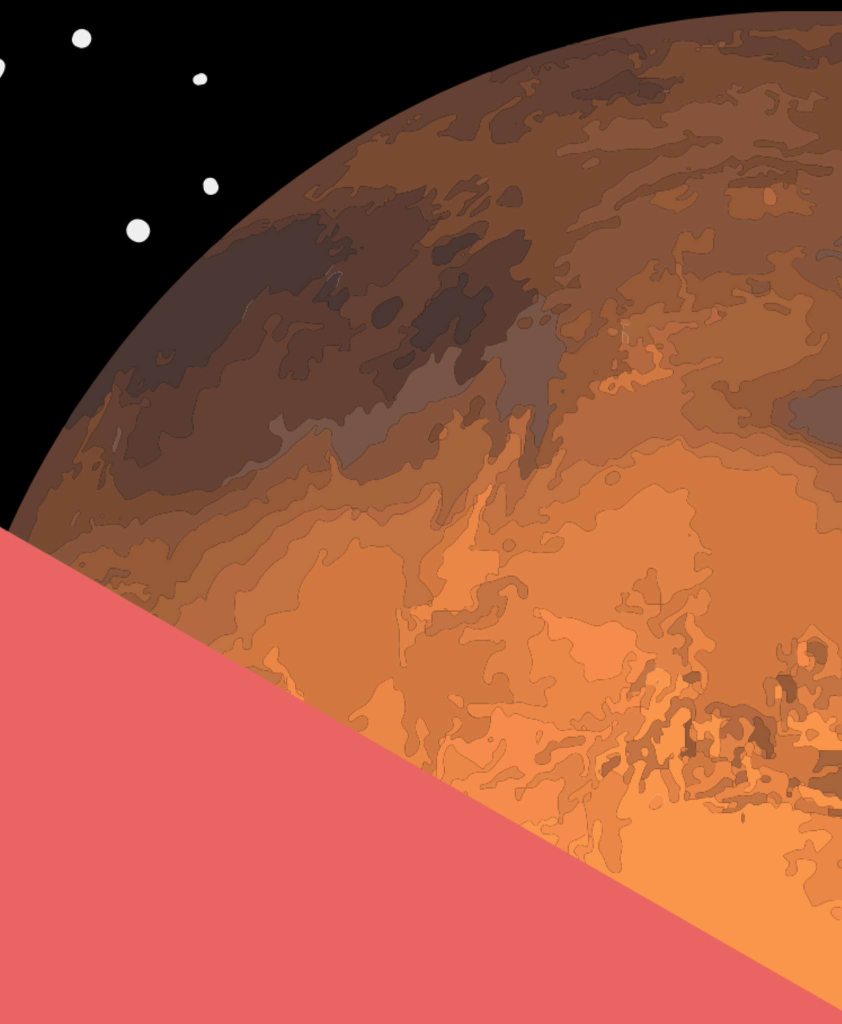
# OLYMPUS ROVER TRIALS 2023-24

## RULES & REQUIREMENTS



UKSEDS COMPETITIONS

SUPPORTED BY

AIRBUS

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RAL Space

# Contents



# 1 Introduction

The Olympus Rover Trials challenges student teams to design, construct and operate a rover for an analogue space mission. Students create a rover concept, trade off performance parameters and pass through a rigorous review process with panels of engineers from the space sector. The competition aims to:

1. Challenge students to perform a complex, systems engineering task of the development of a vehicle to a set of real **space mission requirements**;
2. Enable students to apply taught technical skills and learn new ones relevant to a job in the space industry in an applicable project environment;
3. Provide students with an opportunity to develop and practise other important and **transferable skills**, such as teamwork, leadership and project management;
4. Foster **interest in the activities of the space sector**, especially in space engineering and robotics.

## 1.1 Organisations Involved

### 1.1.1 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 careers 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.

### 1.1.2 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.

### 1.2 Team Structure

**The competition is open to UKSEDS members and students from UK schools and universities, as well as any students on Internships or people on Grad Schemes.** 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 rovers@ukseds.org to enquire about eligibility.

There is a limit of **10 team members per team**. The names of the team members must 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.

### 1.3 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 rover
c. Document Requirements Specification - requirements for the documents delivered by teams in the competition

# 2 Competition Overview

## 2.1 Mission Background and Scenario

A permanent presence on Mars has been established by the collective collaboration of the world's space agencies and companies. However, long-term exposure to radiation is still a major challenge to be overcome, and if not solved, could threaten the long-term viability of another giant leap for mankind.

The currently agreed solution to the radiation environment is to establish a new base below the surface, where the martian soil shall naturally block the radiation. An opening to what is potentially an extinct lava tube has been identified and is to be explored. Within it are potential sources of ice which could be harvested for the new habitat. Local access to ice is essential for the long term viability of a new habitat.

This call to tender requests the design, development and manufacture of a rover that shall explore the cave that has been specified and identify any ice deposits by deploying an end effector that can penetrate the surface of the cave. The data from the samples is to be uploaded to the Mars Relay Network for delivery back to Earth.

## 2.2 Mission Tasks

The company is expected to develop a reconnaissance rover that is able to explore the identified cave. The main tasks of the rover shall be to:

- Enter and traverse a dark environment, providing visual feedback to the controller.
- identify key targets and drill them using the end effector
- Exit the cave in order to recharge solar cells and upload data to the Mars Relay Network.

Several constraints have been identified and are listed:

- A large battery or power generation system (e.g. a Radioisotope Power System) is not feasible due to mass constraints.
- Solar cells shall be used to recharge batteries in the light of the cave entrance. If the battery is fully depleted within the cave the rover shall be lost as the cave has not been found to be safe for human exploration.
- A solar array supplier for the competition has been selected as Airbus Sparkwing, who will supply the standardised panels for integration onto

your rover. A specification of the solar array and interface requirements will be provided.
- A larger solar panel surface area shall increase the rate of recharging when in illumination conditions. However the smallest diameter of the lava tube is not known exactly and it is essential that the rover can navigate without risking damage.
- The power discharge rate will be proportional to the mass of the rover.
- Environmental impacts may decrease the rate of charging during the course of the mission (e.g. due to a dust storm).
- After interactions with drill targets in the cave, the rover must exit the cave and manoeuvre to the 'uplink zone' to be able to 'bank' the points from the previously drilled targets.

**NOTE:** The power and solar array addition to this year's competition will have no impact on the actual battery or power usage of the rover. It is purely analogous to limit the time the rover is able to continuously spend within the cave side of the Mars Yard. Teams are not required to include Solar Array generation in their EPS design.

## 2.3 Mission Details

### 2.3.1 Battery Charge and Discharge

The amount of time you can survive in the dark zone is independent of your chosen battery and power subsystem design. Instead, it will be based on a 'virtual' battery with charge and discharge rates determined by other aspects of your rover's design.

The virtual battery will start fully charged at a capacity of 12Wh, and as your run progresses, you will be shown the state of charge of the battery in real time in order to judge when to enter/exit the cave.

Once you enter the cave, discharge will begin. The rate of discharge will be determined with the following formula:

$$\text{Discharge Rate (W)} = \text{Total Rover Mass} * 15$$

Where 'Total Rover Mass' includes any solar panels integrated onto your rover prior to your run.

If you need to recharge your rover at any point, you will have to re-enter the sunlit zone, at which point your battery will charge in accordance with the following formula:

$$\text{Charge Rate (W)} = \text{Number of Solar Panels} * 180$$

Where 'Number of Solar Panels' corresponds to the integer number of supplied solar panels that you have managed to integrate into your design (see following text for details of the supplied solar panels).

