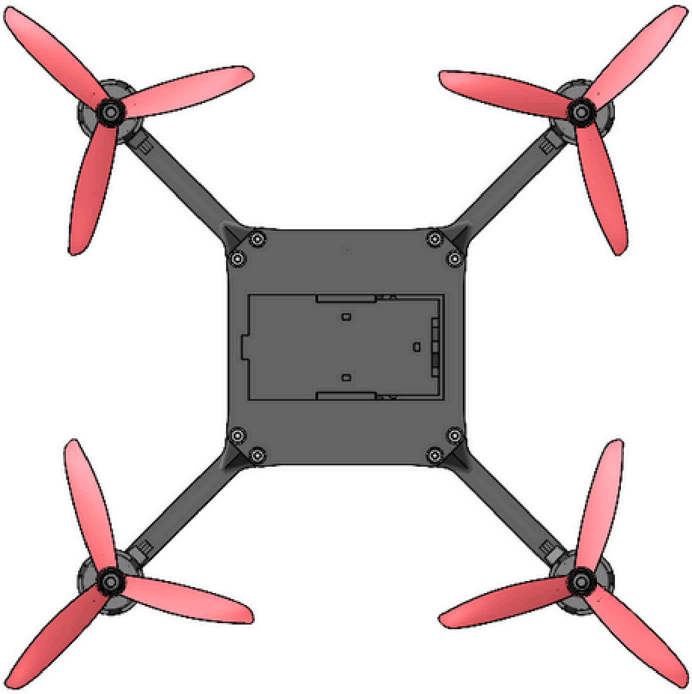
Annex 1.4 Bottom view of the hopper with rotary valve, servo motor, and distance sensor



Annex 1.5 Front-view section of the doser design.

