

University Rover Challenge 2014 – Requirements and Guidelines

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/home>) for updates. All matters addressed in the Q&A are applicable to the requirements and guidelines.

1. Competition Overview

- 1.a. The 2014 University Rover Challenge will be held May 29th – 31st, 2014 at the Mars Society's Mars Desert Research Station (MDRS) near Hanksville, Utah.
- 1.b. The rover shall be a stand-alone, off-the-grid, mobile platform. No tethers will be allowed during its operation for connection to external sources.
 - 1.b.i. A single connected platform must leave the designated start gate and return to this location (except when otherwise indicated). In the open field, the primary platform may deploy any number of smaller sub-platforms, so long as the combined master/slave sub-platforms meet all additional requirements published.
 - 1.b.ii. Any airborne vehicles must meet any and all FAA (United States Federal Aviation Authority) guidelines that apply to operating unmanned aircraft in a remote area. It will be the responsibility of each team to research any such FAA requirements and provide documentation to the judges prior to April 25, 2014.
- 1.c. Teams will operate their rovers from designated command and control stations. These stations will be metal trailer units (such as the back of a small moving truck) or tents with tarp walls restricting visibility of the course (to be provided). Alternatively teams may operate from inside their own vehicles if they elect to do so provided they also bring covers to block the view from the vehicle. In addition the Mars Desert Research Station Habitat (Hab) may be used for one of the control stations. Basic power (120V, 60Hz), tables, and chairs will be provided. All of the competition events will be held in full daylight.
- 1.d. There is no restriction on the number of team members or operators allowed, as long as all operators 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, and non-operator team members may follow a rover at the judges' discretion. Team members following the rover may participate as runners in accordance with Section 2.h, or activate an emergency kill switch (in the event of an emergency), but may not otherwise participate in that task.
- 1.e. The GPS standard shall be the WGS 84 datum. Teams shall adhere to this standard. Coordinates will be provided in latitude/longitude format (degrees/minutes).
- 1.f. The MDRS field site is located in the desert of southern Utah. As such, the site will have a full spectrum of sloped terrain from flat to vertical. Teams should be prepared for any ground conditions that would appear at MDRS (please consult the MDRS web site – <http://mdrs.marssociety.org/> – for field reports, images, and other resources). Except for when noted in this document, the objective sites shall be reachable by paths of no greater

than a 15° slope. The rover shall also be capable of withstanding such an environment in the early summer, including airborne dust and temperatures that can easily reach 100°F. Although it is improbable, rovers shall be able to withstand extremely light rain. Rovers will not be expected to compete in heavy rain or thunderstorms.

- 1.g. URC activities of any sort, including teams practicing, may only be conducted on state managed lands. All land managed by the Bureau of Land Management (BLM) may not be used during URC. [This map](#) highlights the two areas at MDRS that are state managed, and available for use. Please ask URC staff if you are uncertain where these boundaries are.
- 1.h. Teams must provide a video of their rover operating by April 25th 2014 either directly to the judges or via social media. Operations should include the rover moving under remote control at least 10 feet forwards and backwards and turning 90°. If rovers do not have this minimal capability one month before the competition the judges will strongly advise against travelling out to Utah.

2. Rover Guidelines

- 2.a. Rovers shall utilize power and propulsion systems that are applicable to operations on Mars. Air-breathing systems (such as internal combustion engines and certain fuel cells) are permissible, but must be implemented as fixed-supply systems. No power or propulsion system may ingest ambient air for the purpose of combustion or other chemical reaction that yields energy. Teams implementing such systems are required to understand and follow all applicable safety regulations at their university. Teams are required to document their adherence with these safety regulations during the design phase, and submit this documentation to the URC Director prior to implementation. The URC Director further reserves the right to ban any system deemed unsafe from competition.
- 2.b. The maximum allowable mass of the rover when deployed for any competition event is 50 kg. This mass does not include any other hardware used to prepare or maintain the rover, any spare power sources not being used, or any additional rover configuration components not on-board for the particular competition event.
 - 2.b.i. For each event in which the rover is overweight, the team shall be assessed a penalty of 10 points, plus 1 additional point per kilogram over 50.
 - 2.b.ii. Rovers over 75 kg in any given configuration must be cleared with the URC Director by email prior to April 25, 2014 to be eligible to compete.
 - 2.b.iii. The combined mass of spare power sources and additional rover configuration components shall not exceed 20 kg.
 - 2.b.iv. There will be no weight limit imposed on command and control team equipment, base communications equipment or maintenance tools.
 - 2.b.v. If a gas-consuming engine is used, the rover shall weigh-in with all tanks full.
- 2.c. Wireless communication methods used by teams shall adhere to all applicable FCC (United States Federal Communications Commission) standards and regulations. The 900 MHz and 2.4 GHz are further regulated in their use at URC as described in section 2.d.

