

SATELLITE DESIGN COMPETITION 2022-23

RULES & REQUIREMENTS



UKSEDS
COMPETITIONS

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UKSEDS and SSPI Satellite Design Competition 2022–23

Rules and Requirements

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1 Introduction

The 2022–2023 Satellite Design Competition invites students to design, construct and operate a nanosatellite payload system with the aim of developing a detection system for identifying piece(s) of space debris. Students shall create a payload concept, trade off performance parameters and pass through a rigorous review process with panels of experts within the space industry. The competition aims to reach out to students from multiple scientific fields, including, but not limited to, aerospace engineers, computer science engineers, electrical engineers, mechanical engineers and physicists.

The competition aims to:

- Challenge students to perform a complex, systems engineering task for the development of a payload to meet a set of real space mission requirements
- Gain exposure and experience of the typical design processes and protocols in industry projects, including multiple project reviews
- Enable students to apply taught technical skills and learn new ones relevant to a job in the space industry in an applicable project environment
- Provide students with an opportunity to develop and practice other important and transferable skills, such as teamwork, leadership and project management
- Provide students with support and advice from leading industry experts

1.1 Competition and Major Changes

This year marks the sixth instalment of the Satellite Design Competition, which has received continuous support from SSPI. Previous years had teams research and design a CubeSat capable of identifying information about Lunar landmarks, and capture a piece of space debris. A final extensive realistic mission report was then submitted. A build and test phase will be continued as introduced in the previous two iterations of the competition, with fresh challenges for this year's competition day and 'mystery room'. The team size is a maximum of 15 for this year's competition.

Some of the new elements for this year's competition include:

- Fistril Training in Project Management for 1 – 2 members of each team.
- The PDR stage will be solely done through a pre-recorded presentation. Details of this will be provided later in this document

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- Monthly meetings with a UKSEDS' representative, to gauge development of design work, and assess project management elements.

1.2 About the Organisers and Sponsors

The competition has been organised into 2 groups. The strategy and rules are set by a competition committee, consisting of several UKSEDS staff and members of the space industry. It is currently composed of:

Name	Organisation	Position
Lee Ellis	UKSEDS	SDC Team Lead
David Sulley	UKSEDS	Exec Point of Contact
Holly Whitehouse	UKSEDS	Competitions Lead
Robert Bell	SSPI	Executive Director
Tamara Bond-Williams	SSPI	SSPI Membership Director
Peter Selves	Airbus	UniCom
Ciaran Jenkins	Airbus	UniCom

The second group is the Satellite Competition team, made up of UKSEDS volunteers. They shall be responsible for carrying out the day-to-day operations of the competition. For more information, see the volunteering with UKSEDS page of the website: www.ukseeds.org/join.

Name	Organisation	Position
Lee Ellis	UKSEDS	SDC Team Lead
Mohammed Deera	UKSEDS	Vice Lead/SDC Volunteer Support
Mona Elghzal	UKSEDS	SDC Volunteer Support
Tanjin Huda	UKSEDS	SDC Volunteer Support
Saskia Campbell	UKSEDS	SDC Volunteer Support

1.3 Organisations Involved

1.3.1 UK Students for the Exploration and Development of Space (UKSEDS)

Formed in 1988 and now with over 1000 members and 27 affiliated societies located up and down the country, the UK Students for the Exploration and Development of Space (UKSEDS) is a charity run by student volunteers, for students. We support students and enthusiasts across the country by running space projects, hosting conferences and workshops, and doing outreach to inspire and educate the next generation of space enthusiasts. We run and support multiple events throughout each year, including events, workshops,



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competitions and conferences. Our most popular being the National Student Space Conference (NSSC), which is held annually every March.

Our sister site www.SpaceCareers.uk has done an outstanding job of matching students and recent graduates with the huge number of different career paths in the space sector and has been hailed as “a crucial service to thousands of people across the country” by the former Prime Minister, Theresa May.

1.3.2 Space & Satellite Professionals International (SSPI)

Founded in 1983, Space & Satellite Professionals International (www.sspi.org) is on a mission to make the space and satellite industry one of the world’s best at attracting and engaging the talent that powers innovation. It offers free membership to students engaged in full-time or part-time study. With more than 3,700 members in 40 nations, it is the largest space and satellite industry association in the world. It delivers on its mission through programs that promote space and satellite as the invisible but indispensable infrastructure of the modern world, and that help turn individual promise into careers filled with purpose through research, career education for young people, management education for working professionals and talent recognition that spans the industry. SSPI maintains local chapters in the US, UK, Luxembourg, Brazil, Nigeria and Japan, and an international women’s group, Women in Space Engagement or SSPI-WISE.

1.3.3 Airbus

Airbus pioneers sustainable aerospace for a safe and united world. The Company constantly innovates to provide efficient and technologically-advanced solutions in aerospace, defence, and connected services. Airbus is the global leader for modern and fuel-efficient airliners and associated services. Airbus is a European leader in defence and security and one of the world's leading space businesses. In helicopters, Airbus provides the most efficient civil and military rotorcraft solutions and services worldwide. Airbus Defence and Space is the UK’s largest space company with turnover in excess of £1 billion and is the third largest aerospace and defence employer in the UK with more than 3,500 highly skilled employees. Airbus Defence and Space makes up over 70 per cent of the UK’s space industry, providing a vital national industrial capability; and leverages its capability as a system prime to develop SME supply chains, maintain links with UK and global academic institutions, and bring forward the next generation of talent for a future STEM-based workforce both in the space sector and beyond.



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1. 1.3.4 NanoAvionics

NanoAvionics is a smallsat bus manufacturer and mission integrator currently based in four locations across the USA, UK and Lithuania. The company's efforts are focused on enabling critical satellite functions and optimising their hardware, launch and satellite operation costs by providing end-to-end small satellite solutions – ranging from single missions to constellations. Its core engineering team has implemented over 90 successful satellite missions and commercial projects during the past several years. With a modularity such as the fundamental principle of NanoAvionics systems' architecture, NanoAvionics provides economic viability to a wide range of small satellite constellation-based missions, businesses and organisations worldwide.

