Mission Guide Document

For the 2019/20 Edition of the UK CanSat Competition

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A Competition sponsored by:

Airbus Group, The University of Manchester

With support from:

Manchester CanSat Project, the Space Universities Network, the UoM Space Systems Research Group, PCBWay

Updates:

Version	Date uploaded	Description
1.0	19 Sep 2019	First version of 2020 UK CanSat Competition Mission Guide

Contents

1. Introduction

The UK CanSat Competition, organised by Manchester CanSat Project (MCP) 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.

For this year, it is suggested that UK universities send a maximum of three teams per university 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. 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.

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 October 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 2019 at 23:59**. Participation in the competition **will cost £40** for all teams from UK universities for 2019/20. This participation fee will help to cover the costs of rockets, rocket motors, and venue hire. We will contact teams for payment after the application form deadline. The payment will go into MCP's university account.

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 following the template provided. The DR will be assessed by MCP members. **To qualify to the next stage, a team must be awarded at least 50 percent of the maximum points available for the DR. This will be due on 31 JAN 2020 at 11:59PM.**

Flight Readiness Review (FRR) and Systems Launch: 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 before **12:00** on **Wednesday, 1 APR 2020 (TENTATIVE)** to be allowed to launch their CanSats. The FRR will be graded and this will contribute to the final score.

For 2018/19 the Systems Launch is planned **for Wednesday, 1 APR 2020 (TENTATIVE)** and will take place at the **Midlands 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. Teams are encouraged to bring a spare CanSat in the event of a launch failure.

The date of launches is subject to weather conditions.

Post-Flight Review (PFR): The Post-Flight Review (PFR) will be held on **Wednesday, 1 APR 2020 (TENTATIVE), after each team has had their scheduled launch**. The PFR will comprise a seven-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 three minutes of questions from the judges.

1.2. Competition Timeline

The overall plan for the full-scale competition is shown below. All times according to GMT+0 (and GMT+1 during Daylight Saving Time).

Phase 1: Call for teams and team selection

Activity	**Deadline**
Deadline for application forms and fees	**23:59 15 NOV 2019**
Announcement of participating teams	**23:59 22 NOV 2019**

Phase 2: Design Review

Activity	**Deadline**
Design Reviews (DR) submitted	**23:59 31 JAN 2020**
Assessment of DRs	**1-15 FEB 2020**
Announcement of successful teams progressing to next phase	**23:59 16 FEB 2020**

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

Activity	**Deadline**
Flight Readiness Review (FRR)	**10:00 1 APR 2020**
Launches	**12:00 1 APR 2020**
Post Flight Review (PFR)	**17:00 1 APR 2020**
Final Results Announced	**19:00 1 APR 2020**

1.3. Additional Information

There is a maximum limit of **three teams** that can represent each university.

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 UK 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 2019/20 mission simulates a relatively simple 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 LOC IV rocket, details of which are given in Appendix A. The operation sequence shall be:

1. The rocket is launched with the CanSat in its payload bay.
2. The CanSat is released from an altitude of 250 meters above the launch site from the rocket.
3. Once the system is deployed from the rocket, the CanSat shall deploy a parachute to keep the descent rate between 5 and 10 meters per second.
4. During descent, the CanSat shall collect atmospheric temperature and pressure data, hence determining the altitude. The CanSat shall also measure battery voltage, and collect GPS longitude and latitude. All data shall be transmitted back to a Ground Control Station and stored on an SD card for later processing.
5. The CanSat shall reach the ground intact and fully operational. The CanSat shall operate an audio beacon after landing, which shall sound once a second to aid retrieval.

In the event that we are unable to use rockets for CanSat deployment, a drone with a QbCan releaser will be used instead. However, the same CanSat requirements will apply. The main differences between rocket deployment and drone deployment are:

- The drone will travel up to a minimum of 40m and maximum of 100 metres above the launch site, where the CanSat will be released, rather than 250 metres as with a rocket. This wide range of altitudes is due to the drones being unable to safely fly at higher altitudes during high winds.
- Deployment from a rocket will be much more violent than from a drone, hence teams are encouraged to build their CanSat with rocket deployment in mind.