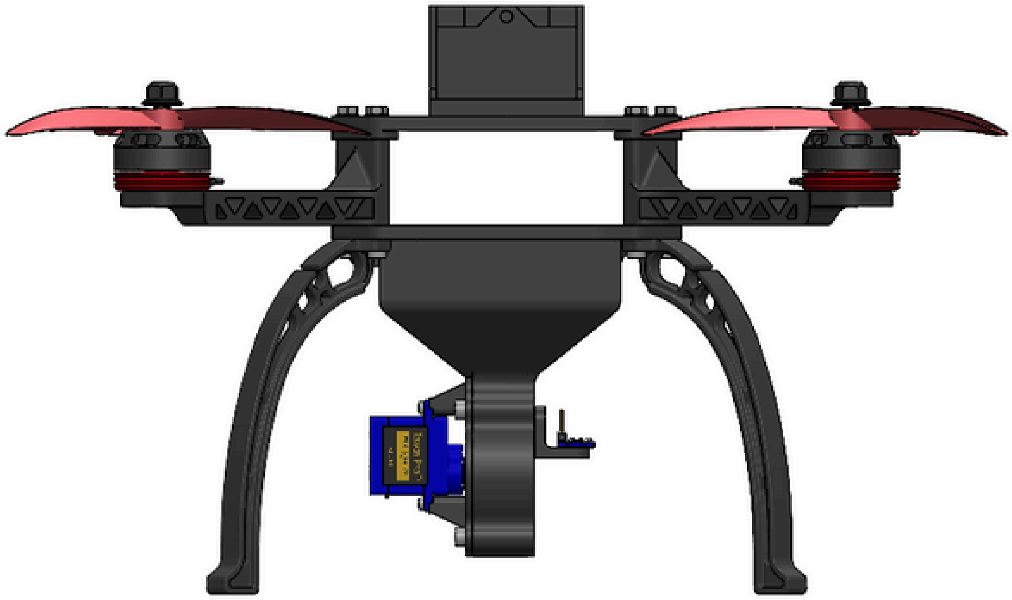


Annex 1.6 Side-view section of the doser design

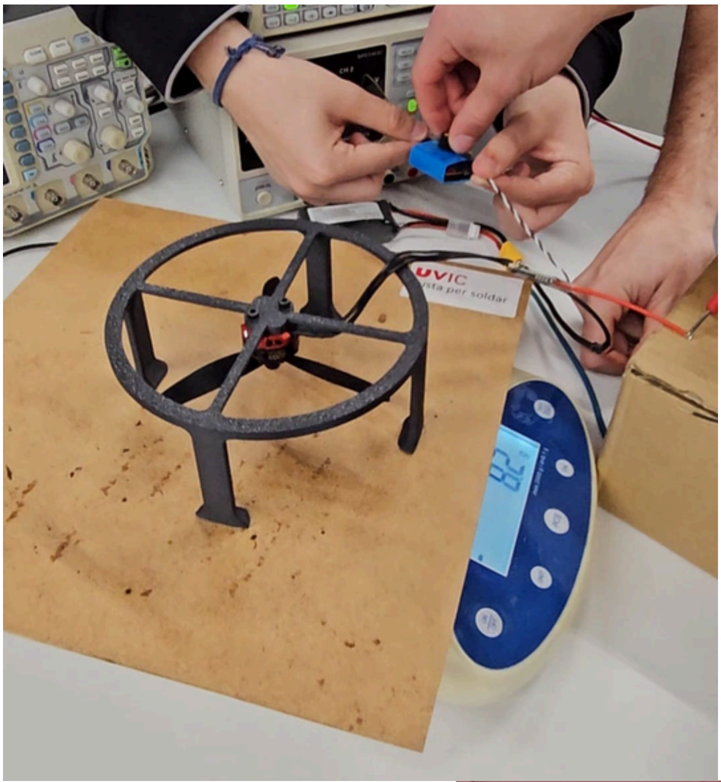


Annex 1.7 Top view of the full drone

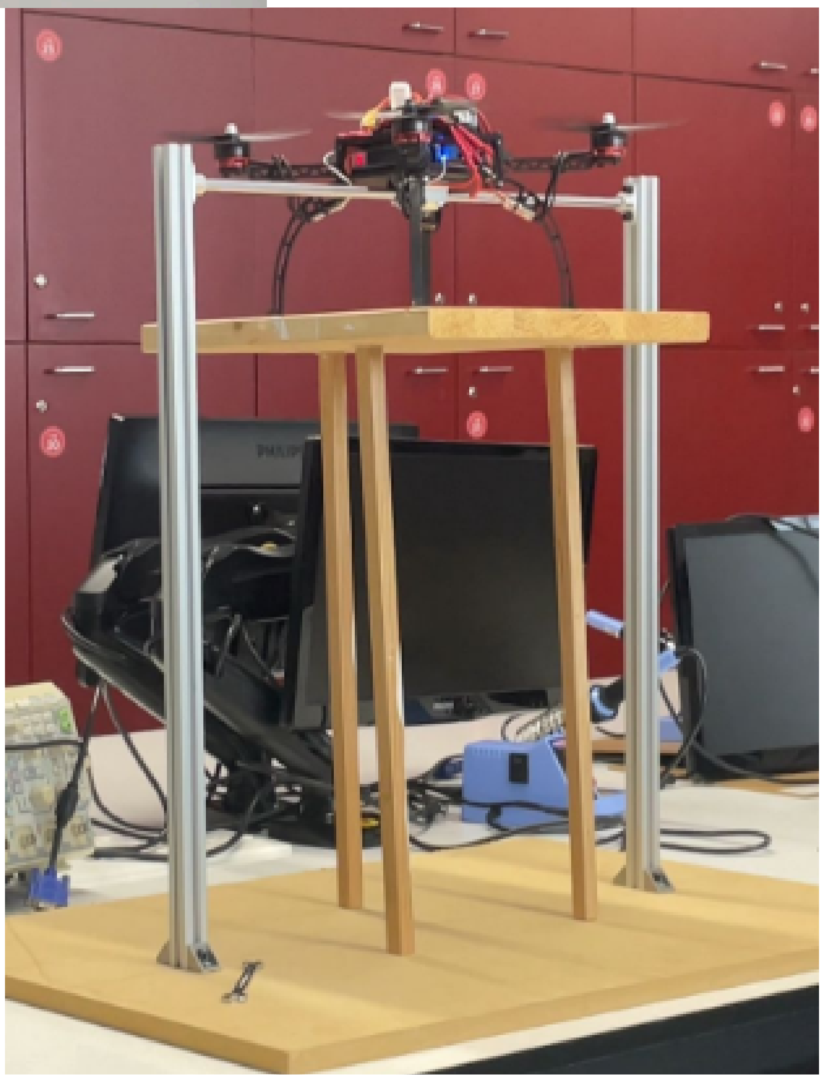
Annex 1.8 Front view of the full drone



