Preliminary Design Review

for **CanSat** competition

Team

SobieskiSat

04.11.2018 Kraków, Poland

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1. Changelog

- Initially we planned to use an outside communication module with a chip supporting LoRa, but since it is already in CanSat kit provided to us, it was deemed unnecessary and we opted to came with some other ideas for the secondary mission.
- As of the PDR, our main goal in the secondary mission has changed. Now we are going to collect humidity and video data alongside PM density.
- In addition to the main goal of the secondary mission we also added plans to develop a descension assistance system.

2. Introduction

2.1. Team overview

- Team composition

Our team consists of 5 students and our tutor, all of us are attending High School No. 2 named after King John III Sobieski in Kraków.

Aleksandra Musiał - Our tutor, CS teacher and also an administrator at our school's 3d printing laboratory.

Jakub Czarny - Team leader & Electronic designer. His primary role is managing our progress and mission but he also specializes in electronic design and is responsible for choosing components according to our financial and electrical constraints.

Andrzej Szablewski - PR spokesperson, he takes care of all PR related missions like finding sponsors and managing and updating our site. He also works on 3D modelling.

Maciej Gamrot - High-Level Developer, he is responsible for main system development and communication with ground station. He also develops our website.

Damian Legutko - Embedded Developer, his job is to write code for managing data retrieved from sensors, designing backup procedures. On top, Damian designs graphical parts of our project when needed.

Krzysztof Parocki - Hardware Engineer, he is responsible for electronic design, testing prototypes and overall design of the construction. Krzysztof makes photo-documentation of our progress, and makes a movie based on our creation process to promote our project in social media.

- Resources and time management

We've established cooperation with our school that provided us a classroom, where we hold our meetings and 3D printing lab that is under our tutor's management. We have access to all the tools needed for the project in a public workshop - Hackerspace Kraków.
Outside of the school we work on our own as well as in group through communication apps like Messenger and Discord. We meet once a week in our classroom to summarize the previous week and divide tasks for the next few days.

- Team promotion

We are looking for a sponsor - we wrote emails to a variety of companies including local industries and big foreign concerns. We are also going to put an announcement on our facebook profile that we are looking for a supporter. We have our own website written in both polish and english. Also we launched the facebook site where we have now almost 200 likes. We will use our media for sharing the progress of building the satellite as well as presenting some interesting facts or showing photos and short movies. There you can follow us and our actions:
- Facebook: https://www.facebook.com/SobieskiSat/
- Website: https://www.sobieskisat.pl/

2.2. Secondary mission overview

Our main goal in secondary mission is to collect humidity and particulate matter density data alongside a video feed and positioning to complete a thorough analysis of its surroundings. Gained information would be later analyzed for life sustainability.

Descension Assistance System (DAS)

Our second goal is to develop a neural network for controlling descension, ultimately leading to landing in a pre-specified area. Servos inside the Can will pull the strings attached to a parachute causing a shift of the centre of mass, that should change body momentum. If control over the probe fails we hope to at least receive predictions as to where it's going to land.

Both sensor readings and DAS together might be used in autonomous missions to other planets in search of an extraterrestrial life.