**NOTE:** *The formulas above have been designed for practicality, so that your rover can charge and discharge in reasonable time during the 30 minute test. They do not in any way represent realistic equations or results for charge/discharge rates of real rovers.*

A new addition to this year's competition will be the inclusion of a supplier for the solar array panels - Airbus Sparkwing (https://sparkwing.space/). Your team must design to integrate **up to** 10 Sparkwing panels onboard the rover via the standardised interface design that will be provided. Before the competition run, each team will have 15 minutes to integrate the solar arrays - therefore access to the rover-side interfaces must be available for this activity. An Interface Control Document (ICD) will be provided for the solar arrays. An initial first issue of the architectural design can be found in Annex E.3.

**NOTE:** *Teams are **not** expected to have a fully functioning Solar Powered system for their rover but merely a place where they can install and integrate the provided solar arrays supplied by Airbus Sparkwing. The array integration shall be indicated appropriately on the rover design and must be included within the mass budget and stowed volumetric considerations. The Solar arrays will need to face upwards and not be obscured by parts of the rover.*

An example charge-discharge profile for a rover with a mass of 3.5kg and 6 solar panels is shown below.

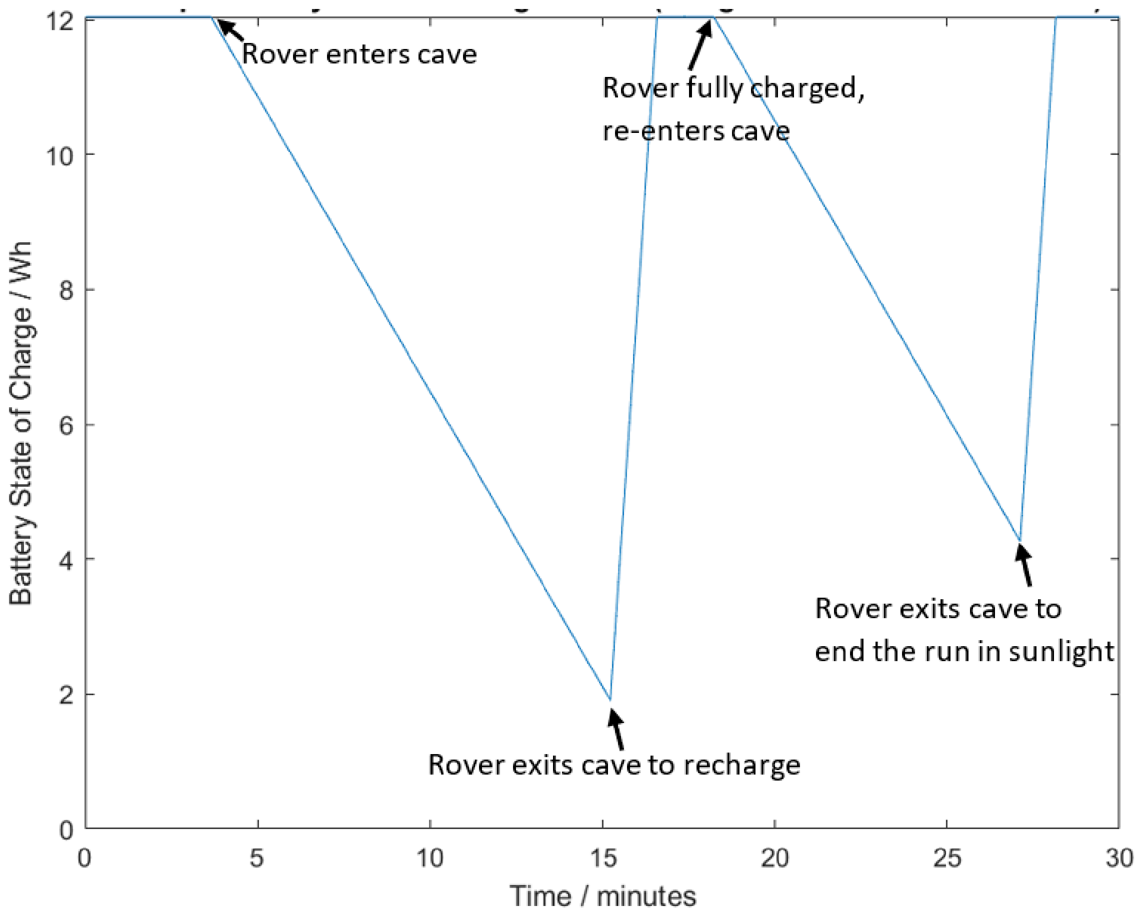



***Figure 2-1: Example Battery State of Charge Profile (3.5kg Rover with 5 Sparkwing Solar Panels)***

NOTE: there is no requirement for your rover to be fully charged before re-entering the cave. Teams will also have a live battery state charge profile on a computer screen in the control room during the competition run.

Teams must "bank" their data received from drilling targets by returning to the uplink zone outside of the cave (see Figure D-1). Therefore, if the rover runs out of charge or time while in the cave, any points collected since the previous upload will be lost. If teams find themselves low on battery, they may want to activate "low power mode" for the power system. This will reduce the rate of discharge of the battery and disable the rover's drill, allowing the teams more time to exit the cave on the current battery level. However, low power mode cannot be turned back off and activating it comes with a large point penalty. This means that once low power mode has been activated, the teams cannot collect any further points as the drill is disabled, and their run will end once the rover exits the cave (or runs out of time/power).

### 2.3.2 Drill Payload

During the competition there will be targets laid out which the rovers will be required to navigate towards. Once they have arrived, the operators will need to control a robotic arm which contains a representative drill. The targets will be circular in shape. The objective is to get the point of the drill as close to the centre of the target as possible, showing capabilities of precise control of the robotic arm even in sub-optimal lighting conditions. The closer to the centre of the target, the more points each team will get. Also, targets that are more of a challenge to reach will result in more points. Reference figure C-2 for a schematic of the test area.

**Note: Teams do not need to design an actual drill. The focus is for teams to display a system which can precisely be controlled towards specified targets. The drill design is meant to be representative of an actual drill.**

The targets can be placed in a variety of orientations and at different heights to the rover. Please refer to the technical requirements for maximum height above ground that could be expected. Figure xx shows some of the potential variations that could be present on competition day.

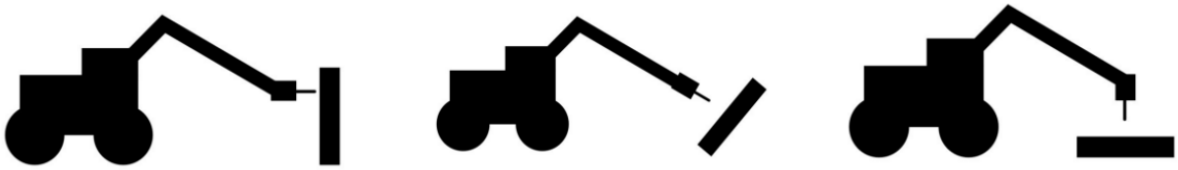


***Figure 2-2: Schematic showing the possible orientations of targets.***

The targets will consist of three scoring 'bullseye' zones. The total points for each target will only be collected if the rover payload touches the central scoring zone of 100%. These targets could be a number of different sizes, though the smallest will have a central 100% scoring zone of no smaller than 20mm in diameter. The points are only fully 'banked' once the rover has entered the 'uplink zone' outside the cave.

