cansats in europe

Team ScanCan

Critical Design Review

Team Name: ScanCan

Country: Poland

www.cansat.eu

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CHANGELOG

PDR

- We decided on our secondary mission. CanSat is now supposed to make photos of the ground below. We will then proceed to make a 3D model of the terrain using photogrammetry.
- We changed our team’s name, it is now called ScanCan not RealDeal.

CDR

- We have decided to use a different model of LoRa, we now use SX1278 Lora Ra-02.
- We decided to use a different model of raspberry pi camera. We now use the raspberry pi original HD camera. We made that decision because the previous model was taking up half of the space we had available.
- There was a change of leader in our team, Andrzej Borys has been occupying this role.

INTRODUCTION

Team organisation and roles

Maciej Kobyliński - hardware, writing:

- Background: General knowledge of python, java, javascript, html
- Field of work: Team leader, assisting in Hardwere, writing reports
- Hours dedicated at school: 6h
- Hours dedicated after school: 6h

Jakub Banach - Lead software engineer:

- Background: Open source contributor and hobbyist machine learning engineer
- Field of work: Lead software engineer, writing code for ground station and CanSat
- Hours dedicated at school: 6h
- Hours dedicated after school: 6h

Andrzej Borys - Team leader, Lead hardware engineer:

- Background: maths enjoyer, extended subject maths, german, computer science
- Field of work: General hardware
- Hours dedicated at school: 4h
- Hours dedicated after school: 6h

Bartosz Purta - hardware engineer, physics:

- Background: maths enjoyer, extended subjects: maths, computer science, python programmer
- Field of work: General hardware, all calculations from physics field are done by him
- Hours dedicated at school: 6h
- Hours dedicated after school: 6h

Mateusz Szczotka - 3D modelling, hardware:

- Background: 3D modelling enjoyer (Blender, Fusion), high maths experience, C++ and Python programmer
- Field of work: 3D modelling, help with hardware
- Hours dedicated at school: 6h
- Hours dedicated after school: 7h

Maja Gustowska - finance, writing, social media promotion, art:

- Background: Experience with 3D modelling (Blender, Fusion360, Maya), animation and graphic design. English,Spanish, Maths and Chemistry enthusiast.
- Field of work: Sourcing sponsors to found our CanSat, building teams presence online, making logo design and writing reports
- Hours dedicated at school: 6h

Jerzy Piwkowski - teacher:

- Background: STEM teacher, Automation and Robotics M. Eng at Warsaw University of Technology, interest in mechanical engineering, climate and DIY
- Field of work: Mentoring the team, substantive support
- Hours dedicated at school: 4h
- Hours dedicated after school: 2h

Mission objectives

We picture a scenario in which our CanSat will be dropped on an alien planet. It will gather information about the planet and what's most important, It will make a 3D model of its landing site. The model will allow for precise choice of landing site for bigger aircraft in need of a flat surface to land safely. After the tests, which we describe in the paragraph "secondary mission tests", we estimate that the model will be depicting a 500m x 500m area. The closer to the landing site, the better the model will be.

Primary mission:

Our primary mission is to measure atmospheric pressure and temperature. To gather this information we will use the BME 680 sensor, while also using a GPS module to locate the CanSat after landing and to track its position during its descent. In the environment of the scenario presented earlier the BME sensor data will provide essential environmental information about the alien planet.

Secondary mission:

For our secondary mission we will make a 3D model of CanSat's landing site. To accomplish that, our CanSat will take photos of the ground beneath the can, which will be used later to create an accurate representation of the landing site. The photos need to be as undisturbed as possible so we will use a Raspberry Pi original HD camera and IMU. Camera will provide a clear image while the IMU will be a key factor for classifying if the photos are going to be used in the 3D model. This will provide us with a model of an uncharted alien terrain, which is necessary for locating a safe landing area for bigger aircrafts transporting humans.

To consider the launch successful the following parameters shall be met:

- The parachute needs to open and slow down CanSat's descent correctly.
- Camera needs to take at least 15 good quality photos.
- Bme 680 needs to correctly measure temperature and atmospheric pressure.
- The LoRa module will be able to send data every second.
- The whole CanSat needs to resist impact at landing.
- Cansat needs to have enough battery reserves to send photos to base.
- Data needs to be saved on the micro SD card.
- We need to be able to locate our CanSat after the landing to retrieve all of the data.

CANSAT DESCRIPTION

Mission overview

Our goal is building a CanSat which will be deployed from a rocket at an altitude of 1,5 to 2,5km. Our primary mission is to measure and record atmospheric pressure and temperature throughout the CanSat's descent. The CanSat should not exceed falling speed of 6m/s, as we estimated that an optimal speed for taking photos is 5 m/s, for them to have a high enough quality, to ensure our 3D model's accuracy. Photos are going to be taken at a frequency of 5Hz to make sure we have enough adequate photos for the model. Every photo will be saved on a micro SD card and logged with the time of the picture's creation and CanSat's tilt which will be used later to identify which photos are good to use in making our model. Primary mission data is stored alongside photos on the micro SD card.