Annex 1.9 Side view of the full drone



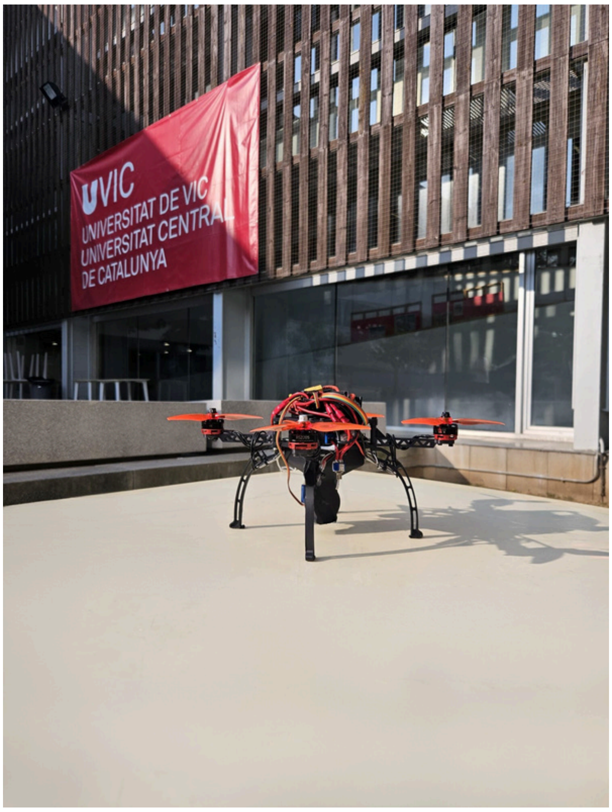
Annex 1.10 Thrust test



Annex 1.11 PIDs test photograph

Annex 1.12 Outside PID test

Annex 1.13 – Drone on the ground

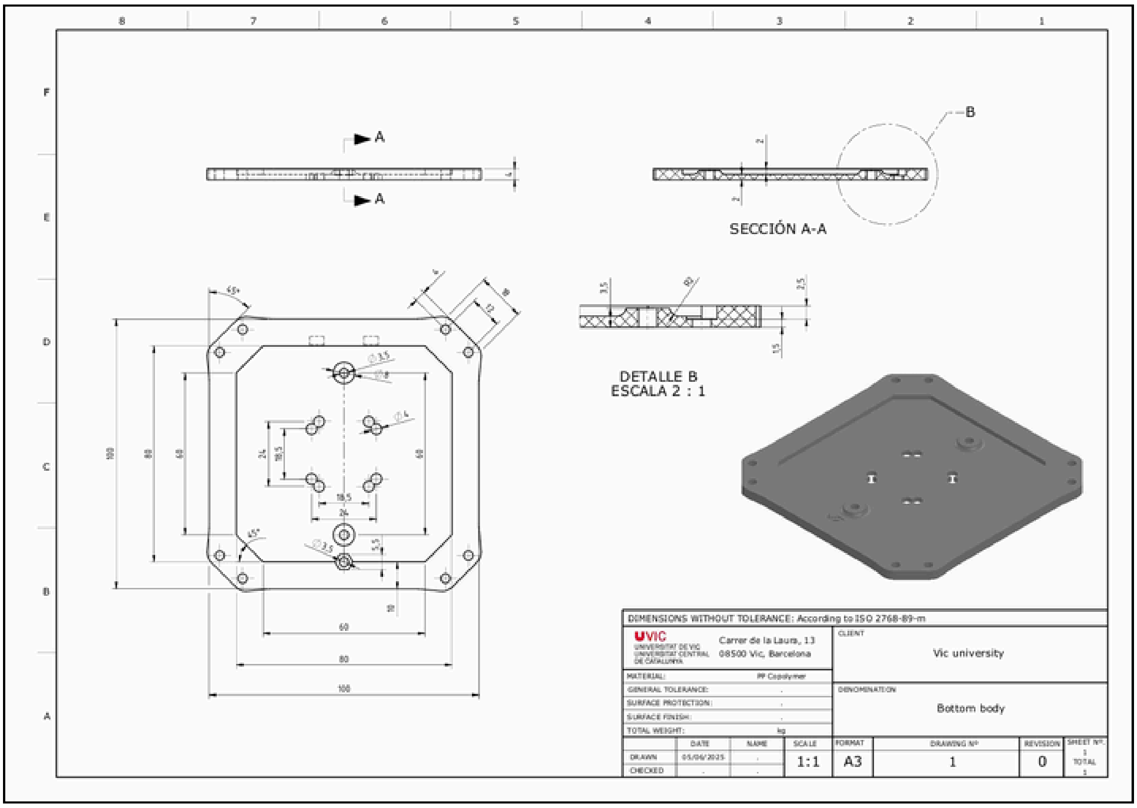


