University Rover Challenge 2017 – 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) for updates. All matters addressed in the Q&A are applicable to the requirements and guidelines.

1. Competition Overview

1.a. The 2017 University Rover Challenge will be held June 1 – 3, 2017 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. Tethered power and communications are not allowed, except as noted in Section 2.c of the rules.

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. Due to increased FAA (United States Federal Aviation Authority) restrictions, no airborne vehicles will be allowed at URC2017.

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 provided by URC) or structures at the Mars Desert Research Station. Visibility of the course by the operators in the control 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.

1.d. There is no restriction on the number of team members or operators allowed. All operators 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, 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.f, or activate an emergency kill switch (in the event of an emergency), but may not otherwise participate in that task.

1.e. 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. The GPS standard shall be the WGS 84 datum. Coordinates will be provided in latitude/longitude format (degrees/minutes). 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. Rovers shall be able to withstand light rain but will not be expected to compete in heavy rain or thunderstorms.

1.f. There should be radio communication line-of-sight from the command station to the rover for the Science Cache and Equipment Servicing Tasks. For the other tasks, line of sight communication is not guaranteed for more than 50% of the courses. Rovers are not expected to travel more than 1 km at most from the command station.

1.g. URC does not regulate teams' test activities, especially those on public land, before, during, or after the competition, but please be cognizant that URC does not have the appropriate permits for off-road activities on Bureau of Land Management (BLM) controlled lands, and only has permission to use the two State Trust Land areas outlined (in the blue boxes) on the MDRS BLM map: http://urc.marssociety.org/files/CowDungRdMap.pdf. All land managed by the Bureau of

Land Management (BLM) may NOT be used during URC. Please ask URC staff if you are uncertain where these boundaries are. Teams are also required not to scout or test on any of the URC courses once the judges begin setup the day before the competition begins, with the exception of the Extreme Retrieval and Delivery Task as described in section 3.c.

1.h. Registration, Milestone Reviews and Down-Selections

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. 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.

1.h.i. Declaration of Intent to Compete

Teams are required to register and declare their intent to compete no later than Friday, December 2, 2016. No significant deliverables are required for this deadline, aside from team details requested via the URC web site.

1.h.ii. Team Proposal

Teams are required to submit a Team Proposal no later than Friday, January 20, 2017. The Team Proposal is expected to focus on the team structure, resources, and project plan. Technical details regarding the rover are encouraged, but not required. Judges will be assessing each team's overall level of readiness to undertake the URC competition. Teams will be assessed on their own merits, not against other teams. Team Proposals may be submitted as early as December 2, 2016, and will be reviewed by judges on a rolling basis.

1.h.iii. Critical Design Review

Teams are required to submit a Critical Design Review (CDR) Package no later than Friday, March 3, 2017. The CDR Package will focus on the overall system design, science plan, and progress to-date of the final system. The CDR Package will consist of both written and video components. The CDR is a competitive milestone and packages will be judged against other teams' submissions by the judges. Only teams who pass the CDR milestone will be invited to compete in the field.

1.i. Teams shall be required to track all finances as related to this project, and submit a final expense record no later than May 22, 2017 (if necessary, teams may submit an updated record – hard or soft copy – on the first day of the URC event – June 1, 2017). 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 (June 3, 2017).

1.i.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, travel expenses, or volunteer labor. Volunteer labor applies to any work done helping out with menial labor and should not make a significant contribution to the rover.

1.i.ii. Corporate sponsorship is encouraged. Teams may acquire donations of equipment and services. However, such donations will count towards the cash budget, except for specific exemptions granted by the URC Director for donations made available to all URC teams.

1.i.iii. Teams may be required to submit receipts as proof of budget upon request (donations must be documented by the donor). For donated equipment or services teams may use the cheapest rate commercially available for the same equipment or service.

1.i.iv. 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 1.i.v.

1.i.v. If a team uses any parts and/or components purchased in previous years and/or leveraged from previous rovers or projects they 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.

