UK CanSat Competition Guidelines 2021-22

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INTRODUCTION

The European Space Agency (ESA) endorses and supports a range of CanSat activities across its Member States (including Canada, Slovenia and Malta), all leading to a European final event – the European CanSat Competition. The CanSat project, aimed at secondary school students, mainly addresses Technology, Physics, and programming curricular subjects. By offering the practical experience of working on a small-scale space project, CanSat makes use of these subjects in an interdisciplinary manner and promotes collaboration and teamwork.

The UK branch of the European Space Education Resources Office (ESERO-UK) organises the UK CanSat Competition. The winner of the UK competition can go on to compete in the European CanSat Competition.

What is a CanSat?

A CanSat is a simulation of a real satellite, integrated within the volume and shape of a soft drink can. The challenge for the students is to fit all the major subsystems found in a satellite, such as power, sensors and a communication system, into this minimal volume. In the UK competition the CanSat is then launched to an altitude of a few hundred metres by a rocket or dropped from a drone or captive balloon and its mission begins: to carry out a scientific experiment and achieve a safe landing. During the ESA European competition (which the winning UK team will attend) the CanSats are launched to an altitude of up to 1km.

Educational value of the CanSat project

CanSats offer a unique opportunity for students to have a first practical experience of a real space project. They are responsible for all aspects of a typical space project: selecting the mission objectives, designing the CanSat, integrating the components, testing, preparing for launch and then analysing the data. Throughout this process the students:

- learn by doing
- get acquainted with the inquiry-based methodology that is typical of real-life scientific and technical professions
- acquire and/or reinforce fundamental Technology, Physics, and programming curricular concepts
- understand the importance of coordination and teamwork
- enhance their communication skills.

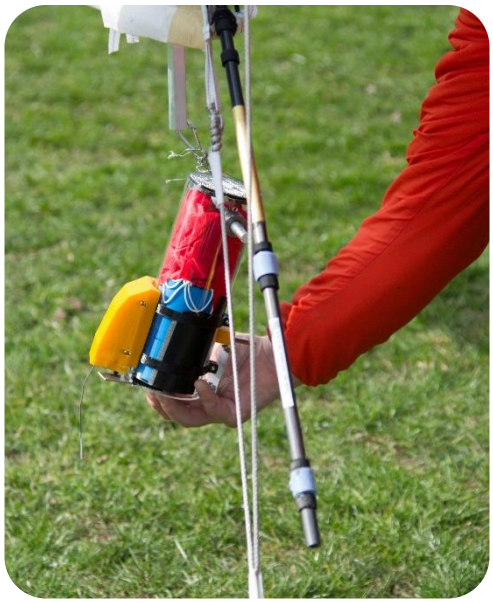
COMPETITION OVERVIEW

The UK CanSat Competition will consist of five phases:

Phase 1 - Call for proposals and team selection
Phase 2 - Teachers' introductory workshop
Phase 3 - CanSat construction and test activities
Phase 4 - Regional launch campaign
Phase 5 - National final launch campaign

TIMELINE

Phase 1: Call for proposals and team selection	
Activity	**Deadline**
Expressions of interest process opens	July 2021
Deadline for expressions of interest	1st October 2021
Phase 2: Teachers' introductory workshop	
Activity	**Deadline**
Teachers' introductory workshops	October 2021
Phase 3: CanSat construction and test activities	
Activity	**Deadline**
Progress report 1	06 December 2021
Progress report 2	11 February 2022
Final report	22 April 2022
Phase 4: Regional launch campaign and post-flight activities	
Activity	**Deadline**
Regional launch campaigns	March 2022
Phase 5: National final launch campaign and post-flight activities	
Activity	**Deadline**
National final launch campaign	May 2022



Phase 1 - Call for proposals and team selection

An announcement of opportunity is published on the ESERO-UK website www.stem.org.uk/esero, with information about the competition and how to apply. Applications are reviewed and if teams meet the eligibility criteria then they offered the chance to take part.

