CAN SAT IN GREECE

PreCDR

SMALL Sat

Table of Contents

1 Introduction

1.1 Organization of Group

Name Last Name	Position	Responsibilities
Aristotelis Thymianos	Supervisor	Mentoring the Team
Denis Romain	Design Manger	Mechanical Design, Primary & Secondary Mission
Yonghan Du	Team Manager	Electrical Design, Primary & Secondary Mission, Telecommunication
Ioannis Apostolopoulos	Avionics Manager	Electrical Design, Telecommunication, Aerodynamics Simulations
Aristeidis Sargkisian	Team Member	Marketing & Social Media, Telecommunication, Data Analysis
Sotiris Minogiannis	Team Member	Mechanical Design
Tanya Haroun	Marketing Manager	Marketing & Social Media
Weijun Ye	Team Member	Webdeveloping, Telecommunication
Filippos Solomos	Team Member	Marketing, Secondary Mission
Philip Psichogios	Team Member	Marketing, Mechanical design
Di An	Team Member	Telecommunication, Secondary Mission
Yubo Chen	Team Member	Mechanical Design
Xinyang Cheng	Team Member	Secondary Mission

1.2 Mission Objectives

The primary mission will include data collections of atmospheric pressure, temperature, and geographic coordinates. This data will be gathered with a barometer sensor (eg. BMP280) and a GPS (eg. adafruit ultimate breakout). The data will be both stored locally on the CanSat with a microSDcard, as well as transmitted to the ground station by using telemetry. All data will then be analyzed and presented by the team in order to extract useful information from the mission.

For the secondary mission, we will be putting the data gathered from the magnetometer on the CanSat through analysis and calculations to forecast magnetic storms and/or substorms, and the GPS data will be going through an algorithm for the Smart autonomous guided landing system. The data(in nanoteslas) from the magnetometer will eventually be plotted into a graph and compared with existing ones from SuperMAG to capture the abnormalities and/or characteristics in order to forecast magnetic weather. The GPS data will both be stored on board of the CanSat and transmitted back to our station through Telecommunication. The on board GPS data will be used for live adjustment of the CanSat flying path in order to achieve guided landing. With the support of guided landing and data from the magnetometer our CanSat has a purposeful real-life application of forecasting magnetic weather and providing data for the magnetic field at locations without access to a stationary magnetic-substorm forecast station such as pacific ocean areas.

The chosen secondary mission will consist of two components: the guided landing of the S.M.A.L.L. Sat and the incorporation of a magnetometer.

The guided landing will act as the technical aspect of the secondary mission, and will be conducted through the use of a RAM chute steered by pivot arms situated within the S.M.A.L.L. Sat. Using a software, the S.M.A.L.L. Sat will be able to interpret its momentary position in relation to the landing spot, as derived from an altimeter and GPS coordinates, and will steer itself accordingly. The guided landing will stimulate situations including sensitive aerial parcel delivery, collecting data for the magnetic field in places where ground stations are not present. We plan to compare our results with the data of SuperMAG magnetometers and as we can see in the picture below (Image 1) the SuperMAG ground stations are limited around the globe with no coverage above sea. Our CanSat will try to provide data for magnetic fields above areas with no data access.

