AUSTRALIAN ROVER CHALLENGE

Founded by the University of Adelaide

AUSTRALIAN ROVER CHALLENGE 2026

RULES AND REQUIREMENTS

VERSION 1.0 20 AUGUST 2025

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Contacts

For *any* general enquiries about the challenge, please feel free to use the general inbox which is monitored by a range of the staff involved with the challenge.

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This is the best way to connect with the technical committee who develop and manage these rules.

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Changelog

Release date	Version	Change notes
09 July 2025	0.9	• Draft released for comment.
20 August 2025	1.0	• Please read this entire document carefully. The most recent version of the rules at the time of competition will apply. Rules from previous challenges do not apply as precedent for any decisions made for 2026. Rulings, defined as decisions made by judges to questions or modifications to the Rules, listed on the FAQ will apply to that year's competition (e.g. FAQ in lead up to 2026 apply to 2026). • Rover Challenge task scoring has been significantly updated with the addition of an Efficiency Multiplier that aims to encourage students to design for real-world constrictions for spacecraft related to size, mass and power consumption. The changes are outlined in appendix D the change, with specific details on how scores for each task will be modified covered in equations eq. (D.1) through to eq. (D.6). • A range of rulings, task activities and point allocations have been modified in these updated rules. These include but are not limited to additional details or revisions of; point allocation for berm construction (see eq. (C.1)), safe carry definition (see rule 3.6.2), cable management (see rule 3.17.3), team communication (see rule 8.12.7), pre challenge checks (see rule 8.2), the use of RFID in the Post Landing task has been removed, with greater emphasis placed on more numerous, and difficult, maintenance activities (see rule 9.7.1), new rulings on the use of materials and thermal management as part of icy regolith processing (see rule 10.5.2.5 and rule B.4.3), point allocation for site prospecting in the space resources task (moved to presentation), and minor changes to imaging requirements for sample site prospecting during the Space Resources task (see rule 10.4.1). • Additional information about a likely NASA International Lunabotics qualifier run in parallel to the Australian Rover Challenge open to Australian teams is provided in rule 3.18.

Vision for the Australian Rover Challenge

The Australian Rover Challenge has been founded with the following four purposes:

- Facilitate the growth of multidisciplinary student teams within Australia.
- Provide a platform for national collaboration towards technological innovation and development within the space industry.
- Pioneer full scale planetary simulation missions to validate new technologies towards resource utilisation on the Moon and Mars.
- Promote collaborative learning and friendly competition for new and growing Australian student teams.

Acronyms and Abbreviations

ARCh The Australian Rover Challenge

AUD Australian Dollars

CDR Critical Design Review

E-STOP Emergency Stop

GLONASS Global Navigation Satellite System

GPS Global Positioning System

ISRU In-Situ Resource Utilisation

QZSS Quazi-Zenith Satellite System

RAZ Regolith Acquisition Zone

SAR System Acceptance Review

Glossary

activity An objective of a competition task that awards points for completion

arena A marked area setup to simulate either a lunar or martian surface on which the rovers compete in the competition part of the challenge

competition The main portion of the challenge held over a number of days in Adelaide, in which the rovers compete physically on the challenge arenas

deliverable One of a number of documents or tasks required to be completed by specific due dates prior to the competition part of the challenge

rover The physical entry of a team in the competition portion of the challenge

supply cache One of a number of large artificial props on a challenge arena

task One of four major rounds at the competition part of the challenge

team The set of individuals tasked with operating a rover entry

the challenge The Australian Rover Challenge as a whole

Part I.

General Rules

1. Key Dates

The key dates and deadlines for the 2026 competition are as follows:

20 August 2025 Rules and Requirements released, team registration open.

4 September 2025 Critical Design Review (CDR) guidelines released

17 September 2025 Team registrations close

29 October 2025 CDR due, System Acceptance Review (SAR) and Cost Report Guidelines guidelines released

11 February 2026 SAR and ”proof of life” video due

11 March 2026 Cost Report due

25 March 2026 Australian Rover Challenge opening cermony and event

26 March 2026 Australian Rover Challenge competition starts

29 March 2026 Australian Rover Challenge competition ends

Dates may be adjusted at the discretion of the judges. In this case, an announcement will be made to all registered teams in advance, and a new version of this document with updated dates will be published.

2. Challenge Rules

2.1. This document outlines the rules and regulations that govern the 2026 Australian Rover challenge.

2.1.1. This document can be updated at any time. The publication of a new version will be announced to all registered teams.

2.1.2. Every effort is made to make these rules as clear and specific as possible. There may still be occasional errors or ambiguities. In these cases, the *spirit* of the rules overrides the exact wording. That is to say, if you *feel* like you are being underhand or getting by on a small technicality, it may be wise to reconsider.

2.1.2.1. The technical team is readily available to all registered teams to clarify any potential misunderstandings, so please do not hesitate to reach out if anything seems misleading or unclear.

2.1.2.2. If concerns are raised by teams to this effect, every effort will be made to provide an updated version of the rules with clarifications present.

2.1.3. Where specific consequences are not given, a fair penalty for breach of any of the rules and regulations may be determined by the judges and/or organising committee, and may include but is not limited to points penalties, disqualification from the challenge, and a temporary or permanent ban from future challenges.

2.2. The key words “MUST”, “MUST NOT”, “REQUIRED”, “SHALL”, “SHALL NOT”, “SHOULD”, “SHOULD NOT”, “RECOMMENDED”, “MAY”, and “OPTIONAL” in this document are to be interpreted as described in RFC 2119, even when not rendered in capital letters.

2.3. The term *team* refers to the individuals tasked with operating a single rover entry. A university is not limited in the amount of teams that they may enter, and teams from a single university may include overlapping team members. Teams may consist of members from more than one university only at the judges’ discretion. Please contact judges for any inquiries related to team/inidividual eligibility (i.e. recently graduated-student or multi-university team participation).

2.4. The Australian Rover Challenge (ARCh), also referred to as *the challenge*, is primarily based around the *competition* made up of the four *tasks* set out in part III. Each task is made up of various point scoring *activities*, and is conducted on a competition *arena*. In addition, in the lead-up to the competition portion of the challenge, a series of *deliverables* are required of each team, as set out in part II.

2.4.1. Teams *must* successfully complete each deliverable on time and to an acceptable standard according to the judges in order to compete in the competition. Given the limited number of places at the challenge, a team may be denied entry even if they meet these minimum standards.

2.4.2. Teams are *not* required to attempt every task in the competition. Teams must notify the judges of which tasks they intend to compete in as part of the critical design review – see rule 5.8.

2.5. The individuals making up a team shall be students of any study level. Guidance and assistance from university staff may be drawn upon, however direct, dedicated involvement from university staff is prohibited.

2.5.1. University staff in this respect refers to any university employee who is not actively studying to attain a higher level of education than they already hold. Students who hold casual or part time positions such as, but not limited to, demonstrating, tutoring or assisting research, are excluded from the definition of university staff in this instance.

2.5.2. There is a one year grace period to continue competing in the challenge after graduating. This is to assist with the handover of leadership between years and ensure that students who have made an impact on a rover and team are able to attend the challenge the following year.

2.6. Cross-university hints, tips, tricks, advice and guidance within the spirit of the challenge is permitted and encouraged. Collaboration on detailed design, technical, or assembly work should be minimal.

2.7. All challenge communications and deliverables will be in English. Teams must have at least two members fluent in English to compete.

2.8. Teams are encouraged to review examples of terrain and obstacles in online media of previous iterations of the challenge available at the official ARCh website. This information should be taken as an indication of how previous years have operated, and while changes are made to the rules and challenge from year to year, the essence of the challenge remains similar.

2.9. The tasks, briefings and associated events will occur at the Adelaide University's Roseworthy campus in South Australia. Each team is responsible for all their travel and accommodation arrangements, including visas where applicable and will need to show evidence that this process is underway in the reviews proceeding the event.

2.10. The Australian Rover Challenge can only have a set number of participants, so reserves the right to limit the total number of teams invited to the competition part of the challenge based on the outcome of submitted deliverables. This is at the judges' discretion.

2.10.1. In alignment with the challenge's vision and values, Australian teams may be prioritised in the selection of teams invited to compete in the competition.

2.10.2. The judges also reserve the right to prioritise a mix of international competitors, that may result in promising developmental teams, or teams from varying regions, being invited into the challenge over teams with higher review scores in some cases.

2.11. Only rules written in the latest version of the rules listed on the official ARCh website, or rulings listed on the website Frequently Asked Questions (FAQ) apply to the current year's challenge. All rules and rulings from prior years are not precedence for future years.

2.12. A formal dispute resolution process is in place. For any disputes, the team and respective sub-team lead are to visit the judge tent after the last task of that day is finished, with clear evidence and supporting documentation (e.g. rule numbers) of the issue you would like to dispute, and

conceptualisation of a reasonable outcome you would like achieved. The judges will then take your dispute under consideration and provide an outcome within a reasonable time-frame – likely by the start of the tasks on the next day, but it may be longer if the situation is complex or contingent on additional factors.

3. Rover Rules

3.1. The *rover* shall be a stand-alone, off-the-grid, mobile platform. Tethered power and communications are not allowed.

3.1.1. Specific activities may allow for the pre-placement of additional payloads or components outside of the designated start area – the specific rules in these cases are found under each task.

3.1.2. Multiple robot systems are allowed (i.e. micro-rover). The total mass and starting dimensions of all system(s) must comply within the mass and volumetric dimensions given in rules 3.4 and 3.5. Similarly, any powered external systems (i.e. external processing plant, micro-rover, deployed relay antenna, etc.) must conform to the E-STOP and LED requirements in rules 3.9. A single, connected system must leave the start gate. All systems must be fully under the team's control at all times, and all communications must adhere to rules given in 3.12. The robot does not have to re-assemble prior to the end of the competition run.

3.1.3. Flying drones, or Unmanned Aerial Vehicles (UAVs), shall not be used.

3.2. During a task, teams shall only communicate with, control, and influence the rover from a remote base station, and must do so wirelessly via antennas or equipment near the challenge arena connected to the base station.

3.2.1. The contents of the base station and connected antennas (other than what is provided as per rule 8.8.1) are entirely provided by the team, and although they are not part of the rover itself, they are considered part of the overall system design.

3.3. The *essence* of the rover system shall be the same for all of the tasks that a team participates in. Different payloads and sensing systems may be present on the rover – or in the case of some specific activities, off the rover – the platform of the rover must be the same from task to task.

3.3.1. The platform of the rover refers to the systems which make up the core of the rover and typically cannot easily be changed or adjusted. This includes, but is not limited to, the chassis, suspension, core computing, power systems, and drive systems.

3.3.2. The platform of the rover must demonstrate novel design work by the team. The platform must not consist of a commercial-off-the-shelf unit.

3.4. Rovers shall be weighed by the judges during the set-up time of each task. The rover must be able to fit on the lander at the beginning of the Post Landing task. The lander constitutes a 1.6 × 1.6 m square platform, and be no taller than 1.6 m in its on-lander orientation. At this time, rovers will also be measured with the width, length, and height of the minimum volume virtual box that could contain the rover recorded. The rover mass and volume will be used to help calculate the efficiency point bonus covered in appendix D.

3.4.1. Rovers may articulate, fold, or bend to fit within the lander, and must not be disassembled to do so. This includes wheels, antennas, and any other system protruding from the rover.

3.4.2. Once a rover is positioned on the lander in a configuration which meets the size requirements, interference from team members is not permitted. If the rover articulates, folds, or bends to fit within the lander, the rover must be able to manoeuvre into a position to start the task by itself.

3.4.3. The same rover footprint requirement will be used for all tasks, even if the rover is not required to start on the lander.

3.4.4. Failure to fit within the specified dimensions will result in a **50% penalty** for each task where the rover is non-compliant.

