# Critical Design Review (CDR)

**Team:** Fusion PV
**School Name & City:** Szolnoki SZC Pálfy-Vízügyi Technikum, Szolnok
**Date:** 14 February 2026
**Video link:** Fusion PV Introduction

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# 1. INTRODUCTION

## 1.1 Introduction of the Team

Team Fusion PV is a student team from Szolnoki SZC Pálfy-Vízügyi Technikum in Szolnok. The team consists of students from different grade levels, working collaboratively on the design, construction, and testing of the CanSat system. Tasks and responsibilities were clearly divided to ensure efficient development and integration.

Ramón Lévai (Grade 13) is responsible for hardware development and overall system integration.
Gergő Farkas (Grade 13) is responsible for ground station software and hardware development.
Zsolt Balázsi (Grade 13) outreach activities, media, documentation and recovery system development.
János Balázs (Grade 9) assists the team in multiple areas as needed.

The team is professionally supported by Lajos Vigh who act as mentor and provide technical guidance and procurement support.

## 1.2 Mission Objectives

The primary objective of the mission is to design, construct, and successfully operate a CanSat that complies with all mechanical, electrical, and safety requirements of the CanSat Hungary competition.

The secondary mission focuses on environmental data collection and controlled orientation during descent or ground operation. The CanSat measures atmospheric pressure and temperature, determines its position using GPS, estimates orientation using inertial and compass data, and captures visual data using an onboard camera. Based on orientation and positional data, the system actively controls servos according to predefined logic.

A successful mission is defined as:

- Safe deployment and recovery of the CanSat,
- Continuous data acquisition during descent,
- Reliable telemetry transmission to the ground station,
- At least four hours of operational capability.

# 2. CANSAT DESCRIPTION

## 2.1 Overview of the Mission

The CanSat developed by Team Fusion PV is designed to be launched to an altitude of approximately max. 2 km, where it will be released and descend using an active recovery system, using micro-servos (SG92R) to slightly control the parachute towards a specific GPS coordinate. During descent and after landing, the satellite will continuously collect environmental and positional data and transmit telemetry to the ground station using a LoRa-based radio link, while also storing all data locally.

The CanSat will remain operational for a minimum of four hours, fulfilling the competition requirements. To be exact when not required our device operate in a low-power mode to increase the battery life significantly, launched this power-saving mode turns off manually. The system is built around a **Raspberry Pi Zero 2 W**, which handles data acquisition, processing, storage, and communication, at power-saving mode we downclock it as much as possible.

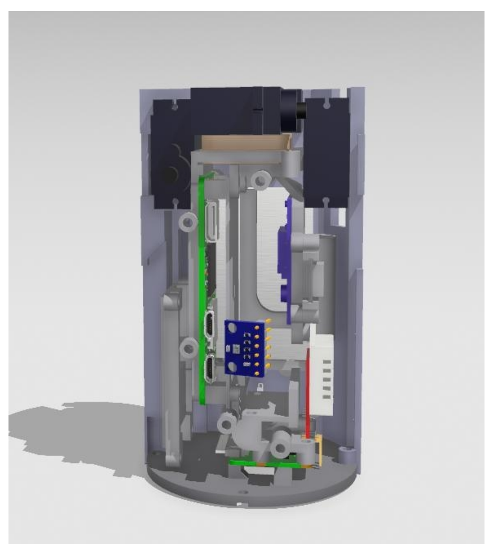
Critical subsystems include:

- Environmental sensors (pressure and temperature),
- Inertial and orientation sensors,
- GPS-based positioning,
- Optical data acquisition via camera,
- Long-range radio communication,
- Independent battery-powered electrical system.

## 2.2 Mechanical / Structural Design

For the structure, we went with an extraordinary design. We positioned the sensors and the Raspberry Pi vertically inside the prescribed dimensions and designed a frame where we can screw the sensors right up. After experimenting with the frame, shrinking and adjusting sizes, we designed a structurally stiff shell around it, which will hold the frame in the right place at several different points.

