1. Introduction

The CanSat competition organised by ESERO consists of teams building and launching a can at around 1km of altitude, using a rocket. The can is meant to contain the necessary equipment to measure both the temperature and pressure of the atmosphere. On top of that, each team is required to find a secondary mission which further enhances their project. Teams are expected to show great innovative skills to overcome the mission's challenges, such as the design of the can, building of antenna to collect data, and set up of different systems.

Can.net is made up of 5 members: Gabriel, Cillian, Aboubaker, Martin, and Ugo. We are 16-year-old students from the "Lycée Français Vauban Luxembourg", each in our penultimate year of High School. Gabriel and Martin are long established members of the Vauban Makerspace (MS20): they are more accustomed to projects like CanSat. Nonetheless, the other members are not lacking the enthusiasm to make our vision come true. Can.net got the idea to participate in this event thanks to Mr. Metzler, our very own technology teacher, but also thanks to past exposure to the project, including Instagram accounts of previous CanSat competitors, and personal research. We intend to go as far as possible in the competition, learning as much as we can (pun intended) and at least completing the primary mission.

Our secondary mission consists in determining our can's position through trilateration and tracing its trajectory. We have chosen this specific scientific subject for our secondary mission as we were greatly intrigued by our can's trajectory throughout its launch. However, we did not want to depend on satellites to locate our CanSat: we wanted to be as independent as possible and go as far as we could, without tasks already done for us. Indeed, we aim to make a project that can be fully recreated with as little third-party tools as possible. We found an alternative to GPS after watching a video about 'SoundThinking' in the U.S. (Source: « Wired » on YouTube, see video below if interested). This video addresses the use of sound and trilateration to locate gunshots. The idea is simple: we can pinpoint the location of a signal emitter by finding its distance relative to three distinct points, using the signal's strength (a weaker signal translates to a greater distance and vice-versa). We then realized we could use this same method with our CanSat to precisely locate it, given that it emits radio signals. With the help of special antennas, we will build a graph that determines the position of the Can. Although we aim not to use GPS, we will rely on it to verify our results.

In this report, we will present our missions' objectives, as well as the means we have put in place to complete them. This includes our different designs and systems, as well as our overall method, tests, and difficulties encountered.

[We Tracked the Secret Police Microphones Hidden Everywhere | WIRED](#) (1)

2. Project description

2.1 Mission overview

Primary Mission

The primary mission consists in loading our CanSat in a rocket that will be fired into the atmosphere. At 1km of altitude, the can should be ejected from the rocket, and a parachute should deploy to assure it descends safely.

The primary goal is real-time transmission as well as storage of temperature, pressure, and humidity data in the atmosphere during this descent. This will be achieved using two Raspberry Pi Pico modules, temperature and pressure sensors, a yagi antenna, and a computer to receive and process data.

Secondary Mission

For the secondary mission, our team, **Can.Net**, aims to replicate an aerial package delivery system, similar to those used for humanitarian or military supplies. Unlike traditional systems relying on GPS modules, our CanSat incorporates an autonomous localization method: trilateration.

Our objective is to track the CanSat's position along the X and Y axes using three ground-based antennas, while estimating the altitude (Z) through pressure sensors, already utilized in the primary mission. Direct visualization of the CanSat's position might be possible, depending on external factors such as weather conditions and 4G/5G signal strength.

Trilateration Methodology

To determine the CanSat's location, we will rely on two key techniques:

- **RSSI (Received Signal Strength Indicator):** By analyzing the signal strength received by each antenna, we can estimate the distance between the CanSat and the antennas.
- **ToF (Time of Flight):** By measuring the time it takes for signals to reach each antenna, we can further refine the position estimation.

Using three antennas, we obtain two possible intersection points in 3D space. The correct one will be identified by incorporating altitude data from the pressure sensor (see Figure 1). Additionally, we plan to compare our trilateration results with GPS data to evaluate the system's accuracy.

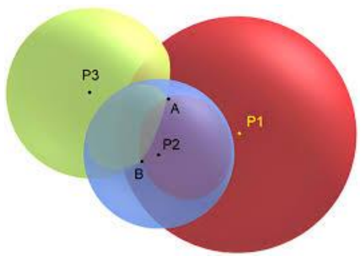


Figure 2: The two intersections (A and B) of three spheres

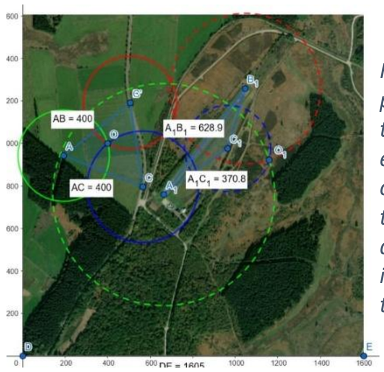


Figure 1: Two potential locations for the three antennas, either at each summit of the equilateral triangle in the field or at each summit of the isosceles triangle on the landing strip.

RSSI and Distance Relationship

The **Received Signal Strength Indicator (RSSI)** is a measure of the power level received from a radio signal. The relationship between RSSI and distance follows an approximate inverse power law, commonly modeled using the **log-distance path loss model**:

$$d = d_0 \times 10^{\frac{RSSI_0 - RSSI}{10n}}$$

where:

- d is the estimated distance between the transmitter (CanSat) and the receiver (antenna),
- d_0 is a reference distance where the signal strength is known,
- $RSSI_0$ is the received signal strength at d_0,
- $RSSI$ is the measured received signal strength,
- n is the path loss exponent, which depends on the environment (e.g., free space, urban, or indoor conditions).

