University Rover Challenge 2016 – 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 2016 University Rover Challenge will be held June 2 – 4, 2016 at the Mars Society's Mars Desert Research Station (MDRS) near Hanksville, Utah. All teams invited to the URC field competition will compete in a Semi-Finals on the first day, June 2. At the end of this one-day Semi-Finals, the top scoring half of teams will qualify for the Ares Finals, while the remaining teams will qualify for the Phobos Finals.

1.b. The rover shall be a stand-alone, off-the-grid, mobile platform. **Tethered power and control are not allowed in the Semi-Finals or the Ares Finals, but will be allowed for a 25% penalty in the Phobos Finals.**

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 22, 2016.

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). 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. 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, non-operator team members, and other spectators 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 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 URC and MDRS web site – http://mdrs.marssociety.org/ – for field reports, images, and other resources). 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). 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. Rovers shall be able to withstand extremely 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 tent to the rover for the sample return and equipment servicing tasks. For the Terrain Traversing and Astronaut Assistance Tasks line of sight communications are not guaranteed for more than 50% of the courses. Rovers are not expected to travel more than 1km 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 permitting 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.

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 4, 2015. 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 22, 2016. 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 4, 2015, 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 4, 2016. 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.

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 70kg. For example a modular rover may have a robotic arm and a sensor that are never on the rover at the same time. The rover plus arm or rover plus sensor must each be under 50kg, but the total rover plus arm plus sensor must only be less than 70kg. The weight limits do not include any spares or tools used to prepare or maintain the rover or command station equipment. There are no minimum or maximum dimensions for the rover, but the Terrain Traversing 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 25, 2016 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 not required to be autonomous although some level of autonomy may be beneficial. It may 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.h regarding the impacts of a loss of communications. **In the Phobos Finals teams may use tethered communications and power instead of wireless, but will be penalized 25% of the points earned during that 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. 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, 2016. 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 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. (Note that antennas suffer extremely degraded performance when operating inside metal structures and this approach is strongly discouraged.)
- 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.

2.d.iii. Antenna height is limited to 3m. Antenna bases must be located within 5 meters of the team's command and control tent, and shall adhere to all applicable regulations. 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, but antenna height is still limited to 3m. **All teams shall bring at least 20m of antenna cable** to be 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 22, 2016. 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 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.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. 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 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.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 not practical for this application.

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. 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").
- 2.h.ii. 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.h.iii. 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.h.iv. 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 task. Runners will still be permitted to retrieve or repair the rover in future interventions. In other words if a team member leaves the command station they are not permitted to return to operating the rover.
- 2.h.v. Interventions will be at no penalty if teams have not travelled more than a set distance from the start gate to be defined by the judges for each task. Beyond that distance 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 0.8x0.8 = 64%.

3. Presentation Task and Supporting Documents

3.a. Presentation Task: Teams shall submit a video presentation by May 13, 2016 to the URC judges describing their team, rover design and functionality. The presentation shall be in English and no longer than 15 minutes. Specific technical requirements for the video will be posted to the URC website. Judges may ask follow-on questions as warranted after reviewing the video. Scoring for this section will be assessed on the following equally weighted categories:

- Team structure, organization, and management
- Core rover design and presented functionality
- Suitability of rover design to competition tasks
- Overall quality of presentation

3.b. Science Plan: Teams shall submit a written science plan by May 13, 2016, which will be factored into the judges' evaluation for the Science Cache Task (Ares Finals) or Rover Science Analysis Task (Phobos Finals). Specifications for the plan will be posted to the URC website. The plan should include:

- Basic knowledge about Mars (for example: geology, regolith chemistry (pH, chemical composition, etc.), 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.

4. Semi-Finals

4.a. All teams invited to the URC field competition will compete in a Semi-Finals on the first day of the competition. At the end of this one-day Semi-Finals, the top scoring half of teams will qualify for the Ares Finals, while the remaining teams will qualify for the Phobos Finals.

4.b. Semi-Finals will take place as a single short course event that combines features from each of the Ares Finals tasks. This will include:

- Basic mobility and maneuverability to overcome small obstacles
- The ability to pick up objects and carry them a short distance
- Simple dexterous tasks such as flipping a switch or pressing a button.
- General scientific knowledge that is applicable to the Ares Sample Return Task.