Eligibility

- The team should comprise of between 4 and 10 students, assisted by a teacher or tutor. To comply with the rules of the ESA European final only teams of 4-6 students will be able to attend the UK final, as the winning team from the UK must comprise of 4-6 students to be eligible to attend the European final. If more students wish to be involved before the final up to a maximum of 10 can do so. But once the final event is reached only 6 students will be allowed to attend. Because of this cap on the number of students who can attend the final schools/colleges can enter multiple teams.
- Students should be aged 14 or over
- The team members must be enrolled as full-time students
- At least 50% of the students included in a team must be nationals of an ESA Member State (a full list of Member States can be found here)
- A completed expression of interest form must be submitted to ESERO-UK by 01 October 2021 for each team taking part. Applications can be made via the link on www.stem.org.uk/esero/cansat

Responsibility for leading the team

Each team should have a teacher or a tutor responsible for monitoring the team's technical progress, available to offer help and advice, and acting as the point-of-contact between the organisers and the student team. The teacher/tutor must be available to attend an introductory workshop and must accompany the team to the competition launch campaign.

It is recommended that the team have a mentor within a university or industry to assist in their project, should they be selected. ESERO-UK can help teams to find a mentor through the STEM Ambassador Programme.

Phase 2 - Teachers' introductory workshop

Before students start work on their projects a workshop will be held for the teachers of each team to introduce the CanSat concept, demonstrate how the hardware and software works and give teachers the opportunity to build their own CanSat. For the 2021-22 competition to following workshops are available:

- The National STEM Learning Centre, York. 09:30 – 16:30 on the 14 October 2021. Sign up to this workshop here.
- Stevenage (venue TBC). If interested in a workshop in this area please email esero-uk@stem.org.uk to confirm your interest)

Phase 3 - CanSat construction and test activities

Students are encouraged to follow a normal space project lifecycle as follows:

- selection of mission objectives
- definition of requirements
- design of hardware and software
- one or more reviews of the design (leading to design refinement)
- integration and testing
- launch and operations
- data analysis and reporting of results

Guidelines for the activities, as well as templates for the required reports, will be provided to each team that is selected to participate in the competition. Expert advice should be made available throughout this phase.

For the 2021-22 competition, basic CanSat kits will be available free of charge to any school or college who would like one. These kits are valued at £50 and this must be accounted for in the team's financial record. Kits must be returned to ESERO-UK if the school decides not to enter the competition. There is no requirement to use these kits and other kits or individual components can be used at the expense of the team/school.

Kits will include:
Microcontroller: Sparkfun Pro Micro RP2040 or Raspberry Pi Pico
Adafruit BMP280 I2C/SPI Barometric Pressure, Temperature and Altitude Sensor (suitable for gathering all the data needed in the primary mission)
RFM96W LoRa 433MHz (Transmitter)
USB Cable (USB C or Micro USB depending on the microcontroller)
220 Ohm resistor (for prototyping)
10 KOhm resistor (for prototyping)
TMP36 Temperature sensor (for prototyping)
Half size Breadboard (for prototyping)
Protoboard
Header sets (suitable for the microcontroller and other breakout boards)

A small number of Pro Micro ATMega32U4 microcontrollers are also available if preferred.

To request a kit once you have had confirmation that you have a place in the competition please email esero-uk@stem.org.uk.

Additional hardware will need to be purchased to meet the requirements of the secondary mission (see below).

Primary and secondary CanSat missions

After release and during descent, the CanSat shall measure the following parameters and transmit the data as telemetry once every second to the ground station:
• Air temperature
• Air pressure

Primary mission

The team must build a CanSat and program it to accomplish the following compulsory primary mission:

It must be possible for the team to analyse the data obtained (for example, make a calculation of altitude) and display it in graphs (for example, altitude vs. time and temperature vs. altitude).

Secondary Mission

The secondary mission for the CanSat must be selected by the team. It can be based on other satellite missions, a perceived need for scientific data for a specific project, a technology demonstration for a student-designed component, or any other mission that would fit the CanSat's capabilities.
Teams should brainstorm their own mission objectives, ideas and constraints to try to define their mission. The student teams are free to design a mission of their choice, if they can demonstrate it has some scientific, technological or innovative value. Teams should also keep in mind the limitations and requirements of the CanSat mission and consider the feasibility (both technical and administrative in terms of time and budget) of their chosen mission.

Some example secondary missions:

1. **Advanced telemetry**

   After release and during descent, the CanSat measures and transmits additional telemetry to that required for the primary mission, for example:
   - Acceleration
   - GPS location
   - Radiation levels

2. **Telecommand**

   During descent, commands are sent from the ground to the CanSat to perform an action, such as switching a sensor on and off, changing the frequency of measurements, etc.

