WCRC CanSat 2022
Final Report

“You never fail until you stop trying.” - Albert Einstein

TEAM MEMBERS

SEVERIN SEBASTIAN

Role: Team leader, project manager, PCB designer, 3D modeling, ground station monitoring

OMER TARIK ILHAN

Role: Software integration, programming and parachute manufacturing assistance, deployment

DANIEL ERZSE

Team mentor and guide, ground station assistance

GHERGHEL BEATRICE

Role: PCB manufacturing, electronics, outreach and PR, assistance to other team members

CANSAT MISSIONS (PROPOSALS)

PRIMARY MISSION

Measure the air pollution. The CanSat will be launched to an altitude of at least 100 meters and it will have to use its parachute to stabilize its flight and shall transmit data about:

- Air temperature
- Air pressure
- Particulate matter
- Presence of volatile gas
- Humidity

SECONDARY MISSION

It consists of sending an uplink message to the CanSat (to change its state mid flight), but also measuring other atmospheric and attitude parameters such as:

- IMU (Acceleration, Gyroscope)
- Altitude

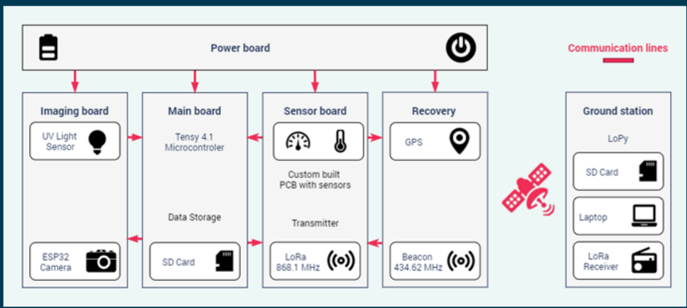
The main result we expect from the first mission is the level of air pollution present in Novi Sad. The data received from the additional sensors and the secondary mission will provide proof of the possibility to integrate complex systems into small space devices.

THE MISSION

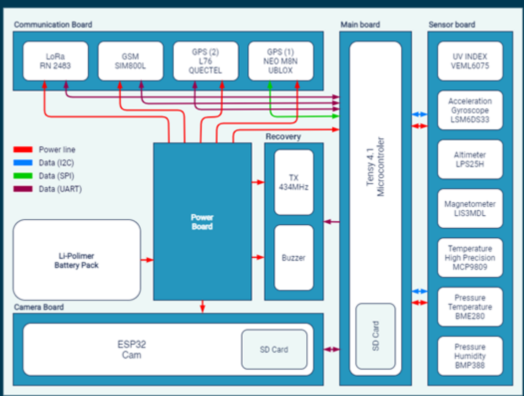
For our secondary mission, we wanted to test the possibility of controlling the CanSat from the Ground Station, not only for possible antenna and solar panel deployments, but also for OBC status changes and sensor control during the flight. Thus, we integrated a status RGB LED on the Can whose color and working behaviour we planned to change mid flight.

Although our CanSat will still be a stack of sensors, we wanted to give our team the freedom to explore new ideas. This wish is what ultimately led us to include an extended list of parameters that we would like to monitor, including particulate matter. By collecting readings from multiple sensors, we can make more informed decisions about the environment the CanSat is landing in.

THE BLOCK DIAGRAM



ELECTRICAL DESIGN



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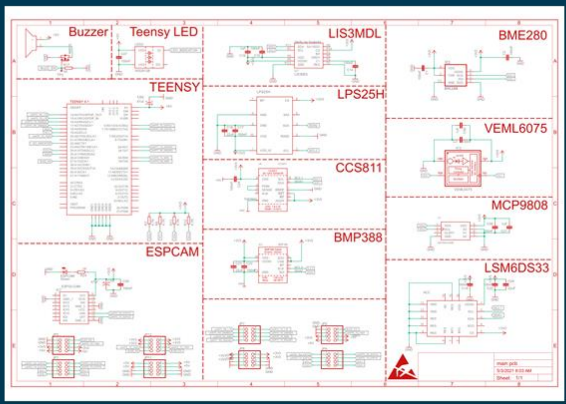
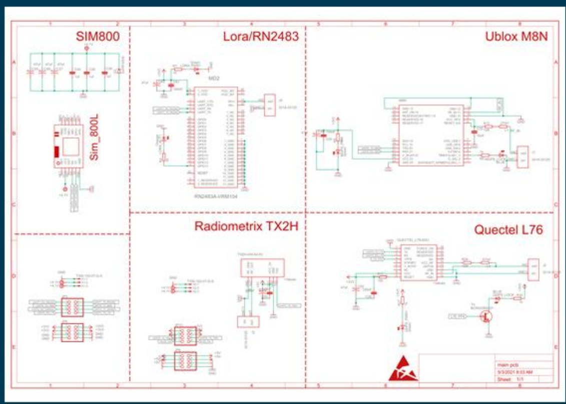
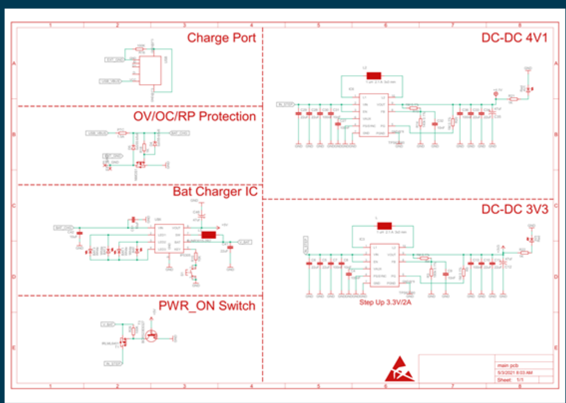


