Mission Guide Document

For the 2018/19 Edition of the UK CanSat Competition

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A Competition sponsored by:

Airbus Group, BAE Systems, The University of Manchester

With support from:

The Manchester CanSat Project, the Space Universities Network, the UoM Space Systems Research Group, the University of Bristol

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1. Introduction

The CanSat competition is a design-build-fly challenge that provides teams with an opportunity to experience the design life-cycle of an aerospace system. The CanSat competition is designed to reflect a typical aerospace project on a small scale and includes all aspects of an aerospace project from the design review to post-mission review. The mission and its requirements are written to reflect various aspects of real- world missions, including telemetry requirements, communications, and autonomous operations. Each team is scored throughout the competition on real-world deliverables such as schedules, design review presentations, and demonstration flights.

In the trial year for this competition it is proposed that a limited set of UK universities send teams to compete with the aim of establishing the key program structure and logistics for a national competition.

1.1. Competition Description

The UK CanSat competition is a design-build and fly challenge for undergraduate aerospace or spacecraft systems engineering students. The aim of the competition is to provide UK undergraduate students with experience of practical space-related engineering design. Teams will work to design build and fly a "CanSat" - a drinks can-sized simulation of a real satellite, similar to the one shown in **figure 1**. Each year a new mission with key aims and objectives will be defined and participating teams will design, build and test fly a solution that meets the mission objectives and system requirements. Teams will be assessed on how well their design meets the mission objectives, as well as their overall design strategy and communication.

Figure 1

The competition consists of three major operational stages, Application Stage, Design Review (DR), and Systems Launch (SL) + Post-flight review (PFR), held in line with the academic calendar for UK universities.

It is intended for the full-scale competition that teams will be established in September with a view to running the design review stage in February. However, to apply for this year, teams **must submit the application form** by **15 NOV 2018**. Participation in the competition is free for all teams from UK universities for 2018/19.

Design review (DR): During this stage, the team must prepare designs and prototypes, as well as test their concepts. Teams will generate a design review document (DRD) following the template provided. The DRD will be assessed by a cross university panel. **To qualify to the next stage, a team must be awarded at least 50 percent of the maximum points available for the DRD.**

Systems Launch and Post-Flight Review (PFR): Prior to the systems launch event, all teams must have finalised the building and testing of their designs. All teams must pass the required flight readiness review (FRR) before **12:00** am GMT **Saturday (27 APR 2019)** to be allowed to launch their CanSats during launch weekend. The FRR will be graded and this will contribute to the final score.

For 2018/19 the launch is planned **for Saturday (27 APR 2019)** and will take place at the Midland Rocketry Club site. It is expected that the launches will begin at noon and will continue until all teams have had the opportunity to launch their CanSats. Second launches will not be allowed, except in the case of a launch failure.

The date of launches is subject to weather conditions.

Post-Flight Review (PFR): Post-Flight Review (PFR) will be held on **Saturday (27 APR 2019), after each team will have had their scheduled launch**. PFR will comprise a five-minute presentation of the data gathered during the flight and a review of any errors or mistakes during the flight. This will be followed by five minutes of questions from judges and audience members.

1.2. Competition Timeline

The overall plan for the full-scale competition is shown below. All times GMT.

Phase 1: Call for teams and team selection

Activity	**Deadline**
Deadline for application forms	**23:59 15 NOV 2018**
Announcement of participating teams	**23:59 22 NOV 2018**

Phase 2: Design Review

Activity	**Deadline**
Design Review Document (DRD) submitted	**23:59 01 FEB 2019**
Assessment of DRDs	**02-14 FEB 2019**
Announcement of successful teams progressing to next phase	**23:59 15 FEB 2019**

Phase 3: Systems Launch & Post Flight Review (PFR)

Activity	**Deadline**
Flight Readiness Review (FRR)	**10:00 27 APR 2019**
Launches	**12:00 27 APR 2019**
Post Flight Review (PFR)	**17:00 27 APR 2019**
Final Results Announced	**19:00 27 APR 2019**

1.3. Additional Information

There is no limit to how many teams can represent one university, as long as each team follows the rules set out in this document.

To receive certificates of accomplishment and be eligible for awards, teams must complete all phases of the competition.