3.5. The maximum allowable mass of the rover and payloads when deployed for the Post-Landing and Mapping & Autonomous tasks is 50 kg. The maximum allowable mass of the rover and payloads when deployed for the Space Resources and Construction & Excavation task is 60 kg. The total mass of all fielded rover parts across all tasks is 90 kg.

3.5.1. For example, a modular rover may have a robotic arm and a sensor that are never on the rover at the same time. The combinations of rover plus arm or the rover plus sensor must each be under 50 kg. The total rover plus arm plus sensor must be less than 90 kg.

3.5.1.1. The weight limits do not include any spares or tools used to repair, prepare or maintain the rover – e.g., swapping out a 1 kg wheel for an identical spare between tasks because it broke in an earlier task still only counts as 1 kg towards the fielded parts limit, not 2 kg. Swapping out the wheels for a slightly different design that is better suited to a specific task, however, *would* include the weight of both sets of wheels towards the limit. Ultimately, what counts as a spare vs. an alternate part is up to the judges' discretion.

3.5.2. For each task where the rover is overweight, teams will be subject to a **10% penalty** *per kilogram* over the limit for that task. For example, a 52 kg rover in Post-Landing scoring 80 points will be awarded 64 points after the penalty is applied.

3.5.3. Teams will not be allowed to attempt a task if the fielded parts would cause them to exceed the 90 kg limit at weigh-in. If time permits, they may remove or adjust parts of their rover and have it re-weighed until they are below this limit. No extra time will be allocated to their task attempt in this case.

3.6. Throughout the challenge, teams may be required to carry their rover up to 200 m. If teams are unable to demonstrate that they are able to perform safely carry their rover with minimal risk of injury (to those carrying and the general public), they will be required to make use of transportation equipment provided by the challenge organisers (trolleys or otherwise) to move their rover. This may result in lost time at critical moments of the challenge, and is the team's full responsibility.

3.6.1. Payloads (i.e. robotic arm) must be capable of being locked or held in place and support themselves during the carry. Standalone space resources processing units, and pavers that will start off the rover are excepted from this rule.

3.6.2. The rover shall have a minimum of four (4) lifting points, safe for human hands or carrying handles, and be clearly marked (ISO 7000-1368) for use. Teams are responsible for

placement and removal of their rover onto the challenge arena. There must be at least one person per 30 kg of mass of the combined system, requiring a minimum of two people to carry the maximum allowed mass of 50 or 60 kg, depending on the task (see rule 3.5).

3.7. The total cost of the rover in its fielded form, all additional payloads/components and base station systems (i.e., everything that is required to operate the rover), and the value of all manufacturing, labour, and in-kind support must be reported to the judges in the Cost Report. Additionally, a cost limit for the entire fielded rover and related systems is in effect – see chapter 7 for details.

3.8. Rovers shall utilise power and propulsion systems that are applicable to off-earth operations. Air-breathing systems are not permitted. No power, propulsion or auxiliary system may ingest ambient air for the purpose of combustion, other chemical reaction that yields energy or to operate any other process requiring the ambient air. Fans are allowed for the purpose of cooling the rover.

3.8.1. Rovers may carry onboard reservoirs of material to support pneumatic, hydraulic or other systems requiring such materials. Teams should take care to minimise outgassing and other loss of material, especially hazardous material.

3.9. All independent electrical subsystems on the rover or any other payloads must have at least one Emergency Stop (E-STOP) switch.

3.9.1. There should be at most one independent electrical subsystem per discrete system, e.g. one for the rover and all on-board payloads, one for a separate resource processing payload, etc.

3.9.1.1. It may be allowable to have more than one electrical subsystem per discrete system if required and appropriate at the judges' discretion. In this case, the E-STOP switches shall be easily accessible and ideally co-located so that all power draw can be stopped simultaneously in the case of an emergency.

3.9.2. The E-STOP switch must consist of a "Commercial Off-The-Shelf" (COTS) red latching button with a yellow surround, that is easily visible and accessible on the exterior of the rover by judges and team members.

3.9.3. The E-STOP switch must be easily accessible from any direction, even when payloads are attached.

3.9.4. This E-STOP switch shall immediately stop all movement and cease all power drawn from batteries in the event of an emergency such as a battery fire.

3.9.4.1. The button should disconnect the batteries from all controllers (high current, forklift type button) and it should isolate the batteries from the rest of the active sub-systems as well.

3.9.4.2. Resetting of the E-STOP alone shall not resume operation. A second deliberate action shall be needed, such as the pressing of a reset button.

3.10. All independent electrical subsystems shall have a clear external light-based indication of powered on/active status, such as an LED strip or rotating beacon light that can be viewed in broad daylight from all sides of the rover, even when payloads are attached.

3.10.1. This light must be visibly and clearly on if the subsystem is powered, and visibly and clearly

off if the subsystem is unpowered.

3.10.2. The indicator light must either a) be statically amber in colour the entire time that the rover is powered, or b) adhere accurately at all times to the following list of colours and their respective states:

3.10.2.1. **White (R+G+B):** Interactive – safe interaction with rover is possible, rover is not going to start moving until light changes (ensure new light colour – likely blue or cyan – is visible for a short countdown before starting any motion when transitioning out of this state)

3.10.2.2. **Blue:** Motion – motion enabled, rover is under manual control

3.10.2.3. **Cyan (G+B):** Initiating automatic motion – will begin to move automatically soon

3.10.2.4. **Green:** Automatic motion – currently carrying out an automatic program of movement (ensure a short countdown in the cyan state before transitioning into this one)

3.10.2.5. **Yellow (G+R):** Locked – mechanically locked or otherwise inoperable

3.10.2.6. **Magenta (R+B):** Conflict – rover starting up, conflicting light state signals, or error with the *indicator light* (make this the default/timeout state for the light)

3.10.2.7. **Red**: Error – an error with the *rover* beyond the indicator light has occurred

3.10.3. Teams must ensure that a static amber light is very clearly distinct from a colour-coded light displaying red or yellow. It is recommended that a commercial off-the-shelf amber safety beacon is used to ensure this.

3.10.4. Teams may use both a static amber light and a state-based colour-coded light, but the states indicated by the coloured light must still be accurate at all times if in use.

3.10.5. If using a commercial off-the-shelf *stacked* safety beacon tower with standardised red, green, and blue lights to represent the different states, teams may use the co-located green and blue lights illuminated simultaneously to represent cyan (and so on for the other secondary colours), plus all lights illuminated to represent white.

3.10.5.1. Most standardised beacon towers will contain an amber light between the red and green lights. If teams use a tower where an amber light is present, they should use this as a static indicator light while the subsystem is powered.

3.11. Teams maintain responsibility for the safety of their rover, as it pertains to other challenge participants and the general public, at all times.

3.12. The following considerations apply to communications:

3.12.1. It is expected that teams bring their own two-way handheld radios (i.e. walkie-talkies) for the base-station and field teams to communicate during setup and packdown. To reduce radio-communication interference, teams must ensure these radios operate on Ultra High Frequency Citizen Band (UHF CB) frequencies (476.4250 to 477.4125 MHz) to reduce

radio-interefence with competing rovers, as many cheap off the shelf radios may operate on 2.4 Ghz and not appear on spectrum analyzers.

3.12.2. It is recommended that at least one member from each team obtains an amateur radio licence.

3.12.3. Teams may operate on any of the 900 MHz, 2.4 GHz, or 5 GHz bands, but are responsible for ensuring that they comply with ACMA regulations for the frequency band in which they operate.

3.12.3.1. The use of specific low power (these power consumers are not part of the total powerconsumed COTS meter) Bluetooth transmission equipment in the 2.4 GHz range is allowed for sensors and other robot communications. Bluetooth is allowed only at power levels of Classes 2, 3, and are limited to a maximum transmit power of 2.5 mW EIRP. Class 1 Bluetooth devices are not allowed.

3.12.3.2. The use of ultra-wideband (UWB) transmission equipment is allowed but must conform to appropriate ACMA regulations and require written approval from ACMA and the ARCH judges. Teams operating on UWB must adhere to relevant antenna requirements (rule 3.15) and operating windows in regard to their task start and end times (See Figure 8.1).

3.12.4. As there are two pitches, two teams will be attempting tasks concurrently. To minimise interference between competing teams and nearby non-competing teams, specific 'competition' and 'practice' non-overlapping 20 MHz bands will be allocated for each pitch.

3.12.4.1. For 2.4 GHz during competition, pitch A (for Post Landing and Excavation & Construction tasks) will compete on channel 1 (2412 MHz) and pitch B (Space Resources and Mapping & Autonomous tasks) will compete on channel 11 (2462 MHz) – see fig. 3.1. This leaves channel 6 (2437 MHz) available for teams to practice. Whilst competing, a team is permitted to bond two 20 MHz channel to form a 40 MHz band (i.e. Channel 1-5 or Channel 9-13) and do so at their own choice and increased risk of interference. During practice or setup teams are not permitted to bond two channels, for risk of interfering with a competing team.

3.12.4.2. Although teams can occupy channel 6 on 2.4 GHz for practice under remote control, it is strongly recommended that teams use a hardwired connection, to reduce congestion on the network and out of respect for competing teams.

3.12.4.3. For 900 Mhz, teams must adhere to ACMA regulations regarding power (-dB) and frequencies occupied.

3.12.4.4. For 5 GHz, teams are permitted to channel hop and use parts of U-NII-2A (5260-5350 MHz), U-NII-2C (5470-5710 MHz) or U-NII-3/4 (5730-5850 MHz). It is the teams' responsibility to adhere to ACMA regulations. As per AS/NZS 4268 B1 and B2, transmitters designed to operate in any part of 5250–5350 MHz and 5470–5725 MHz bands shall implement dynamic frequency selection (DFS) in accordance with sections 4.7 and 5.3.8 and Annex D of ETSI EN 301 893 or alternatively in accordance with FCC paragraph 15.407(h)(2). Also as per AS/NZS 4268 B3 and B4, transmitters designed to operate in any part of 5250–5350 MHz and 5470–5725 MHz bands shall implement Transmit Power Control (TPC) in accordance with sections 4.4 and 5.3.4 of ETSI EN 301 893 or

alternatively in accordance with FCC paragraph 15.407(h)(1).

3.12.4.5. Teams are permitted to power on and occupy their allocated competition band at the start of their setup time, and must power down and fully disconnect at the end of their task time. Teams are not permitted to occupy their competition band during the brief and weigh in, or during the base station clear out. See Figure 8.1.

3.12.5. The 2.4 and 5 GHz channels will be monitored by judges. Frequencies outside this range (i.e. 900 MHz) will not be monitored.

3.12.5.1. The competition takes place at Adelaide University's Roseworthy campus, which can be a highly congested RF (particularly WiFi) environment. Teams should consider this when designing their communications systems, and take steps to avoid foreseeable complications.

3.12.5.2. Teams shall ensure that their communications equipment can automatically or manually switch between frequency bands, should there be any interference such as those from the audio-visual (AV) equipment used to livestream the ARCh. Interference from sources not related to, or under control of the ARCh judges, which includes the Eduroam wifi network and AV equipment, will not be grounds for protest by any team.

3.12.5.3. Teams shall be prepared to adjust their communications in the scenario that 'competition' or 'practice' bands need to be reallocated by judges due to an unforeseen event.

3.12.5.4. Teams must be prepared to adapt to unforeseen technical or AV disruptions without expectation of time extensions or scoring adjustments. Such issues, while regrettable, are outside the judges control and will not be grounds for appeal. To mitigate this, teams must verify compatability with provided AV equipment and the ARCh livestream as part of the mandatory requirements check prior to competition, as per rule rule 8.2.

