Lunar

Lunar CanSat Critical Design Review
Team name: LUNAR
Country: Poland

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1. CHANGELOG

Our team has undergone a few changes since the last report - we have welcomed new members, introduced new ideas for the can, and refined our mission concept.

Pola Mogielnicka and Marcel Aftanas have joined our team as new members. Pola will serve as our new leader and finance manager. Marcel is the new electrical and 3D engineer. We have lost two members due to school or family issues.

We have redesigned our can. Instead of having a case slide down and strings push the two parts of the probe apart, we will be using magnets, and given enough force, they will not be able to hold the two parts together, causing them to split apart.

Our mission has also faced slight changes - every half-sat will now have more than one sensor for every parameter. It allows us to check the actual measurement error, since each half-sat is going to fall in a different place. The issue is properly explained in the secondary mission part of the report.

2. INTRODUCTION

Mr. Daniel Pawlikowski

is a physics teacher who became the team's mentor thanks to his qualifications, extensive knowledge, and his enthusiasm for helping and supporting our team.

Pola Mogielnicka-16-year-old student

Pola is the leader of our team. Her hobbies include writing poetry, which has given her a strong command of language and communication. She is primarily responsible for writing reports and external contacts. Pola is also a competitive swimmer, driving the team forward with her energy and dedication.

Marcel Aftanas-16-year-old student

Marcel is a drummer and a multi-instrumentalist with a passion for making music. Experimenting with digital graphic design to bring his ideas to life is our main structural, mechanical, and electrical engineer. He was chosen for the role as he has a vast knowledge of the subject and a drive to succeed.

Bartosz Glinka-18-year-old student

Bartek is a multi-instrumentalist who, as a bassist, is a member of the school band. He is also fascinated by the culture of Kurpie, where he comes from. In our project, Bartek is an English language specialist and the person responsible for writing reports as well as programming.

Kacper Kuczmier-16-year-old student

Kacper is a vocalist and pianist of the school band. As a photography enthusiast, he is responsible for the
images on our social media, and as an IT pupil, he is in charge of writing the code for our Cansat. He also handles outreach and sponsorship acquisition.

3. MISSION DESCRIPTION

3.1. Primary mission

PRIMARY MISSION	
Mission description	Measuring temperature, pressure, height, and analysing the dependencies between measurements and time from both satellites. The data will be sent to the ground station.
Mission assumptions (for every part of the Can)	Analyse the relations between: Temperature and pressure Temperature and height* Pressure and height* Temperature and time Pressure and time Height* and time Sending data every one second to the ground station. **Height above ground level*
Use of data	After receiving data from satellites, the program will compare the results individually and then present them using graphs.
Criteria for CanSat launch to be considered successful	Getting the correct measurements of temperature and pressure Correctly counted height above ground level Successful communication between the probes and the ground station

The purpose of the primary mission is to collect measurements of temperature and pressure parameters and interpret the following dependencies:

1. Temperature against pressure
2. Temperature against height
3. Pressure against height
4. Temperature against time
5. Pressure against time
6. Height against time

MEASUREMENTS EXECUTION PLAN

Each probe will be equipped with a set of sensors, which includes: thermometer, barometer, accelerometer, and GPS. This system will enable the collection of the required parameters. Satellites will be equipped with a LoRa module, which will transmit readings to the ground station every second.

Height above ground

A barometric sensor measures atmospheric pressure, which decreases as altitude increases. The altitude above the launch site

(AGL) can be calculated using the simplified barometric formula:

$$h = \frac{T_0}{L}\left[\left(\frac{P}{P_0}\right)^{-\frac{RL}{g}} - 1\right]$$

Throughout the CanSat fall probes send information about the measurements to the server on the ground, where the crew monitors outgoing changes. Data is collected in real time on our ground station, and in addition, readings are stored on a microSD card. This is to ensure that, in case of a LoRa system failure, the mission objectives can still be achieved once the CanSat is recovered.

Following the data analysis, the results will be visualised in the form of graphs and uploaded to the website, where they will be publicly accessible for scientific research.

3.2 Secondary mission

SECONDARY MISSION	
Mission description	The mission's primary objective is to validate multiple atmospheric parameters and analyse measurement errors of budget sensors under dynamic suborbital flight conditions. The mission is based on the innovative Symmetric Twin-Sat architecture, which separates the CanSat into two identical measurement units during the operational phase of the flight.
Mission assumptions	Separation of the Can into two independent probes. Performing measurements from the primary mission and measuring the intensity of UV light and humidity by every sensor in both half-sats. Transmitting data from the satellites to the ground station. Analysis and comparison of the collected data by a special program.
Use of data	Comparison and calculation of the differences in corresponding parameters between: - Every sensor on one probe, - Two probes. The results of the analysis will then be displayed in the form of graphs and comments from the team. They will appear on our website for educational purposes.
Criteria for the CanSat launch to be considered successful	Successful separation of the half-sats. Correct operation of probes after separation. A properly functioning calculation program. A well-functioning communication system between the probes and the ground station.