Other bands are not further regulated. Teams must submit details regarding any wireless communication devices being implemented and operator licenses (when applicable) to the URC Director no later than April 25, 2014. Teams must notify the URC Director immediately of any changes after this date. Teams may be required to power down communications equipment at the event sites while not competing, so as not to interfere with other teams.

- 2.c.i. Communications equipment must not rely on the team's ability to watch and track the rover first hand. Equipment may be directionally steered if kept inside the command and control tent. Any communications equipment outside of the tent shall be stationary. The stationary requirement does not impose mechanical rigidity, just a rigid, stable base. An automated azimuth-finding antenna is permissible, as long as it is safe and stable. Electrically steered antennas are also permissible, as long as they are operated within FCC regulations (as applicable).
 - 2.c.ii. Teams may have a member visually track the rover and rotate/steer communications equipment placed outside of the tent. This person may not communicate with the rest of the team inside the tent, and will result in a penalty of 10 points per event utilized.
 - 2.c.iii. Antenna bases must be located within 5 meters of the team's command and control tent, and shall adhere to all applicable regulations. Any such antenna must be documented as part of the communications documentation deadline. Any ropes or wires used for stability purposes only may be anchored within 10 meters of the command and control tent. The exception to this is the use of the MDRS Hab where antennae may be located up to 20m away from the Hab to avoid underground pipe and cables. Teams should bring at least 20m of antenna cable to be to deal with this scenario.
 - 2.c.iv. Lighter-than-air devices are not allowed for communications at URC.
- 2.d. Teams must notify the organizers of the communications standards they will be using, including frequency bands and channels, by April 25, 2014. The URC restrictions on the 900 MHz and 2.4GHz bands are as follows:
- 2.d.i. 900 MHz frequency band (902-928 MHz): Teams shall not use frequency bandwidths greater than 8 MHz. Teams must also be able to operate exclusively within one 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 task, and teams must be able to shift to another sub-band if 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.
 - 2.d.ii. 2.4 GHz frequency band (2.400-2.4835 GHz): Teams shall use center frequencies that correspond to channels 1-11 of the IEEE (Institute of Electrical and Electronics Engineers) 802.11 standard for 2.4 GHz. Teams shall not use frequency bandwidths greater than 22 MHz. The competition schedule will notify teams which channels may be used for each task. Teams shall be limited to using no more than three channels in the 2.4 GHz band.

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 one other team operating on a different 900 MHz sub-band and different 2.4GHz channels

and be able to operate their rover under these conditions. Teams must also be able to deconflict communications as specified above (the URC Director will mediate as necessary). Beyond this requirement a 0.8 km minimum separation between competition areas will be guaranteed, which will include large terrain barriers, and event scheduling will avoid communication interference to the greatest extent possible.