Annex 1.14 – Corporation image of the drone

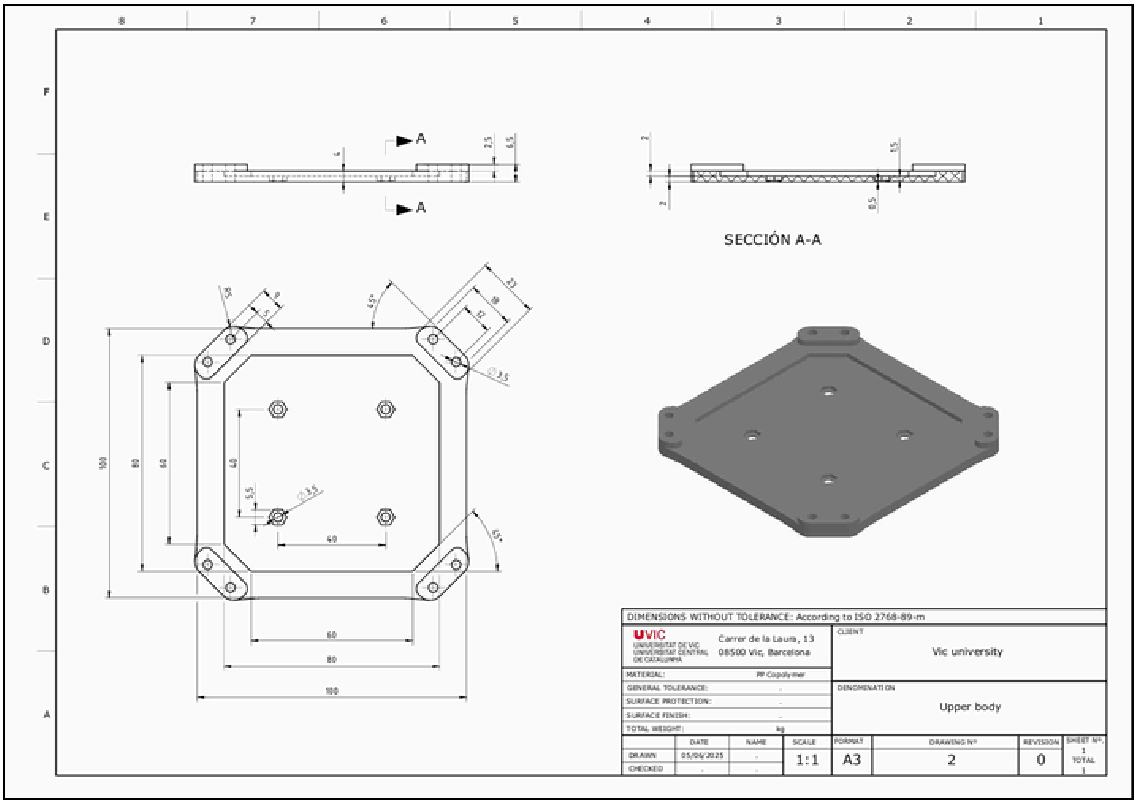
Annex 1.15 – Front view of the drone

Annex 1.16 – Bottom view of the drone

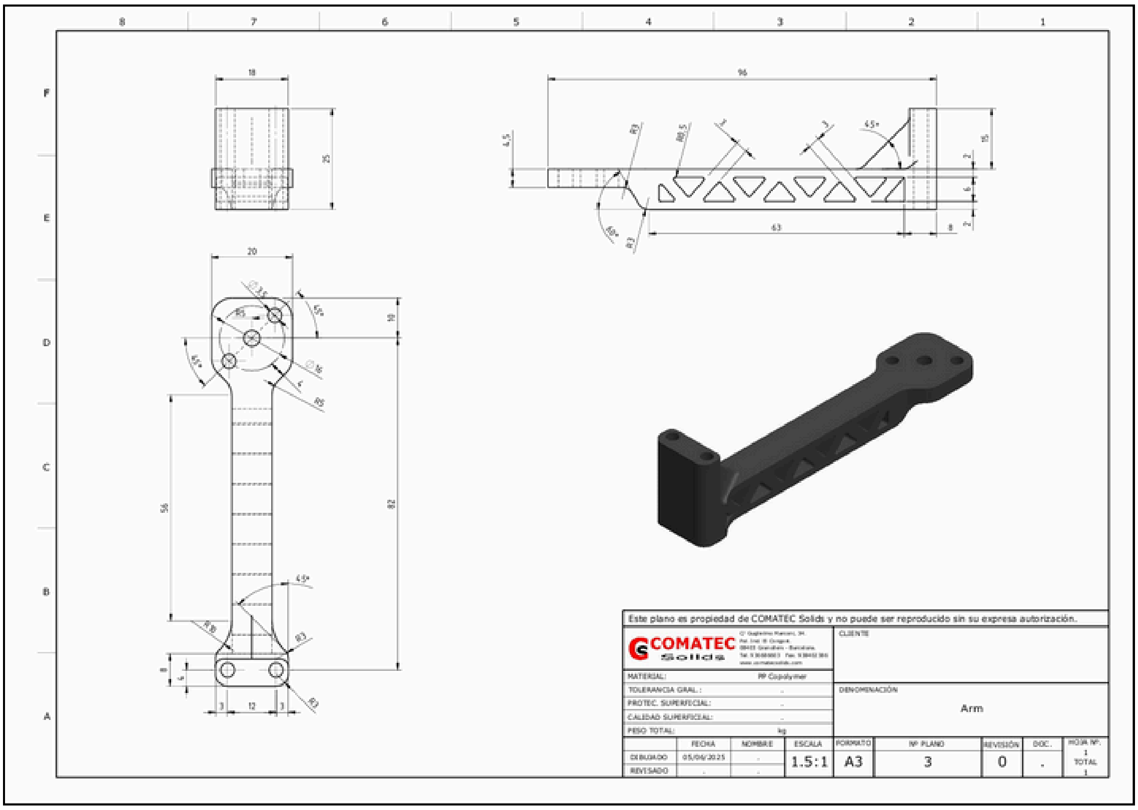
Annex 2 – Technical drawings of 3D printed parts