3.3 The course of our secondary mission

1. The rocket sets off.
2. The whole CanSat exits the rocket.
3. The probe divides into two half-sats.
4. Half-sats start to measure the parameters in the air.
5. Measurements are being sent to the ground station every second using the LoRa system.
6. A special program calculates the differences between the measurements of:
    - every same sensor on each half-sat,
    - Both half-sats (every half-sat measure will be a calculated average of every sensor on the sat)
7. The results of the calculations are studied by the team and posted on our website for educational purposes, along with comments from us.

3.4 Placing multiple sensors on each probe

We are going to place more than one of every sensor on each probe(for example: three pieces of different BME), because it is the only way to actually check their reliability, since both half-sats are going to fall in different places. That means they can detect different values of the parameters, and the analysis results would not indicate any possible unreliability of the components. Every one of these sensors is going to be different for I2C to work properly.
The program is first going to check the value differences between the sensors on each half-sat and calculate an average.
Secondly, both counted averages are going to be analysed and compared to each other. This change in our mission will make the research results more sensible and reliable.

3.5. HALF-SATS SEPARATION SYSTEM

To perform our secondary mission, it is inevitable to create a reliable separation system for the half-sats that is also simple and easy to construct. We are putting 35 weak 3x1mm **magnets** on the flat surface(inside). Weak magnets are the perfect solution to keeping the half-sats together while putting the CanSat inside the rocket, yet their weakness allows them to separate once the probe leaves its capsule. We had chosen to place them on the flat side (inside), because it is the most optimal and probable place for the half-sats to separate.

The separation of the half-sats will begin right after the aerodynamic force hits our probe and makes the magnets come loose. From that moment, both halves start measuring the given parameters on their own.

3.6. RATIONALE BEHIND OUR SECONDARY MISSION

The core rationale for selecting this secondary mission is to address the critical challenge of sensor reliability and data integrity in high-stress suborbital environments. In modern aerospace engineering, particularly within the *NewSpace* philosophy, the use of Commercial Off-The-Shelf (COTS) components is widespread. However, these sensors often exhibit unpredictable drift and measurement errors when subjected to the extreme vibrations, pressure drops, and thermal gradients typical of a rocket launch. Our mission aims to quantify these phenomena through a unique Symmetric Twin-Sat architecture.

Multi-Point Sensing & Spatial Gradients: By separating the CanSat into two identical units, we transition from a single-point measurement to a multi-point network. This allows the team to distinguish between local atmospheric fluctuations (e.g., localised humidity pockets or UV shading) and actual sensor inaccuracies.

Implementation of Redundancy and "Voting Logic": This enables the implementation of "majority voting" algorithms to identify and isolate failing components in real-time.

Cross-Platform Validation: While single-sensor validation is common, comparing two independent, autonomous platforms (Mother-Daughter/Twin-Sat) provides a higher level of data assurance. By correlating GPS-synchronised data packets from both units, we can calculate the **Standard Deviation of Measurement Error** in a dynamic environment, which is far more representative than static laboratory calibration.

Technological Maturity and Risk Management: The choice of a passive magnetic separation mechanism reduces the "Single Point of Failure" risk associated with active deployment systems, ensuring that the mission's primary scientific goal—data collection—is not compromised by mechanical complexity.

Ultimately, this mission serves as a proof-of-concept for low-cost constellation deployment. It provides our team with a rigorous framework to evaluate which COTS sensors are best suited for future, more complex aerospace applications based on their performance and error margins during actual flight.

4. CanSat Description

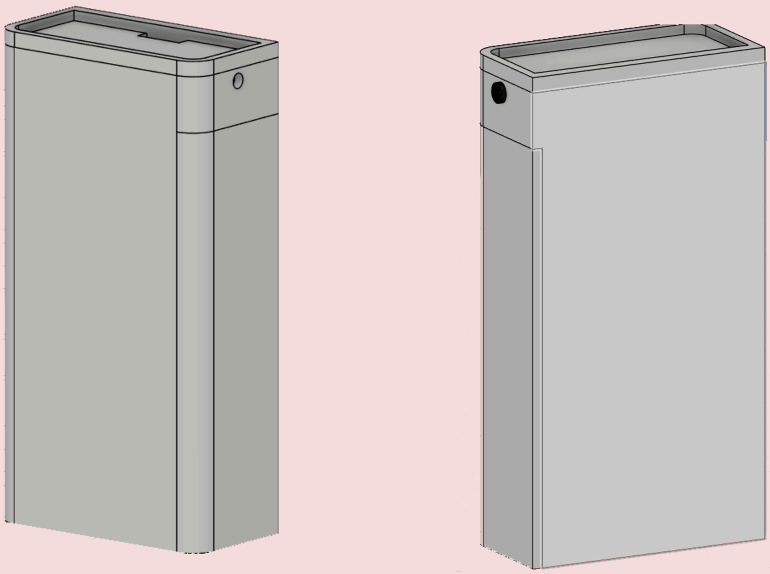
4.1 Structural design

4.1.1 DETACHMENT

The probe is held by 35 magnets. They allow the CanSat to fit inside the rocket smoothly. The detachment is based on wind force - the magnetic force of magnets is just strong enough to hold the two halves barely. As soon as the wind hits our probes, the magnetic field gets loose, and the half-sats detach.

