COSMOCHILL

Pre-Launch Report

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Other information regarding development and mission status are available at:

https://www.cosmochill.space

Contents

1 Introduction

1.1 Mission objectives

Our primary focus has always been on environmental issues, topics about we heard a lot in school, but in which we never had the possibility to make an actual difference. The CanSat project turned out to be a perfect way to start, in fact we decided to select, as secondary mission, the detection of VOCs (volatile organic compounds). These molecules are, as the name explains, organic and highly volatile, so they get easily spread in the atmosphere. This class of molecules contains a very large number of compounds, such as hydrocarbons (linear and aromatics), aldehydes, ketones and alcohols. They all have different physical and chemical characteristics, causing different interactions both with the human body and the environment.

Our CanSat goal is to track these compounds with a system of three sensors. One, in particular, can detect concentrations between 0 and 1000 ppb. The other two sensors are less precise, but very reactive, making it possible to understand where there has been contact with the VOCs, even if in a small quantity.

This system could be used in the near future to analyze the entire troposphere, in order to plan a real intervention to remove the excess of VOCs, solving all the health issues linked with them and part of global warming.

2 CanSat Description

2.1 Mission Outline

Design and build a CanSat to be launched and deployed from a rocket at an altitude of about 1000 metres. The CanSat will descend no slower than 5.5 metres per second and no faster than 8 metres per second (depending on onsite air temperature and humidity).

While descending, the CanSat will transmit to the ground control station data about: air temperature, air pressure and GPS location of the device.

The satellite will also save these data on the two on-board microSD cards.

During the descent, the CanSat will gain data regarding VOC concentrations in the PPB order (parts per billion) in the atmosphere through the use of 3 different sensors.

The increase in VOC concentrations is one of the most debated topics in recent times. In addition to the issues related to common air pollutants, VOCs are playing an increasingly active role in the research sector. Studies are mainly focused on indoor environments, as these substances are primarily released by household items such as paints, adhesives, and

dyes. Despite this, concentrations are also rising in the atmosphere and can cause both health and environmental problems. Prolonged exposure to these substances generally causes mild health issues such as fever, sore throat, and headache. More severe problems stem from compounds like benzene and formaldehyde, which are carcinogenic to the human body at the respiratory and circulatory levels. Furthermore, the presence of carbon compounds with free radicals causes an abnormal production of ozone in the lower layers of the troposphere, where it should not normally be found. The result is an amplification of the greenhouse effect by up to 16%. At the moment, there is not much data on VOC concentrations at various altitudes; therefore, our research aims to engage in a field that is still new and stimulating for the team. We expect very low concentrations in outdoor environments between 0 and 10 parts per billion.
This would enable us to analyze VOC pollution at various altitudes, track their movements in the atmosphere through time and give a general picture of air quality in the area.

2.2 Mechanical/structural design

The CanSat has been developed on four different levels (see picture) consisting of one PCB board each, connected through brass spacers to guarantee resistance to accelerations and impacts. To ensure the CanSat's weight complied with the competition guidelines, a 128g lead disk was inserted in the structure.
The satellite's outer casing is made from recycled plastic and is open at the bottom, where there is a net section to block debris from infiltrating the VOC sensors.
Furthermore, for shock resistance, a special rubber has been applied to the bottom for energy absorption. Go to appendix A for figures 3, 4 and 5.

2.3 Electrical design

Go to appendix B for more informations.

2.4 Software design

2.4.1 CanSat Firmware

The firmware integrated into the device was developed to ensure functioning in every environment, condition and case scenario.
On the main board, we find the firmware for the primary mission, which will gather air pressure, air temperature and GPS location data from the sensors, send them to ground control through the radio module and save those data on the microSD card.
On the VOC PCB, we find the firmware for the secondary mission, which will gather VOC

concentrations data from the 3 different sensors and save them on the dedicated microSD card.

