cansats in europe

2015/16
UK CANSAT COMPETITION
Registration form

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CanSat or team name	Cyclone
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How will you distribute the work between the team members? Consider all aspects of your experiment (structure, software, data analysis, etc.)	We will split the group into four main groups each of which will have a team leader who will have (at least) weekly meetings to allow for the best cooperation between the teams. The heads of the four teams will also cooperate with one another, in order to best ensure efficient integration of the various sub teams. The team has large amounts of experience, since two members were part of Team Impulse - the winners of the UK competition last year, and 4 were part of Team Colossus - a beginner entry to last year's competition.
	Software Engineering **Ashwin Ahuja** - Head of Software Engineering **William Eustace** - in charge of Base Station Software
	Electrical Design **Monty Evans** - Head of Electrical Design **Daniel Halstead** - in charge of Flight Control
	Structural Design **Benjamin Yass** - Head of Structural Design **Philip Fernandes** - in charge of Data Analysis **Nicholas Palmer** - in charge of the Presentation
	Outreach **Quentin Guéroult** - Head of Outreach **James Crompton** - in charge of Social Media and Online presence

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Do you have access to a workshop or a laboratory?	In school we have a number of well-equipped technology laboratories and a workshop with a large range of tools and equipment - including a Laser Cutter, a 3D printer. Also, though we do have facilities for the production of PCBs we will likely outsource this, given we could produce more accurate, smaller and multi-layer (up to 8 layers) PCBs, for a relatively low cost.
How much time will you have available to work on your CanSat and how will you spend it?	We aim to meet as an entire group once a week during Monday lunch breaks to summarise our individual progress, and organise inter team collaboration. We will also have a meeting on Thursday afterschool for the team management to organise the future plans. It is anticipated that each team member will be able to dedicate roughly three lunch breaks each week to the project (each of around 1 hour), and at least one afterschool (1.5 hour). Additionally, a number of members have equipment to work at home, including a 3D printer, therefore approximately 3 hours of work could be completed at home per week. This should amount to around 7.5 hours of work per team member, amounting to an average of 67.5 man-hours of practical work, every week.

During the holidays, we will conduct research and communicate using Telegram Messenger (telegram.org) which will allow us to easily exchange messages and files. We will also use Google Drive to complete shared documents (such as we have done in the creation of this proposal form).

We hope to have finished research and design by the end of the summer, for both the mechanical parts, and for the electronics. We also hope to confirm the parts required, and order them, which would be important given the vast array of countries from which they would have to be imported. Thence, we hope to begin the manufacturing processes for the produce and assemble a working prototype (remedying the inevitable issues that would ensue) by Christmas. |
| How do you plan to finance your expenses? Are you supported by your school or other sponsors? | Though it is likely that we might receive some financial assistance from the school, we hope to raise the majority of the funds ourselves. This would probably be mostly from corporate sponsorship, from both companies from whom we would buy components and any other companies from whom we could gain sponsorship. We also hope, at some point, to complete a fundraising effort in our school (such as was achieved by Team Colossus last year (including the majority of this year's team)) both allowing us to improve awareness of CanSat within our school and also to raise further funds. |

Please state in which category would you like to compete? (Beginner or Advanced)	Advanced
What is the secondary mission that you have chosen for your CanSat?	To produce a quadcopter capable of surveying an extra-terrestrial planet, using a live-feed camera, finding the topography and investigating the possibilities of flora and fauna. The drone should be capable of investigating the air through which it is passing: finding the dew point of the air, useful for finding the quality (combining with the temperature) of the area for agriculture, thus human inhabitability. Finally, the drone should be able to navigate autonomously, in order that it can investigate specific sites.
Outline the scientific or technical objective of your secondary mission and highlight any innovative aspects.	There are largely four main parts to our secondary mission, each one contributing to the success of the mission 1. Produce a quadcopter a. The majority of the mission revolves around the quadcopter, which will pose a large challenge, to produce a system with foldable arms that extend out of the parameters of the can and unfurl to provide a stable platform to fly. Research dictates a motor to motor distance of at least 150mm, as a minimum in order to provide any kind of stability, and propeller sizes of about 50mm. In the end, due to the design (Figure 1), there is a question of balancing a greater motor to motor distance for a lower propeller size, and finding the best compromise. Figures 1 and 2 show a preliminary design, which allows us to have the required motor to motor distance, while allowing us to still have large enough propellers. Additionally, we will have a number of problems in ensuring the can is the correct mass, since components such as brushless motors (and large batteries as would be required) tend to be rather heavy. The idea is innovative, since the design allows the production of a drone which takes up a lower volume than other drones of a similar wing span, and also being a more convenient (cylindrical) shape. There are also a number of challenges with the electronics, primarily in the MCU. We must decide whether to manufacture our own control board or to purchase one, which would be relatively effective, even implementing features such as auto-hold (using a gyro and accelerometer)