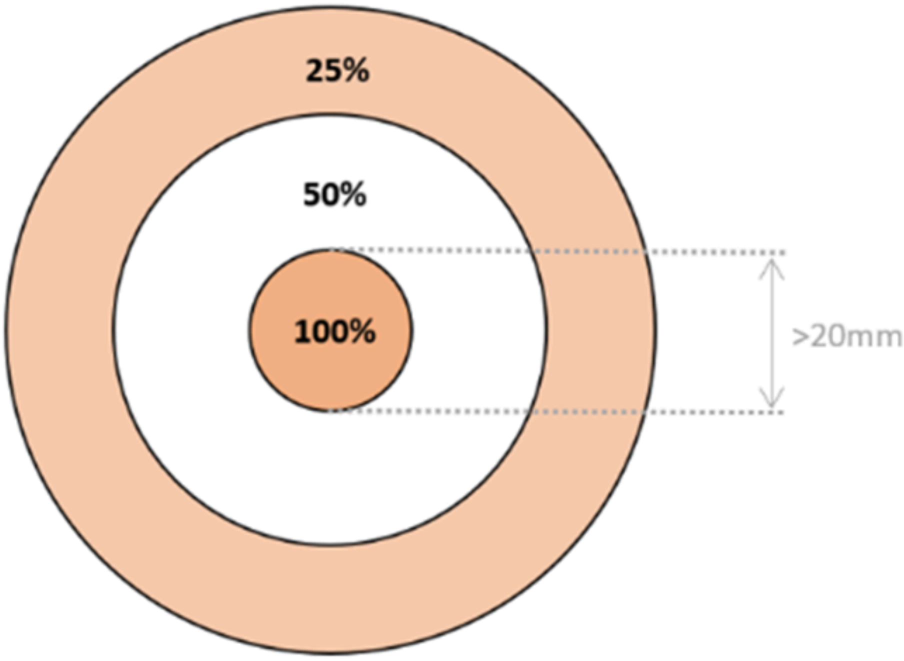



***Figure 2-3: Representative target scoring layout.***

# 3 Description of Work

For the project, the competing companies are expected to follow an accelerated variation of the ESA project lifecycle. This shall be split into four stages: **Preliminary Definition, Detailed Definition, Qualification & Production and Utilisation**. Each of these stages shall be completed upon the deliverance of a document that shall be reviewed by the customer and feedback provided upon review.

## 3.1 Preliminary Definition

The main deliverable at the end of Preliminary Definition Stage is the **Preliminary Design Review (PDR).** This 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 deliverable expected at this stage is the **Preliminary Design Review (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)

It is therefore expected that you present methodology resembling this format. The primary deliverables for the project at this stage shall be:

- Project Management
    - Assigned Roles
    - Preliminary Work Breakdown Structure
    - Preliminary Timeline
    - Preliminary Budget
    - Project Risks and Mitigation
- Preliminary Concept
    - Derivation of more requirements from the initial ones provided
    - Preliminary system architecture
    - Functional definition of the subsystems
    - Evidence of trade-offs and explanation of decisions made

### 3.2 Detailed Definition

The main deliverable at the end of the Detailed Definition Phase is the **Critical Design Review (CDR)**. This 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 rover design
- Release assembly, integration and test planning
- Release flight hardware/software manufacturing, assembly and testing

The expected deliverables for the CDR are:

- Project Management
    - Assigned Roles
    - Complete Schedule
    - Complete Budget
    - Project Risks and Mitigation

  - Initial Test Procedure
- Critical Design
  - Complete description of System design
  - Complete description of Electronic design
  - Complete description of Mechanical design
  - Complete description of Software design
- Requirements Verification
  - Indicate new requirements and/or pivots from the PDR.
  - Indicate how **all** requirements (both in this document and the PDR) have been met by the design

The Critical Design Review should be to a level of detail where the proposed rover design is ready to build in its entirety.

### 3.3 Qualification & Production

Upon completion of the CDR teams shall be able to begin the build of their rovers. Once completed, teams shall be required to demonstrate the key features of their rover to demonstrate that they are able to safely perform the tasks required of them on competition day. For the TRR the teams shall submit videos of their rover to confirm the following:

- Demonstration of functioning kill switch.
- Demonstration of rover under user control, moving on sand or another granular surface.
- Demonstration of rover's ability to connect to the vibration table (demonstrate that the rover can be connected to the vibration plate with M8 bolts).
- Visual demonstration of batteries and wires being protected and not exposed.
- Demonstration of the end effector system (movement of the mechanism).

The TRR shall not be graded but be based on a "pass" or "fail" system. In order to be guaranteed to be deployed in the Mars Yard, the rover must "pass" the TRR. If the rover upon review is considered to pose a threat to safety it may not be permitted to participate on the competition day. These subsystems do **not** need to be demonstrated to be functional simultaneously.

## Appendix A: Acronyms

***Table A-1: Table of Acronyms***

| Acronym | Description |
|---|---|
| ASD | Acceleration Spectral Density |
| CAE | Computer Aided Engineering |
| CE | Cave Entrance |
| CDR | Critical Design Review |
| ECSS | European Cooperation for Space Standardisation |
| ICD | Interface Control Document |
| ITT | Invitation To Tender |
| ORT | Olympus Rover Trials |
| PDR | Preliminary Design Review |
| TRR | Test Readiness Review |
| UKSEDS | UK Students for the Exploration and Development of Space |
| UZ | Uplink Zone |

## 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 |
| 3 | - | **Sparkwing Interface Control Document** (to be provided post-PDR) |
| 4 | - | **Mechanical Test Interface Control Document** (to be provided) |

## Appendix C: Competition Rules & Regulation

The ORT rules are issued by UKSEDS annually. Official announcements by UKSEDS should be considered to have the same validity as these rules. UKSEDS reserve 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 rovers@ukseds.org.

| | |
|---|---|
| 1 | **Team Eligibility** |
| 1.1 | All students enrolled in a UK School, University, Apprenticeship or Graduate Scheme are eligible to participate |
| 1.2 | Teams shall not be composed of more than 10 members at a time |
| 2 | **Plagiarism** |
| 2.1 | Teams must reference any work that is not performed by the 10 team members (support from mentors, lecturers etc.) |
| 2.2 | Teams are not permitted to reuse software or scripts that were created by previous teams |
| 3 | Requirements Specification |
| 3.1 | Teams shall be compliant with ALL requirements stated in Appendix C & E |
| 4 | Submission Deadlines |
| 4.1 | Teams must submit all competition documentation within the deadlines (unless an extension has been agreed upon with reasonable notice). |
| 5 | Funding |
| 5.1 | Teams must comply to the funding breakdown detailed in Annex D.3 |
| 6 | Reuse of Previous Components |
| 6.1 | Teams may reuse COTS components from previous entries. (e.g. microcontrollers, screws etc.). COTS components that are reused must have a justification beyond "being readily available" or any equivalent wording. |

| | |
|---|---|
| 6.2 | Any reused COTS parts must have their market value accounted for within the team budgets. They cannot be assumed to be free. |
| 6.3 | Teams may not reuse raw components or components that have been processed by previous teams from previous years (e.g. metal from chassis, complete arm assemblies. |
| 6.4 | Teams may not reuse any code or software from previous competition entries. This constitutes as plagiarism |
| 7 | Competition Day |
| 7.1 | Teams and participants shall adhere to all rules and regulations enforced by UKSEDS or competition day hosts and partners. |

# Appendix D: Competition Information & Support

## D.1 Team Structure

By its nature, robotics is incredibly interdisciplinary. We recommend building a team with students from a number of disciplines. Key disciplines are mechanical engineering, electronic or electrical engineering, computer science (particularly for autonomy) and geology (understanding the properties of the surface).

Standard engineering practices are advised for creating a team structure. It is also recommended that at least one team member takes the role of systems engineer. This role will be critical in defining how different parts of the rover interface with one another.

**Example Team Structure**

An example Team structure is provided below. This is not considered the “best” organisation method as teams may find structures that better suit their skills.