ELECTRICAL DESIGN



ELECTRICAL DESIGN



OVERALL MISSION CONCLUSIONS

EXPECTATIONS

- Can structural integrity will hold;
- The safety mechanisms (parachutes mainly) will function fine;
- The power board and the battery will work;
- The sensors will function correctly;
- TX/RX will function correctly;
- GPS data will be collected and transmitted to the base station;
- Data transmitting will work;
- The systems used for the recovery of the can would not be damaged;
- Uplink message will be received and the CanSat will execute the given request

REALITY

- The 3D printed can was not damaged at all, due to the fact that we were able to catch it in our hands before landing
- The power board and the battery couldn't be tested (not enough flight time). On ground tests resulted in a 4 hour battery lifetime for acquiring data.
- Despite of previous issues, almost all sensors worked properly, with only one exception caused by a programming error.
- Data transmission through SMS worked perfectly until the Romanian provider cut us off.
- We got good GPS information during the second launch, having at least 4 GPS satellites in the view of our sensors.
- Our Camera got damaged during pre-launch testing and it had to be removed.

THE PRIMARY MISSION

- Technically, we consider the primary mission a success because we landed and recovered the data.
- We collected **561** data readings, including the ones from the launch and landing. One of the sensors had minor hiccups in reading data (the CCS811, due to a programming error was not adding it's readings to the packets sent to the ground/stored internally), so we were able to get almost all the main parameters for the primary mission;
- Regarding data quality, the mission can also be considered a success. Almost all the sensors providing information for the primary mission functioned correctly.
- The Can's structural integrity couldn't be tested this time.

THE SECONDARY MISSION

- We successfully sent the uplink message to our Can and as a result just before the separation from the rocket the status LED changed from green to displaying the national flag of Romania fact that could be seen we the Can was recovered.
- Also the additional sensors provided all the data needed about GPS location, particulate matter (PM1, PM2.5), and IMU (acceleration, gyroscope and magnetic fields).
- The impact velocity of the CanSat would have been around 9.2 m/s if we did not catch it.

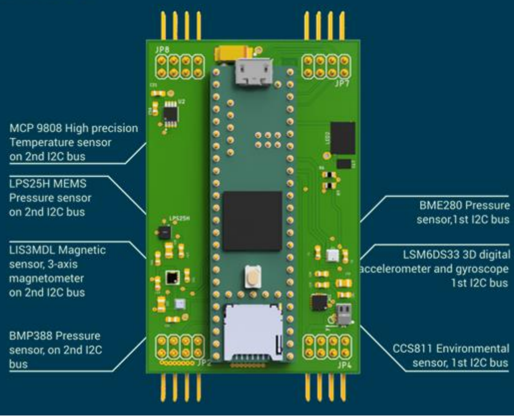
HARDWARE ISSUES

The CanSat core is composed of four boards, positioned into a frame, and is located in the lower part of the satellite to assure stability during flight:

- One Power board, which assures the power for all the microcontrollers and sensors, contains also the Recovery module with the 434.42 MHz RTTY transmitter and the buzzer;
- The Mainboard, a Teensy one in the modified version, runs the program during the mission. It also contains all the I2C connected sensors used by the satellite for gathering precious data during the mission;
- The Communication Board (with LoRa and GSM capabilities) is the primary communication system of the satellite and also the communication relay for transmitting telemetry and parameters during the flight time;
- A Camera Board with the ESP32 Cam. On the Camera Board images are stored on a SD Card. Unfortunately, the Camera did not function during the launch.