for a relatively low cost and with a small footprint. Finally, the decision must also occur of how to open the arms. Though this could occur by simply spinning the rotors, the use of locking servos would be faster and more reliable, but would however also take up valuable space.

2. Produce a live-feeding camera
   a. Since one cannot use Arduino, or similar systems to produce the streaming of video, given the very high processor power required, we have to use a Linux computer and Wi-Fi to transfer the video. Though the list (Figure 3) tentatively states that we will use an Intel Edison, alternatives such as the GumStix are also being evaluated. According to a number of online examples, the power of the Edison is such that one could even stretch to 720p video at 30fps.Though we could also use pre built FPV cameras and transmitters, the cameras tend to be very large, taking up most of the space we would have and the transmission quality would be worse than the Edison (due to the bandwidth of transfer). In fact, as shown by the list, a very small, high quality camera. However, we would have to write the software for the live transfer of video using Node.js, which will pose a challenge. Also, ensuring that the Edison maintains a Wi-Fi connection would be a challenge, as this is necessary for the camera to continue to work.

3. Find the dew-point of the air
   a. The dew point of the air requires the readings of the temperature and air humidity, then inputting it into calculations, to find the temperature at which condensation occurs at the same rate as the rate of evaporation (the Dew Point). The production of an algorithm to compare this to the viability of agriculture is very innovative, as though the connection between yield and dew point is well-known, no calculations exist. We will, using experimental data, calculate a scale, thus allowing us the find the potential agricultural yields (on an arbitrary scale) for the launch site. This algorithm must be well-rooted in experimental evidence (using data from farms and suchlike), posing a challenge. There are also a few challenges with the temperature and humidity sensing that must be

solved. Firstly, we must ensure that there is a constant air supply passing through the sensors, thus allowing the readings to be as accurate as possible. Also, we must deal with the calibration of the sensors, to ensure that the readings are accurate, since small change in the either the temperature or pressure readings could have a large effect on the resultant dew point value.

4. Autonomous navigation
   a. The autonomous navigation could occur using a number of mechanisms, either using software in the can, or from the base station. Though, given the use of a pre-built control board, such software already exists, previous experience has found it to not be very good, in fact very unreliable, thus it is innovative in itself that we will produce the software ourselves. At the moment, we plan to reverse engineer the transmission system, thus controlling the inputs (throttle, pitch, yaw and roll) from a laptop during launch, thus utilising the much higher processing power of these computers. However, there appears to be little precedent online for this having been completed successfully, but there are a few specific transceivers which can plug into a computer. The autonomous navigation allows the craft to investigate set sites, which would be almost impossible to find by eye, especially if they are far away.

Figure 1 - Design of the Quadcopter with the arms folded inside (CAD model made using SolidWorks)

Figure 2 - Design of the Quadcopter with the arms folded open (CAD model made using SolidWorks)

Quadcopter	
Motor	Quanum MT Series 1806 2300KV
ESCs	Turnigy 20A
Control Board	OpenPilot CC3D
Transceiver	Turnigy 9ch transmitters
Servo	Adafruit Micro Servo
Battery	Turnigy Nano-tech 850mAh 3s
Sensors	
Microcontroller	Teensy 3.1
Pressure Sensor (with temperature sensor built in)	MS5637
Humidity Sensor (with temperature sensor built in)	IST HYT-271
GPS Breakout	Trimble Copernicus II
GPS Antenna	Sparkfun Active Antenna
LoRa Transceivers	Hope RF RFM98W
Camera	
Intel Edison	
Base Breakout Board	Sparkfun DEV-13045
UVC HD camera	AliExpress

