University Rover Challenge 2025 – Requirements and Guidelines

The Mars Society's University Rover Challenge challenges students to build remotely operated rovers that can accomplish a variety of tasks that might one day assist astronauts working on the surface of Mars. Rovers will compete in four missions: 1) a Science Mission to investigate a site for the presence of life; 2) a Delivery Mission to deliver a variety of objects to astronauts in the field across rugged terrain; 3) an Equipment Servicing Mission to perform dexterous operations on a mock lander using a robotic arm; and 4) an Autonomous Navigation Mission to autonomously travel to a series of locations and find objects. For 2025 a drone (aerial vehicle) may be used to assist the rover in the Delivery Mission, but is not required.

The 2025 University Rover Challenge will be held May 28-31, 2025 at the Mars Society's Mars Desert Research Station (MDRS) near Hanksville, Utah, USA. The competition is open to both graduate and undergraduate students, and teams are permitted to include secondary (high school) students.

Any issues not covered by these published rule sets will be addressed on a case-by-case basis by the University Rover Challenge (URC) Director. Please consult the Questions and Answers (Q&A) portion of the URC web site (http://urc.marssociety.org) for updates. All matters addressed in the Q&A are applicable to the requirements and guidelines.

1. Competition Missions

1.a. The rover shall be judged in the four competition missions outlined below and also on the System Acceptance Review (SAR – described in Section 2.a.iii).

- **1.a.i.** Each event and the SAR shall be worth 100 points, for a total of 500 points. Penalties for overweight rovers, interventions, and other penalties are additive: e.g. penalties of 10% and 20% would result in a score of 70% of the points earned. Missions are scored independently and it is not possible to score less than zero on a mission.
- **1.a.ii.** From the time teams are given access to their command and control (C2) station, they shall be able to set up all necessary systems, including all communications systems, and be **ready to compete in no more than 15 minutes**. Teams shall be able to fully disassemble all equipment in no more than 10 minutes at the end of the event, and will be asked to switch off radio equipment immediately.
- **1.a.iii.** For the four competition events, the rover is not required to be in the same configuration so modular pieces can be swapped between missions. On days that teams compete in the Science and Delivery Missions, teams will only compete in one Mission. Teams may be required to begin the Autonomous Navigation Mission as soon as 10 minutes after the completion of the Equipment Servicing Mission, operating from the same C2 station on an adjacent course.
- **1.a.iv.** **Teams do not need to return to the start gate, or collect any deployed items (e.g. radio repeaters, cameras, tools) before the end of time for any of the missions.** However, they must be collected immediately after competing.
- **1.a.v.** The rover will be accessible throughout the competition and modifications can be made at any point.

1.b. Science Mission

The goal is to collect sample(s) chosen by the team at site(s) selected in the field, perform basic science evaluation of these samples with onboard instrumentation, and store at least one sample

as a cache. Sites shall be analyzed for their likelihood to support microbial life with at least one life detection method. The team should evaluate at least two sites and acquire samples from only one site to use as the returned cache.

1.b.i. **Teams shall submit a written Science Plan by May 16, 2025**, which will be factored into the judges' evaluation and score for the Science Mission. This will expand upon the science plan submitted in the System Acceptance Review (see Section 2.a.iii). Specifications for the plan will posted to the URC website.

1.b.ii. Teams will be given a field briefing by the judges to discuss the tasks at the science site. Through the information relayed by the rover, teams shall then select sites of potential biological interest within a 0.5 km radius of the C2 station. Teams will be given between 20 and 30 minutes to collect and analyze data with the rover, and may visit as many sites as time allows.

1.b.iii. Teams shall document each site investigated by:

- A wide-angle panorama showing the full context of the site. The panorama must indicate cardinal directions, and have some indication of scale.
- A close up, well focused, high-resolution picture with some indication of scale (scale can be indicated post-capture) at the sampling site.
- Teams will be required to take a stratigraphic profile using the on-board cameras to determine the depositional environment and history of water in the sedimentary structures visible at the site.
- GNSS coordinates of each site, to include elevation and accuracy range.