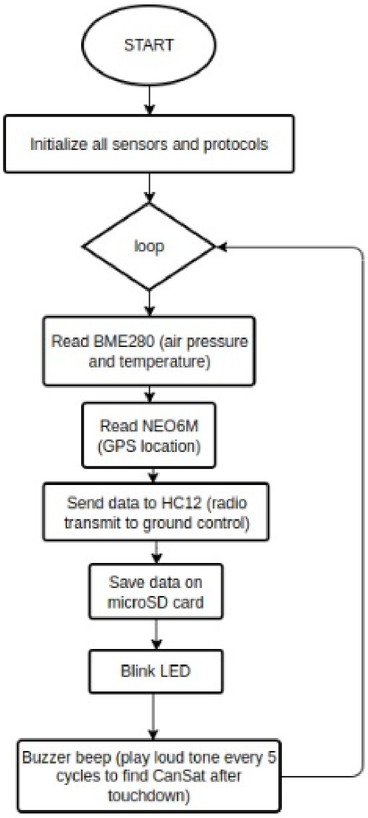


Figure 1: Flowchart of the firmware on the CanSat Main board

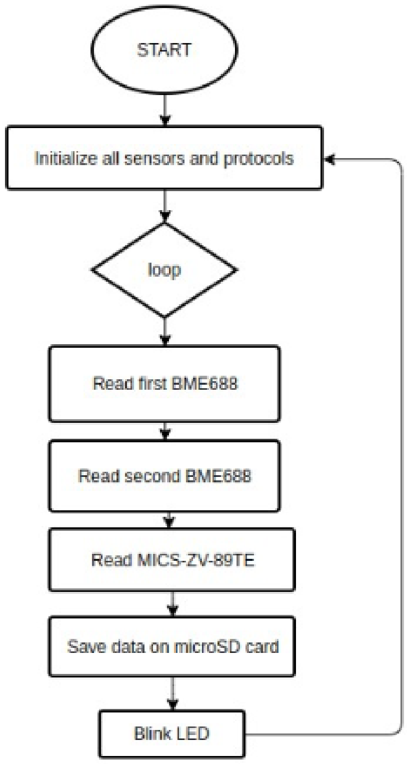


Figure 2: Flowchart of the firmware for VOC PCB board

2.5 Recovery system

The parachute has a hexagonal shape, with a diameter of the inscribed circumference of 41/42 cm. It has a spill hole in the middle of around 16.6% of the diameter just given, so around 7 cm. Furthermore, the parachute is affixed to the main structure by a couple of circular shaped poly-carbonate slabs, around 1 cm thick, with some holes to let the paracords pass through, which are then blocked by the other slab and then fixated to the structure via a threaded hole in the middle of the slabs. The use of paracords is needed to ensure the structure and the recovery system do not take dangerous shocks and, also, to ensure it can bear 50N of static force. The expected flight time from 1000 meters of height from the soil is 150 (+/- 13%) seconds, with an average vertical speed between 5.88 and 7.69 meters per second.

2.6 Ground support equipment

We have developed a software solution that enables us to receive real-time data from the ground station via the serial port. This software not only allows us to update and visualise dynamic graphs displaying temperature and pressure measurements but also provides a live map for accurate localisation. The software was developed Python, leveraging the capabilities of the PyQt5 graphical library to create an intuitive user interface.
Furthermore, for in-depth data analysis and visualisation after the launch, we will employ the robust and feature-rich Grafana platform. Grafana will enable us to explore and interpret the collected data with advanced analytical tools and visually appealing dashboards.

3 Project Planning

3.1 Time schedule of the CanSat preparation

Go to appendix C for more information.

4 Resource estimation

Go to appendix D for more information.

5 Testing

5.0.1 Primary mission

We successfully completed the primary mission test of the CanSat, demonstrating the functioning of temperature and pressure sensor data collection, as well as data transmission beyond 1.8km. The sensors accurately gathered temperature and pressure readings, which were then transmitted wirelessly to the ground control station located over 1.8km away. This successful outcome showcases the capabilities of the CanSat and its ability to collect and transmit data over long distances.
In addition, we also demonstrated the functioning of external ground control software programmed by the team.

5.0.2 Secondary mission

Regarding the secondary mission tests, we decided to try out our sensors in a laboratory. We simulated three different polluted environments, with three different substances: formaldehyde, acetone and butane. These can be seen as three representatives for three of

the biggest VOCs classes: aldehydes, ketones and alkanes. We put our detection system in a tailed flask, letting the cables pass through the tail. Then we added a few drops of substance and heated with a plate, to make the process faster.
This process has been very important to be sure of the correct functioning of the sensors, and to see their precision and stability in case of a fast change in pollutant concentration. The graphical results are shown in the research document, linked here.

5.0.3 Recovery system testing

In order to ensure a correct deployment and opening of the parachute it will be folded in a conical shape and then folded again in a roll-like shape. The tests were executed from 8-9 meters of height, with a free fall time between 1.5 (for the tests without the parachute) and 2.2 seconds (with the parachute in its definitive form, all of them adjusted to remove the fixed error due to the not completely straight trajectory, imposed by the place of the tests).