Block diagram:

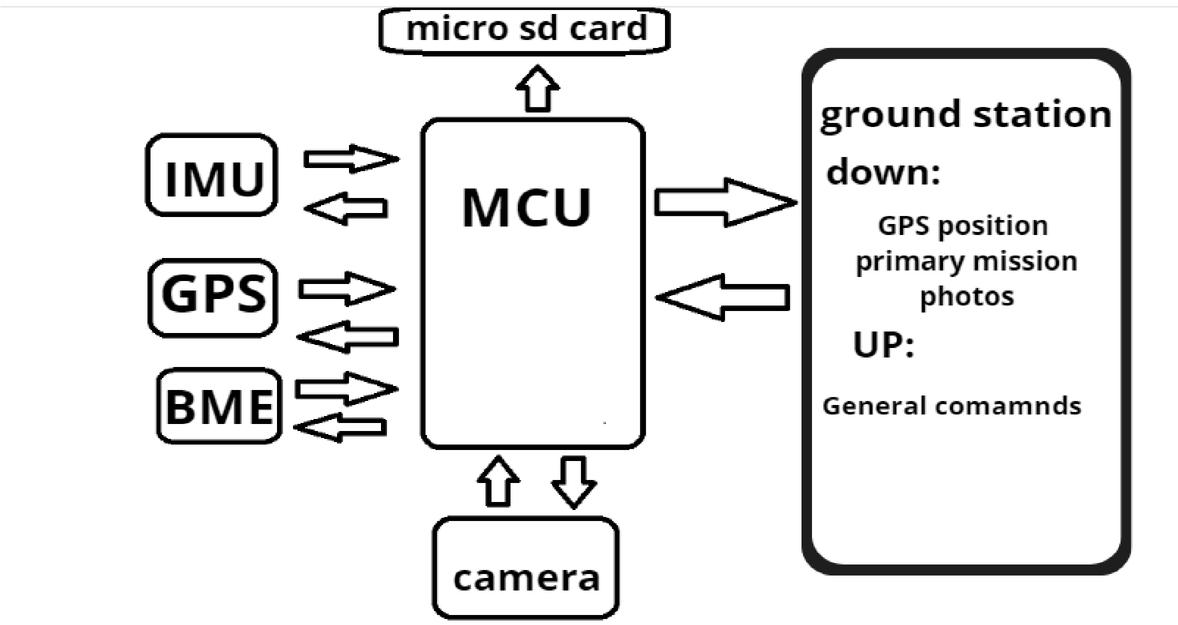
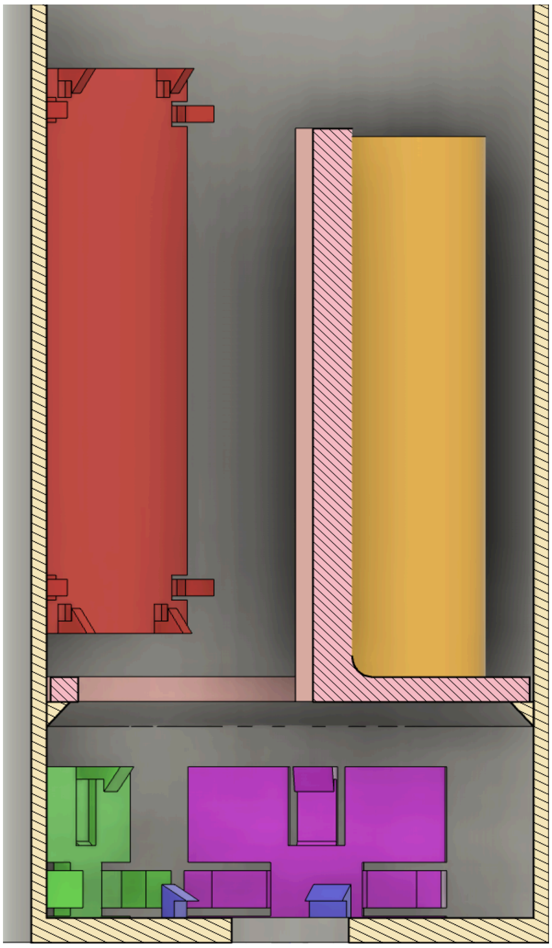


Figure 1. Block diagram

Mechanical/Structural design

We use PLA plastic for our CanSat's shell and all the internal structures, we use small nuts, screws and inserts for plastic.



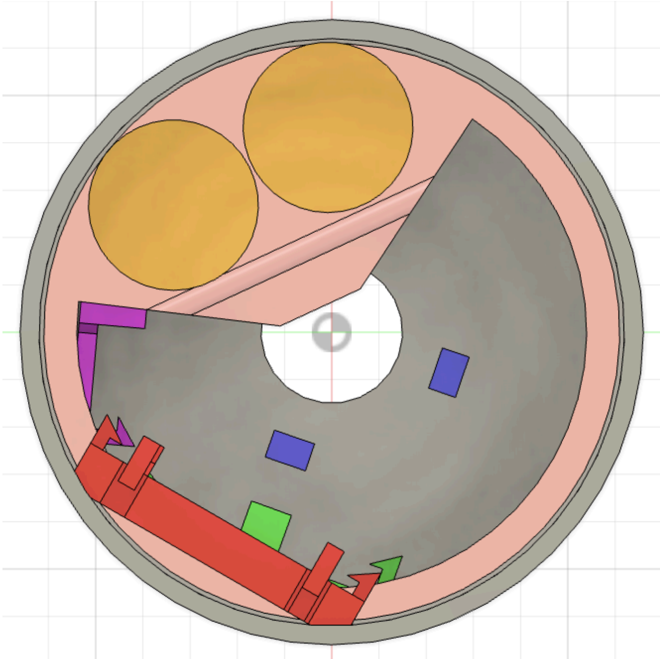


Figure 3. Top view of the 3D model

Figure 2. 3D model of handles for parts of our cansat

Mass budget:

Our CanSat weighs around 224g. Here we present the weight of individual components:

- Battery pack and BMS - 96g
- IMU - 2g
- BME - 3g
- Camera - 4g
- Raspberry 10g
- GPS - 21g
- CanSat's shell - 88g

Electrical design

General architecture

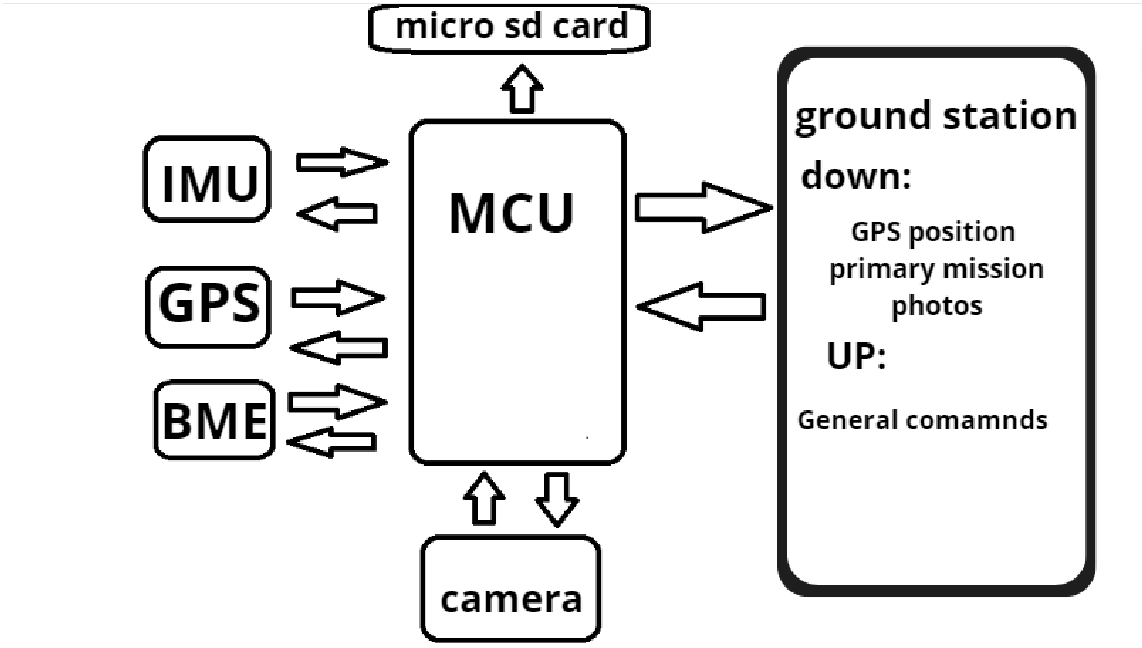


Figure 4. Block diagram

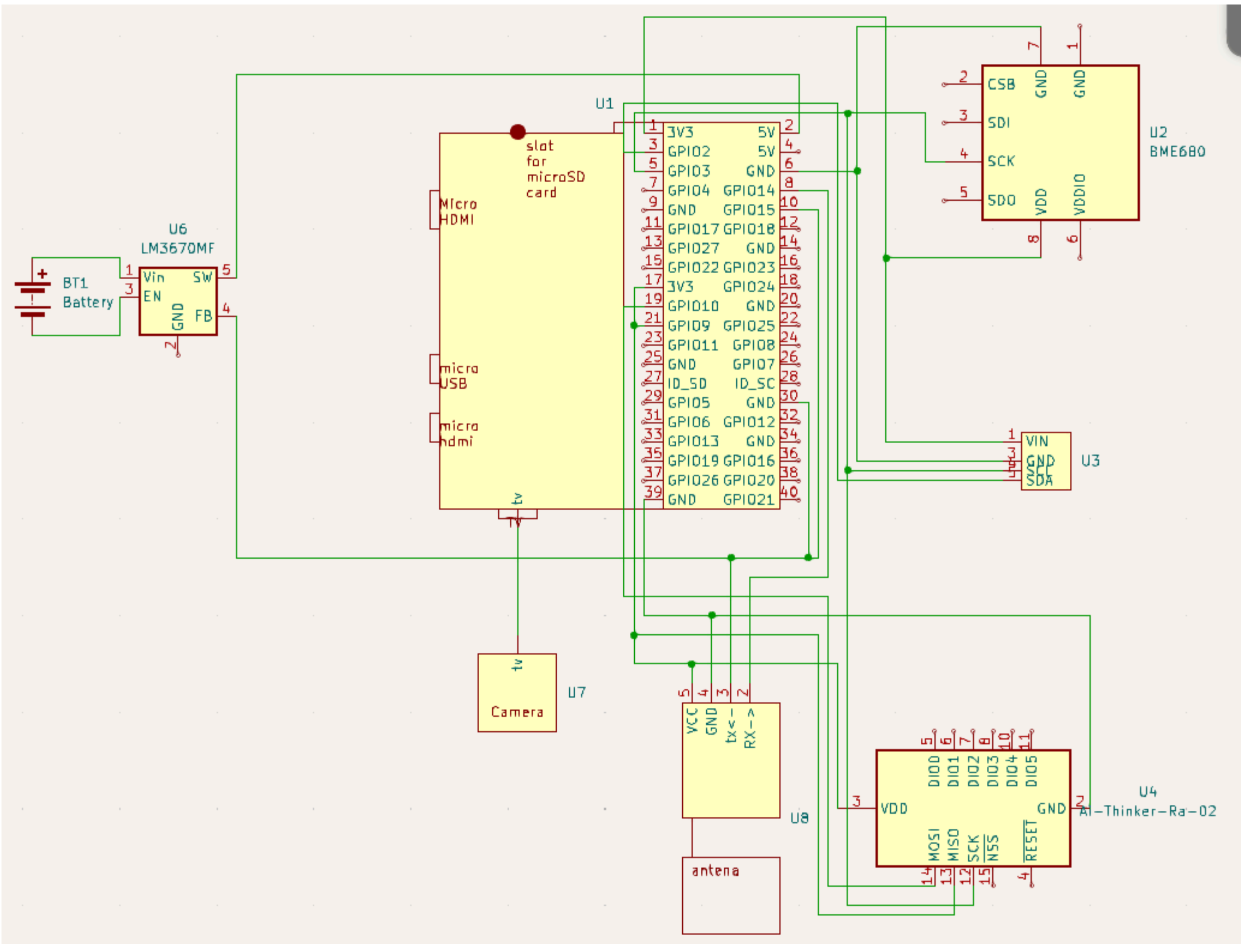


Figure 5. Electrical design schematic

Description:

GPS - L76X Waveshare gps module

Camera - Raspberry Pi original HD camera

LoRa - 02 SX1278 radio

ISM330DHCX 6DoF IMU - 3 axis accelerometer

BME 680 - pressure and temperature sensor

Primary mission devices:

Our cansat's components are:

Raspberry pi zero 2w - our computer controls all the other components of the CanSat.

SX128LoRa Ra02 - the radio module we are using to communicate with our CanSat.

BME 680 - pressure and temperature sensor.

GPS - we use it to locate our CanSat after landing.

Secondary mission devices:

For our secondary mission devices we will use the raspberry pi original HD camera and IMU. In the first design we were planning to use a raspberry pi global shutter camera because we were worried that our photos could be affected by the global shutter effect. As it turned out it was not true. So we decided to use a much smaller and lighter camera. and IMU is an accelerometer and gyroscope which we will use to select the usable photos.

Power supply:

We have planned to use two li-ion 18650 batteries, but due to a huge roadblock which was the size of our camera we were unable to fit them in the can. To countermeasure this problem we decided to use 6 18350 li - ion batteries. Then we decided to change the camera we were using. So we came back to the idea of using just two batteries. With two cells, 3400 mah each we are looking at 24,4Wh of stored energy.

- Raspberry Pi Zero 2 W ~ 0.7 W
- Raspberry Pi Global Shutter ~ 0.7W
- BME680 ~ 0,1W
- IMU - Negligible
- GPS - Negligible
- LoRa ~ 0,1W

total - 1,6W

Our CanSat will have enough power supply to be fully operational for 15,25 hours.

