UK CanSat Competition Progress Report 1

GWC CanSat

George Watson's College

November 2020

1 Introduction

1.1 Team Organisation and Roles

Team Leader - Harry
Vice Team Leader – Neil
Head Programmer - Fraser
Head of Electronics – Struan
Head of Outreach – Ross
Head of Aeronautics – Jamie
Design Coordinator – Kasper
Secondary Mission Coordinator – Finlay
Head of Finances and Administration – Neil

1.1.1 Mission Objectives

This year, the CanSat will feature a gyroscope so we can transmit the orientation of the can (in its descent and landing) to the base station, where it will be processed into a 3d visual image. Alongside this, the design will include a heads-up display which will be cast on top of the data from the CanSat - showing the primary mission data as well as other parameters in real-time.

Primary Mission:

The primary mission proposes the measuring of both air pressure and air temperature. The chosen sensors will also have the capability to measure air humidity.

Secondary Mission:

The aim of the secondary mission is to utilise the visual access of the orientation of the satellite. With this information we can obtain the value for the angular motion, which is essential for a satellite in space for the control and stabilization of its attitude.

1.1.2 What will you measure, why and how?

Table of the sensors required for both the primary and secondary missions along with their measurements.

What will be measured?	Why will it be measured?	How will it be measured?
Position	For retrieval and tracking.	GPS
Orientation	For a visualisation of orientation which is important for positioning solar panels and others.	Gyro
Magnetic Field	Important for navigation and gives information about the magnetic field in a potential planet if there is one.	Magnetometer
Pressure	Primary mission and so we can calculate altitude.	Pressure sensor
Directional Velocity	Important for calculating positioning and potential orbit time and radius.	Accelerometer
Humidity	Important in getting information about the weather of a potential planet.	Humidity Sensor
Temperature	Primary mission and to calculate altitude.	Temperature Sensor

2 CanSat Description

2.1 Overview

This year, the aim is to construct a CanSat with the ability to get information on it's orientation, which in a real life situation would be used by the attitude control system to make the satellite orbit the right way round or land safely in its current direction. With this data, getting data from other sources will be more reliable and efficient, and this will make completing the satellite's objectives easier and less time consuming.

2.2 Mechanical design

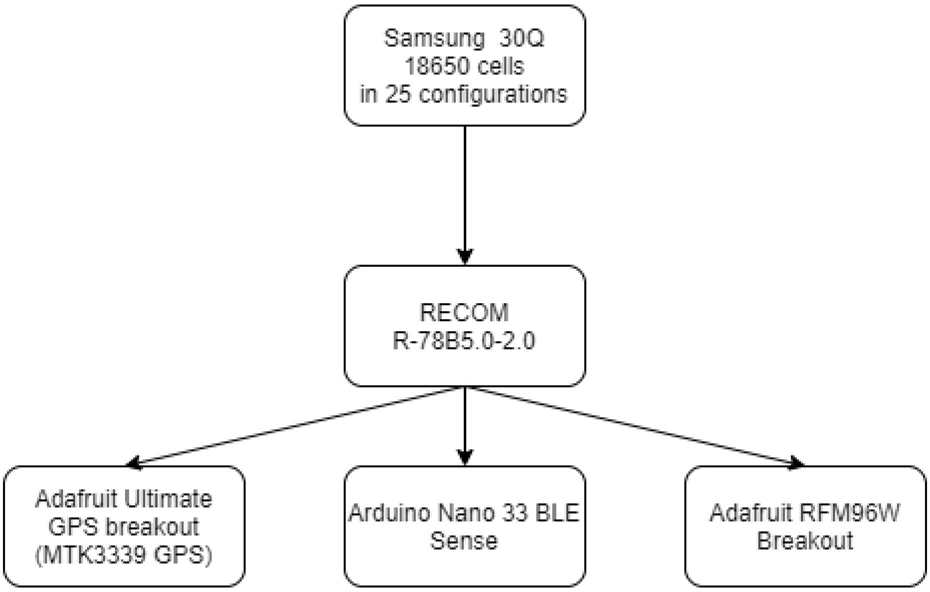
The PCB is responsible for the power delivery and data transfer to and from all the other sensors. The sensors themselves will be mounted onto the PCB using female and male pin headers rather than directly with solder, as this significantly decreases the likelihood of soldering errors and short-circuiting. It also means that if components are damaged or break during testing they can easily and quickly be replaced.

This year, an improved external shell will be 3D printed for the CanSat. The new design will incorporate a dual-access system whereby the components inside the CanSat can be removed and/or implemented from either end. This will ensure a more careful and logical arrangement of the components and prevent issues with packing from arising. In terms of the external shell itself, it will be printed using ABS filament. ABS is low cost, tough, durable and able to withstand a wide range of temperatures; meeting the requirements of the mission.