2. 1.3.5 Oxford Space Systems

Oxford Space Systems is aiming to become the global leader in deployable antennas for space, providing effective solutions to unlock the future of satellite services. We use techniques inspired by origami and space qualified stored energy materials to create deployable antennas that stow into a compact volume for launch and unfold to an accurate form when deployed in orbit. Our antennas enable a wide range of space-based services for the Internet of Things and vessel tracking (AIS/VDES) using deployable helical and yagi structures, Synthetic Aperture Radar using deployed reflector surfaces and data relay using deployable high gain steerable antennas. Oxford Space Systems is based in the Harwell Campus, United Kingdom.

1.4 Team Structure

The competition is open to any UKSEDS member, which extends to students from UK universities, apprentices, as well as any students on Internships or those who have graduated within the last 3 years. It has been designed to be carried out as a group project towards a degree, or by a UKSEDS branch team. If you have any queries about potential eligibility, please email satellites@ukseds.org to enquire.

There is a limit of **15 team members per team**. The names of the team members should be provided to UKSEDS in a team roster and should be kept up to date if there are any changes. There may be an additional limit on the number of attendees to the competition event. Additionally, the work should be demonstrable as being done by the team members, and not academic supervisors or other advisers.



1.5 This Document

This document is formatted in the style of a European Space Agency (ESA) Invitation to Tender (ITT). ESA publishes ITTs when it wants companies to bid for contracts.

It is organised as follows:

1. A brief competition overview discussing the mission background and scenario
2. A comprehensive State of Work (SoW) – a description of the activities and deliverables during the competition
3. A series of Appendices:
 - a. Competition Rules – discussing team structure, funding opportunities and the competition format
 - b. Technical Specification – a full set of requirements and specifications needed to design the satellite payload
 - c. Document Requirements Specification – requirements for the documents delivered by teams in the competition



2 Competition Overview

This section provides a description of all the major components of the competition, and includes references to additional material where necessary.

2.1 Mission Background and Scenario

Space Sustainability is a topic that has often been neglected throughout the decades of space development. This meant that defunct satellites were simply left to drift in space until they eventually fell back to Earth. However, this may take centuries. The 1958 Vanguard probe is expected to remain in orbit for 240 years, for example. Because of these concerns, much effort has gone into cataloguing the number of debris objects in geostationary (GEO) and low-earth (LEO) orbits. This can be seen in Figure 1 below.

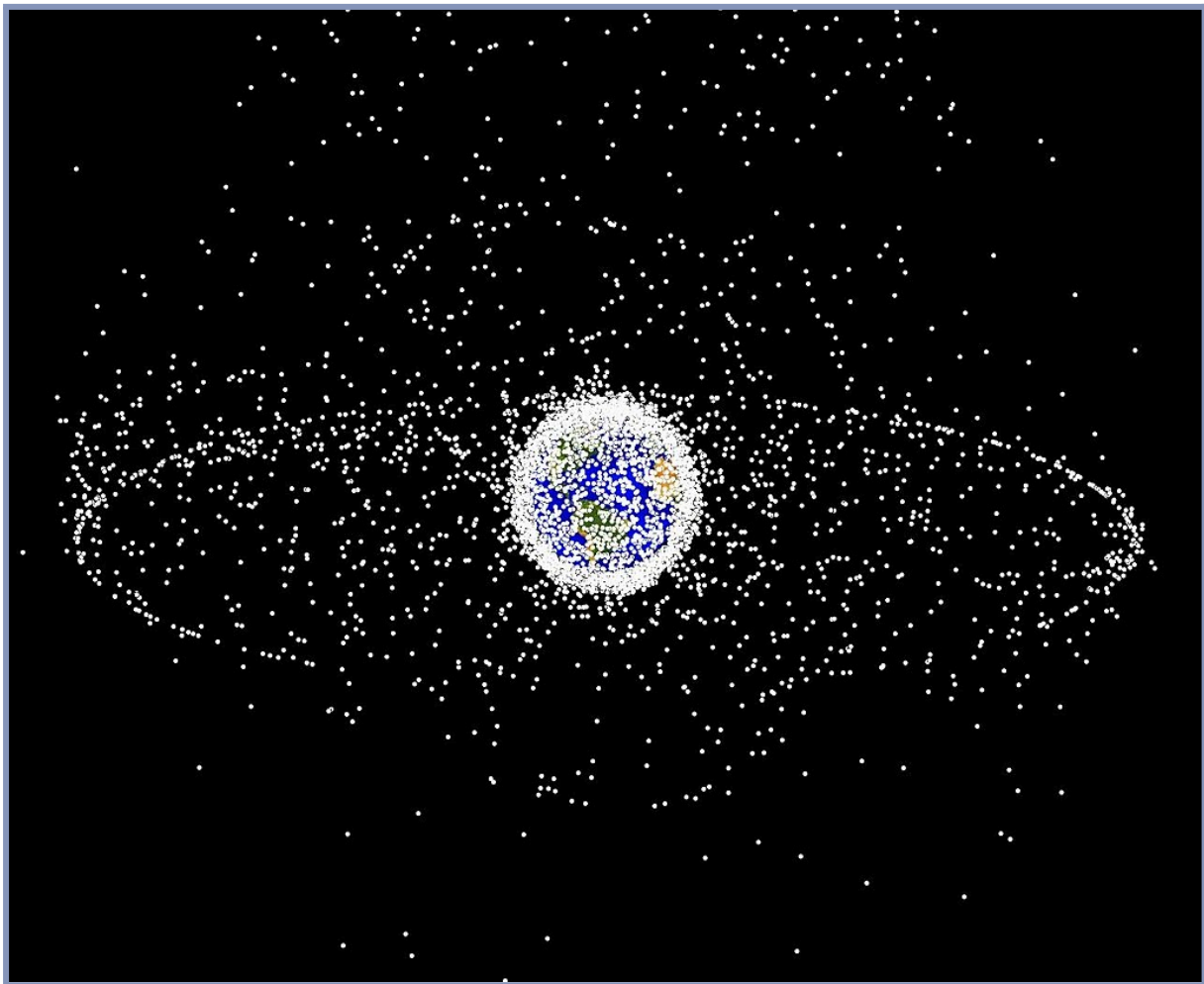


Figure 1 Representation of debris in the GEO and LEO regions of space. (NASA image)

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This, however, only includes objects that are detectable and trackable by ground-stations. Objects that are less than 10 centimetres in length are too small to be detected. The size of these objects, however, does not stop them causing significant damage to operational satellites upon impact. This is due to the high-velocities that they travel at. The following quote from The Aerospace Corporation gives a good illustration of this danger.