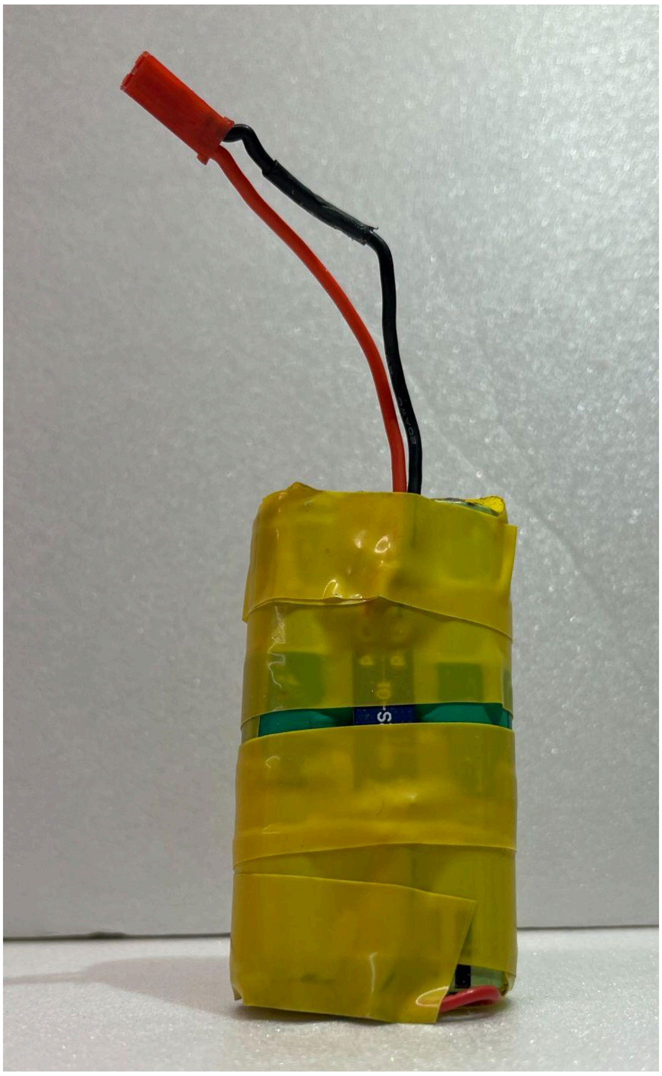


Figure 6. Battery pack

Communication system:

Right now our radio link frequency is 433MHz but we haven't decided yet on what radio frequency is the best for the final build. Our lora can use the radio Frequency link from 420 MHz to 450 MHz. For our transceivers we are using LoRa-02 sx1278 on both cansat and ground station. Because of our primary and secondary mission, we need two communication modes, from ground station to cansat and back. We use Yagi-Uda antenna on the ground station and an antenna made by ourselves on cansat.

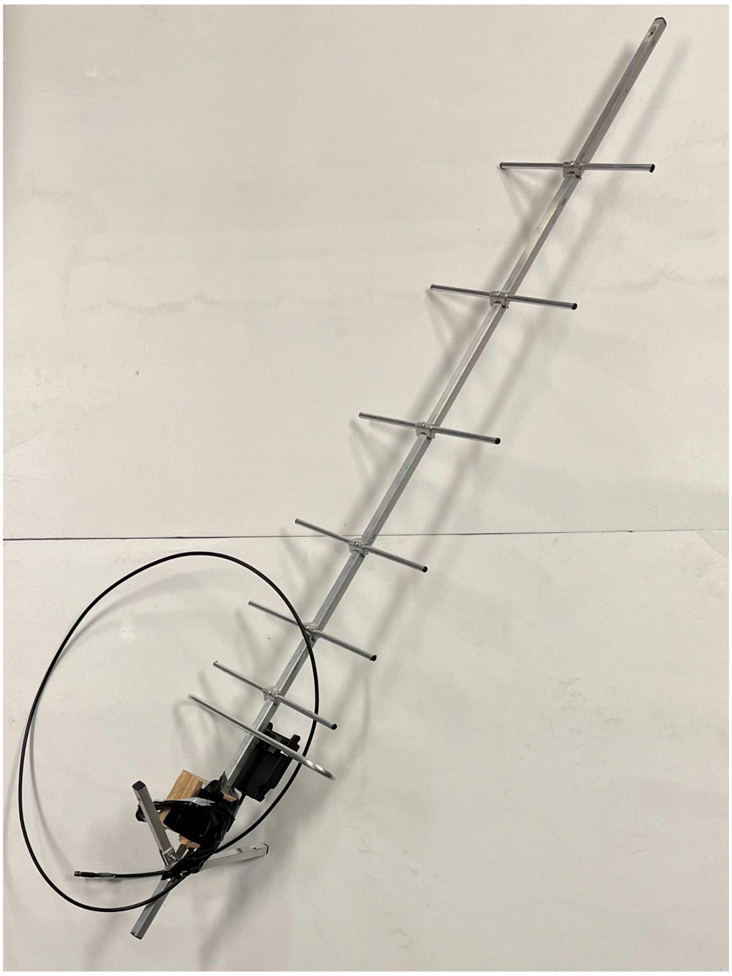


Figure 7. Yagi Uda directional antenna

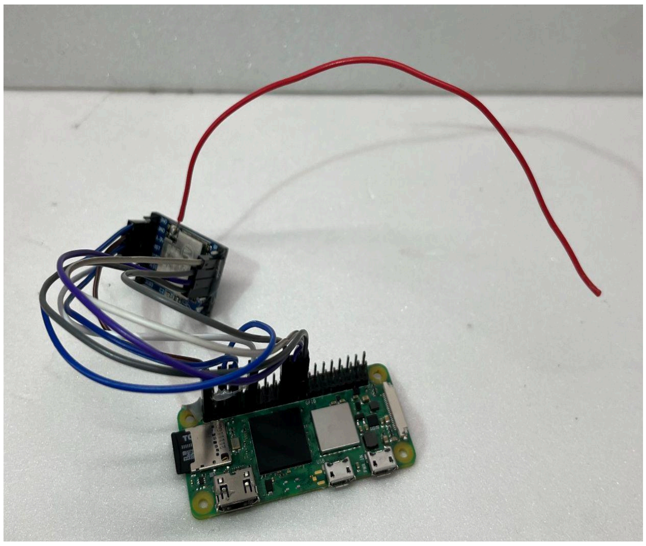


Figure 8. CanSat's antenna

Software design

Our software design will consist of a python program, saving all the data into a json file on a micro SD card. We utilise existing libraries to gather inputs from sensors. We handle temporary sensor failures by storing timestamps of different measurements and marking failures, expecting them to be a small percentage of data points.

