cansats in europe

TeamVLO CanSat Preliminary Design Review

Team Name: TeamVLO

Country: Poland

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www.cansat.eu

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1 INTRODUCTION

1.1 Team organisation and roles

Our mentor is **Dr Dawid Kotrys**. He is our math's teacher and the tutor of our class. He always devotes to all projects proposed by his students. He supports our team computationally and he motivates us to the action.

Emil Kielar is our team leader. He found the information about the competition and started our team. He supervises all the work and sets the tasks individually for every team member. Emil is interested in coding as well as electronics. He is responsible for them during the mission. With the help from Mr. Kotrys, they will cover the computational site, which will allow us to design and build our CanSat.

Krzysztof Janota is a lover of aeronautics that's why he engaged into the project. Krzysiek knows very well the construction of airplanes and their dynamics, what will help us greatly in the project. He is responsible for mechanical design and recovery system design.

Zuzanna Sekta is a girl with her head in stars. She is interested in Space and Astronautics. Zuzia always have a lot of good ideas, what is very helpful during the planning of this mission. She wants to master her knowledge in coding and that's why she is helping Emil in it. Zuzia also wants to master her knowledge in Astronautics.

Julia Zielińska is responsible for reporting, describing our activities and outreach programme. She is endowed with literary skills. Julka is also picking up on small errors and she is an attentive observer what allows her to correct our errors. She is still looking for her interests and she hopes that this competition will help her in it.

1.2 Mission objectives

The objective of our mission is to collect data from the sensors of the primary mission and the secondary mission to determine whether the planet and the area where our CanSat is landing is suitable for growth of plants. We will also take photos which will allow us to measure vegetation index of the area where our CanSat is landing. We were inspired to select this secondary mission by the mission of Perseverance rover which is looking for signs of life on Mars. In order to consider our CanSat launch successful, we have to get several photos of the landing area from different heights as well as the readings from the sensors.

2 CANSAT DESCRIPTION

2.1 Mission overview

The secondary mission of our CanSat is to determine whether the planet and the landing site is suitable for growth of plants. When our CanSat is launched from the rocket, the parachute will be opened, and it will take photos of the landing site using the near infrared camera (Raspberry Pi NoIR camera) located on the bottom of CanSat. Every photo will be analyzed, and we will measure Normalized Difference Vegetation Index (NDVI), using Red and Near Infrared band from the photo and a code written by our team. The code will prepare photos with marked NDVI colors (as on the picture below):