- Project Manager
  - Team Organisation
  - Budget Allocation
  - Project Schedule
  - Document Overseeing
- Systems Engineer
  - Interfacing all the different disciplines with one another
  - Top level architecture of the rover
  - Monitoring requirements compliance
- Electronics Lead
  - Top level electronics decisions
- Electronics Engineer
- Mechanical Lead
  - Top level mechanical decisions
- Mechanical Engineer
- Software Lead
  - Top level software decisions
- Software Engineer

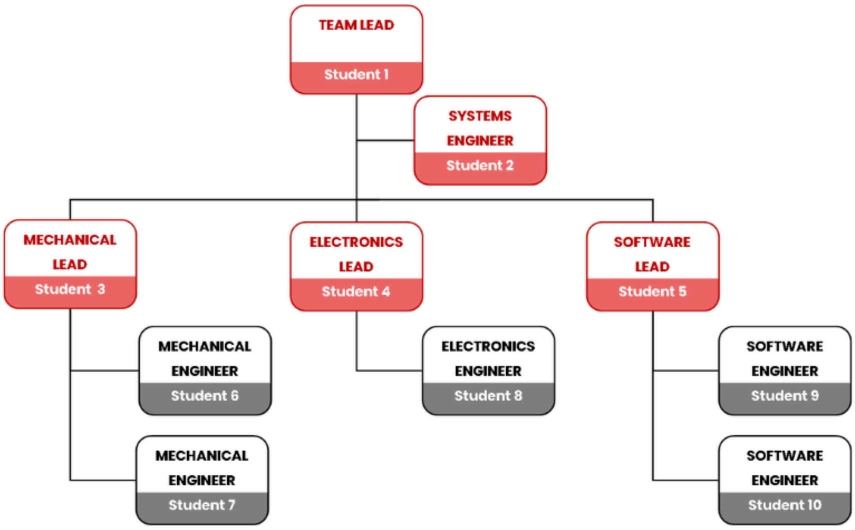



**Figure D-1: Example Team Structure**

**Support: Finding Team Members**

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

**Support: Team Connect**

Designing, building and testing a rover 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 your team contact. We may be able to find another group that has a complimentary skillset 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

## D.2 Competition Schedule

The rover competition consists of several stages, which have been illustrated in fig. 2. A comprehensive overview of the tasks and deliverables are located in the

Description of Work (section 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.

Table D-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 D-1: Competition Schedule***

| Date & Time | Activity |
|---|---|
| 17/12/2023 23:59 | Submit PDR |
| 14/01/2024 08:00 | PDR Feedback Released |
| 03/03/2024 23:59 | Submit CDR |
| 08/04/2024 08:00 | CDR Feedback Released |
| 23/06/2024 23:59 | Submit TRR |
| 28/06/2024 08:00 | TRR Verdict Received |

## D.3 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 D-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. 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 rover
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 rover 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. The Grant has a rolling application deadline. Teams can only apply for funding once. The team structure can meet the criteria at the PDR, CDR or TRR Stage. Additionally, this grant qualifies as external funding and could be listed as such for the competition match-funding (see example below).

***Table D-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 rovers@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 stages
3. The grant shall not exceed £250
4. The grant shall only be used for components or the construction of the rover
5. Representation on the competition day should reflect the diversity of your team

## D.4 Competition Day

The final part of the Mars Rover Competition is the test on the competition day. This will be held at Airbus Defence and Space, Stevenage. The date and travel and accommodation arrangements will be released at a later date.

**Prizes**

Table D-4 provides a full description of the prizes available for this year's competition.

***Table D-4: Full List of Prizes***

| Prize | Description |
|---|---|
| **Best Rover** | For the best rover based on the successful completion of the mission objectives (awarded to the team with the most points). |
| **Best Outreach** | For the team with the best outreach programme connected to their rover. Further details on how this will be marked can be found in Appendix F. |
| **Best Innovation Award** | To the team with the best innovative engineering solution (decided by the judges). |
| **Best CDR** | The highest scoring CDR shall receive this award |
| **Automation Prize** | A prize for the team with the most impressive automation capabilities will be awarded a special prize. The judges will assess this award. |

## D.5 Test Definition

Each team will have one attempt to complete the objective. The attempt may involve more than one traversal between the logistics depot and a cargo area. Subsequently, the rover will be tested on the vibration testbed. An area will be provided for teams to prepare their rovers, carry out any repairs, and otherwise spend time. Bolts and components can be adjusted/tightened before the vibration test, however teams shall not be able to add parts or physically alter the position of parts (setting the arm in a unique locking position for example) unless this can be performed by remote control. The following sections include some information on key aspects of the testing process.

**Competition Trials Area**

The test runs will be carried out in the Mars Yard - a facility specifically built to test rover concepts on analogous Martian terrain (such as ExoMars and Sample Fetch Rover). The dimensions and layout of the test are shown in Figure D-1 and Figure D-2. The Mars Yard is an indoor facility, with the surface primarily consisting of fine loose sand, as shown in Figure D-3. Previous years have had difficulty with the rover wheel and motor selection for such terrain and have 'dug' themselves into the sand whilst trying to manoeuvre. Please consider this in your designs. A number of rocks and boulders are also distributed around the area. The exact conditions of the surface will not be provided before arriving on the day.

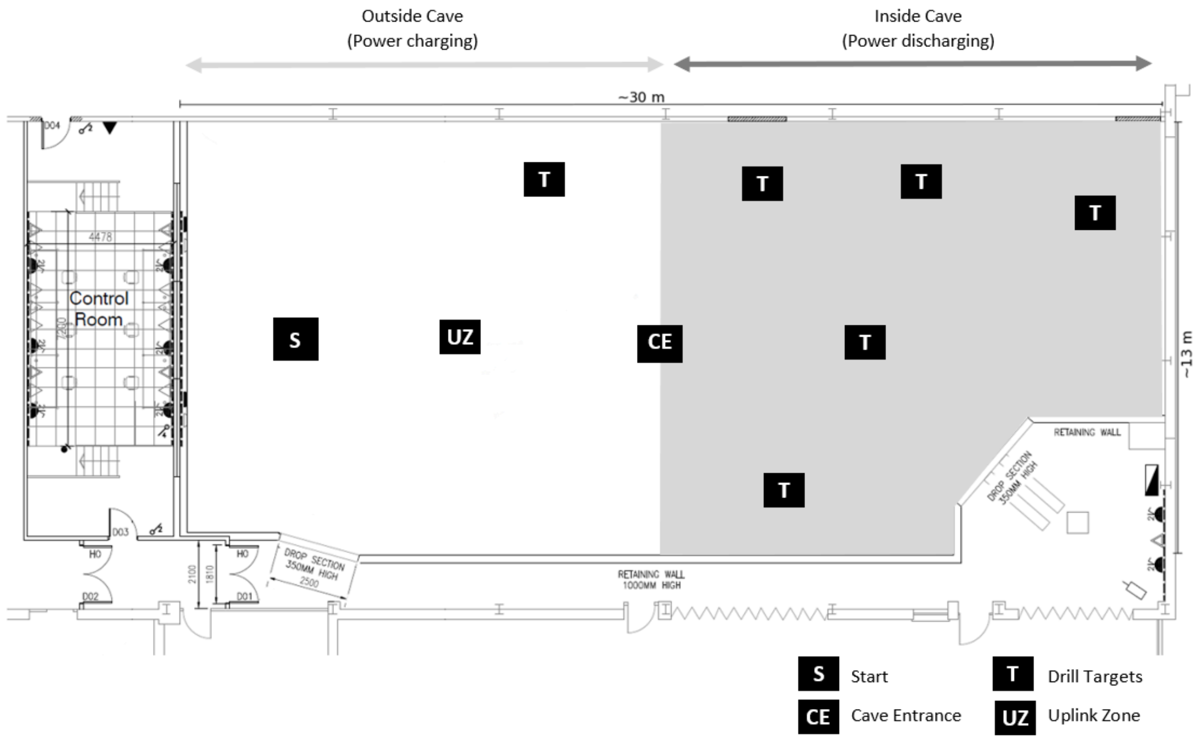



***Figure D-2: Airbus D&S Mars Yard - Architectural Schematic (preliminary start, cave entrance and uplink zone locations demonstrated - these may change on the day)***