“An aluminium sphere 1.3 mm in diameter has damage potential similar to that of a .22-calibre long rifle bullet. An aluminium sphere 1 cm in diameter is comparable to a 400-lb safe travelling at 60 mph. A fragment 10 cm long is roughly comparable to 25 sticks of dynamite.”

It is therefore necessary to conduct studies in-situ to detect and determine both the frequencies of these debris collisions, and the material properties of the objects. This will help satellite manufacturers better understand and deal with the threat of small debris impacts. Investigations into how this data changes with the geometry of an orbit would also prove invaluable to satellite operators. In this regard, CubeSats could be indispensable. Their low-cost and mass makes them ideal for data-cataloguing in a wide range of orbits. This is where this year's competition places its focus; can CubeSats be used to help us better understand the nature of <10 cm debris-sized objects?

2.2 Mission Tasks

The challenge is to design a 3U CubeSat that can detect and conduct in-situ testing on space debris that are millimetres in size. The aim of these tests is to gather any data that may prove relevant to spacecraft operators. The competition is separated into two main phases: a **research & design phase** and a **build & test phase**. Teams will have to submit a Preliminary Design Review, followed by a Critical Design Review and once all these reports have been reviewed and marked the **5 best teams** will be selected to progress to the build & test phase.

2.2.1 Competition Day

The competition day consists of **two** components; an attempt to complete the objectives inside a mystery room and a 10–15 minute presentation. Teams shall be tested inside a **mystery room** that shall simulate the different phases of the mission, from pre-launch to end of life. The objectives will be split into **three** parts, which are as follows:



1. Pre-launch

This will involve a structural testing of the CubeSat to determine if it is able to survive the launch load. This will be done in the form of vibration testing. The requirements to adhere to for this can be found in the structure section in appendix D-1. **This test will likely be last due to its possible destructive nature.**

2. In-orbit state of health check of subsystems

These tests will check whether the subsystems of the CubeSat are operational 'post-launch'. It will involve testing of the TT&C system, and that data is able to be sent to and from the cubesat remotely. It will also check the CubeSat's power subsystem and confirm that any components that draw current are operational. A separate AOCS test will be included in the TRR submission, as there is unlikely to be enough time on the competition day to conduct this test. This is an optional test but additional marks will be awarded during the TRR stage for successful demonstration of an AOCS subsystem.

3. Science experimentation

These tests will focus on the main aim of the mission: the scientific data collection. This will be done through two tests:

1. Track the rate of debris objects passing in the vicinity of the cubesat.
2. Determine characteristics of the debris, such as size, the number of pieces and anything else relevant that could be determined such as the rate of rotation. This will mimic the scientific experimentations that would be done on the debris in a real mission, but is simplified in scope.

Full details and test definition of how the tasks above shall be tested and marked can be found below in Appendices C.8, C.9 and C.10.

2.2.2 Post-Competition Opportunities

Once the competition has finished, SSPI are interested in **publishing** the five best CDR reports, accompanied with a brief write-up on each team and their members. Furthermore, there will be the opportunity for up to 3 teams to be



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invited to speak on the SSPI podcast, sharing their experiences throughout the competition.

2.3 Description of Work

This section contains a complete description of the work that is expected to be carried out by teams. Its main subsections follow the blocks described in Figure C.1. Each is split into the objectives of the work, the inputs, outputs and a description of the task. This can be used at the top level by a team to devise its work process, in line with the deadlines given in the competition schedule (Table C.1).

After each major deadline, all team's submitted work will be judged by a **panel of reviewers and mentors**, consisting of space industry professionals and representatives of SSPI. Once entry into the competition is confirmed, teams will be assigned an industry mentor. Mentors will be available for advice in decision making throughout the competition and provide guidance for important deadlines, in particular for the PDR and CDR report deadlines. Mentors are current members of the space community and can provide excellent insight into the space sector as well as specific technical guidance. **We strongly encourage that you have regular meetings with your mentor, as the support they can provide is extremely valuable. Evidence of regular meetings (using a minutes template provided) will form part of your marks for project management through the competition.**

In addition to the work stated below, teams will be asked to attend monthly meetings with a representative from the UKSEDS SDC team. This will be used primarily to gauge the progress of teams throughout the year, but more specifically will assess the project management elements, and additional work to supplement understanding for the build phase. This will be done mostly through a form that should be completed prior to these meetings, in order to ensure the meetings remain focused and productive. More details of this can be found in Appendix C.7

2.4 Concept and Requirements

Objectives

1. Consolidate satellite requirements
2. Define the system-level configuration for the satellite
3. Create a satellite design concept



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Inputs

2. Competition Statement of Work (this document)
3. PDR guidance document

Outputs

1. Satellite concept design
2. PDR (See Appendix E.1)

In this task, teams will create an initial concept for their satellite and mission design. Teams will work using this document to ensure all requirements listed in Appendix D.1 are met. This stage is expected to last 1 – 1.5 months and concludes with the Preliminary Design Review (PDR). **A change to this year's competition is that the PDR submission will be through a pre-recorded presentation, and a submitted appendix document.** Guidance for this can be found in Appendix E.1. Written feedback will be provided to teams by the review panel. It is hoped the change from a formal report to presentation will allow teams more time to plan for the build phase, by developing skills in electronics, for instance, such as through the use of a breadboard and a Raspberry Pi. Progress in this area will be tracked in the monthly meetings between teams and the UKSEDS SDC team.