3.12.5.5. Each team will be assigned a SSID at check-in that they must use for all WiFi networks across the competition, to facilitate monitoring of the communications environemnt and assigned frequencies. If teams have multiple networks, they may add short suffixes to the assigned SSID to disambiguate (e.g. '-5G' or '-rover'). Even though we are not allocating specific 5 GHz frequencies, teams must still use their SSID for 5 GHz networks.

3.12.5.6. If a team is found to be on the wrong channel during their competition attempt, they will be required to power down and re-start the task with no time extension. If a non-competing team is found to be occupying a competition band as another team is competing, they will be given one strike. Any further strikes will suffer a 50% point penalty to their subsequent competing task.

3.13. The use of any global navigation system (Global Positioning System (GPS), Global Navigation Satellite System (GLONASS), Galileo, Baidou, Quazi-Zenith Satellite System (QZSS)) or any other off-board positioning system is not permitted.

3.14. Similarly, the use of magnetometers is not permitted for any kind of positioning or orientation-based

application.

3.14.1. Magnetometers may be used as part of the ilmenite sensing for the Space Resources task.

3.14.2. Otherwise, COTS components that contain magnetometers may still be used, providing no data from the magnetometer is collected and this can be demonstrated to the judges.

3.15. The following considerations apply to base station antennas:

3.15.1. Base station antennas shall be positioned during the set-up period and, after the start declaration of task conditions, shall only be repositioned by a team member during an intervention as in rule 8.12.

3.15.2. Base station antennas must be no greater than 2 m tall.

3.15.3. Teams are required to supply their own cable at least 20 m in length to reach from the base station to their antenna.

3.15.4. Antennas will be placed in close proximity to the competition arenas, in a small area designated by the judges, which means that a wide beam width is required to ensure reliable communication with the rover anywhere on the arena. A minimum beam width of 90 degrees is recommended, unless active tracking technologies are used in combination with a more directional antenna.

3.15.5. Metal crowd barriers and large metal seating may line the arena and surrounds, which can interfere with, or block, some wavelengths.

3.15.6. Teams may use any number of antennas, for example for different bands, provided they are all positioned within the small antenna area adjacent to the arena.

3.16. The challenge arena may experience different forms of extreme weather (hot, dry, cold, windy or wet). Although rain is uncommon at this time of year in Roseworthy, rovers must be able to operate in variable conditions, such as in a light rain shower.

3.16.1. Judges reserve the right to consult and implement any amendment relating to adverse weather implications that rovers are at risk of significant damage from the weather event e.g. rain. This could include postponement or cancellation of an entire day. Judges may consult and confer with team leads to evaluate their preference to compete during inclement weather. Judges are not responsible if a rover becomes nonfunctional for the remainder of the competition if a team chooses to continue.

3.16.2. If, due to weather, one team cannot compete for the full duration of a task, judges will endeavour to defer them to another time. Please note, this may not be possible dependant on site access, safety and after-hours facility and judge availability.

3.16.3. If, due to weather, two or more teams cannot compete fully in a task, that task will not be included in overall scoring for all teams competing. Please note, for teams on the day who are still able to compete in that task, a score will still be calculated with the sole intention of providing a metric of performance, but will not contribute towards points for that task.

3.16.4. In the scenario of a catastrophic fire warning by the South Australian Country Fire Service, which are published daily (and communicated to Adelaide University by the Bureau of

Meteorology) at approximately 4:30 pm AEST, Roseworthy Campus will not be accessible for any teams and non-critical staff. Due to the unpredictable nature of fire warning, conditions may change at any instant. Teams are required to explicitly follow the directions of judges and university staff if on campus. Teams must have their own fire-safety plan related to their operations and management of their team.

3.17. To increase alignment with real-world design constraints when designing, building and flying space-craft, the following factors will influence points calculated for each task, and ultimately the final ranking; minimizing system size & mass, and minimizing power consumption.

3.17.1. See appendix D for details on how task scores will be modified according to the design efficiency of each teams' rover, with specific details on scoring outlined by equations D.1 through to eq. (D.6).

3.17.2. The energy consumed by the rover (or any independantly powered system, adhering to rule 3.1.2) must be recorded with a COTS electronic data logger device. Teams are recommended to use this device, or some similar alternative that allows judges to clearly record the power consumed during a task. Actual energy consumed during each attempt must be shown to the judges on the data logger immediately after the attempt.

3.17.2.1. The power data logger must not be switched off in the event of an E-STOP. The logger shall be schematically located between the battery and kill switch, so the readings are not erased if the E-STOP button is activated. The devices shall be placed on a practical location on the system and be easily visible to judges.

3.17.3. The cable management of each rover and any independant systems will also be evaluated by judges during the Mandatory Requirements Check (See rule 8.2) prior to competition start. This is to incentivize student alignment with industry best practice. Team's will be advised of a Go/No-Go at the judges' discretion, similar to rules related to LEDs and E-STOP. Teams must justify to judges why any cables or wires are exposed, and if they are exposed, if they have been properly fastened to avoid catching, snagging, or interfering with any other sub-system or system functionality.

3.18. An Australian team *may* receive a letter of invitation to participate in the upcoming International Lunabotics competition held at the NASA Kennedy Space Centre in late 2026. Selection will be based on a teams' performance in an International Lunabotics qualifier held in parallel with ARCh. The task for this event will be similar to the Berm Construction activity from the Excavation & Construction task, and will be held in the Covered Regolith Analogue Terrain for Experimental Research (CRATER) facility located next to the ARCh competition arena. Scoring will be based on the total volume of berm constructed in the allocated time with adjustments for rover size, mass and power consumption. Prior to participation in these qualifiers, teams must show evidence of pre-approved support of their host university to both finance any travel, support the postponement of exams (if required) and assist with any travel visas or additional requirements (i.e. shipping the rover via freight, rather than transport via personal luggage on passenger aircraft). More information about the event will be provided to registered Australian teams as it is developed.

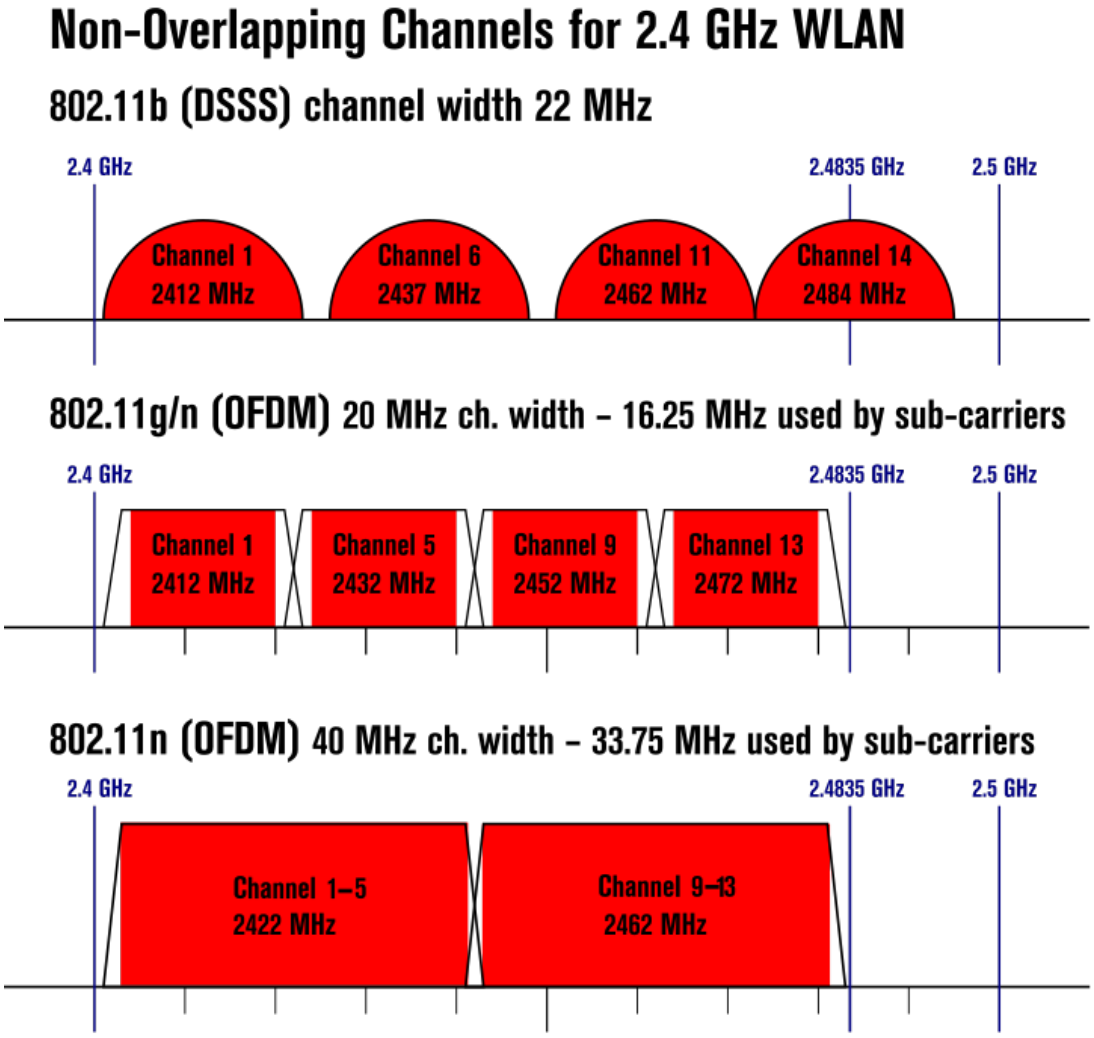

Figure 3.1.: 2.4 GHz Frequency Diagram

4. Scoring and Prizes

4.1. The scoring and prizes will be awarded by the panel of challenge judges. The judging panels will be made up of professionals from academia and industry, and will be confirmed closer to the competition.

4.2. Teams are awarded points based on their performance in competition tasks, as well as the assessed quality of some of their provided deliverables.

4.2.1. Each competition task is made up of point-awarding activities, with a total of **100 points** available in each task.

4.2.2. Each task will also have up to an additional **25 points** available for efficient operation, with details outlined in appendix D.

4.2.3. Additionally, up to **100 points** will be available between the CDR and SAR, with the points breakdown of these available at a later date.

4.2.4. The total number of points available across the whole challenge is **600 points**.

4.3. As set out in these rules, teams may receive penalties from the judges.

4.3.1. These penalties are assigned per task. They can be an absolute number of points, but are generally a percentage e.g. the 50% penalty for oversized rovers as in rule 3.4.4.

4.3.1.1. In rare cases, these penalties are assigned per activity. In these cases, similar rules to below are used to determine the score for each activity, and then task-level penalties are applied to the sum of the adjusted activity scores.

4.3.2. These percentage penalties are *additive*, and the sum percentage will be subtracted from the team's total score for the task.

4.3.2.1. Note that this is a percentage of the team's actual awarded score, not the maximum available.

4.3.2.2. For example, if a team received a 30% penalty and another 20% penalty for a task in which they scored 60 points, their final score would be $60 \times (1 - (30\% + 20\%)) = 30$ points.

4.3.3. Total penalties are capped at 100%, and teams cannot score lower than zero for each individual task or deliverable.

4.4. A number of prizes will be awarded to teams as follows:

4.4.1. Awards for the best performing team in the pre-challenge design review reports, and for each task at the challenge.

4.4.2. An overall challenge prize will be awarded based on the sum of all scoring activities.

4.4.3. Best team culture and display of camaraderie throughout the event.

4.4.4. Community spirit and demonstration of challenge values throughout the event.

4.4.5. Best first year team will be awarded to the new team with highest score (noting participation at other international challenges will discount a team from competing in this category).

4.4.6. Stellar progress award for most improved team will be awarded to the team with the biggest increase in points from the previous year's competition.