1.i.vi. Non-US teams have an allowable budget equivalent to $15,000 US based on the most advantageous documented currency conversion rate between August 1, 2016 and June 1, 2017.

1.j. The competition is open to both graduate and undergraduate students. Teams are permitted to include secondary school (high school) students, and 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 and leaders, budget, donated equipment, or purchased equipment.

1.k. 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.

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 task 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 sensor that are never on the rover at the same time. The combinations of rover plus arm and rover plus sensor must each be under 50 kg, but the total rover plus arm plus sensor must be less than 70 kg. The weight limits do not include command station equipment or any spares or tools used to prepare or maintain the rover. There are no minimum or maximum dimensions for the rover, but the Extreme Retrieval and Delivery Task provides operational constraints that may affect design.

2.b.i. 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.

2.b.ii. Rovers over 70 kg in any given configuration must be cleared with the URC Director by email prior to April 28, 2017 to be eligible to compete.

2.b.iii. If a gas-consuming engine is used, the rover shall weigh-in with all tanks full.

2.c. The rover is only required to be autonomous for the Autonomous Navigation Task. In the other tasks autonomy is not required, although some level of autonomy may be beneficial, such as the ability to backtrack to the last good communications location. Besides the Autonomous Navigation Task, the rover shall be operated remotely by a team which will not be able to view the rover on the site or the site itself directly, and line-of-sight communications are not guaranteed for all of the tasks. 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.f regarding the impacts of a loss of communications. **Teams may use tethered communications instead of wireless, but will be penalized 50% of the points earned during that task**. When operating in tethered mode, teams cannot progress beyond the first stage of any staged task.

2.d. 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.e. Other bands are not further regulated, but we strongly suggest teams use Dynamic Frequency Selection, Frequency Hopping, or at least be able to manually change channels on other bands such as the 5.8GHz band. Teams may utilize multiple bands at the same. Teams must submit details regarding any wireless communication devices being implemented and operator licenses (when applicable) to the URC Director no later than April 28, 2017. 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. 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.d.i. Internet is not available in the field or at MDRS, but is available at nearby hotels in Hanksville.

2.d.ii. Both omnidirectional and directional antennae are allowed, but communications equipment must not rely on the team's ability to watch and track the rover first hand. If a team wishes to steer a directional antenna they may:

- Steer it manually from inside the control station with no visual feedback on position.
- Use a mechanized antenna mounted outside that is controlled via an electronic signal from the command station or operates autonomously.
- Place someone outside to manually turn the antenna to point at the rover. Since they can see the rover they are not allowed to communicate with operators inside the control station. This option comes at a 20% penalty per event used.

For any of the above options, signal strength, relayed GPS, or other strategies may be used to give feedback on antenna direction. Teams may not mount a camera on top of the antenna for visual feedback, but a camera may be deployed by the rover in the field.

2.d.iii. Antenna height is limited to 3m, and shall adhere to all applicable regulations. Any antennae must be documented as part of the communications documentation submitted by April 28, 2017. Antenna bases must be located within 5 meters of the team's command station, and any ropes or wires used for stability purposes only may be anchored within 10 meters of the command station. The exception to this is the use of structures at the MDRS

where allowable antennae locations will be given by the judge and may be located up to 20m away from the Hab to avoid underground pipe and cables, and other structures which may block radio signals. **All teams should bring at least 25m of antenna cable** to deal with this scenario.

2.d.iv. Lighter-than-air devices are not allowed for communications at URC.

2.e. Teams must notify the organizers of the communications standards they will be using, including frequency bands and channels, by April 28, 2017. The **URC restrictions on the 900 MHz and 2.4GHz bands are as follows:**

2.e.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 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 task, 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.

2.e.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, and teams must be able to shift to other channels as required. Teams shall be limited to using no more than three channels in the 2.4 GHz band.**

2.e.iii. Teams may use spread spectrum or narrowband (fixed channel allocation) within the sub-band limits as they fit.