This phase details how each of the functional requirements are going to be verified and gives a framework for performing this testing during the Build and Test phase. Tests do not need to be comprehensive or fully defined in the PDR, but they must cover the whole scope of the satellite (i.e. be broad rather than deep).

More details on guidance can be found in the PDR guidance document, released in conjunction with this document.

2.5 Detailed Design

Objectives

1. Finalise a detailed design
2. Gain confidence in the feasibility of the design

Inputs

1. Satellite concept design
2. PDR Feedback

Outputs

1. Detailed satellite design



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2. Prototype testing results
3. CDR (See Appendix E.2)
4. Presentation of the design given at the CDR

In this task, teams will flesh out the preliminary design from the previous stage, taking into account any new design decisions. Teams should consider any feedback received on the PDR and implement any recommendations. The main goals of this stage are to finalise their design of the satellite payload, start functional testing of the components which are novel or involve technology unfamiliar to the team. Such components should be highlighted, and justification presented in the CDR.

Design and construction during this stage should be largely limited to prototyping and testing, as teams are expected to implement feedback from the CDR during the build stage.

The end of this phase is the Critical Design Review. Guidance on the contents of the CDR documentation is provided in the Document Requirement Specification (Appendix E). The CDR process is as follows:

1. The CDR reports are submitted by competing teams. **Note: Presentations are not being submitted for this stage.**
2. Reviewers assess the submitted reports, and will issue a feedback sheet
3. Teams have an online meeting with their reviewers, addressing any concerns
4. Reviewers pass or fail the teams

There are **5 build positions** available for this year's competition. The five teams that produced the best CDR shall be selected to advance to the build and test phase. This decision will be made by the reviewers and the competition committee. Although only 5 teams can advance to the build phase of the competition, UKSEDS encourages all teams to continue developing the payload and mission design. Exploring the fine details of a mission is an excellent experience to develop specialist expertise, as well as to continue developing soft skills such as responsibility, leadership and teamwork. SSPI have confirmed they are happy to continue providing support through their mentors that are assigned at the beginning of the competition.



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2.6 Build and Test

Objectives

1. Construct the payload
2. Test the systems and operation of the satellite

Inputs

1. Detailed satellite design
2. Prototype testing results
3. CDR feedback

Outputs

1. Constructed and tested satellite
2. TRR (see Appendix E.3)

Teams will carry out the construction and test of the CubeSat as specified in the preliminary and detailed design. Teams should execute the test plan defined in the PDR (with appropriate modifications for design changes since that time) and provide a summary of how each component was tested prior to the challenge day.

A Test Readiness Review (TRR) is also required after this stage. It is carried out a few weeks before the challenge day, and is intended to ensure teams are ready to compete. It requires a demonstration of physical compliance with several key requirements (mass, volume) and also that the payload is in a state of relative completeness. More information is provided in Appendix E.3.



Appendix A: Acronyms

Table A-0-1: Table of Acronyms

Acronym	Description
CDR	Critical Design Review
ECSS	European Cooperation for Space Standardisation
ESA	European Space Agency
HIL	Hardware in the Loop
ITT	Invitation To Tender
NASA	National Aeronautics and Space Administration
NSSC	National Student Space Conference
PDR	Preliminary Design Review
RF	Radio Frequency
SDC	Satellite Design Competition
SSPI	Space & Satellite Professionals International
TRR	Test Readiness Review
UKSEDS	UK Students for the Exploration and Development of Space
LEO	Low Earth Orbit
GEO	Geostationary Equatorial Orbit



Appendix B: Useful Reference Documents

Table B-1: Table of Useful Reference Sources

No.	Document	Description
1	ECSS-M-ST-10C Rev. 1	Space project management – Project planning and implementation
2	ECSS-S-ST-00-01C	Glossary of Terms – A list of commonly used terms in ECSS documents



Appendix C: Competition Rules

C.1 Competition Authority

The Satellite Design Competition rules are issued by UKSEDS annually. Official announcements by UKSEDS should be considered to have the same validity as these rules. UKSEDS reserves the right to alter the rules, clarify ambiguities, and disqualify teams at any point from taking part in the competition, for safety reasons or otherwise. Teams that enter agree to comply with the rules, and report ambiguities or mistakes to UKSEDS at satellites@ukseds.org.

C.2 Eligibility and Team Structure

The competition is open to any UKSEDS member, which extends to students from UK universities, apprentices, as well as any students on Internships or those who have graduated within the last 3 years. It has been designed to be carried out as a group project towards a degree, or by a UKSEDS branch team. If you do not fit in either of these categories, please email satellites@ukseds.org to enquire about eligibility.

There is a limit of **15 team members per team**. The names of the team members should be provided to UKSEDS in a team roster, and should be kept up to date if there are any changes. There may be an additional limit on the number of attendees to the competition event. Additionally, the work should be demonstrable as being done by the team members, and not academic supervisors or other advisers.

Tip: Team Structure

By its nature, payload design is incredibly interdisciplinary. We recommend building a team with students from a number of disciplines. We advise using standard engineering practices when developing the team structure. One key position we highly recommend is the systems engineer, to track technical project progress, manage hardware interfaces, and lead system integration and requirement compliance. The team should also have a project manager to oversee the progress of the project.

Support: Finding Team Members

UKSEDS might be able to help find team members if it is proving to be tricky. We have an extensive network of contacts at branches and in departments at universities across the country. Please get in touch with the team contact if you need some help.



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Support: Team Connect

Designing, building, and testing a satellite payload is a multidisciplinary and collaborative exercise. In the real world, these projects are carried out by hundreds or thousands of scientists and engineers, all over the world. If your group does not have all the expertise you think you need, please get in touch with the team contact. We may be able to find individuals/another group that has a complementary skill-set at another university for you to collaborate with.

For example:

- University 1 consists of a group of mechanical and electronic engineers, with very little experience or skills in software development
- University 2 are a group of computer science students
- UKSEDS puts university 1 in touch with university 2, who form a team together

C.3 Plagiarism

Teams shall endeavour to use appropriate citations for all work that is not their own. Should any team be found to have plagiarised portions of other bodies of work, UKSEDS reserves the right to penalise or even remove teams from the competition. This is not something that is done lightly but is necessary to ensure the integrity of the competition. A detailed description of what is judged as plagiarism and possible consequences are outlined in the [UKSEDS Competitions Plagiarism Guidelines](#).