Thorough documentation is especially crucial for the sample that is returned onboard the rover.

1.b.iv. The rover may use cameras or other sensors to investigate the area, and may collect regolith/soil for analysis by instrumentation on-board the rover. Samples must be analyzed by the rover on-site, and may not be brought back to the team for investigation or laboratory analysis.

1.b.v. Onboard equipment at a minimum should include:

- A life detection capability.
- A second science capability of the team's choice to accomplish the task goals (a second life detection capability would be permissible).
- Capability to measure the soil moisture (relative humidity) and subsurface temperature at least 10 cm below the surface.
- Additional sensors, subsystems, and test procedures are left to the discretion of the teams to meet the science-driven objectives of this task.

1.b.vi. Any chemicals used onboard, including water and any reaction products, must follow a no-spill policy of being contained on the rover and not spilt on the ground. **Use of hazardous chemicals must be pre-approved prior to competition by submitting a plan of transportation, usage, disposal, safety precautions, and accident plan.** Teams should consider that URC takes place in a remote desert location with very limited water supplies and no quick access to emergency medical care.

1.b.vii. Based upon investigation of at least two sites, teams shall then **collect a sub-surface sample from one of the sites at a depth of 10 cm or deeper. Sample(s) must be at least 5g** and may consist of a single rock, hardpan (hard compacted soil), loose soil, or anything in between. Sample(s) may return the full depth including the topsoil but teams must be able to distinguish the soil depth for any sample. **The portion of the sample from below 10 cm will be used to determine the sample mass.**

1.b.viii. After collection of the sample, the rover must then store and close/seal it in a cache container onboard the rover, and return the sealed cache to the C2 station. Sealed cache

must prevent sample from spilling if laid on side or upside down. Cache must be removable from rover within 5 minutes after end of roving time. Team members must remove cache and hand it to the judges. Cache must reasonably be able to be opened by the judges.

1.b.ix. After giving the cached sample to the judges, teams will have a debrief and discussion with the judges. **Discussion with the judges is allowed even if the rover was unsuccessful in performing any of the field tasks**. The discussion should include:

- The stratigraphic profile and evidence of water in the profile.
- Results of on-board rover and laboratory tests performed.
- Method used to ensure sample was collected at least 10 cm below the surface and transferred to the judges without contamination.
- Reasoning for sample site selection and documentation of each of the two sites.
- Meaning of data collected with respect to the habitability potential, the geology of the site (past and present) and implications of the site being suitable for life.
- Scientific knowledge of Mars based on responses to judges' questions.

1.b.x. The score for this task will be based on the following components:

- Thoroughness of the investigation of sites (panoramas, site selection, stratigraphic profile).
- Quality and applicability of the onboard analysis (life detection, science capabilities of choice, and other measurements on-board the rover including relative humidity and temperature).
- Quality of the sample returned (weight, depth, possible contamination).
- Scientific knowledge of astrobiology.

1.c. Delivery Mission

1.c.i. This will be a staged mission in which rovers shall be required to assist astronauts in the field, such as by finding, picking up, and delivering objects, all while traversing terrain of increasing difficulty. In this mission the rover may be assisted by a drone. Teams will be given a fixed amount of time for each stage. Each stage will include multiple tasks as described below, and teams must achieve a specified minimum score within a stage and the allotted time in order to proceed to the next stage. Any time remaining at the completion of Stage 1 is added to the time allowed for Stage 2. Total on-course time will be between 30 and 60 minutes. A script describing the course stages and tasks to be accomplished will be given to the teams prior to the competition.

1.c.ii. The natural terrain around MDRS includes soft sandy areas, gravel, rough stony areas, rock and boulder fields, vertical drops and steep loosely consolidated slopes. Terrain will range from flat close to the starting line, to exceedingly difficult obstacles at distances of up to 1 km from the start gate also involving navigation challenges. Portions of this mission, in later tasks, will be intentionally placed beyond direct line-of-sight of the C2 station antenna.

