

## **Rules for 2017 American Mars Exploration Rover Challenge**

Any issues not covered in this document will be addressed on a case-by-case basis by the American Mars Exploration Rover Challenge (AMERC) Director. Please consult the Questions and Answers (Q&A) portion of the AMERC web site (<http://rcs.marssociety.org/amercc>) for updates. All matters addressed in the Q&A are applicable to the requirements and guidelines.

### **1. Competition Overview**

- a. The 2017 American Mars Exploration Rover Challenge will be held May 13-14, 2017 at the Wings Over the Rockies Museum in Denver, Colorado.
- 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.d of the rules.
  - 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.
  - ii. Aerial vehicles are not allowed.
- c. Teams will operate their rovers from designated command and control stations. Visibility of the course by the operators in the control station will be blocked. Basic power, tables, and chairs will be provided. Power will be US standard - 120V, 60Hz. All competition events will be held in an indoor environment, however team “pits” (areas designated for rover maintenance between tasks) may be outdoors under covered tents.
- d. There is no restriction on the number of team members or operators allowed. All operators must remain in the designated operators’ area. Team members spectating or observing 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.
- e. No team members may enter the Mars yard except for an emergency shutdown, or to retrieve or repair their rover. Members of the judging team, media, non-operator team members, and spectators will be able to observe the rover's operation, but must not communicate any aspect of the rover's position, condition, or state of the course to the operators while their rover is on course.
- f. An artificial Mars Yard will be created for the competition area. This area will be approximately 100 ft x 150 ft. The artificial terrain will be a landscaped mixture of rocks and sand-based dirt. The course will not be available for practice prior to the competition.
- g. Registration, Design Review and Down-Selections  
Specific details for each deadline (including deliverable format, submission requirements, and judges' expectations) will be posted to the AMERC web site (<http://rcs.marssociety.org/amercc>).
  - i. Registration  
Teams are required to register and declare their intent to compete no later than

January 13, 2017. [Note: This supersedes the previously announced deadline of November 30, 2016.] No significant deliverables are required for this deadline, aside from team details requested via the AMERC web site, and a \$25 registration fee.

ii. Design Review

Teams are required to submit a Design Review Package no later than February 5, 2017. [Note; This supersedes the previously announced deadline of January 31, 2017.] The Design Review Package will focus on the team's overall design, technical progress, team structure, and project plan.

- h. Teams shall be required to track all finances as related to this project, and submit a final expense record no later than May 6, 2017 (if necessary, teams may submit an updated record – hard or soft copy – on the first day of the AMERC event – May 13, 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 AMERC event (May 14, 2017).
- i. The maximum allowable cash budget to be spent on the project is **\$5,000 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.
- ii. Corporate, school, and private sponsorships and donations are 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.
- 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.
- 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.h.v.
- 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 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](#).

- vi. Non-US teams have an allowable budget equivalent to \$5,000 US based on the most advantageous documented currency conversion rate between August 1, 2016 and May 13, 2017. Shipping costs are not included in the \$5,000 budget cap.
- i. The competition is open to high school students. Students from multiple schools may compete on the same team. A single school may field multiple rovers and multiple teams, however there may be no overlap between team members and leaders, budget, donated equipment, or purchased equipment. All student team members must be actively enrolled in a high school, or home schooling equivalent, or have graduated after the declaration of intent deadline of January 13, 2017
- j. Teams are required to work with an adult advisor or advisors who can provide oversight, and guidance. Advisors are expected to foster an environment of self-learning, team-building, and independence among the students. Advisors should assist students with the execution of nontechnical team management duties, including tracking finances, and preparation of reports. The actual design, fabrication, testing, and operation of the rover is to be entirely done by student team members as defined in section 1.i.

## **2. Rover Guidelines**

- a. Teams are free to design and build their rover as they see fit to meet the objectives outlined in these rules. Teams are free to base their design upon such models, or use completely original designs. There are no restrictions against using robotics kits or building custom rovers as long as they adhere to these rules.
- b. Rovers shall exclusively utilize rechargeable batteries for their power source.
- c. The maximum allowable mass of the rover when deployed for any competition task is 15 kg. The total mass of all fielded rover parts for all events is 20 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 15 kg, but the total rover plus arm plus sensor must be less than 20 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 some tasks may provide operational constraints that affect design.
  - 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 15.
  - ii. Rovers over 20 kg in any given configuration must be cleared with the AMERC Director by email prior to April 28, 2017 to be eligible to compete.
- d. Rovers are expected to be teleoperated in real-time (controlled by students). 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 AMERC 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 60% of the points earned during that task.**

- e. Teams are required to use standard WiFi for all wireless communications between the command and control station and the rover. Other wireless frequencies should not be used.
  - i. Teams are required to implement their own dedicated wireless Local Area Network (LAN) with their own wireless router. Teams are required to password protect their networks to prevent external devices from accessing their networks. Teams are also required to implement automatic channel switching protocols (fixed channel wireless networks are not reliable in crowded environments with multiple networks).
  - ii. Large antennas are not required, as all command and control stations are expected to be within 50 m of the Mars Yard.
  