4.1.2 EXTERNAL DESIGN

External design is simple. To maximise the space onboard and keep all components organised, we chose this square shape, optimised with rounded edges. It allows us to place the components we want to use in the probes (if the half-sats were half-cylinders, the components would not fit inside them properly, since the round shape would take up too much space).
Our CanSat is going to be made of **ABS** plastic on the outside - ABS is highly resistant to external factors (e.g., hitting the ground when landing), and it is lighter than other materials.



4.1.3 INTERNAL DESIGN

Inside, there is a slider that is used for taking electronic parts in and out. We chose this solution to have easy access to them in case of an emergency or need for change.
To protect our CanSat's internal part, we are using **PETG** plastic filament. It is a widely chosen option for constructing mechanical and moving parts of devices because of its durability. resistance to high temperature, humidity, or UV, and its flexibility.

4.1.4 MAGNETS PLACEMENT

As previously mentioned, we are using magnets to keep the 2 halves together before separation. As soon as it hits, the force of the wind is going to split them apart. We used 35 magnets - it is the quantity that allows them to keep the structure together. After tests, we concluded that we would rather use fewer, stronger magnets instead of a high quantity of the weak ones. It's easier to place and remove the possibility of magnets falling out of their place.

To ensure the integrity of the collected data and the reliability of the onboard electronics, we plan on implementing a strategic physical layout to minimise the impact of the magnetic separation system. The permanent magnets are going to be positioned at the maximum possible distance from sensitive electronic components.

- **GPS Antennas and GNSS Modules:**

  Placement: Positioned at the top/bottom faces of the units, shielded by the internal PETG structure.

- **Flash Memory and SD Card Slots:**

  Placement: Centrally mounted on the internal frame.

- **LoRa Transceivers and Inductors:**

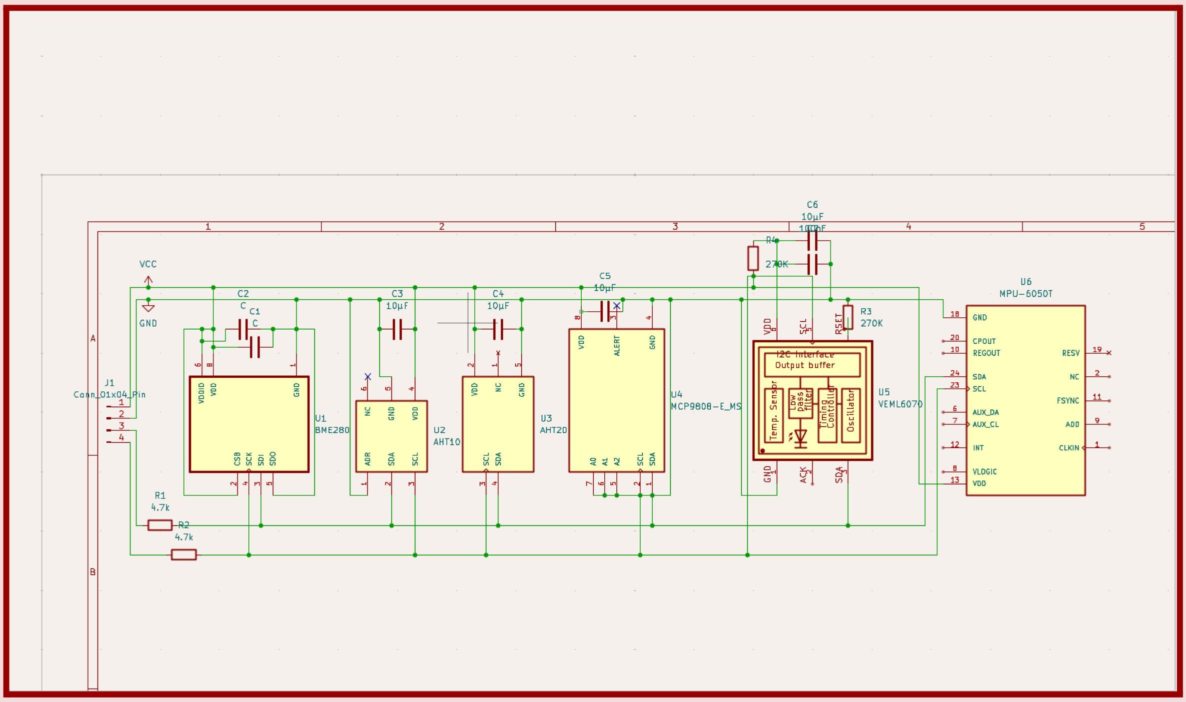
  Placement: Isolated from the separation plane.