2.e.iv. 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 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 0.5 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.v. Teams are allowed to operate in bands outside of 900 MHz and 2.4 GHz, but should implement spread spectrum, automatic channel switching, frequency hopping, or other interference-tolerant protocols. **In the event of interference outside of 900 MHz and 2.4 GHz, teams will not be granted additional time or special considerations.**

2.f. 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.f.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 command station and become runners.

2.f.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 task will be considered terminated although the rover may compete in other subsequent tasks.

2.f.iii. If a team member leaves the command station to become a runner they will not be

permitted to return to the command station to participate in operating the rover, or analysis of any data, after this point for the current task. Runners will still be permitted to retrieve or repair the rover in future interventions.

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

2.f.v. If the rover is returned to the command station runners and spectators shall not communicate any details about the task site to the team members operating the rover (judges will monitor conversation), however all team members are permitted to take part in the diagnostic and repair process.

2.f.vi. Spectating team members may carry tools and the command station may radio out to them to request an intervention.

2.f.vii. Teams will be penalized 20% of the total points in that task for every intervention. The task clock will continue to run during an intervention. Multiple intervention penalties in a single task are additive: e.g. two interventions would result in a score of 60% of points earned, not 0.8 x 0.8 = 64%.

2.g. All rover shall have a "kill switch" that is readily visible and accessible on the exterior of the rover. This switch shall immediately stop the rover's movement in the case of emergency. Teams are encouraged to configure their rover such that the kill switch immediately ceases power draw from batteries in the event of a dangerous exothermal runaway event.

3. Competition Tasks

3.a. The rover shall be judged in the four competition tasks outlined below in 3.b to 3.ee. and also on the Critical Design Review.

3.a.i. For the four competition events, the rover is not required to be in the same configuration so modular pieces can be swapped between tasks. Teams will all compete in the Equipment Servicing and Autonomous Traversal Tasks back-to-back, in that order, with 10 minutes of allowed repair time between the two tasks. On days that teams compete in the Science Cache and Extreme Retrieval and Delivery Tasks, teams will only compete in one Task. The rover will otherwise be accessible throughout the competition and modifications can be made at any point.

3.a.ii. Each event and the CDR 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, not 0.9x0.8 = 72%. Tasks are scored independently and it is not possible to score less than zero on a task.

3.a.iii. From the time teams are given access to their command 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 may be asked to switch off radio equipment immediately.

3.b. Science Cache Task:

The goal is to collect samples at sites selected in the field, perform basic science evaluation of these samples with onboard instrumentation, and store at least one sample in a cache for further scientific analysis. A single or multiple sites can be sampled. Sites shall be analyzed for their likelihood to support microbial life using the geological context such as evidence of water flow, minerals present and soil structure.

3.b.i. Teams shall submit a written science plan by May 12, 2017, which will be factored into the judges' evaluation for the Science Cache Task. Specifications for the plan will posted to the URC website. The plan should include:
- Basic knowledge about Mars (for example: geology, regolith chemistry, pH, chemical composition, why the surface is red), current operating missions and their instrumentation.
- What the team has done to improve their knowledge for the science task (articles read, experiments performed, experts consulted).
- What instruments and methods the team has chosen for the rover and lab testing, and why.

3.b.ii. Teams will be given a field briefing by judges to discuss the tasks at the science site. Through the information relayed by the rover, teams shall then select sites of potential geological and biological interest within a 0.5 km radius of the command station.

3.b.iii. Teams shall document each site investigated by:
- 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.
- 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 evidence of water.
- GPS coordinates of each site, to include elevation and accuracy range. Thorough documentation is especially crucial for the sample that is returned onboard the rover.

3.b.iv. Based upon investigation of the selected sites, teams shall then collect and return a sub-surface sample, to be stored and sealed in a cache container onboard the rover, from a depth of 5 cm or deeper. Sample(s) must be at least 5 g and may consist of a single rock, 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 5 cm will be used to determine the sample mass.

3.b.v. **Onboard equipment at a minimum should test the soil moisture (relative humidity), subsurface temperature (at least 10 cm below the surface), and use an additional science capability of the team's choice**. Additional sensors, subsystems, and test procedures are left to the discretion of the teams to meet the science-driven objectives of this task.