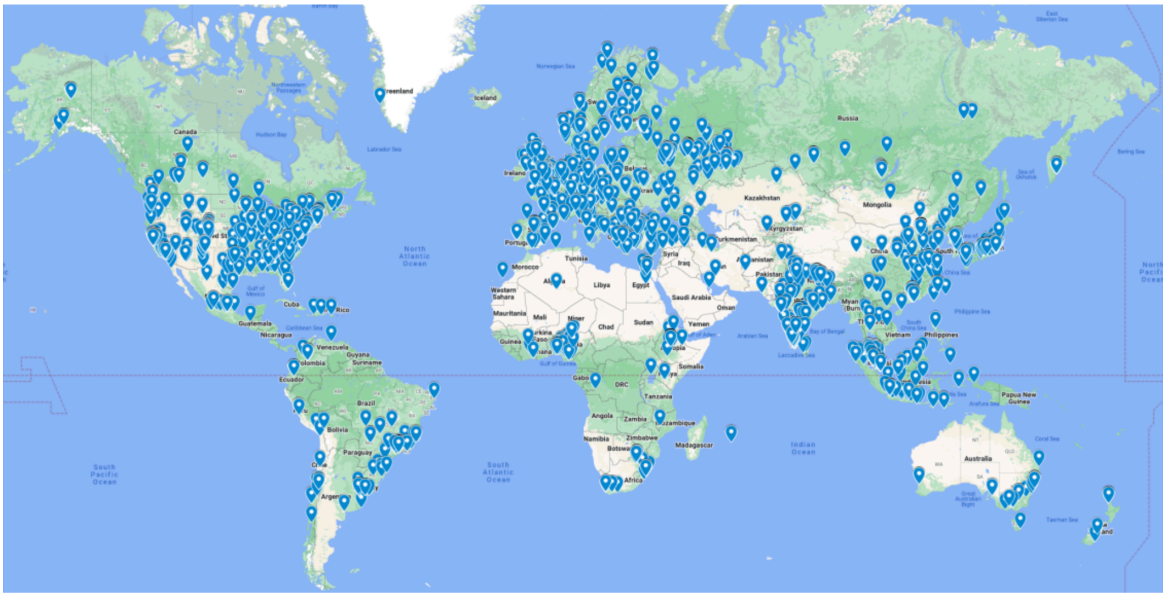


Image 1: SuperMAG Magnetometers location

Alternatively, the magnetometer will be the scientific component of the secondary mission, collecting data regarding the magnetic field, which will then be analyzed to predict and forecast magnetic storms. The significance of these forecasts include the evasion of cosmic radiation exposure in high altitude polar flights under conditions of geomagnetic storms, as well as the projection of disruptions in accurate Satellite communication and navigation.

2. CanSat Description

2.1 Mission Overview

Main Mission Overview:

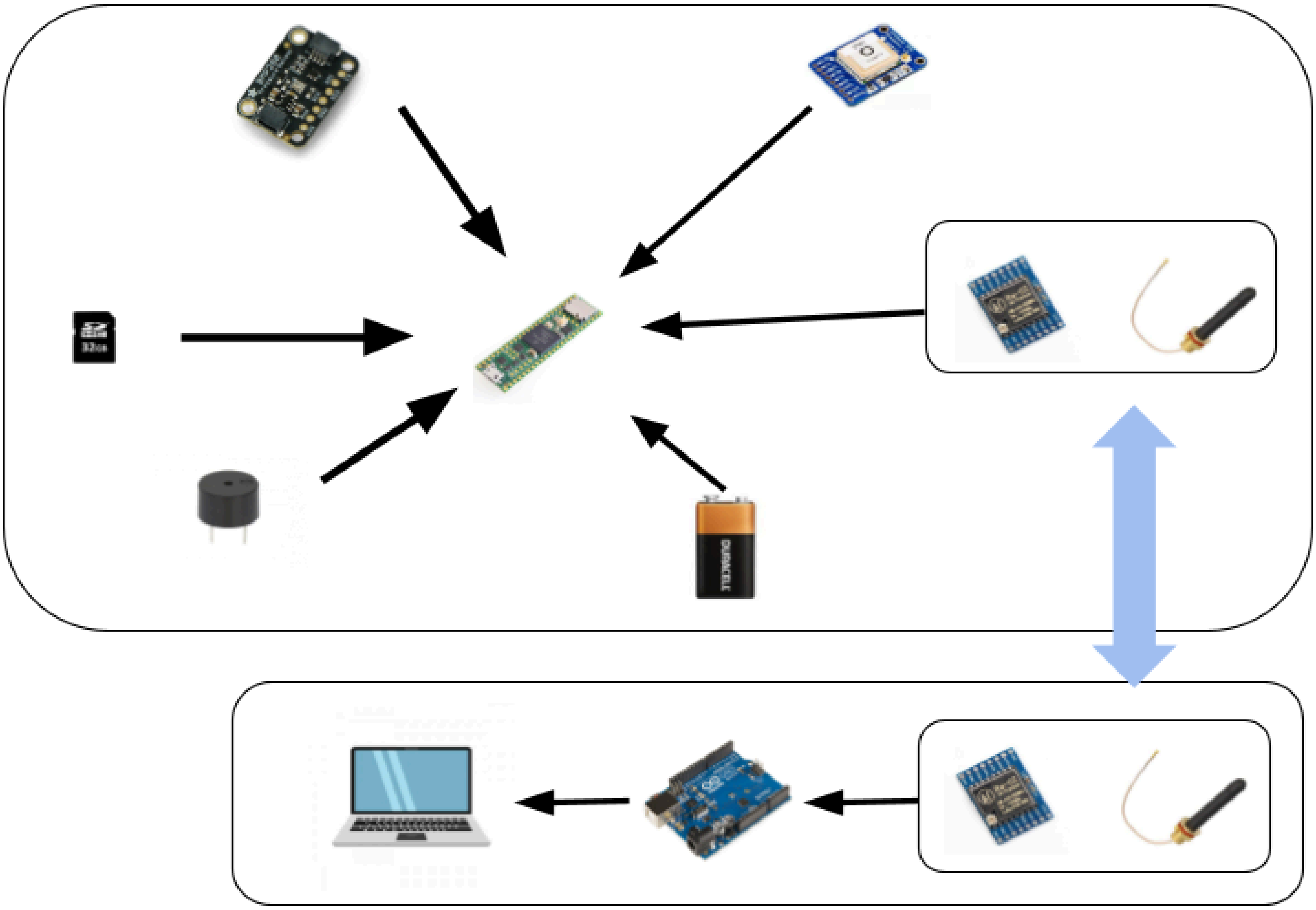


Image 2: Graphic representation of the main components used for the CanSat and Ground Station.

2.2 Mechanical / Construction Design

The mechanical design of the CanSat will consist primarily of an inner structure, an outer casing, and a RAM chute. Two arms on either side of the CanSat will be connected to lines of the RAM chute, and will be controlled by servo motors to steer the CanSat. It should be noted that the CanSat will be horizontally oriented such that the longer side of either primary mechanical component will be parallel to the lateral axis. The outer casing will take the shape of a tube surrounded by a pattern of hexagonal holes for the sake of ventilation. These hexagonal holes will be normal to the shell at their central points, and will hence face the central lateral axis of the CanSat. The outer casing will have a diameter of 66mm, whilst the length of the tube, its longest dimension, will be 102.9mm. The inner structure will take the shape of two vertical discs parallel to the longitudinal axis of the CanSat, and joined by two longer, parallel plates normal to their faces. One of the discs will be a full 66mm in diameter, whilst the other will be slightly smaller at a diameter of 56.6mm such that the outer shell will be able to fit on and be bounded laterally by the wider disk. Screws will hold the inner structure to the outer casing. The length of the inner structure will be 106mm. The inner structure will house all electronic components of the CanSat, which may be placed on either side of the plates, or in the space in between them. The arms will take a teardrop-like shape, normal to which a small, cylindrical joint will be extended. These joints will pass through holes in the disks of the inner structure, where they will be joined to servos between the plates. The servos will be used to actuate the arms, the joints of which will have cavities corresponding to the servo shafts to improve connection. The steering lines of the RAM chute will be connected to the narrow ends of the teardrop by a knot passing through a small hole normal to the main face of the teardrop. The teardrop section of the arms will have a thickness of 4mm, whilst the joint will extend 6mm outward from the teardrop. The inner structure, outer shell, and arms of the CanSat will be 3D printed with light weight ASA (LW-ASA) as it is the toughest 3D printing material (absorbs the most impact energy), and more stable under UV or extreme thermal conditions compared to LW-PLA. PLA has the highest static strength but is more brittle.