4.2 Electrical design

Currently, we are at the end of the testing stage. After that, we plan on finishing the PCB design and sending it off to the manufacturer. In order to minimise the space needed for electronics, we decided to design custom PCBs. It allows us to put all our crucial components in one place. Our components are going to be divided into 3 categories, therefore we plan on creating 3 PCBs.

1. Sensor PCB

The sensor plate is a component that is seated on top of our probe; the plate is crucial for the UV sensors to work. It's going to take the same shape as our cansat, but offset by 2mm from the outside. Additionally, we plan on sticking the gps antenna on this plate.



Temperature, pressure, and humidity:
-BME280
-AHT10
-AHT20
-MCP9808

UV levels:
-LDR390
-VEML6070

Accelerometer:
-MPU6050
-BMA220
-SEN0405

2. Computing PCB

After putting in batteries and all the other necessaries we were left with the dimensions 23,5mm x 21,85mm x 80mm. We separated them into 2 smaller sub-plates, one containing the MCU and microSD Card, the other one is equipped with the GPS chip and communication system.
-ESP32-C3
-LoRa Ra-02
-MicroSD Card
-GPS (chip)

3. I/O PCB

The basis of this plate is identical to the first one. The only change is that it's placed much deeper inside the probe. This plate aims to give information and access to our satellite without taking it apart.
-USB-C
-Status LED (multiple)
-LoRa communication switch

We are going to connect all the PCBs with FPC connectors. The NFC tag will be placed inside our probe, so anyone who finds our CanSat after landing will be able to find us by the tag.

4.3 Battery Replacement System

The 18650 battery is going to be placed right next to a wall. The wall is going to be removable, which allows for easier access to the batteries.

BRS (Battery replacement system) is used for fast and effective battery exchange. BRS is equipped with clips for closing.

4.4 Recovery system

Our CanSat, after falling out of the rocket, will split into two probes, each with its own parachute. We are aiming for speeds of 10 m/s on one half-sat and 7m/s on the other. The probes will be tracked using a GPS signal, ensuring quick localisation and allowing us to read the altitude.
They will also have a LoRa-02 module, which can be used for both transmitting packages and receiving them, depending on how it was programmed beforehand. This time, it will be used for sending data to our ground station.

Each probe will have its own parachute. One of them is aimed to fall faster than the other, so they will show different measurements due to factors such as greater cooling of components (resulting from faster airflow).
Besides achieving the target descent speed, we need to calculate the force created by both parachutes to acknowledge the target force of the magnets we want to use. The magnet force is going to be about 60% - 70% of the parachute deployment force.
Below we present the calculations made to obtain the areas of the parachutes and a table consisting of our parachutes' parameters and the force they will create when the can starts its descent.

Parachute	Unit A (Slow)	Unit B (Fast)
Target Descent Rate	7 m/s	10 m/s
Mass (m)	150 g	150 g
Required Surface Area (A)	0.0490 m2	0.0240 m2
Calculated Diameter (D)*	25.0 cm	17.5 cm
Canopy Shape	Hexagonal / Flat	Hexagonal / Flat
Material	Ripstop Nylon	Ripstop Nylon
Separation Force at Deployment**	≈6.7 N	≈3.3 N

4.5 Ground station

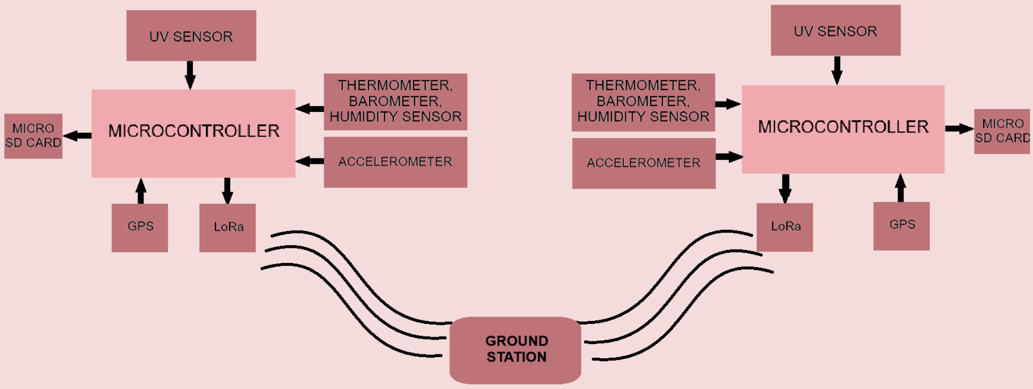
On our ground station, we will be using a Raspberry Pi 3b+, which will have a LoRa-02 receiver connected to it, and it will all be wired to two CDMA ATK-10/400-470 MHz aerials. This allows us to quickly and efficiently process and show our data in the form of graphs on a monitor. In our case, (because we have two halves of a cansat), we have decided on ‘marking’ each transmitter. This will help us sort the data and not falsely read it.
We are also going to use two aerials - each one dedicated to one half-sat. It makes it easier to keep the communication between every component without the probes “shouting over” each other, which could create difficulties in collecting data by the ground station.

