SATELLITE DESIGN COMPETITION

Rules and Requirements

2023/2024

SSPI AIRBUS Astroscale inmarsat OXFORD SPACE SYSTEMS

Contents

1 Introduction

The 2023-2024 Satellite Design Competition invites students to design, construct and operate a nanosatellite payload system with the aim of developing a payload subsystem focused around Earth Observation. 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 before getting the opportunity to build their CubeSat designs. 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 practise other important and transferable skills, such as teamwork, leadership and project management
- Provide students with support and advice from leading industry experts

Teams will spend roughly 9 months developing their designs to compete in a 'mystery room' environment. This is a mock-space environment that will simulate a real mission, where teams can demonstrate their CubeSats capabilities in a series of challenges.

The competition is currently in its seventh year, and previous years have had teams tasked with identifying lunar landmarks, capturing mock space debris objects, and performing data collection on a number of orbiting debris objects.

1.1 Competition and Major Changes

This year marks the seventh instalment of the Satellite Design Competition, which has received continuous support from SSPI. Previous years have had teams research and design a CubeSat capable of identifying information about Lunar landmarks. More recently, the competition has placed its focus on space debris. In

the past two years, we have tasked teams to design a CubeSat payload for capturing a piece of space debris and, more recently, to collect data on a number of debris objects. For each of these past years, 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'.

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
Tanjin Huda	UKSEDS	Competitions Team Lead
Holly Whitehouse	UKSEDS	Exec Point of Contact
Robert Bell	SSPI	Executive Director
Peter Selves	Airbus	UniCom
Ciaran Jenkins	Airbus	UniCom
Louis Soccard	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.ukseds.org/join.

Name	Organisation	Position
Lee Ellis	UKSEDS	SDC Team Lead
Mohammed Deera	UKSEDS	Vice Lead/SDC Volunteer Support
Tanjin Huda	UKSEDS	SDC Volunteer Support
Joel Cabrera	UKSEDS	SDC Volunteer Support
Vishalya Kontham	UKSEDS	SDC Volunteer Support
David Sulley	UKSEDS	Competitions Adviser

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, 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. Moreover, Airbus takes a prominent role as a European leader in defence and security while making significant contributions to the global space industry. It provides the most efficient civil and military rotorcraft solutions and services worldwide in the

helicopter industry. 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.

1.3.4 Astroscale

Astroscale is the first private company with a vision to secure the safe and sustainable development of space for the benefit of future generations, and the only company dedicated to in-orbit servicing across all orbits. Founded in 2013, Astroscale is developing innovative and scalable solutions across the spectrum of in-orbit servicing, including life extension, in situ space situational awareness, end-of-life, and active debris removal, to create sustainable space systems and mitigate the growing and hazardous build-up of debris in space. Astroscale is also defining business cases and working with government and commercial stakeholders to develop norms, regulations, and incentives for the responsible use of space.

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. They 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. The 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 (SAR) using deployed reflector surfaces and data relay using deployable high gain steerable antennas. The company is based in the Harwell Campus, United Kingdom.

1.3.6 Open Cosmos

Open Cosmos designs, builds, launches and operates advanced satellites. They enable organisations to access and share data via a mutualised OpenConstellation infrastructure and offer AI-powered data analysis from a growing range of satellite sources and analytic partners via the DataCosmos

platform. Their approach not only dramatically lowers the costs, complexity, and timescales of missions, but it also simplifies access to EO data in a way that removes the barriers for all companies – even non-space customers – to address society's most urgent challenges.

1.3.7 Inmarsat

Inmarsat's global mobile satellite communications services and solutions answer the demand for reliable connectivity – wherever and whenever it's needed. They work with customers to solve their hardest connectivity challenges. They allow vessels to navigate the oceans safely and enable wardens to safeguard against forest fires. They support governments coordinating disaster relief efforts while keeping aircrafts in constant communication at 35,000 feet.

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 so it could be carried out as a group project towards a degree. If you have any queries about potential eligibility, please email satellites@ukseds.org to enquire.