The frame itself does not provide sufficient structural stability, because instead of relying on the 3D-printed frame, we rely on the strength and stiffness of the sensors' PCBs, especially the Raspberry Pi's PCB, and the two-part shell, which will also be screwed onto the frame at several points. As of now, the structure may undergo minor revisions so the tolerances can be fine-tuned and all components can fit together properly.

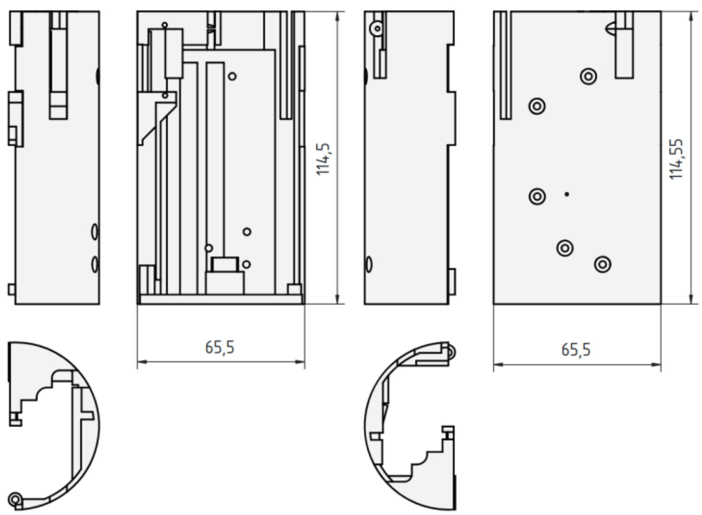


Inside The Shell

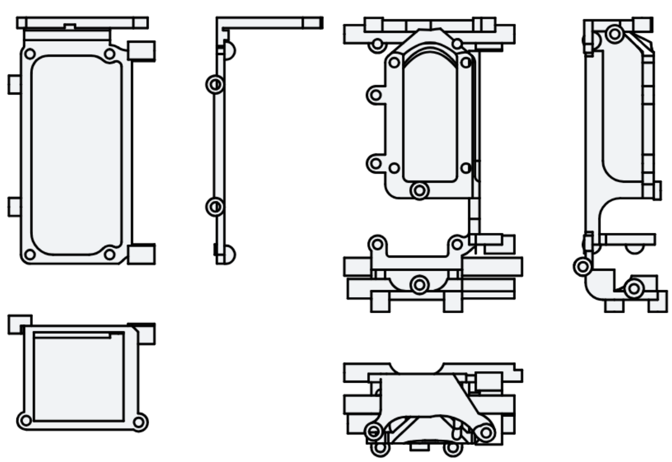
Because our CanSat is significantly lighter than the required minimum mass, we plan to fill the shell with pellets (3D printing pellets or nylon samples) to reach the required weight.

Due to the structure being unique, we needed materials capable of enduring extreme forces. For the internal frame, we plan to use either **TPU 98A** or **PET-G**, as these materials can absorb shock and are flexible enough to survive the high mechanical stress experienced during launch and landing. For the outer shell, we plan to use **ABS**, **ASA**, or **PA**, which depends on the tests later on.

All components are fixed using screw connections. This approach ensures mechanical robustness, ease of disassembly, and compliance with safety requirements. The complete structure is designed to withstand accelerations of up to 25 G.