4.4.7. Additional prizes may be added to this list or awarded at the competition at the judges' discretion.

4.5. The design of each task and the point distribution for each activity has been curated to accommodate teams of varying experience levels - from new teams to more advanced and mature teams. In general, each task's activities can be categorised based on their complexity levels: basic, intermediate, and complex. Activities in a task are sequenced from least to most difficult.

4.5.1. Basic activities: These activities are designed to assess the fundamental capabilities of the rovers. They typically involve basic navigation and sensing tasks, such as driving forward, backward, turning, and utilising cameras for visual feedback. These activities serve as a foundation for all teams and should be achievable by even the newest participants.

4.5.2. Intermediate activities: The intermediate activities require teams to integrate a dedicated subsystem or component into their rovers. Examples of these subsystems could include a robotic arm, construction payload, or processing unit. This level of complexity allows teams to demonstrate their ability to incorporate specialized functionalities into their rover design.

4.5.3. Complex activities: The complex activities are intended to challenge experienced teams and their rovers. These activities involve using the integrated subsystems in more intricate and sophisticated ways. Teams need to demonstrate not only technical proficiency in dealing with obstacles and executing complex tasks but also strong operator training and time management skills.

4.5.4. In general, approximately the first 25 to 50 points of a task consist of basic activities, with the subsequent 25 to 50 points consisting of intermediate activities, and the final 25 points being complex activities. A single activity can also be broken down into basic, intermediate and complex segments, in order to provide greater distribution of points.

4.5.5. The organising committee strongly recommends that new or novice teams focus on mastering basic activities and rover functionality before progressing to intermediate or complex activities. It is essential to prioritise achieving full points in fewer tasks rather than spreading a team's time and resources thinly across multiple, difficult activities, as has occurred in the past. This approach will allow teams to build confidence and expertise iteratively, making their overall experience in the competition more rewarding and successful.

4.5.6. Teams must nominate in the SAR which tasks they intend to compete in (updated from original nomination during CDR), and demonstrate that their rover will be ready for that task. On the basis of the SAR submissions, judges then have the final say of which teams may compete in each task. This is to streamline scheduling, avoid scenarios of a non-functional

rover.

Part II.

Deliverables

5. Critical Design Review

5.1. Teams will be required to submit a Critical Design Review (CDR) on 29 October 2025.

5.2. The purpose of the CDR is to show that teams are taking a systems engineering approach to their project, demonstrating that the maturity of the design is appropriate to support proceeding with full-scale fabrication, assembly, integration, and testing, and that the technical effort is on track to complete the development of the core rover systems to meet the rules and requirements of the ARC, within the teams' identified cost and schedule constraints.

5.3. NASA videos explaining key project management and systems engineering concepts created for their Lunabotics challenge, along with advice on how to apply them to a university-level design project such as this one, are available at https://www.youtube.com/watch?v=7ieMjLO8cMI&list=PLStC43yAV6zRhiTcHM4x5pF1e-ODXs2Ht&index=1. You do not have to use this specific approach, but it expected that there is clear evidence of selection of a specific systems engineering approach and tailoring to your situation.

5.4. The CDR is in the form of a written report.

5.5. Each CDR report shall contain an identified and tailored systems engineering lifecycle, a clear system hierarchy, mention of identified essential requirements driving design, and indication of tasks the team intends to compete in as entry conditions for the review. Each report will undergo an initial review entry conditions check within 48 hours of the submission deadline. CDR reports addressing all expected elements will receive an "Accepted" message. Any CDR missing these elements upon first submission will receive a "Rejected" message, with the team then having a further 48 hours to update and resubmit the report. Rejected reports will incur a 20% penalty for this element.

5.6. Core Rover systems to be reported upon include, but are not limited to:

5.6.1. Power systems, power delivery, and power safety

5.6.2. Drivetrain

5.6.3. Chassis construction and materials

5.6.4. Perception systems

5.6.5. Base station design and control

5.6.6. Rover communications

5.6.7. Drive control systems (software based)

5.6.8. Additional hardware and software that is specific to each task in which the team intends to compete.

5.7. Teams will also be required to supply a timeline, highlighting consequential tasks, and contingency plans for delayed completion of said tasks.

5.8. The submission of the CDR is also when teams are required to notify the organising committee of the tasks in which they plan to enter their rover.

5.9. Teams are required to nominate the details of the frequency bands that they plan to communicate in.

5.10. Given the limited number of teams that can attend the event, teams may be excluded from the competition based on their CDR performance, taking into account other ARCh constraints.

5.11. More detailed information regarding the CDR will be released according to dates specifed in chapter 1.

6. System Acceptance Review

6.1. Teams will be required to submit a System Acceptance Review (SAR) on 11 February 2026.

6.2. The SAR involves teams explaining their executed systems design process, outlining their final implemented design, and their planned approach to each ARCh task in which they intend to compete. Teams will not be permitted to revise their decision to not compete in a task after the submission of the SAR.

6.3. The SAR will be in the form of a written report, with associated ”proof of life” supporting video.

6.4. Each SAR report shall contain clear evidence of attempted verification for identified essential requirements with associated ”proof of life” video supporting this verification as entry conditions for the review. All rovers shall be capable of manoeuvring on sand at this point, though additional consideration will be given to new teams at judges discretion. Each report and video pair will undergo an initial review entry conditions check within 48 hours of the submission deadline. SAR report and video pairs addressing all expected elements will receive an “Accepted” message. Any SAR report and video pair missing these elements upon first submission will receive a “Rejected” message, with the team then having a further 48 hours to update and resubmit the report and video. Rejected report and video pairs will incur a 20% penalty for this element.

6.5. It is expected that ”proof of life” videos contain footage from laboratory and field tests. At a minimum, it is expected that teams provide evidence that they meet the key requirements for ARCh participation, and that they can set up a base station and tele-operate their rover to drive forward and turn on a simple simulated course environment (i.e. beach or sandy environment).

6.6. More detailed information about the SAR will be provided in the SAR guidelines document, which will be made available prior to submission.

6.7. Failure to meet the minimum rover requirements specified at the time of the SAR may result in teams being excluded from the competition.

6.8. Failure to meet minimum requirements for each task may result in teams being disallowed from competing in those tasks.

7. Cost Report

7.1. Teams will be required to submit a cost report on 11 March 2026.

7.2. The total cost of the rover (in its final form) and base station systems (that is, everything that is fielded/required to operate the rover) must not exceed $35,000 Australian Dollars (AUD).

7.3. The cost limit does not include any team labour, team development software (unless it is also required to run the base station systems), research and development, plant, machinery, or tools. Although these costs do not count towards the cost limit, you must keep track of them regardless as they will still be a required inclusion in the Cost Report.

7.4. The reportable cost for each component is that which any member of the public could acquire the components and parts that make up the whole rover system.

7.4.1. This means that the retail value of components provided as in-kind support must be included.

7.4.2. Costs must not include discounts of any type, but must include the delivery and import fees paid, regardless of the location and jurisdiction in which the components were delivered.

7.4.3. The cost of transporting the complete rover to Adelaide to compete in the challenge does not need to be included.

7.4.4. The reportable cost of components manufactured by the team includes the raw material and fees associated with acquiring the material (sales tax, import fees, shipping and handling.)

7.4.5. For purchases in any currency other than AUD, any widely-available currency conversion rate from the date of the purchase to the date of the cost report submission may be used to find the equivalent value in AUD. All such costs must be reported in both their original currency and in AUD with the purchase date and conversion rate and date included. Only the AUD value will be used for assessing the value of the rover.

7.5. More information regarding the Cost Report and reportable costs are in a separate document, to be made available from February 2026.

Part III.

Competition Tasks

8. Competition Task Logistics

8.1. It is the team's responsibility to transport their rover to the challenge.

8.2. In the 3 days leading up to the competition, teams may arrive on-site and sign-up for the mandatory safety brief and requirements check. Teams are required onsite the day before the challenge starts at the latest.

8.2.1. Team lead(s) must participate in a safety brief, to be given at the judges tent, before being allocated a workshop bay, using any tools or setting up their rover.

8.2.2. Teams must also participate in a mandatory requirements check where the team has an opportunity to verify with judges that the rover adheres to all requirements, and for judges to ensure smooth operations. This includes AV-checks in the base stations to ensure teams can stream views from their rover as part of the ARCh live stream to global audiences.

8.2.3. Further details on the schedule and on-site logistics of the competition will be provided as a Participant Handbook closer to the competiton dates.

8.3. The 2026 competition will take place on two simulated lunar arenas.

8.3.1. The challenge arena is expected to be no smaller than 15 × 15 m, and up to 35 × 35 m and consist of dry, fine-grained sand.

8.3.2. The challenge arena may have any number of the following obstacles:

8.3.2.1. *Supply caches*, which range in height and have footprints varying from 1 × 1 m to 3 × 3 m.

8.3.2.2. Rocks, which may vary in size from passable 20 cm objects to 1 m rocks which may be necessary to avoid, depending on the design of a rover.

8.3.2.3. Terrain features made out of the sand, like ridges and craters, which may present a challenge for rovers to pass, or may be impassable.

8.3.3. All challenge objectives and targets will be located such that traversal of large terrain features and obstacles can be avoided.

8.3.4. Small obstacles (such as 20 cm rocks or drops, or embankments of 30° slope and 0.5 m height) may be necessary to traverse to navigate to all task activities during the allocated time period.

8.3.5. Team members must not walk on the arena unless they are carrying the rover to the starting position, or if they are a nominated part of the field team for a given task. There will be

sufficient space around the perimeter of the arena so that team members can monitor the rover.

8.4. The times allocated to a team for each task they are competing in will be published in a schedule in advance of the competition. These times may be adjusted during the competition at the judges' discretion.

8.5. For each team's attempt at a task, there will be a panel of judges assigned to coordinate, provide information to team members, and score.

8.5.1. During a task, there will always be a judge inside the base station who is able to communicate with the other judges.

8.5.2. During a task, there will always be at least one field judge present. For most tasks, these are the judges who are responsible for scoring the rover as it operates and completes the activities.

8.6. Teams will be given a field briefing at least 10 minutes before the start of their setup time for each task, where they will have to nominate their base station and field teams for the task.

8.6.1. Teams must make themselves available to the judges at their scheduled briefing time, or risk forfeiting their attempt of that task.

8.6.2. During the field brief, teams must clearly demonstrate that the E-STOP is operational and accessible, and that the signal light (i.e. LEDs) are functional, in addition to size and weight requirements from rule 3.4.

8.6.3. If teams are late to the brief they will first incur a strike, then a points penalty for subsequent late attendance.

8.7. The field team must wear safety glasses at all times during a task. Teams must supply their own safety glasses.

8.8. After the briefing, teams will have at least 10 minutes before the beginning of each task to set up their base station.

8.8.1. The base station will include at least two 6-foot tables, four chairs, power sockets, two monitors and HDMI/USB-C splitters to allow the AV team to view and share the monitor feeds as part of the ARCh live stream to global audiences - this shared feed is mandatory and will be verified as part of the mandatory requirements check (see rule 8.2).

8.8.2. The base station will not have any inherent ability to see or communicate outside the base station once a task has commenced (beyond the defined communication with the rover).

8.8.3. During this time:

8.8.3.1. Members from the team may move freely between the base station and arena, to ensure their rover is working as planned.

8.8.3.2. The base station may communicate to other team members in the field using hand-held radios provided by the judges, but teams are encouraged to bring their own.

8.8.3.3. Teams may begin operating in their allocated radiocommunications competition band and operate radios during setup.

8.8.3.4. The rover must not be operated on the arena. An area adjacent to the arena will be available to teams to operate and test their rover to ensure it is operating as planned prior to the beginning of the task.

8.9. Once the setup is complete, the team will notify the judges, and the judges will instruct the field team to move the rover to the start position for the task. Once all team members are clear of the arena and judges have setup the arena, the task will begin.