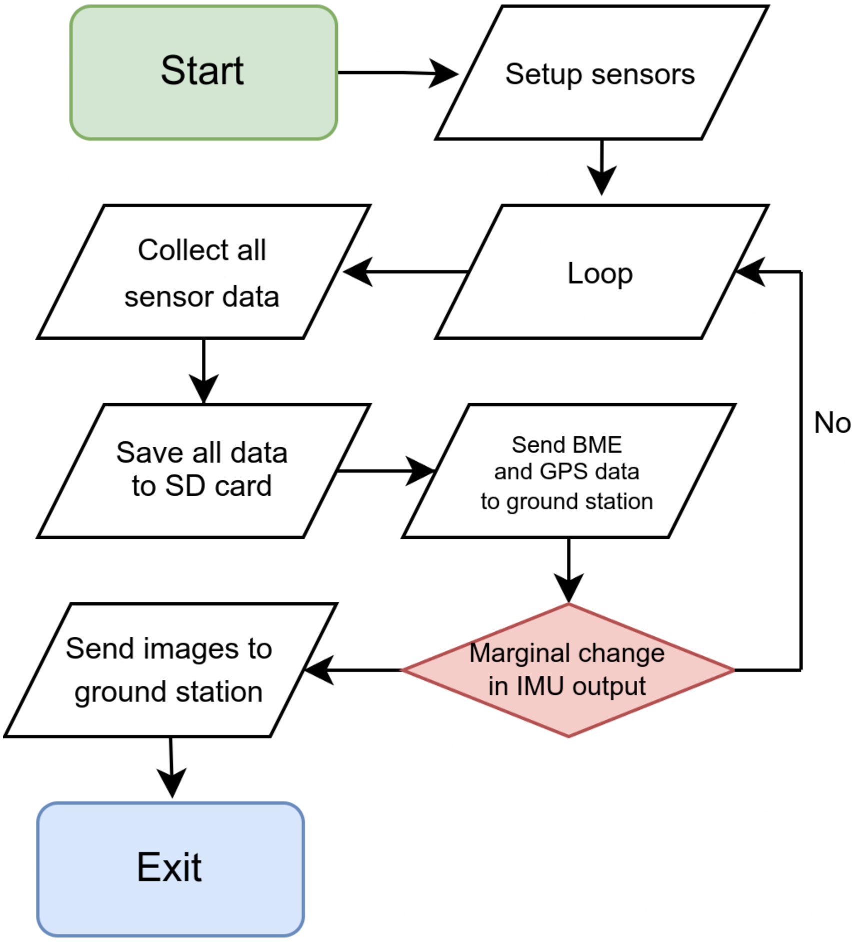


Figure 9. - Program flowchart

We are going to gather data from IMU, BME, GPS and camera. Data from BME and GPS will be saved and sent instantly to the ground station but photos and data from IMU will be only saved. They will be sent at the end of the mission to prevent any data loss due to the instability of the cansat. We estimated that we will send about 32 bits or 4 bytes every second:

bme ≈ 10 bits

gps ≈ 22 bits

For testing, we used:

Language: Python, C

Environment (libraries used):

- bme680-python, adafruit-circuitpython-lsm6ds,
- sx1278-LoRa-RaspberryPi (C library)

In final program, we plan to utilise ctypes library to call functions from sx1278-LoRa-RaspberryPi using Python

Our source code: https://github.com/TeamScanCan/CanSat

Recovery system

We use a hemisphere parachute with a spill hole. The estimated velocity of our CanSat was 5 m/s. We compared the calculations with our tests and established that the actual descent velocity is 5,67 m/s. We made 3 parachute prototypes, and tested them in various environments.

The formula for terminal velocity is: $v = \sqrt{\frac{2mg}{pACd}}$

We can transform it to get a equation with A: $A = \frac{2mg}{pC_d v^2}$

where:	in our case:
v = velocity	v = 8 m/s
m = mass	m = 0,330kg
g = gravity	g = 9,81 m/s^2
p = air density	p = 1,225 kg/m^3
A = area	A = ?
Cd = drag coefficient	C_d = 1,75

$$A = \frac{2\cdot 0{,}33kg\cdot 9{,}81\frac{m}{s^2}}{1{,}225\frac{kg}{m^3}\cdot 1{,}75\cdot 64\frac{m^2}{s^2}}$$

$$A = \frac{6{,}4746\frac{kg\cdot m}{s^2}}{137{,}2\frac{kg\cdot m^2}{m^3\cdot s^2}}$$

$$A \approx 0{,}047m^2$$

We have tested a parachute with the area that we calculated, which was supposed to guarantee a descent speed of 8m/s. Our calculations were correct and the CanSat was falling with a speed of 8m/s, but we came to a conclusion that due to this speed, photo quality was low, and the quantity of the photos was also affected. To countermeasure this effects we made a parachute prototype with a bigger surface which correctly slowed the CanSats descent to 5m/s.

Ground support equipment

We use a Yagi-Uda directional antenna to receive information, and send instructions to our CanSat. LoRa-02 sx1278 serves as a radio module in our can. It is connected to a raspberry pi zero 2w, for it to be able to receive and save the data on a sd card. We will also have a soldering station to perform last minute repairs if needed.