3. **Targeted landing**

   The CanSat navigates autonomously with a control mechanism such as a parafoil. The objective is for the CanSat to land as close as possible to a fixed target point on the ground after it has been released from the rocket. This mission is an advanced telemetry/telecommand mission - navigation data is exchanged between the CanSat and a ground station throughout the descent.

4. **Landing system**

   For this mission, an alternative safe landing system for the CanSat would be deployed, such as a bespoke parachute or airbag.

5. Planetary probe

The CanSat simulates an exploration flight to a new planet, taking measurements on the ground after landing. Teams should define their exploration mission and identify the parameters necessary to accomplish

CanSat Requirements

The CanSat hardware and missions must be designed to the following requirements and constraints:

1. All the components of the CanSat must fit inside a standard soda can (115 mm height and 66 mm diameter), with the exception of the parachute. An exemption can be made for radio antennas and GPS antennas, which can be mounted externally (on the top or bottom of the can, not on the sides), based on the design.
2. The antennas, transducers and other elements of the CanSat cannot extend beyond the can's diameter until it has left the launch vehicle.
3. The mass of the CanSat must be between 300 g and 350 g. CanSats that are lighter must take additional ballast with them to reach the 300 g mass limit required.
4. Explosives, detonators, pyrotechnics, and flammable or dangerous materials are strictly forbidden. All materials used must be safe for the personnel, the equipment and the environment. Material Safety Data Sheets (MSDS) will be requested in case of doubt.
5. The CanSat must be powered by a battery and/or solar panels. It must be possible for the systems to be switched on for three continuous hours.
6. The battery must be easily accessible in case it has to be replaced or recharged in the field.
7. The CanSat must have an easily accessible master power switch.
8. The CanSat should have a recovery system, such as a parachute, which is able to be reused after launch. It is recommended to use bright coloured fabric, which will facilitate recovery of the CanSat after landing.
9. The parachute connection must be able to withstand up to 500N of force. The strength of the parachute must be tested, to give confidence that the system will operate nominally.
10. The descent rate must be at least 10m/s or 6m/s for a guided landing.
11. The CanSat must be able to withstand an acceleration of up to 2g for balloon or drone launch, or 20g for rocket launch.
12. The recovery of the CanSat is not guaranteed after the launch.
13. The total budget of the CanSat should not exceed £400. This does not include ground support equipment, such as laptops, power supplies, antennas. **This includes the cost of the basic boxed kit if provided to your school, which costs £50.** For the ESA European final the total budget is set at 500 euros.
14. The CanSat must have the function to alter the frequency, as required for the European competition.

Reporting

We require 3 reports at different times during the competition:

Activity	Deadline
Progress report 1	06 December 2021
Progress report 2	11 February 2022
Final report	22 April 2021

A template version of the report can be found in **Annex 1**. Feedback will be provided on progress report 2 and the final report. Progress report 1 and 2 will be used to select the teams that have qualified for the National final launch campaign.

Phase 4 - Regional launch campaign

The highlight of the competition are the launch campaigns, where each CanSat will be launched. These events will be held in March 2022.

Regional launch events will comprise of one day at a number of locations across the UK. Teams should have their CanSats flight ready upon arrival at the launch site. There will be time for final launch readiness checks but any integration or test of the CanSat must have been carried out beforehand. The regional launches are not competitive, and every team is encouraged to attend a launch, even if their CanSat is not completely finished. The only requirement is that it is fit to launch on the method being used. The regional launches are not used to choose teams for the National final launch, they are more of an opportunity for all teams to have a go at launching their CanSat. However, if a regional launch is available, it will be a valuable part of the test campaign for a team's CanSat.

The sites for the launch events will depend upon the chosen launch platform. The most common options are:

- A drone, dropping from 120m
- A captive (tethered) balloon, dropping from ~150m
- A Kestrel 100LD rocket which launch to around 275-425m

On launch days there will be prep area for teams to make last minute adjustments to their CanSats but we ask that as much preparation is done before arrival to ensure that the day runs smoothly and that ever team can launch their CanSat.