C.4 Design Requirements

Teams shall comply with all requirements listed in the Technical Specification in Appendix D.1. Teams may choose to comply (or identify and explain areas of non-compliance) with other applicable space standards, such as the ECSS standards. The requirements may change until the **Requirements Freeze on the submission deadline (see competition schedule, Table C-1)**, after which requirements will only be changed under special circumstances. Teams will be informed of changes to the requirements.

C.5 Competition Schedule

The Satellite Design Competition shall consist of several stages, shown in Figure C-1. A comprehensive overview of the tasks and deliverables are located in the Description of Work (Section 2.3) and in Appendix E. Each deliverable must be

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handed in on time to the competition organisers for a team to progress to the next stage.

Figure C-1: Competition Overview

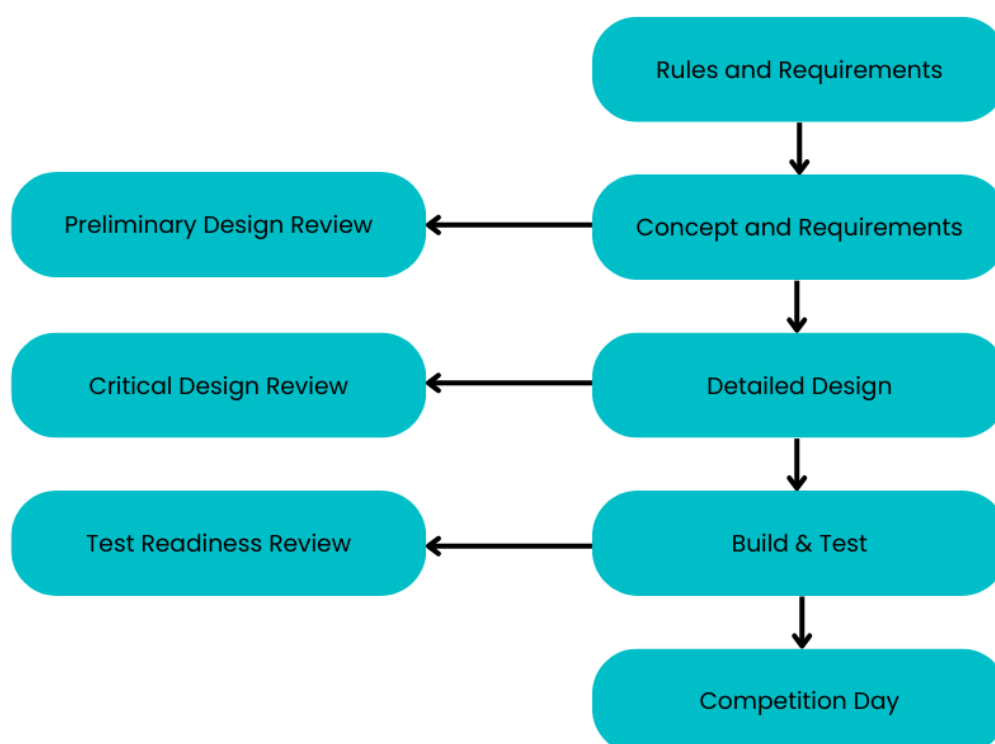


Table C-1 provides a preliminary schedule for the competition, presenting the major milestones, paperwork deadlines and other events within the competition itself. Please note these dates may be subject to change, where the UKSEDS competition team shall be responsible to notify all teams if this does occur. There is [a live timeline spreadsheet](#) that will be regularly updated.

Table C-1: Competition Schedule

Date	Activity	Deliverable
1st October 2022	Competition Launch	–
31st October 2022	Deadline for Competition Submissions	Entry Form

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12th November 2022	Requirements Freeze	–
12th November 2022	Competitions Launch Event	–
19th December 2022	Preliminary Design Review and Meeting	PDR Report
10th January 2023	PDR Feedback	–
27th March 2023	Critical Design Review	CDR Report
10th April 2023	CDR Reviewer Meeting	–
14th April 2023	5 Teams selected	–
15th May 2023	Competition Grant Deadline	–
1st July 2023	Test Readiness Review	TRR Report
8th July 2023	Competition Challenge Day	–

C.6 Costs and Funding

There is no fee to enter the competition. Teams should source funding for the project themselves, via grants from their universities, student unions or departments or sponsorship. There are two types of financial support available through UKSEDS: a competition grant and diversity grant.

Competition Grant

Teams who pass their CDR are eligible to apply for a grant through the competition sponsors' grant pool. This grant operates on a cost-match basis. The grant will match external funding (i.e. from universities, sponsors etc.) up to £250, for example:

Table C-2: Example of how the competition grant is structured

Source	Amount
Department	£100
Universities' Student Union	£150
Match Funding from UKSEDS	£250

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Total	£500
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Competition grants have a rolling application deadline, no later than June 20, 2023. Teams can only apply for funding once. If teams are ready to submit earlier in the competition phase, the application can be processed quickly and the funds reimbursed at an earlier date. Teams will receive a Google form to which they must attach a bill of materials on an excel spreadsheet and copy of receipts. The following terms and conditions are attached to this funding:

1. The grant can be applied for only after passing the CDR
2. The grant shall not exceed funding raised from other sources
3. The grant shall not exceed £250
4. The grant shall only be used for components or the construction of the satellite
5. The grant will be paid in arrears after the competition day upon receiving:
 - a. A completed claim form (will be distributed at a later date)
 - b. A satellite Bill of Materials
 - c. Receipts demonstrating the spend on components or construction
 - d. Evidence of matched funding

Gender Diversity Grant

Following the recent announcement of Orbex becoming title sponsor of the National Rocketry Championship, we are pleased to also announce the Orbex Gender Diversity Grant, a new funding source for teams in our Rocket, Satellite, and Rover competitions with 50%+ women or non-binary members.