3. Probe description

3.1. Introduction

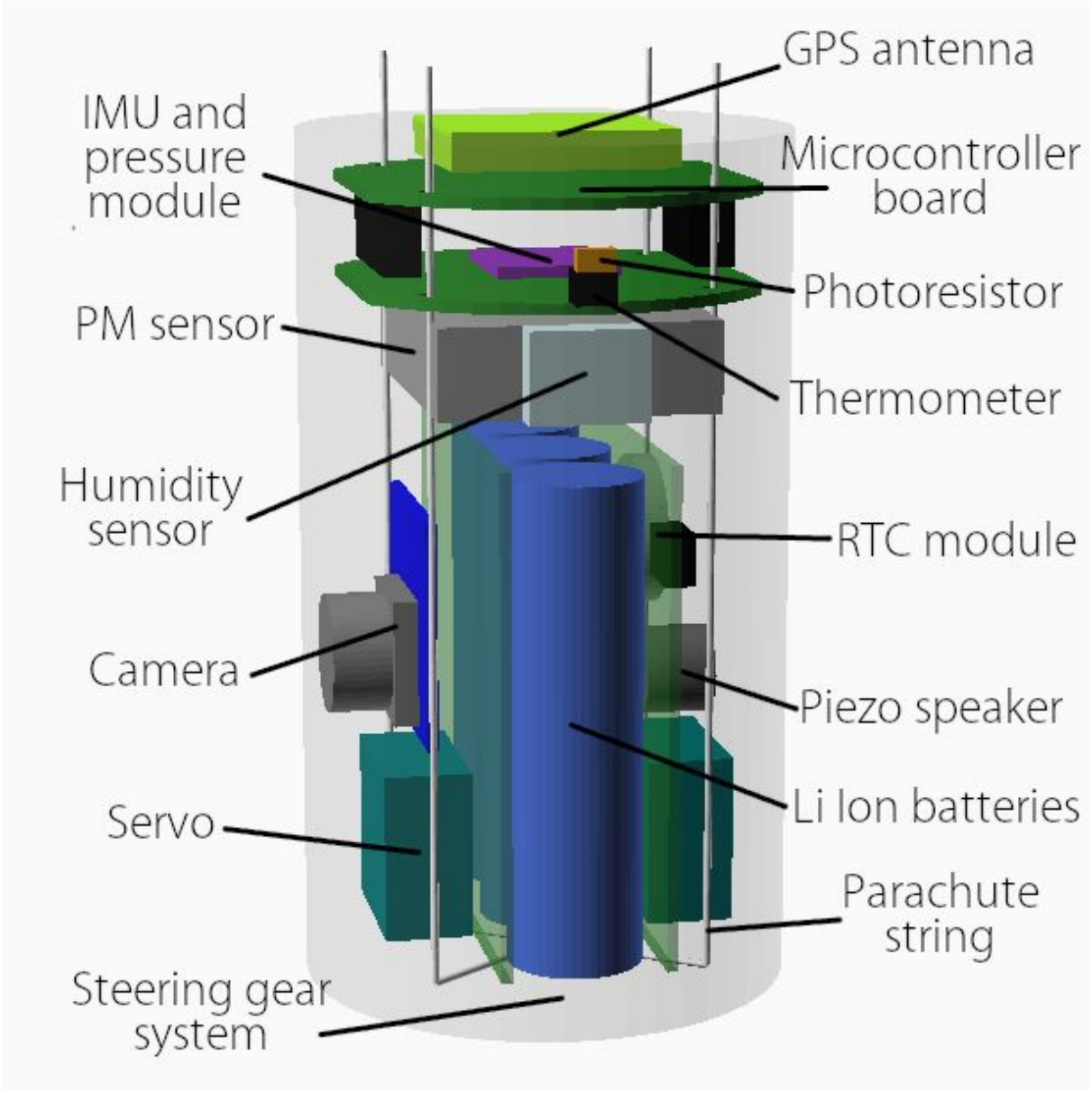
We managed to test the CanSat Kit microcontroller board and decided to use it inside the probe due to its big capabilities. The whole probe will fit in a 3D printed case.

Components chosen for collecting data are:

- Temperature sensor - LM35
- Pressure sensor - BMP280
- Gyro, magnetometer and accelerometer - MPU9250
- Camera - OV7670 (subject to change)
- RTC module - DS1307
- PM sensor - PMS7003
- Humidity sensor - DHT22
- GPS module - NEO_6EM