Rocket launches

Rocket launches are subject to strict legal and safety requirements, which will be investigated well in advance. CanSats will be launched in twos or threes on-board the 75mm diameter, 4ft long 'Kestrel 75' rockets, powered by advanced re-usable solid fuel rocket motors. It is expected that there will be around 5-10 minutes of prep time as the rocket is fuelled and loaded for launch between the CanSats being loaded and the rocket sealed and launched. The CanSats must be able to remain operable during this period.

The launch itself will exert around 10G to 20G of acceleration on the CanSats for a short 0.5 to 1.5 second thrust duration, followed by around a 5 to 7 second 'coast' before the rocket reaches between 900ft and 1400ft (275m and 425m) peak altitude. At peak altitude the CanSats are pushed out of the rocket to begin their descent.

Phase 5 - National final launch campaign

The National final launch campaign takes place at the National STEM Learning Centre, York. Teams will be chosen to attend the National final launch based on their reporting. We usually select 10 teams to attend this event.

A typical programme for a launch event is as follows:

Day 1

- Final integration and technical inspection of the CanSats

Day 2

- Launch and recovery operations
- Analysis of the mission data and conclusion of results

Day 3

- Student teams present data analysis and results to the jury
- Competition prize ceremony

A report on the results from the launch is required from each team. The competition winners will then be chosen based on the team's performance throughout the project, as well as the final flight operations and results.

Evaluation and scoring

The teams will be evaluated on an ongoing basis, via submitted progress reports and presentations during the final, with the following items being taken into account:

1. Educational value

For this item, the jury will consider the quality of the reports and the team presentations, the level of effort made by the team and how much the team appear to have learned throughout the project.

2. Technical achievement

Innovative aspects of the project will be judged, for example: the mission selected and the hardware/software used. It will be also taken into account how the teams obtained the results, how reliable and robust the CanSat was and how the CanSat performed. If the CanSat did not succeed in accomplishing the missions but the team is able to explain the reasons why and suggest improvements, it will be also taken into account positively.

3. Teamwork

The jury will assess how well the team worked together on the assignment, the distribution of tasks, the planning and execution of the project and the team's success in obtaining the necessary funding, support and advice.

4. Outreach

The team will be scored on how well the project was communicated to the school and the local community, taking into account any webpages, blogs, presentations, promotional materials, media coverage, etc.

Marking scheme

Educational value	20%
Technical achievement	50%
Teamwork	15%
Outreach	15%
TOTAL	**100%**

Winning team

There will be one overall winning team from the teams that taking part in the National final launch campaign. The overall winning team will then be invited to take part in ESA's European CanSat competition alongside the overall winners from other ESA member states taking part in the competition. More information about the European competition and the guidelines for taking part can be found here.

The winners will be decided on by a judging panel appointed by ESERO-UK, comprised of CanSat experts, education experts, or engineers and scientists who will evaluate the teams' performances. The jury members will score the teams during the launch campaign and announce the results from their scoring on the final day of the launch event.

FINANCE

This section outlines the expectations as to ownership of costs for the competition. This is for guidance only and does not constitute an agreement between ESERO-UK and any third party.

ESERO-UK will pay for

- Catering for the duration of the teachers' workshop (if face to face rather than online)
- Accommodation and catering for the 3 days of the National final launch campaign for one teacher and up to six students
- The cost of the any CanSat kits made available to teachers

The school or sponsors will pay for

- Transport to and from each event outlined above
- Any additional electronic equipment required for the secondary mission or ground support
- Costs associated with more than one teacher and six students from each team attending an event
- Any costs of cover for teaching
- Any other costs incurred by the team not specified above

Bursaries

Bursaries may be available for schools and colleges to help cover the costs associated with either a regional launch event or the National final launch event. The value of these bursaries are likely to be £400 to attend a Regional launch event and £400 if for attendance of the National final launch campaign. Schools and colleges do not need to apply for this, it will be automatically awarded to them after attendance of the event and sent to their school if bursaries are available.

CONTACT US

All questions should be directed to:

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FURTHER REFERENCE

- ESA CanSat resources https://www.stem.org.uk/resources/collection/460386/cansat
- CanSats in Europe Portal http://www.esa.int/Education/CanSat
- CanSat in Europe Facebook page www.facebook.com/cansatsineurope/

ANNEX 1 – Reporting

***Instructions**: this is a template for the CanSat report – please copy and paste the below template into a separate document and follow it as it is. Maximum page limit for the report is 30*

pages, plus unlimited appendices. You should consider your technical solution, your outreach and teamwork and lessons learnt from the process.