Each team must have a **minimum of 4 members and cannot exceed a maximum of 15 members**. 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

Wildfires, often referred to as nature's infernos, pose a significant and growing threat to both human communities and the environment. In recent years, the world has witnessed catastrophic wildfires that serve as alarming reminders of their destructive potential. The 2020 wildfires in Australia, colloquially known as the "Black Summer," burned more than 46 million acres and destroyed thousands of homes. The smoke from these fires had far-reaching consequences, affecting air quality as far away as South America. Similarly, in the United States, the 2020 wildfire season saw unprecedented blazes in California, Oregon, and Washington, scorching millions of acres, displacing residents, and causing significant economic losses. These devastating events underscore the urgency of addressing the dangers of wildfires.

One critical tool in the fight against wildfires is the use of Earth observation satellites. These advanced satellites provide crucial real-time data and imagery that can help detect and monitor wildfires with remarkable precision. They can identify hotspots and track the spread of fires, allowing for timely evacuation of at-risk populations and the allocation of firefighting resources. Furthermore, satellites equipped with infrared sensors can detect heat signatures, even in remote or densely forested areas, aiding in early detection efforts. In an era where climate change is contributing to more frequent and severe wildfires, the utilisation of Earth observation satellites is paramount to enhance our ability to

predict, respond to, and mitigate the devastating consequences of these infernos, ultimately safeguarding both human lives and the natural world.

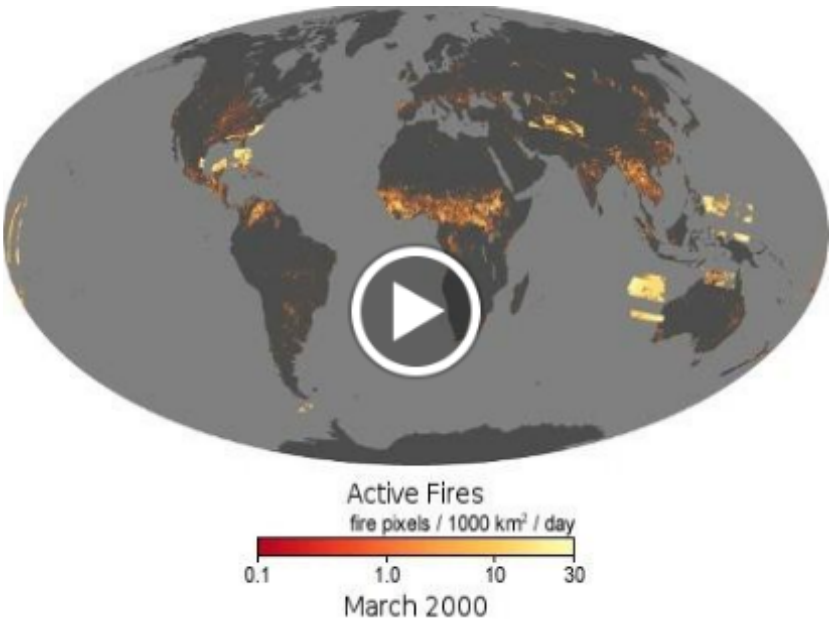

Figure 1 - Global active fires from 2000 to 2023 (source: nasa.gov)