1.c.iii. For 2025 no task in the Delivery Mission will require geological expertise. The rover teams can expect a combination of the following tasks:

- Follow a marked path that requires precise maneuvering of the rover.
- Open boxes with hinged lids such as toolboxes.
- Pick up, carry, and deliver objects to a different location. Objects may consist of small lightweight hand tools or instruments, rocks, or supply containers. Objects may be up to 5 kg in mass and will be smaller than 40 x 40 x 40 cm. All objects will have some sort of graspable feature, no greater than 7.5 cm diameter, varying in complexity from a handle to natural features.

- Read signs carried by astronauts or placed in the field.
- Find a piece of equipment in a large search area.
- Find objects in an area with poor radio reception. Sought objects will be readily identifiable.

1.c.iv. Approximate Global Navigation Satellite System (GNSS) coordinates will be provided for each pickup/delivery location. In certain cases, specific instructions will be provided for each object in advance, and in other cases, the object(s) to be delivered will be indicated at the delivery location (for example, on a small sign held by an astronaut). **Working GNSS is essential for this mission.**

1.c.v. Teams will be scored on their ability to pick up and deliver the correct objects to the correct locations. Points may be awarded for partial completion of any particular task.

1.d.Drones

1.d.i. Use of a drone is optional for the Delivery Mission, but a drone may assist during each stage in the mission. Drones will be remotely operated by a pilot in the C2 station.

1.d.ii. A drone may be especially useful in reading signs, searching large areas, picking up objects, acting as a radio relay, or operating in areas where a rover on the ground may have poor radio reception.

1.d.iii. Drones must be of a rotary wing design and able to hover in a fixed location. No lighter-than-air vehicles are allowed as they are impractical on Mars, and fixed-wing drones are being excluded for safety reasons.

1.d.iv. Drones may start from either the rover or a designated start location near the C2 station. After initial launch drones may take off and land as many times as desired in any safe location. Any immobile drones must be removed from Stage 1 at the end of the Stage 1 time (no penalty is assessed).

1.d.v. **Drones are exempted from the weight, size, and budget restrictions for the rover and other deployed equipment.**

1.d.vi. To simulate flight on Mars the **drone must carry a dummy mass of the same weight as the battery**. The dummy mass must be inert and of no functional use. It may not be a spare battery. The dummy mass and battery must be easy to remove for weighing. **In the event of high winds (>24 kph/15 mph), the dummy mass requirement will be waived.**

1.d.vii. Drones should be able to operate in a 48 kph / 30 mph wind. This requires a top speed of least 64 kph / 40 mph for safe operation. Teams may fly their drone in any wind speeds they feel confident it can handle. Teams should expect highly variable wind conditions throughout URC and are not guaranteed that they will be scheduled during a period of low wind.

1.d.viii. **Drones may not exceed 5 kg (11 lb)** including the dummy mass. **All drones in excess of 250 g (0.55 lb) must be registered with the United States Federal Aviation Administration (FAA) DroneZone and marked with the registration number**.

1.d.ix. **Drones must be equipped with a Remote ID** meeting FAA requirements.

1.d.x. **All pilots must complete the FAA TRUST** (The Recreational UAS Safety Test), and **carry proof of passing** with them. It is a free online training course that takes about 30 minutes, and is valid for 3 years.

1.d.xi. Airborne vehicles must meet any and all FAA guidelines that apply to recreational drone operation. It will be the responsibility of each team to research and comply with FAA requirements. The area around MDRS is class G (uncontrolled) airspace, and drones are required to fly **below 400 feet (120 m) above ground level**. Please beware

that MDRS is fairly close to Capitol Reef National Park, and **drones are not permitted in National Parks**. It is also about 5 miles from the uncontrolled Hanksville airport, and drones must give way to any manned aircraft.