Teams will be notified before the Systems Launch event if drones will be used for deployment. As the decision to change from rockets to drones will likely be taken the day before the competition, your CanSat should be able to accommodate these changes by design.

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 bonus objectives that teams can choose to meet in order to receive extra points.

1	CanSat mass shall be 250 g +/- 10 g.
2	The CanSat shall fit in a cylindrical envelope with the following dimensions: 66 mm diameter x 160 mm height.
3	The CanSat should not have any sharp edges to cause it to get stuck in the rocket.
4	The rocket should not be used as part of the CanSat operation.
5	The CanSat shall deploy from the rocket payload area.

6	A Descent Control System (parachute) must be deployed immediately after release from the rocket, and shall be enclosed prior to deployment.
7	The descent rate of the CanSat shall be between 5-10 m/s.
8	All electronics should be hard mounted, or glued using hard adhesives.
9	The frame/structure of the CanSat shall accommodate all electronics.
10	All electronics components shall be enclosed and shielded from the environment with the exception of sensors.
11	During descent the CanSat shall collect and transmit air pressure, outside temperature, battery voltage, and GPS longitude and latitude at least once a second.
12	The CanSat shall determine altitude with respect to ground level based on pressure and temperature readings.
13	Each sensor data packet shall be tagged with mission time and packet count.
14	Packet count and mission time do not reset with processor reset.
15	The sensor data packet shall meet the following structure: packet count, mission time, pressure, temperature, altitude, battery voltage, GPS longitude, GPS latitude, soft state, Bonus.
16	The CanSat shall store all sensor data packets onboard.
17	The CanSat shall transmit all sensor data packets to the Ground Control Station during flight.
18	The CanSat shall include a power indicator such as an LED or buzzer, which shall indicate a successful startup and that the CanSat is operational.
19	The audio beacon is required to sound at least once a second after landing.
20	The audio beacon shall indicate if any electronics is not functioning.
21	Battery source may be alkaline or lithium. No lithium polymer or lithium ion.
22	The battery shall be easy to remove/replace in 60 seconds.
23	It shall be possible to program the microcontroller with a USB plug, without having to disassemble the CanSat in its entirety, within 60 seconds.
24	The ground station shall include one laptop computer with a minimum of two hours of battery operation and a hand-held antenna.
25	All received data packets must be displayed in real time, in SI units.
26	A box shall be used to carry all necessary tools and equipment to the launch site.

2.2. Bonus Requirements

B1	Include a HD Camera to video the descent in colour at a minimum of 20 fps. The video should start at apogee and be initiated by the flight software.
B2	The parachute is deployed through an active mechanism. The mechanism cannot use chemicals, and those that use heat cannot be exposed to the environment.
B3	An accelerometer is included to establish the location of the CanSat separate to the GPS. The final position recorded by the accelerometer should be within 20 m of the GPS position of the CanSat.

Every team's main goal should be to design a CanSat that fulfils the base requirements. While teams are encouraged to attempt the bonus requirements, it is not advisable to attempt multiple, unless the team is absolutely sure that they can handle the requirements. We have seen teams who attempt multiple bonus requirements and underestimating them, leading to component failures at the launch. This thus caused teams to be unable to complete the bonus requirements and some base requirements, as too much priority had been placed on completing the bonus requirements and the base requirements were neglected.

3. Team Composition

Students currently enrolled in undergraduate or undergraduate integrated degree programs (for example, 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.

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

MCP will assign a competition liaison, who will act as a link between the team and the competition committee. The liaison 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 and will be provided after registration.

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.

The DR will be 30% of the final score.

4.2. Flight Readiness Review

The purpose of the Flight Readiness Review (FRR) 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. A mark scheme for the FRR will be provided.

The first test is designed to determine the 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 the CanSat by the "ground station" via a 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 the highest priority. Any CanSat deemed not flight worthy will be disqualified.

The FRR will be 20% of the final score.

4.3. Launch Operations

Launch Operations (LO) will handle the flying aspect of the Competition. Teams will drop their CanSats via a LOC IV rocket provided by MCP.

During LO, the CanSat shall collect atmospheric data and descend under the required 5 to 10 meters per second.

Teams will be assessed on their telemetry data, the amount of packets they receive and whether the CanSat beeps via a buzzer upon landing to aid recovery.