Late submissions will not be accepted, and any team that fails to meet any deadline will be disqualified from the competition.

The results are final and not subject to change. Example score sheets will be available with quantitative scoring to ensure maximum objectivity.

Please note the CanSat competition is organised by volunteer students and academic staff engaged in supporting various phases of the competition. The competition is designed to provide teams with a valuable educational experience while maximizing the support provided by the limited time resources of these volunteers. For greatest efficiency, adherence to strict due dates, file templates, and file name formats is required.

2. Mission Overview

The 2018/19 mission simulates a relatively simplistic atmospheric sampling system. The CanSat shall consist of a single payload containing all the electronics. The CanSat shall be released from the payload bay of a QbCan releaser, details of which are given in Appendix B. The operation sequence shall be:

1. The CanSat is released from an altitude of 100 meters to 150 meters above the launch site from the payload bay of a QbCan.
2. Once the system is deployed from the QbCan, the CanSat shall deploy a parachute to keep the descent rate between 5 and 10 meters per second.
3. During descent, the CanSat shall collect atmospheric temperature and pressure data, hence determining the altitude. The CanSat shall also measure battery voltage. All data shall be transmitted back to a Ground Control Station and stored on an SD card for later processing.
4. The CanSat shall reach the ground intact and fully operational. The CanSat shall operate an audio beacon continuously after landing to aid retrieval.

2.1. Base System Requirements

Each CanSat must fulfil a number of requirements set by the competition organisers. The key requirements are given in the table below. In addition to the requirements, there are a number of bonus objectives that teams can choose to meet in order to receive extra points. Any other bonus requirements must be identified and justified in the Design Review Document.

1	Maximum allowable CanSat mass is 0.35 kg.
2	The CanSat shall fit in a cylindrical envelope with the following dimensions: 66 mm diameter x 115 mm height + 45 mm extra height for external elements (parachute)
3	Structures must survive 20gs of shock.
4	Structures must survive 15gs of launch acceleration.
5	The CanSat should not have any sharp edges to cause it to get stuck in the QbCan.
6	The QbCan should not be used as part of the CanSat operation.
7	The CanSat shall deploy from the QbCan payload area.
8	A Descent Control System (parachute) must be deployed immediately after release from the QbCan.
9	The descent rate of the CanSat shall be between 5-10 m/s.
10	All electronics should be hard mounted, or glued using hard adhesives.
11	The frame/structure of the CanSat shall accomodate all electronics.
12	All electronics components shall be enclosed and shielded with the exception of sensors.
13	During descent the CanSat shall collect air pressure, outside temperature and battery voltage once a second.
14	The CanSat shall determine altitude with respect to ground level based on pressure and temperature readings.
15	Each sensor data packet shall be tagged with time and packet count.
16	The sensor data packet shall meet the following structure: packet count, mission time, pressure, temperature, altitude, battery voltage, soft state.
17	The CanSat shall store all sensor data packets onboard.
18	The CanSat shall transmit all sensor data packets to the Ground Control Station during flight.
19	The CanSat shall include a power indicator such as an LED or buzzer, which shall indicate that the CanSat is operational.
20	The audio beacon is required for the CanSat to continuously operate after landing.
21	The audio beacon shall indicate if any electronic is not functioning.
22	Battery source may be alkaline or lithium. No lithium polymer or lithium ion.

23	The battery shall be easy to remove/replace.
24	It shall be possible to access the microcontroller with a USB plug, without having to disassemble the CanSat in its entirety.
25	Teams shall build their own Ground Control Station.
26	All received data packets must be displayed in real time, in SI units.

2.2. Bonus Requirements

- **Receive pressure, temperature and altitude data from an altimeter, but without employing pre-existing libraries.**
- **Packet count and mission time do not reset with processor reset.**
- **Have beacon indicate successful run of setup sequence.**
- **Receive and plot data in real time, using USB cable.**
- **Include a HD Camera to capture the descent.**
- **Include a tilt sensor. Use tilt data to simulate the orientation of the CanSat in flight.**

Teams can choose to have multiple bonus objectives. Teams are welcome to come up with their own bonus objectives, as long as they still satisfy the base requirements (table above).