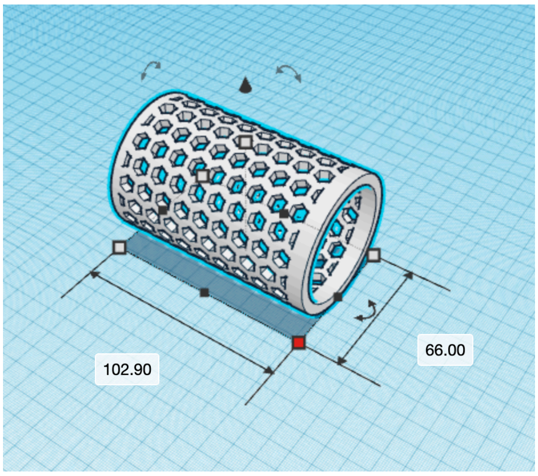


Image 3: Mechanical design of the outer casing

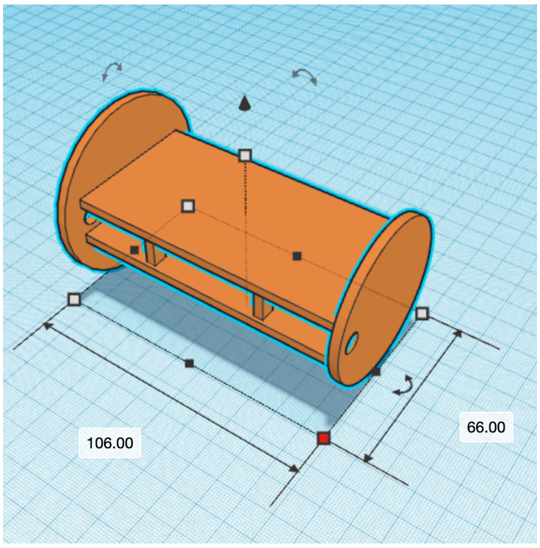


Image 4: Mechanical design of the inner structure

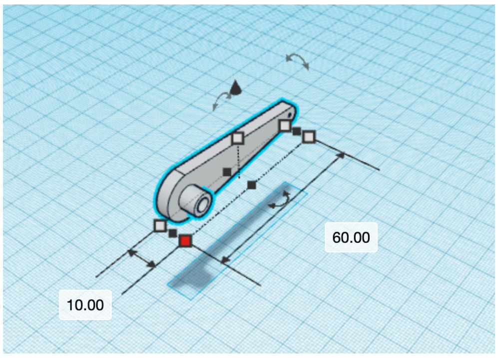


Image 5: Mechanical design of the arm(s)

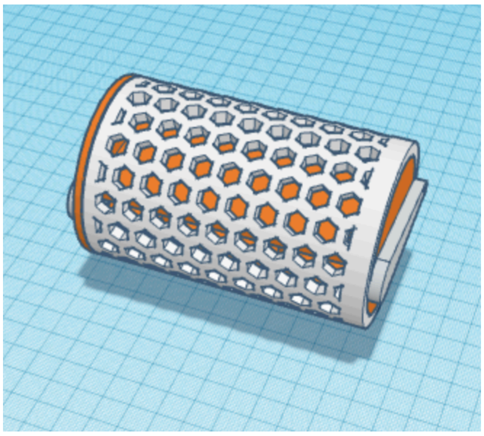
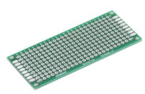
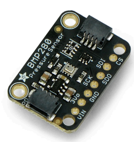
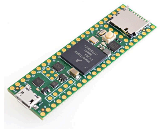
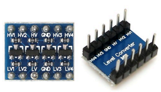


Image 6: Virtual snapshot of the assembled CanSat (excluding electronic components)

Primary mission(including ground station):

sensors/components	quantity	image	Function
Perfboard	1		Prototyping board to connect wires and to build circuits.
Adafruit BMP280	1		Measure barometric pressure and temperature with very good accuracy. Used in weather sensing.
LoRa Module 433Mhz - SX1278	2		Used for long-range spread spectrum communication. It uses the SPI communication protocol and can be used with any microcontroller that supports SPI. Long transmission distance and high reliability.