A USB drive will be provided for teams to submit their telemetry data.

The LO will be 20% of the final score.

4.4. 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.

The PFR will be judged by a panel of industry sponsors and related representatives.

The PFR will be 30% of the final score.

4.5. 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	**31 FEB 2020**
Data from flight	cansat_XXX_FL.csv	**01 APR 2020**
Post-Flight Review	cansat_XXX_PFR_vYY.pdf	**01 APR 2020**

XXX – assigned team number, YY – revision number

4.6. 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 presentations, excluding the PFR, should not contain any links, embedded files, or movies.

4.7. 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.

Should a university have more than 3 teams representing, only the top 3 teams will progress to the Launch Stage.

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 2020 we are trialing high-powered rocketry as a delivery method. Details of the Launch stage of the competition are given in this section.

5.1. Schedule

The competition Launch Day is **Wednesday, 01 APR 2020 (Tentative).**

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

All launches will take place on Wednesday, unless rescheduled due to poor weather conditions. Refer to the following subsection.

Post-Flight Review presentations and the final results announcement will take place Wednesday evening.

A detailed schedule with launch orders will be provided closer to the Launch Day. Do note that the launch order could be changed at any time based on weather conditions.

5.2. Poor weather conditions

If all launches are to be cancelled due to poor weather, the Launch will be cancelled. Teams will then present their final design in a modified version of the Post-Flight Review, which will be provided beforehand. Final scores will then be calculated from the DR, FRR, and the modified PFR.

If some launches have to be cancelled due to poor weather conditions, then teams that have launched will present their PFR on Launch Day (Wednesday, 01 APR 2020), while other teams will have to reschedule their launches to another day, and present their PFR on that day. In this case, the launch order will be changed such that teams closer to Manchester will have lower priority, and teams further away from Manchester will be able to launch first, and complete their PFRs on Launch Day. The remaining teams will have their launches and PFRs rescheduled to another date.

Note that teams using drone deployment will not be at a disadvantage compared to teams using rocket deployment.

Appendix A – CanSat Deployment

Rocket – System Description

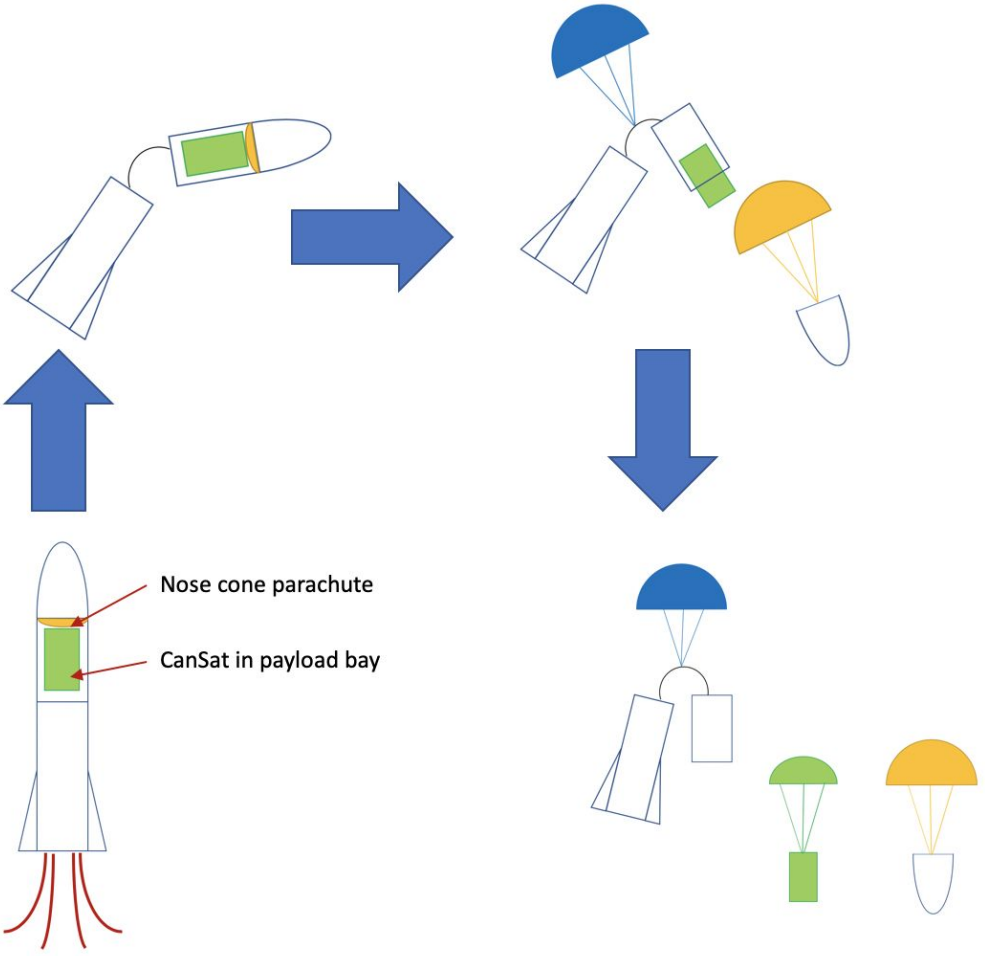
The rocket MCP will be using is the LOC IV rocket, which consists of a main body, payload bay, and nose cone.