1.d.xii. **A spotter must maintain visual line of sight at all times.** The pilot will not have a direct view of the drone so a designated team member in the field must act as a spotter. In the event of an emergency the spotter will use radio communication with the pilot to avoid unsafe behavior of the drone, or may take direct control of the drone if a dual-pilot setup is used. The spotter may only intervene in the event of potentially unsafe operation, and may not otherwise participate in the mission.

1.e. Equipment Servicing Mission

1.e.i. Rovers shall be required to perform several dexterous operations on a mock-up lander. The rover shall have to travel up to 0.25 km across relatively flat terrain to reach the lander. Equipment requiring interaction will be between 1.5 m height and the ground.

1.e.ii. The Equipment Servicing Mission will involve delivering a cached science sample to a lander and performing maintenance on the lander. It will include the following sub-tasks which may be performed in any order:

- Pick up a metal sample tube (test tube sized) and insert it into a larger cache container.
- Pick up the cache container and transport to the lander. Cache will have a handle at least 10 cm long and not more than 5 cm in diameter. Cache will weigh less than 5 kg.
- Open a drawer on the lander. Insert cache into a close-fitting space in the drawer, and close the drawer.
- Undo a latch on a hinged panel of the lander and open panel.
- Autonomous Typing: Team operators will be given a 3-6 letter launch key prior to the start of the mission which they may program into the rover prior to the start of this task. The rover must autonomously input this launch key on a keyboard. Typing must be correct for full points, but spelling mistakes or repeated letters may be corrected using the backspace/delete button or ignored for partial points. The protocol for entering/exiting autonomous mode will be similar to the Autonomous Navigation Mission (see Section 1.f). The rover shall only have 1 attempt at entering the launch key, and operator intervention is allowed only to exit autonomous mode and abort the attempt on this task. The keyboard will be vertically mounted and specifically is this keyboard.
- Operate a joystick (4-position, spring-return) to direct an antenna while observing a gauge. The gauge will be up to 20 cm away from the joystick.
- Remove and insert a rugged USB memory stick into a USB (type A) slot on the lander.
- Push buttons, flip switches, turn knobs.

1.e.iii. Teams will receive points for every task completed successfully. Teams will have 30 minutes to complete the mission.

1.f. Autonomous Navigation Mission

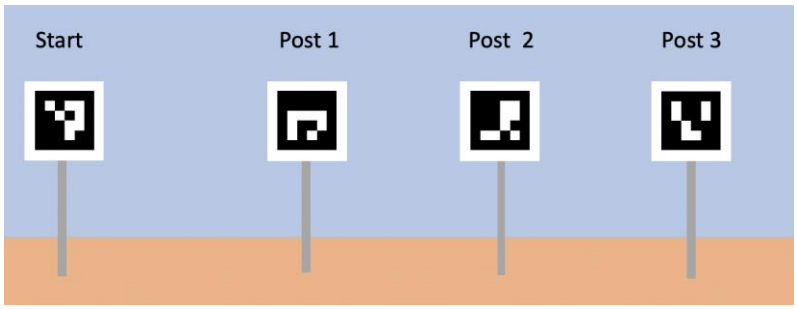
1.f.i. Teams may be required to begin this mission as soon as 10 minutes after the completion of the Equipment Servicing Mission, operating from the same C2 station on an adjacent course. Total time on course will be 30 minutes, and the cumulative distance shall be no greater than 2 km.

1.f.ii. Rover shall be required to autonomously traverse to 2 GNSS-only locations, 3 posts

marked with Augmented Reality (AR) tags, and 2 objects left on the ground. **Teams may visit locations in any order.** Teams will be provided with a high-accuracy coordinate at a start gate as a reference. Teams are strongly encouraged to implement differential GNSS for higher accuracy.

1.f.iii. The 2 locations with only GNSS coordinates will be given highly accurate coordinates without any visual markers to enable computer vision to be of assistance. Stopping within 3 m of the GNSS location will be considered successful.