3.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, 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.

3.b.vii. Teams will be given between 20 and 30 minutes to collect data and the sample with the rover. Teams may investigate as many sites as time allows.

3.b.viii. After return of the rover to the command station, teams shall remove the cached sample from the rover, while minimizing any possibility of contamination. Teams will have the opportunity to use these samples for subsequent laboratory analysis at a later time in the competition.

3.b.ix. At a later time the cache will be returned to the teams and they will be given 15-30 minutes for analysis and preparation of data for a 10 minute discussion with the judges. A discussion with the judges is allowed even if the team was unsuccessful in obtaining samples with their rover. The discussion should include:

- The stratigraphic profile and evidence of water in the profile.
- Results of on-rover and laboratory tests performed.
- Method used to ensure sample was collected at least 5 cm below the surface and stored without contamination.
- Reasoning for sample site selection and documentation of each site.
- Meaning of data collected with respect to geology of the site (past and present) and implications of the site being suitable for life.
- Scientific knowledge of Mars astrobiology.

3.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 and laboratory analysis (moisture, temperature, rover capability of choice, laboratory analysis)
- Quality of the sample returned (weight, depth, possible contamination)
- Scientific knowledge of Mars astrobiology.

3.c. Extreme Retrieval and Delivery Task:

This will be a staged task in which rovers shall be required to retrieve and deliver objects in the field, and deliver assistance to astronauts, all while traversing a wide variety of terrain. Teams will be given a fixed amount of time for each stage. Each stage will include multiple objectives as described below, and teams must complete each component of a stage as defined below within the allotted time in order to proceed to the next stage. Failure to complete a stage will result in the end of the task. Teams may walk the course ahead of time when other teams are not actively competing.

3.c.i. Terrain may include soft sandy areas, rough stony areas, rock and boulder fields, vertical drops potentially in excess of 0.5 m, and steep slopes in excess of 45°. There is no limit placed on the slopes or size of drops or boulders that may be encountered. Terrain may include routes indicated by visual markers. Terrain will range from very easy and close to the starting line, to exceedingly difficult obstacles at greater distances also involving navigation challenges. Portions of this course, particularly in later stages, will be intentionally placed beyond direct line-of-sight of the control station antenna.

3.c.ii. Rovers will be required to complete a set of objectives not more than 1 km from the start gate. In some areas a set path may be defined. All paths will be at least 2 m wide. Teams will be given approximate GPS coordinates of the object retrieval and delivery locations and any required waypoints. Teams will be scored for each object they successfully retrieve and deliver. Points will be awarded for partial completion, and will be deducted for failure to stay within marked routes.

3.c.iii. Objects to be retrieved in the field will consist of small lightweight hand tools (e.g. screwdriver, hammer, wrench), supply containers (e.g. toolbox, gasoline can), or rocks up to 5 kg in mass. All items will have graspable features (such as a handle) no greater than 5 cm in diameter. The maximum dimensions shall be no larger than 40 cm x 40 cm x 40 cm, but teams should expect a variety of sizes and weights. Rovers may pick up multiple items at a time, but are not required to do so.

3.c.iv. Objects shall be retrieved from and delivered to designated locations, which may include markers or astronauts identifiable by simulated space suits. Approximate GPS coordinates will be provided for each retrieval/delivery location, although accuracy may vary, particularly for astronauts. In certain cases, specific instructions will be provided for each object in advance; in other cases, the object to be delivered will be indicated at the delivery location (e.g. on a small sign held by the astronaut). A 1 m delivery radius from the designated marker will be awarded the maximum score. A 5 m delivery radius from the

designated marker will be the minimum threshold required for successful completion of a stage.

3.c.v. Certain objectives of this task will require field science proficiency in order to complete. This can include picking a specified type of rock from an assortment for the retrieval/delivery.

3.c.vi. Teams must successfully complete each objective of a stage in order to advance to the next stage. Any time remaining at the completion of a stage is added to the allotted time of the subsequent stage, which begins immediately. Successful completion of each objective is defined as successful retrieval of all required objects, successful placement of the correct object within 5m of the correct location, and scoring at least 60% of the available points for each route-based objective.