Potential Errors and Mitigation Strategies

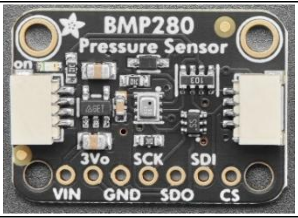
The trilateration system may be subject to errors due to various factors:

- **Signal Interference**: External disturbances can cause antennas to misinterpret signals, leading to inaccurate position estimations
- **Weather Conditions**: Adverse weather, such as rain, may weaken or disrupt reception signals
- **RSSI Variability**: RSSI-based distance estimation is inherently imprecise due to fluctuations in signal strength caused by environmental changes and multipath effects.

To mitigate these issues, we can:

- **Enhance signal strength** from the CanSat
- **Implement an encryption key** to reduce the impact of interference
- **Regularly calibrate the RSSI-distance equation** on the day of the launch, adjusting for real-time environmental conditions to ensure accurate calculations

<table>
<tr><th>Key Equipment</th><th>Picture</th><th>Characteristics</th></tr>
<tr><td>BMP280 (Temperature and pressure sensor)

https://www.adafruit.com/product/2651</td><td>
</td><td>Accuracy:
±1°C
±1hPa

3.3 or 5 V systems</td></tr>
<tr><td>Breakout RFM69HCW - radio Transponder (433 MHz version)

https://www.adafruit.com/product/3071</td><td>
</td><td>-3.3V
-50-150mA

Good component for the price, and compatible with the system</td></tr>
<tr><td>Rasberry Pi-Pico (RP 2040) micro-controller

https://datasheets.raspberrypi.com/pico/pico-datasheet.pdf</td><td>
</td><td>We have chosen this module as the price is good for the performance. On top of that, it is compatible with the system and some of our members are already accustomed to rasberry Pi-Pico modules.</td></tr>
<tr><td>Adafruit Ultimate GPS Breakout

https://www.adafruit.com/product/746</td><td>
</td><td>-5V, 20mA
-10 location updates/s

Good component for the price, and compatible with the system</td></tr>
</table>

Other Components:

- 1 Yagi antenna to fulfill the primary mission
- 3 omnidirectional Turnstile antennas built with the help of the radio amateur group of Thionville, to fulfill our secondary mission. We would need 3 of these antennas
- 3D-printed can
- Computers for data collection

Data Transmission Method

The radio module operates on a **low-power RF communication protocol**, allowing for long-range data transmission while maintaining energy efficiency. The RFM69HCW transmits data using **FSK (Frequency Shift Keying) modulation**, where digital information is encoded by varying the carrier frequency. The transmission process follows these steps:

1. Data Encoding: Telemetry data are **formatted into packets**.
2. Packetization: Each packet includes a **header, payload (data), and checksum** for integrity verification
3. Modulation: The encoded data is modulated using **FSK** and transmitted at **432.5 MHz**
4. **Transmission:** The CanSat periodically emits signals
5. **Reception and decoding:** The packets received undergo **error checking (CRC validation)** to ensure data accuracy. If errors are detected, retransmission may be requested.

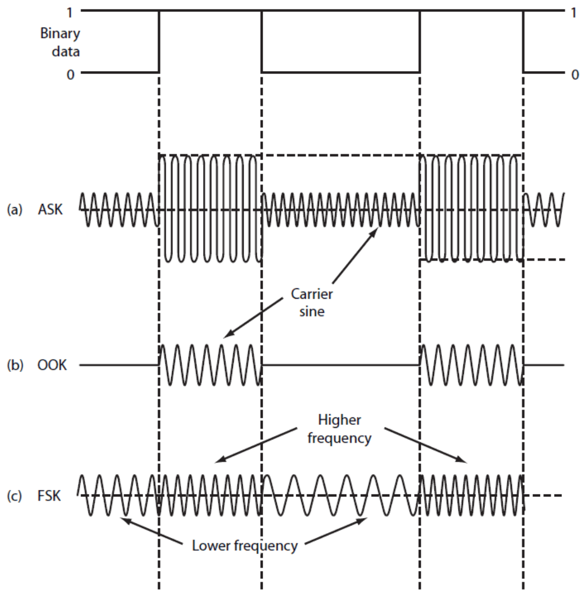


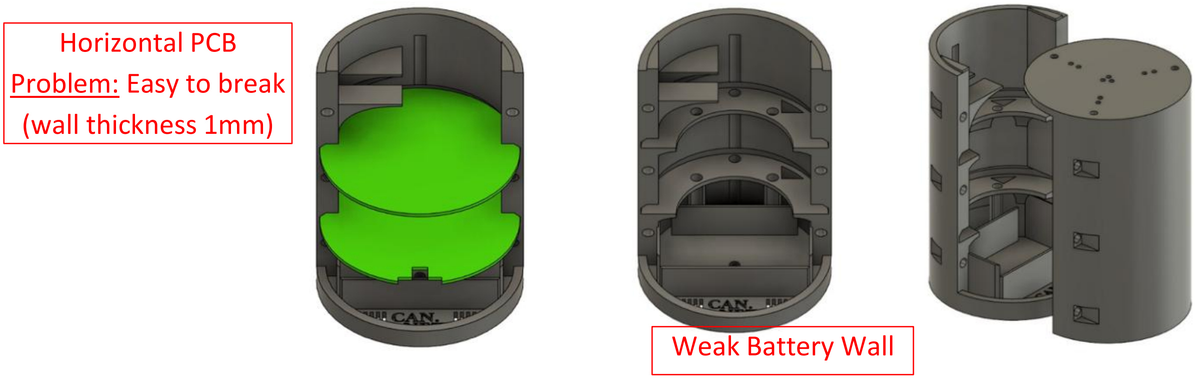
Figure 3: Three basic digital modulation formats are still very popular with low-data-rate short-range wireless applications: amplitude shift keying (a), on-off keying (b), and frequency shift keying (c). These waveforms are coherent as the binary state change occurs at carrier zero crossing points.