Figure 3 - list of possible components

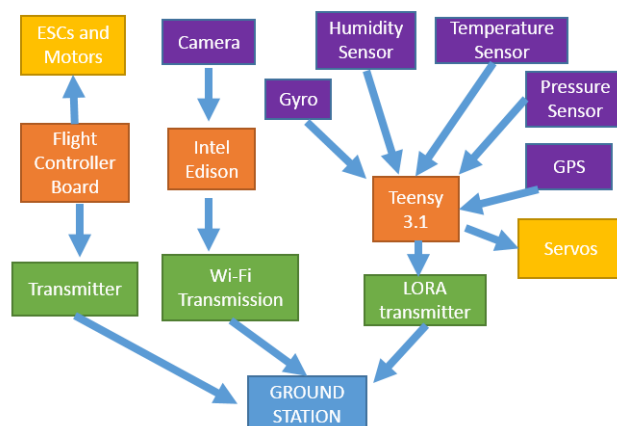| Describe your secondary mission. This part should link the scientific objective to the experiment itself. Explain how you are going to fulfil the scientific goal.	

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Figure 4 - Flowchart describing the parts of the circuit

Figure 4 above shows how we will split the electronics into 3 different parts (with possible components listed in Figure 3), to ensure the parts are independent - so if one part fails the other two will still work. One part will manage the quadcopter flying itself, using largely purchased components, such as ESCs and Flight Controller Board. Though we could technically produce boards that would do this ourselves, it would likely be very ineffective and prevent the quadcopter from flying. Additionally, purchased Control Boards would be relatively cheap and very efficient, including the ability to use inbuilt (on the OpenPilot CC3D - Figure 3) barometer, accelerometers and gyros to help to stabilise the craft. ESCs, also, are being purchased as it allows us to use a much smaller board, thus helping us to meet the space regulations. The transceiver system will also be bought, as it would be very reliable (and relatively small), especially over a long distance.

The second part is the camera section, using the Intel Edison microcontroller. Though the Intel Edison could also be used to control the sensors (using its GPIO pins), it was good to separate the two systems, thus ensuring that both systems would work well, while the second microcontroller (Teensy 3.1) is very small. We will use the Teensy because it is very powerful, containing the ARM-based Cortex M4, with the processor running at 96MHz. It also contains 64KB of storage, which would be ample space for the data, thus ensuring that an SD card would not be required. The Teensy will also control the Servos to open the arms of the quadcopter. With the Teensy, we would also be able to program all the sensors easily using i2c. It would also be relatively easy (as Team Impulse did last year) to produce a specific PCB for the MCU, containing all required components.

Figures 1 and 2 show the general design of the can, where the arms of the quadcopter, containing the motors, opens up (controlled by the servos - and locked using a moving pole) allowing the propellers to spin and lift the craft. The idea is that this would occur directly after release, thus negating the requirement of a parachute. We will need to ensure a system for opening the servos and starting up the motors most

	effectively. The supports of the can will be on the outside allowing the electronics to sit comfortably inside the can. The camera will be at the bottom of the can, with the Teensy & Main PCB, Intel Edison, GPS Breakout and Control Board in the middle of electronics, with a second breakout containing the pressure sensor, humidity sensor and GPS antenna at the top of the stack; this allows air to pass over the pressure and humidity sensor, and allows direct contact between the GPS antenna and satellites, thus allowing the GPS to get a fix. There will also be two transceivers (for the quadcopter and of the LoRa) on the outside of a can, allowing for the optimal exchange of data between the can and the base station. Due to the complexity of the design, the entire design will be 3D printed out of ABS, due to the material's strength, though some pieces may be prototyped in PLA, due to the lower cost. The 3D printing also allows us to have a single piece design, thus increasing the strength of the can, and ensuring that all components can be satisfactorily held in place.
Which data will you measure and how?	**Sensors** Pressure Sensor - MS5637 Humidity Sensor - IST HYT-271 GPS Breakout - Trimble Copernicus II *Additionally, the Control Board (OpenPilot CC3D) contains a barometer, accelerometer and gyro, whose raw data could be extracted and saved.* In order to fulfil the primary mission, both the Pressure Sensor and Humidity Sensor also contain accurate (about to the nearest thousandths of a degree Celsius) Temperature Sensors. Depending on the success of each of the sensors, we will likely average the two temperature results to find the best result. In order to transmit the data (as required by the Primary Mission), we will use a LoRa transceiver to transmit data. From personal experience, (according to Team Impulse who use this transceiver), the transceivers have a large range with a very good reliability. Though they found it slightly hard to communicate with, the fact that they have done this before, will make the task easier. The entire sensor system will be controlled by the powerful Teensy 3.1, running the Arduino Bootloader, allowing the sensors to easily be controlled and monitored. The Trimble Copernicus will talk with the Teensy using Serial, with a good library allowing the easy communications between the MCU and breakout. It also