3.c.vii. It is anticipated that there will be a total of two stages in this task, however judges may revise this number for the final schedule. Total time on course will be no greater than 75 minutes.

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 0.25 km across relatively flat terrain (minimal slope) to reach the equipment. The equipment servicing task will involve performing maintenance on a generator and will include the following sub-tasks:

- Connect a carabiner to a wagon containing a fuel can and use it to tow the wagon to the generator. The wagon will have an attachment point at least 1" in diameter and no more than 0.25" thick, to which the carabiner can be connected. Teams should provide the tow rope and carabiner. The carabiner may be of custom design but must be removable by the rover. The tow rope must be flexible, not a rigid arm for full points to be awarded.
- Flip open a cap on the fuel tank. It will be a press-to-fit cap with a large tab to grip, and hinged on one side.
- Pour the fuel (ethanol simulated by dyed water or simulated magnesium powder) into the tank. Tank opening will be no higher than 0.5m from the ground. Filled fuel can will weigh less than 3 kg. The fuel can will have a handle not more than 5cm in diameter and at least 10cm in length. Other details will not be provided in advance.
- Unscrew a regulator from a simulated empty O2 tank and screw onto a "full" tank. Attaching screw fitting will be a DIN style collar approximately 1" in diameter attached to a hose and may include pressure gauges limiting the ability to grasp from the end.
- Start generator by pushing a button or flipping a switch
- Verify operation by reading a message on a LCD display

3.d.i. 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. Teams will have between 20 and 45 min to complete the task.

3.e. Autonomous Traversal Task:

Rovers shall be required to autonomously traverse between gates in this staged task across moderately difficult terrain. Teams will be given a fixed amount of time for a given stage, and may conduct any activities during this time, including conducting teleoperated excursions (such as previewing routes). Each stage will have one or more legs as described below, and teams must complete each leg of a stage within the allotted time in order to proceed to the next stage. Failure to complete a stage will result in the end of the task.

3.e.i. Teams will begin on this task 10 minutes after the completion of the Equipment Servicing Task, operating from the same control station on an adjacent course.

3.e.ii. A leg is defined as the rover autonomously traversing between a start gate and a finish

gate. Gates shall be provided as GPS coordinates, and marked with small visual identifiers not typically observable from a long distance. Each visual marker will include a standard tennis ball elevated 10 – 50 cm off the ground. The finish gate of one leg may be used as the start gate of a subsequent leg.

3.e.iii. To complete a leg, teams must start with their rover within 2 m of the designated start gate (arriving at this gate via teleoperation is permitted). Before proceeding, teams must formally announce to judges that they are entering autonomous mode. In autonomous mode team members may monitor video and telemetry information sent from the rover, but may not transmit any commands that would be considered teleoperation.

3.e.iv. At any time operators may abort autonomous operation and revert to teleoperation, but the time will continue to run and teams shall be required to resume that leg in autonomous mode from the start gate. Interventions that require the physical intervention of runners are still penalized as in rule 2.f.

3.e.v. The rover shall autonomously navigate from the start gate to the finish gate. The rover's on-board systems are required to decide when it has reached the finish gate, and transmit a message back to operators that is displayed for judges to observe. Scores for each leg will be based on proximity to the final gate when the rover perceives that it has completed the leg. A 3 m radius from the gate will be considered successful.

3.e.vi. Teams may resume teleoperation mode between legs and conduct any operations prior to attempting the subsequent leg but competition time will not stop.

3.e.vii. Teams must successfully complete each leg of a stage in order to advance to the next stage. Any time remaining at the completion of a stage is added to the allotted time of the subsequent stage, which begins immediately.

3.e.viii. It is anticipated that there will be a total of three stages in this task at increasing levels of difficulty, however judges may revise this number for the final schedule. Total time on course will be no greater than 75 minutes, and the cumulative distance of all legs shall be no greater than 1000 m.