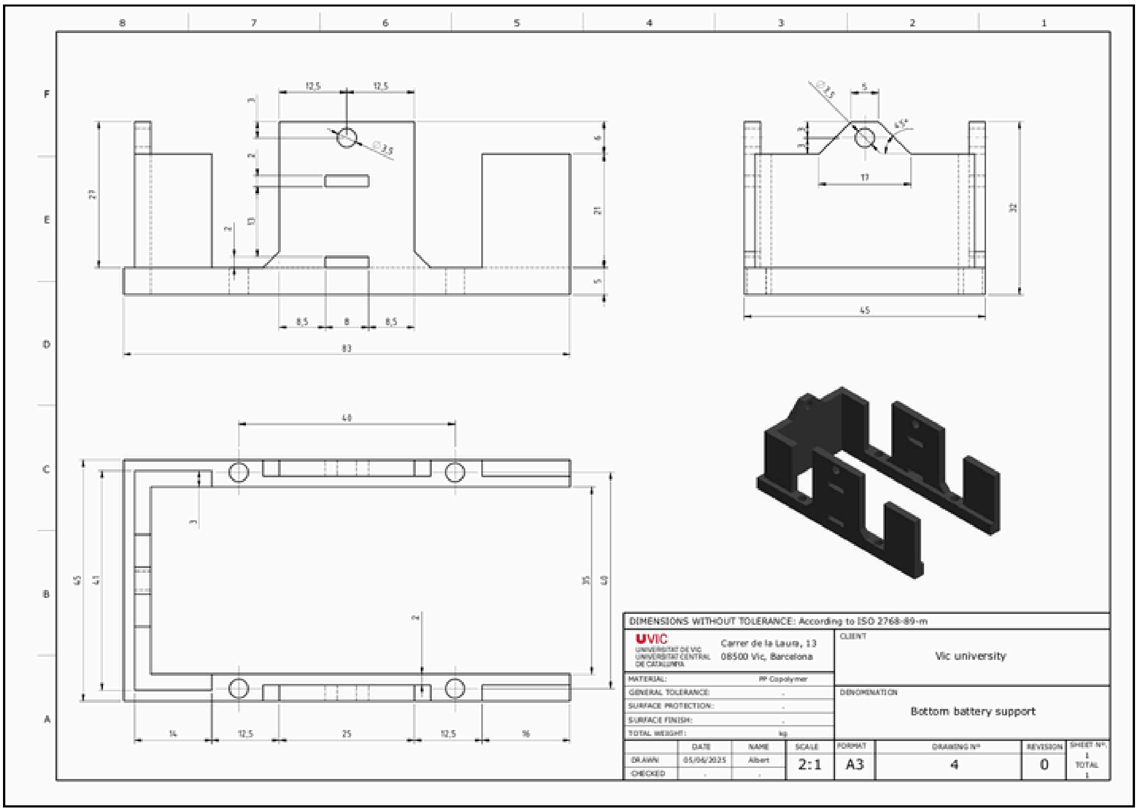
Annex 2.1 – Bottom Body



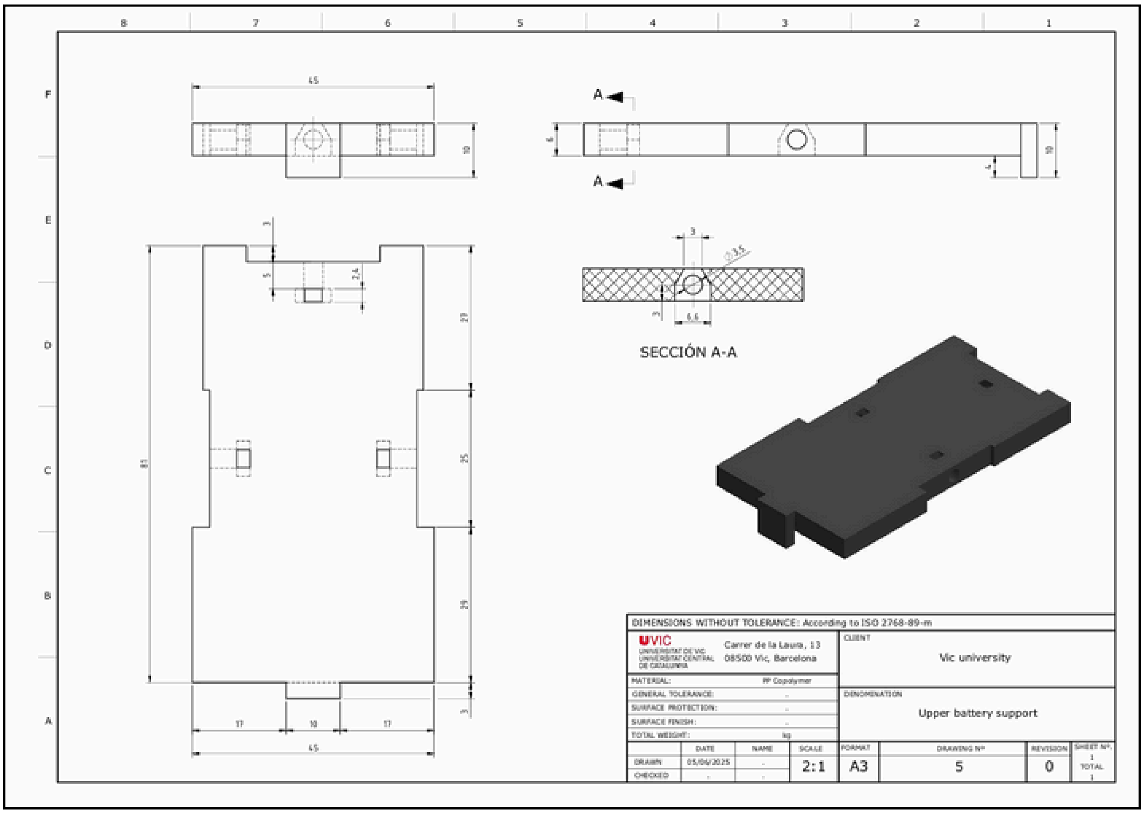
Annex 2.2 – Upper Body



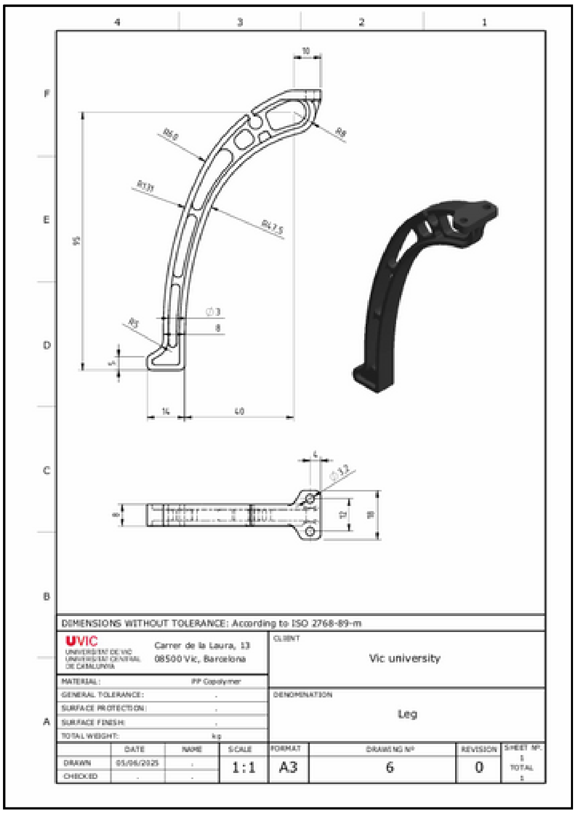