2.2 Mechanical design

We now have a final design for our can. We should keep it as it is, unless we encounter technical problems further along with the project. We have elaborated multiple can designs as shown below and decided to keep the most recent one. The third design has incorporated fittings for the battery at the bottom and the PCBs. The PCB fittings are inclined to maximize the wall's width, assuring the can's sturdiness. At the top the can, we have included holes to attach the parachute, and for aeration. Aeration holes can also be found at the bottom of the can. Finally, the CanSat will be filled with soft material like cotton, foam, or sponge to absorb shocks and vibrations, and keep components in place. The can has also been 3D-printed and made of PLA. Here are its characteristics:

- height: 115mm
- width: 66mm
- thickness: 3mm

<u>First Version</u>



<u>Second Version</u>

<u>Third Version</u>

The parachute has been completed and consists of a circle made of red nylon ripstop. Its diameter is approximately 26cm and we pierced a hole of approximately 2cm in diameter. We then pierced 8 holes for eyelets. On top of that, we used a fishing string of 70mm and with a force resistance of 27.5 Kgs, which should be more than enough to resist throughout the Can's flight. With our current model of the Can, we can only attach 4 strings out of the 8, but we plan to find the best configuration.

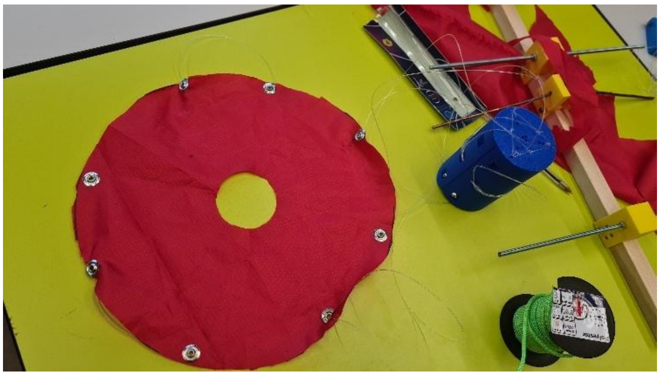


Figure 4: The parachute attached to the can

Here are the calculations we used to calculate the area of the parachute:

$$A = \frac{2 \times m \times g}{Cd \times \rho \times v^2} = \frac{2 \times 0.3 \times 9.81}{0{,}8 \times 1{,}2 \times 112} = 506{,}7cm2$$

$$r = \sqrt{\frac{A}{\pi}} = \sqrt{\frac{506{,}7}{\pi}} = 12{,}7cm$$

$$D = 2 \times r = 2 \times 12{,}7 = 25{,}4cm$$

2.3 Electronic design

The electronic setup includes:

- An emitter. This setup on breadboard shows the alimentation of the system, as well as the connections betwen the sensors, GPS, radio emitter, and GPS to the rasberry pi module. We estimate our current battery is enough to supply the system for the whole mission, so we have not elaborated backup, which might lead to more technical issues.
- A receiver. This setup includes connections between the radio receiver and rasberry pi module. This module will be connected to a computer to interpret data, and the radio receiver to our Yagi antenna to correctly receive data.

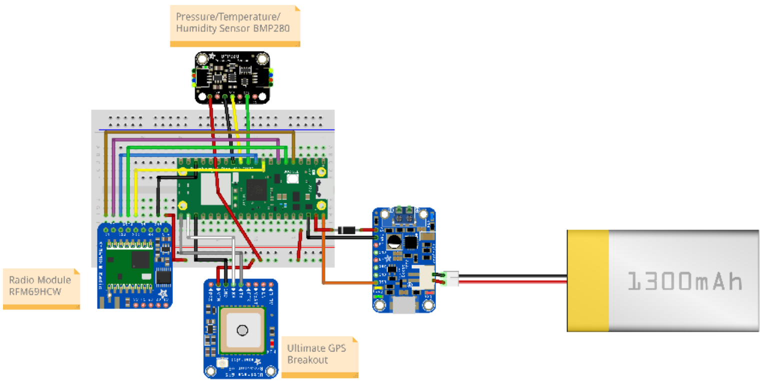


Figure 4: The emitter on breadboard

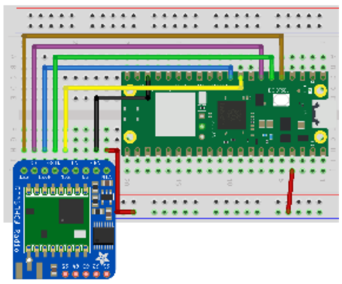


Figure 5: The receiver on breadboard

2.4 Ground station design

Primary mission

Our ground station will consist of 1 standard Yagi antenna, receiver module, and computer to receive/store and exploit the can's data. However, it is important to note we will also store the data directly into the Cansat, in case we fail to receive a signal but manage to retrieve the can.

Secondary mission

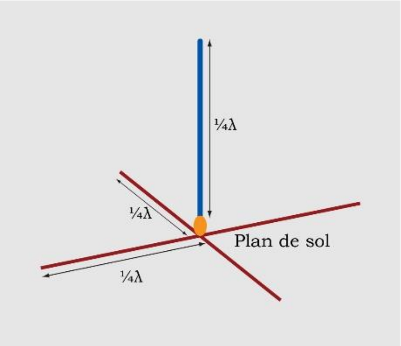
This setup is more complex than the latter. For this mission's requirements, we require 3 omnidirectional antennas, each greatly spaced form one another, for the trilateration to work. We will try our best to exploit the data in real time. For this, we will need to couple each antenna with a computer. These computers will then need to be interconnected with each other, using either cables, or 4G/5G if the cables prove to be too cumbersome or expensive. In the event both the cables and the 4G/5G fail, we will first collect the data on the computers locally and assemble it once the launch is over.