2.3 Electrical design

To power the CanSat this year, we will be using some combination of battery cells connected in series, and will be used through a 3.3V regulator to deliver the power to the cansat. This will power the electronic components at 3.3V. Unlike last year, we will not be using a Raspberry Pi, but instead will be using an Arduino Nano 33 BLE sense as it already has a lot of built-in sensors which we can utilize without the need for lots of other external sensors. This will greatly reduce the number of components on the PCB and therefore decrease the complexity and maximize space. The components are all connected with a single custom PCB to facilitate facile connection and simple replacement.

Power delivery is as below:



Data flow is as follows:

<u>Bi-directional data flow between Arduino Nano 33 BLE Sense and the following:</u>
I2C: Adafruit RFM9x LoRa Radio Transceiver
SERIAL: Adafruit Ultimate GPS BreakoutT
Adafruit CCS811 Breakout

The estimated battery life of the CanSat is as below, considering the power draw of all components:
Minimal voltage - 2x 18650 Samsung 30Q Li-ion batteries = 6000mAh @ 7.4V 2x 18650 Samsung 30Q Li-ion batteries = 44.4Wh

Estimated maximum power draw = 200mA @ 3.3V as this is a small amount, the cansat should last a long time.

2.4 Software design

The Arduino Nano 33 BLE sense will run a custom-written script that gathers data from all the sensors (Arduino Nano BLE Sense built in sensors, CCS811 and Adafruit Ultimate GPS), and then processes it into a form the base station software can understand (.csv file). The code is designed in such a way that even if one of the sensors were to fail, it would recover itself and send the details to the base station, so that it can be repaired remotely.

This data would then be sent to the Adafruit RFM9x transmission module - transmitting the data to the base station on the ground. While the data is being received, the base station's software would process it (such as calculating the altitude from pressure) and display it in a graphical user interface. After the mission, the user interface will also allow for the creation of graphs to analyse the relationships in the collected data.

2.5 Landing and recovery system

A simple decagonal drag parachute made of Ripstop Nylon will be used to regulate the CanSat's descent speed. On landing, the CanSat's shell will absorb the impact.

To determine the size of the parachute, the team made some calculations which consider the CanSat's mass, the velocity it is required to fall at, as well as other variables:

$$\text{Air pressure} = 1.04 \text{ bars; Temperature} = 15°\text{C; Humidity} = 75\%\text{; Air density} = 1.25 \text{ kg/m}^3$$