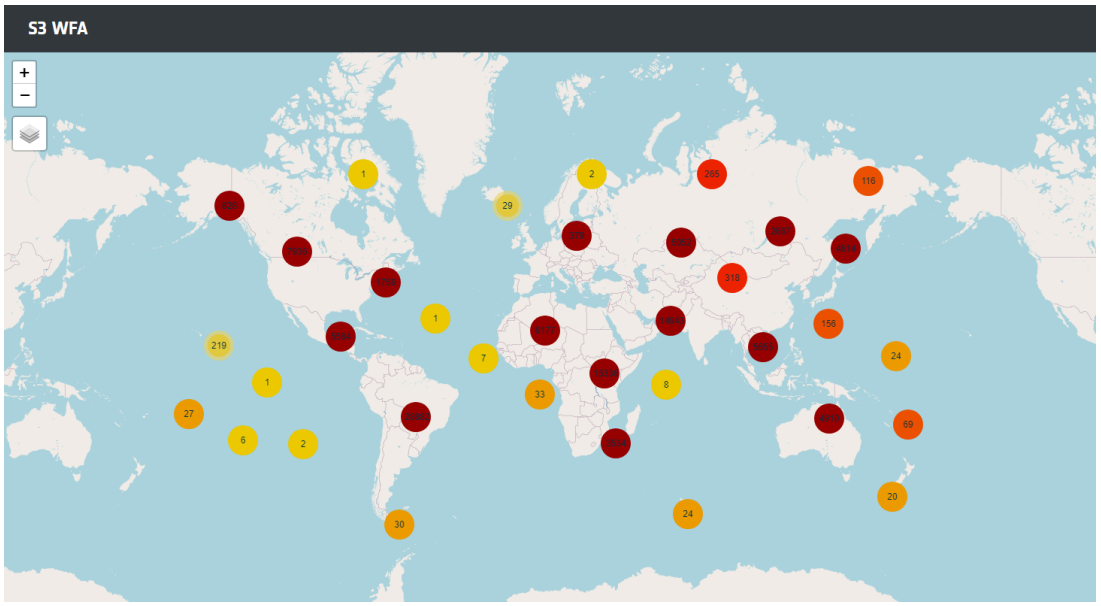

Figure 2 - World fires from July 2022 to July 2023 (source: s3wfa.esa.int)

Therefore, this year's competition aims to address the pressing issue of wildfires and explore innovative solutions in Earth Observation technology. One promising avenue centres around the use of 3U CubeSats, and how they could play a pivotal role in improving our ability to detect wildfires as they develop. Equipped with the right equipment, a CubeSat could provide near-real-time data on temperature

variations and wildfire movements. Teams will therefore be challenged to develop a CubeSat design that could aid in the fight against wildfires.

2.2 Mission Tasks

The overall challenge is to design a 3U CubeSat that can measure temperature variations in heat sources and determine the movement of such heat signatures. Additional testing will require teams to locate and track such sources autonomously using an AOCS system. Due to the difficulty of the tasks, teams should first focus on achieving Phase 1 and 2 before focusing on the Phase 3 tests.

In general, the competition is separated into two main phases: a **research & design phase, which is split into a PDR phase and a CDR phase,** and a **build & test phase.** Teams will have to submit a Preliminary Design Review, followed by a Critical Design Review.

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 TVAC, vibration and shock 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. **Confirmation on the exact testing to be done will be confirmed at a later date, along with additional details on design requirements.**

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. More information on the exact data that is expected and the format is specified in **appendix C.9** of this document.

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. **Wildfire Payload Test**. The CubeSat will be required to detect the temperature and its relative movement across a simulated map, in order to determine if locations of interest, such as towns, are in danger and need evacuating. This testing will be done in steps to simulate the need for the satellite to complete a revolution of its orbit before it has visibility of the target location again.

2. **AOCS Test.** Relocate the heat sources after a simulated loss of attitude, using the CubeSats AOCS system. This is a stretch goal and is likely to be challenging. Teams should therefore prioritise the earlier tests first.

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

2.2.2 Post-Competition Opportunities

Once the competition has concluded, 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 an opportunity for up to 3 teams to be 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

Inputs

1. Competition Statement of Work (this document)
2. 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). **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
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. There will also be a live Q&A session for each team for this stage. **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.

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, with a minimum of 4 team members**. 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.