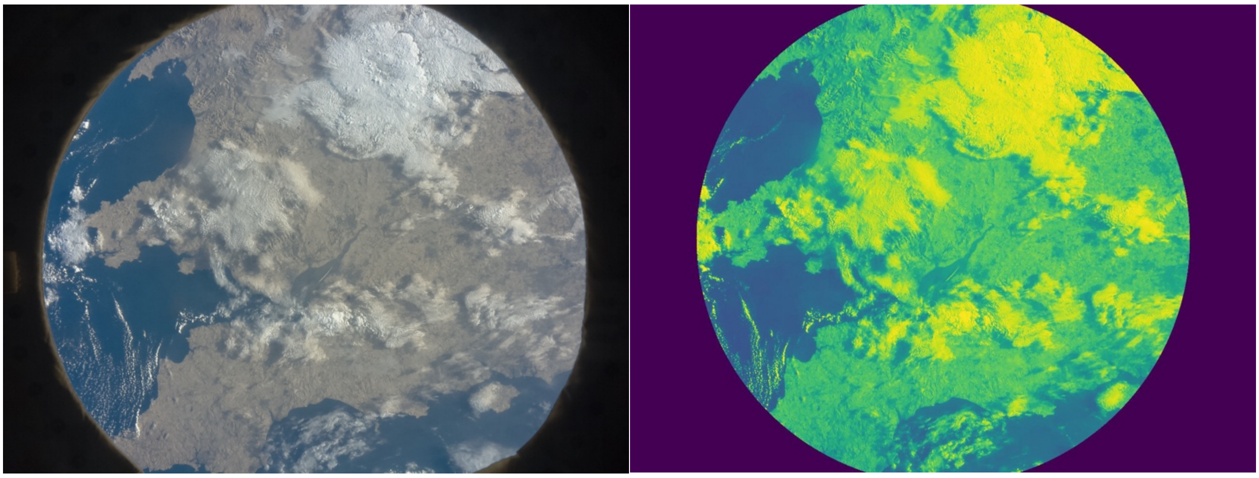


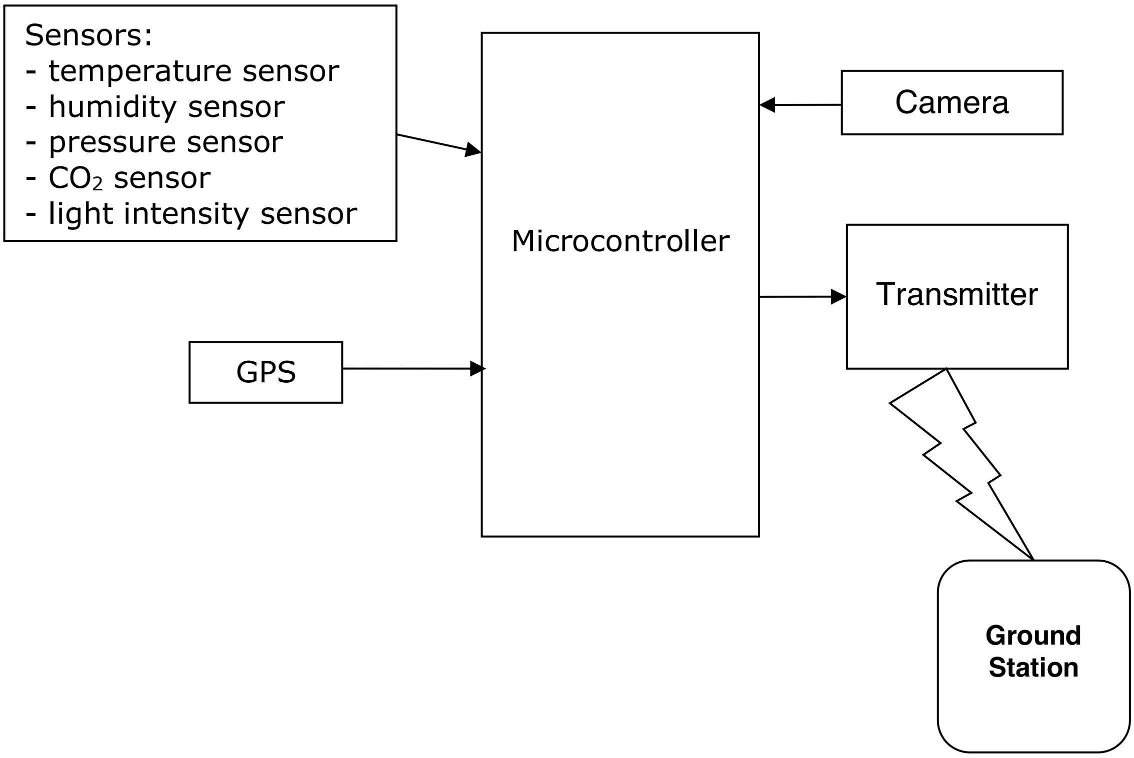
Figure 1: original photo (on the left), marked NDVI photo (on the right)

During the flight our satellite will measure temperature, humidity, air pressure, CO_2 level and sunlight intensity. These data will allow us to determine whether conditions in the place of landing are suitable for growth and life of plants (water, temperature, sunlight and CO_2 needed for photosynthesis)

We will analyze all the data after the landing and after a deep analysis of it, we will determine whether the landing site is suitable for growth of plants. In case our CanSat

isn't found, we will send via radio few photos and the readings from the secondary mission sensors after the landing of CanSat.
The primary mission of our CanSat will be conducted using temperature sensor, air pressure sensor and radio transmitter sending the data from those sensors to our ground station.