TEST CAMPAIGN

Primary mission tests

We have tested the sensor in a multitude of ways, such as putting it in the fridge and warming it with our hands. We have yet to perform more sophisticated tests. We also plan to expose the sensor to multiple environments to see how it will perform in different settings.

Secondary mission tests

We have already performed some tests by making a 3d model of a terrain using pictures made by a skydiver. The results were surprisingly good as we were expecting them to be very blurry and unrecognisable, because the photos were taken at a speed much higher than the one that will be reached by our cansat.

We are also planning to do tests in a controlled environment by attaching our CanSat to a drone and setting it to a free fall from around 120 metres, then we will analyse photos that were taken during that fall, and try to make a model out of them. We have to keep in mind that a descent of 120 metres gives us way less data than one in which our can will be falling from 2,5 km.

Tests of recovery system

We have tested 3 parachute prototypes to see which speed will be ideal for our mission. The First one had a descent speed of about 8m/s while the second and third were falling at a speed of 5m/s which we decided would be ideal for balancing the photo quantity and quality.

To test out chutes we dropped them from an 8 story building then used a Tracker Video Analysis program to check if the speed of the descent was calculated correctly. As it turned out our calculations were correct and we made a final version of our parachute prototype.

Figure 10. Final parachute prototype. View from the top.

Communication system range tests

For now we did general tests on our communication system, testing max range and max file size that it can transfer but we still have problems with setting up lora to transmit for longer periods of time. And as soon as we will be able for it to transmit consistently we will test its limits in different terrains and weather conditions.

Energy budget tests

We have calculated the battery life to last for 15h 15m. We are planning to run further tests by connecting all the sensors that we need (imu, bme, gps, LoRa, camera) and measure the time that it can run for.

PROJECT PLANNING

We made a Gannt chart showing our work plan and progress, it covers the timeline from PDR to FDR.