6 Lesson learnt from the National Competion

Go to appendix D.2 for more information.

7 Outreach programme

Regarding the outreach part of the project, we have decided to:

- Create a website: https://www.cosmochill.space;
- Create an Instagram page: @cosmochill;
- Conduct conferences within the school environment regarding the CanSat competition;
- We have given two interviews for a local newspaper;
- Engage the entire community with the Send Your Name initiative inspired by NASA's.

8 Requirements

Go to appendix G.1 and G.1 for more information.

A Mechanical/structural design

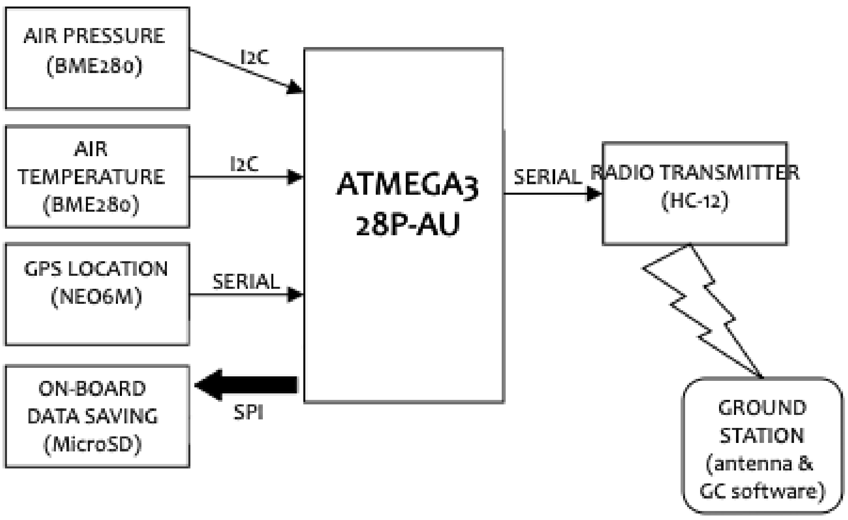


Figure 3: Primary mission diagram

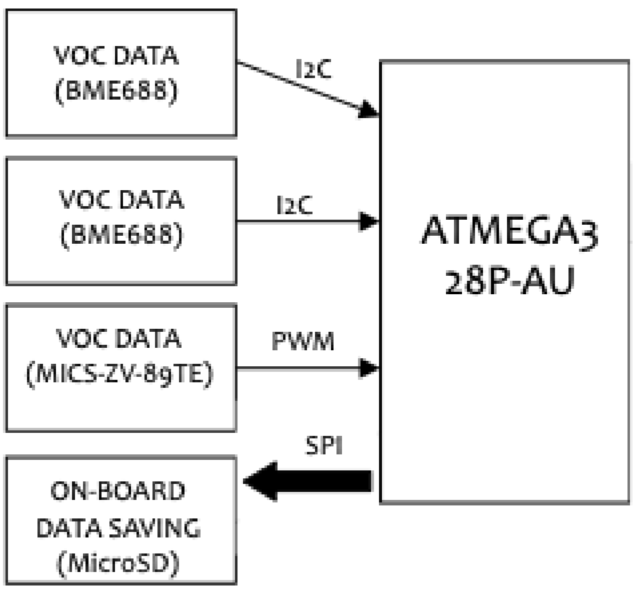


Figure 4: Secondary mission diagram

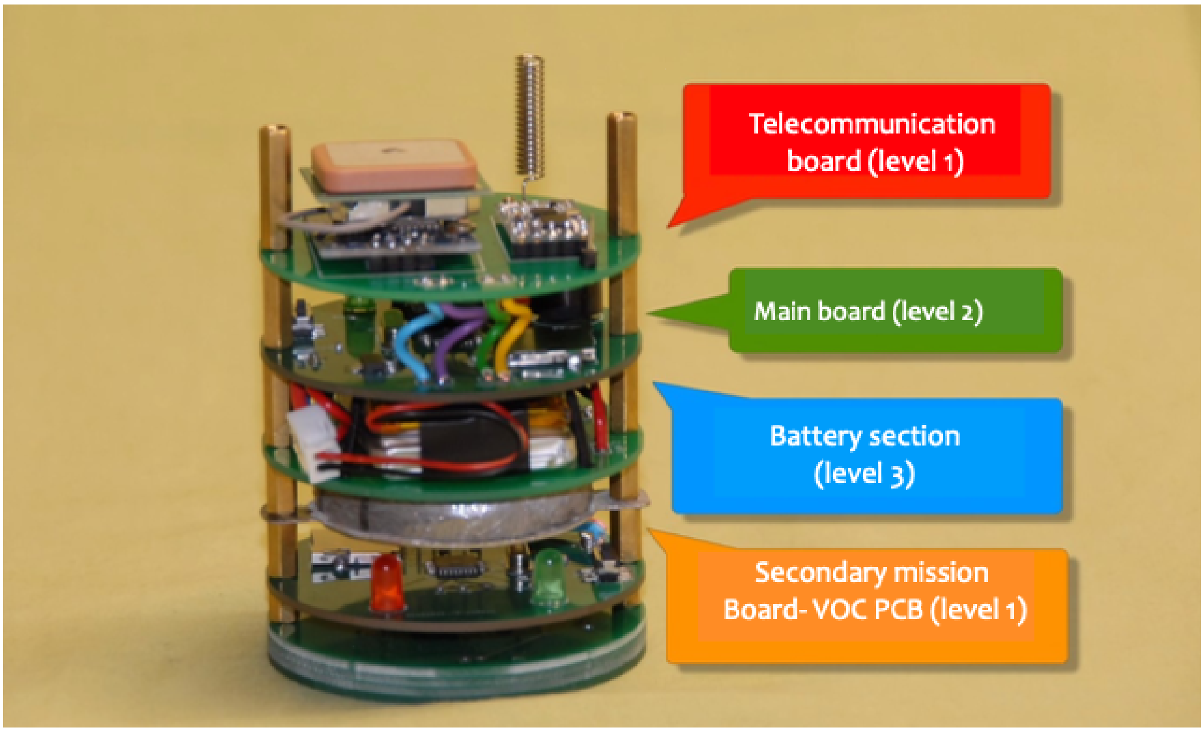


Figure 5: CanSat structural design and PCB placement

B Electrical design

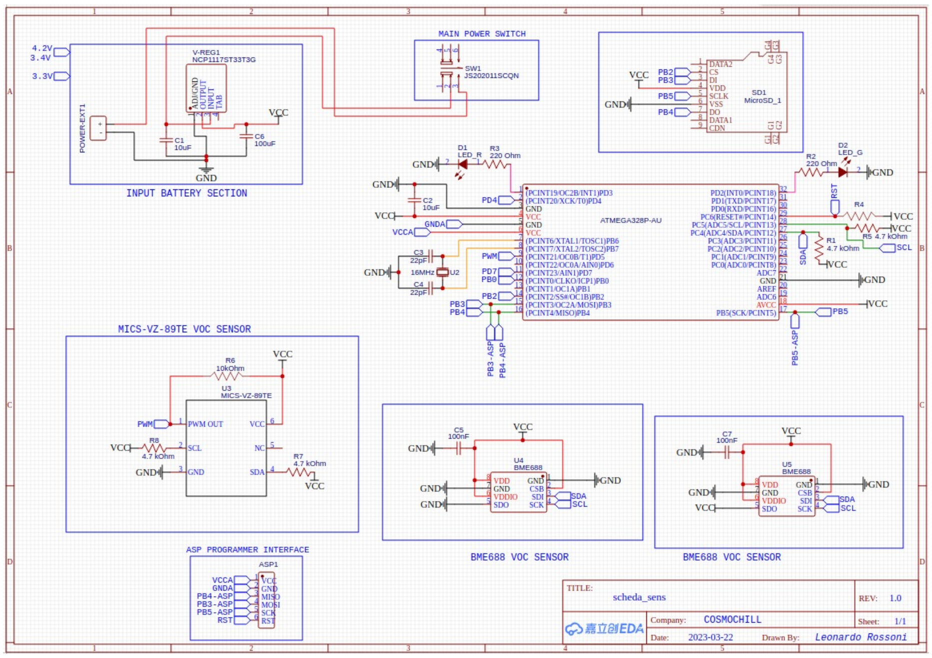


Figure 6: Secondary mission PCB (level 4)