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

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

Figure C-1: Competition Overview

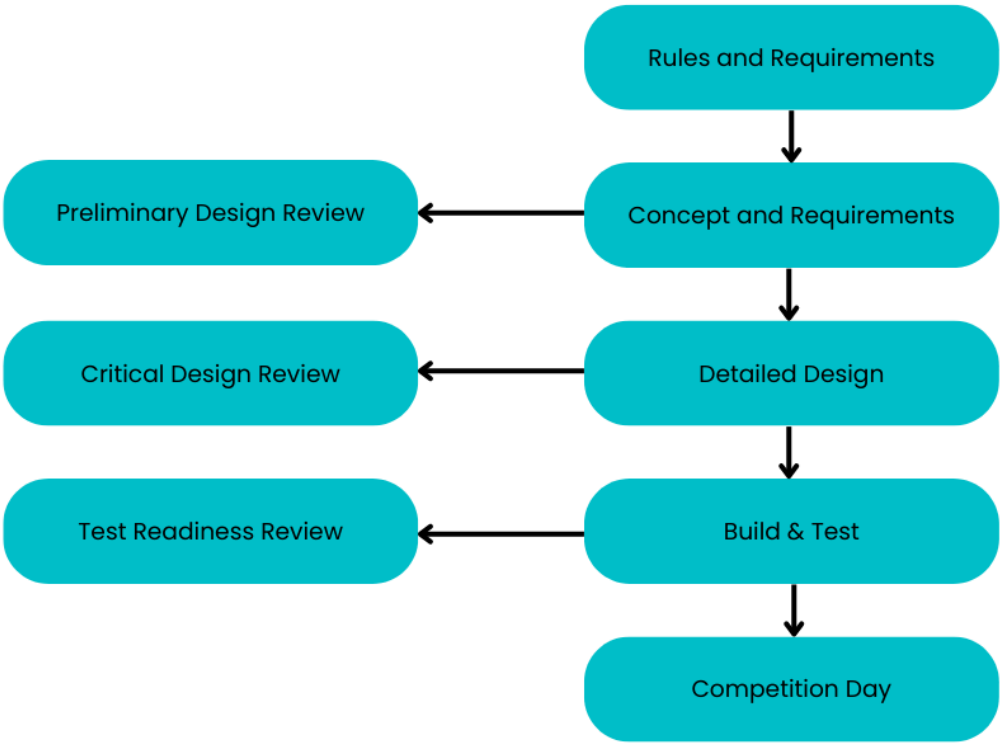

Table C-1 provides a preliminary schedule for the competition, presenting the major milestones, paperwork deadlines and other events within the competition itself. Please note these dates may be subject to change, where the UKSEDS competition team shall be responsible to notify all teams if this does occur.

Table C-1: Competition Schedule

Date	Activity	Deliverable
23rd October 2023	Deadline for Competition Submissions	-
28th October 2023	Competition Launch	Entry Form
12th November 2023	Requirements Freeze	-

20th December 2023	Preliminary Design Review and Meeting	PDR Report
12th January 2024	PDR Feedback	-
25th March 2024	Critical Design Review	CDR Report
12th April 2024	CDR Reviewer Meeting	-
15th April 2024	5 Teams selected	-
7th June 2024	Competition Grant Deadline	-
28th June 2024	Test Readiness Review	TRR Report
6th July 2024	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
Total	**£500**

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. If you receive more than 50% of costs from the university funding or otherwise, the grant shall only reimburse the remainder of the costs incurred. I.e. if total costs equal £250, and university funding equals £200, UKSEDS will only reimburse the remaining £50
5. The grant shall only be used for components or the construction of the satellite
6. 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
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. 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!

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 Report	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**.

Mystery Room

Teams shall be tested inside a **mystery room** that shall simulate a 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.

While in the mystery room, the satellite will observe a map of a countryside with towns shown as a 1mx1m grid (Figure C-3) with the wildfires represented as heating elements on the grid which will move through the forested countryside.