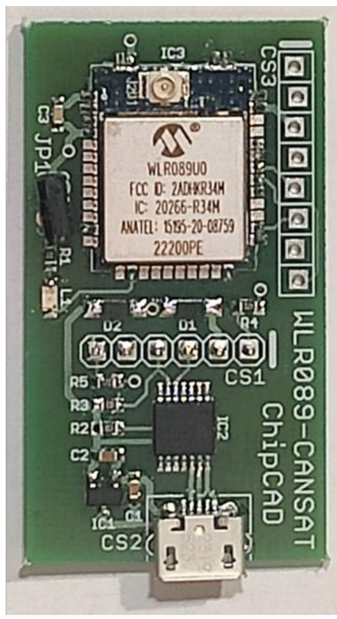

*Shell Design*



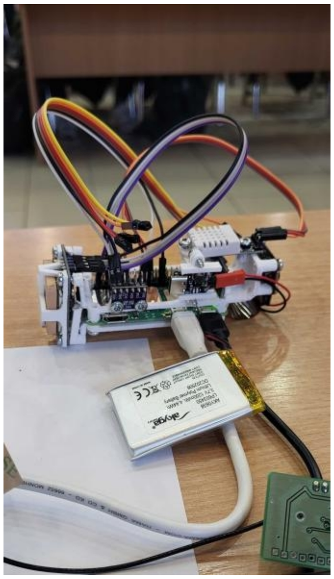
*Inner Frame Design*

## 2.3 Electrical Design

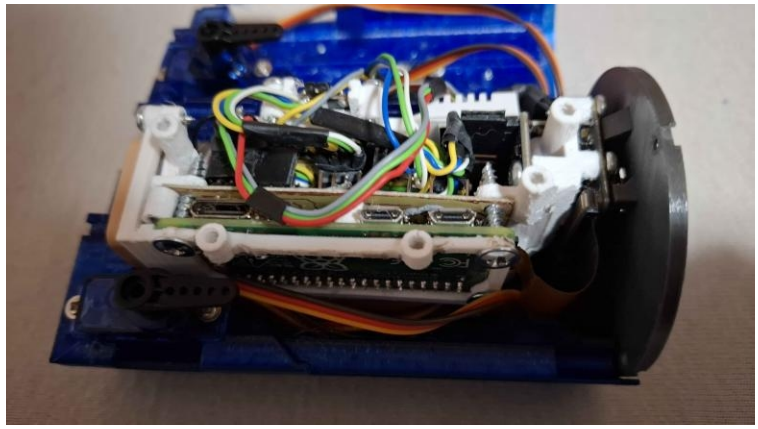
For the electrical design we have designed and fabricated a hat for our Raspberry Pi out of a one-sided PCB template, and etched out with $FeCl_3$. The hat breaks out all the ports necessary for the sensors and the servos, which is 7 $I^2C$ interface bridged together (not all will be used), 4 PWM outputs for the servos (servos are powered from the battery), a one-wire interface for the DHT22 and a single UART for the GPS module. We have directly soldered the hat onto the Raspberry Pi. The sensors and servos we chosen are all off the shelf products so we didn't need to design the PCB for them. The sensors are connected with pin rows which are technically secured by clutch well enough but they will also be secured by glue or epoxy to avoid any cable getting loose.