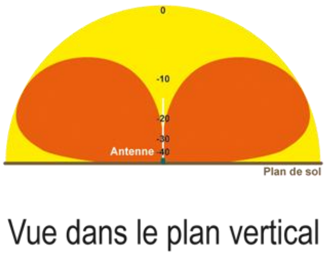
Initially, our team reached out to Pierre-Marie Gayral, a member of the Thionville Amateur Radio Club for some help regarding the ground station. Through a Zoom discussion, we learned about different types of antennas, their radiation patterns, and their suitability for tracking our CanSat. Mr. Gayral introduced us to two main types of antennas: the Ground Plane Antenna and the Turnstile Antenna, which is harder to construct.

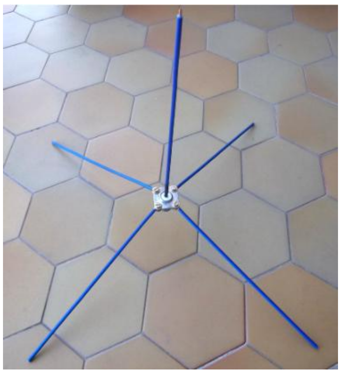
Ground plane

The Ground Plane Antenna is a type of monopole antenna that uses a conductive surface (the "ground plane") to reflect the radio waves and enhance the radiation pattern. It is typically a ¼ wavelength vertical antenna, with four radial elements (the "ground plane") placed at a 120° angle to each other to improve performance.

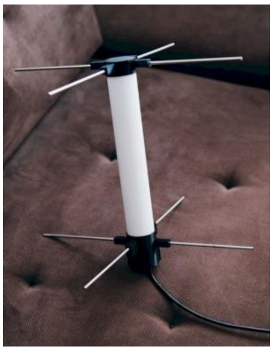
Key Consideration: This antenna type has an insufficient vertical radiation pattern, which may affect precision for applications like CanSat tracking, especially at high altitudes.







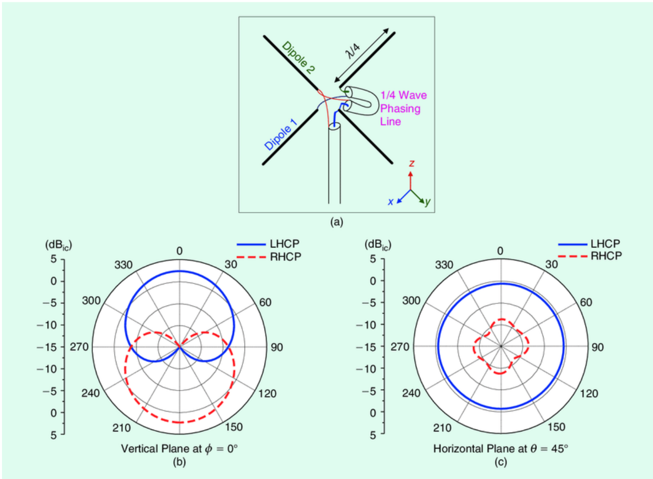
[Turnstile Antenna](https://alicja.space/blog/how-to-build-turnstile-antenna/) (https://alicja.space/blog/how-to-build-turnstile-antenna/)



The Turnstile Antenna is a type of antenna that is used for omnidirectional reception with both horizontal polarization and elevation polarization, making it well-suited for receiving signals from all directions. The Turnstile antenna uses two dipoles arranged in a specific orientation to create a circular polarization, which can help improve signal reception in some cases.

Key Consideration: While this antenna provides a good radiation pattern, its construction is more complex compared to a ground plane antenna, which may require more time and effort to build and align.

Figure 5: Our home-made turnstile antenna



2.5 Software design

Primary mission

While our primary mission code is finished, we have yet to make schematics, diagrams, or graphs to illustrate it. To put it simply, our code collects data from the sensors and sends them through a precise radiofrequency with an emitter to our Yagi antenna. In parallel, the data will be saved directly within the can.

Secondary mission

The secondary mission code is in progress. In theory, the can should be constantly emitting radio waves. These waves will be intercepted by three different antennas on the ground. Using the strength of the signal, the program will use a formula to determine the distance from each antenna and finally determine a relatively precise location through trilateration. For it to take height into account, this program will simply use the pressure data collected from the primary mission.

Formula for Distance Using Signal Strength (Path Loss Model):

The distance estimation is based on the **free-space path loss equation** (FSPL), which describes how a radio signal weakens over distance:

$$\alpha(dB) = 32.4 + 20\log_{10} F\ (\mathrm{MHz}) + 20\log_{10} D\ (\mathrm{km}) \quad (\text{ITU-R P.525-3})$$

where:

- $\alpha(dB)$ = signal attenuation (path loss) in decibels,
- $F(\text{MHz})$ = frequency in megahertz,
- $D(\text{km})$= distance between the CanSat and the antenna in kilometers.