Figures C-2 and C-3 give an overview of the mystery room layout

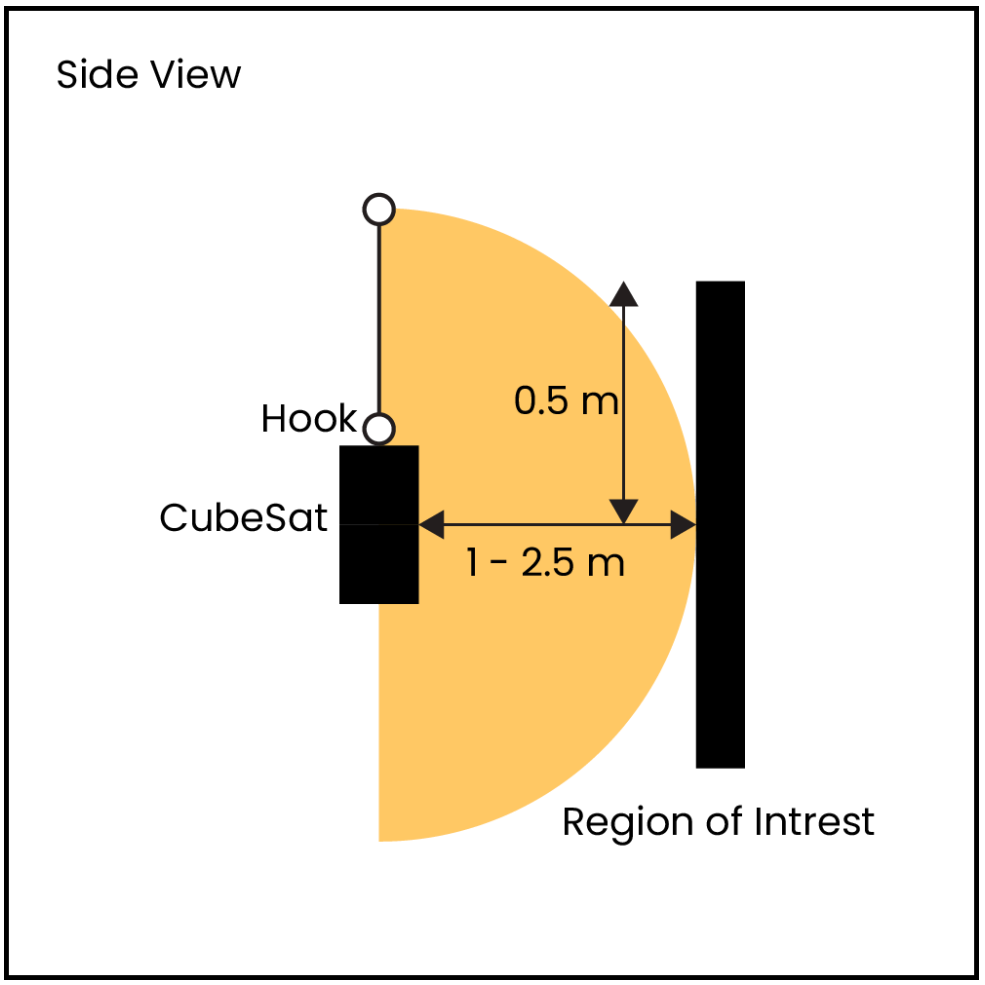

Figure C-2: Side profile of the mystery room setup to define the reference coordinates