- 2.e. The rover is not required to be autonomous. However, it shall be operated remotely by a team which will not be able to view the rover on the site or the site itself directly. The rover may be commanded by the team using a wireless link, with information needed for guiding the rover acquired by the rover's own on-board systems and transmitted to the team wirelessly. There shall be no time delay in communications, as the URC is based on the assumption that the rovers in question are telerobots, being operated by astronauts on or orbiting Mars. Refer to rule 2.h regarding the impacts of a loss of communications.
- 2.f. If the rover carries a deployable airborne vehicle, that is not a lighter-than-air system, in addition to conforming to rules 1.b.i and 1.b.ii it must also simulate a vehicle that could fly on Mars. While the ground level air density on Mars is much lower than on Earth the gravity is lower too. In order to simulate these effects on Earth the vehicle shall carry a dead weight equal to the weight of the battery(s) used. For example if the airborne vehicle is powered by a battery that weighs 50g it must carry a dead weight of 50g. Teams shall provide the dead weight(s) and may distribute it (them) as they see fit provided that the dead weight and battery(s) are removable from the vehicle so they can be weighed. A dead weight shall not provide power, add structural or aerodynamic support, perform computation or sensing, or otherwise add functional utility to the system.
- 2.g. Lighter-than-air vehicles are not allowed at URC since lighter-than-air vehicles on Mars are only practical for heavy lift applications.
- 2.h. If a rover suffers a critical problem during a task that requires direct team intervention (including a loss of communication that requires the team to move the rover to reestablish communications), that intervention shall be subject to the following:
 - 2.h.i. The team may designate any number of members (herein referred to as “runners”) who may retrieve the rover, and return it to the blind side of the command and control station (such that the other members may work on the rover without being able to view the task site).
 - 2.h.ii. Runners shall not communicate any details about the task site to the rest of the team (judges will monitor conversation), however are permitted to take part in the diagnostic process.
 - 2.h.iii. After completing work on the rover, the runners may relocate the rover to any position within the start gate area.
 - 2.h.iv. The runners shall not be permitted to participate in the command and control of the rover, or analysis of any data, after this point for the current event. Runners will still be permitted to retrieve the rover in future interventions, although only at the direction of the eligible command and control team.

2.h.v. Teams will be penalized 10 points for every intervention. The task clock will continue to run during interventions.

3. Competition Tasks

- 3.a. The rover shall be judged in the four competition tasks outlined below in 3.b to 3.e, in addition to the presentation task outlined in 3.f. The five tasks will be independent events.
- 3.a.i. For the four competition events, the rover is not required to be in the same configuration. Teams will have at least 2 ½ hours to reconfigure, adjust and repair their rovers in between competition events, and will not have to compete in more than 2 such events in a single day.
- 3.a.ii. Each event, including the presentation task, shall be worth 100 points, for a total of 500 points. The minimum points awarded for a single event is zero, even if the penalties are greater than the points earned.
- 3.a.iii. From the time teams are given access to their command and control tent, they shall be able to set up all necessary systems, including all communications systems, and be ready to compete in no more than 25 minutes. Teams shall be able to fully disassemble all equipment in no more than 15 minutes at the end of the event.

3.b. Sample Return Task:

Teams will be given a field briefing by judges to discuss the task site. Teams controlling their rovers shall then select multiple (3-6) sites of potential biological interest within a 0.5km radius of the start gate. Based upon investigation of the selected sites, teams shall then collect and return a single sub-surface sample from the site they determine to have the greatest likelihood of containing photosynthetic bacteria such as cyanobacteria/blue-green algae, other bacterial colonies such as are associated with desert varnish, as well as other nonbacterial extremophiles such as lichen. The sample must be collected from just below the topsoil at 5cm (2") depth or deeper. The mass of this sample must be at least 25 grams, but no greater than 250 grams, and may consist of a single rock, or a soil sample. The primary indicator of the extremophiles of interest is reflected light in the visible spectra.

In addition to visual observation teams must select and an in-situ science capability of their choice that the rover will perform in the field on the sample collected. Teams must explain the value of that capability, why they chose it, and the trade-offs made. Rovers shall return the collected sample to the team's command and control tent by the end of the time allotted.

Teams shall document each site investigated according to the following procedure:

- 3.b.i. At a given site, the team must take a close up, high-resolution picture with some indication of scale (scale can be indicated post-capture).
- 3.b.ii. Produce a wide-angle panorama showing the full context of the site and immediate surrounding area. The panorama must indicate cardinal directions, and have some indication of scale.

3.b.iii. Teams must also record the GPS coordinates of each site, to include elevation and accuracy range. Thorough documentation is especially crucial for the sample that is returned.