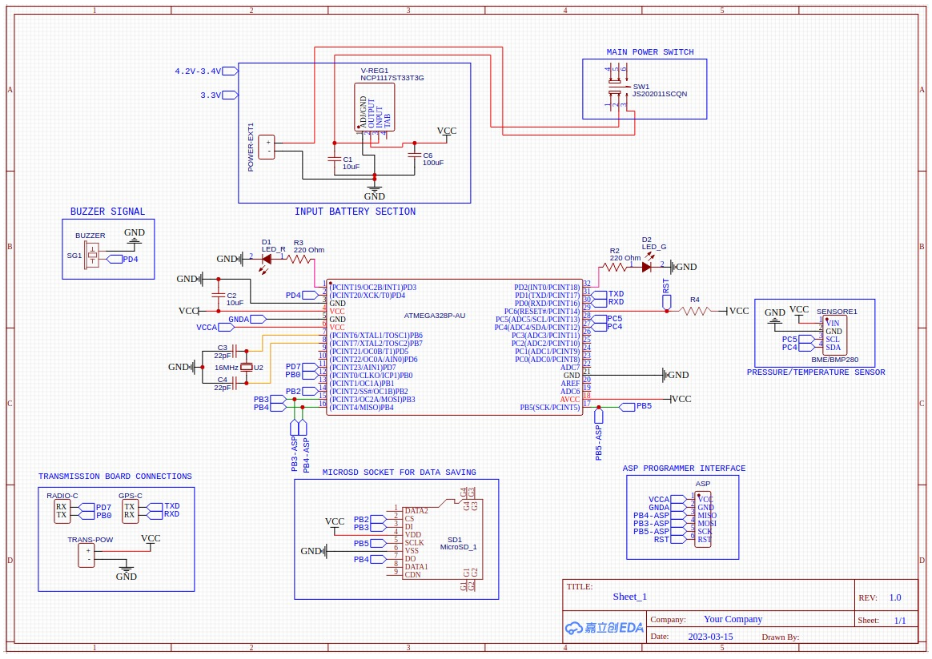


Figure 7: Main board PCB (level 2)

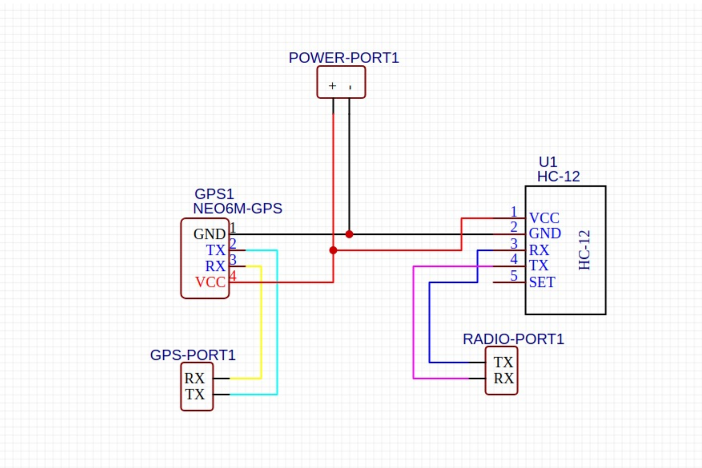


Figure 8: Telecommunication board PCB (level 1)

C Project planning

The phases for the CanSat model development started in January 2023, as soon as the team discovered of being chosen for the Italian final, and are the following:

- 24/01/23 - 30/03/23: Designing all components, making custom recovery systems, developing and launching the website, scientific research and scientific documents drafting;
- 30/03/23: Conference with school students, opening the Instagram account;

- 31/03/23 - 06/04/2023: CDR drafting using LaTeX, publication on social media and website;
- 07/04/23 – 22/04/23: Completion and testing of ground control and transmission structures on the first full-working prototype, closed and open environment tests, updating of social media and website;
- 22/04/23 – 11/05/23: CanSat definitive model manufacturing completion, finishing of videos for social media and website;
- 12/05/23 – 14/05/23: Italian competition;
- 15/05/23: Analysis of possible improvements and updating of social media and website about the Italian phase results.