1.f.iv. The 3 posts will have GNSS coordinates that are within the vicinity of the posts, increasing in range from approximately 5-20 m. Stopping within 2 m of the post will be considered successful. The posts and gate will have 3-sided visual markers with 20 x 20 cm faces, 0.5 – 1.5m off the ground. **Each marker will display a black and white ARUCO tag using the 4x4_50 tag library exactly as shown below.** Each tag will have a white border 1 cell in width, so cells are 2.5 cm across. The same tag will be displayed on each of the 3 sides so that it is visible from any direction. **The last post may have obstacles in the way that require autonomous avoidance, such as being in a boulder field.**



1.f.v. The 2 objects will have GNSS coordinates withing the vicinity of the objects (<10 m). Autonomous detection of the objects will be required. The first object will be an orange rubber mallet similar to (see similar object here). The second object will be a standard 1 liter wide-mouthed plastic water bottle (approximately 21.5 cm tall and 9 cm diameter) and of unspecified color/markings color (not the same bottle used at URC2024). **This last object may have obstacles in the way that require autonomous avoidance, such as being in a boulder field.** Rovers are not required to interact with the objects, but must stop within 2 m to be considered successful.

1.f.vi. **There must be an LED indicator on the back of the rover, visible in bright daylight** (e.g. LED array or high power LED), that will signal:

- Red: Autonomous operation
- Blue: Teleoperation (Manually driving)
- Flashing Green: Successful arrival at a location.

1.f.vii. **The rover's on-board systems are required to decide when it has reached a location. The rover must then stop and signal using the LED indicator. It must also display a large and obvious message or signal on the operator's display for the C2 station judge to observe.**

1.f.viii. Operators may at any point send a signal to the rover to abort the current attempt and autonomously return to the previous post/gate or GNSS coordinate and stop within 10 m of it. **Operators may teleoperate back to any previously visited object, AR tag, or GNSS coordinate for a 20% penalty on the points available for that location. Teleoperation should take the most direct reasonable route back and may not go scouting for the location.** There is no penalty for an autonomous return.

1.f.ix. While stopped at any location (whether after a successful arrival, an unsuccessful

arrival, or from an abort), teams may do any programming including entering the GNSS points or waypoints, and making changes to the controls and algorithms, but may not drive the rover.

2. Competition Rules

2.a. Schedule

Prospective teams will undergo a review and down-selection process, meaning that only teams who pass each milestone will be invited to compete in the field. Teams failing to qualify for the field competition are strongly encouraged to enter other Rover Challenge Series events (http://rcs.marssociety.org/). Specific details for each deadline (including deliverable format, submission requirements, and judges' expectations) will be posted to the URC web site (http://urc.marssociety.org). Judges may respond to teams with follow-up questions or requests for clarification at any of these milestones.

2.a.i. Registration

Teams are required to register and declare their intent to compete **no later than Wednesday, October 30, 2024.** No significant deliverables are required for this deadline, aside from team details requested via the URC web site.

2.a.ii. Preliminary Design Review

Teams are required to submit a Preliminary Design Review (PDR) document no later than Wednesday, December 4, 2024. The PDR document must include the team structure, resources, and project management plan (including a Gantt chart, initial budget, fund-raising plans, recruiting, and educational outreach). Technical details regarding the rover should include the current state of design, development, and prototyping. Judges will be assessing each team's overall likelihood of being ready in time to compete in the URC competition. Teams will be assessed on their own merits, not against other teams.

2.a.iii. System Acceptance Review

Teams are required to submit a System Acceptance Review (SAR) no later than Friday, February 28, 2025. The SAR will focus on demonstration of the capabilities and customization of the rover systems/sub-systems to perform each of the missions. This includes the overall system design, and progress to-date of the final system. The SAR will consist of both written and video components. The SAR is a competitive milestone and packages will be judged against other teams' submissions by the judges. The 36 teams who score the highest in the SAR milestone will be invited to compete in the field.

2.a.iv. Field Competition

May 28-31, 2025 at the Mars Society's Mars Desert Research Station (MDRS) near Hanksville, Utah, USA.