4.6 Communication between the probe and our ground station

Since our probe will be split into two smaller ones, we have to put a transmitter inside both of them.

They will communicate with our ground station via LoRa technology, which allows us to send a lightweight amount of data over long distances. At the ground, we will be receiving a handful of data at a rate of 0.5s, which will be collected by a directional antenna, to cover the maximum distance we can.

Here is a representation of how the communication will proceed:



As described in section 4.5, we will have two variables, each for one transmitter, so that our data will not mistakenly get mixed up(for example, from probe #1 the temperature reading will be displayed as “TEMPERATURE A” and from probe #2 “TEMPERATURE B”).

4.7 Ground station

Our half-sats are going to have an ESP 32-C3, which is programmed to send all data captured from the components, such as the thermometer, et cetera. Whilst a programme on our ground station will be receiving and displaying all data in a GUI, which is really intuitive and will display data in the form of graphs, as shown in this example.

In November, we acquired a new sponsor - Solveit. A company specialising in marketing, mainly website design. With their help, we have a beautifully designed website, which we are planning to host at the end of January. More about our website is explained in the outreach section of the report.

5. Tests

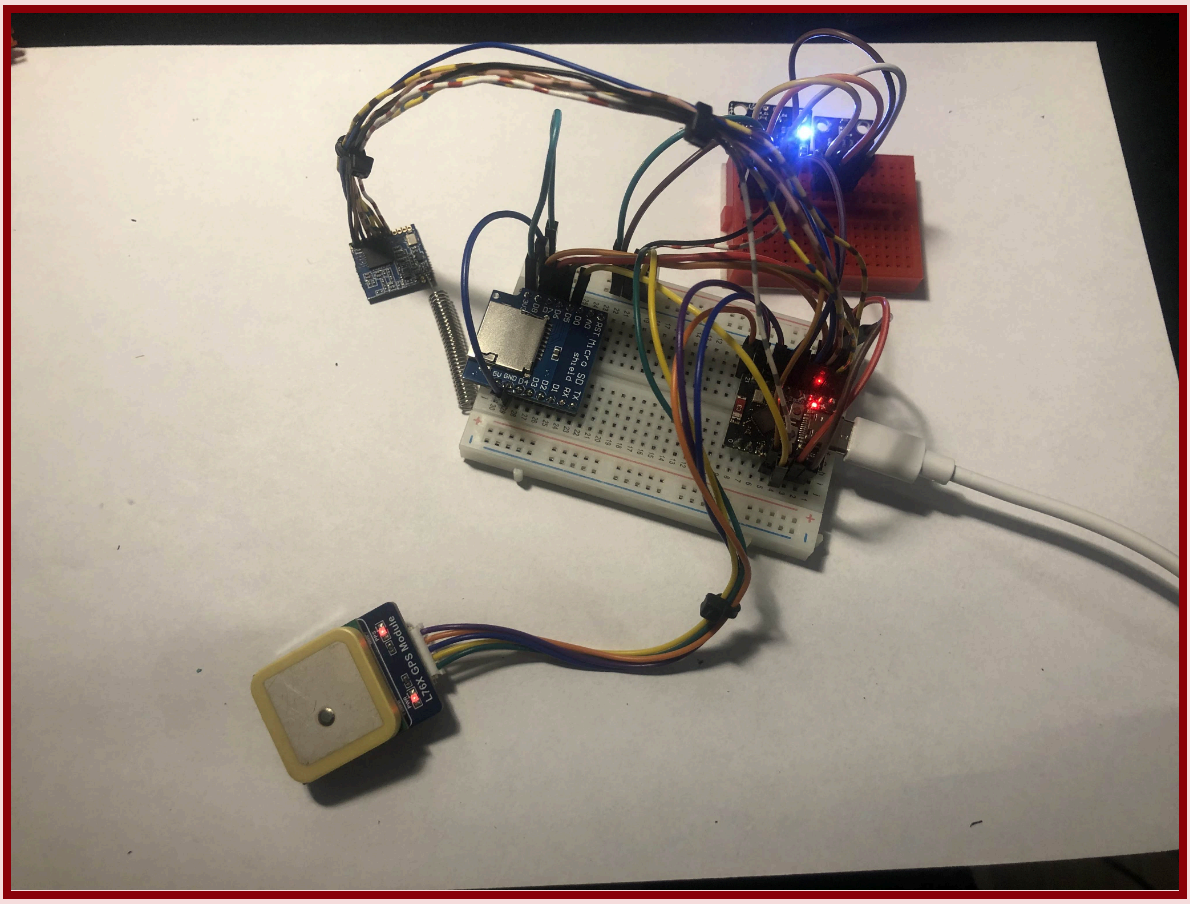