Teams will be given 30-60 minutes to collect data and the sample with the rover (exact amount of time to be announced on-site), after which they will be given a similar amount of time (not necessarily equal to the on-course time) to prepare data for a field briefing to the judges (which will last 15 minutes, to include questions from the judges). In the field briefing to judges, teams will be required to describe and analyze their data for all sites investigated, and provide a justification for returning the sample that was selected. The score for this task will be based on the following, equally weighted, components: 1) thoroughness of the investigation of sites; 2) quality and applicability of the analysis of the field science; 3) quality of the sample returned; and 4) quality and applicability of the analysis of the sample returned.

3.c. Astronaut Assistance Task:

Teams shall be required to collect multiple objects left in the field and deliver/deploy them to multiple locations throughout the field. The location and description of the equipment will be given in GPS coordinates to within 3m. There will be two distinct types of deployment as described below.

3.c.i. The equipment will include small lightweight hand tools (e.g. a hammer) and supply containers up to 5kg in mass. Items will include visual markings to help distinguish them. Teams will be provided with instructions to deliver specific pieces of equipment to specific astronauts throughout the field. The astronauts will be identifiable by simulated space suits, and approximate GPS coordinates (to within 25m) will also be given for the astronauts. A successful delivery is defined by placing the appropriate equipment on the ground within 1m of the appropriate astronaut.

3.c.ii. A single wireless repeater box that is required to service an unattended sensor deployed in the field out of line of sight communications with the control station. Teams will be provided with a “black box” receiver and signal monitor in the control station. Teams shall deploy the repeater in the field such that the communications path between the unattended sensor and command station receiver is successfully completed. The receiver shall provide confirmation of connectivity between the receiver and repeater, as well as between the repeater and unattended sensor. Teams will only be provided with 75m accurate GPS coordinates for the sensor, and will need to scan for the sensor’s signal using the repeater and receiver feedback. Teams are not required to actually locate the exact sensor position.

All items to be picked up by the rover in this task will have stable graspable features no greater than 5cm in width or diameter. Containers and the repeater box shall be no larger than 40cm x 40cm x 40cm, with a mass no greater than 5kg. Rovers may pick up

multiple items at a time, and are also permitted to make multiple trips to retrieve additional objects.

As many as half of the objects or astronauts will be intentionally located out of line-of-sight communication with the control station. A maximum time limit between 30 and 60 minutes, and approximate GPS coordinates (as previously described) for the equipment, unattended sensor, and the astronauts will be provided to teams. All equipment, astronauts and the unattended sensor will be located within a 1.0 km radius of the start gate. Line of sight communication with the start gate will only be guaranteed for 50% of the course. The equipment and the astronauts will be accessible via relatively benign terrain. Scores will be based on the number of objects delivered to the correct astronaut, signal quality between the unattended sensor and receiver, and the time taken. The rover is not required to return to the start gate at the end of this task.

3.d. Equipment Servicing Task:

Rovers shall be required to perform several dexterous operations on a mock-up equipment system. The rover shall have to travel up to 0.5km across relatively flat terrain (negligible slope) to reach the equipment. Teams and their rover shall then have to read directions, printed on a panel, describing the sequence of tasks to be performed. This year the equipment servicing task will involve performing maintenance on a series of pipes, hoses and valves and switching on a compressor to inflate an inflatable structure. Tasks may include connecting pipes into fittings, turning valves, screwing on connections, pushing buttons, and reading pressure gauges.

Teams will only be required to manipulate one end of a pipe or hose to make connections that a human could do with one hand so that a single robotic arm should be sufficient to perform the task. Pipes will include PVC plumbing pipes less than 2" in diameter either rigid or flexible with push in or threaded screw connections. Flow valves may have knob or handle actuation.

Fittings, valves, or gauges will be between 0.2 and 0.5m above the ground and may be mounted horizontally or vertically. Loose parts that need to be connected will be located within the general workspace but may be lying on the ground or leaning against equipment. All text on the panel shall be printed in the equivalent of Times New Roman 18 point font in black ink against a white background.

Teams will receive points for every sub-task completed successfully, but will be partially penalized for subtasks completed out of order. Sub-task point weights will be consistent with the level of difficulty (i.e. making screw connections will have the largest weight, pushing buttons the smallest weight).