Annex 2.3 – Arm



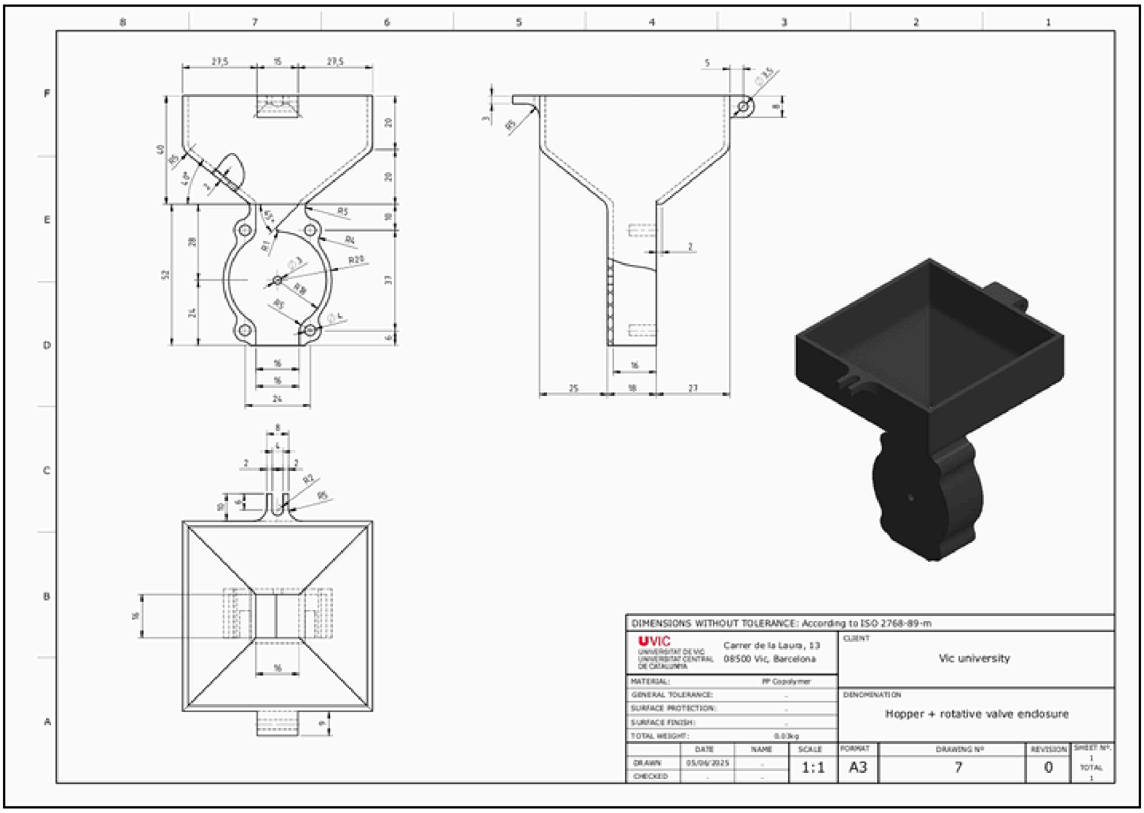
Annex 2.4 – Bottom Battery Support



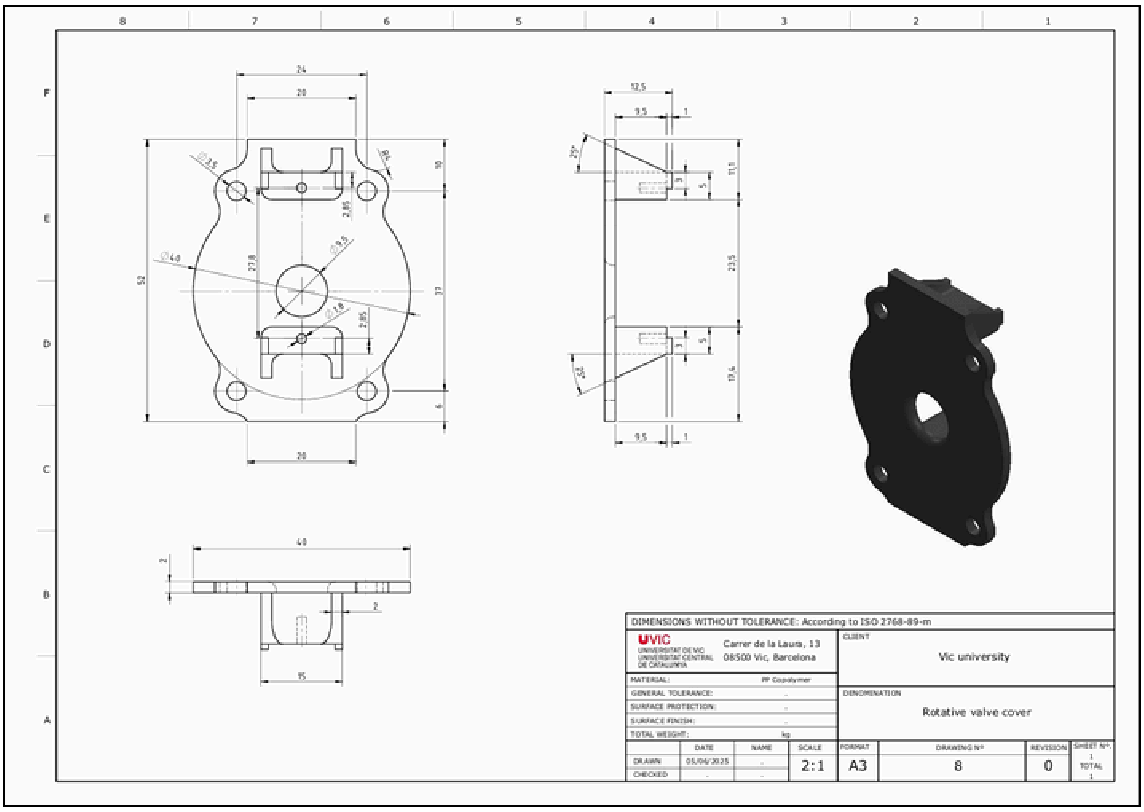
Annex 2.5 – Upper Battery Support