WLR089-CANSAT ChipCAD

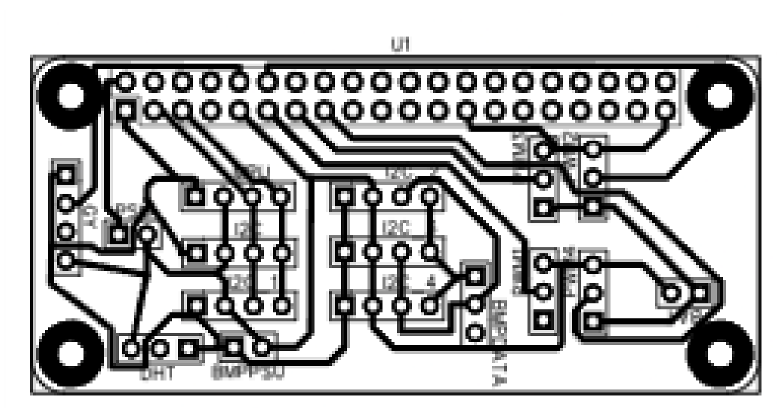


CanSat Prototype Without Shell



Inside The CanSat

We have gone with a Lithium Polymer battery. Going Lithium might seem risky, but our secondary missions need the raw power so we had to go with battery which can last us up to 4 hours. 4 hours might fit the requirement but to be safe we have designed a practical solution. We need the power when the device is in the air, but not when it is right at the ground, so before the monitoring and the recording would begin, the Raspberry Pi is downclocked to 600mHz. Before the launch of the satellite, we will put the device in a high-performance mode for 10 minutes. This can be easily done with TTY using Wi-Fi access and shell commands.




*Raspberry Pi Zero 2 W custom hat*

## 2.4 Software Design

The onboard software is written primarily in Python and runs on a Linux-based operating system. The software architecture is modular and event-driven, allowing reliable data acquisition, processing, storage, and communication throughout the mission.

A custom-developed frontend application is used to control mission logic related to navigation and orientation. Using real-time GPS position data and compass heading information, the software calculates orientation corrections and controls the servos accordingly. This enables directional alignment of the CanSat based on predefined mission logic.

Sensor data is collected via I²C and UART interfaces and processed by the Raspberry Pi. The processed data is packaged into structured telemetry frames. These telemetry packets follow two parallel paths:

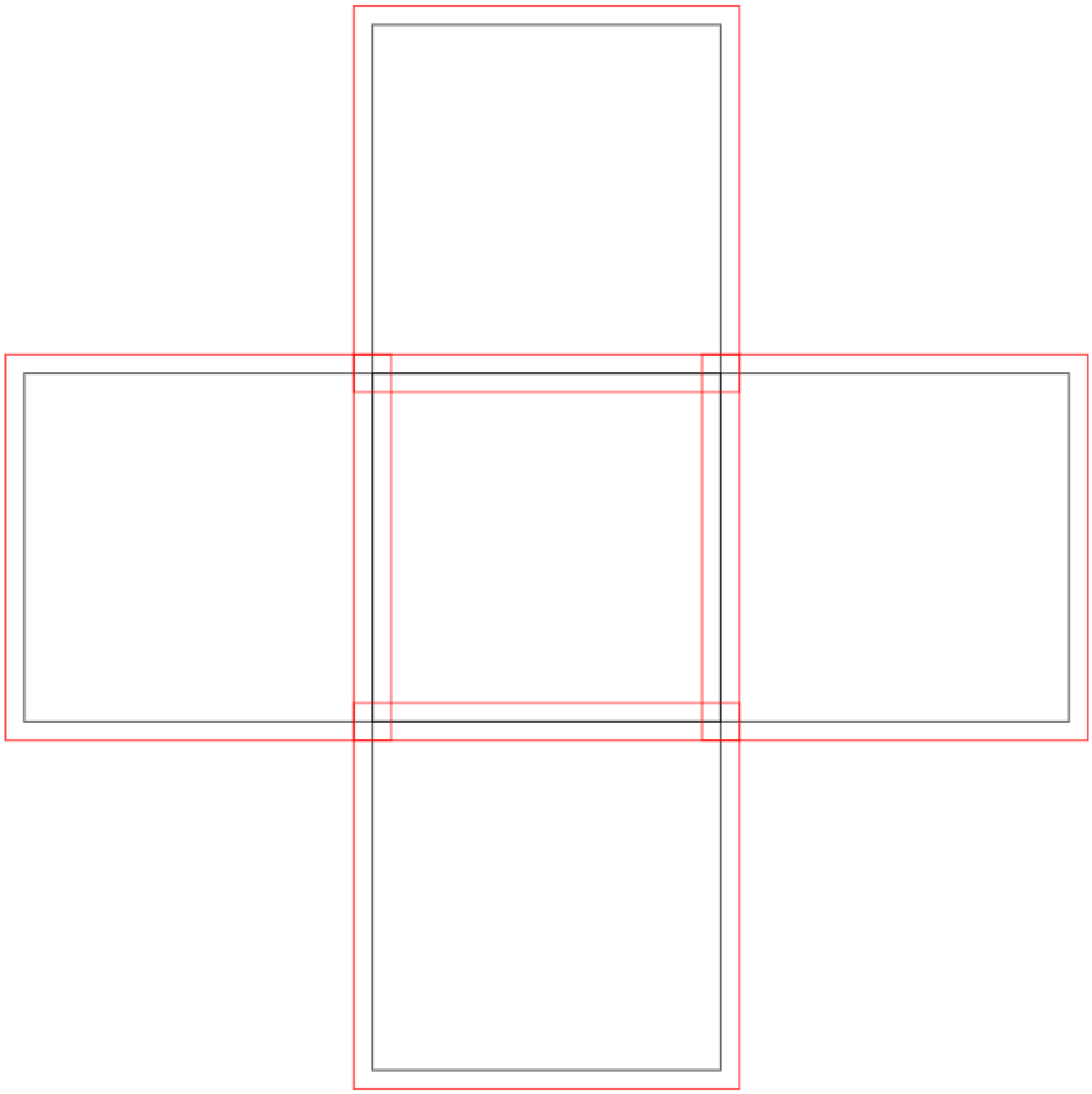
1. Real-time transmission to the ground station via the LoRa radio link,
2. Local storage on onboard memory for redundancy and post-flight analysis.