If your team has 50% or more women or non-binary members taking part in the competition, and your team passes the CDR report, you will be able to apply for a £250 grant from Orbex. The Orbex Gender Diversity Grant has a rolling application deadline, no later than June 20, 2023. Teams can only apply for funding once. The team structure can meet the criteria at the PDR, CDR or TRR/EDR Stage. Additionally, this grant qualifies as external funding and could be listed as such for the competition match-funding (see example below).

Table C-3: Example of how the diversity grant is structured

Source	Amount
Orbex Gender Diversity Grant	£250



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Match Funding from UKSEDS	£250
Total	£500

If you qualify for this grant, please send an email to satellites@ukseds.org. Similarly to the competition grant, teams will receive a Google form to complete. The following terms and conditions are attached to this funding:

1. The grant can be applied for only after passing the CDR
2. The team has 50% or more women or non-binary members at the PDR, CDR or TRR/EDR stages
3. The grant shall not exceed £250
4. The grant shall only be used for components or the construction of the satellite
5. Representation on the competition day should reflect the diversity of your team

c.7 Monthly meeting with UKSEDS team

For this year's competition, there will be two meetings every month with the UKSEDS' team. One will be a general Q&A with all teams, and the other will be a meeting with individual teams to gather information about the teams progress and assess the project management elements, learned through the fistral training workshop. This will form part of the team's marks for each phase.

A form will be released that will need to be filled in prior to these meetings. This is to ensure that these meetings are focused, and marks will be given for the information provided. Part of the document will track the project management elements and part will track additional work done to supplement training/practice for the build phase.

c.8 Competition Day

The competition finale is the challenge day hosted by UKSEDS and **Airbus**. All competing teams shall bring their satellite so that the functionality of their hard work can be tested. The final date, location and travel arrangements will be released at a later date. We encourage all teams to design their own team patches, we would love to see your own personal touches to the competition!

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Prizes

Table C-4 provides a full description of the prizes available for this year's competition. Once the competition has finished, SSPI are interested in publishing the five best CDR reports, accompanied with a brief write-up on each team and their members. Furthermore, there will be the opportunity for up to 3 teams to be invited to speak on the SSPI podcast, sharing your experiences throughout the competition.

Table C-4: Full List of Prizes

Prize	Description
Best Satellite	Prize for best satellite that achieved the highest score by the judges
Best Innovation	Awarded to the team with the best innovative engineering solution (decided by the judges)
Best Outreach	Prize for the team with the best outreach programme connected to their satellite payload (decided by the judges)
Best CDR	Judges will decide which CDR from all teams was the best (taking into account the following parameters: quality of the report, matching the design to the mission requirements, performance during the review meeting in addressing any comments raised by the reviewer, simplicity and achievability)
Best Presentation	Judges will decide on the best presentation based on parameters found in Appendix C.10

C.9 Test Definition

Teams will be tested based on their satellite payloads' performance in the **mystery room**, and a **team presentation**.

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Mystery Room

Teams shall be tested inside a **mystery room** that shall simulate an LEO environment. The satellite will be suspended in the centre of the mystery room by a piece of string/rope. The tests will be broken up into separate phases:

During the first phase, teams will have **10 minutes** to run a state of health check of the TT&C subsystem and power subsystem. Teams will have to transmit the current state of the power subsystem, the location of the cubesat (Lat and Long) and its current velocity. This data must then be exported as a .txt file and emailed to the **Mystery room manager**. This email will be provided on the day. Marks will be deducted after 10 mins.

During the second phase of testing, the orbital debris objects with sizes ranging from 1 – 10 cm in diameter will then move past the satellite at an unknown velocity at an unknown distance. Teams will then have **20 minutes** for the second phase of tests.

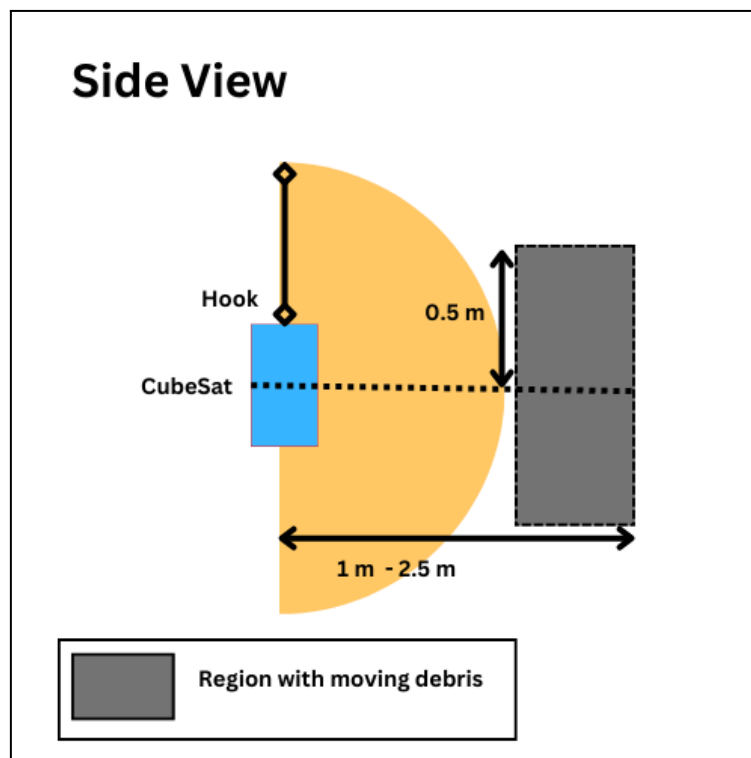


Figure C-3: Side profile of the mystery room setup to define the reference coordinates