3. Team Composition

Students currently enrolled in undergraduate or undergraduate integrated degree programs (BEng or MEng) are counted as undergraduate students. Students currently enrolled in a post- graduate degree programs (Master's and PhD candidates) are counted as graduate students.

3.1. Team Composition

All teams shall comprise between three and eight students enrolled at a university. Teams may consist entirely of undergraduate students, entirely of graduate students, or a combination.

In the case of two or more teams representing the same university, each team must develop its designs independently from the others. Sharing materials such as electronics and raw materials for construction, as well as tools and services, is permissible, but designs must originate uniquely from within each team.

There is no limit as to how many teams can represent one university.

3.2. Faculty Advisor

Each team must nominate a faculty advisor, who will be responsible for:

- Aiding procurement of resources.
- Providing non-technical guidance during the competition.

The faculty advisor should be a part of the academic staff from the university being represented by the team. They shall not influence the design or provide direct recommendations concerning any part of the design.

3.3. Competition Liaison

Each team will be assigned a competition liaison member, who will act as a link between the team and the competition committee. The liaison member will be responsible for coordinating communication between the team and the competition committee, which includes answering any questions the team may have, tracking the team's general progress, and providing general guidance. The competition liaison member shall not provide any design recommendations.

3.4. Additional Support for Teams

A set of presentations and additional materials relevant to designing, building, testing, and reviewing simple CanSat designs is available upon request.

4. Deliverable Items

Each team's score will be based on a series of deliverables provided at various phases of the competition. The deliverable items are selected to simulate a real aerospace engineering project and to reflect real-world milestones used for tracking the development of a project.

4.1. Design Review

The design review (DR) is a multi-disciplined technical review to ensure that the system under consideration can proceed into detailed design and can meet the stated performance requirements within cost (program budget), schedule (program schedule), risk, and other system constraints. Each team is to demonstrate the following in the DR:

- Understanding of the requirements detailed in section 3.
- Allocation and derivation of system and subsystem requirements.
- Overview of the design.
- Predicted budget.
- Identification of necessary trades supporting the design.
- Results of testing, prototyping, or both as needed to transition from the design to build sections of the project.

A DR template will be provided for teams to complete. A quantitative scoring method will ensure objective scoring.

4.2. Post-Flight Review

The Post-Flight Review (PFR) provides an assessment of flight operations and results of the demonstration flight. The PFR provides an assessment of successful and unsuccessful flight operations. The PFR shall provide:

- Overview of the whole mission and CanSat design.
- Raw and processed data from the flight.
- Failure analysis and assessment for unsuccessful mission objectives.

PFR will be conducted **after the designated launch window, on Launch Day**. PFR presentations shall be limited to ten minutes, including questions.

A presentation outline will be provided. A quantitative scoring method will be put in place to ensure objective scoring.

4.3. Deliverable Submissions and Scheduling

All deliverables shall be submitted by a designated team member by the dates listed below. All files shall be in PDF format using the naming convention as shown below. Note, "v#" corresponds to a unique revision number for the review package that can be used to track revisions.

Adherence to the filename and format specification is scored during the competition.

Updated presentations will only be accepted before the deadline. It is understood and expected that the design will change between DR and the launch day. The teams will be expected to talk about those changes during the PFR.

Points will not be deducted for design changes between DR and launch day, as long as the final design fulfils all the requirements.

Deliverable	Filename Format	Deadline
Design Review Document	cansat_XXX_DR_vYY.pdf	**01 FEB 2019**
Data from flight	cansat_XXX_FL.csv	**27 APR 2019**
Post Flight Review	cansat_XXX_PFR_vYY.pdf	**27 APR 2019**

XXX – assigned team number, YY – revision number

4.4. Slide Format

The following formatting rules apply for presentations:

- Use the provided templates. Failure to use the template will result in loss of points.
- All slides should have simple white background.
- All slides should have the page number in the footer.
- The presentation should not contain any links, embedded files, or movies.

4.5. Progression to Launch Stage

Any team that achieves less than 50 percent during DR phase will not progress to the Launch Stage.

Any team found to be copying another team's work will be disqualified.

Any team that fails to submit any document before the appropriate deadline will be disqualified.

A team can be disqualified if a member's behaviour is deemed highly inappropriate.