D Resource estimation

D.1 Budget

The total cost of the CanSat model: 151.09€

ID	Price	Number	Object description (Brand)	Link	Total
PHB1	16,00 €	1	HC12 Module (HC01)	Amazon	16,00 €
PHA4	12,00 €	1	BME280 Pressure/Temperature	Amazon	12,00 €
PHA9	9,99 €	1	Flight control GPS module with antenna (NEO6M-GPS)	Amazon	9,99 €
PHA3	8,20 €	1	Batteria LiPo 1100mAh	Amazon	8,20 €
PHB4	6,00 €	1	PCB power supply	JlcPCB	6,00 €
PHB5	6,00 €	1	PCB trasmission	JlcPCB	6,00 €
PHB6	6,00 €	1	PCBs for primary mission	JlcPCB	6,00 €
PHA2	3,08 €	1	ATMEGA328P-AU	Farnell	3,08 €
PHC1	1,20 €	1	MicroSD card slot socket	Amazon	1,20 €
PHA1	0,80 €	1	Active buzzer 5V (ICQUANZX)	Amazon	0,80 €
PHB7	0,56 €	1	Tension regulator	Farnell	0,56 €
PHB2	0,50 €	1	Slide switch	Farnell	0,50 €
PHA5	0,25 €	1	SMD ceramic capacitor (100uF)	Farnell	0,25 €
PHA8	0,24 €	1	Crystal 16 MHz	Farnell	0,24 €
PHA6	0,07 €	2	SMD ceramic capacitor (10uF)	Farnell	0,15 €
PHB3	0,05 €	2	LED	Amazon	0,10 €
PHB8	0,03 €	1	SMD Resistor(10kΩ)	Farnell	0,03 €
PHB9	0,02 €	2	SMD Resistor SMD D11(220Ω)	Farnell	0,03 €
PHA7	0,01 €	2	SMD ceramic capacitor (22pF)	Farnell	0,02 €
	71,01 €	**23**		**TOTALE:**	**71,16 €**

Figure 9: Total for the primary mission

ID	Price	Number	Object description (Brand)	Link	Total
SHA7	26,86 €	1	MICS-VZ-89TE VOC sensor	DigiKey	26,86 €
SHB1	12,42 €	2	BME688 VOC sensors	Digikey	24,84 €
SHA2	8,20 €	1	LiPo Battery 1100mAh	Amazon	8,20 €
SHB4	6,00 €	1	PCBs for secondary mission	JlcPCB	6,00 €
SHA1	3,08 €	1	ATMEGA328P-AU	Farnell	3,08 €
SHB8	1,20 €	1	MicroSD card slot socket	Amazon	1,20 €
SHB2	0,71 €	4	SMD resistor (4.7kΩ)	DigiKey	2,84 €
SHB5	0,56 €	1	Tension regulator	Farnell	0,56 €
SHA8	0,50 €	1	Slide switch	Farnell	0,50 €
SHA3	0,25 €	1	SMD ceramic capacitor (100uF)	Farnell	0,25 €
SHA6	0,24 €	1	Crystal 16 MHz	Farnell	0,24 €
SHB3	0,09 €	1	SMD ceramic capacitor (0.1uF)	DigiKey	0,09 €
SHA4	0,07 €	3	SMD ceramic capacitor (10uF)	Farnell	0,22 €
SHA9	0,05 €	2	LED light	Amazon	0,10 €
SHB6	0,03 €	2	SMD Resistor (10kΩ)	Farnell	0,06 €
SHB7	0,02 €	2	SMD resistor (220Ω)	Farnell	0,03 €
SHA5	0,01 €	2	SMD ceramic capacitor (22pF)	Farnell	0,02 €
	60,30 €	27		TOTALE:	75,10 €

Figure 10: Total for the secondary mission

D.2 External support

Our sponsor is "Involve Space", a start-up company that launches stratospheric balloons with the goal of shooting advertising spots or accomplishing specific missions requested by third-party companies. Their help is not economic and is solely focused on technical advice. We have not and will not use their facilities to build the CanSat model, considering the advisory-only partnership stipulated. Furthermore, no school has supported us in the development of the project in any economical or advisory way, the only support given to us by them regards facilities either for the scientific publication to other students or for the laboratory facilities.

E Lessons learnt from the National Competition

During the national competition, the greatest challenge was the analysis of post-launch data. Although we had already carried out various analyses in the previous months, the launch results were very different from what we expected. The launch took place at a time when there was strong wind, as well as continuous weather changes. For this reason, the analyses required much more time and interpretation compared to an ordinary situation.

After being able to handle such a complicated situation, we believe we have gained a lot of experience that will also be useful in the European competition. Throughout the entire launch campaign, no changes were needed in the satellite and parachute structure, confirming the good work done during the previous months. Surely, the national competition has prepared us well for the next phase, where we will face situations we have already encountered before.