***For the final report**: For the final version of this report, we have included sections on the launch day and lessons learned to be included. You should also start to prepare a 7-8 minute presentation that will include aspects of this report but also a placeholder for final results from the launch day if your team are chosen to attend – this will be presented on the day after the launch.*

UK CanSat Competition Report

Team Name
School

Progress report 1
Progress report 2
Final report
(delete as applicable)

Date: -------

1 INTRODUCTION

1.1 Team Organisation and Roles

(This part should contain a simple list of people involved, their skills and expected roles)

1.2 Mission Overview

1.2.1 Mission Objectives

(This part is not a description of the CanSat, it is only a summary of the main goals that you CanSat will achieve, and a sentence on what these goals achieve with relation to scientific/engineering objectives)

Primary Mission:

(This part should contain a list of primary objectives of your mission – such as given in CanSat requirements)

Secondary Mission:

(This part should contain a concise list/description of the secondary mission you are planning to achieve)

1.2.2 What will you measure, why and how?

(Concise description of what measurements your CanSat will make, why will you take these measurements and what sensing capabilities will be required. Include some thought on how will you analyse the data)

2 CANSAT DESCRIPTION

2.1 Overview

(A summary on the configuration of your Cansat – detailed information is included in the sections below. A high level description of CanSat and how the implementation will be performed).

2.2 Mechanical design

(This part should involve a high-level design description of mechanical parts and must include easy to understand sketch of the CanSat, its components and ideas of suitable materials (and their justification))

2.3 Electrical design

(High level description of initial electrical design. Must have a block diagram of the electronic system, devices and how they are interconnected as well as ideas for these devices (and their justification))

2.4 Software design

(High level description and initial block diagrams or flow diagrams of the operation of software)

2.5 Landing and recovery system

(Ideas and justification for landing and recovery system/parachute. This section should be more in-depth if the mission includes some special landing gear or separating parts)

2.6 Ground support equipment

(High level description of ground equipment and block diagrams of mechanics, electronics and operation. This includes your laptops, Yagi antennas, or any other equipment that you need on the ground to support the launch.)

3 PROJECT PLANNING

3.1 Time schedule

(A detailed project time plan which shows the tasks required to complete the project and the time (suggested to be hours required) allocated to each step. This should cover all scientific, technical and outreach tasks that need to be done and is updated with each report. A Gantt chart may be used to display this project planning.) (This must be at least a high level weekly plan)

3.2 Team and External Support

(Your team is your most vital resource. You must be aware of your competencies and be able to identify where you may need to expand the team or ask for external support. Please describe the tools and support

available to you and what external support you are planning to get. Please identify, based on your team skills, what support you may need).

3.3 Risk Analysis

(What could go wrong for the project? Think about the team, time constraints, equipment or technical issues. This will change as the project develops.)

3.4 Test Plan

(A brief summary of ideas for testing. The test plan should detail how you are going to test your equipment to show the CanSat will meet your objectives given in Part 1. How can you best simulate the conditions for your launch?)

4 OUTREACH PROGRAMME

(Consider all types of media to promote and disseminate information about your project. Write a general summary of media and schools that are planned to be reached)

5. LAUNCH DAY PREPARATION*

5.1 Launch checklist/countdown

(a ordered list of tasks with times, durations and team members responsible that you shall follow on the launch day to setup your CanSat and ground support equipment ready for launch)

5.2 Post mission checklist

(a ordered list of tasks with times, durations and team members responsible that you shall follow once your can is back on the ground. Might be as simple as "1. save data 2. turn can off")

5.3 Results analysis procedure

(description of procedure of how you are to interpret and use your sensor data for use in your presentation. Include details of any calculations used and how this analysis relates to your primary/secondary mission objectives. How will you determine if your measured data is valid and what is your criteria for a successful mission?)

6 LESSONS LEARNED*

(Reflect on the last 6 months. What have you learnt from the process? Has this changed anything for you in terms of subject or career decisions? What has been the most challenging part? What has been the best part?)

*Only required for final report