We will also put a GPS locator, that will send the GPS coordinates to our ground station via radio. The block diagram of our CanSat looks as follows



2.2 Mechanical/structural design

2.2.1 Materials

To make the main body of our CanSat we will use 3D printer. All design elements will be 3 mm thick. Material used to build our construction is ABS plastic.

2.2.2 Realization

Our design will be divided into 4 separate segments:

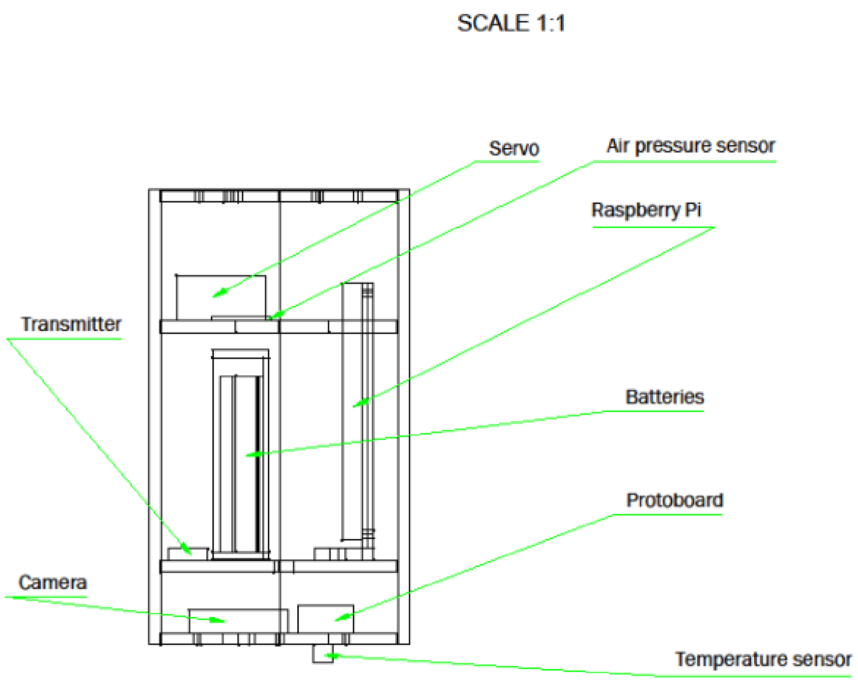


Figure 2: Side view of the CanSat

Segment a: Camera and temperature sensor section which consists of camera, temperature sensor, protoboard and CO_2 sensor (not included on the figure below)

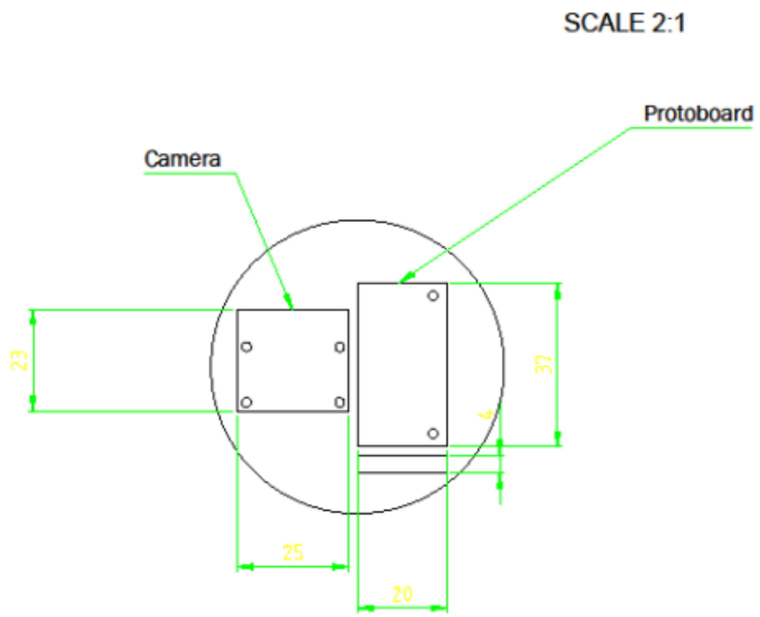


Figure 3: Segment a

Segment b: Power source and motherboard section which consists of batteries, Raspberry Pi Zero and a Transmitter.