3.2. Mechanical design

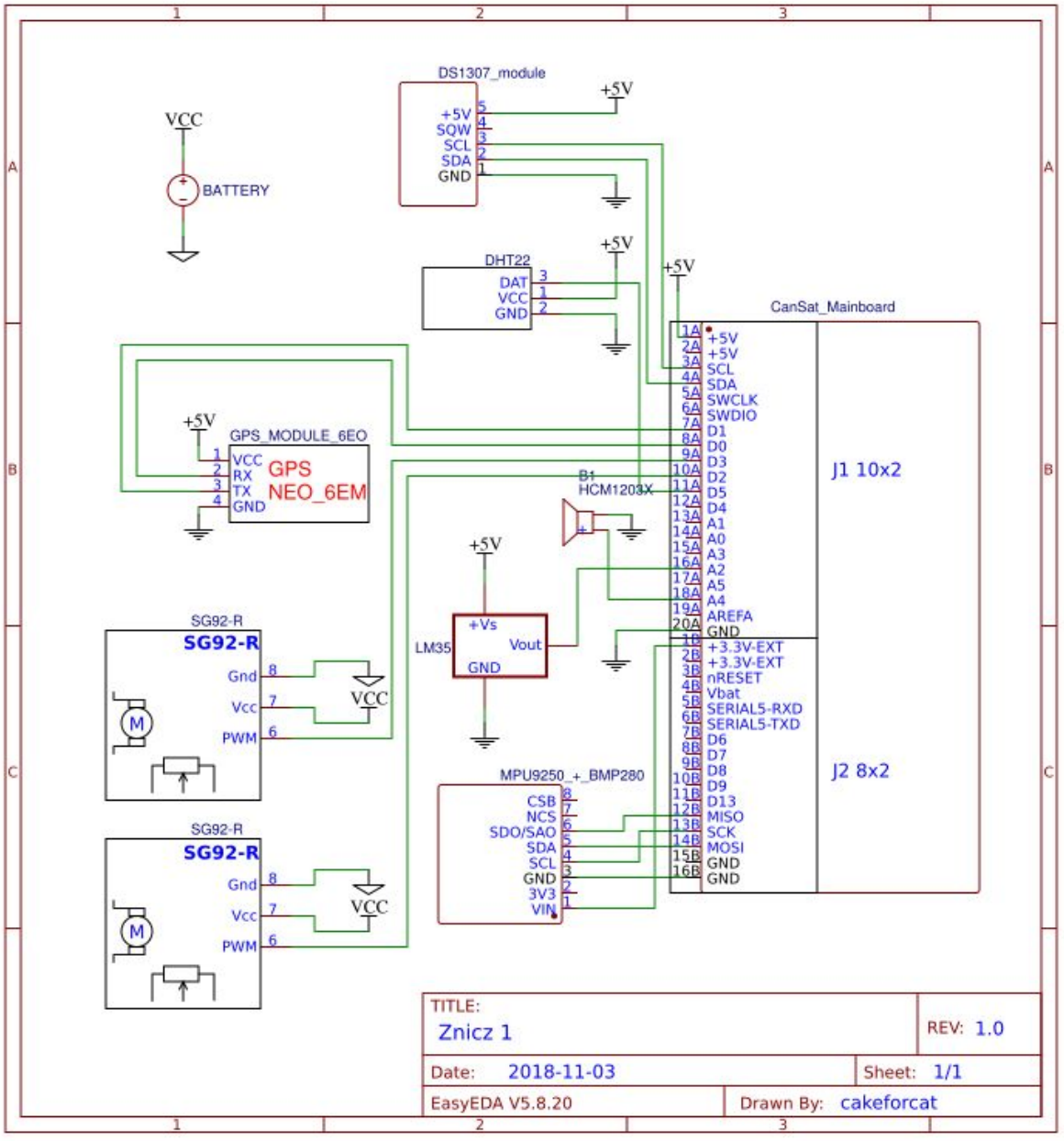
We have decided to use ABS based filament called Z-UltraT for 3D printing the case, because it's very strong and light. The parachute will be made from a professional grade material - Skytex 27 Classic. Paratuche strings will be tied to gears inside the DAS but due to a risk of breaking, emergency strings will be attached alongside the main ones. We will have access to the internals through an opening made by dividing the whole case in half vertically. The two halves will be connected by screws or latches. In emergencies it will also be possible to use tape to temporarily close the case. We will try to minimize the use of steel screws in favor of lighter methods of connection.
Initial component placement is presented on image below.