Since the **RFM69HCW** operates at **432.5 MHz**, we can determine the signal wavelength λ using:

$$\lambda(m) = \frac{300}{F(\text{MHz})}$$

which gives:

$$\lambda = \frac{300}{432.5} \approx 0.694 \text{ m}$$

From the path loss equation, we can **rearrange** to solve for the distance DDD based on the measured signal strength:

$$D(\text{km}) = 10^{\frac{(\alpha - 32.4 - 20\log_{10} F)}{20}}$$

Formula for Height using pressure:

$$h = \frac{Pa - Pb}{\rho \times g} = \frac{Pa - Pb}{1000 \times 9.81}$$

where:

- ρ = volumic mass of air (≈1204 kg/m^3at 20° degrees Celsius)
- g = the Earth's gravitational pull (9.81 N/kg)
- Pa = atmospheric pressure at the can's height (Pascals)
- Pb = atmospheric pressure on the ground (Pascals)

Please note we will determine Pb before launch for more precise calculations.

2.6 Recovery system

Our CanSat relies on five different and relatively simple systems that ensure its recovery.

The first one consists of a standard 85db buzzer provided at the meeting on the 15th of January. This buzzer will emit a constant sound allowing us to locate the can. While this is theoretically a good idea, the efficiency of this method will depend on meteorological conditions and a bit of luck. Indeed, if the weather is « noisy », it might be more difficult to perceive the signal. On top of that, if the can falls into a very unexpected location, we might not hear the sounds if we are not close enough.

The second system is directly incorporated into our secondary mission, which consists of locating the can using trilateration. Again, this is theoretically a good idea, though, it will highly depend on whether or not the signal is obstructed, and whether or not the signals reach the antennas. On top of that, reconstituting the data might be challenging. However, this method costs nothing as it does not require any extra components, meaning technical issues can be avoided.

The third system is very similar to the latter. This concept relies on the GPS module used to compare the trilateration values with GPS ones. The pros and cons are the same as for the second method. This acts, in a way, as a backup plan for the second method, and vice versa.

The penultimate method consists in simply adding an AirTag inside the can. This technique allows for relatively precise localization, using our phones, in case both the trilateration and GPS methods fail. This object takes minimal space in the can and provides rather precise values.

Lastly, our last identification system is based on our parachute’s color: its bright fluorescent red fabric should make it easier for us to spot it. The inconvenience, however, is that this identification method only works at a very short range, to spot the can through foliage for instance, otherwise, it will not be of great use.

With all this, we are confident we will not, in fact, be sad! Overall, these 5 methods work in harmony to maximize chances of retrieval, while keeping risks of technical issues and general difficulties to a minimum. The GPS, trilateration, and AirTag should give us a global idea of the can’s position. The buzzer and bright parachute will then stimulate our senses to help locate the can, at closer range.

2.7 Testing

Primary Mission

Components

We have tested all the sensors, micro-controllers, receivers, and emitters on breadboard before soldering. We have concluded that our primary mission was operational for the emitter modules. Though, as time went by, we started experiencing problems with the receiver modules. We tried reconnecting the cables, changing breadboard, troubleshooting our code, but found no answer to the problem. We believe one of the components of the receiver is malfunctioning as our antenna receives data form the emitter but cannot interpret them. As a result, we decided to replace either the radio receiver, or the micro-controller, depending on our needs. Concerning the GPS module, we have not managed to make it work. After doing research online, we realised it might be due to urbanisation that prevents the GPS from getting a proper lock with a satellite. We will need to try it again in an isolated area, like the drop site on the 27th of March. Finally, we have not yet tested the buzzer.

PCB/soldering

We have started the soldering process. At the beginning, the wrong raspberry pi-Pico microcontroller was put on the PCB (it was malfunctioning on breadboard and didn’t work on PCB either for an unknown reason). This greatly slowed the process, but we decided to get a new PCB as unsoldering the component damaged the original PCB. As of right now, the components for the primary mission only have been soldered in place but not tested while in this state.

Antennas

The antennas were tested near the running track of Athénée. We spaced the emitter and receiver by approximately 200 meters. At first, the signal went through, but stopped after a while, which is when we detected the problem with the receiver. However, we still managed to evaluate the Turnstile's performance using a software named "SDR#", which indicated us a reading of −10 db (see video: Turnstile Test).

Figure 8: -10dB on SDR# for the Turnstile's performance

Figure 9: Yagi Antenna Training (22/01/25)

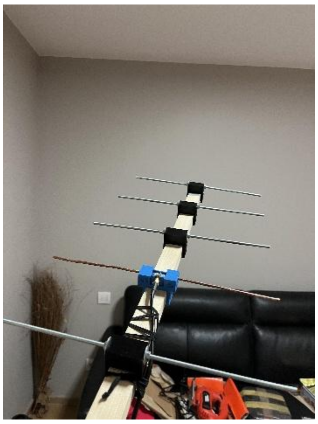


Figure 6: Our Yagi Antenna

Figure 7: Yagi Test in the street

(Videos: Yagi Test)

Parachute

To test our parachute, we first tested the strings' solidity by swinging the can around. On top of that, we tested air resistance by dropping the can from a 10 meter drop approximately and observed a slow in motion. A person was placed below to film the can. Moreover, we have realized that our parachute only used one piece of fabric, too many eyelets, and a very big center hole. To further optimize it, we will use 2 sheets of fabric, reduce the hole's size, as well as the number of eylets. We will continue to test our parachute, by attending the drop test organized on the 27th of March. (see video: Parachute Test)