5.1. SEPARATION SYSTEM

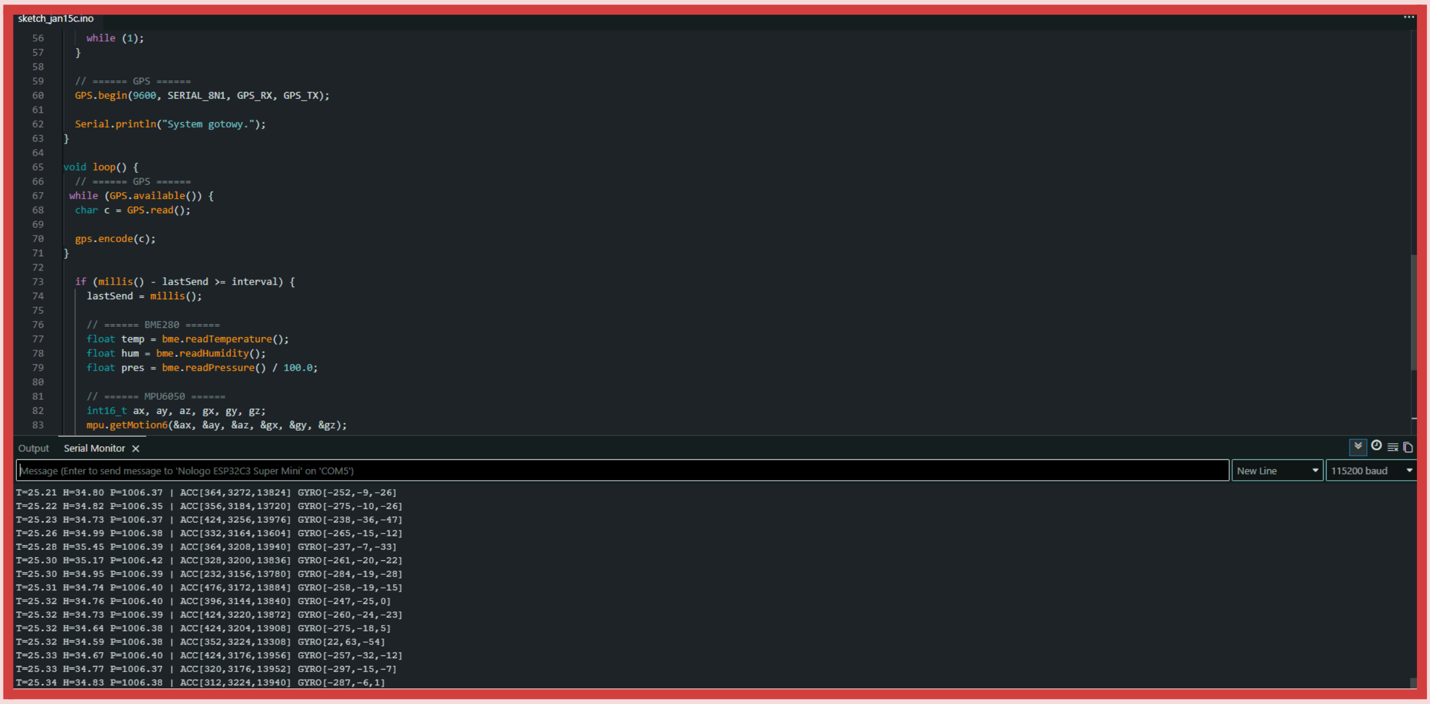
We have conducted a test to make sure our separation system works properly and is going to actually detach the two half-sats.
At first, we thought that we would need an extremely small force, yet it turns out our magnets are too weak. In order to keep the two sats together, we had to put 35 magnets in each HS*. This works, but we are going to experiment with bigger magnets for the future tests.
After placing the magnets in their proper places on the probes, we experimented with various weights. We concluded that about 25-30g of force is needed to separate the two halves. (added item is an off-brand 18650 battery).
Additionally, we provide the video material from the tests:
https://youtu.be/6pocxrvSy4Y

*HS stands for half-sats

5.2. Program + Electronics

We have tested our program and electronic parts. The result of the test says we have managed to run: MCU, Sensors, GPS, and SD. Everything went as expected, and we did not have any thermal issues. The next step is to check the program with all the other sensors. After that, we are planning on manufacturing our custom PCB. Here are pictures from our Program and electronics tests:





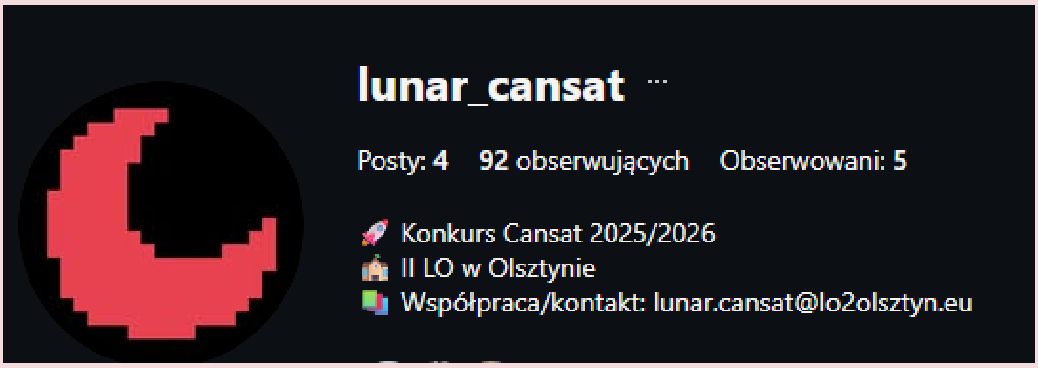
5.3. Failed LoRa test

Unfortunately, we also had some disappointments. We could not figure out how to get the LoRa to work properly. We decided on abandoning these tests to focus on other necessities. Right now, fixing LoRa communication is our top priority.