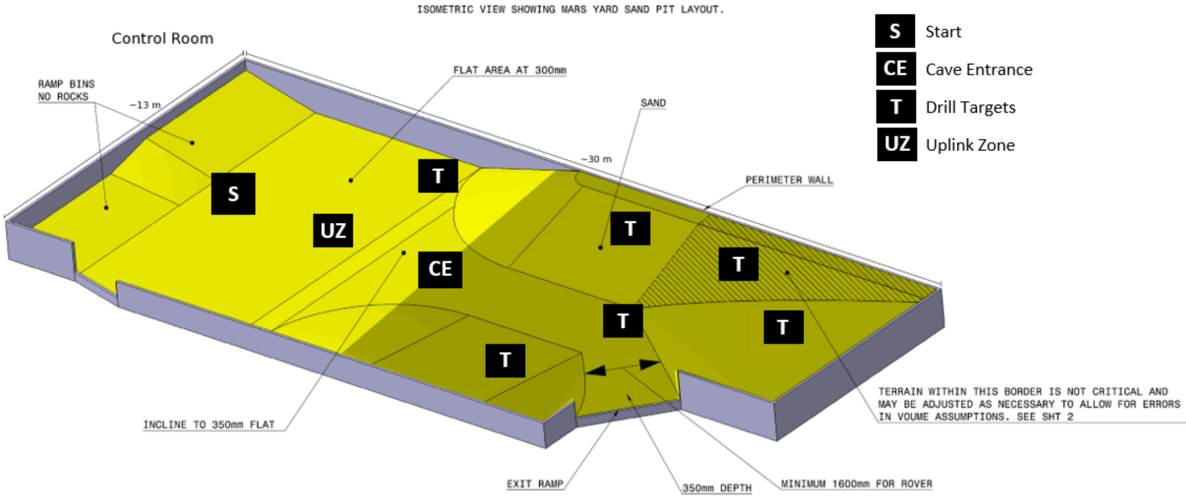



***Figure D-3: Airbus D&S Mars Yard - Topology Schematic - (Light and dark side of cave, with start, cave entrance and uplink zone shown. Drill target site locations demonstrated - these may change on the day)***

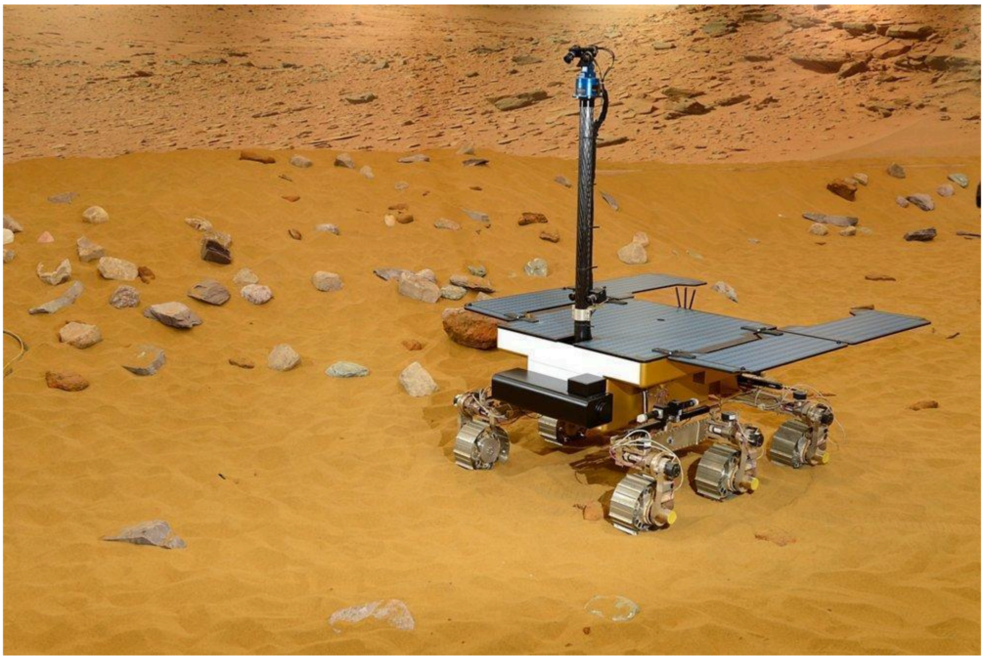


***Figure D-4: Airbus D&S Mars Yard surface conditions***

**Test Format**

There is a 30 minute time limit for each test run. Each team will make one or more traverses from the uplink hub into the cave, where they will 'drill' the target sites before returning out of the cave to the uplink area. A single rover team will be on the Mars Yard sand at any one time. Teams will be able to control their rover from a control room. Teams will have line-of-sight view from the control room, though the cargo areas may be up to 30 metres away from the control room. It is therefore advised to have an adequate camera(s) and/or sensor(s) for the sampling section of the mission.

Teams must have a method of controlling their rovers wirelessly from behind a glass window.

There will be a separate preparation area near to the Mars Yard. Teams will need to navigate the rover from the landing site position to the drill sites and back to the uplink zone. No charging will be allowed for the rover during the test.

Once a rover has performed its test run, it will be mounted on the vibration test bench, as shown in Figure D-5. The vibration specification for the rover is described in appendix E.2 and [RD-4].


***Figure D-5: Vibration Testbench Setup***

If unforeseen events lead to unavailability of vibration facilities, an alternative shock test will be performed (see figure D-5). The shock test apparatus features the same interface as the vibration test bench.