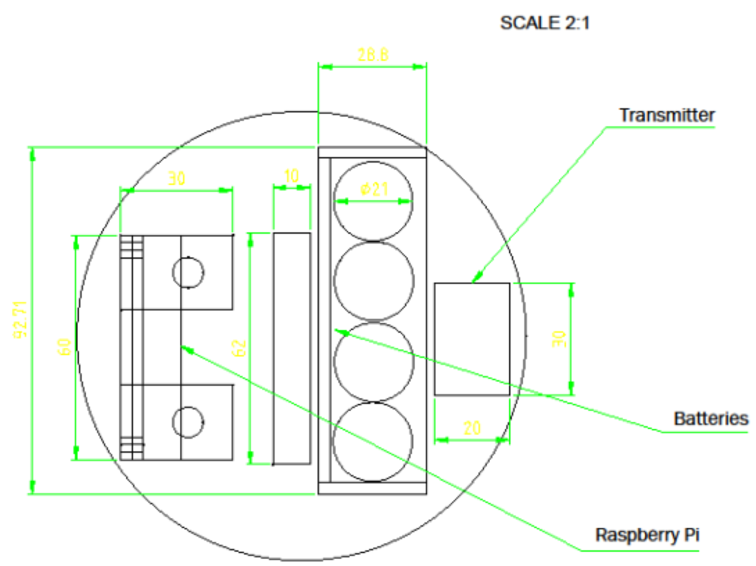


Figure 4: Segment b

Segment c: Recovery system section which consists of servo, air pressure sensor and light intensity sensor (not included on the figure below)

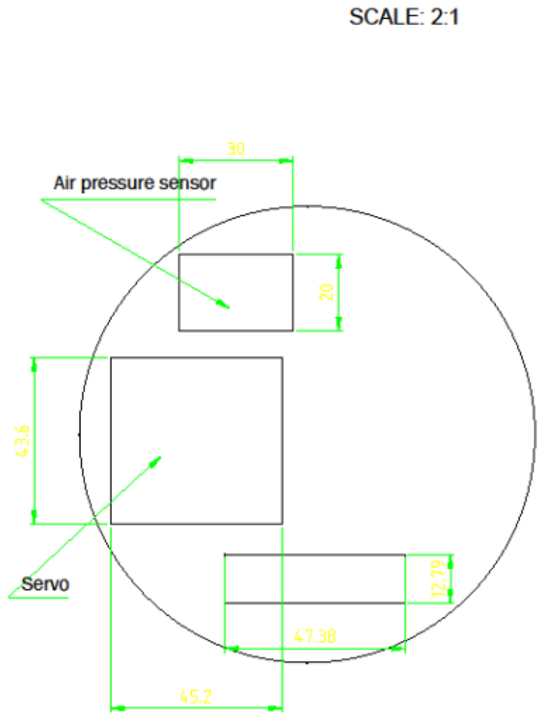


Figure 5: Segment c

Segment d: Parachute section which consists of the main parachute, the auxiliary parachute, and an antenna.