3.3. Electrical design

The probe will be powered by 3 Li-ion cells, with 3000mAh capacity each, connected in parallel. By our calculations current draw for the whole can shouldn't exceed 500mA at maximum load, so it should be able to run for about 15 hours.

We are working on a PCB for all of the loose modules and the first iteration is shown below. We are expecting to buy all components soon so we can test them out and resolve initial problems that may occur.



3.4. Software design

- **Primary mission:**

  When turned on, probe will be waiting for USB Serial messages for *debug & calibration*. If no data is received probe will initialize *awaiting mode*. In this state CanSat waits for an interrupt signal from the launch switch and occasionally collects sensor values in order to save battery energy.

  When launch switch gets pressed the *mission mode* is initiated, probe collects temperature and pressure data with sampling rate of at least 2Hz. Gained information is sent to ground station in packets marked by time from RTC module. All events and data will be stored in logs on an SD card.

  After an estimated falling time probe goes into *retrieving mode*. Sound and radio signals are sent in order to help the search team with finding it. When launch switch is pressed again the probe turns itself off.

  Primary mission would be independent from the secondary mission except for accelerometer and GPS readings used as additional information about the mission phase.

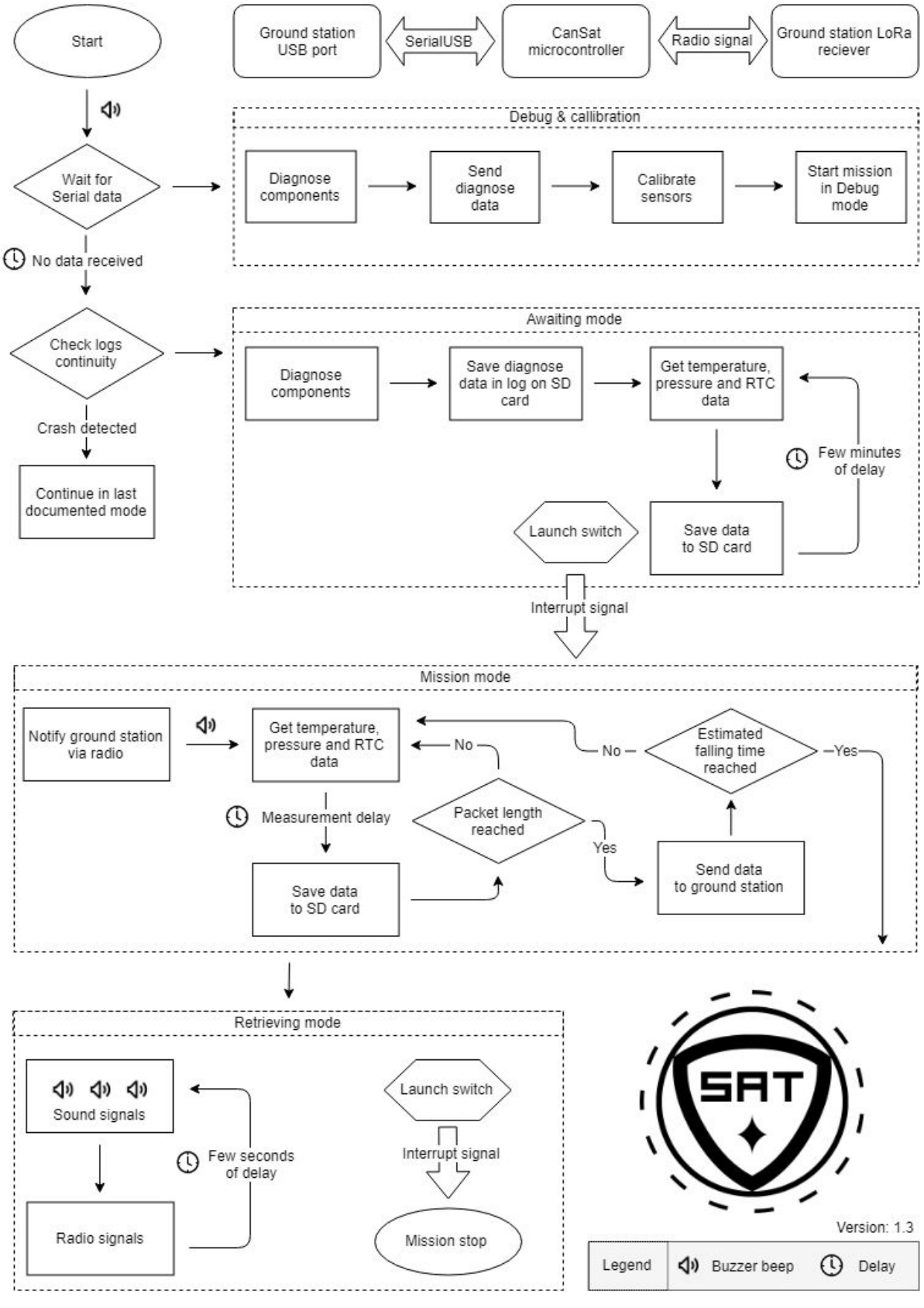
- **Secondary mission:**

  The probe in *mission mode* will collect sensor and positioning data.

  Neural network model used in DAS will be trained in a simulation in Unity3D. Model will require position, acceleration and tilt in three axes as an input, giving two values used for controlling servos changing direction of the probe.

  Initial block diagram of primary mission is presented below.

CanSat Primary Mission software design - SobieskiSat Team

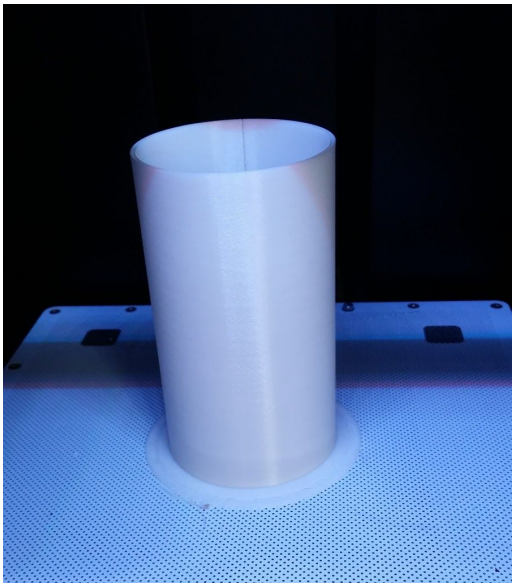


4. Project summary

4.1. Current project phase

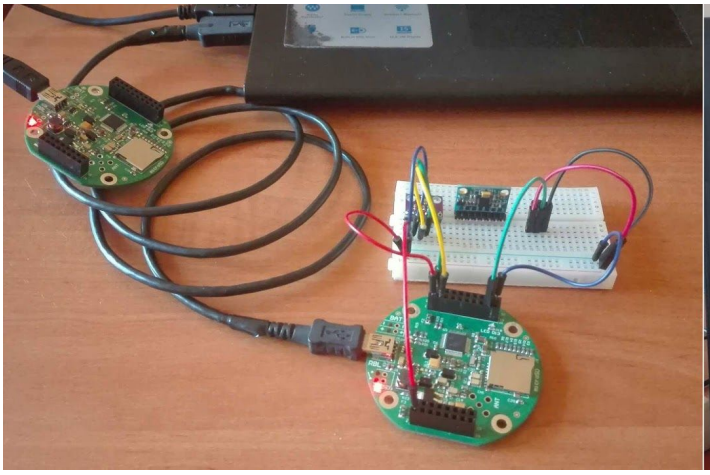
- Printing CanSat case:

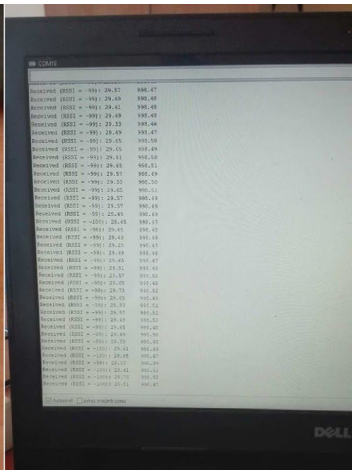
  First thing we did after getting permission to use our school's 3D printers is printing a cylinder the size of a typical CanSat to help us better visualize the placement of our planned internal components.