F Outreach programme

Figure 11: Conference in the school's Auditorium

Il satellite in miniatura realizzato da cinque studenti di «Galilei» e «Carcano» nella competizione dell'Agenzia spaziale ha fatto centro

I «Cosmochill» erbesi vincono la fase nazionale e volano a Granada

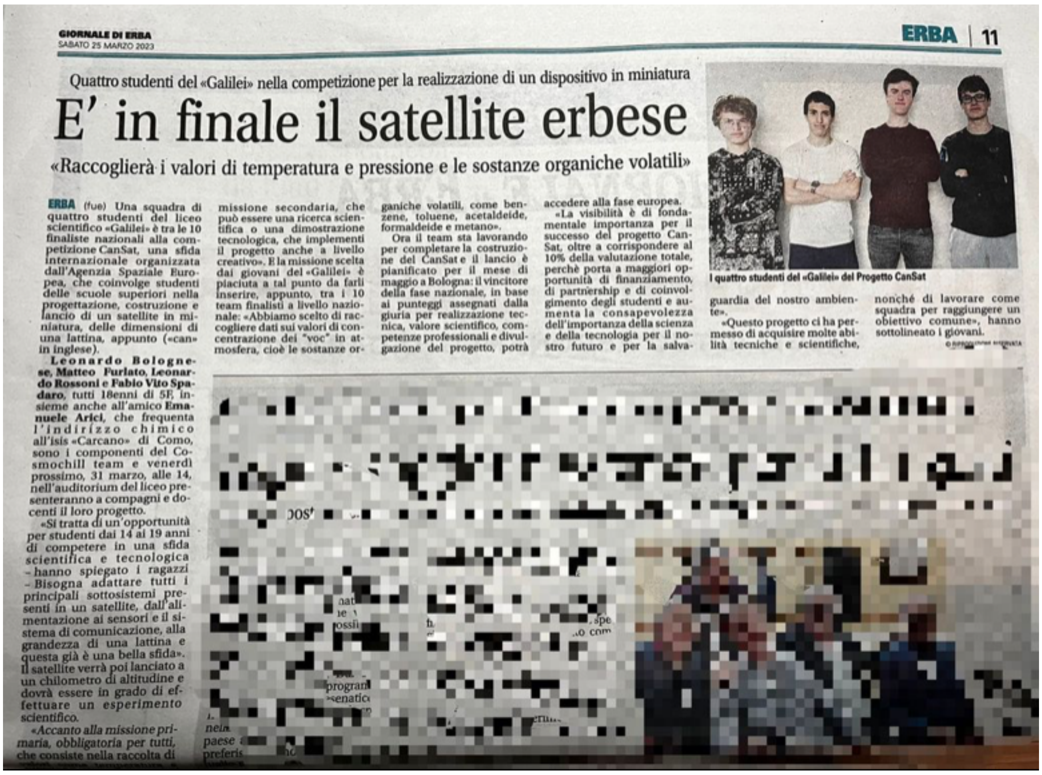
ERBA (fue) Il team erbese «Cosmochill» è il vincitore assoluto della finale italiana di «CanSat», l'iniziativa di Esero Italia, un programma congiunto dell'Agenzia spaziale italiana e quella europea, che sfida gli studenti a realizzare un mini satellite delle dimensioni di una lattina.

I quattro studenti del liceo scientifico «Galilei», **Leonardo Rossoni, Leonardo Bolognese, Matteo Furlato, Fabio Spadaro**, e l'amico dell'isis «Carcano» di Como, **Emanuele Arici**, accedono dunque di diritto alla fase europea prevista a Granada dal 26 al 30 giugno, incastrando questo appuntamento tra gli esami di maturità.

La fase nazionale si è tenuta dal 12 al 14 maggio a Molinella, Bologna, dove si sono sfidati 10 team, per un totale di 60 ragazzi dai 14 ai 19 anni. L'obiettivo era quello di adattare tutti i principali sottosistemi presenti in un satellite - come alimentazione, sensori e un sistema di comunicazione - nel volume e nella forma di una lattina, fino a giungere alla fase di lancio e raccolta dati. E con il loro mini satellite i cinque ragazzi erbesi hanno fatto centro: «E' andato tutto come doveva andare: il lancio perfetto, la raccolta dati e la giuria ha apprezzato anche le diverse fasi di preparazione che ha seguito a distanza grazie alla divulgazione che via via abbiamo fatto – hanno raccontato – Ora a Granada i team saranno 25 e dovremo preparare documentazione e presentazione in inglese. E anche ritoccare qualche parte più fragile del satellite perché, a differenza di Bologna, dove il lancio è stato fatto da un drone, a Granada sarà fatto con razzi. Ma siamo pronti e agguerriti».