I2C BUS ANALYSIS

Both I2C busses worked properly and almost all the sensors sent environmental data as planned. Despite some previous issues with the I2C bus, this time the data loss was caused by a programming error. A few missing lines of code resulted in the loss of the CSS811 data. Instead of adding the measurements from it to the stored and transmitted data packets, the data was just printed on our debug UART port. This issue was only identified post-launch when analysing the data received from the Can.

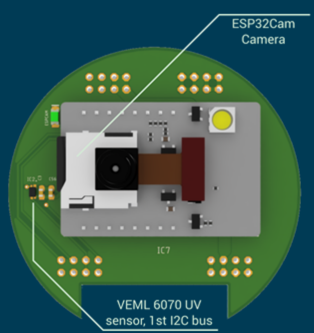


COMMUNICATION ANALYSIS

We had a very good GPS connection on one of the GPS receivers (at least 4 satellites in view). For power management reasons, we configured the SMS sending interval to 30 seconds in the stationary phase of the CanSat and 10 seconds for the flight mode. Due to this setup, we received the data messages during pre-launch preparations, but as the launches started, the Romanian roaming service provider did not allow us to send more messages and we couldn't log the SMS data anymore.

The LORA module worked perfectly, sending the collected packages from the CanSat through radio on 868.1 MHz. We did not have packet loss in our radio communication.

The Camera, however, was damaged during the pre-launch setup. The photos it tried to take during the assembly procedure and flight were all black, due to the fact that the optic sensor had to be removed before the launches.



RECOVERY SYSTEM ANALYSIS

CONCLUSIONS

We consider that we achieved:

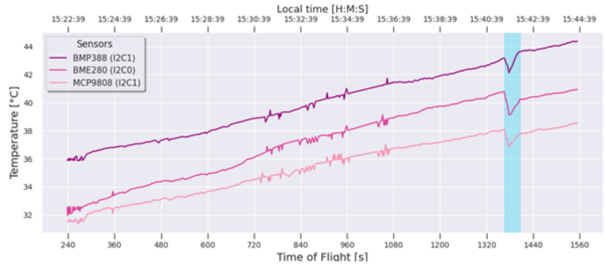
- 90% percent of our goals on the primary mission;
- 100% percent success ratio of the 1st part of our secondary mission, since we successfully controlled the CanSat remotely
- 90% percent of our purposes of measuring additional parameters data on the 2nd part of our secondary mission because the data could not be sent via SMS during the flight

Overall, we conclude that the success rate of the missions is at least 92% because we found the can, recovered the data from the can, and also received data through LoRa on the base station, with a minimal error rate, but we failed to send data via SMS.

DATA ANALYSIS

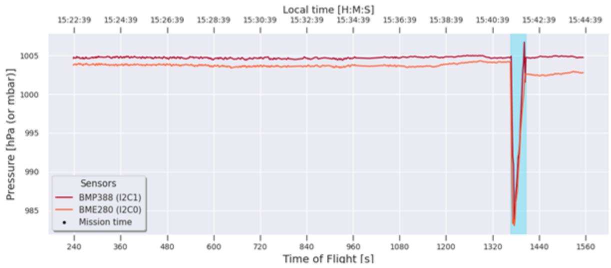
From the beginning, we imported the received data in Python, together with the recovered data from the CanSat. We collected **561** data packages from the base station and the same amount from the Can. The cleaned data is summarized (**24** data packages for the actual flight) in the following combined graph.

THE PRIMARY MISSION



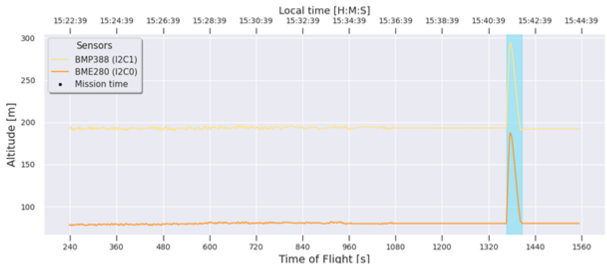
The temperature was measured using three sensors: the Bosch BMP388, the Bosch BME280, and a Microchip MCP9808. The sensors were all placed in different places and experienced different conditions during the flight. Since there are many "extra" temperature differences in the graph, those could be caused by the different airflow channels and different proximity to heating sources such as the OBC.

THE PRIMARY MISSION



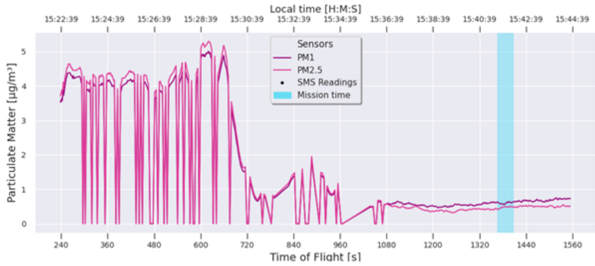
The pressure sensor data was gathered from two simultaneous I2C buses with two Bosch sensors BMP388, BME280. One can see on the graph that the pressure from both sensors drops once the rocket lifts off and then spikes when the CanSat was caught.