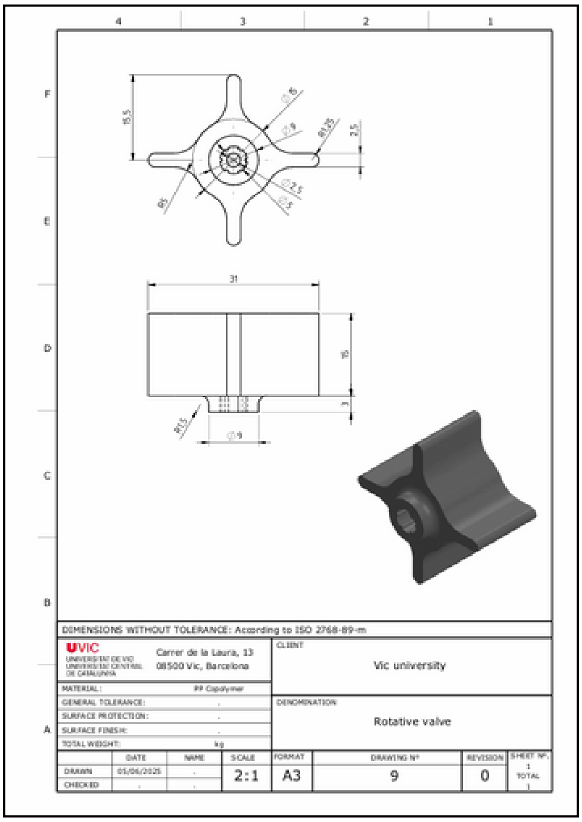
Annex 2.6 – Leg



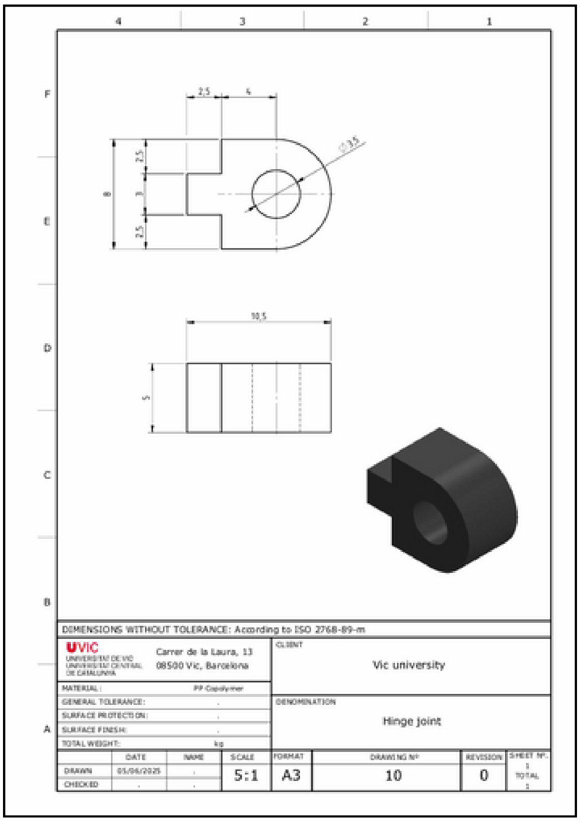
Annex 2.7 – Hopper + Rotative Valve Enclosure