The system supports multiple operating modes, including a low-power monitoring mode and a high-performance mode. Mode switching is handled via Python scripts and Linux shell commands, enabling CPU frequency scaling and peripheral control.

The ground station software consists of a Unity-based frontend written in C#, which provides real-time visualization and user interaction, and Python-based backend scripts responsible for telemetry decoding, data logging, and communication handling.

## 2.5 Recovery System

The CanSat uses an active parachute-based recovery system to ensure a controlled and safe descent after release. The parachute is stored in the upper section of the CanSat and is mechanically attached inside in the main structural to 4 individual micro-servos (SG92R) using a reinforced cord connection designed to withstand forces exceeding 60 N, in compliance with the competition requirements.



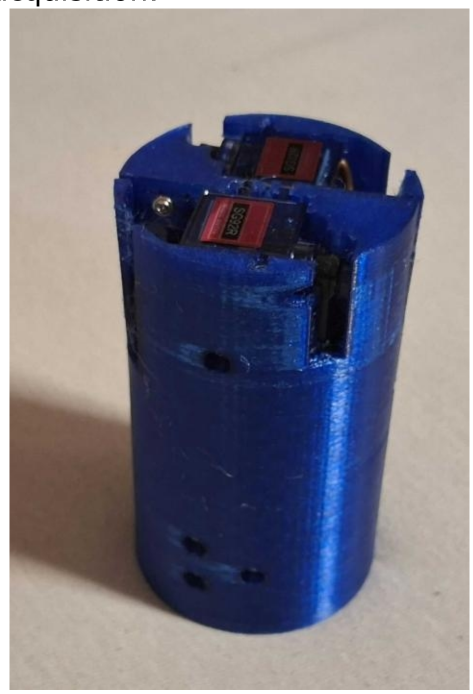
Parachute Blueprint

The parachute is made of lightweight, brightly colored fabric to improve visibility during recovery. Its attachment point is directly integrated into the structural shell, ensuring that the load during descent is distributed evenly across the structure.

Based on preliminary calculations and comparable CanSat configurations, the expected descent rate is between **8 and 10 m/s**, which falls within the recommended safety limits. This descent speed provides a balance between structural safety and recovery reliability while ensuring sufficient time for in-flight data acquisition.

No active deployment mechanism is used; the parachute is deployed immediately upon ejection from the launch vehicle. This design choice reduces mechanical complexity and increases overall system reliability. The recovery system is designed to be reusable after launch.