8.9.1. A team may start a task before their set-up time elapses. Teams will not be granted additional time to complete the task in this case.

8.9.2. Teams may take longer than the allotted set-up time to ensure their rover is working as planned, consuming their task time. The task timer will begin at the conclusion of the scheduled set-up time in this case.

8.9.3. During task time, the use of communication devices such as phones and handheld radios are prohibited within the base station, except during an intervention or reposition.

8.10. Once a team has started a task, team members inside the base station are not permitted to communicate with any team members outside the base station.

8.10.1. This includes that the field team and other team members must not influence the rover's operation or signal to the base station in any way, pursuant to rule 3.2.

8.10.2. Team members not inside the base station at the declaration of the start of the task will never be permitted to enter the base station during that task.

8.10.3. Team members inside the base station may leave at any time, however, they will not be permitted to re-enter.

8.10.4. Teams can expect a limit to the number of members allowable in the base station at the start of a task. Teams should be prepared to operate, in the worst case, with four base station members.

8.11. At any time during the task, the base station team may elect to call the task finished by making this intention clear to the base station judge.

8.11.1. This will also automatically occur at the end of the team's allocated task time.

8.11.2. In this instance, the task is ceased immediately and scored based on the rover's performance up until that point.

8.11.3. Once a task is called finished, under no circumstance shall the task be resumed.

8.11.4. Once the task is over, the base station and field teams are free to move around and communicate with each other.

8.12. An intervention may be called by the base station at any time by clearly indicating this intent to the judges.

8.12.1. The intent of an intervention is to allow teams the chance to pause their task attempt and fix and adjust parts of the rover in-situ so that it can continue in a task where it otherwise could not. During them, teams must not alter the rover's environment or directly influence its task progress.

8.12.2. Teams will receive a **10% penalty** to the current task for each intervention called (note that this applies to points awarded on the field, not for any subsequent presentation).

8.12.3. If a rover becomes immobilized (e.g., becoming bogged in loose regolith), teams are permitted to physically intervene by lifting and rotating the rover by up to 45deg and / or moving the rover to either side by no more than one wheel width to facilitate task intervention. This is permitted solely for the purpose of resolving minor entrapment and must not be used to reposition the rover significantly within the arena. The classification of an intervention or reposition will be at the discretion of the judges.

8.12.3.1. This also applies to independent systems, such as micro-rovers, the paver payload box for the Excavation & Construction task, or the standalone processing unit for the Space Resources task. A single intervention can be called to intervene with any/all of the rover and other standalone systems.

8.12.4. During an intervention, the base station may communicate to the field team using hand-held radios provided by the judges.

8.12.5. Teams may use the E-STOP to power cycle their rover during an intervention if needed without automatically ending the task.

8.12.6. The field team must not relay any information describing any part of the arena, nor the rover's position in it, and doing so will result in immediate termination of the task.

8.12.7. To facilitate judge enforcement of rule 8.12.6, all communication must be done in English.

8.12.8. The field team (and any base station team member who has exited) are the only people who may tend to the rover during an intervention.

8.12.9. The use of any power tools such as drills, saws, soldering irons, ect during an intervention are not permitted.

8.13. A rover reposition may be called by the base station at any time by clearly indicating this intent to the judges.

8.13.1. The intent of a rover reposition is to allow teams to attempt point-scoring activities even if their rover becomes immobile.

8.13.2. Teams will receive a **40% penalty** for any activities attempted after one or more repositions. Note this applies to *whole* activities, even if part of an activity was attempted or scored points prior to the first reposition.

8.13.3. During a reposition, the base station may communicate to the field team using hand-held radios provided by the judges.

8.13.4. The field team must not relay any information describing any part of the arena, nor the rover's position in it, and doing so will result in immediate termination of the task.

8.13.5. The base station must instruct the field team where to reposition the rover, which they must do while the rover is inactive. The rover must not become active again (control any actuation) until the reposition is has been concluded, as declared by the base station.

8.13.5.1. Any rover activity during the reposition may be grounds for the E-STOP to be activated.

8.13.6. Activities which allocate points based on navigation or way-finding are not eligible to score penalised points after a reposition.

8.14. At any time, the field team may elect to activate the E-STOP switch on the rover. In cases of obvious risk of harm to people or property, field judges may also activate the E-STOP.

8.14.1. This is the only time during a task (outside of an intervention as in rule 8.12) that the field team may enter the arena, and if a team member enters, they must activate the E-STOP immediately.

8.14.2. If the E-STOP switch is activated for this reason, the task is immediately ceased and scored as in rule 8.11.

8.14.3. There is no penalty for activating the E-STOP switch.

8.15. Teams do not need to return to the start gate, or collect any deployed items (radio repeaters, cameras, tools, etc.) before the end of time for any of the missions. Deployed items must be collected immediately after the end of the task.

8.16. Once a task has ended teams are required to vacate the arena and base station as soon as possible to facilitate changeover for the next competing team.

8.16.1. Before the team can touch the rover, judges must record the total power consumed during the task.

8.16.2. Teams will then have at least 5 minutes to vacate the base station. During this time the rover and any radio communications must be switched off and safe-carried off the arena

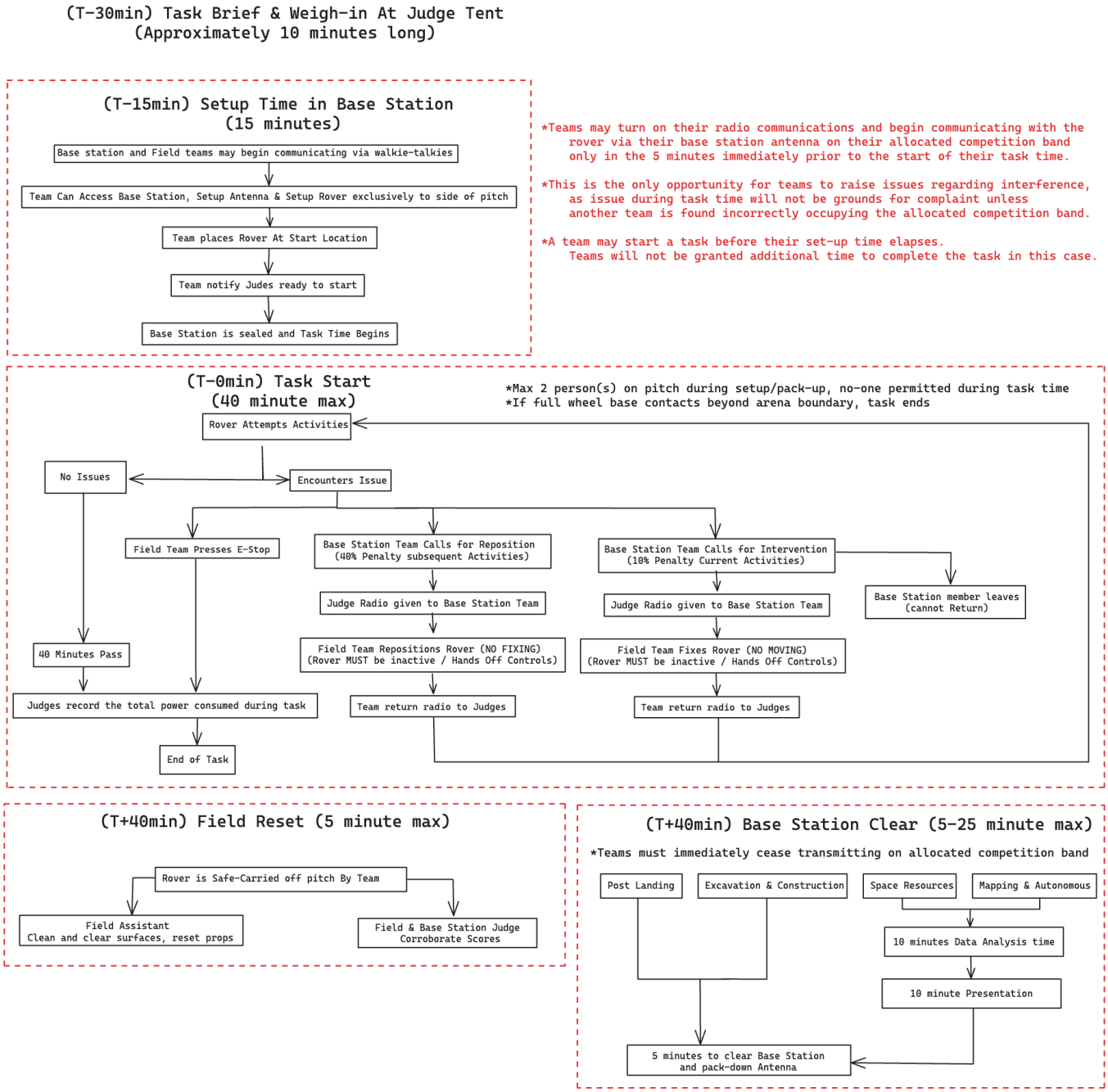

Figure 8.1.: Logistics Flowchart

9. Post-Landing Task

9.1. A total of **125 points** will be available for this task. **100 points** during the task, and up to an additional **25 points** through application of an Efficiency Multiplier as outlined in appendix D.

9.2. Teams will have at least 40 minutes to complete this task.

9.3. Your rover has just landed on the surface of Moon. Your team is required to execute a series of activities to work towards establishing an operational In-Situ Resource Utilisation (ISRU) outpost in preparation for an upcoming human landing.

9.4. Tasks may be done in any order.

9.5. **Activity 1:** Systems Check (**20 points**)

9.5.1. Descend down egress ramp on the Lander (start gate, 1.6 m wide with 20° decline) **5 points** awarded once all wheels contact the ground. **10 points** are awarded for circumnavigate the lander, and **5 points** are awarded for noting any damage that has occurred to the lander during flight and descent to the judges.

9.5.1.1. Visual asset inspection can be done using images collected from onboard cameras and other sensing instruments of the team's choosing.

9.6. **Activity 2:** Site Evaluation (**30 points**)

9.6.1. **10 points** are awarded for navigating to and relaying the status readout of three supply caches around the arena to the judges. Obstacles of a range of difficulties may be encountered (rocks, berms, craters, etc.)

9.7. **Activity 3:** Processing Plant Maintenance (**30 points**)

9.7.1. Perform a series of 6 maintenance jobs using a robotic arm, or otherwise, to interact with buttons, switches, dials, keyboard, plugs/sockets, joysticks or other graspable objects at the processing plant. Instructions will be provided by Base Station judge upon request, and can be completed in any order. **5 points** are awarded for completing each maintenance job.

9.8. **Activity 4:** Propellant Hose Connection (**10 points**)

9.8.1. Your rover is tasked with connecting the lander to a gas line, to support refuelling on the surface. Given the connection is not part of existing lunar infrastructure, teams are required to design and utilise both sides of the connection.

9.8.2. Before the start of the task, teams will be required to affix both sides of the connection to the relevant hardware. One end to the propellant hose, and one end to the lander.

9.8.3. The lander side of the connector must be designed to be affixed to the lander. The lander will provide an interface (which must be used) of 4 x M4 threaded bolt holes, where the centres of the bolt holes on the lander form the corners of a 10 cm square.

9.8.3.1. As the interface consists solely of the bolt holes, teams will need to bring their own bolts.

9.8.3.2. The bolt holes will be configured to allow bolts of any reasonable length to be used.

9.8.4. The hose will then be placed on the arena surface by the field judge, within 2 m of the lander.

9.8.5. During the task, the rover must connect the provided hose, to the lander.

9.8.6. **5 points** are awarded if the hose connector makes any physical contact with the lander side of the connector. Full points will be awarded for this activity if, at the end of the task, the field judge confirms that the hose is connected securely to the lander.