4.c. Once a team's rover crosses the start line, no interventions are allowed. Teams are allowed to work on their rover between runs.

4.d. Teams will compete in heats with multiple teams per heat. During each heat teams will receive 3 runs (opportunities on the course) with 5 – 10 minutes per run. Time between runs will be determined in the final schedule but is expected to be 5 – 15 minutes. Scores will based on tasks completed within the time limit. There are no points for finishing before the time limit. Scores will not be applied to either of the Finals.

5. Ares Finals

5.a. The rover shall be judged in the four competition tasks outlined below in 5.b to 5.e in addition to the presentation task outlined in Section 3. The five tasks will be independent events.

5.a.i. For the four Ares Finals events, the rover is not required to be in the same configuration so modular pieces can be swapped between tasks. Teams will have at least 2 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. The rover will be accessible throughout the competition and modifications can be made at any point.

5.a.ii. Each event, including the presentation task, 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.

5.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 20 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.

5.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.

5.b.i. 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 0.5km radius of the command station.

5.b.ii. 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.

5.b.iii. 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 5cm or deeper. Sample(s) must be at least 5g 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 5cm will be used to determine the sample mass.

5.b.iv. **Onboard equipment at a minimum should test the soil moisture (relative humidity), subsurface temperature (at least 10cm 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.

5.b.v. Any chemicals used onboard, including water, must follow a no-spill policy of being contained on the rover and not spilt on the ground, including any reaction products. 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.

5.b.vi. Teams will be given between 20 and 30 minutes to collect data and sample(s) with the rover. Teams may investigate as many sites as time allows.

5.b.vii. 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 open the sample for subsequent laboratory analysis at a later time in the competition.

5.b.viii. At a later time the cache will be returned to the teams and they will be given 15-30 minutes to analyze the sample and prepare 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 the sample was collected at least 5cm 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.

5.b.ix. 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.

5.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. All items to be delivered will need to be picked up in the field by the rover. The location and description of equipment will be given in GPS coordinates to within 3m.

5.c.i. The equipment to be delivered to astronauts deployed in the field may include small lightweight hand tools (e.g. screwdriver, hammer, wrench) and supply containers (e.g. toolbox, water jug, gasoline can) up to 5kg in mass. Teams will be provided with instructions to deliver specific pieces of equipment to specific astronauts and return specific equipment or samples from them.

5.c.ii. 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. The exact number and nature of objects and astronauts is intentionally not

specified.

5.c.iii. All items to be picked up by the rover in this task will have a handle no greater than 5cm in diameter. Each containers shall be no larger than 40cm x 40cm x 40cm, with a mass no greater than 5kg, but teams should expect a variety of sizes and weights. Rovers may pick up multiple items at a time, and may make multiple trips to retrieve additional objects.

5.c.iv. As many as half of the objects or astronauts will be intentionally located out of line-of-sight communication with the control station. The maximum time limit will be between 30 and 60 minutes. All equipment and astronauts will be located within a 0.8 km radius of the start gate. The equipment and the astronauts will be accessible via relatively benign terrain if routes are well chosen. Scores will be based on the number of objects delivered to or retrieved from the correct astronaut, and the time taken.

5.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 0.25km across relatively flat terrain (minimal slope) to reach the equipment. The equipment servicing task will involve performing maintenance on a generator which may 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 a U-hook 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.
- Flip open a cap on the fuel tank.
- 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 2.5 kg.
- 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.
- Start generator by pushing a button or flipping a switch
- Verify operation by reading a message on a LCD display

5.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.

5.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. Unlike the other tasks, this task poses a significant hazard to the rovers, and teams may want to weigh the risk vs. reward before attempting some of the obstacles, especially early in the competition.

5.e.i. Terrain obstacles will be of two types: gates that must be passed through, and routes marked out by visual markers. Obstacles will range from very easy and close to the starting line, to exceedingly difficult obstacles at greater distances also involving navigation challenges. Obstacles may include:

- A steep slope in excess of 45°.

- Descending a vertical drop of up to 1m or ascending a drop of up to 0.5m or both.
- Operation beyond direct line of sight of the ground station antenna.