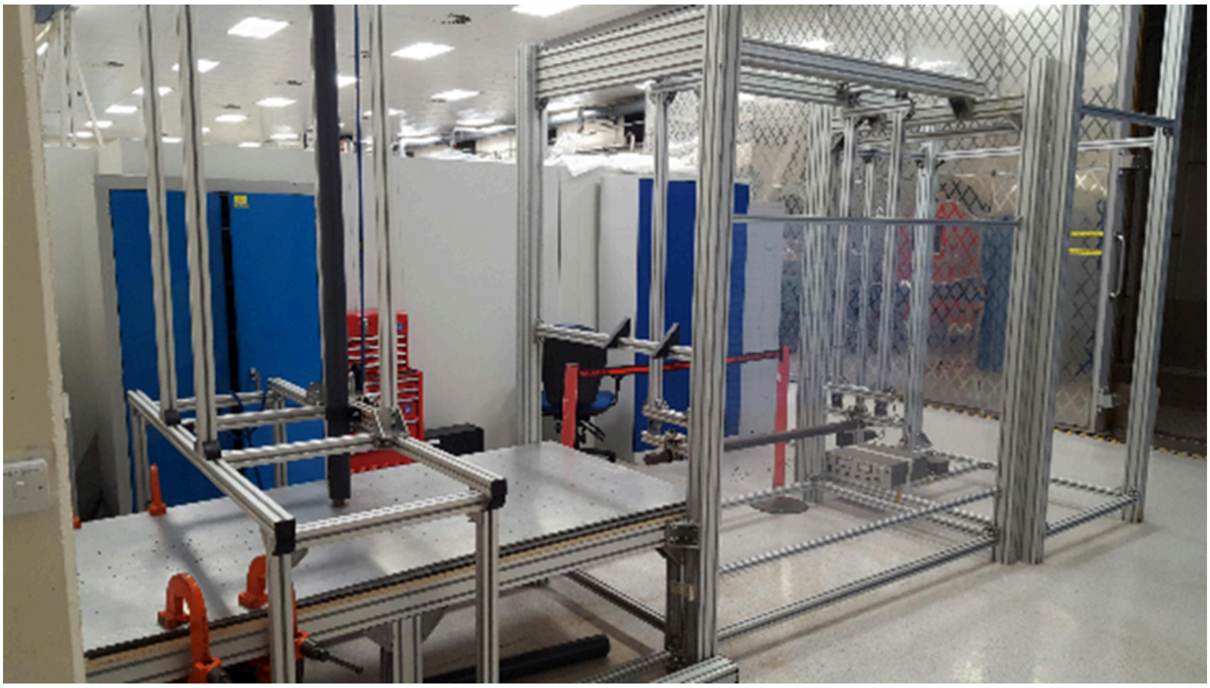


***Figure D-5: Shock Test Setup***

**Test Restart or Repairs**

During the test, a team may wish to restart or make emergency repairs to their rover. These will be allowed, but the 30-minute clock will not be paused or reset. If a repair is made, the rover will restart from the logistics depot. If the rover run is reset one or more times, the attempt which accumulates the most points will be counted.

There will be a competition judge on the sand to return the rover to the starting position if required.

**Drill Targets**

Multiple drill targets will be distributed around the cave side of the Mars Yard, with one to two low scoring targets outside the cave entrance. An updated version of the Mars Yard map (fig. 3) and (fig. 4) identifies the current understanding of where the target sites will be selected during the competition. This location may change closer to the day due to Airbus' Sample Fetch Rover Project test campaign usage of the Mars Yard, with an update provided in such an event. The properties of the drill targets are described in the technical requirements.

Each piece of drill target bullseye will have three distinct scoring zones. The centre of the target will be full points, the middle zone 50% points and the outer zone will be 25% points. At least half of the drill bit end must be within a scoring zone to receive the zone points.

Each target will receive a difficulty weighting which will vary the available points of each target.

## D.6 Scoring

**Vibration**

A team can earn a maximum of 1000 points for vibration if the rover is operational, from which points will be subtracted depending on the level of damage as described in the table below. Negative marking is at the judge's discretion. Negative points will be given for the following types of damage:

| | |
|---|---|
| **Minor No impact on performance (i.e. loss of fasteners of non-mission critical part)** | -50 |
| **Loss of one function (i.e. driving, communication, cargo collection abilities)** | -250 |
| **Loss of multiple functions (i.e. at least 2 of driving, communication, cargo collection abilities)** | -500 |
| **Catastrophic Loss of mission (i.e. rover non operational)** | -1000 |

**Mission Performance**

The team shall be scored on the quantity and complexity of "ice" sources they are able to successfully identify during their rover's operation. Each Ice deposit successfully drilled and the data successfully uploaded whilst in the 'uplink zone' will 'bank' the points for those targets.

**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 E: Technical Specification

The technical specification given here contains all the requirements that must be met by a team to progress through both the PDR and CDR, and to progress to the competition event.

## E.1 Rover Requirements

***Table E-1: Structure and Mechanics***

| # | Requirement | Description |
|---|---|---|
| MEC-1.1 | Mass | The integrated rover and cargo payload shall have a combined mass of no more than 5kg. |
| MEC-1.2 | Stowed Volume | The rover, including any stowed payload and solar arrays, shall be limited to a stowed boxed volume envelope of 0.03 cubic metres. There are no specific dimension limits. |
| MEC-1.3 | Deployed Volume | The deployed rover shall have no specific dimension limits.<br>NOTE 1: Deployment takes place after the run start and must be remotely activated |
| MEC-1.3 | Vibration Environment | The rover shall be designed to survive the launch vibration environment as specified in appendix D.2.<br>Note on use of adapter plates: Simple spring adapter plates typically lead to low resonant frequencies which would cause large increases in the loads experienced by the rover and as such are not recommended. Complex designs, which would be allowed for space use, are likely to be cost prohibitive.<br>The mass of any adapter plates will be included in the calculation of requirement #1.1. |
| MEC-1.4 | Vibration Test Attachment Mechanism | The rover shall be attached to the vibration system with the interface described in appendix D.2. |
| MEC-1.5 | Static Stability | The integrated rover and sample collection system shall be statically stable in all directions to an angle of at least 30 degrees. |

| | | |
|---|---|---|
| MEC-1.6 | Minimum number of interfaces | The rover shall have a minimum number of 4 bolts to interface with the vibration bed. |
| MEC-1.7 | Bolted Interface to Vibration Plate | The interface to the vibration plate must allow a bolt of at least 40mm in length to pass from the inside of the rover to the vibration plate.<br>NOTE: this means that access to the internal side of the interface holes of the rover must be accessible |
| MEC-1.8 | Rover Interface Access | Access to the internal side of the interface holes of the rover must be accessible for easy insertion of the M8 bolts |

***Table E-2: Power and Propulsion***

| # | Requirement | Description |
|---|---|---|
| PROP-2.1 | Atmosphere | In fitting with the Mars setting of the competition, the Rover shall use a form of locomotion that does not require a significant atmosphere (i.e. no aircraft). |
| PROP-2.2 | Surface | The rover shall be able to traverse an unknown surface of sand and rocks (a description of material conditions is available in appendix C). Rock dimensions range from a vertical height of between 5 to 40 cm, with a nominal diameter range of 5 to 30 cm. The rock distribution should be considered random. The maximum incline of the slope is approximately 15 degrees. |
| PROP-2.3 | Travel Distance | The expected distance of travel that the rover will have to cover during the test is 60 m total. Adding a safety margin to this value is recommended. |
| PROP-2.4 | Time on Surface | The rover must have sufficient power to enable 30 minutes of on-sand operations. |

***Table E-3: Command and Control***

| # | Requirement | Description |
|---|---|---|
| COM-3.1 | Primary communication | Communication between the operating base and the rover shall be wireless (refer to the range in the test pit specification). No time delay is added to the communication system. |
| COM-3.2 | Backup communication | An alternative communications capability shall be included. This may be wired (e.g. Ethernet) and will only be used if unpredictable external factors influence the testing (such as interference). An Ethernet cable will be available for use on the day. |
| COM-3.3 | Legality | All wireless communications must use UK legal frequencies, and should be used responsibly. |
| COM-3.4 | Equipment placement | RF Equipment may be placed at the landing site (location of the rover start). |

| | | |
|---|---|---|
| COM-3.5 | Light of sight and sensing | The teams shall not have line of sight with their rover during the challenge. The team shall be able to operate the rover using its onboard navigation systems only |

***Table E-4: Safety***

| # | Requirement | Description |
|---|---|---|
| SAF-4.1 | Live Voltage | No exposed point or area of vehicle shall carry a live voltage > 12V at any point during operation for the rover. |
| SAF-4.2 | Battery | The vehicle's batteries shall 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 shall be followed (check out the Resources page of the competition website). In the case of LiPo batteries, charge bags and a CE marked LiPo charger shall be used. |
| SAF-4.3 | Kill Switch | The rover shall have an external and easily accessible manual hardware kill switch that isolates battery power from the rest of the rover. |
| SAF-4.4 | Declaration of Autonomy | Rovers with autonomous capabilities shall be highlighted to the judges to ensure that sufficient safety measures are in place. |
| SAF-4.5 | Locomotion Design | Motors & motor connections must be protected from the environment to reduce the risk of exposed wires in the event of a collision. |
| SAF-4.6 | Drill Part | The drill end effector shall not be operated at a speed greater than 60 RPM (1 revolution per second). |