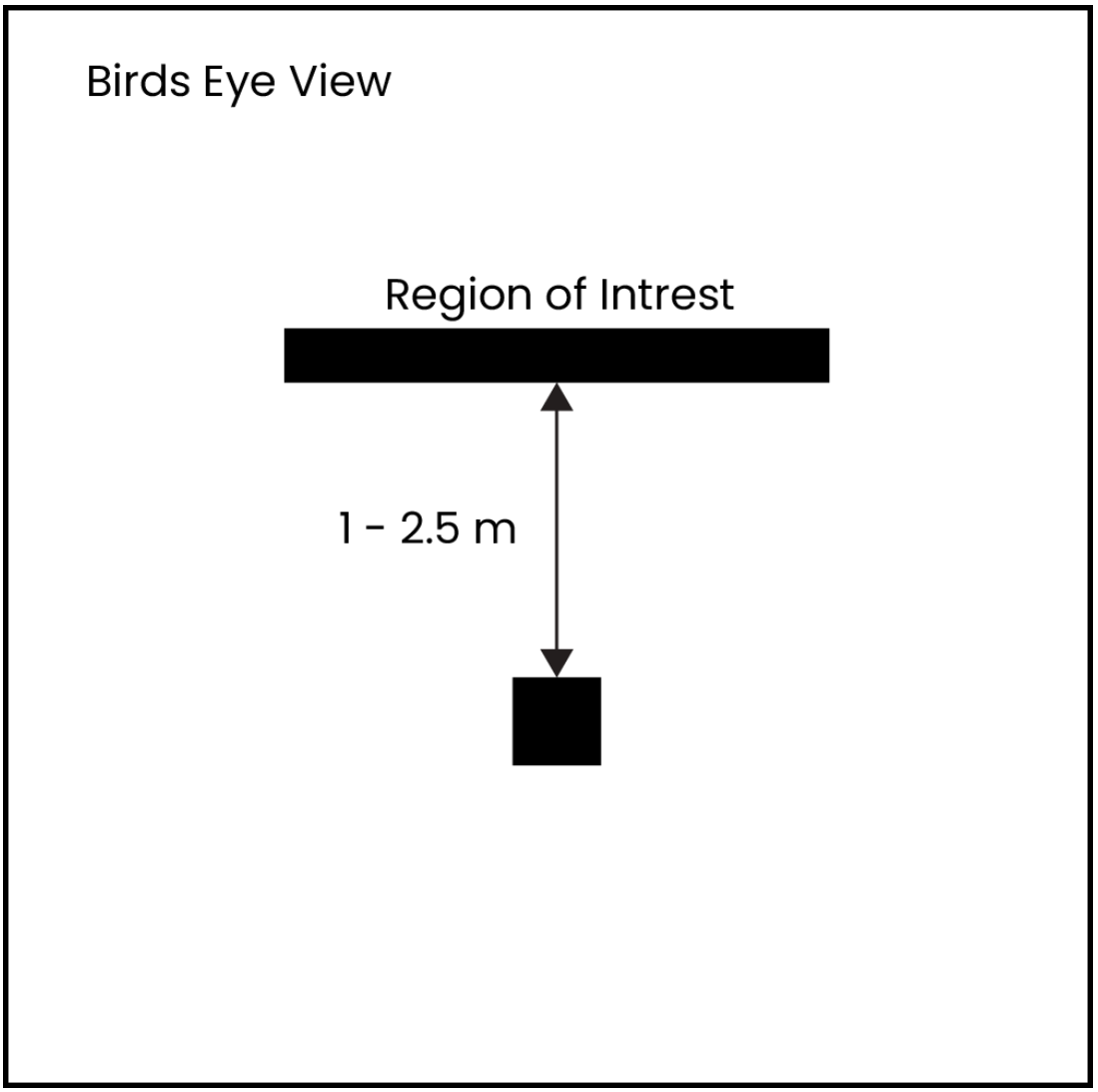

Figure C-2: Birds eye view of the mystery room setup to define the reference coordinates

Teams will **not** be able to enter the mystery room **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

Phase 1 - State of Health Check
Up to 3 students can be present in the set up of the CubeSat in the Mystery Room.

Teams will have **10 minutes to set up.**

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 and their axial velocities.

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.

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 m^2.

During this state of health testing, teams will be able to calibrate to the grid points using known locations of heat sources

This must be exported as a .txt file in the layout as below:

State of Health Test	
Power (Motor, On-board Computer etc)	0.00 (Voltage)
Power (Motor, On-board Computer etc)	0.00 (Current)
Latitude	0.00
Longitude	0.00
Attitude	0.00 (Deg)

Phase 2 - Wildfire Payload Test

During the second phase of the test, the CubeSat will be required to detect the temperature at each grid reference and determine its relative movement pattern within a 1x1m grid. Each subsection of the grid measures at 20x20 cm, and is labelled A,B,C etc from the top left corner to the bottom right corner. (Figure C-4).

The heat location can move vertically, horizontally or diagonally and will remain at each grid point for a period of time to enable the temperature to stabilise.

There can be **up to** 10 steps across the grid. Each step represents an orbit of your CubeSat, where you will have visibility of the target location.

The temperature can range from 25°C up to 100°C and teams must detect the temperature within a ± 5°C accuracy.

There will be no light source in the room for this phase.

There can be up to 3 locations of interest (LOI) to be evacuated.

The wildfire may or may not reach the LOI's.

For each orbit, teams must determine the following:

1. If location is safe
2. If evacuation is required
3. If the location is on fire

The outputs are as follows:

1. If a heat source is located directly adjacent to a LOI in the grid (i.e. A wildfire detected at X, S, T with a LOI at Y), teams should output "**Evacuate**".
2. If the heat source is located on the same grid location of a LOI, teams should output "**Location on Fire**".
3. Outside of this, teams should output "**Location is Safe**".

Teams must use the calibration from the State-of-Health Test to analyse the movement pattern and output a series of steps that the emulated wildfire took and if it reached the town and its changing temperatures along the way.