I cinque ragazzi erbesi del team «Cosmochill» che andrà alla finale europea

Figure 12: The second journal article



GIORNALE DI ERBA
SABATO 25 MARZO 2023

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Quattro studenti del «Galilei» nella competizione per la realizzazione di un dispositivo in miniatura

E' in finale il satellite erbese

«Raccoglierà i valori di temperatura e pressione e le sostanze organiche volatili»

ERBA (fue) Una squadra di quattro studenti del liceo scientifico «Galilei» è tra le 10 finaliste nazionali alla competizione CanSat, una sfida internazionale organizzata dall'Agenzia Spaziale Europea, che coinvolge studenti delle scuole superiori nella progettazione, costruzione e lancio di un satellite in miniatura, delle dimensioni di una lattina, appunto («can» in inglese).

Leonardo Bolognese, Matteo Furlato, Leonardo Rossoni e Fabio Vito Spadaro, tutti 18enni di 5F, insieme anche all'amico **Emanuele Arici**, che frequenta l'indirizzo chimico all'isis «Carcano» di Como, sono i componenti del Cosmochill team e venerdì prossimo, 31 marzo, alle 14, nell'auditorium del liceo presenteranno a compagni e docenti il loro progetto.

«Si tratta di un'opportunità per studenti dai 14 ai 19 anni di competere in una sfida scientifica e tecnologica - hanno spiegato i ragazzi - Bisogna adattare tutti i principali sottosistemi presenti in un satellite, dall'alimentazione ai sensori e il sistema di comunicazione, alla grandezza di una lattina e questa già è una bella sfida». Il satellite verrà poi lanciato a un chilometro di altitudine e dovrà essere in grado di effettuare un esperimento scientifico.

«Accanto alla missione primaria, obbligatoria per tutti, che consiste nella raccolta di missione secondaria, che può essere una ricerca scientifica o una dimostrazione tecnologica, che implementi il progetto anche a livello creativo». E la missione scelta dai giovani del «Galilei» è piaciuta a tal punto da farli inserire, appunto, tra i 10 team finalisti a livello nazionale: «Abbiamo scelto di raccogliere dati sui valori di concentrazione dei "voc" in atmosfera, cioè le sostanze organiche volatili, come benzene, toluene, acetaldeide, formaldeide e metano».

Ora il team sta lavorando per completare la costruzione del CanSat e il lancio è pianificato per il mese di maggio a Bologna: il vincitore della fase nazionale, in base ai punteggi assegnati dalla giuria per realizzazione tecnica, valore scientifico, competenze professionali e divulgazione del progetto, potrà accedere alla fase europea.

«La visibilità è di fondamentale importanza per il successo del progetto CanSat, oltre a corrispondere al 10% della valutazione totale, perchè porta a maggiori opportunità di finanziamento, di partnership e di coinvolgimento degli studenti e aumenta la consapevolezza dell'importanza della scienza e della tecnologia per il nostro futuro e per la salvaguardia del nostro ambiente».

«Questo progetto ci ha permesso di acquisire molte abilità tecniche e scientifiche, nonché di lavorare come squadra per raggiungere un obiettivo comune», hanno sottolineato i giovani.

I quattro studenti del «Galilei» del Progetto CanSat

[redacted]

Figure 13: The first journal article

G Requirements

G.1 Characteristics

Characteristics	Figure (Units)
Height of the CanSat	11.3cm
Mass of the CanSat	330g
Diameter of the CanSat	6.4cm
Additional length of external elements	NONE
Flight time scheduled	150s
Calculated descent rate	5.7m/s-6.5m/s
Radio frequency used	433MHz
Power consumption	150 mAh (MAX consumption)
Total cost	151€

G.2 Power budget

The power consumption of single PCBs has been tested through the use of laboratory devices while being at "MAX current usage" and "MIN current usage" state. The battery section of the CanSat is equipped with two 1100mAh LiPo batteries (2200mAh total) which can provide energy to the satellite for at least 10 hours at a continuous "MAX current usage" state.

PCB Name	**Max power consumption**
Telecommunication PCB	90mAh
Main PCB	40mAh
Secondary mission PCB	70mAh
TOTAL	200mAh