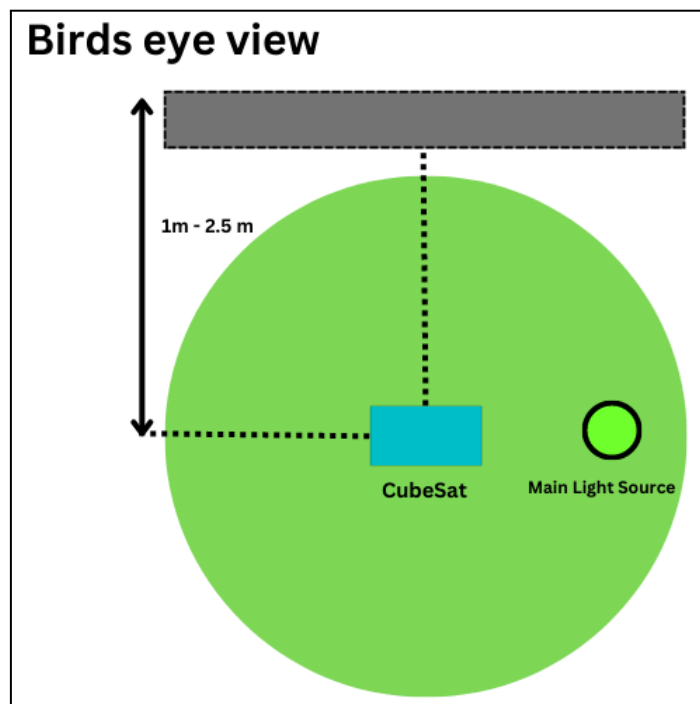


Figure C-4: Birds eye view of the mystery room setup to define the reference coordinates

The room will have one main light source (as shown in Figure C-4) acting as the 'sun'. This light will be bright enough to illuminate the whole room, but varying levels of exposure can be expected across the room. The room will be approximately 30 m².

For the 1st test of the science phase, the CubeSat will be suspended in the same way as in the first test, and as described in figures C-3 and C-4. The pieces of debris will move past the Cubesat at 1 - 2 m/s and at a distance of between 1 - 2.5 m, and at a height range ± 0.5 m of the CubeSat plane. Assume that the objects will be moving in a straight line. The size of debris will range from 1 - 10 cm in diameter. There will be three distinct diameters of debris, with a total of 10-20 pieces. Students need to **identify the number of debris** objects and the **distance**.

Bonus marks will be awarded for determination of average velocity of the cluster of debris within an accuracy of ± 0.2 m/s. Please use the provided table below as an example.

No. of Debris	Distance [m]	Velocity [m/s]

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For the 2nd science test, 1 – 3 objects will be placed at the same distance range as the previous test, and will be within the same size range. Teams will then need to determine characteristics of the object(s) such as velocity, distance, size or anything else detectable for which bonus points will be awarded. Teams must identify and get as much information about each source as possible using the table below as an example.

Debris #	Velocity [m/s]	Distance [m]	Size [cm]	etc

Teams will **not** be able to enter the mystery room **before or during** their tests, and must perform all satellite operations in a separate room. Once a team's testing is complete, they may enter the mystery room and retrieve their satellite.

There will be a separate preparation area near the operations room for any last minute adjustments before the test. No charging will be permitted for the satellite during the tests.

Presentation

Teams shall present their work throughout the competition for 10-15 minutes, focusing on the method and process for deciding on the final payload design, what could be improved and what the next steps will be. Furthermore, we advise teams to aim for a slide a minute to stay concise and engaging to the audience.

C.10 Scoring

Mystery Room

The main driver of this category is the **accuracy of the velocity determination, distance and size of the piece of debris**. Object(s) simulating the debris will be placed in the room for the purpose of these tests. A breakdown of the scoring is given below:

Correct Identification of debris #	10 points
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Correct Identification of distance	10 points
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Correct Identification of average velocity	5 points
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Correct Identification of velocity	5 points/per object
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Correct Identification of size	5 points/per object
---------------------------------------	---------------------

Correct Identification of distance	5 points/per object
---	---------------------

Bonus points for extra information	10 points
---	-----------

This data must be logged and exported as a .txt file

Presentation

The list below provides the key points to focus on when presenting to the audience on the challenge day:

- Quality of presentation deck
- Content of the presentation (two categories to score)
 - Evolution of the project
 - The main challenges faced
- Performance of the presenter/s



Appendix D: Technical Specification

The technical specification given here contains all the requirements that **must** be met by a team to progress through the PDR, CDR & TRR and to progress to the competition challenge day.

The teams will use WiFi as their main communications link on the competition day, but will also include backup communications capability. This will be a wired connection (Ethernet interface) and will only be used as a worst-case scenario if unpredictable external factors influence the testing (such as interference). An Ethernet cable will be available for use on the day.

As well as the requirements listed in the tables below, teams will also be required to **deposit all data acquired into a specific folder location**, during the mission test. The 'Ground Station' can then download this folder and give it to respective teams to process the information collected. Data from sensors can be downloaded at any point during the 30 mins in the mystery room. Since we have a WiFi or Ethernet connection to the satellite in the mystery room, the additional folder encourages teams to consider their data budget and prevents teams from having a live feed video connection to their satellite.

D.1 Satellite Requirements

Table D-1: Structure and Mechanics

#	Requirement	Description
SDC-21-ST R-001	Mass	The total satellite mass shall not exceed 6kg
SDC-21-ST R-002	Volume	The total satellite volume shall not exceed 3U* *1U refers to an independent volume of (10x10x10) cm **Volumetric envelope shall follow the cubesat standard specification (see CubeSat Design Specification Rev. 13)
SDC-21-ST R-003	Cubesat Standard	All satellite components and mechanisms shall be compliant with cubesat standard specification volumetric envelope in stowed configuration.
SDC-21-ST R-004	Deployables and Mechanism	Deployable elements are allowed under release command.

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SDC-21-ST R-005	Interface	The satellites shall accommodate the interface for suspension (this can be to interface with a hook or rope).
SDC-21-ST R-006	Pyrotechnics	No pyrotechnic components shall be used.
SDC-21-ST R-007	Debris Mitigation	No item or parts shall be released into "space". This includes all lock-down and release mechanisms.
SDC-21-ST R-008	Vibration	To be given at a later date
SDC-21-ST R-009	Shock	To be given at a later date

Table D-2: Power

#	Requirement	Description
SDC-21-P WR-001	Power System provision	The on-board power system shall be designed and provided by each team. Teams are not required to design solar panels.
SDC-21-P WR-002	Power Storage	The on-board power system shall store enough energy to ensure power throughout the test mission.
SDC-21-P WR-003	Hazardous Materials	No hazardous, explosive, or toxic components shall be used.