9.8.7. Additional information regarding the hose connection for this activity is available in appendix A.

9.9. **Activity 5:** Modular Propellant Hose Connection (**10 points**)

9.9.1. Your rover is tasked with connecting the processing plant supply cache to a gas line, to support other ISRU operations on the surface.

9.9.2. For this activity, a custom outlet hose connection has been designed by the judges to support a modular approach to lunar settlement, whereby any lunar explorer may interface with the connection. The connection will be present on the processing plant supply cache. Teams must design and manufacture a custom corresponding connection that will be mounted to a provided hose.

9.9.3. Before the start of the task, teams will be required to affix their side of the connection to the end of the provided hose.

9.9.4. The hose will then be placed on the arena surface by the field judge, within 2 m of the processing plant. This is the other end of the same hose used in activity 4.

9.9.5. During the task, the rover must connect the provided hose, using their connector, to the provided outlet on the processing plant.

9.9.6. **5 points** are awarded if the hose connector makes any physical contact with the lander side of the connector. Full points will be awarded for this activity if, at the end of the task, the field judge confirms that the hose is connected securely to the processing plant.

9.9.7. Additional information regarding the hose connection for this activity is available in appendix A.

10. Space Resources Task

10.1. A total of **125 points** will be available for this task. **100 points** during the task, and up to an additional **25 points** through application of an Efficiency Multiplier as outlined in appendix D.

10.2. Teams will have at least 40 minutes to complete this task.

10.3. Towards the goal of supporting future astronauts which need breathable oxygen, potable water and construction materials, your rover must now begin the evaluation, collection and extraction of critical lunar resources including frozen volatiles like H_2O, and metals like Titanium (Ti) and iron (Fe) from ilmenite ($FeTiO_3$)-enriched soils. To do this, your rover has two primary tasks to perform; 1) *in-situ* resource prospecting, 2) then the excavation and processing of a target resource to hand to judges. There will be two types of resource deposits your rover must investigate; dry ilmenite-doped soil representing ilmenite-rich regolith on the Moon, and frozen ice-cemented soil representing deposits of frozen volatiles in persistently shadowed regions (PSRs). Your rover is only expected to process frozen water to extract liquid H_2O.

10.4. **Activity 1:** Prospecting (**8 points**)

10.4.1. Visit two sites of ice-cemented regolith (Site 1 and 2) and two sites of ilmenite-enriched regolith (Site 3 and 4). To receive points, teams must show judges in the base station that the rover has successfully imaged each sample site to the base station judge. **2 points** are available for imaging each site up to a total of **8 points**.

10.4.2. Ice-cemented sites and mineral-enriched deposits will be located in relatively easily accessible regions of the challenge arena.

10.4.3. Passive sensors or any other chosen method to investigate each site. Teams may sample a small amount of regolith from each site to aid in their identification.

10.4.4. An additional **12 points** are avilable as part of the Space Resources Presentation for providing close up, well focused, high-resolution pictures of each sample site where individual grains can be resolved, with some indication of scale.

10.4.5. A further **20 points** are available as part of the Space Resources Presentation for quantifying; (1) the amount of ice and, (2) the amount of ilmenite in each of the respective sites. See rule 10.6.1.3 for point breakdown calculations.

10.5. **Activity 2:** Excavation & processing (**50 points**)

10.5.1. Excavate regolith from an icy sample site of the team's choosing with the aim of extracting the highest amount of liquid water as possible. Teams may use mechanical means or any other approach chosen by the team to excavate the material.

10.5.2. Processing can be performed on-board the rover and/or by a separate standalone processing

unit. Processing must be done entirely within the allocated task time.

10.5.2.1. The maximum dimensions of the standalone processing unit are 40 x 40 x 40 cm.

10.5.2.2. The standalone unit will be weighed with the rover prior to the task start time. The combined weight of the unit and rover must be below the allocated 60 kg for this task, and below the total weight for the challenge, as specified in rule rule 3.5.

10.5.2.3. The unit must be a standalone, self-powered, untethered system. It must have its own LED, E-STOP and power logger in adherance to rules rule 3.9, rule 3.17.2 and rule 3.17.2.1, and can be placed and initialised by the team immediately prior to the task start time in the allocated payload zone in the challenge arena.

10.5.2.4. Up to **50 points** will be awarded based on the recovery (total mass) and grade (purity) of processed material handed to judges at the end of the task. See equation eq. (B.3) in appendix B for a detailed breakdown of materials and methods for sample preparation, and point breakdown allocation for this activity.

10.5.2.5. Chemical reagents and cryogenic materials are not permitted. Instead, teams must use entirely electrical means for thermal management for water extraction and processing. Additionally, thermal pre-conditioning is not permitted, all parts must start at ambient temperature. Any power used to heat or cool a component must be recorded during task time in adherance with rule 3.17.2. For further clarifications see rule B.4.3.

10.5.3. If a rover fails to extract or deliver material for processing, the base station team can request a manual load of a sample with known mass and ice content to attempt processing. Teams will receive a **60% penalty** for processing if they required a manual loading.

10.5.3.1. Manual loading can only be requested and carried out during task time.

10.5.3.2. Once a manual load has been called, the base station must cease all movement of the rover and be ”hands-off” to ensure safety of persons on the field. A judge will then bring a sample with total mass of 100 g, with an identical ice content to the highest grade icy regolith sample, to be loaded by the judge in the respective loading bay on the rover or standalone processing unit, as directed by a member of the field team. Depending on ice content, samples can be highly cemented, and if required, will be manually disaggregated into smaller chunks no larger than 5 cm by hand.

10.5.4. Processed material must be collected in a sealed, air-tight container, like a small bottle, with dimension and material of the team’s choosing, with a removable lid.

10.5.4.1. Teams may retreive the container at the end of the task time, before removing the rover off the arena.

10.5.4.2. The container must be removable, must allow the material to be poured out, and must be handed to judges promptly at the end of the task. Assume the container will be left free-standing on a table in the judge tent for several hours, and so must be resistant to evaporation or being knocked over.

10.5.4.3. The container must be clearly labelled with the team name and total dry mass of the empty container including lid or any other components, to assist with determining the mass of material extracted.

10.5.4.4. If a container does not meet any of the specified requirements, judges will not carry out measurements of the container.

10.5.4.5. Only material that can be poured out of the container will be measured and used for calculating scores. Any residual material in the container represents loss, indicating poor efficiency. Difference in container mass before and after pouring of material will also be measured, to validate calculated metrics and to account for residual particulates retained within the container.

10.6. **Activity 3:** Space Resources Presentation (**42 points**)

10.6.1. Based on the data collected by the rover during this task, prepare a presentation for the judges which should address the following questions:

10.6.1.1. What prospecting tools were used to evaluate each of the sites, and how is the data collected valid? Up to **5 points** available depending on the quality of answer.

10.6.1.2. Was each of the four sites imaged (in focus, high quality picture, individual grains resolvable, with indication of scale? **3 points** per site, for a total of **12 points**.

10.6.1.3. How much water (by mass wt.%) did each ice-cemented site contain, and how much ilmenite (by wt.%) did each site contain? Up to **5 points** per site are available depending on the accuracy of obtained resource estimates, for a total of **20 points**. See rules rule B.6 in appendix B for a detailed breakdown of scoring for this activity.

10.6.1.4. What excavation and processing methods were used, and why? Up to **5 points** available depending on the quality of answer.

10.6.2. The presentation (maximum 10 minutes in duration and maximum 5–10 slides) will begin 10 minutes after the conclusion of the task time and take place within the base station, allowing teams to review data collected by the rover during the field task and prepare slides.

10.6.3. Team members from the field, including those who intervened, are allowed to participate in the presentation. The presentation and discussion with the judges is allowed even if the team was unsuccessful in collecting data with their rover.

11. Excavation & Construction Task

11.1. A total of **125 points** will be available for this task. **100 points** during the task, and up to an additional **25 points** through application of an Efficiency Multiplier as outlined in appendix D.

11.2. Teams will have at least 40 minutes to complete this task.

11.3. Your rover must now scale-up operations and prepare the site for a future human landing by conducting some foundation services which include; removing hazards by clearing rocks, excavating and transporting regolith to construct a berm, and constructing a feature of the team's choosing using dust-mitigating pavers brought from Earth.

11.4. **Activity 1:** Leave the start gate and descend the lander ramp (**5 points**)

11.5. **Activity 2:** Rock clearing (**30 points**)

11.5.1. Rocks must be removed from a designated area and placed into a collection zone, no more than 5 m away. To receive points, the entire top-down projected view of the rock must not be overlapping the marked boundary for the collection zone. For example, if at the end of a task, a rock has an outer edge still overlapping the marked boundary from the collection zone, then no points are awarded for that rock. Rocks of basaltic composition of varying size and weights will be used, with bulk densities of approximately 2.5 g cm^{-3} to 2.9 g cm^{-3}.

11.5.1.1. Two small rocks will be no larger than 8 × 8 × 8 cm weighing less than 1 kg.

11.5.1.2. Two medium rocks will be no larger than 11 × 11 × 11 cm weighing between 1 kg to 3 kg.

11.5.1.3. A large rock will be no larger than 15 × 15 × 15 cm weighing between 3 kg to 5 kg.

11.5.1.4. A huge rock will be no larger than 17 × 17 × 17 cm weighing between 5 kg to 10 kg.

11.5.1.5. For each small and medium-sized rock, a total of **4 points** are available. **2 points** for moving the rock any distance from its starting position, and **2 points** are awarded for placing the rock in the collection zone.

11.5.1.6. For each large and huge rock, a total of **7 points** are available. **3 points** for moving the rock any distance from its starting position, and **4 points** are awarded for placing the rock in the collection zone.

11.6. **Activity 3:** Excavation & Berm construction (**30 points**)

11.6.1. Excavate regolith from a designated Regolith Acquisition Zone (RAZ) and then deliver

the excavated regolith to a designated marked area (2 m length and 0.7 m width) near the processing plant. Markers will conist of red and white vertically buried striped sticks.

11.6.2. Teams may use mechanical means or any other approach chosen by the team to excavate regolith.

11.6.3. A volumetric scan before and after the run will be performed. Only the berm volume within the designated marked area will be counted. Points will be awarded based on the volume of ther berm measured at the conclusion of the task.

11.6.3.1. **5 points** will be awarded for depositing at least 2000 cm^3

11.6.3.2. Up to an additional **25 points** will be awarded for depositing larger quantities, as a function of the largest quantity deposited by any team using. See equation eq. (C.1) in appendix appendix C for the point breakdown allocation for this activity.

11.7. **Activity 4:** Paver construction (**30 points**)

11.7.1. Begin construction of a dust-mitigating feature of the team's choosing, using individual pavers that can cover an area of up to 1.1 m^2. No penalties are applied for covering a larger area.

11.7.2. Individual pavers must start disconnected in one of two locations; either 1) on the lander in a designated paver box at the rear of the lander, or 2) in a dedicated payload made by the team.

11.7.2.1. The paver box will consist of a planform area of at least 25 × 110 cm (Width x Length). The base of the box will be between 10 and 50 cm off the surface. The paver box will not have a lid and the front side will be open, meaning that it can be accessed by the rover from the front or the top.

11.7.2.2. If pavers start in a dedicated payload, teams will be directed to place the payload on the challenge arena surface in an allocated area before the beginning of the task by the judges.

11.7.2.3. If pavers start in the paver box on the lander, the total size of objects placed in the box must not exceed 25 x 110 x 25 cm (Width x Length x Height)

11.7.2.4. If a paver payload is used, the maximum dimensions of the payload must not exceed 35 x 120 x 35 cm (Width x Length x Height). During the task, the rover is free to interact with the paver payload in any way.

11.7.3. Teams must design and build their own pavers.

11.7.3.1. Pavers must consist of individual, rigid, stiff pieces that do not experience permanent deformation. Any signs of irreversible plastic or brittle deformation (i.e. cracking, creasing, bending or buckling) of a paver at the end of the task means the paver is damaged and non-rigid.

