UK CanSat Competition Report

GWC CanSat

George Watson’s College

November 2018

1 Introduction

1.1 Team Organisation and Roles

Harold - Team Leader, Secondary Mission Coordinator, Mechanical, Outreach
Abhijith - Team Co-leader, Software, Outreach
Kristy - Secondary Mission Coordinator, Outreach
Alexander – Electrical
Nikolai - Electrical, Mechanical
Neil – Outreach
Fraser - Electrical, Software

1.2 Mission Overview

1.2.1 Mission Objectives

This year, the team is proposing a technology that will display information about the CanSat as it is descending towards the ground. This technology will be able to provide detailed information about the CanSat's acceleration, gyroscopic position and the impact of magnetic forces on the CanSat. The unification of these measures will also allow for 3-axis space orientation permitting the displaying of the orientation of the CanSat as it is falling.

Primary Mission:

The primary mission proposes the measuring of both air pressure and air temperature. The chosen sensors will also have the capabilities of measuring air humidity and VOC (volatile organic compound) gas.

Secondary Mission:

The aim of our secondary mission this year is to display the 3-axis orientation of the CanSat as it descends. By utilising the accelerometer, gyroscope and magnetometer capabilities of the 9-DOF sensor, the team will be able to create a frequently updated digital display of a 3D model of the CanSat showing it's orientation as it descends towards the ground. This will allow us to determine how the CanSat will land and, in later designs, use this information to alter the way in which the CanSat is landing for optimal landing conditions. Potentially (depending on mass requirements), we may also attach a camera to the base of the CanSat to show the elevations in the terrain below, which will determine whether these conditions are suitable for a controlled landing.

1.2.2 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 is it measured?	How is it measured?
GPS coordinates	Show the relative position of the CanSat in the air	Using the Adafruit 2479
Temperature, barometric pressure	To fulfil the requirements of the Primary Mission and display other measurements about the CanSat's surroundings	Measured using the BME680 from Adafruit
Acceleration, gyroscopic position	Unification of these readings used to display the 3-axis orientation of the CanSat	Using the Adafruit 9-DOF and IMU fusion breakout - BNO055
Quality of terrain below the CanSat	Used to determine whether the condition of the terrain is suitable for a safe and controlled landing	Measured using Arducam Mini-SMP-Plus
The strength of magnetic forces	Show the magnetic forces the CanSat is experiencing from the surrounds and if these will interfere with other electrical components	Measured using the Adafruit 9-DOF and IMU fusion breakout - BNO055
Humidity, VOC gas content	Additional measurements to accompany the primary mission and display other meteorological elements in the vicinity of the CanSat	Using the BME680 from Adafruit