Time schedule

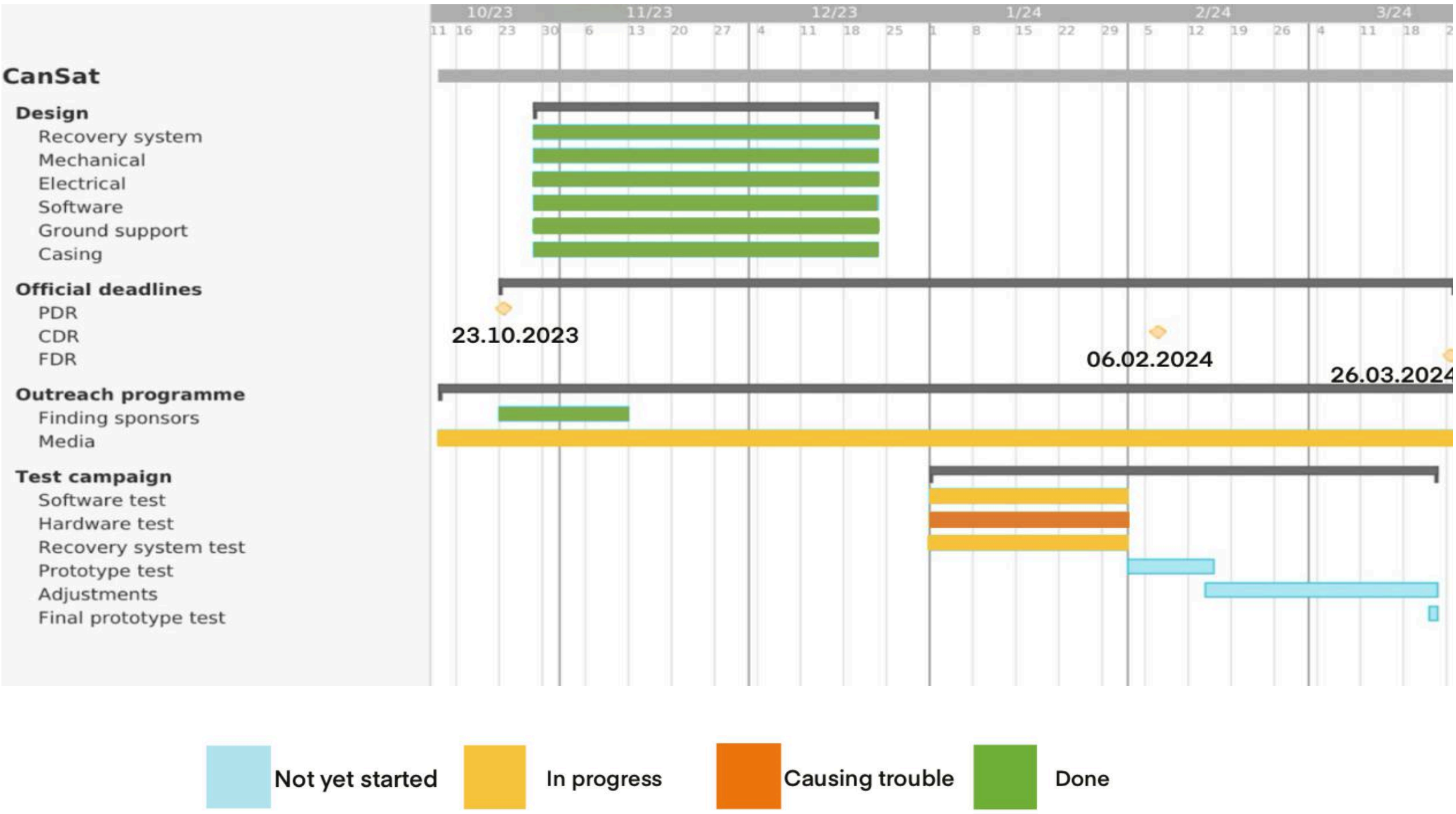


Figure 11. Gantt chart

Task list

Software:		
In progress	Writing code for LoRa	
	In Progres	Finding working library
Done	Writing code for BME 680	
Done	Writing code for IMU	
In progress	Writing code for GPS	
	In Progres	Calibrating gps to show
In progress	Writing code for Camera	
	In progress	Problems with calibrating the camera
In progress	Writing code for Raspberry	
Communication system:		
Done	Picking right antena for our mission	
	Done	Checking what would be the best antena for us to use both on ground station and on cansat
In progress	Tests of our range	
	In Progres	Testing how range is changing based on whether conditions

Hardware:		
Done	Connecting BME 680	
	In progress	Testing BME 680 results
Done	Connecting Lo-Ra	
	In progress	Testing Lo-Ra results
Done	Connecting IMU	
	Done	Testing IMU
Done	Connecting GPS	
	Done	Testing GPS results
Done	Connecting Camera	
	In progress	Testing camera
Done	Connecting Rasberry	
	Done	Testing Raspberry
In progress	Making cansatshell design	
	In progress	Adjusting and testing what is the best design for our cansat

Recovery system:		
Done	Making parachute design	
	Done	Checking what is the best parachute design for us
	Done	Calculate how big our parachute should be
	Done	Checking which material to use when making parachute
In progress	Making parachute for our final cansat design	
	In progress	Testing how it behaves in different weather conditions

Media:		
In progress	Updating our followers on progress in our project	
	In progress	Post about software
	In progress	Posts about hardware
	Done	Post about tests
Done	Explaining details about competition	
Finance:		
In progress	Finding sponsors	
	In progress	„Mam pomysł"
	Done	Crowdfunding

Figure 12. Task list

Resource estimation

Budget:

Budget	Total cost PLN - 807.63 PLN	Total cost euro - 182.08 €
Item	Cost-PLN	Cost-Euro
Filament	About 10 PLN	2.24 €
Lora module	220.58 PLN	49.42 €
GPS module	78.80 PLN	17.65 €
IMU module	150 PLN	33.60 €
BME 680	100 PLN	22,40 €
Raspberry PI zero 2 W	84,90 PLN	19,02 €
Raspberry Pi original HD camera	79.89 PLN	18.46 €
Li-ion batteries + BMS	83.46 PLN	19.29 €

Figure 13. Budget

External support:

For now we've made a deal with Botland - the tech shop we buy components from. The shop gives us up to 25% discount for every purchase and in exchange we publish unboxing videos on our instagram page.

We are also working on getting a sponsorship from „Mam pomysł", which is run by KIK (https://www.kik.waw.pl/projekty/mam-pomysl2/). The very last step we have to take is setting up a meeting and signing the contract.

Last but not least, we gathered over 1900 PLN through crowdfunding.

Outreach programme:

Our outreach plan is mainly focused on gathering attention through social media platforms. We want to show every aspect of our work in a fun and humorous, but educational way. We are active on Instagram, FaceBook, TikTok, GitHub and Twitch. For now we have published over 35 posts and gathered 125 followers on instagram. Our Instagram reels generate from 500 to 5800 views and reach many accounts that don't follow us. We do short form content on TikTok and more informative on Facebook while our Instagram is a mix of both. Another way of spreading awareness about our project is streaming on our Twitch channel. We broadcast our daily work as well as the tests.

Instagram: instagram.com/project.scancan

Facebook: facebook.com/project.scancan

TikTok: tiktok.com/@project.scancan

Twitch: twitch.tv/projectscancan

GitHub: github.com/TeamScanCan

On 27.11.2023 our team gave a presentation about CanSat during the BSR school open day, in front of over 150 people. We are planning to do another one on the next open day which is 17.02.2024.

Additionally we made an effort to spread outreach through more traditional media. We contacted a radio station, several TV channels and a few newspapers, and we are still waiting for a response. An article about our project is going to be published soon in Warsaw High School times (https://www.instagram.com/warsawhstimes).

Besides that, we have designed a logo. It is included on the first page of this document. We have also made a design for our merch, which we plan to make available to buy.

CANSAT CHARACTERISTICS

Characteristics	Figure
Height of the CanSat	110mm
Diameter of the CanSat	65mm
Mass of the CanSat	224g
Estimated descent rate	5,5 m/s
Radio transmitter model and frequency band	sx1278-LoRa, no frequency bound yet
Estimated time on battery (primary mission)	15 hours 15 minutes
Cost of the CanSat	182.08€