11.7.3.2. Adhesives, meshes and magnets must not be used to connect pavers or pre-attach pavers either prior to or during deployment. Note that this does not

preclude using adhesives or magnets within the structure of a *single* paver.

11.7.3.3. Pavers may be any mass, as long as the mass for all objects fielded for this task (rover + pavers + payload to store pavers, if applicable) conforms to the task mass limit.

11.7.3.4. Pavers may be any size or shape, as long as the dimensions of an individual paver conforms to rules rule 11.7.2.1 to rule 11.7.2.4

11.7.4. Teams can choose to cover any area of the challenge arena, in any shape with their pavers to receive the points for paver placement as long as the pavers are flat and connected at the end of the task. **30 points** will be awarded at the end of the task for the proportion of the 1.1 m^2 area that is covered.

11.7.4.1. The successful placement of a paver is at the discretion of the judges.

11.7.4.2. A paver is considered successfully placed if it is completely flat on the surface at the end of the task (i.e. its entire base is in contact with the ground).

11.7.4.3. Pavers cannot overlap in a way that means they do not lie flat. Small areas of overlap are permitted as part of connection mechanisms, if applicable.

11.7.4.4. Pavers are considered connected if a light tug on any other paver translates that force through the connected tiles.

11.7.4.5. The maximum allowable gap between the edges of any two connected pavers cannot exceed 1 cm. If any point along a paver's edge or interlocking mechanism of a paver is greater than 1 cm away from an adjacent paver, it is not interconnected, and the paver is not successfully placed.

11.7.4.6. Pavers have to be contiguous. If they are not, the largest contiguous set of connected pavers will be awarded points.

11.7.4.7. At least one paver must be placed in order to be eligible to score this activity.

11.7.5. Up to **5 points** are available for justifying to judges the relevance and utility of the constructed feature using pavers (size, location, context, etc.)

11.7.6. Prior to the task, teams must demonstrate that the placement of all their pavers covers 1.1 m^2, and that all pavers can be successfully placed and interconnected. For the sake of time, this can be done by hand and will take place nearby the challenge arena prior to the commencement of the task.

11.7.6.1. If a team cannot cannot demonstrate that they have sufficient pavers to adequately cover the required area (i.e. cannot demonstrate that achieving full points is feasible), they cannot attempt this activity.

12. Mapping & Autonomous Task

12.1. A total of **125 points** will be available for this task. **100 points** during the task, and up to an additional **25 points** through application of an Efficiency Multiplier as outlined in appendix D.

12.2. Teams will have at least 40 minutes to complete this task.

12.3. Your rover now needs to explore a new area given a rudimentary map, perhaps derived from data collected by orbiters. This map will contain a series of landmarks that scientists are interested in imaging in more detail, and the rover will need to navigate to these without human intervention. Then, either autonomously or under operator control, a larger-scale map of the arena will need to be constructed, and the locations of previously-unknown landmarks will need to be determined.

12.4. All data and measurements regarding the arena *must* be derived from data provided by the judges or collected *only* during the task time. The rover must not make use of any prior knowledge, estimates, or maps of the arena from either earlier tasks or observations made by the team earlier in the competition or during setup. If teams cannot explain to the base station judges how their outputs are derived from data collected by the rover during only this task, they may be penalised or disqualified.

12.5. As the purpose of this task is exploration, teams may not call for a reposition of the rover during it.

12.6. This task is split into two distinct phases – the autonomous phase, and the non-autonomous phase.

12.6.1. Some points for this task are available only during the autonomous phase.

12.6.2. The tasks starts during the autonomous phase, in which base station team members shall interact with the controls *only before* the rover has moved for the first time.

12.6.2.1. "The controls" includes any kind of human-machine interface in the base station, regardless of form or function – including keyboards, mice, touch screens, gamepads, joysticks, and so on. All interactions (even things that do not directly influence the rover, like repositioning GUI windows) count as interacting with controls and are forbidden in the autonomous phase once the rover has moved for the first time.

12.6.2.2. Moving for the first time includes the rover driving, the arm moving, and also things like the operation of pan-tilt-zoom cameras, whether or not this movement is visible from the exterior of the rover.

12.6.2.3. The intent of this rule is to permit interactions required to initialise the rover and its autonomous subsystems, perform brief in-situ calibration like adjusting camera exposure, set up the base station displays as required, and so on – not to allow the collection of data that is meaningfully contributing to the task activities.

12.6.2.4. During the autonomous phase, teams are not allowed to call an intervention and remain in the autonomous phase. If they do call an intervention, this will immediately move the task to the non-autonomous phase.

12.6.2.5. During the autonomous phase, teams will incur a **10% penalty** for *each* collision with a supply cache or artificial obstacle.

12.6.2.6. If the rover leaves the arena bounds, the E-STOP must be immediately pressed.

12.6.3. At any time the team may resume manual control and enter the non-autonomous phase by interacting with the controls.

12.6.3.1. Teams may remain in the autonomous phase and interact with the controls (e.g. for downloading and processing rover data) if and only if the rover stops moving within 10 seconds of resuming control. In this instance, if at any point the rover does move again, the team will automatically enter the non-autonomous phase. This uses the same definition of movement above that precludes e.g. the operation of pan-tilt-zoom cameras.

12.6.4. Teams may elect to skip either phase – either beginning immediately in the non-autonomous phase, or end the task by shutting down the rover in the autonomous phase.

12.7. **Activity 1:** Leave the start area autonomously (**5 points**)

12.7.1. The points will be awarded if the rover entirely exits the starting square (which will be on the ground, not on the lander) during the autonomous phase.

12.8. **Activity 2:** Autonomous landmark navigation (**30 points**)

12.8.1. Prior to the start of the competition task, teams will be provided a schematic showing the approximate locations (with dimensions) of the key supply caches and obstacles on the field. This schematic will also include the approximate locations and heights off the ground of 5 postcard-sized placards that contain some kind of text or figure.

12.8.2. Teams will be awarded **6 points** for each placard they can traverse to and whose content they can successfully image and relay to the base station judge *while in the autonomous phase*.

12.8.3. The schematic will not necessarily include details of every single obstacle (especially the smaller ones), and nor will it include details of the cubes in activity 3, so the rover should be designed to handle such obstacles autonomously.

12.8.4. No further points will be awarded for this activity once a team has entered the non-autonomous phase.

12.9. **Activity 3:** Exploratory mapping (**40 points**)

12.9.1. Teams must explore the broader arena, beyond the landmarks provided for activity 2.

12.9.2. Spread throughout the arena, there will be four 100 × 100 × 100 mm cubes in bright colours: red, green, blue, and white.

12.9.3. Teams must report the coordinates of these blocks in a coordinate system defined relative to the rover's starting area, the details of which will be provided to teams in the task briefing.

12.9.4. For each block, **5 points** are available for reporting its location to within 300 mm of the ground truth value as determined by the judges. **2 points** will be awarded for less-accurate solutions that are still within 600 mm.

12.9.5. These point values are increased to **10 points** and **5 points** respectively for coordinates reported to the judges during the autonomous phase.

12.9.6. The base station team may remain in the base station and continue the task time if the E-STOP is hit, but in this case an intervention is unable to be called and the rover is unable to be switched back on. This is to allow teams to continue to process data they have already downloaded to get coordinates to submit to the judges.

12.9.7. Teams should also use this activity time together with the data from the previous activity to collect data to construct a map of the whole arena to present to the judges in activity 4.

12.9.7.1. The precise format and features included in the map is entirely up to the team.

12.9.7.2. As part of selecting the format and features to include in the map, teams should consider the purpose of mapping in planetary exploration, and potential downstream applications of the data.

12.10. **Activity 4:** Autonomous and mapping presentation (**25 points**)

12.10.1. Based on the data collected by the rover during this task, prepare a presentation for the judges which should address the following points:

12.10.1.1. The design and justifications thereof for the autonomous landmark navigation system, and the advantages and limitations of such a design. Up to **5 points** will be awarded for the quality of the answer.

12.10.1.2. The design and justifications thereof for the navigation component of exploratory mapping system, and the advantages and limitations of such a design. This should include a discussion of the choice of an autonomous/non-autonomous system, and the key considerations involved in this choice. Up to **5 points** will be awarded for the quality of the answer.

12.10.1.3. The details and visualisations of the map of the whole arena that teams have constructed in the previous two activities as per rule 12.9.7. Up to **5 points** will be awarded for the quality of the design and justifications for the format and features of the map. Up to a further **10 points** will be awarded for the quality of the map itself as expressed through visualisations included in the presentation, based on criteria including coverage, completeness, resolution, and accuracy.

12.10.2. The presentation (maximum 10 minutes in duration and maximum 5–10 slides) will begin 10 minutes after the conclusion of the task time and take place within the base station, allowing teams to review data and prepare slides.

12.10.3. Team members from the field, including those who intervened, are allowed to participate in the presentation. The presentation and discussion with the judges is allowed even if the

team was unsuccessful in mapping with their rover.

Appendices

A. Post-Landing Task

Propellant Hose Connection

A.1. Teams must design and manufacture the cognate connector for the hose.

A.2. The hose which the interface is to be connected to is a standard garden hose that can be procured from a hardware store, with a cut end, no off-the-shelf adapter or likewise.

A.2.1. The inner diameter of the hose is approximately 12 mm and outer diameter is approximately 16 mm.

A.2.2. The hose is flexible.

A.2.3. The hose must not be damaged in attaching or detaching the interface.

A.2.4. The interface must be connected and disconnected in a few minutes – no adhesives are permitted in the connection as it will be used by other teams.

A.2.5. The hose connection designed by the team must not protrude from the hose such that the hose is greater than 2cm off the arena surface.

A.2.6. The hose connection must not occupy a volume greater than 10 × 10 × 10 cm.

A.2.7. The hose connection must not physically contact with the processing plant upon connection.

A.2.8. The connection needs to be snug, and must not come loose if pulled lightly.

A.2.9. The connection must feasibly be able to pass liquid through it (through an obstructed channel through the centre of the connection, or similar). The connection is not required to be water tight.

A.3. The processing plant will be fitted with a connector which will be 3D printed with PLA plastic and fastened to one side of the processing plant.

A.3.1. The connection will be at a height between 30 and 100 cm from the surface of the arena.

A.3.2. The connection will be placed on a face of the processing plant that does not have any obstructions near the surface of the arena such as the processing plant support legs, material conveyor belt or rocks.

A.3.3. STL and STEP files for the male processing plant connection can be found here.

B. Space Resources Task

Materials & Method

B.1. To make a simulant lunar regolith sample similar to what will be used for the lunar resources task, the following items are recommended to be used due to their low cost, availability and safety:

- White washed sand (like this sand. If not accessible, Playground sand will do)
- Tap water
- Oven capable of at least 110 °C
- Large oven trays
- Large ziplock bags
- Containers with maximum dimensions of 162 × 176 × 100 mm (length × width × height) such as these containers. Note this is external dimensions, we are waiting on receiving the product to provide exact internal dimensions.

B.2. The preparation of frozen icy regolith shall be performed following a modified method taken from Atkinson *et al.* (2020):

1. Preheat oven to 110 °C
2. Pour and spread the sand evenly onto a baking tray(s).
3. Once the oven is heated and sample trays are ready, bake at 110 °C for at least 4 hours. If possible, do all several trays at once. For optimal results, bake overnight (24 hours). A rapid check to see if material is dry is to place a small strip of torn paper on top of the material while it is in the oven or just upon removal from the oven. If the paper strip curls the material is not dry and requires additional drying time.
4. Once dry, remove tray and immediately close the oven door to prevent moisture absorption if other samples present, and slowly pour the dry sand into a large ziploc bag.
5. Using a measured beaker or syringe, add a known amount of water to the ziploc bag to achieve a target water content between 0 to 30% by mass. The mass of added water is determined by the formula

$$M_{water} = \frac{MC}{1 - MC} M_{regolith}, \tag{B.1}$$

where MC is the moisture content expressed as a fraction and $M_{regolith}$ is the simulant mass.