Antenna RF 434MHz 2dBi 63.6mm u.FL	2		Used to transmit and receive radio frequency signals at a frequency of 434MHz.
Adafruit Ultimate GPS Breakout - 66 channel w/10 Hz updates - Version 3	1		Used to track location and log GPS data with high accuracy. Designed to be used with microcontrollers and can do up to 10 location updates a second. Have a built in datalogging ability.
Teensy 4.1	1		The Teensy 4.1 is the newest iteration of the astoundingly popular development platform that features an ARM Cortex-M7 processor at 600MHz, with a NXP iMXRT1062 chip, four times larger flash memory than the 4.0, and two new locations to optionally add more memory. The highlight feature of this chip is the built-in SD card slot, making it suitable for a wide range of data logging purposes.
Arduino UNO	1		A microcontroller board that is based on the ATmega328p microcontroller. It can be used in a wide variety of applications and is similar to the Arduino Duemilanove but made for the use of a breadboard and has no dedicated power jack
Buzzer	1		A simple buzzer that makes tones upon command, and can be viewed as just a resistor in the circuit.
Level shifter()	1		Level shifters are used to enable communication between devices operating at different logic levels (voltages). An Arduino Uno runs at 5V but a device like the NodeMCU uses 3.3V logic level.

2.3 Wiring diagram

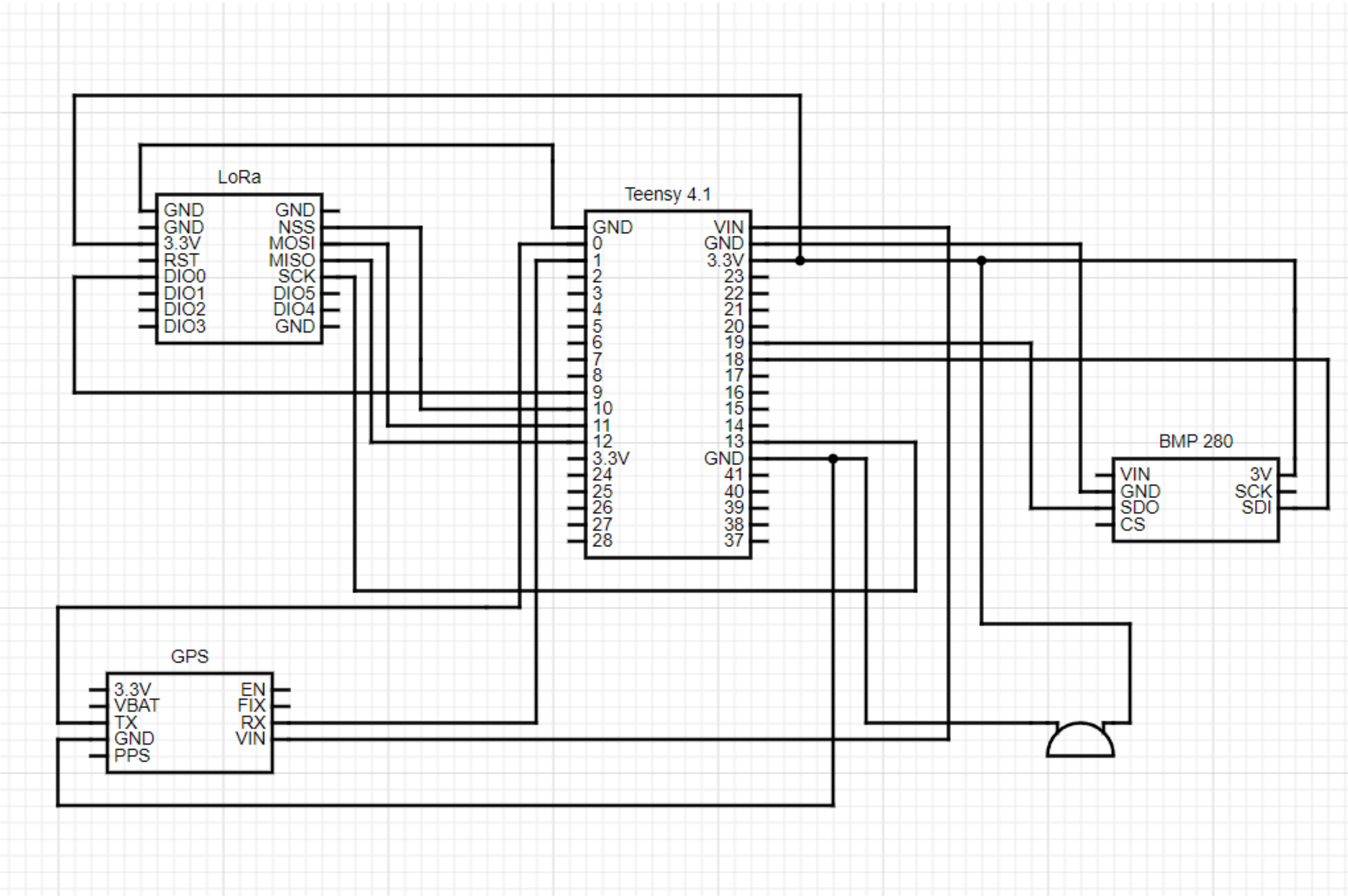
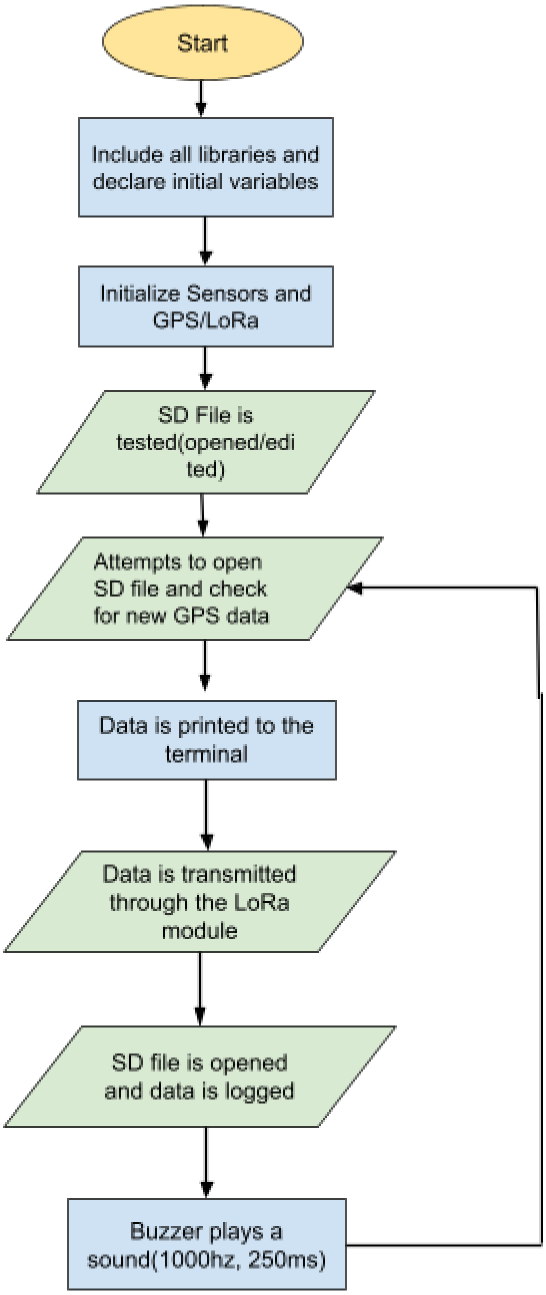


Image 3: Wiring diagram of the CanSat.