$$F_d = 0.5\, C_w\, \rho\, v^2 A$$

$$A = \frac{mg}{0.5\, C_w\, \rho\, v^2}$$

$$A = \frac{3.43}{0.5 \text{ x } 0.24 \text{ x } 1.25 \text{ x } 8^2}$$

$$A = 0.36\, m^2$$

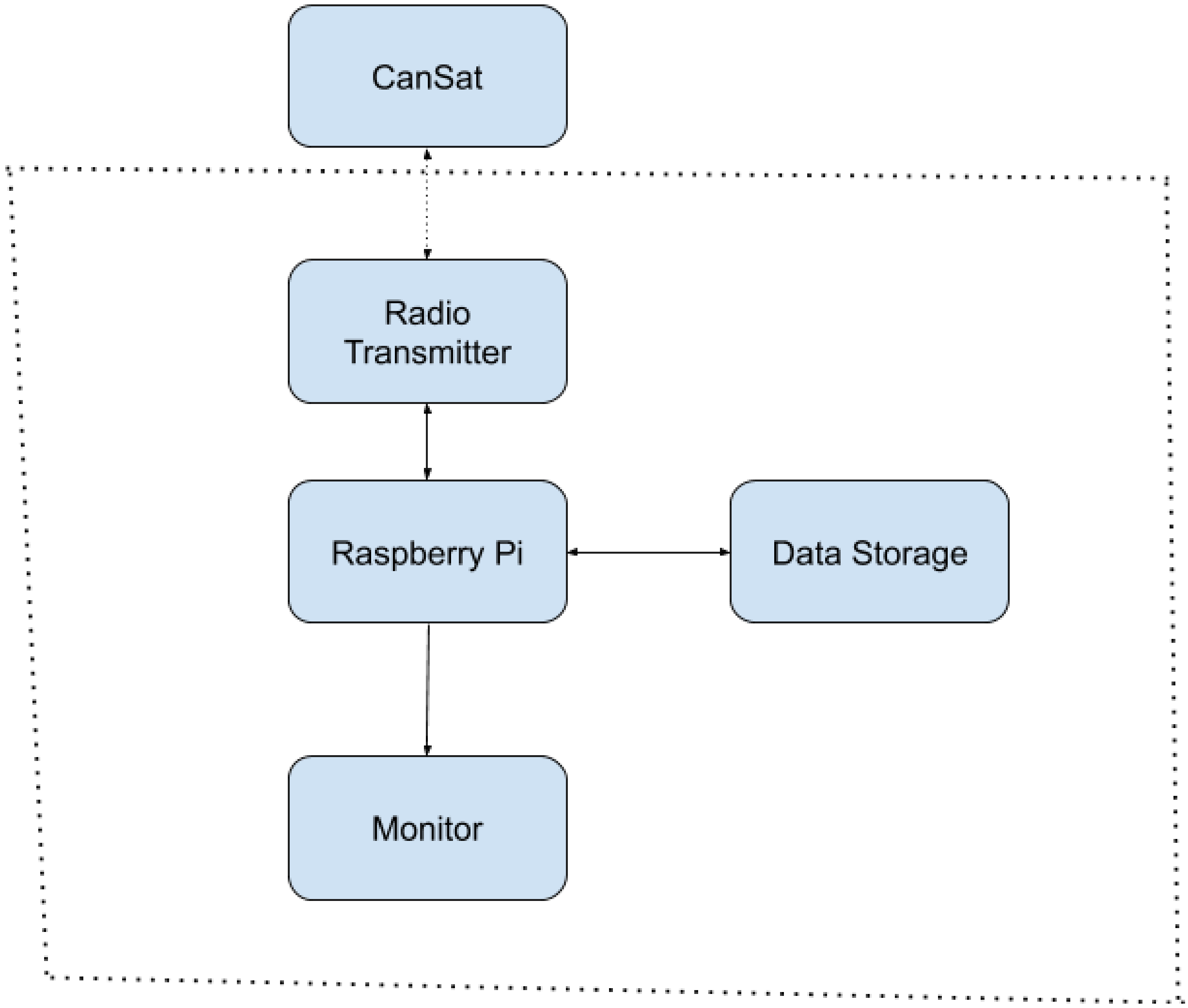
$$\therefore r = 0.33\, m$$

2.6 Ground support equipment

The team's software developers are developing a fast, complete and robust base station program, which can be executed with low system requirements. The software will run on a Windows or Linux based laptop and will only require a USB connection to receive data.

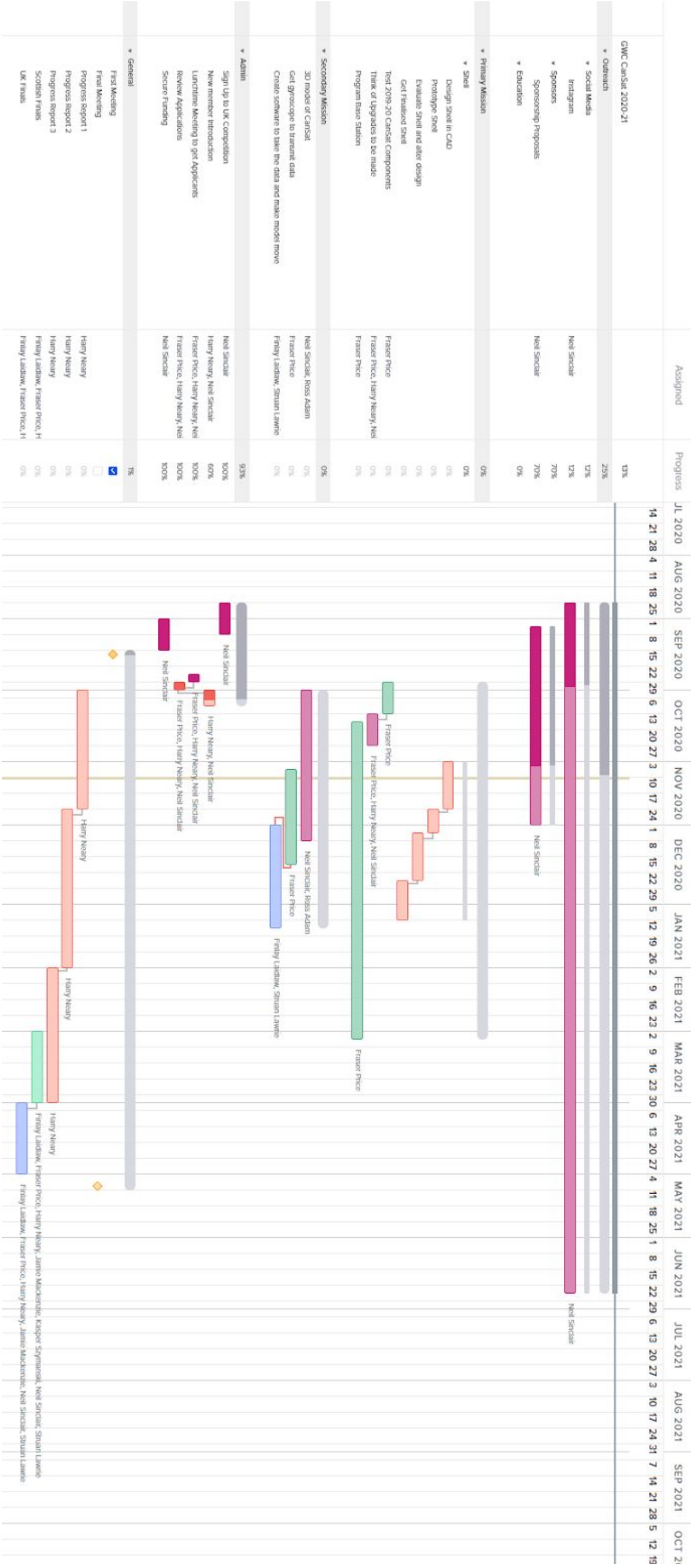
The base station equipment will include:

- Laptop with Wi-Fi connectivity and 2 USB Type-A ports
- RFM9x communications module connected to a Raspberry Pi 3 or 4 to act as the receiver
- Battery charging station with the ability to charge cells used in CanSat



3 Project Planning

3.1 Gantt Chart



3.2 Team and External Support

Currently the team consists of eight members each with their own skill sets and specialities relating to every aspect of the CanSat's design. The team also features specialists in outreach, graphic design and electronics alongside those of the pre-existing members. With these new-found members we intend on keeping the output and quality of our outreach program, as well as developing a more stable and reliable parachute.

In terms of funding, our school has very kindly agreed to offer us a baseline amount after we presented the CanSat project pitch to the school principal. The remainder of our funding comes from our sponsors TeamGantt, Tecbridge, and University Of Edinburgh who aside from providing us with adequate funding for our more ambitious ideas, have also given us free software and electrical components.

3.3 Risk Analysis

Potential Issue Solution

CanSat is over budget:
Remove non-essential systems from the CanSat or resort to a less expensive, more conservative design.

CanSat is underweight:
Add ballast and/or cushioning to the base of the CanSat to not only increase mass but act as padding to further protect the CanSat upon landing.

CanSat is overweight:
Resort to less heavy components which can easily be replaced such as the buzzer or cells.

Lacks transmission range:
Incorporate a range amplifier into the design.

Lack of internal space in the CanSat:
Alter organisation setup inside the CanSat to maximise space.

3.4 Test Plan

Feature to test Method of testing

In the future we will do the following:

- The parachute will be tested by dropping a can with the same mass as the CanSat from a height of 100 to 200 metres to accurately represent how it will perform on the day of the launch.
- The range of the transmission will be tested line on-site in an open field.
- Battery life tests will be conducted by measuring the length of time the CanSat can stay powered and comparing that to our calculations.
- Ensure that all the sensors are both receiving and recording data by testing the sensors in a variety of conditions.
- Complete a test run of how the CanSat should perform on launch day and verify that the base station is receiving data and displaying it in the appropriate format.

4 Outreach programme

Our use of Facebook and Twitter will remain primarily the same (regular updates), Instagram – as it has the greatest following and the most traction – will use a new-and-improved theme/colour scheme for each post to create a more recognisable and consistent brand. In addition, we will continue to host our state-of-the-art website at gwccansat.com.

5. Launch Day Preparation

5.1 Launch checklist/countdown

Checklist of tasks to complete when preparing the CanSat for launch:

- Turn CanSat on and ensure it is transmitting data – Struan(2:00 minutes)
- Start up the base station – Niel (2:00 minutes)
- Turn on the receiver – Fraser (30 seconds)
- Ensure that the parachute is secured to the CanSat – Harry (30 seconds)

5.2 Post mission checklist

1. Save data received by base station
2. Retrieve CanSat (made easier by the inclusion of a buzzer and other systems)
3. Turn CanSat off
4. Briefly inspect for any damages to the exterior of the CanSat

5.3 Results analysis procedure

The primary and secondary mission data transmitted from the CanSat will be displayed and stored in the base station. The data from the CanSat will be recorded by the base station and a physical copy will also be stored on the CanSat itself. In order to validate the results from our array of sensors, the collected data will be compared to that of the preliminary test done on the ground prior to the launch. Although the data from the launch will differ slightly to that of the test, we will still be able to identify anomalies in it and determine whether it is usable.