This data must be exported as a .txt file each 'orbit' in the format below:

Location	Temperature	Status
A	25 C	Location is Safe
B	25 C	Location is Safe
C	25 C	Location is Safe
D	25 C	Location is Safe
E	25 C	Location is Safe
F	25 C	Location is Safe
G	25 C	Evacuate
H	25 C	Evacuate
I	25 C	Location on Fire
J	25 C	Location on Fire

Teams will have **15 minutes** for this phase of testing.

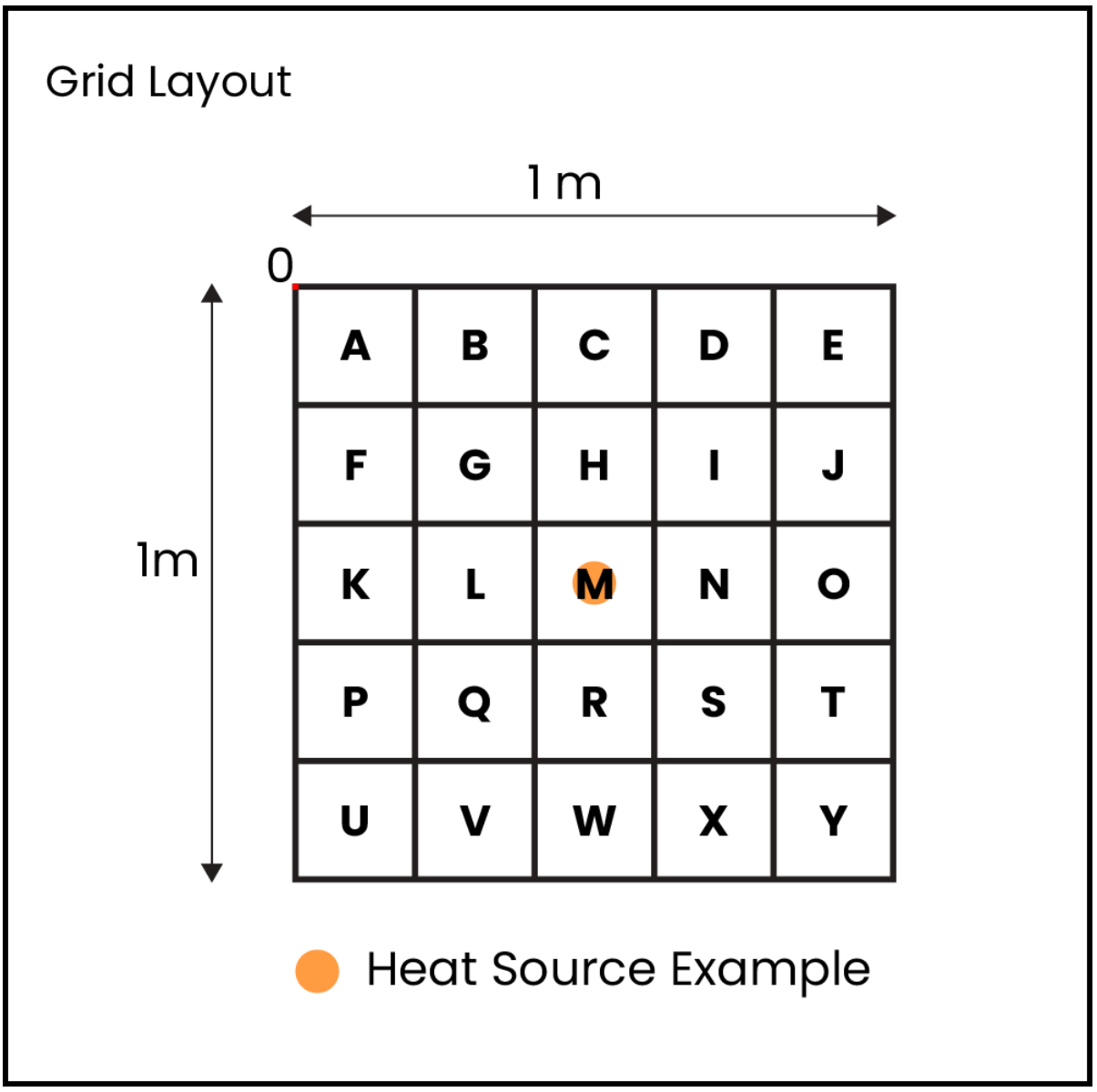

Figure C-4: Grid layout of the mystery room setup to define the reference coordinates