2.2.3 Mass

Overall mass of our CanSat is about 246 g. It's too little so we will add some weight so that the mass is correct. The table represents a mass of each element:

Element	**Mass (g)**
Raspberry Pi Zero W 512 MB	9
Raspberry Pi NoIR v2 Camera	2
Temperature sensor LM-35	0,6
Air pressure BMP-280	1
4 Li-Ion baterries	100
Servo SG-90	9
Case	71,4
GPS	7
Transmitter	10
Humidity sensor	1

Light intensity sensor	~15
CO_2 sensor	~20

2.3 Electrical design

2.3.1 General architecture

The system of our CanSat will be powered by lithium-ion batteries (the exact model of batteries will be decided during the construction of CanSat). Our main onboard computer will be Raspberry Pi Zero. We will also use consecutive sensors: Raspberry Pi NoIR Camera v2, DHT22 temperature and humidity sensor, BMP280 air pressure sensor (the one from the CanSat starter kit), CO_2 sensor, light intensity sensor, radio module and GPS module. Here is a simple block diagram showing our electrical system:

2.3.2 Primary mission devices

In the primary mission we will use temperature sensor and air pressure sensor. The readings from them will be sent to the ground station via radio. The readings from the air pressure sensor will allow us to count how high the CanSat is. We will also use readings from these sensors in our secondary mission: temperature and air pressure readings will allow us to determine whether the conditions on the planet are good for growth of plants.

2.3.3 Secondary mission devices

In the secondary mission we will use the camera module, CO_2 sensor, light intensity sensor, humidity sensor and GPS module. The readings from those sensors will be sent via radio after the landing of CanSat. The photos will be sent via radio after the landing as well as the GPS coordinates (to locate our CanSat).

2.3.4 *Power supply*

We will use the lithium-ion batteries to power our CanSat. The voltage needed to power our onboard computer is 5V, so our batteries will give together at least this value of voltage. The batteries will allow our CanSat to work for at least 8-12 hours.

2.3.5 *Communication system*

We are going to use a radio transmitter compatible with Raspberry Pi. The module will be compatible with both Polish and European CanSat regulations. We are going to use a module like X-Bee, Lora or APC220. For the ground station we will use the radio transmitter from the CanSat kit or if it isn't compatible with the module in the CanSat, we will use another consistent module.

2.4 Software design

We will write our code in Python. The Raspberry Pi and other modules used in our CanSat are compatible with this language. The Ground station code will be written in Python or C. We will use consecutive libraries: picamera (to take photos), OpenCV (to count the NDVI index) and the libraries provided by sensors producers.

The data gathered in the experiment will be stored on the SD card in our Raspberry Pi. Some of the data will be sent to the ground station via radio (in case our CanSat wouldn't be found). The data from the sensors will be collected once for 1 second and a photo will be taken once for 5 seconds.

Our CanSat's code will work like this (during the flight):

- Collecting the data from the sensors and taking a photo
- Saving the data in CSV file
- Sending the temperature and air pressure readings via radio

And the code of our CanSat after the landing will work like this:

- Turning off all sensors (after 30 minutes)

- Sending the part of secondary mission data via radio
- Turning on and off the buzzer for 3 seconds
- Sending the GPS coordinates via radio every second

We wrote a code for calculating NDVI index on the photos for Astro Pi mission. The code for CanSat mission will have some minor changes. Here is our code and example photos that were gathered and analyzed during our experiment on the ISS:

https://drive.google.com/drive/folders/10sl22qQhoHfY5MkGJe1vAnIbtAo2a17k?usp=sharing

The photos in our CanSat mission will be analyzed in our ground station.

2.5 Recovery system

We will use a hexagonal parachute with a surface of about 891 cm^2. We calculated the surface using equation mentioned bellowed and then rounded the result:

$$F = \frac{1}{2}CdAv^2$$

F – resistance force; C – drag coefficient; d – density; A – surface; v – speed

Resistance force must be equal to gravity force so:

$$F = mg = \frac{1}{2}CdAv^2 \leftrightarrow A = \frac{2mg}{Cdv^2} = \frac{2 \cdot 300 \cdot 9.81}{0.8 \cdot 0.00129 \cdot 8^2} cm^2 = 891 cm^2$$

$$m = 0.3;\ g = 9.81;\ C = 0.8;\ d = 0.00129;\ v = 8$$

So, we will use a hexagonal parachute with a surface of 891 cm^2, with the length of the side of about 18.53 cm.