1. Requirements

1. We focused more on the primary mission and the technical issues that we would face with our secondary mission so our Can still hasn't been made
2. We don't have the weight of our parachute and of our can at the time of our report
3. Our can doesn't contain any sort of projectiles or fireworks or easily flammable objects/hazardous objects
4. For now, our can will rely on 1 lithium battery of 3.7 Volts, 1300 mAh and a 5 volts converter and lithium battery charger, that will convert the power of the battery to a 5 volts power source for the Raspberry. It will also recharge the battery when the kit is powered by USB
5. Our can will have a main, switch accessible from the top or bottom of the can, that will be openable
6. Our Cansat will have a parachute that will deploy from a small compartment at the top of the Can. The parachute color will be fluorescent red. The deployment mechanism of the parachute will either be a spring loaded that will push the parachute out or a weight will pull the parachute out of the can.
7. We will use nylon strings to attach our parachute to the can. Those strings will be firmly attached to hooks on top of the cansat. The strings can withstand a force of up to 250 kilos or 2452 Newtons
8. Our parachute isn't ready yet but in theory it should bring the descent speed to 11m/s
10. The materials that we are going to use to build the parachute should be strong enough to resist up to 5 Gs of force
11. For more info check "Budget"
12. We do not have any sponsors for the moment
13. Our primary mission is already working, and we can measure the temperature and the air pressure. However, we can only make it work over a short distance, but this problem should be resolved with the antenna
14. Not done
15. All our data will be stored in the Raspberry Pico, in the form of a data table

3. Overall progress

3.1 Human resources

Team members and roles:

- **Gabriel:** *Gabriel is a bike enthusiast and triathlete. He regularly indulges in activities such as climbing, swimming, running, and mountain biking. The discipline he gained from sports helps him stay focused on his tasks. On top of that, Gabriel has proven time and time again he detains critical thinking skills helpful in our task.*
- **Ugo:** *Ugo is a student passionate about science and Engineering. His BIA (Brevet d'Initiation à l'aéronautique) diploma reflects his interest in the matter. He is impatient to learn and make the project come true, yet composed enough to take all the necessary steps without rushing. His ability to analyze situations and problems has been crucial for the team so far.*
- ***Martin:*** *Martin, like the other members, is very dedicated in the project. Like Ugo, he aspires to be an engineer and shows great interest in science*

in general. This explains his past involvement in the « First Global Robotics Competition » and internship at the SES (Société Européenne des Satellites). Martin is probably the most well-versed member when it comes to coding and exploiting software, a skill that has not gone unnoticed.

- ***Aboubaker:*** *Aboubaker is a division 2 basketball player. The sportsmanship and ability to learn strategies he acquired from basketball enables him to clearly see the objective and follow the rules.*
- ***Cillian:*** *Cillian takes on the role of our math specialist, a subject which he is very passionate about. He got second place in the « Olympiades de Mathématiques Belges » (OMB) preliminary round in Luxembourg.*

Work repartition:

So far (as of the 28 March 2025) our team has equally divided the work between all the members:

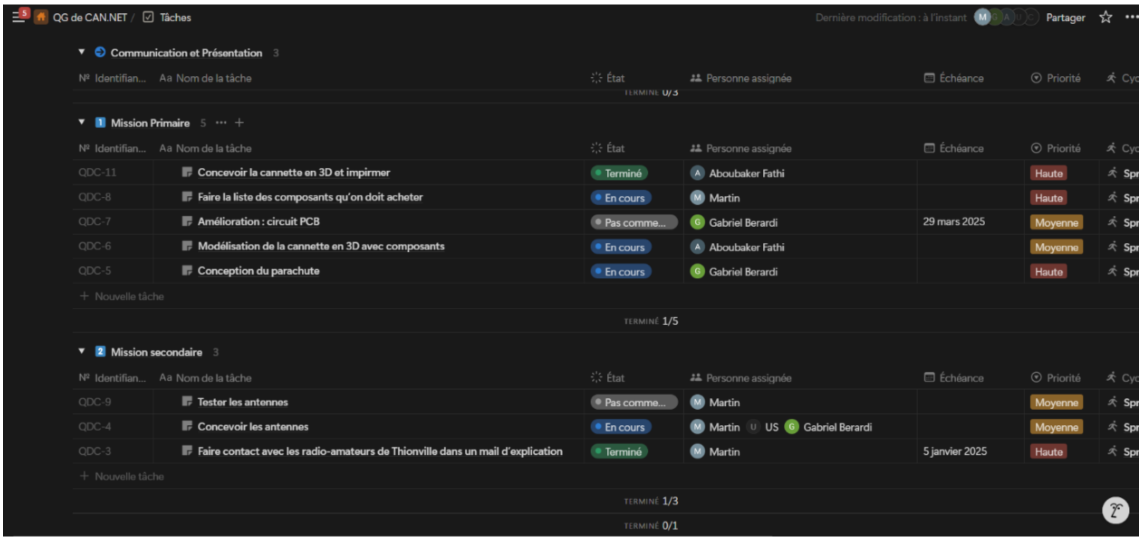
- *Martin has been taking care of creating the Turnstiles Antennas, the codes for the second and primary mission, enhancing the signal received from our Yagi antenna, and creating our beautiful can*
- *Ugo helped Martin on the creation of the Turnstiles Antennas and has been working on the codes and on the modelling of the can with him*
- *Aboubaker helped build the Yagi Antenna and worked on the modelling of the can. His current task is soldering on the PCB*
- *Gabriel built the Yagi Antenna with Aboubaker and completed the parachute. He also is the courier of the team and almost has the fidelity card at Hornbach with all the times he went there.*
- *Cillian has been and is keeping the report updated at each new milestone achieved by the group. He is in charge of our Instagram.*

Events (in order):
1st February: Making and finalization of the Yagi antenna during Vauban's open day, Gabriel and Aboubaker
10th February: Making the Turnstiles antenna, Martin
15th February: First test of the antenna, Ugo and Martin (it works!)
7th March: First model of then can, Martin
20th March: Finalization of the Turnstiles antenna, Martin
22nd March: Second model of the Can, Martin
24th March: Making of the parachute, Gabriel + Third model of the can, Martin
25th March: Start of the souldering on the PCB, Ugo, Aboubaker, Martin
28th March: Finalization of the parachute, Gabriel
Every day: Working on the report, everyone