- Successful primary mission tests:

  One board sends pressure and temperature data to another, which then displays the received data on a computer screen.





- First positive sponsor response:

  We managed to get in contact with the CEO of Allincard about sponsoring our project and after initial conversation we received a green light and are awaiting the final decision from the foundation's council. We expect to receive around 200 PLN (~46 EUR), which should cover our initial expenses.

4.2. Resource management

We have created spreadsheet with all components and their properties presented below.

Component	Quantity	Mass [g]	Price [zł]	Price [EUR]	Voltage [V]	Current draw [mA]	Efficiency	Power [mW]	Full name
Max	-	*350*	*2 000,00*	*€500,00*	*5,0*	*1000*	-	*33300,00*	-
Current	-	*330*	*565,85*	*€131,29*	-	*390,3*	-	*2149,23*	-
				€0,00					
Primary misssion:				*€0,00*					
Li-Ion Battery	3	150	60,00	*€13,92*	3,7	-	-	-	18650
Can	1	43	10,75	*€2,49*	-	-	-	-	Z-UltraT
Parachute	1	20	40,00	*€9,28*	-	-	-	-	Skytex 27 Classic
Microcontroler board	1	20	150,00	*€34,80*	3,3	20	0,5	132,00	ATSAMD21G18 48 MHz
Temperature Sensor	1	2	5,00	*€1,16*	5,0	1	0,8	6,25	LM35
Pressure, gyro, magnetometer, accelerometer	1	3	42,90	*€9,95*	3,3	8	0,5	52,80	MPU9250 + BMP280
LoRa	1	-	-	-	3,3	90	0,5	594,00	SX1278
Buzzer	1	2	1,20	*€0,28*	5,0	10	0,9	55,56	HCM12
RTC module	1	2	8,00	*€1,86*	-	-	-	-	DS1307
Secondary mission:									
GPS module	1	10	70,00	*€16,24*	5,0	80	0,9	444,44	GPS NEO-6M
Camera	1	15	30,00	*€6,96*	3,3	30	0,9	110,00	OV7670
PM sensor	1	40	100,00	*€23,20*	5,0	60	0,8	375,00	PMS7003
Servo	2	18	26,00	*€6,03*	5,0	40	0,7	285,71	SG92-R
Humidity sensor	1	4	20,00	*€4,64*	5,0	0,2	0,9	1,11	DHT22
Photoresistor	1	1	2,00	*€0,46*	5,0	0,1	0,9	0,56	10 kOhm photoresistor

By our calculations current CanSat price is around 130 EUR (73 EUR for primary mission and 57 EUR for secondary)

4.3. Challenges and problems

- Gaining money from sponsors
- Without further tests we are not able to tell if DES would work as we expect
- Long distance radio communication
- Metal PM sensor case may interfere with GPS and LoRa signals, if so 3D printed case would be needed
- Some of our components using the SPI and I2C interfaces require pull-up resistors to the 5V line, but the board already has them, but to the 3.3V line. This may force us to unsolder the resistors on the CanSat kit board.

4.4. Schedule

We have created a Trello timetable, here are few important dates from it:

- Buying all necessary components - 18.11
- CanSat on breadboard - 20.11
- Finishing parachute design - 20.11
- Successful primary mission test - 25.11
- Testing long distance radio communication - 01.12
- Testing DES system - 04.12
- First working prototype - 11.12
- Christmas break; time for testing can and writing CDR - 21.12 to 02.01
- CDR - 13.01