5. Flight Operation

The key practical element of the competition is the launch stage where all competing teams assemble and their CanSats are given a flight opportunity. For 2019 we are trialing various delivery methods including high powered rocketry and drone release. Details of the Launch stage of the competition are given in this section.

5.1. Schedule

The competition Launch day is **Saturday (27 APR 2019).**

The Flight Readiness Review and safety inspection, as well as the pre-flight briefing, will be held Saturday morning and afternoon.

All the launches will take place on Saturday, unless rescheduled because of weather conditions.

Post Flight Review presentations and the final results announcement will take place Saturday afternoon.

A detailed schedule will be provided.

5.2. Flight Readiness Review

The purpose of the Flight Readiness Review is to ensure CanSats function safely and are airworthy. CanSats must be fully functional by the time of the review and suitable for immediate launch.

The first test is designed to measure safety of the design. This includes inspection of electronics, sensors, and mechanical mechanisms to identify any potential hazards associated with the designs.

The next test shall be the drop test. The CanSat must be in flight configuration and will be subjected to the drop test. If the test fails, the team must make repairs before being allowed to fly. The CanSat must pass the drop test to be allowed to launch.

The final test aims to ensure that the electronics inside the payload are in working order. To assess this, teams will be asked to show data received from CanSat by the “ground station” via an USB cable.

If any CanSat is determined not to be flight ready, the team has the opportunity to make repairs and modifications ahead of their scheduled launch. The tests are necessary to assure that each CanSat is completed before arriving at the competition and to ensure the safety of everyone on the field during the competition. Safety is highest priority. Any CanSat deemed not flight worthy will be disqualified.

Appendix A – QbCan Releaser

System Description

The releaser is a time delay operated device designed to deploy CanSats by gravity from aerial vehicles such as balloons and drones.

The Open Cosmos qbcan releaser consists of two main parts:

Releaser body: Main body of the releaser holding the hinged door, the electronics box, volume for the CanSat and four attachment points.

Electronics box: Enclosure that contains the electronics that allow operation of the releaser: electronics, door's hook mechanism and battery.

The two parts of the releaser are 3d printed and assembled by Open Cosmos. The releaser is delivered with the software already in it with a default timer

Releaser Body

The main releaser body contains the main volume to load the CanSat to be released.

The CanSat volume is a totally enclosed volume without any apertures in order to avoid entangling of any CanSat features with the releaser.

This volume is closed by a spring actuated door locked by the door mechanism. The latch mechanism and door have been designed to offer some level of protection for landings. The door hinge is spring actuated allowing a rapid removal of the door from the CanSat way when the releaser is actuated to drop the CanSat.

The four attachment points at the top of the main body are used to attach the releaser to the aerial vehicle.

CanSat Specifications

The releaser has been designed following the official ESA CanSat guidelines that can be found in the following link: http://www.esa.int/Education/CanSat

CanSat max dimensions: 66 mm diameter x 115 mm height + 45 mm extra for external elements

CanSat max mass: 350 grams

Loading a CanSat inside the Releaser

To load a CanSat inside the releaser:

- Switch ON the releaser.
- Move the OPEN/CLOSE switch to OPEN position.
- Load the CanSat inside the releaser.
- Manually rotate the lid. Do not rotate manually the latch mechanism.
- Activate the CLOSE switch to lock the door via the latch mechanism while holding the door in place manually reacting the door hinge spring moment. At this point the timer is activated and starts counting.

Typical Sequence to operate the Releaser

A typical sequence to operate the releaser would be:

- Attach the releaser into the aerial vehicle.
- Switch ON the releaser.
- Operate the OPEN/CLOSE switch to OPEN position, to reset the timer and/or unlock the door if its closed.
- Place the CanSat inside.
- Manually rotate the lid. Do not rotate manually the latch mechanism.
- Activate the CLOSE switch to lock the door via the latch mechanism. At this point the timer is activated and starts counting.
- Lift the releaser with the aerial drone.
- *Releaser is activated* after the timer has timed out, *dropping the CanSat by gravity*.
- Lower the releaser to ground.
- Switch OFF the releaser.
- Detach the releaser from the aerial vehicle and store safely.

For reference only, see QbCan Releaser picture below.