Ground-based drop tests are planned to verify the correct deployment of the parachute, the mechanical integrity of the attachment points, and the structural resistance of the CanSat during landing.



Recovery System Inside The CanSat

## 2.6 Ground Station

The ground station is responsible for receiving telemetry data transmitted by the CanSat during descent and after landing. It consists of a laptop computer, a USB-connected LoRa receiver module, and a suitable antenna compatible with the selected frequency band.

The CanSat communicates with the ground station using a LoRa-based radio link operating in a frequency band compliant with Hungarian radio amateur regulations. The exact operating frequency will be defined by the competition jury prior to the launch campaign. The system is designed so that the radio frequency can be modified via software, even on the day of the event, as required by the competition rules.

Our most preferred radio frequency band is **868.1 MHz**.

The ground station software is responsible for:

- Receiving and decoding telemetry packets,
- Displaying real-time sensor data,
- Logging received data for post-flight analysis,
- Monitoring signal strength and link stability.

All received telemetry data is time-stamped and stored locally on the ground station computer. The system is designed to operate continuously throughout the entire mission duration and during post-landing operation.


LoRa Antenna

Coded packet:
ACBEBF18F43F53FBF1929E04FAF02410E506F9990E00F23E7FF58E2F0E02FFD0E01FF0E98FF0E12FFD0E35FF0E03F24E1F100985F127E3

Decoded packet: 18,43,53,B,1929.04,A,02410.506,9990.00,23.7,58.2,0.02,-0.01,0.98,0.12,-0.35,0.03,24.1,100985,127.3

| | | | |
|---|---|---|---|
| Time | t1 | 18 | |
| Time | t2 | 43 | |
| Time | t3 | 53 | |
| GPS | Latitude hemisphere | B | North |
| GPS | Latitude | 19.2904° | 1929.04 / 100 |
| GPS | Longitude hemisphere | A | East |
| GPS | Longitude | 24.10506° | 02410.506 / 100 |
| GPS | Altitude | 9990.00 m | |
| DHT22 | Temperature | 23.7 °C | |
| DHT22 | Humidity | 58.2 % | |
| MPU9250 | Accel X | 0.02 g | |
| MPU9250 | Accel Y | -0.01g | D → negative |
| MPU9250 | Accel Z | 0.98g | |
| MPU9250 | Gyro X | 0.12 | |
| MPU9250 | Gyro Y | -0.35 | |
| MPU9250 | Gyro Z | 0.03 | |
| BMP280 | Temperature | 24.1 °C | |
| BMP280 | Preassure | 100985 Pa | |
| BMP280 | Altitude / Height | 127.3m | |

# 3. PROJECT PLANNING

## 3.1 Time Schedule

**Feb 2026:** Assembly, parachute, communication test and minor code modifications if needed;
**Mar 2026:** Field tests, data collection, competition, presentation

## 3.2 Resource Estimation

### 3.2.1 Budget

| **Component / Item** | **Unit Cost (EUR)** |
|---|---|
| Raspberry Pi Zero 2 W | 10.55 € |
| Custom Raspberry Pi HAT PCB & Materials | ≈ 3 € |
| BMP280-M Sensor | 0.57 € |
| MPU9250-M Gyroscope/IMU | 5.88 € |
| Raspberry Pi Camera Module 3 NoIR | 13.56 € |
| WLR089-CANSAT ChipCAD (LoRA) | 45 € |
| GPS Module (GY-NEO6MV2) | 6.15 € |
| Battery – AKY0622-LP883440 | 5.33 € |
| Servos (4× SG92R) | ≈ 12 € |
| Miscellaneous (cables, connectors, screws) | ≈ 8 € |
| Parachute and Recovery Materials | ≈ 10 € |
| 3D Printing Materials (ABS / TPU / PET-G) | ≈ 8 € |
| Power Management & Charging Module | ≈ 5 € |
| Total | ≈ 140 € |

### 3.2.2 External support

The CanSat project is primarily developed using the resources of **Szolnoki Szakképzési Centrum** and also **our school** provides access to basic laboratory equipment, 3D printing facilities, and computing resources required for design and development.