2.4 Software Design



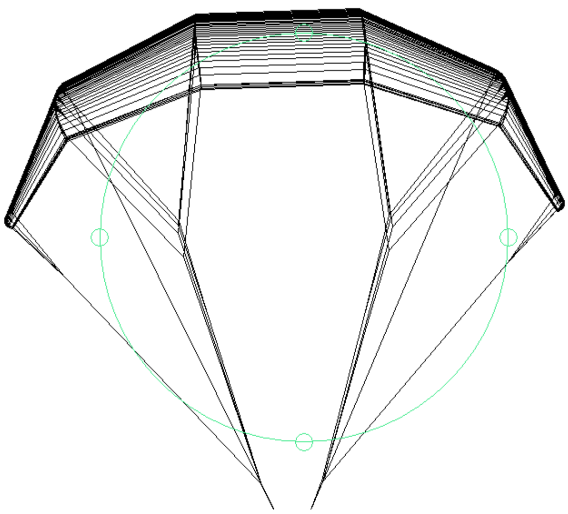
Software Explanation:
The purpose of the software aspect of the SMALLSat is to bring functionality and data collection. This is done through a series of sensors and loggers. The primary mission of the SMALLSat uses the libraries: TinyGPS, Adafruit BMP280 Library, LoRa by Sandeep Mistry, and SDFat.
The software begins with the declaration of all global variables, as well as the inclusion of the libraries used. The setup() function is then run, initializing the BMP280 module, the Adafruit GPS module, the SDFat library is then initialized, and the datafile contained in the MicroSD card is opened as a test. The LoRa library and module are then initialized. The two sensors share the same SPI pins, requiring the software to initialize them, as well as adjust the SPI library in order to allow them to work in unison.
The code moves onto the loop() function, which repeats for the duration of the mission.

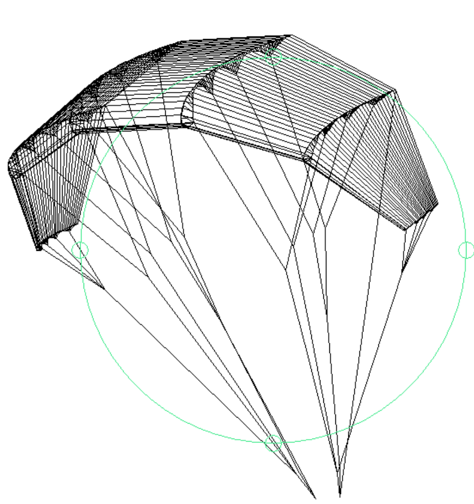
For the software of the SMALL Sat, we used “Arduino”, which is an open source electronic prototyping platform that consists of physical boards as well as an Integrated Development Environment, which uses a variant of C++, consisting of C and C++ components. The software(currently primary mission) of the SMALLSat has been created in this IDE(Arduino IDE 2.2.2). This software allows the Arduino to connect to multiple components, including a 16GB storage SD card for data logging.

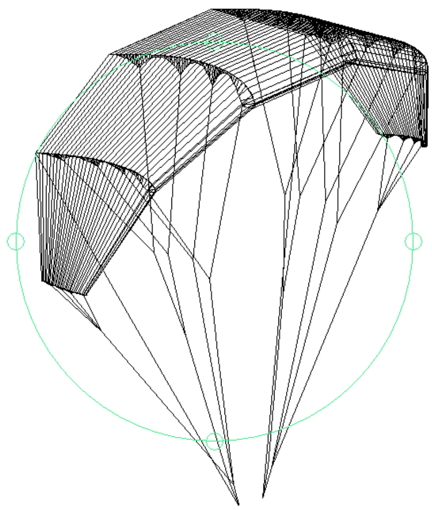
2.5 Recovery System

Our Recovery system will include a RAM type parachute in order to complete our secondary mission which includes navigation and targeted landing. Our Parachute is a single skin paraglider designed with a special software called Singleskin and sewed by the team members in our laboratory using an electrical sewing machine. Below you may find some information about our paraglider along with some pictures of our design for reference.