Table D-3: Communications

#	Requirement	Description
SDC-21- COM-001	Communication system provision	The communication system shall be designed and provided by each team.
SDC-21- COM-002	Wireless	The communication system shall be wireless.
SDC-21- COM-003	Operation	The communication system shall be able to operate the satellite from an isolated operating room with no line of sight.
SDC-21- COM-004	Dedicated Communications	The communication system shall not make use of pre-existing infrastructure (No Bluetooth/NFC usage is permitted).

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		*RF Equipment may be placed in the control room.
SDC-21-COM-005	Legality	All wireless communications must use UK legal frequencies and should be used responsibly.

Table D-4: Environment

#	Requirement	Description
SDC-21-ENV-001	Temperature	The satellite shall be able to operate at temperatures between 0°C to +40°C.
SDC-21-ENV-002	Access	The satellite shall not be accessed during the test mission.

Table D-5: Safety

#	Requirement	Description
SDC-21-SF-T-001	Live Voltage	No exposed point or area of vehicle should carry a live voltage at any point during operation of the satellite payload.
SDC-21-SF-T-002	Battery	If a battery is integrated, the satellite batteries should be protected from the following conditions; over voltage, under voltage, over current, over temperature, short circuit and reverse connection. Lead Acid batteries are not allowed. The batteries shall be removable. Battery good practice should be followed (check the Resources page of the competition website). In the case of LiPo batteries, charge bags and a CE marked LiPo charger shall be used.
SDC-21-SF-T-003	Kill Switch	The satellite shall have an external and easily accessible manual hardware kill switch that isolates battery power from the rest of the satellite payload system.
SDC-21-SF-T-004	Non-toxic propulsion methods	Any propulsion methods that eject gas shall be non-toxic.
SDC-21-SF-T-005	Declaration of Autonomy	Satellites with autonomous capabilities shall be highlighted to the judges to ensure that sufficient safety measures are in place.



D.2 **Mystery Room Hook Interface**

Throughout the mystery room test, the team's satellites shall be suspended on a piece of string in the centre of the room to enable rotational movement in one axis. The satellite structure should have holes in the frame to allow for an easy insertion and attachment of a hook. This shall be provided by UKSEDS and we will provide a specification of where and how it will be hooked onto the nanosatellite. We encourage teams to create a simple hook during the build and test phase so you can perform preliminary tests in preparation of the competition challenge day.



Appendix E: Document Requirements Specification

Templates for each will be made available on the competition website for guidance.

E.1 Preliminary Design Review (PDR)

The Preliminary Design Review is normally held at the end of Phase B of the project process defined in the space project management standard (ECSS-M-ST-10C Rev. 1). The following excerpt is taken directly from this document, and describes what is expected in a PDR.

The primary objectives of the PDR are:

- Verification of the preliminary design of the selected concept and technical solutions against project and system requirements.
- Release of management, engineering and product assurance plans
- Release of product tree, work breakdown structure and specification tree
- Release of the verification plan (including model philosophy)

There is a growing practice in industry for PDRs to be done in the form of a presentation. Therefore, this year's competition will involve a presentation recording, and an appendix document. A template for the PDR will be uploaded to the competition website. It contains sections which you can use as a basis to construct your presentation. It will also contain advice on what to include in the appendix.

- Project Management
 - Assigned roles (and team roster)
 - Preliminary schedule
 - Preliminary budget
 - Project risks and mitigation
- Preliminary concept:
 - Summary of requirements
 - Proposed concept for meeting these requirements
 - Brief discussion of the reasons for design choices
 - Evidence of trade-offs in the design process

This document should be submitted by the deadline (see Table C-1) and will be marked by a small team of internal assessors. Upon receiving confirmation that you have passed the PDR, you may progress with the next stage of the competition – preparing for the CDR.



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E.2 Critical Design Review (CDR)

The Critical Design Review is a major milestone in the development of a space mission, and it is similarly an important obstacle in this competition. It is normally carried out at the end of Phase C (detailed definition) of a project, and according to ECSS-M-ST-10C Rev. 1 should address the following objectives:

The primary objectives of the CDR are:

- Assess the qualification and validation status of the critical processes and their readiness for deployment for phase D
- Confirm compatibility with external interfaces
- Release the final satellite design and mission design
- Release assembly, integration and test planning
- Release flight hardware/software manufacturing, assembly and testing

The following items should be addressed in your CDR documentation:

- Project Management
 - Assigned roles
 - Schedule
 - Budget
 - Project risks and mitigation
 - Test plan
- Indicate any new requirements
- Indicate how requirements identified in PDR and early stages have been met
- Fully describe the software and satellite subsystems
- Identify and address any safety risks in the design
- Include a section on how to use the satellite

This should be submitted by the CDR deadline (see Table C-1), and will be subsequently reviewed by a panel of industry experts. The reviewers will then return a set of points to be addressed and clarified. A Skype call between the team and the reviewers will give the team an opportunity to address any concerns raised, and if this is done successfully, the team will progress through the CDR.

E.3 Test Readiness Review (TRR)

The Test Readiness Review allows the organisers to assess the maturity of the satellite built. To maximise the value for teams, the TRR will ensure minimal setup



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on the day is required. Some critical parameters will be verified against the requirements of the competition through documentation, and some through live demonstration either via an internet call or in person. More details will be distributed closer to the date.

The following items should be demonstrated in your TRR documentation:

- Satellite is compliant with the mass constraint
- Satellite is compliant with the volume constraint
- Satellite can rotate in one axis of freedom

In addition to the document above, the committee will award extra points to teams that demonstrate the drive mechanism(s) of the satellite in operation (e.g. rotating via reaction wheels). This extra task is optional. However, **teams will have to pass the TRR to earn their entry to the challenge day.**



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