2 CanSat Description

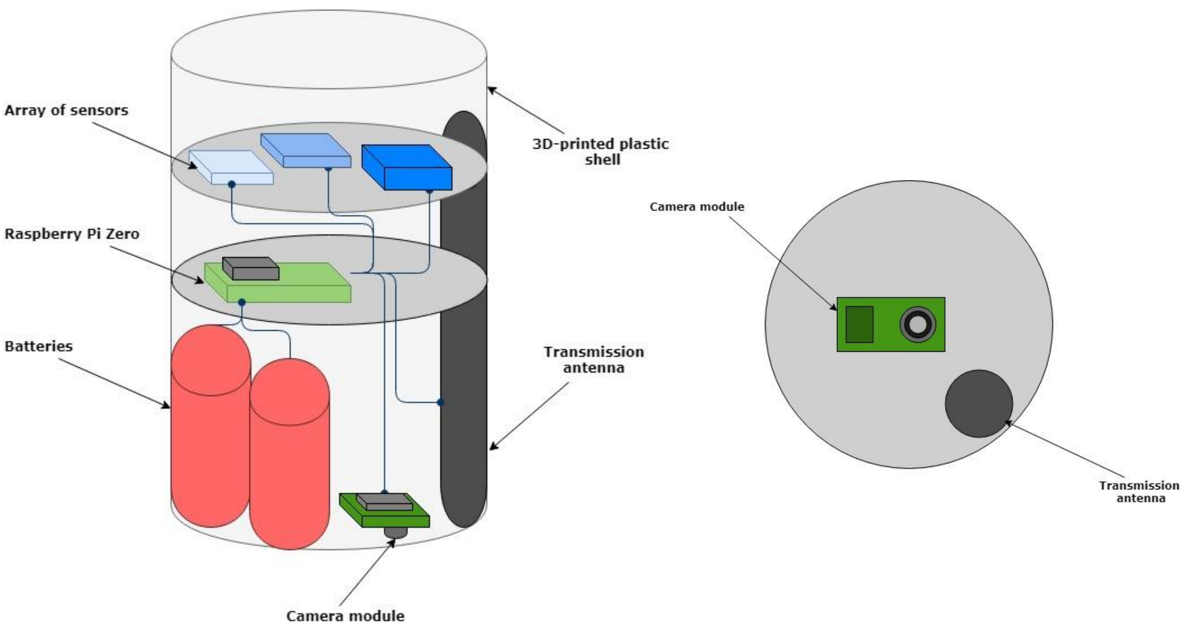
2.1 Overview

This year, we aim to focus on producing a frequently updated display of a 3D model the CanSat as it descends. We have designed the CanSat with a focus on technical and scientific accuracy and have achieved this by ensuring that the electrical components function properly and with precision. We intend to further verify this with more testing of both the individual components and when all the components are functioning together in a launch day setting. The CanSat will also be entirely assembled in-house, with none of the construction being outsourced.

2.2 Mechanical design

For this year's entry, the team will implement a layered design for the internals of the CanSat. Due to the sensors all being of a similar size, we intend on positioning the sensors in a shelf-like layout. This layout will use a fairly simple design of 3D printed circular plates connected to four metal prongs in order to maintain the CanSat's shape. The plates will also allow for ample amounts of space between the sensors, enabling them to cool, not overheat, and not interfere with each other. Furthermore, this layout will allow for the sensors to be changed if necessary because it is easily accessible once the outer shell of the CanSat is removed.

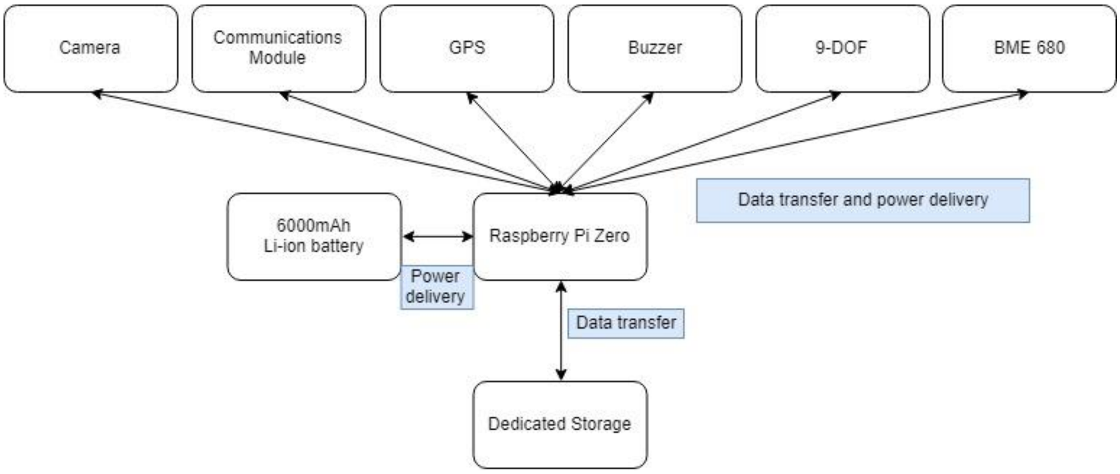
The external shell of the CanSat is composed of a lightweight 3D printed plastic, preventing the components on the interior from being damaged on impact. This external shell will absorb the shock sustained from the landing and if it were to shatter, the internals would remain protected. The parachute will be mounted to the external shell as well, as to prevent the stress of the parachute affecting the internal setup and potentially damaging it. The antenna will be located inside the external shell pointing downwards towards the receiver - the signal being transmitted through a slit in the base.



(Fig.2.1, digitally designed renders of CanSat standing vertically and the CanSat's base)

2.3 Electrical design

In order to power the CanSat we intend on using two Samsung 30Q 3000mAh 18650 cells connected in parallel, delivering 3.7V to a 5V step-up regulator to then power the MEMS components at 5V, with the Raspberry Pi Zero providing power to the other components as well. The built-in power management circuitry of the Raspberry Pi Zero provides management of power delivered to other sub-systems in the CanSat, allowing for dynamic power delivery.