3.e. Terrain Traversing Task:

Rovers shall be required to traverse a variety of difficult terrains as part of an engineering field test of the ruggedness and route-finding ability of the rovers. Terrain may include soft sandy areas, rough stony areas, rock and boulder fields, vertical drops potentially in excess of 0.5m, and steep slopes in excess of 60°. There is no limit placed on the slopes or size of drops or boulders that may be encountered. It will be advantageous to be able to climb or descend near vertical faces but will not be required.

Rovers will be required to pass through a set of target gates not more than 1km from the start gate. Gates will consist of 2 white PVC pipes no less than 10cm in diameter, standing vertically from the ground to a height of 1-2 meters, and spaced at least 2m apart, and will be numbered or lettered so they can be distinguished from each other. Teams will be given GPS coordinates of the gates and may walk the terrain course ahead of time. In some areas teams may be asked to follow marked routes to the gates, and in others they may be required to pick their own route. Teams may deviate from marked routes if their rover cannot overcome a specific obstacle but will suffer a penalty.

Teams will have a maximum time of between 30 and 60 minutes on course and do not have to return to the start gate. Teams will be scored on the number of gates they pass through, any deviations from marked routes, and the time taken.

3.f. Presentation Task:

Teams shall prepare and deliver a presentation to the URC judges describing their team, rover design and functionality. The length of the presentation (not including questions) shall be no longer than 15 minutes. Judges may ask follow-on questions as warranted after this time. Scoring for this section will be assessed on the following equally weighted categories:

- Team structure, organization, and management
- Core rover design and presented functionality (rover need not function for presentation)
- Suitability of rover design to competition tasks
- Response to follow-on questions
- Overall quality of presentation

4. Team Management

4.a. Teams shall be required to track all finances as related to this project, and submit a final expense record no later than May 23, 2014 (if necessary, teams may submit an updated record – hard or soft copy – on the first day of the URC event – May 29, 2014). Teams shall be penalized 25 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.

4.a.i. The maximum allowable cash budget to be spent on the project is \$15,000 US, which shall include money spent on parts and components for the rover, rover modules, rover power sources, rover communications equipment, and base station communications equipment (only that equipment used to communicate with the rover). The budget limit shall not apply to command and control equipment not

- included above (i.e. base station computers and monitors), tools, volunteer labor time, or travel expenses.
- 4.a.ii. Teams may acquire in-kind donations of equipment. Such donations will count towards the cash budget at its documented value. Corporate sponsorship is encouraged.
 - 4.a.iii. Teams may be required to submit receipts as proof of budget upon request (donations must be documented by the donor).
 - 4.a.iv. Any parts and/or components purchased in previous years and/or leveraged from previous rovers or projects for this year's rover shall be valued at purchased prices unless teams elect to document the current newly purchased value of all components.
 - 4.a.v. Teams have the option of using either the as-bought prices or may apply depreciation rules to 50% of their re-used components. If teams apply depreciation rules they must determine the current prices of all components. The idea is that teams not close to the maximum limit do not need to spend a lot of time here looking up current prices. However teams close to the maximum budget and re-using a lot of components may gain some benefit from depreciation rules if they are willing to go to the effort of finding current prices for everything, some of which like computers may be cheaper but others like raw materials and machining labor may have increased. For information regarding depreciation, teams may consult the U.S. Internal Revenue Service's [website](#).
 - 4.a.vi. If used equipment is purchased commercially the as-bought price may be used. If used equipment is donated to the team and no used market exists for a component then the cost of a new component must be used. Depreciation rules may then be applied if desired according to rule 4.a.v.
 - 4.a.vii. International teams have an allowable budget equivalent to \$15,000 US based on the most advantageous documented currency conversion rate between August 1, 2013 and May 29, 2014.
- 4.b. There shall be one division of competition open to both graduate and undergraduate students. Teams are permitted to include secondary school (high school) students. A single university may field multiple rovers and multiple teams, however there may be no overlap between team members and leaders, budget, donated equipment, or purchased equipment.
- 4.c. Teams are encouraged to work with advisors. However, advisors are expected to limit their involvement to academic level advising only. It is incumbent upon the student team leaders to ensure that their respective teams uphold the integrity of this competition. Nontechnical team management duties, including tracking finances, fall within the duties of the students.