The payload bay will be modified with the use of a sleeve such that a CanSat's maximum dimensions shall be 66 mm diameter x 160 mm height. The maximum mass as stated in the requirements shall be 250 g +/- 10 g.

The concept of operations of the rocket is as follows:

1. The rocket containing the CanSat in its payload bay is launched and ascends to apogee at approximately 250 m above the launch site.
2. The nose cone and payload bay tip over at apogee.
3. The expelling charge will cause the nose cone and payload bay to separate from the main body of the rocket, allowing the CanSat to slide out via gravity.
4. The rocket main body and payload bay, the nose cone, and the CanSat will then descend using parachutes.

It is recommended that CanSats are placed in the payload section upside-down.



QbCan Releaser – System Description

The QbCan 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 MCP. The releaser is triggered by the drone operator via a handheld controller.

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 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.

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 manually rotate 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.

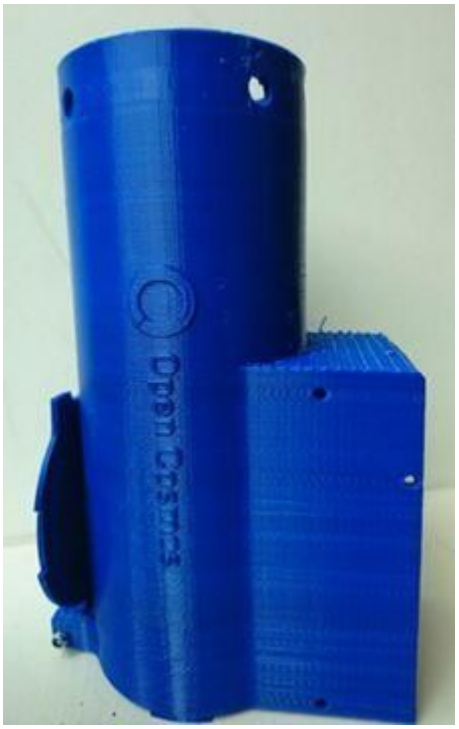
Typical Sequence to operate the Releaser

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 manually rotate the latch mechanism.
- Activate the CLOSE switch to lock the door via the latch mechanism.
- Lift the releaser with the aerial drone.
- Drone operator releases the CanSat at the desired height.
- Lower the drone to the ground.

- Switch OFF the releaser.
- Detach the releaser from the aerial vehicle and store safely.

For reference only, see QbCan Releaser picture below.



Appendix B – Field Safety Rules

1. The consumption of alcohol and/or drugs is strictly prohibited at Midlands Rocketry Club.
2. Do not smoke or vape at the launch site.
3. No food or drinks are allowed at the launch site.
4. Do not touch the rockets or the rocket motors.
5. During the launch, remain behind those in high-vis jackets.
6. While the CanSat and rocket descends, do not attempt to catch the CanSat or the rocket.
7. Do not run after the CanSat as it descends.
8. Teams are only allowed to search for the CanSat after given permission from Competition organisers.

Teams who fail to obey field safety rules will receive a reduction of marks, or be disqualified.