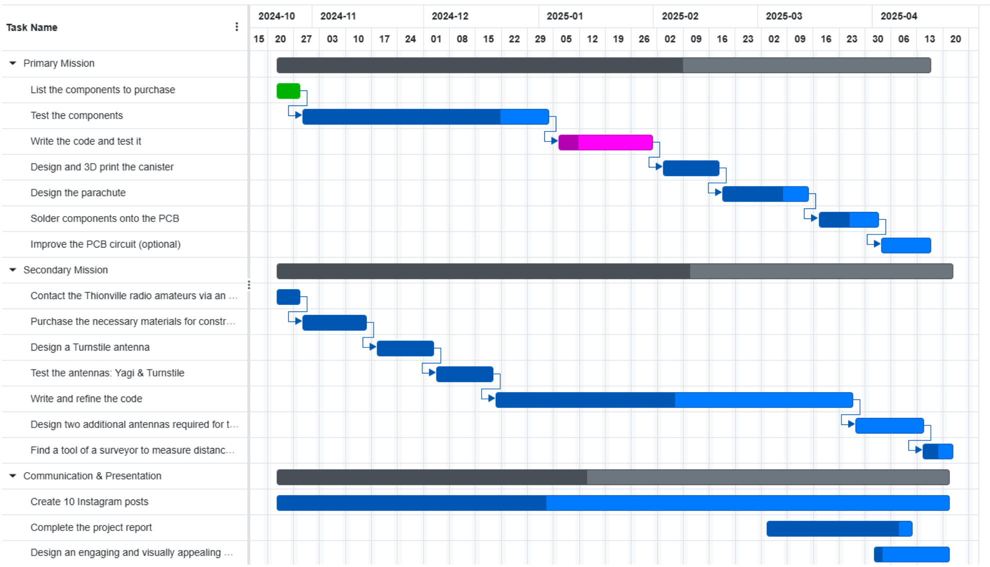
Instagram account posts/stories: *Everyone*
Making of the report: *Martin, Ugo and Gabriel*

3.2 Planning

*To manage our project's timeline effectively, the team utilizes **Notion**, a powerful organizational tool. Notion helps us keep track of tasks, deadlines, and progress in a structured and collaborative manner. Each member has assigned their name to a task and updates the team as regularly as possible. Moreover, we try to organize a weekly meeting to clarify points of uncertainty as well as our progress.*



Gantt chart illustrating task progression over time.



3.3 Budget

Parts	Price	Origin	Date of purchase
CanSat Components			
Adafruit Electronics			
Ultimate GPS Adafruit	$36{,}24€$	https://www.reichelt.com/fr/fr/shop/produit/cartes_de_developpement_-_carte_de_breakout_gps_mtk3333-235482	25/01/25
DC 3V-24V Piezo Buzzer	$5{,}50€/_3 = 1{,}83€$	https://www.amazon.com/3-Pack-3V-24V-Electric-Buzzer-Active/dp/B0761WSXDK	Received for free
Parachute			
Parachute Textil	$34{,}99€$	https://amzn.eu/d/acVu2Tr	Received for free
Paraloc Mamutec Polyester Rope Ø 3 mm, 20 m	$8{,}95€$	https://www.hornbach.lu/fr/p/corde-paraloc-mamutec-polyester-o-3-mm-20-m/8442210/	29/01/25
50 medium-sized eyelets	$50 \times 0{,}16€ = 8€$	In bulk at Hornbach	
15 flat washers	$0{,}031kg \times 21{,}45€/kg = 0{,}66€$	In bulk at Hornbach	
Ground Antennas			
Yagi Antenna			
Rough Spruce/Pine Batten 20x30x2000 mm	$6{,}60$ €	https://www.hornbach.lu/fr/p/tasseau-konsta-pin-epicea-brut-20x30x2000-mm/5485737/	29/01/25
1-meter threaded rod, DIN 976, M5, galvanized zinc-coated	$2 \times 0{,}85€ = 1{,}70€$	https://www.hornbach.lu/fr/p/tige-filetee-din-976-m5-electrozinguee-1-m/10544377/	
H07 V-U conductor, 1G2.5 mm², 20 m	$10{,}38€$	https://www.hornbach.lu/fr/p/conducteur-h07-v-u-1g2-5-mm-20-m-vert-jaune/5116020/	Received for free
Hex nut, Sencys, galvanized, M5, pack of 40	$4{,}09€$	https://www.brico.be/fr/quincaillerie/fixations-techniques/ecrous/ecrous-hexagonaux/ecrou-hexagonal-sencys-galvanise-m5-40-pieces/5367596	
Wide flat washer, Sencys, M5, pack of 40	$7{,}99€$	https://www.brico.be/fr/quincaillerie/fixations-techniques/rondelles/rondelles-plates/rondelle-plate-large-sencys-m5-40-pieces/5368786	