THE SECONDARY MISSION



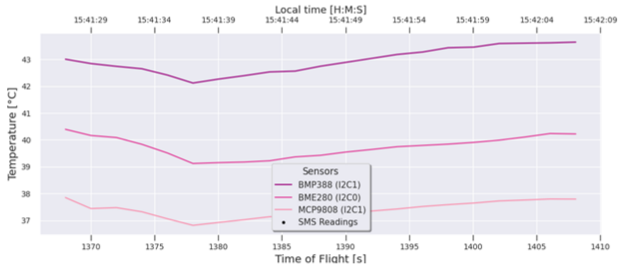
Altitude was recorded using sensors on two I2C buses. Because we had average-to-low signal quality, we had readings from only one of the two GPS modules. As for pressure, because Altitude is inversely related to Pressure, the graph presents a pretty sharp rise in altitude once the launcher rose toward the top altitude spot and a similar drop back to the airport's ground altitude.

THE SECONDARY MISSION



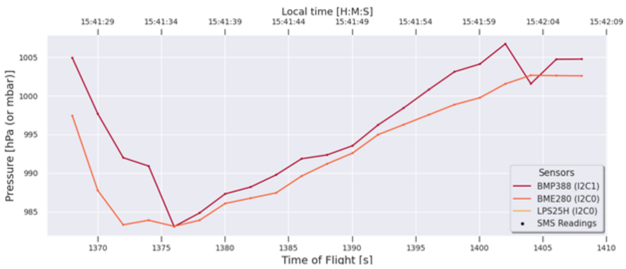
Our mission was to collect environmental parameters like Particulate Matter and CO2 levels. The latter was not collected due to programming errors. The Particulate Matter sensor, being connected to UART, worked well, and we have data readings from our mission. In the graph, the level of PM particles dropped as the CanSat rose. There are a few spikes in the data, but we think they might have been created by air movement caused by the rocket itself.

MISSION ANALYSIS



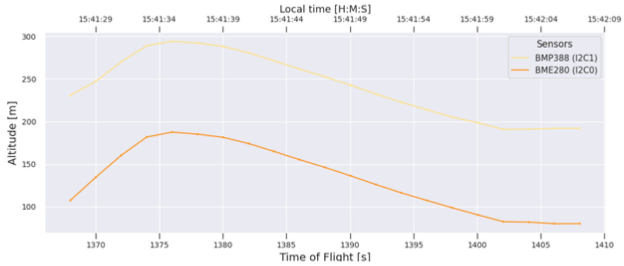
We analyzed the core mission phase when the rocket rose and then came down with the CanSat. From the graph, one can see that the ascension to the peak point took 10 seconds and the descent took 38 seconds. Even so, temperature readings were performed during landing, but the number of records is not impressive.

MISSION ANALYSIS



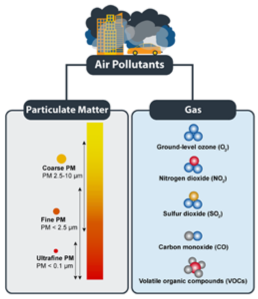
The same analysis performed on temperature was used for the pressure readings. As the rocket reached peak height, pressure levels fell. Once the CanSat got separated from the rocket and started its descent, the pressure started to rise again.

MISSION ANALYSIS



In reverse, we can see the altitude of the rocket as it ascended up to a height of around 104 m above ground level. When the CanSat descended, it captured altitude data and pressure measurement readings on its way down.

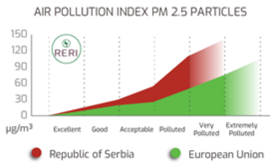
DATA INTERPRETATION



During the flight the **humidity** level didn't have a considerable variation probably due to its position inside the can and the average value was around **77%**

Based on the temperature measurements, pressure levels, humidity average and pollutant particles presence we can conclude that the air is mostly clean.

Based on the levels of pollution that we measured beforehand in Bucharest and Constanta in Romania we can conclude that the air in Novi Sad is cleaner.



GROUND STATION

The CanSat was being monitored and controller by our ground station operators. The station consists of a laptop computer with certain apps for data flow management and radio package intake, a data logger and an antenna.

OVERALL STATISTICS FROM OUR POINT OF VIEW

A. Technical Achievement -> 92%
B. Scientific Value -> High
C. Professional Competence -> Proficient adaptability, despite the various issues that appeared during the whole competition
D. Outreach -> Effective

ROSPIN-Sat

Romanian Space Initiative