***Table E-5: Payload***

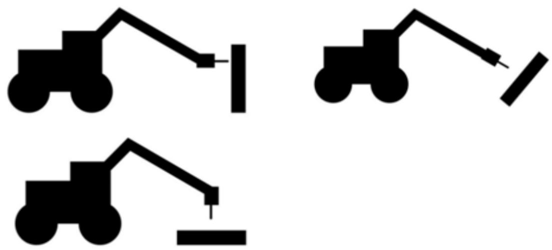
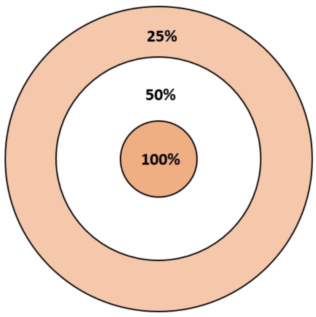
| # | Requirement | Description |
|---|---|---|
| PAY-5.1 | Drill Bit | The rover shall feature a maximum of one 'drill' bit which must be less than 10 mm in diameter at the point of contact with the target |
| PAY-5.2 | Target Axis | Targets could be at any angle in accordance with the following diagram:  |
| PAY-5.3 | Locating Targets | The rover must be able to detect where the targets are in reduced light conditions of a cave and without line-of-sight |
| PAY-5.4 | Target Maximum Height | Targets will be less than 40 cm above the ground |
| PAY-5.5 | Target Definition | The target layout and points % zones will be in accordance with diagram below:   |
| PAY-5.6 | Target Size | Targets may vary in size (and therefore total points), with the smallest central 100% zone diameter being 20 mm |
| PAY-5.6 | Target Contact | The only part of the rover that can be put in contact with the target is the drill bit |
| PAY-5.7 | Vibration Testing | The drill arm must be able to be secured rigidly to the rover body during structural testing |

***Table E-6: Environment***

| # | Requirement | Description |
|---|---|---|
| ENV-6.1 | Illumination Conditions | The illumination conditions for the entire mission will be between 1500 lux to 5 lux<br>NOTE: Half the Mars Yard lights will be turned off. These are the range of readings from one end to the other in the competition light configuration |
| ENV-6.2 | General Environment | The rover shall be designed to operate on dry sand in room temperature conditions |

**NOTE:** The following requirements in Table E-7 and E-8 apply to the virtual power system that will be used to determine your state of charge. They are not applicable to your actual rover power subsystem.

***Table E-7: Power System***

| # | Requirement | Description |
|---|---|---|
| PWR-7.1 | Capacity | The total power system capacity is 12 Wh |
| PWR-7.2 | Power Usage | The discharge rate (W) shall be = Total Rover Mass (kg) * 15 = 15 W/kg |
| PWR-7.3 | Charge Rate | The charge rate (W) shall be = Number of Solar Panels * 180 = 180 W/panel |
| PWR-7.4 | Charge Rate Variability | There will be two events that occur during the mission - a solar flare, which will double the charging rate, and a sand storm, which will halve the charging rate. The rover will only be affected by these events while outside the cave. The forecast for the timings of these will be given closer to the day. |
| PWR-7.5 | Low Power Mode | Low power mode can be activated at any time during the run, and will halve the discharge rate, disable the drill, and give a point penalty of half of what points the rover is currently carrying (but has not transmitted). Once enabled, it may not be turned off, and so no more points can be collected after activating it due to the drill being disabled. |

***Table E-8: Solar Panels***

| # | Requirement | Description |
|---|---|---|
| SA-8.1 | Solar Array Panel Size | A single solar array panel has the L x W x H dimensions of 100 x 50 x 15 (mm). |
| SA-8.2 | Solar Array Mass | The mass of a solar array is <50 grams |
| SA-8.3 | Solar Array Modifications | The solar arrays cannot be modified in any way e.g. cutting or shaping |
| SA-8.4 | Maximum Number of Solar Arrays | The maximum number of individual solar arrays that can be supplied is 10 |
| SA-8.5 | Solar Array Interface | The primary interface of a single solar array panel will be as shown in Annex E.3: |
| SA-8.6 | Solar Array | The solar cell side of each solar array, once integrated to the rover and deployed, must not be covered in any way. Solar arrays that are covered will not be counted towards the power budget. |
| SA-8.7 | Vibration Plate interface | The interfaces of the solar panels may also be used as interfaces with the vibration plate |

**NOTE: a Sparkwing interface control document will be provided post-PDR.**

**Please see section E.3 for the architectural drawing of a single Sparkwing solar array**

### E.2 Vibration Specification

Part of the competition is to build the rover to be able to withstand a test on the vibration table at Airbus. Vibration tables are used to simulate the conditions of a rocket launch and a propulsive landing on Mars. Teams shall build their rovers to withstand the mission vibration environment described here.It is recommended that teams take into account both the mechanical and electrical/electronic problems associated with vibration.