Turnstile Antennas			
PVC pipe, 40mm in diameter, 500mm in height	$3 \times 1{,}35€ = 4{,}05€$	https://www.hornbach.lu/fr/p/tube-ht-dn-40-500-mm/209767/	
RTL-SDR V4 Dongle	$31{,}18€$	https://fr.aliexpress.com/item/1005005952682051.html	
CW 8500 Flux Gel - No Clean	$18{,}67$ €	https://www.reichelt.com/fr/fr/shop/produit/gel_de_flux_cw_8500_-_no_clean-112697	
SO 239 Female embedded UHF connector	$1{,}72€$	https://www.reichelt.com/fr/fr/shop/produit/connecteur_uhf_femelle_encastre_montage_a_bride-19218	
PL 259 UHF connector for a cable diameter of 4.5 mm	$0{,}97€$	https://www.reichelt.com/fr/fr/shop/produit/prise_uhf_pour_un_diametre_de_cable_de_4_5_mm-14692	25/01/25
Cable type RG58 C/U	$2 \times 0{,}76€ + 4{,}50€ = 6{,}03€$	https://gigatek.be/fr/kabel-c-ble-coax-rg-59-75-ohm-b500--kobrg59	
SMA Male to SMA Female Cable RG58A/U	$12{,}78€$	https://amzn.eu/d/eUK25X2	
Stainless Steel Rods 4 mm x 100 mm	$7{,}85€$	https://amzn.eu/d/7TrxGDK	
Stainless Steel Round Rods 4 mm x 400 mm, Pack of 5	$(3 \times 16{,}31€) \times 0{,}9 = 44{,}04€$	https://amzn.eu/d/73RTc5X	29/01/25
3D Printed Objects			
Creality, Ender-3 V2		Example of calculations For a 72.64g 3D print of the can using Bambu Lab X1 and blue PLA: 1. **Material Cost**: Weight: $0.07264\ kg$ PLA cost: $€18.03/kg$ $Material\ Cost = 0.07264\ kg \times €18.03/kg = €1.31$ 2. **Electricity Cost**: Power consumption: $0.11\ kW$ Printing time: $2.65\ hours$ (2h39min)	
Yagi Support Total $3.69€$	Material Cost $2 \times \mathbf{63.2g} \times 10^{-3} \times €18.03/kg = 2.28€$ Electricity Cost $2 \times \mathbf{7.9h} \times 0.350kW \times €0.255/kWh = 1.41€$		28/01/25
Turnstile Support	Material Cost		10/02/25

Total 6.61€	$4 \times \mathbf{56.7g} \times 10^{-3} \times 18.03€/kg = 4.08€$ Electricity Cost $4 \times 7.08h \times 0.350W \times 0.255€/kWh = 2.53€$	$Energy\ used = 0.11\ kW \times 2.65\ hours = 0.2915\ kWh$ Electricity price: €0.255/kWh $Electricity\ Cost = 0.2915\ kWh \times €0.255/kWh = €0.074$ 3. **Total Cost** = Material Cost + Electricity Cost $= €1.31 + €0.074 = €\mathbf{1.38}$	
Bambu Lab X1			
Can	$3\ versions = 3 \times 1.38 = 4.14€$		24-25-26/03/25
Total Prize (only paid material + shipping cost)	Reichelt: (0.97+18.67+36.24+1.72+**6.95**) **=**64.55€ Amazon: (12.78+7.85+**3.50**) +(44.04) =24.13+44.04=68.17€ Ali-Express: 32.19€ Gigatek: 6.03€ Hornbach: (6.6+1.7+8.95+8+0.66) +(4.05) +(10.09) +(8.29) +(8.90) =57.24€ 3D Printed Objects: 3.69+6.61+4.14=14.44€ Total: 64.55+68.17+32.19+6.03+57.24+14.44=**242.61€** All culminated: 233.72+10.38+4.09+7.99+34.99+1.83=278.55€		

Invoices: Invoices

3.4 Outreach

In order to communicate our work to our entourage, Can.Net has primarily opted for social media. We have created an instagram account in which we try to actively post, update, and interact with our followers. This is done through the publishing of photos, instagram « reels » and stories. Furthermore, we do not hesitate to share our projects with those curious enough at social and scientific gatherings such as the « Makerfest ». Finally, our involvement with the "Club Radioamateur Thionville" has led to an article being published about our project (see link below).
https://f8kgy57.wordpress.com/2025/01/21/la-trilateration-vous-connaissez-le-club-f8kgy-a-ete-sollicite-par-jerome-metzler-professeur-au-lycee-vauban-luxembourg-pour-le-choix-optimal-du-type-dantenne-et-le-traitement-du-signal/
Instagram: c4n.n3t (don't forget to follow!)

As of now, we have 70 followers and 6 posts. We aim to be more active in the following days by posting more stories, reels, and photos given that major events are coming up and that we are nearing the finalization of our project. We have accumulated 230 views in the last 30 days and 131 likes.

4. Scientific results

Of course, this part will come after the launching. Explain your results using graphics, tables, …

5. Discussion

Give your opinion about your project, results, future improvements, …

6. Conclusion

So far, we faced some challenges such as a lack of equipment (like for the antennas), faulty equipment (like the receiver), manipulation errors (like putting the wrong micro controller on the PCB), and complexity of manipulations (like with the turnstile antennas' build). From this, we learned that we need to plan more in advance, communicate correctly, keep track of faulty components, and make sure that we have everything we need before proceeding with our tasks. This could help us gain time and efficiency, thus helping us complete our projects faster, and leaving us more time to focus on other problems at hand.

References

1. **WIRED.** We Tracked the Secret Police Microphones Hidden Everywhere. *YouTube.* [Online] December 19, 2024. [Cited: December 30, 2024.] https://www.youtube.com/watch?v=USNJ2eOme8E.

2. **Marie, Jacky.** La trilatération vous connaissez ? *f8kgy57.* [En ligne] 01 01 2025. https://f8kgy57.wordpress.com/2025/01/21/la-trilateration-vous-connaissez-le-club-f8kgy-a-ete-sollicite-par-jerome-metzler-professeur-au-lycee-vauban-luxembourg-pour-le-choix-optimal-du-type-dantenne-et-le-traitement-du-signal/.

Appendix

If you want to add files (keep in mind the max 20 pages)