Flat area = $0.99\, m^2$
AR = 4.7
Wingspan = $2.15\, m$
Projected area = $0.74\, m^2$
Projected AR = 3.27
Angle at wingtip = 115.5 deg
Average bridle angle = 95.3 deg
Num of cells = 5
Sell width = 47.32 cm
Root chord = 0.54 m
Wingtip chord = 0.18 m
Bridles height = 1.44 m







The reason we choose this type of parachute is to allow us to navigate the CanSat. Our Satellite will have two small arms which will unfold after the release from the rocket and they will steer the glider by breaking down each side of the wing.

2.6 Base Station Equipment

For our base station we are using an arduino UNO with the SX1278 LoRa model in order to receive the telemetry signal from our CanSat. We will upgrade the base station once we finish the main parts of our mission including secondary.

3 Project Scheduling

3.1 CanSat Preparation Timeline

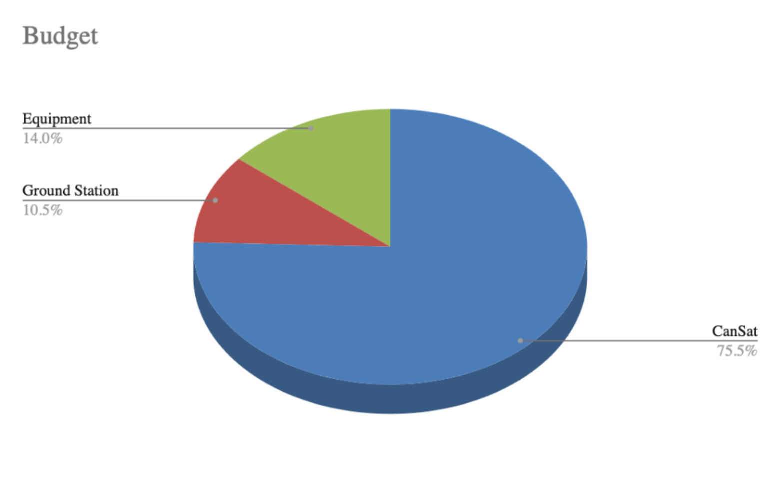
[SMALL SAT Timeline.xlsx]

3.2 Assessment of needs

3.2.1 Budget

Our budget until this time can be seen below.

CanSat in Greece 2023		SMALL SAT	
ID	Budget	% of Total	Subtotal
1.	CanSat	75.51%	107.90€
2.	Ground Station	10.50%	15.00€
3.	Equipment	14.00%	20.00€
4.	Travel	0.00%	0.00€
5.	Other	0.00%	0.00€
	Total:	100.00%	142.90€



3.2.2 External Support

- Fundings for the purchase of the materials needed for the primary mission was raised from our participation in the Christms bazaar of our School.
- Fundings for the materials needed for the secondary mission was raised from our sponsorship with the ACS Athens - The institute.
- We are currently seeking external funding from possible companies/businesses in Greece in order to cover potential further expenses.

3.2.3 Test Plan

We have been testing all sensors and the GPS with various methods including moving the CanSat from higher altitude to lower altitude and performing a range test for our telemetry system. Additionally we did a drop test on the mechanical design of the outer shell of the CanSat

4 Promotion Plan

The promotion Plan includes the following steps. To begin with we started by creating Social Media to communicate our work with other people. So far we have an instagram account and we are also creating a Site. On our site there will be blogs with frequent updates of our work and progress.

5 Standards

Characteristics	Measurement (Unit)
Width of CanSat (mm)	115mm
Mass of CanSat (g)	250g
Diameter of CanSat (mm)	66mm
Length of folded recovery system (mm)	45mm
Scheduled Flight Time (s)	1200s
Calculated descent speed (m/s)	9m/s
Energy consumption (Wh)	0.21Wh
Used Radio Frequency (hz)	433mHZ
Total cost (€)	500