	allows us to connect an external GPS antenna, which can go at the very top, increasing the probability of receiving a fix. The Copernicus also has a faster chip, leading to better reliability and a much faster start up, a large problem both Team Impulse and Team Colossus had last year. Finally, we will attempt to extract (OpenPilot's software allows one to easily control this) the raw data from the gyro on board the OpenPilot CC3D.
What do you plan to do with your results after the flight?	Results Received (post calculations) **Pressure Sensor** - pressure in millibars **Temperature Sensor -** temperature in Celsius **Humidity Sensor -** humidity in % **GPS -** latitude and longitude in degrees **Gyro -** degrees of rotation (per second) in x, y and z axis In order to receive the figures listed above, we will use i2c sensors for the Pressure, Temperature, Humidity and Gyro sensors, thus ensuring that we only have to calibrate the readings by predetermined amounts to generate a very high accuracy of reading. For the GPS, Serial will be used as the mechanism of transfer of data, allowing us to find the exact location relatively easily. Many of the results would likely be used in comparison to the altitude, finding any possible changes that we would expect as we rise through the atmosphere. Though we could find altitude using GPS readings, from past experience, especially when one has an accurate pressure sensor (to the thousandths of a millibar), these readings would be more accurate. Additionally, it does not rely upon the existence or strength of a connection with satellites, with which Colossus struggled last year. In order to calculate the altitude using the pressure figures, we will use a variation of the formula ($\Delta P = h\varrho g$), comparing the pressure value to one found on launch day, at ground level, thus allowing us (assuming, given the relatively low height, a constant acceleration due to gravity and density of the air. Then we will graph our results for temperature against altitude and assess whether there is a correlation between them, and if so the strength of this correlation using Spearman's rank

	correlation coefficient. Our expectations are that the temperature will increase as the altitude decreases. We will also graph humidity against altitude, and humidity against air temperature and look for relationships between them, again using Spearman's rank correlation coefficient to find the strength of the relationships. For this we expect the humidity to increase as altitude decreases, and humidity to decrease as temperature decreases. We will calculate the dew point using the temperature and humidity readings, and investigate how dew point varies with location and altitude to help understand the agricultural potential of the area. With these findings we will create an algorithm which has as its input temperature and dew point (as scientific research suggests that these are two factors that greatly contribute to the yield of a field) and will use the results generated by this to place, on an arbitrary scale, the viability and suitability of an area for agricultural use. Finally, we will try and map this potential against a flight path generated from the GPS data overlaid on a satellite image of the area. Information such as this would be particularly useful if this was to be used on another planet, and this could help to determine the ability of a human settlement to be developed.
Describe your outreach programme for before, during and after the CanSat competition campaign. e.g. newspaper articles, local radio, webpage, presentation at school, etc.	Our outreach programme before, during and after the CanSat competition will be focused on three distinct strategies to increase the publicity of the CanSat competition and our project. These are publicity aimed at the local community, pupils of our school and the wider public. **Local Community** We shall attempt to increase the publicity of our project within other schools within the area by giving talks at other schools and forming links with science societies in other schools within our area. We may also distribute flyers within our local area outlining our project to the local community and thus further increase the awareness of our project within our local community. **School** Frequent talks will be made at the school at societies such as the SPS Space Society to outline our project, our progress during the competition and more importantly to inspire the younger years within the school to enterprise this project in the future.

Also, we hope to further publicise CanSat through a series of events such as cake sales within the school where we are able to further increase the awareness of our project.

In addition, we hope to publish articles within the school magazine Black and White as well as the weekly magazine This Week. We hope to outline our project and what occurred in Black and White in several articles. The first one would be outlining the project, the second would discuss the progress we were making at the time as well as the problems we had encountered and dealt with and the third article would be after the CanSat competition and would discuss our overall experience and encourage the younger years to also participate in a competition most of the group have already taken part of and have thoroughly enjoyed previously. The information in This Week would be much briefer and could be one team member discussing what they have done during the week and the tasks they might have completed as well as their future objectives.

The Wider Public

We hope to also publicise our project to a much greater public through the internet. We also hope that this will maintain interest with the public reached in the local community and in the school.