At the time of submission, no industrial sponsors are involved in the project. The team relies on publicly available documentation, manufacturer datasheets, and open-source software libraries. External professional expertise is not strictly required; however, access to additional RF measurement equipment would further improve communication testing.

#### 3.2.3 Test Plan

A comprehensive test plan has been defined to verify that the CanSat meets all functional, mechanical, and safety requirements.

Planned tests include:

- **Electrical functionality test:** Verification of sensor readings, GPS fix acquisition, camera operation, and servo control.
- **Communication test:** LoRa link testing between the CanSat and the ground station, including range and data integrity tests.
- **Power consumption test:** Measurement of current draw in different operating modes to validate the energy budget.
- **Software test:** Validation of data logging, mode switching, and fault-free operation over extended periods.
- **Mechanical integrity test:** Inspection of structural stability and fastening after assembly.
- **Recovery system test:** Ground-based drop tests to verify parachute deployment, attachment strength, and landing survivability.

All tests will be documented, and any identified issues will be addressed prior to the launch campaign.

# 4. OUTREACH PROGRAMME

The outreach activities of Team Fusion PV focus on promoting STEM education and raising awareness of the CanSat competition within the local community.

Planned outreach activities include:

- Presentations at the team's school to introduce the CanSat project to fellow students.
- Informal demonstrations of the CanSat prototype during school events or open days.
- Informations about this project in our school's digital notice board.

At the time of CDR submission, no public social media platforms are actively maintained. These will be created and populated during the later phases of the project to comply with outreach requirements.

## 5. REQUIREMENTS

The CanSat is designed to meet all dimensional, mass, power, and safety requirements of the CanSat Hungary competition.

| Characteristics | Quantity (unit) | Requirement | Eligible (Yes or No) |
|---|---|---|---|
| Height of the CanSat | 114,9 mm | 114-115 mm | yes |
| Mass of the CanSat | 320 g (with ballast) | 300–350 g | Yes |
| Diameter of the CanSat | 65.9 mm | Max. 66 mm | yes |
| Length of the recovery system | Within limits | 40 mm | yes |
| Flight time scheduled | < 120 s | Max. 120 s | yes |
| Calculated descent rate | 8-11 m/s | 5–12 m/s | yes |
| Radio frequency used | LoRa (jury assigned) | Adjustable via software | yes |
| Power consumption | > 5 h operation | ≥ 4 h operation | yes |
| Total cost | ≈ 140 EUR | ≤ 500 EUR | yes |

## 5.1 Preliminary Energy Budget

| Device | Voltage | Current | Power |
|---|---|---|---|
| **Raspberry Pi Zero 2 W** | **5 V** | **max. 350 mA** | **max. 1,75 W** |
| **DHT22** | **3,3 V** | **1-2 mA** | **3,3 – 6,6 mW** |
| **BMP280-M Sensor** | **3,3 V** | **2,7 μA** | **9 μW** |
| **MPU9250-M Gyroscope/IMU** | **3,3 V** | **4,5 mA** | **15 mW** |
| **Raspberry Pi Camera Module 3 NoIR** | **3,3 V** | **max. 400 mA** | **max. 1,32 W** |
| **WLR089-CANSAT ChipCAD (LoRa)** | **5 V** | **max. 115 mA** | **max. 575 mW** |
| **GPS Module (GY-NEO6MV2)** | **3,3 V** | **45 mA** | **150 mW** |
| **Servos (4× SG92R)** | **3-4,2 V** | **133 mA – 1,9 A** | **0,04-8 W** |
| **Total Power (sum of all)** | **/** | **/** | **0,93-11,82 W** |

The batteries will last about 4,5 hours.