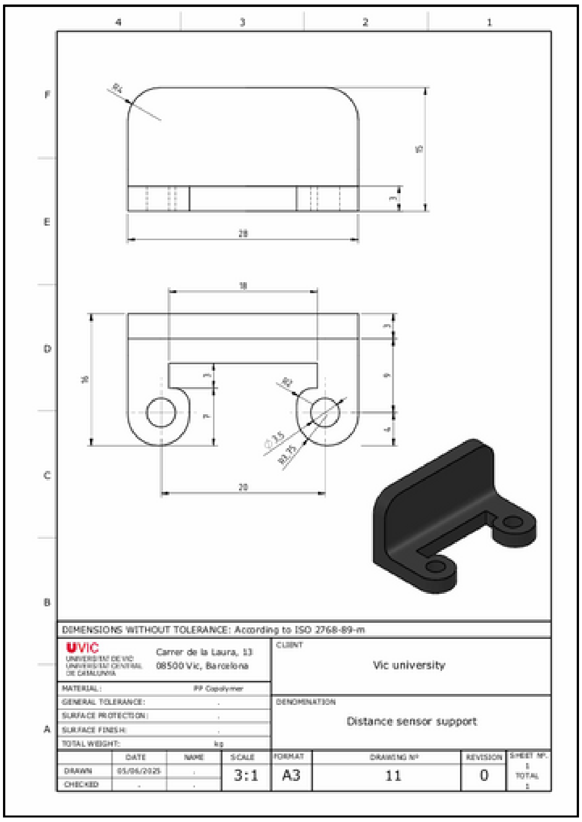
Annex 2.8 – Rotative Valve Cover



Annex 2.9 – Rotative Valve

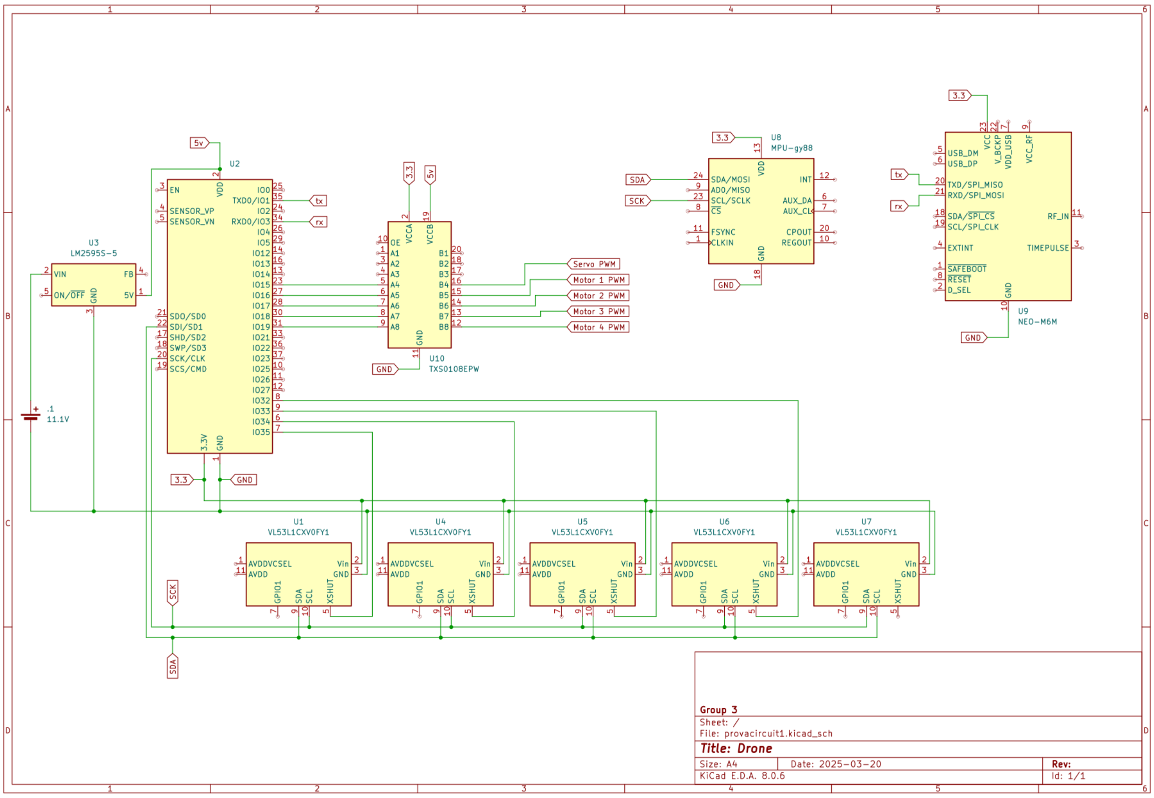


Annex 2.10 – Hinge Joint

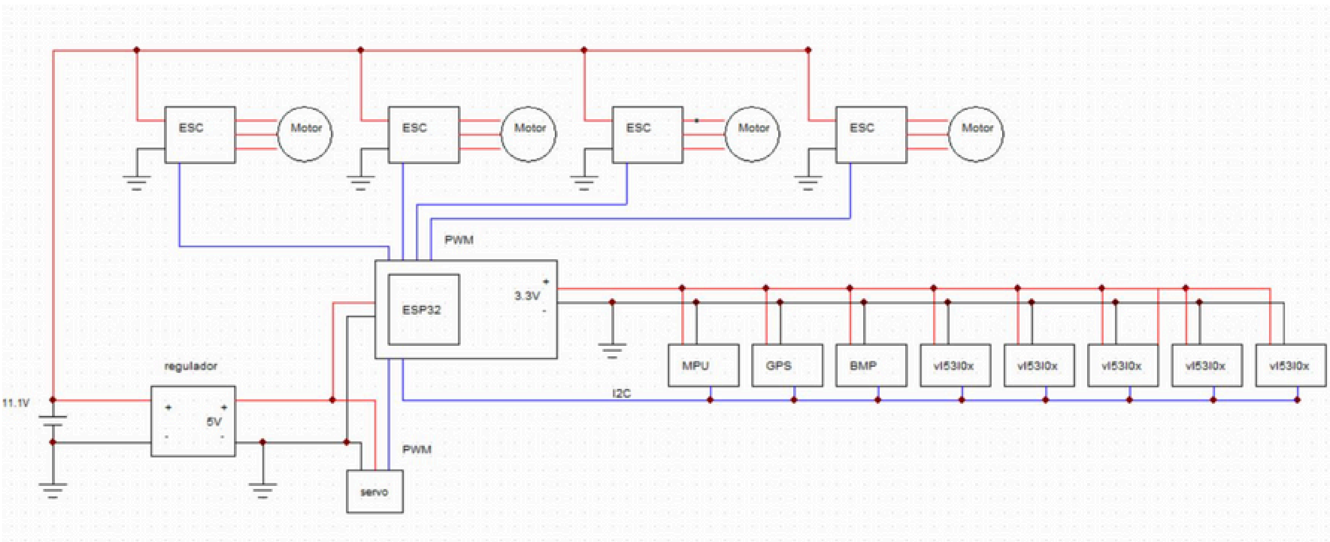


Annex 2.11 – Distance Sensor Support

Annex 3 – Additional content



Annex 3.1 – Electrical schematic



Annex 3.2 – Electrical bloc diagram