We hope to create a Facebook and Twitter account to keep people informed about our progress throughout the project. We could further increase this publicity by launching a YouTube channel where a team member may produce a short video where he discusses his role at the time. Moreover, we may also create a blog to discuss even more in depth how the project is developing. The activity on these platforms will increase as we draw nearer to the launch. After the launch we shall discuss the whole project on the platforms and our own personal experiences and hopefully inspire others to also attempt the CanSat project.

We are also developing a number of possible recognisably logos to further increase the publicity of our CanSat campaign.
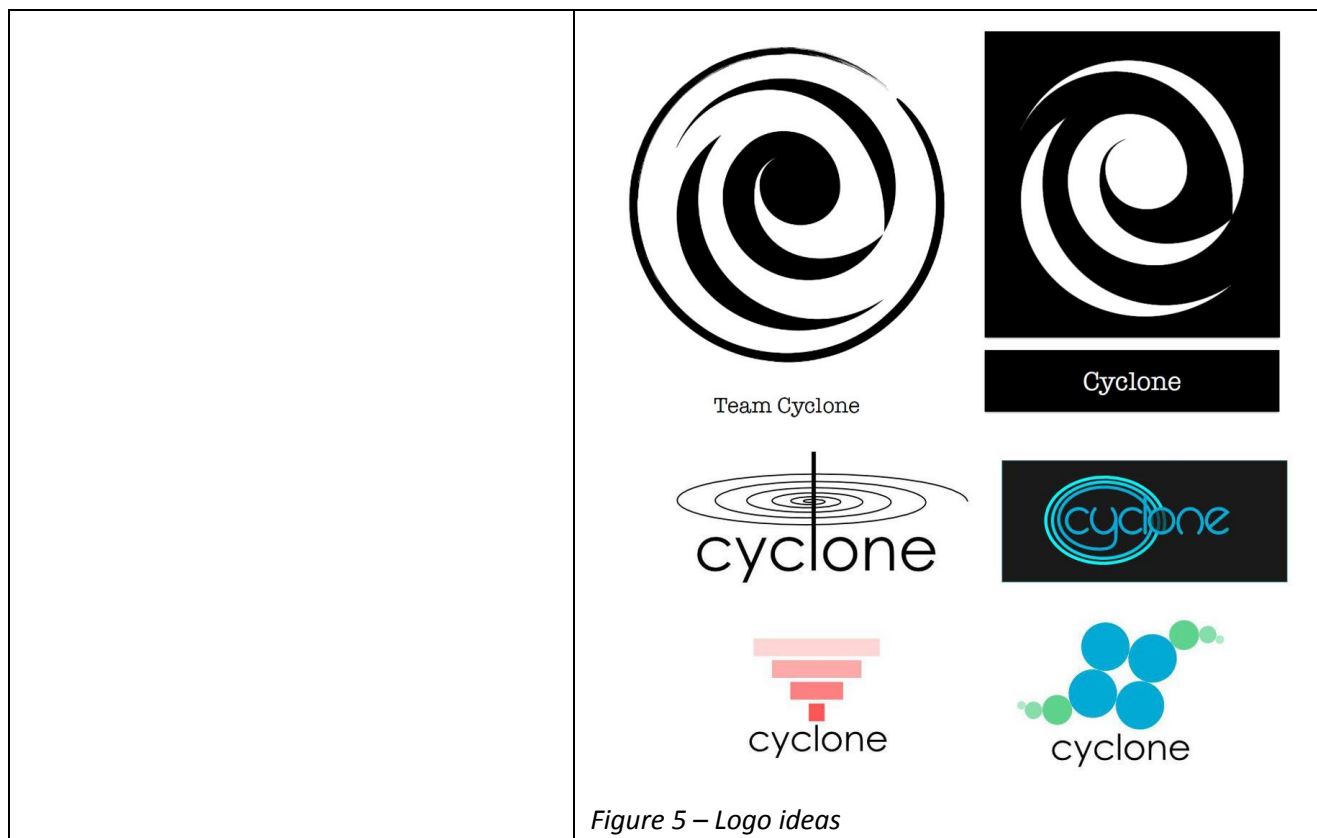
Figure 5 – Logo ideas

Before submitting your proposal, please ensure that you have carefully read the competition guidelines, available at www.esero.org.uk/cansat and e-mailed the completed proposal form to Tom Lyons t.lyons@nationalstemcentre.org.uk before the deadline of 6th July 2015.