2.b. Operations

2.b.i. Teams will operate their rovers in real-time from designated C2 stations. These stations will be metal trailer units (such as the back of a small moving truck provided by URC) or structures at the Mars Desert Research Station. **Visibility of the course to the operators in the C2 station will be blocked.** Basic power (120V, 60Hz), tables, and chairs will be provided. All of the competition events will be held in full daylight.

2.b.ii. There should be radio communication line-of-sight from the C2 station to the rover for the Science, Equipment Servicing, and Autonomous Navigation Missions. For the Delivery Mission, line of sight communication is not guaranteed for more than 50% of the course. Rovers are not expected to travel more than 1 km from the C2 station.

2.b.iii. Temperatures at MDRS can easily reach 100°F and winds frequently whip up dust. Rovers shall be able to withstand these conditions and also light rain, but will not be expected to compete in heavy rain or thunderstorms.

2.b.iv. **Testing will not be allowed at MDRS before, during, or after URC2025**. Teams may test in town or at other nearby sites where off-road vehicles are allowed (e.g. Factory Butte OHV Open Area). Land controlled by the Bureau of Land Management, that is not specifically designated for off-road use, is strictly not allowed for any URC purposes.

2.b.v. The Global Navigation Satellite System (GNSS) standard shall be the WGS 84 datum. Coordinates will be provided in latitude/longitude format (e.g. decimal degrees; degrees decimal minutes; degrees minutes seconds).

2.c. Team Members

2.c.i. There is no restriction on the number of team members allowed. Students must be enrolled at least half-time in a degree or high school diploma granting course. Students from multiple universities may compete on the same team. A single university may field multiple rovers and multiple teams, however there may be no overlap between team members, budget, donated equipment, or purchased equipment.

2.c.ii. Teams are encouraged to work with advisors. Advisors should limit their involvement to academic level advising only. Nontechnical management duties, including tracking finances, registration, fundraising, websites, promotion, submission of deliverables, and communication with URC staff, fall within the duties of the students. Advisors can spectate from the field, but may not spectate from within the C2 station.

2.c.iii. All team members operating the rover must remain in the designated operators' area. Nobody may follow alongside the rover for the purpose of providing feedback to the operators. Members of the judging team, media, non-operator team members, and other spectators may only follow a rover at the judges' discretion. Team members following the rover may participate as runners in accordance with Section 3.c, or activate an emergency kill switch (in the event of an emergency), but may not otherwise participate in that mission.

2.c.iv. It is incumbent upon the student team leaders to ensure that their respective teams uphold the integrity of this competition.

2.d. Finances

2.d.i. Teams shall be required to track all finances as related to this project, documented in the Project Budget Table, which is included in the PDR and SAR submissions.

2.d.ii. In addition, each team must **submit a final Rover Expense Report no later than May 21, 2025** (if necessary, teams may submit an updated record on the first day of the URC event – May 28, 2025). Teams shall be penalized 10% of total points per day if they are late in submitting the expense report, and will be disqualified for not submitting their expense report by the end of the URC event (May 31, 2025).

2.d.iii. The maximum allowable cash budget to be spent on the fielded rover is **$22,000 US**, which shall include any fielded components for the rover, rover modules, rover power sources, rover communications equipment, and base station equipment including the antenna and transceiver, and all C2 equipment (i.e. base station computers, monitors, controllers, etc.).

2.d.iv. The Director may allow certain sponsorships that are available to all teams to count as an extension of the rover budget limit.

2.d.v. The budget limit pertains only to rover and C2 station expenses and does not include

other project expenses such as travel, accommodation, rover transportation, tools, prototype parts not used on the fielded rover, and spare parts that can be replaced one-for-one in the case of damage to the original.

2.d.vi. If used equipment is purchased commercially the as-bought price may be used. Re-used equipment from prior competitions must be valued at either the original as-bought cost, or the current cost for a new version of the same or equivalent item.

2.d.vii. Any rented equipment must be valued at purchase cost (new or used).

2.d.viii. Shipping and taxes must be included in the cost since these are a standard part of the cost of any item.