6. Outreach Programme

6.1. Social media

The Lunar team runs a profile on *Instagram*, which serves as an important communication and promotion channel for the project. The published content documents the progress of work, technical tests, and successive stages of mission preparation, while also presenting the project’s goals and assumptions to a wider audience. The profile is also used to announce new sponsors and to express appreciation to partners supporting the team. In addition, posts introducing the members of the Lunar team present their roles, competencies, and areas of responsibility, highlighting the interdisciplinary nature of the team and helping to build an engaged community around the project.



6.2. Website

We are now in the process of creating our website in collaboration with our sponsors - Solveit. The website is going to be in a pixel-like design in our colour palette, with bookmarks. It will appear as a professional website, since we are receiving help from marketing professionals.
We are going to include all of our research and mission results - graphs, comments from the team and possibly a blog describing our work in this year's project. We will also post about our outreach programme - school visits, poster placement, merch and our social media.

Everything that is going to appear on our website and its design is included in the presentation below. One of them shows a website mockup we have created, and the other shows the design of the website without any real text yet.
We plan to publish our site around the end of January and the start of February.

Website mockup provided to us by Solveit

Our website plan

6.3. Gadgets

We plan on distributing our team's own gadgets that will help us reach more audiences and make us more memorable to the people we present our work to. Below, we present a table consisting of all the gadgets and merch we are going to make.

Gadget	Placement/usage	Quantity
Posters	Displaying them in: - Public transport vehicles, - Cafes, - Schools, - Other possible places of culture.	20
Leaflets	Handing them out to potential sponsors and partners	20
Stickers	Handing them out to students in schools after presentations	500
Roll-up	Setting it up during the project finals	1
Hoodies	Getting one for every team member	5

6.4. Visiting schools

To reach as many audiences as we can, we are regularly visiting primary schools in Olsztyn. We make a presentation about the project, its objectives and progress. We also explain our work as a team, show prototypes and make a live presentation of how LoRa works by sending information from one end of the class to another. Our way of making the lesson more memorable is handing out stickers to students.
We have already been to two schools, yet several others have recently contacted us expressing their interest in our workshops.

6.5. Sponsors and help

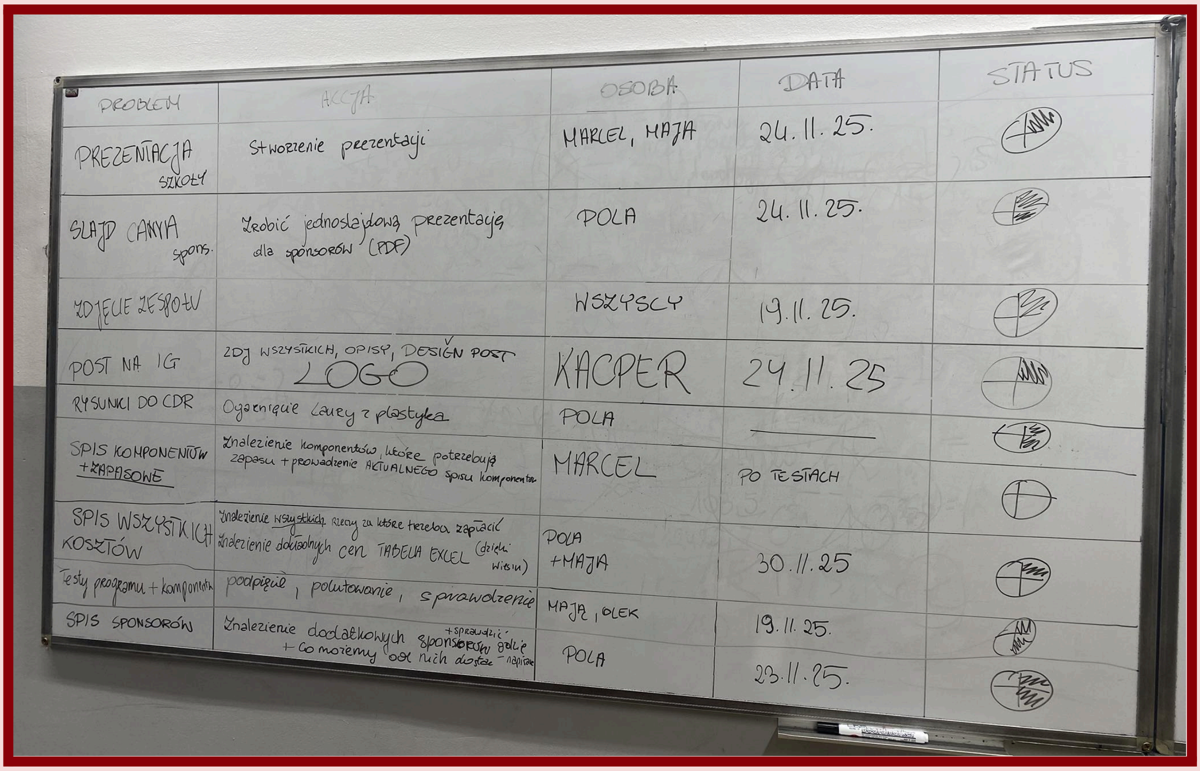
In order to obtain the necessary funds and receive needed help, we reach out to several sponsors - mostly in our town. They not only help us with the budget, but also with the outreach and the educational side of the project in exchange for advertisement and including their logo on our posters, leaflets, social media posts, or roll-up, as well as mentioning the companies during our presentations in primary schools. Below we present a table consisting of our sponsors and people willing to help us.