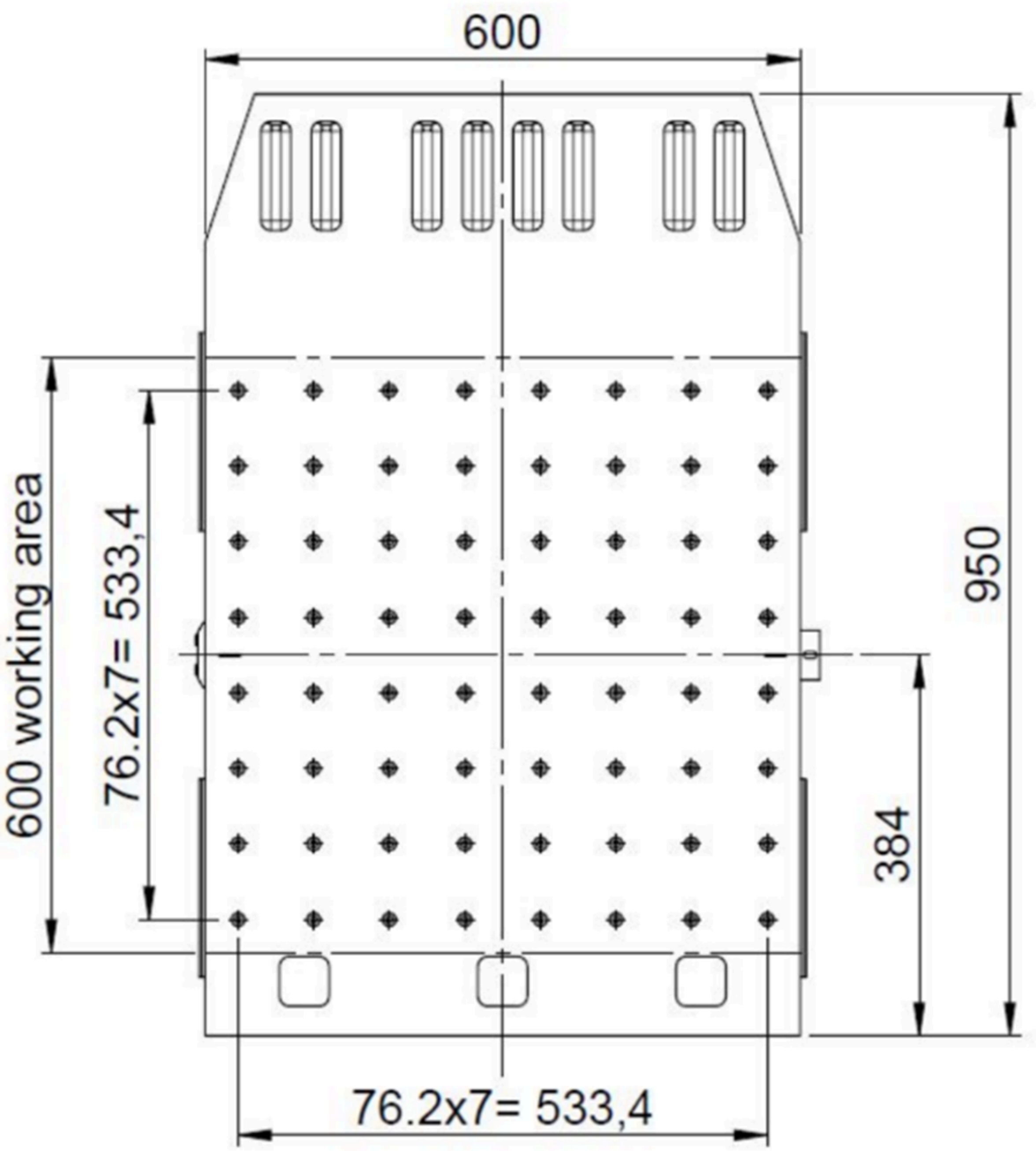
***Table E-9: High Sine Test***

| Frequency Range | Amplitude | Sweep |
|---|---|---|
| 5 - 7.7 Hz | 25 mm | 2 octave/min |
| 7.7 - 100 Hz | 6 g | 2 octave/min |

***Table E-10: Random Test (Duration = 60 seconds)***

| Frequency | ASD* $g^2$/Hz |
|---|---|
| 20 - 80 Hz | +6 dB/octave |
| 80 - 500 Hz | 0.025 |
| 500 - 2000 Hz | -6 dB/octave |
| Overall | 4.5 $G_{RMS}$ |
| *ASD: Acceleration Spectral Density | |

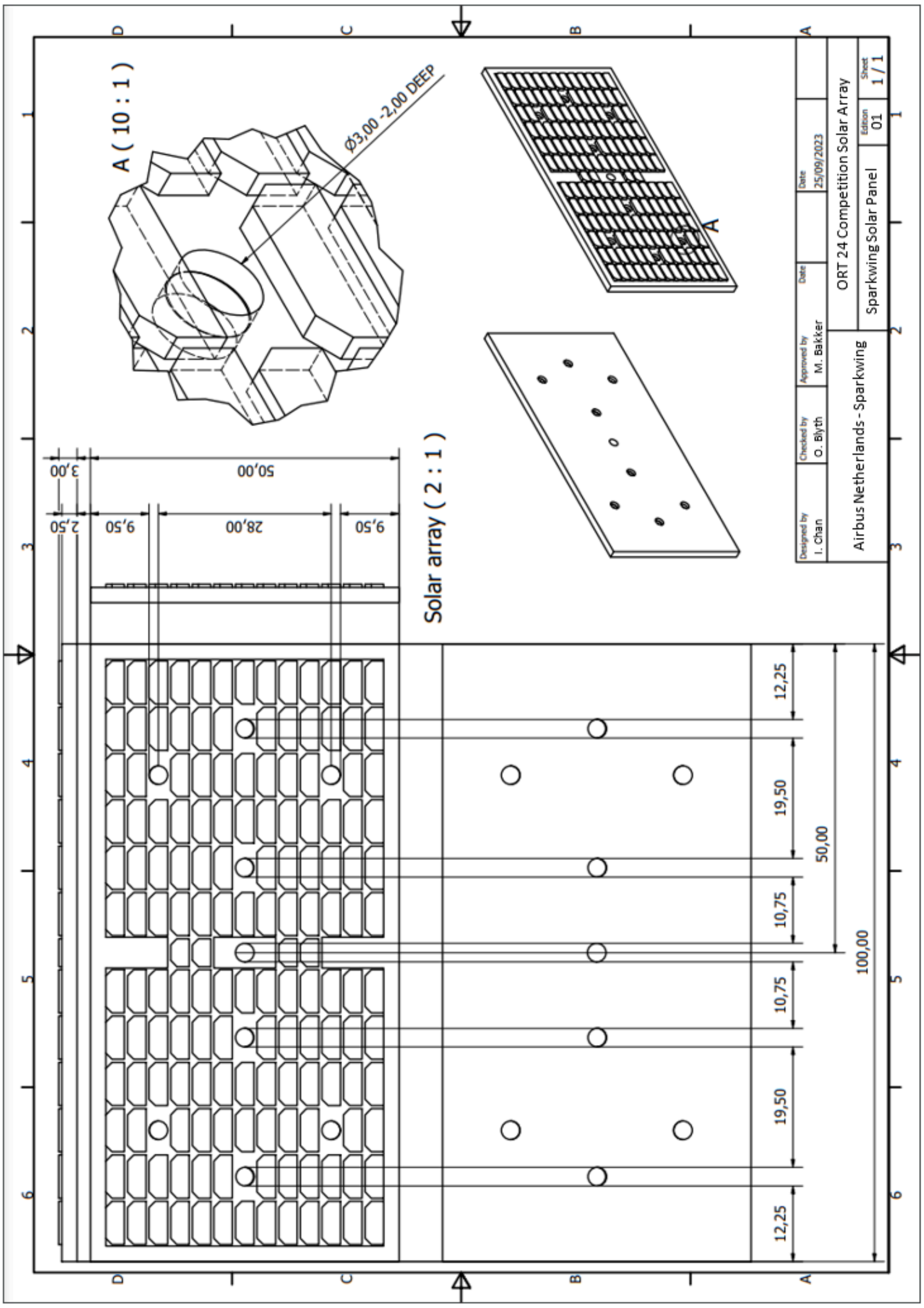



## Key Info

- 76.2mm pitch M8
- 12mm max thread depth

## E.3 **Sparkwing Solar Array - Architectural Drawings**

As SA-8.4 states, teams will have up to 10 of these arrays to be able to integrate on the competition day



## Appendix F: Outreach Award

One of the most important parts of our roles in this industry is to inspire future generations to look at STEM areas for career opportunities. Therefore, we want to encourage teams to perform outreach through their entry into the competition. To win the outreach prize this year, there are two major ways of scoring points; **social media outreach** and **direct outreach** by visiting schools and other groups to talk about STEM.

### Social Media Outreach

To be involved in Social Media Outreach, teams shall create a **rover-specific** public Instagram and/or Youtube account for their rover and share the link of the page to their ORT Point of Contact (If the team already have a rover specific account they can use this as well). Teams can then choose to create posts of their work for the rover and/or any outreach they have performed at schools (if consent from the school and any relevant parties has been granted).
Teams shall not be marked based on the number of likes and/or views of their posts. They shall be scored based on the quality and consistency of their posts and/or videos.

### Direct Outreach

*NOTE: Before performing any outreach activities, please speak to your university outreach/EDI teams to ensure that they can help support you. Some universities may already have rules in place regarding outreach.*
Direct reach is the best way for us to inspire future generations to find interest in STEM. Here teams shall be judged on the total number of hours they spend participating in STEM outreach for schools. Each outreach activity shall be recorded with suitable information.

### How to record an event

To record an event you shall need to create a STEM UK account and register as a STEM UK Ambassador. Once done you shall need to apply for a Disclosure & Barring Service (DBS) check. Most schools require STEM volunteers to have completed this before they attend schools. This process can take two weeks and shall require a short reference. This likely would be best provided by your university mentor. Once your account is completed, you can complete the introduction information on how to attend and record a volunteering event.

**What counts**

Any outreach-related activities can count toward your team's score. This can be presentations, tutorials or anything else. Bonus points can be awarded if the work done is related to your Mars Rover project. The number of students reached out to however shall not impact the scoring. This is because smaller events can also offer a lot of benefits to students and provide more educational benefits than just lectures. The uniqueness of the outreach activities shall also play a factor in the scoring.

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