In preparation for launch day, the team calculated the estimated battery life of the CanSat based off the power output of the cells and the power consumption of the Raspberry Pi Zero:

$$\text{nominal 18650 cell capacity} = 3000\text{mAh}$$
$$2\text{x nominal 18650 cell capacity} = 6000\text{mAh}$$

$$\text{Wh capacity} = 3.7 * 6 = 22.2\text{Wh}$$

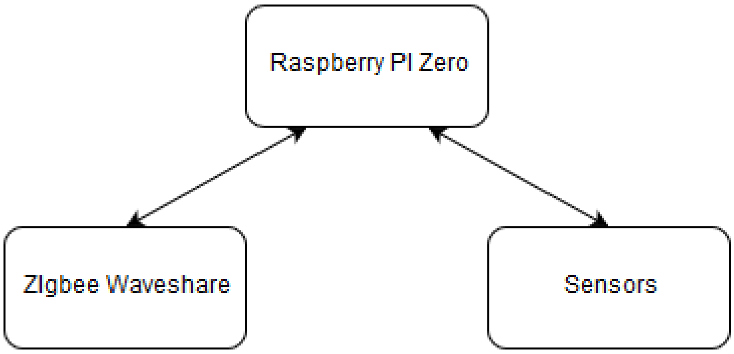
$$\text{Raspberry Pi Zero power draw (max.)} = 1.2\text{A @ 5V} = 6\text{W}$$

$$\text{Time available} = (22.2*0.8\ (80\%\ \text{efficiency}))/6 = 2.96\ \text{hours (at Pi max power draw)}$$

As shown in the above calculations, the team have also considered the power draw of all the sensors, as well as how their power draw has a negligible impact on the resulting battery life.

2.4 Software design

The Raspberry PI Zero will run a custom written Python script that gathers data from all the sensors (BME680, Adafruit Ultimate GPS, BNO055), processes it into a form the base-station software can understand, and then is sent via USART to the Zigbee transmission module - transmitting the data to the base-station on the ground. The code is designed in such a way that even if one of the sensors were to fail, it would recover itself and signal to the base-station the details, so we might attempt to fix it.



2.5 Landing and recovery system

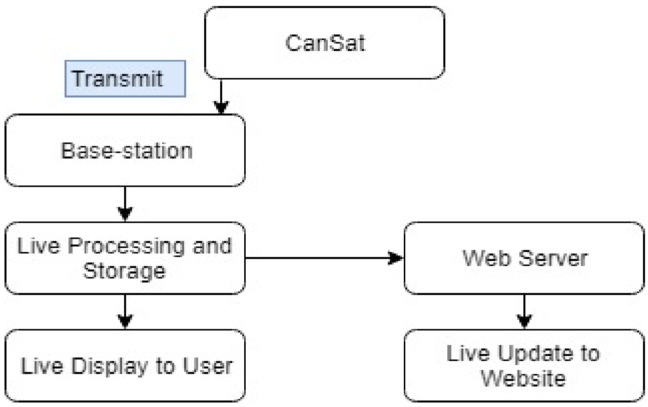
We plan to use a simple drag parachute to regulate the CanSat's descent speed. On landing, the CanSat's external shell will absorb most of the impact and protect the internals. Our CanSat will also use a communications antenna to transmit sensory data and the camera footage to the base station.

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.

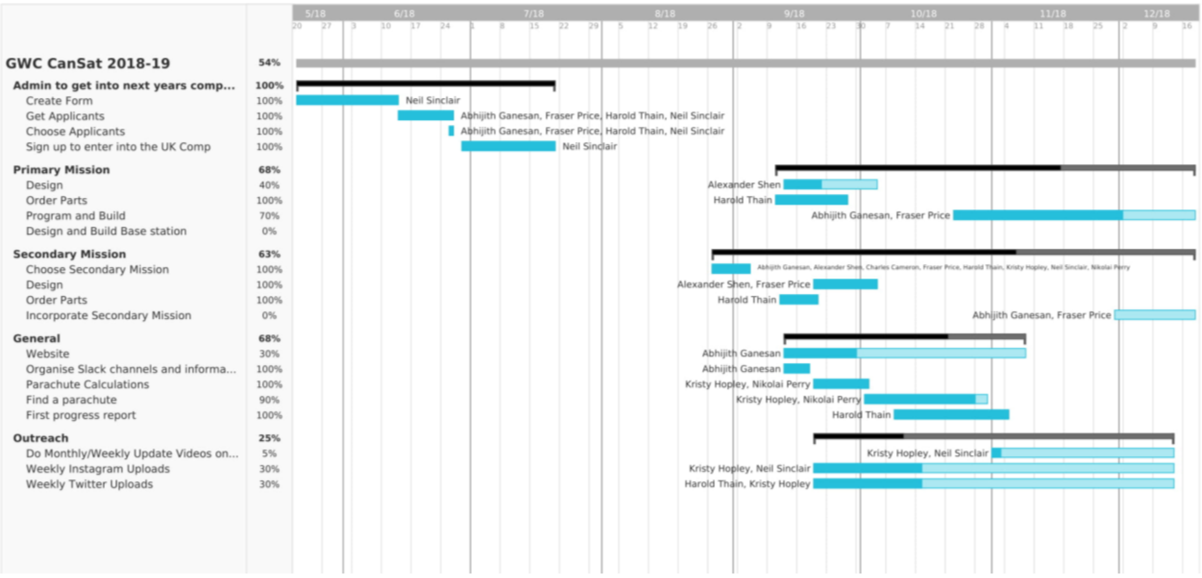
Our base station equipment will likely include:

- Laptop with Wi-Fi connectivity and 1-2 USB Type-A ports
- XCore2530 communications module and HackRF One 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 is comprised of seven members each with their own roles relating to the mechanical, electrical and software design of the CanSat. Unlike last year, this year's team members all have clearly defined roles and significant amounts of experience in the field which they have been assigned based on their skillset. We have also communicated with several professionals in relevant industries about further improving the quality of our electronics and mechanical design, as well as our secondary mission.

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 plastic disks used in for the mechanical design 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	Remove the metal prongs from the shelf-like layout (mentioned in the mechanical design section) to reduce mass.
Lacks transmission range	Resort to HC-12 radio module used in last year's CanSat.
Lack of internal space in the CanSat	Alter organisation setup inside the CanSat to maximise space.

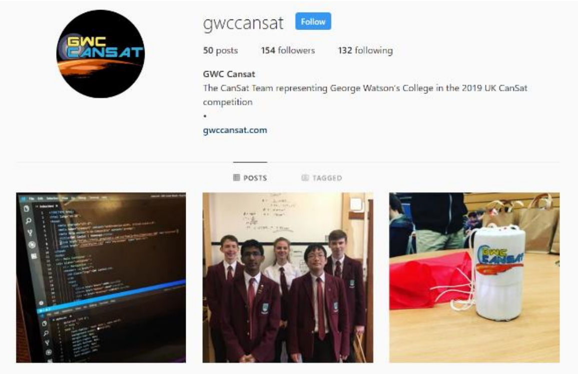
3.4 Test Plan

Feature to test	Method of testing
CanSat parachute	The parachute will be tested by dropping a drink can with the same mass as the CanSat from a height of 100 to 200 metres to accurately represent the height it will be dropped from on launch day.
Radio transmission range	The range of the transmission will be tested line-of-site in an open field.
Battery life	Battery life tests will be conducted by measuring the length of time the CanSat can stay fully powered and comparing this to our predicted results.
Effectiveness of sensors	Ensure that all the sensors are both receiving and recording data by testing the sensors in a variety of conditions (varying in temperature, humidity etc…)
Base-station information display	Complete a test run of how the CanSat should preform on launch day and verify that the base-station is receiving data and displaying it in the appropriate format.

4 Outreach programme

This year we have completely redesigned our website to not only make it easier to navigate on both desktop and mobile versions, but to also make it one of the more suggested websites when searching for the CanSat competition. We will be hosting this website at gwccansat.com.

We also host pages on Instagram, Facebook and Twitter which are all updated quite regularly. This year, we also intend on using YouTube more frequently, making video updates on the progress of our CanSat. Furthermore, in the coming weeks, we will visit several primary schools in the local area to talk about STEM and complete activities - designed to introduce younger children to STEM - with them.



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 – Fraser (2:00 minutes)
- Start up the base-station – Abhijith (2:00 minutes)
- Turn on the receiver – Fraser (30 seconds)
- Ensure that the parachute is secured to the CanSat – Nikolai (30 seconds)

5.2 Post mission checklist

1. Save data received by base-station
2. Retrieve CanSat
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 by the base-station. The CanSat's real-time 3D-axis orientation and the footage from the CanSat will be screen recorded by the base-station and stored as well (which will be shown in the final presentation). In order to validate our results, we will compare the measured data to data that was recorded during testing. Although the information collected will be different from what was received during our testing (because of geographic location and differing weather conditions), we will still be able to identify anomalies in the data and whether the data is usable whatsoever.