Phase 3 - AOCS Test

In this test, your CubeSat will have undergone a 'anomaly' that results in it being repointed towards the 'sun' (a light source will be added to the room for this test) Teams will then be required to utilise their AOCS system to reorient their CubeSat towards the grid. This test will be performed **3** times. Teams will be marked based on the length of time it takes to achieve **stable** pointing at the target location and to determine the temperature of the heat source.

Teams will have **10 mins** to detect, orient and analyse the heating source and provide the temperature.

This must be exported as a .txt file in the layout as below:

Phase 3	**Temperature**
Heat Source	25 C

Phase 4 - Structural Testing

The final test will be one or more structural tests to emulate the launch of the team's satellite. **More information on this will be provided at a later date.**

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
This will be provided at the start of the CDR phase.

Presentation
The list below provides the key points to focus on when presenting to the audience on the competition 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-22-STR-001	Mass	The total satellite mass shall not exceed **6kg**
SDC-22-STR-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-22-STR-003	Cubesat Standard	All satellite components and mechanisms shall be compliant with cubesat standard specification volumetric envelope in stowed configuration
SDC-22-STR-004	Deployables and Mechanism	Deployable elements are allowed under release command.

SDC-22-STR-005	Interface	The satellites shall accommodate the interface for suspension (this can be to interface with a hook or rope).
SDC-22-STR-006	Pyrotechnics	No pyrotechnic components shall be used.
SDC-22-STR-007	Debris Mitigation	No item or parts shall be released into "space". This includes all lock-down and release mechanisms.
SDC-22-STR-008	Vibration	The satellites should be capable of attaching to the vibration system (to be updated with appendix section at later date)
SDC-22-STR-009	Shock	**To be given at a later date**

Table D-2: Power

#	Requirement	Description
SDC-22-PWR-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-22-PWR-002	Power Storage	The on-board power system shall store enough energy to ensure power throughout the test mission.
SDC-22-PWR-003	Hazardous Materials	No hazardous, explosive, or toxic components shall be used.

Table D-3: Communications

#	Requirement	Description
SDC-22-COM-001	Communication system provision	The communication system shall be designed and provided by each team.
SDC-22-COM-002	Wireless	The communication system shall be wireless.
SDC-22-COM-003	Operation	The communication system shall be able to operate the satellite from an isolated operating room with no line of sight.
SDC-22-COM-004	Dedicated Communications	The communication system shall not make use of pre-existing infrastructure (No Bluetooth/NFC usage is permitted).

		*RF Equipment may be placed in the control room.
SDC-22-COM-005	Legality	All wireless communications must use UK legal frequencies and should be used responsibly.

Table D-4: Environment

#	Requirement	Description
SDC-22-ENV-001	Temperature	The satellite shall be able to operate at temperatures between 0°C to +40°C.
SDC-22-ENV-002	Access	The satellite shall not be accessed during the test mission.

Table D-5: Safety

#	Requirement	Description
SDC-22-SFT-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-22-SFT-002	Battery	When handling batteries, good battery practice should be followed, including but not limited to requirement SDC-21-SFT-002
SDC-22-SFT-003	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-22-SFT-004	Battery	Lead Acid batteries shall not be used
SDC-22-SFT-005	Battery	All batteries used shall be removable
SDC-22-SFT-006	Battery	In the case of LiPo batteries, charge bags and a CE marked LiPo charger shall be used

SDC-22-SFT-007	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-22-SFT-008	Non-toxic propulsion methods	Any propulsion methods that eject gas shall be non-toxic.
SDC-22-SFT-009	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.

D.3 Structural Testing

As part of this year's mystery room, a test will be conducted that will simulate the loads that will be placed on the satellite during the rocket launch. Teams should build their satellites to withstand the loads described in this section, taking into account both the mechanical and electrical problems associated with such vibration. More information will be provided on these tests at a later date.

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, the PDR 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.

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 Q&A session 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 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.**

END OF DOCUMENT