6. Seal the bag and then mix the water into the sand by hand, breaking up clumps and evenly distributing so that no dry spots remain.

7. Once mixing is complete, place the ziploc bags somewhere at room temperature and let them cure overnight, allowing the water to evenly distribute via capillary forces.

8. To verify the water content of the prepared simulants, small samples can be removed and measured following ASTM-D2216-71.

9. Once cured, pour the moist simulant into an empty container and freeze overnight.

10. The target bulk density for frozen samples should be between 1.3 g cm^{-3} to 1.5 g cm^{-3}

B.3. For testing, the preparation of ilmenite-enriched regolith can be performed as per the following methods:

1. The mass of ilmenite ($FeTiO_3$) to add is determined by the formula

$$M_{FeTiO} = \frac{En}{1 - En} M_{regolith}, \tag{B.2}$$

where En is the degree of enrichment expressed as a fraction and $M_{regolith}$ is the regolith mass.

2. Combine the sand and ilmenite in a ziplock bag or container of your choosing, mix evenly for at least 2 min to achieve homogeneity

3. To verify the ilmeneite content of the prepared simulants, once can utilise a Marcy pulp density scale to determine the specific gravity of the material, and then calculate the enrichment.

4. Pure Ilmenite sand (mesh size 30) will be used to prepare samples, and can be purchased here or here.

5. The target bulk density for frozen samples should be between 1.3 g cm^{-3} to 1.5 g cm^{-3}, with ilmenite enrichment of between 0 to 15 wt.%.

Processing

Icy regolith

B.4. Up to **50 points** are available for processing water from ice-cemented regolith and are awarded corresponding to a score which is function of the total mass and purity of water given to judges within a container, as per rule 10.5.4.3, and also in comparison to the total mass and purity of water processed by other teams.

B.4.1. **30 points** are awarded for collecting any mass of liquid H_2O, regardless of purity.

B.4.2. Only material that can be poured out of the container will be weighed.

B.4.3. Up to an additional **20 points** are awarded for collecting larger quantities processed material as a function of purity following the equation

$$\text{Points} = 20 \times \frac{M_{\text{YourTeam}} - M_{\text{Particulates}}}{M_{\text{BestTeam}}} \tag{B.3}$$

Where:

$$M_{\text{YourTeam}} = M_{\text{Beaker}} + M_{\text{Residual}} \tag{B.4}$$

$$M_{\text{Residual}} = FP_{\text{Wet}} - FP_{\text{Dry}} \tag{B.5}$$

$$M_{\text{Particulates}} = FP_{\text{Dry}} - FP_{\text{Clean}} \tag{B.6}$$

M_{Beaker} is the mass of water provided by your team, determined by pouring water from the provided container into a conical flask with qualitative Grade 1 filter paper, on a tared, high accuracy scale (0.01 g).
M_{residual} is the mass of residual water trapped in the filter paper during pouring, calculated as the difference in mass between the wet filter paper immediately after filtration (FP_{wet}) and the dry filter paper after all the water has evaporated (FP_{dry}).
$M_{\text{particulates}}$ is the mass of solid particulates, calculated by subtracting the mass of the clean, dry filter paper (FP_{clean}) from the mass of the dry filter paper after filtration (FP_{dry}).

Materials and Thermal Management Requirements

B.5. The following restrictions apply for thermal management of the on-board or standalone processing unit for the Excavation & Processing activity of the Space Resources Task:

B.5.1. To avoid hazards and on-site logistical hurdles associated with safe and practical storage of chemical or cryogenics, no chemical reagents are permitted to be used for direct reaction with the icy regolith simulant (i.e. mixing); for the extraction of water from regolith to generate heat (i.e. exothermic reaction in a closed system) internal or external to the chamber/system containing the icy regolith; or for condensing water vapor (i.e. use of ice packs or dry ice to cool condensation chambers).

B.5.2. Fluids to facilitate the thermal transfer of energy between components (e.g. condensation chamber chiller) are permitted as per rule 3.8.1, but must be entirely closed loop (i.e no venting or leaking, with hermetically sealed fill point). Any such working fluid must be declared in CDR & SAR materials, accompanied by SDS/MSDS, and pre-approved by the judges prior to use in competition.

B.5.3. Teams are required to use entirely electrical means of generating heat (e.g. resistive heaters) for water extraction, or creating cold zones (e.g. thermoelectric Peltier coolers, or closed-loop vapor compression chamber in accordance with rule B.5.2) for water condensation. This is to ensure fair and auditable comparison of power consumption and overall efficiency between teams, in accordance with the goal of 'designing for efficinecy' as outlined in appendix D, and for the calculation of the total energy consumed (P_i) to determine the Efficiency Scaling Factor given by equation eq. (D.3).

B.5.4. Thermal pre-conditioning is not permitted before the start of the task. This reflects real-world operations where systems must overcome environmental temperatures, and ensures fairness by requiring all teams to begin at ambient conditions. This also prevents any team from utilizing external unrecorded energy, conflicting with rule 3.17.2.

B.5.5. Stored latent energy intended to supply or absorb heat during the task is also prohibited. This includes, but is not limited to: phase-change packs (e.g., paraffin wax), hydrated salts (e.g., sodium acetate packs), ice blocks (i.e. solid H_2O or CO_2), pre-chilled absorbents, compressed-gas expansion (e.g., CO_2 cartridges), or chemical sorbents/desiccants (e.g., zeolites or silica gel). Only the inherent heat capacity of system materials and sealed, closed-loop working fluids declared under rule B.5.2 may be used.

B.5.6. All thermal energy actively used during the task (heating or cooling beyond the initial thermal state) must be supplied electrically and logged in adherance with rule 3.17.2 and rule 3.17.2.1

B.5.7. Due to the wide variety and combination of processes, materials and methods to carry out extraction and processing, teams are encouraged to clarify with judges if the intended implementation adheres to the rules and spirit of the competition, prior to competition, with participation in a task and the award of points ultimately being up to the judges discretion.

B.5.8. In the context of lunar ISRU, you are extracting pure water for downstream applications with strict purity requirements. Although chemically driven extraction techniques are feasible, they introduce contaminants which can accumulate within the reaction vessel and reduce long-term yield, and also require replenishmen which means more mass to be shipped from Earth, reducing profit margins and overall efficiency.. Additionally, lunar cold traps are under extreme vacuum (0.1 nPa and are perenially cold (<110 K), enforcing strict requirements for any materials to be used in this environment.

Space Resources Presentation

B.6. **5 points** points are available for determining the mass (by weight %) of resource enrichment at each site, up to a total of **20 points** across the four sites.

B.6.1. Points will be awarded based on the accuracy of the team's estimate according to the following criteria:

B.6.1.1. If the team's estimate is within 0.5% of the true value, **5 points** will be awarded.

B.6.1.2. If the team's estimate is within 2.0% of the true value, **3 points** will be awarded.

B.6.1.3. If the team's estimate is within 5.0% of the true value, **2 points** will be awarded.

B.6.1.4. If the team's estimate is greater than 5.0% away from the true value **0 points** will be awarded.

C. Excavation & Construction Task

Berm construction

C.1. A total of **30 points** are available for constructing a berm using regolith excavated from the designated lunar surface, defined by rule 11.6. Points for this task will be awarded as a function of the volume of the berm deposited by all teams.

C.1.1. **5 points** will be awarded for depositing at least 1000 cm^3

C.1.2. Up to an additional **25 points** are awarded for collecting larger quantities processed material as a function of purity following the equation

$$\text{Points} = 25 \times \frac{V_{\text{YourTeam}}}{V_{\text{BestTeam}}} \tag{C.1}$$

C.1.3. Where V_{YourTeam} is the volume of berm constructed, determined using a lidar scan of the feature contained within the designated marked area at the end of the task time.

D. Rover design efficiency

Designing for efficiency

D.1. Space vehicle design is notoriously resource constrained. Optimising for volume, mass and power consumption is a space engineer's objective, and battling the interplay between these metrics is the cause of many heartaches and long nights.

Typically volume and mass is constrained by the launch vehicle, however articulations and mechanisms are always possible to extend the deployed volume of a space vehicle. Power is the life of space vehicles - if the vehicle is not power positive, the mission is not possible. But be wary, adding power generation capability is not always possible in the other resource constraints to design to.

Optimising space vehicle design will always result in a cheaper, more efficient solution. To prepare students for the space workforce, design optimisation now plays a more critical part in scoring points for the Australian Rover Challenge.

D.2. An Efficiency Multiplier (EM) shall be applied after task scores are finalised (i.e. after penalties applied for interventions and repositions, and once all competitors in a task have competed). This effiency-based score then represents the final score for that task which will be considered by judges for final rankings.

D.2.1. The EM rewards teams for building compact, lightweight, and power-efficient rovers.

D.2.2. This system is intended to encourage intelligent design trade-offs and for students to consider real-world limitations for the design and operation of spacecraft

D.2.3. The final task score (S_{final}) for each task is calculated using the raw score (S_{raw}) and the EM as:

$$S_{final} = S_{raw} \cdot EM \tag{D.1}$$

where EM is calculated as:

$$EM = 1 + k \cdot ESF \quad \textbf{with } k = 0.25 \tag{D.2}$$

where k is the maximum possible change (%) to the final task score. The Efficiency Scaling Factor (ESF) is a weighted average of three normalized parameters:

$$ESF = \frac{w_m M_n + w_v V_n + w_p P_n}{w_m + w_v + w_p} \tag{D.3}$$

Each normalized parameter is calculated based on competition-wide bounds:

$$M_n = 1 - \frac{M_i - M_{min}}{M_{max} - M_{min}} \quad \text{(D.4)}$$

$$V_n = 1 - \frac{V_i - V_{min}}{V_{max} - V_{min}} \quad \text{(D.5)}$$

$$P_n = 1 - \frac{P_i - P_{min}}{P_{max} - P_{min}} \quad \text{(D.6)}$$

Where:

- M_i: Measured rover mass for team i during the task brief (kg)
- V_i: Measured rover bounding-box volume for team i during the task brief (length × width × height, in m^3)
- P_i: Total electrical energy consumed by team i during that task (kWh)
- M_{min}, M_{max}: Minimum and maximum rover mass measured across all teams for that task
- V_{min}, V_{max}: Minimum and maximum rover volume measured across all teams for that task
- P_{min}, P_{max}: Minimum and maximum task energy consumption measured across all teams for that task

The parameters M_n, V_n, and P_n are normalized with respect to these observed competition-wide bounds (eq. (D.4)–eq. (D.6)), not from a single team's multiple configurations.

When calculating ESF, the following fixed weightings are applied, reflecting a priority placed on minimizing rover mass, while also valuing a reduction in volume and power consumption. The weightings are:

$$w_m = 0.5, \quad w_v = 0.25, \quad w_p = 0.25$$

D.2.4. The normalization of parameters based on the observed minimum and maximum mass, for example, was chosen because it is less sensitive to extreme outliers, does not penalize teams too severely, and helps prevent teams from exploiting the scoring system. In contrast, a simple ratio—such as that used to calculate icy regolith processing and berm volume scores in Equations eq. (B.3) and eq. (C.1)—was deliberately chosen to more directly reward the highest performing teams with more clear delineation between teams based on performance during that activity.

D.2.5. In the event that a team fails to provide a valid power consumption reading for a task, their power usage will be approximated as the highest recorded power consumption from all teams participating in that task (i.e. least efficient). This estimate ensures fairness by penalising the absence of required data.