2.d.ix. Corporate sponsorship is encouraged. If equipment or services are donated to the team either free or at reduced cost, the full cost of a new or second-hand component must be used. Donations must be documented by the donor, but teams may use the cheapest rate commercially available for the same equipment or service.

2.d.x. Non-US teams have an allowable rover budget equivalent to $22,000 US based on the most advantageous documented currency conversion rate between August 1, 2024 and May 28, 2025.

2.d.xi. Teams may be required to submit receipts as proof of the rover expenses upon request.

3. Rover Rules

3.a. Size, Weight, Power

3.a.i. The rover shall be a stand-alone, off-the-grid, mobile platform. Tethered power and communications are not allowed. A single rover carrying all deployable items except the drone, must leave the designated start gate. In the open field, the rover may deploy any number of smaller sub-platforms, so long as the combined system meets all additional requirements published.

3.a.ii. Rovers shall be weighed by the judges during the set-up time of each mission. For weighing the rover **must fit completely within a 1.2 m x 1.2 m x 1.2 m box**. Rovers may be placed in any orientation, and articulate/fold/bend to fit within the "transport crate," but may not be disassembled to do so. This includes wheels, antenna, and any other system protruding from the rover. **Failure to fit within the specified dimensions at weigh-in will result in a 40% penalty. After weighing, rovers may unfold/expand to any size.**

3.a.iii. The maximum allowable mass of the rover when deployed for any competition mission is **50 kg**. The total mass of all fielded rover parts for all events is **70 kg**. For example, a modular rover may have a robotic arm and a science module that are never on the rover at the same time. The combinations of rover plus arm and rover plus science module must each be under 50 kg, but the total rover plus arm plus science module must be less than 70 kg.

- The weight limits do not include any spares or tools used to prepare or maintain the rover, but does include any items deployed by the rover such as sub-rovers, cameras, communication relays.
- Rover weight will be rounded down to the nearest whole kilogram.
- For each event in which the rover is overweight, the team shall be assessed a penalty of 5% of the points scored, per kilogram over 50.

3.a.iv. Rovers shall utilize power and propulsion systems that are applicable to operations on Mars. Air-breathing systems are not permitted: No power or propulsion system may ingest ambient air for the purpose of combustion or other chemical reaction that yields energy.

3.a.v. All rovers shall have a red push button emergency stop that is readily visible and

accessible on the exterior of the rover. This button shall immediately stop the rover's movement and cease all power draw from batteries in the event of an emergency such as a battery fire.

3.b. Communications Equipment

3.b.i. The rover shall be operated remotely using wireless communications with no time delay. The operators will not be able to directly view the rover or the site, and line-of-sight communications are not guaranteed for all of the missions. Normal wireless internet is not available in the field or at MDRS, and use of satellite internet is not allowed. Teams are required to power down communications equipment at the event sites while not competing, so as not to interfere with other teams.

3.b.ii. Wireless communication methods used by teams shall adhere to all applicable FCC (United States Federal Communications Commission) standards and regulations. **Teams must submit details regarding communication devices and operator licenses (when applicable) to the URC Director no later than Friday, April 25, 2025**. Team members are permitted to obtain and utilize any relevant licenses, but must document the license, applicable regulations, and devices as part of the communications documentation deadline. Teams must notify the URC Director immediately of any changes after this date.

3.b.iii. Both omnidirectional and directional antennae are allowed, but communications equipment must not rely on the team's ability to watch and track the rover firsthand. Steered directional antennae may use a mechanized antenna mounted outside that is controlled via an electronic signal from the C2 station. Signal strength, relayed GNSS, or other strategies may be used to give feedback on antenna direction, but it is not allowed to mount a camera on top of the antenna for visual feedback.