Sponsor	The type of help we receive	State of cooperation
Solveit	- Creating our website, - Designing and distributing our posters and leaflets, - Rebranding, - Marketing.	Working on the website and posters.
Cormo Software	Financial support	Help provided
Panda Marketing	Financial support	Help provided
WM ZDZ	Financial support	Help provided
Egmat	Financial support	Help provided
JLC PCB	Distributing custom PCB's created by us	Discussing the details
Irex	Displaying posters in public transport	Waiting for the posters to be distributed
People willing to help us		
Mrs. Ewa Gbur-Matejuk	Our school's physics teacher - she helps us solve problems appearing through work.	
Laura Januszewska	Laura has created drawings of us that appear in the introduction of the report and will also appear on our website.	

7. Project Planning

7.1. Organisation of teamwork

Our team tries to meet as often as possible. We usually meet in school, where Mrs. Ewa Gbur-Matejuk makes her classroom available for us. There is a large whiteboard that allows us to easily brainstorm and plan work for the next few weeks together - it makes everything visible to each team member. Thanks to this, everyone can focus on their own quest properly.
In our meetings, we not only plan future work, but also check the state of every task's completion. We use various note-taking apps and a traditional whiteboard to summarise what needs to be done.



7.2. Budget

Thanks to our sponsors, we have already completed our finance budget for the entire project. Below we present a table consisting of our project cost estimate + the funds we own.

Components		Hoodies		Merch	
Subject	Price	Subject	Price	Subject	Price
HalfSat	764,68 zł	P&B Hoodie	387,00 zł	Stickers	55,24 zł
SMD,,PCB, etc.	849,28 zł	House Hoodie	318,00 zł	Keychains	79,00 zł
Testing	146,59 zł	DTF Transfer	60,00 zł	Roll-up	0,00 zł
Summ	1 760,55 zł	Summ	765,00 zł	Summ	134,24 zł

Parachute		Launch	
Subject	Price	Subject	Price
Materials	0,00 zł	Hotel	850,00 zł
Sewing	100,00 zł	Tickets	0,00 zł
Summ	100,00 zł	Summ	850,00 zł

Overall
3 609,79 zł

7.3. Schedule

MEETINGS + REPORTS	DATES
Kick-off meeting	8th of September 2025
Reflections on our idea	15th of September 2025
Deadline for submissions	**21st of September 2025**
Report 1 (Preliminary Design Review, PDR)	**19th of October 2025**
Technical Workshop	3rd - 4th of November 2025
Technical meeting 2 (electronics, program)	5th November 2025
Organisational meeting (what's next)	23rd of November 2025
Technical meeting 3 (tests)	10th of December 2025
Webinar with the Jury (Q&A Session)	8th of January 2026
Technical meeting 4 (tests 2)	9th of January 2026
Report 2 (Critical Design Review, CDR)	**18th of January 2026**
Jury's comment on CDR	2nd of February 2026
Technical meetings	6th of February - 10th of March 2026
Outreach meeting (progress check)	15th of March 2026
Report 3 (Final Design Review, FDR)	**29th of March 2026**
Selection of teams for the finals	**7th of April 2026**
Starting Campaign	**18-19th of April 2026**
Online Final Meeting with Mission Presentations	24th of April 2026

8. REFERENCES

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KCAjw1NK4BhAwEiwAVUHPUMiXGNjjHi8UA6ohft2EhuAtHAHn5FUAExZaCJt5WOuPJ_yu4AlcMho CvTIQAvD_BwE https://en.wikipedia.org/wiki/Arithmetic_mean
https://en.wikipedia.org/wiki/Standard_deviation
https://en.wikipedia.org/wiki/Standard_errorhttps://en.wikipedia.org/wiki/Standard_error https://en.wikipedia.org/wiki/Mean_absolute_error
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