To mount our recovery system to our CanSat we will use 6 strings with spherical element on each preventing the strings from getting out of CanSat. The strings will be attached to a servo inside the CanSat through the string with lower mechanical strength. When servo will start to pull this string, it will break causes the parachute to open.

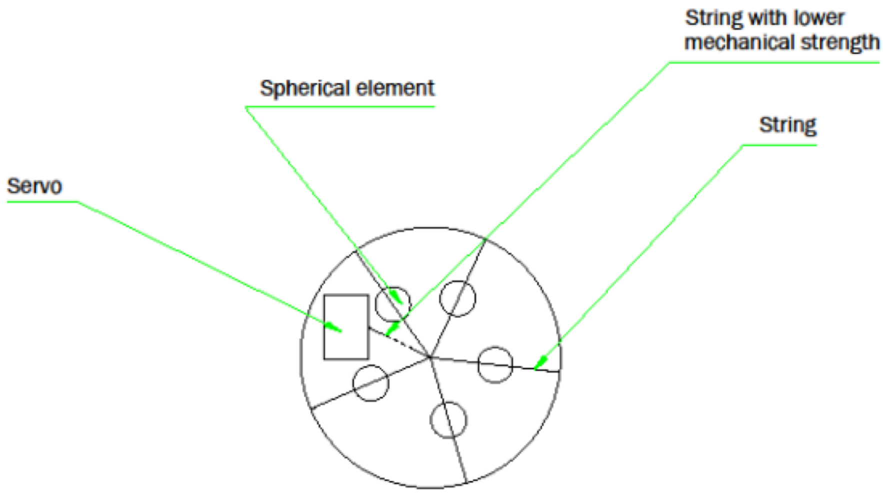


Figure 6: Recovery system

2.6 Ground support Equipment

Our ground support equipment will consist of a Raspberry Pi computer or the CanSat main module, a laptop and a Yagi-Uda antenna. All the data from CanSat will be sent to Raspberry Pi/CanSat main module and stored in the CSV file. The photos will be stored in the memory of the computer. The photos will be analyzed on our laptop using a code for calculating NDVI. Using the data gathered in the CSV file and analyzed photo we will decide whether the area where our CanSat landed is suitable for growth of plants.

3 TEST CAMPAIGN

We will test our CanSat during the tests in our workroom as well as during outdoor tests. The electrical design, energy budget as well as first and secondary mission sensors will be tested firstly in our workroom outside the case, in the case and outside the room during the fall in the case.

We will test our recovery system by throwing a prototype from different heights: starting from few meters (a chair) to few hundred meters if we find appropriate facility (like drone). We will also test our CanSat by throwing it from a building (not forgetting about the safety rules!)

Our communication system range will be tested firstly in our workroom on small distances and then on a meadow or glade by going further and further away from the ground station with the CanSat.

4 PROJECT PLANNING

4.1 Time schedule

We divided the realization of our project into 4 phases:

1. Projecting
   - Inventing our mission
   - Finding the elements needed for our mission
   - Pseudocode of our code

2. Prototyping
   - Making a 3D project of our CanSat
   - Writing a code

3. Building the CanSat
   - Composing all parts of the CanSat together

4. Testing the CanSat
   - Testing our CanSat using the help from our partners and our facility

4.2 Task list

During the process of creating the task list, we were focusing on our abilities, passions, and reasons why we want to take part in this competition. Here is a screenshot from Notion showing our task list:

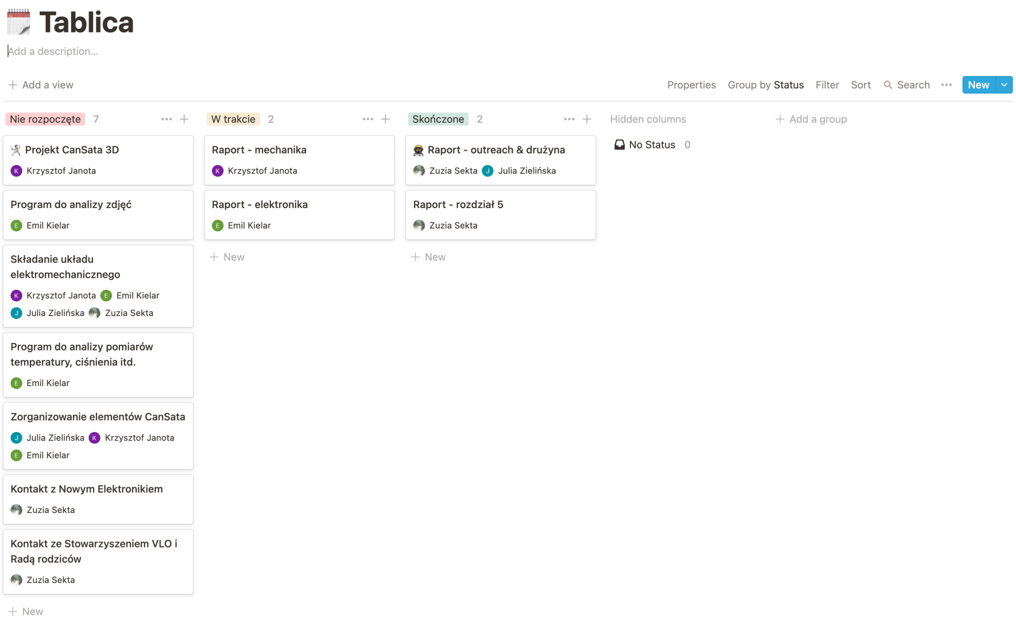


Figure 7: Task list

4.3 Resource estimation

4.3.1 Budget

Here is a table showing all foreseen costs of our CanSat (€220):

Element	**Cost (€)**
Raspberry Pi Zero W 512 MB	13.1
Raspberry Pi NoIR v2 Camera	28.4
Temperature sensor LM-35	5.0
Air pressure BMP-280	2.2
4 baterries	31.5
Servo SG-90	4.1
Case (filament)	17.5
GPS	50.0
Xbee Radio module (transmitter)	~30
Humidity sensor	6.6
Light intensity sensor	3.5
CO_2 sensor	26.1
Σ	~220

We took the prices from https://botland.com.pl/

4.3.2 External Support

Nowadays, we have the substantive support from our mentor (Mr. Dawid Kotrys) who is a doctor in Mathematics as well as from our Physics and IT teacher Mr. Andrzej Koźmic. We also get the support in creating our CanSat in our school. Our school has a modern IT room with very efficient computers as well as a 3D printer.

We are also looking for the support in other places We will contact electronic shops like Botland or Nowy Elektronik to ask whether they want to support us.

We will be looking for the financial support in our school's PTA and V High School association.

5 OUTREACH PROGRAMME

Our team is positively oriented for the advertising of the project and our actions. We have a lot of great ideas, and we are planning them now. We will start realizing them as soon as we are sure that we are qualified to the next phase, because we don't want to engage organizations as well as companies and then informing them that we weren't qualified. We are planning consecutive actions:

- We want to set up our page on Facebook and Instagram as soon as we get to know that our team is qualified for the next phase. We will post regularly there on our actions, advances in the project and other facts about the CanSat
- We also want to design our logo. We find it as one of the most pleasant promotion actions of our team. Our logo will be circular with a beetle inside.
- We are also looking for some sponsors for our mission. Although it's only the beginning of the mission so we don't have any, but we have some ideas whom to ask. We are going to look for the sponsors in our area: in our school we are going to contact the PTA and the V High School association. Outside of the school we are looking for the Electronic, Mechanical, Astronautic and IT companies.

Presumably, we won't stop on those 3 actions, and we will prepare more of them.