5.e.ii. Rovers will be required to pass through a set of obstacles not more than 1km from the start gate. Gates will consist of either 2 white PVC pipes or colored tennis balls. Tennis balls may be partially buried to prevent rolling. PVC pipes will be no less than 10cm in diameter, standing vertically from the ground to a height of 1-2 meters. All gate markers will be spaced at least 2m apart. Required routes will be defined by tennis balls, ropes, or other visual markers placed at least 2m apart creating a lane that the rover must pass through. Teams will be given GPS coordinates of the obstacles and may walk the terrain course ahead of time. The terrain is hilly and undulating and direct line-of-sight communications is not guaranteed, but there should be reasonable line-of-sight communications for most of the course.

5.e.iii. Teams will have a maximum time of between 30 and 60 minutes on course and do not have to return to the start gate. Exact details including the number of gates will not be specified in advance. Teams will be scored for each gate and marked route they pass through. Points will be awarded for partial completion, and will be deducted for failure to stay within marked routes. Obstacles may be attempted in any order.

5.e.iv. In the event of an intervention as per section 2.h the rover may be repaired in place or may be moved to a location as defined by the judge in the field. However, when on extreme terrain, the judge may require the rover to be moved for the safety of team members or preservation of the course.

6. Phobos Finals

6.a. The rover shall be judged in the two competition tasks outlined below in 6.b to 6.c in addition to the presentation task outlined in Section 3. The three tasks will be independent tasks.

6.a.i. For the two Phobos events below, the rover is not required to be in the same configuration so modular pieces can be swapped between tasks. Teams may only have minimal time between runs to reconfigure, adjust and repair their rovers due to schedule constraints. The rover will be accessible throughout the competition and modifications can be made at any point.

6.a.ii. The Presentation Task and Rover Science Analysis Task shall each be worth 100 points, and the Phobos Obstacle Course Task shall be worth 200 points, for a total of 400 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.

6.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 20 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.

6.a.iv. As specified in rule 2.c, **Phobos Finals teams may use tethered communications and power instead of wireless at the cost of a 25% penalty**.

6.b. **Rover Science Analysis Task:**

Teams will compete in a modified version of the Ares Finals Science Cache Task (see Section 5.b), but no sample collection will be required. Teams shall be required to investigate a particular region to learn as much as possible about the habitability potential of that region using a rover. Teams shall provide a detailed analysis of each site, including measurements of local soil moisture, and subsurface temperature. Samples must be investigated by the rover on-site, and shall not be brought back to the crew for investigation.

6.b.i. Scores will be based on the following equally weighted components:

- Thoroughness of investigation of the sites (panoramas and stratigraphic profile)
- Quality and applicability of the onboard analysis (moisture, temperature, rover capability of choice)
- Quality and applicability of the planned laboratory analysis.
- Scientific knowledge of Mars astrobiology.

6.c. **Phobos Obstacle Course Task:**

Teams shall be required to complete an obstacle course-style task that incorporates elements of the Terrain Traversing, Astronaut Assistance, and Equipment Servicing Tasks of the Ares Finals. The components that make up the Phobos Obstacle Course Task will be scaled appropriately to allow teams to accomplish them all within a single event, and in a single configuration.

Teams will be scored based on completion of tasks, with additional points awarded for overall speed of completion. Depending upon the final event schedule, teams competing in the Phobos Finals may have the opportunity to make more than 1 attempt at this course, with the single highest score being used for the team's overall score.

7. Team Management

7.a. Teams shall be required to track all finances as related to this project, and submit a final expense record no later than May 20, 2016 (if necessary, teams may submit an updated record – hard or soft copy – on the first day of the URC event – June 2, 2016). 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.

7.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.

7.a.ii. Teams may acquire in-kind donations of equipment. Such donations will count towards the cash budget at its documented value, except for specific exemptions granted by the URC Director for donations made available to all URC teams. Corporate sponsorship is encouraged.

7.a.iii. Teams may be required to submit receipts as proof of budget upon request (donations must be documented by the donor).

7.a.iv. 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 http://www.irs.gov/publications/p946/index.html.

7.a.v. 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 7.a.v

7.a.vi. International teams have an allowable budget equivalent to $15,000 US based on the most advantageous documented currency conversion rate between August 1, 2015 and June 2, 2016.

7.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, 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.

7.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.