3.b.iv. **Base station antenna height is limited to 3 m** and shall adhere to all applicable regulations. Any antennae must be documented as part of the communications documentation submitted by April 25, 2025. Antenna bases must be located within 5 meters of the team's C2 station, and any ropes or wires used for stability purposes only may be anchored within 10 meters of the C2 station. The exception to this is the use of structures at MDRS where allowable antennae locations will be given by the judge and may be located up to 20 m away from C2 stations to avoid underground pipe and cables, and other structures which may block radio signals. **All teams should bring at least 25 m of communications cable** to deal with this scenario.

3.b.v. **Restrictions on the 900 MHz band** (902-928 MHz): Teams shall not use frequency bandwidths greater than 8 MHz. **Teams must also be able to operate exclusively within each of the following three sub-bands: "900-Low" (902-910 MHz), "900-Mid" (911-919 MHz), and "900-High" (920-928 MHz). The competition schedule will notify teams which sub-band may be used for each mission, and teams must be able to shift to another sub-band as required.** There is no limit on the number of 900 MHz channels a team uses, so long as they are all within the designated sub-band. **These restrictions apply to both the C2 station and rover communications, including any local area network (LAN) between devices at the C2 station, onboard the rover, or between the C2 station and rover**. There will be spectrum monitoring on-site to ensure that teams are not interfering with channels outside those allotted. Teams should anticipate being within signal range of other teams operating on different 900 MHz sub-bands.

3.b.vi. **No restrictions on the 2.4 GHz band**. Frequency restrictions in 2.4 GHz band are being removed for 2025. Within the 2.4 GHz band teams may use the band they chose,

providing they comply with FCC requirements. Teams must expect to be operating within close proximity of other teams and be able to deal with any potential interference. Teams are strongly encouraged to investigate frequency hopping, automatic channel selection, automatic channel switching, or other interference-tolerant protocols. Teams are also highly encouraged to operate in bands outside of 900 MHz and 2.4 GHz and to obtain ham radio licenses to allow operation on less used bands.

3.c. Interventions

If a rover suffers a critical problem during a mission that requires direct team intervention (anything requiring touching of the rover), that intervention shall be subject to the following:

3.c.i. **A request for an intervention can only come from the team members operating the rover, not any team members spectating in the field.** They may designate any number of team members who may go to repair or retrieve the rover (hereafter referred to as "runners"). Spectating team members may be asked to act as runners, and also rover operators may leave the C2 station and become runners. Spectating team members may carry tools and the C2 station may radio out to them to request an intervention.

3.c.ii. **If a spectating team member intervenes with the rover without request from the operators, it counts as an emergency stop.** This is allowed such as to rescue the rover to prevent a fall or a fire. The current mission will be considered terminated although the rover may compete in other subsequent missions. All points earned in a mission to this point are preserved, and in the Science Mission teams may still conduct their field briefing.

3.c.iii. **If a team member leaves the C2 station to become a runner they will not be permitted to return to the C2 station** to participate in operating the rover, or analysis of any data, after this point for the current mission. Runners will still be permitted to retrieve or repair the rover in future interventions.

3.c.iv. Runners may fix the rover in the field without moving it, or return the rover to the C2 station, or return the rover to the start of that obstacle/task as defined by the judge in the field. Judges may require the rover to be moved for the safety of the team members or preservation of the course.

3.c.v. If the rover is returned to the C2 station, the operators may take part in the diagnostic and repair process, but runners and spectators may not communicate any details about the mission site to the operators.

3.c.vi. When an intervention is called, the team members in the field may communicate directly with their team members operating the rover to facilitate repairs. **If teams wish to use radios for this purpose they must bring their own radios, but they may be used only during an intervention. All radio communication must be in English so judges can properly monitor conversations.**

3.c.vii. Teams will be **penalized 20% of the total points in that mission for every intervention**. The mission clock will continue to run during an intervention. Multiple intervention penalties in a single mission are additive: e.g. two interventions would result in a score of 60% of points earned.

3.c.viii. For the Delivery Mission if a drone is used and an intervention is required on either the drone or the rover, teams may continue to operate the working vehicle. If the drone returns to the C2 station under its own power, it should land at the start marker and be carried to the C2 station by a runner. Swapping batteries on either vehicle counts as an intervention.