- 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:
  - 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.
  - 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.
  - 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.
  - 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.
  - 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.
  - vi. Spectating team members may carry tools and the command station may radio out to them to request an intervention.
  - 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  $0.8 \times 0.8 = 64\%$ .
  
- 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. The kill switch should cut the main power from the battery to all systems, and should create a physically open circuit for all power to the rover when activated.

### **3. Competition Tasks**

- a. The rover shall be judged in the four competition tasks outlined below in 3.b to 3.e.
  - 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.
  - ii. Each event shall be worth 100 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  $0.9 \times 0.8 = 72\%$ . Tasks are scored independently and it is not possible to score less than zero on a task.
  - 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 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.
  
- b. **Terrain Trek Task:**
  - i. The rover will proceed through a defined course and through a series of gates over a variety of terrain obstacles of varying and generally increasing difficulty. Terrain may include soft sandy areas, rough stony areas, rock and boulder fields, vertical drops or climbs of up to 30cm, and steep slopes or banks of up to 45 degrees. Rocks or boulder obstacles may be up to approximately 20cm in height.
  
  - ii. Terrain obstacles will be of two types: gates that must be passed through, and routes marked out by visual markers. Obstacles will range from relatively close and easier obstacles to more challenging ones further from the start line. The course will be defined by small traffic cones, tennis balls, or other small but high contrast markers. The gates will be defined by traffic cones or poles. The gates and path will be approximately 1.5 meters wide. Exact details of the course, including the number of gates, will not be specified in advance. Teams will be able to visually inspect the course from outside of the course area prior to the competition. Judges will conduct a one-time on course walkthrough with no more than two members of each team prior to the event.
  
  - iii. Points will be awarded for each gate or obstacle cleared, with increasing points for increasingly difficult gates or obstacles. To obtain credit for a gate, the rearmost portion of the rover must completely clear the line between the goal markers. Points will be deducted for each time the rover leaves the defined path. The course is expected to be conducted in a specific path and order, and points will be deducted for failure to pass through the obstacles in order. However, there is no penalty for skipping an obstacle. A team will not receive negative points for the event, regardless of point deductions.

- iv. 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.

**c. Tool Delivery Task:**

- i. 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 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, fuel can) up to 2kg 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.
- ii. The astronauts will be represented by clearly visible markers of human size (for example, a utility suit and helmet lying on the ground). The exact number and nature of objects and astronauts will be revealed at the competition, but the number of astronauts will not exceed 4. Each astronaut will need no more than one object delivered or returned (ie: maximum of 4 objects to deliver and 4 objects to retrieve). The delivery objects will all be in a 'supply' area, and the retrieved objects will need to be placed within a retrieval area. Both will be clearly marked circles approximately 1 m in diameter. The supply and retrieval areas may not be the same location.
- iii. All items to be picked up by the rover in this task will have a handle no greater than 3cm in diameter. Each container shall be no larger than 20cm x 20cm x 20cm, with a mass no greater than 2kg, 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.
- iv. Scores will be based on the number of objects delivered to or retrieved, whether the objects were delivered to the correct astronaut, and how close the delivered objects were to the astronaut, and how close the retrieved objects were to the delivery station. Full credit is given if the correct item is placed within 25 cm of the correct astronaut, and if the retrieved object is placed within the delivery area. Deductions will be taken for delivery of objects further than 25 cm from the astronaut, delivery to the incorrect astronaut, or placement of the retrieval object outside of the retrieval area. The objects may be delivered and retrieved in any order. A negative score can not be received regardless of the number of deductions.

**d. Equipment Servicing Task:**

- i. Rovers shall be required to perform several dexterous operations on a mock-up equipment system. The equipment servicing task will involve performing maintenance on a simulated piece of equipment.
- ii. The rover will be asked to manipulate the controls on a simulated control panel. The controls will be designed for human operation, and consist of controls such as push

buttons, switches, and simple dials. All controls will be within 50cm of the ground. The size and force required will be such that a single ungloved human hand could easily operate them. Any dial will not require turning more than 90 degrees. Controls will be of normal household size, such as wall light switches, etc, and will be large enough that they can be easily manipulated by a gloved human hand. The controls may be operated in any order. Points will be awarded for each control properly manipulated. points will be deducted for rough operation that damages the controls, or that pushes the control panel on the ground.

**e. Fossil Hunt Task:**

- i. For the fossil hunt task, no more than 10 simulated or real fossils will be placed in the Mars yard. The fossils will be of stone, cement, shells or other hard material, and may be similar in color to the terrain. They will be between approximately 5 cm and 20cm in size. Their appearance will be such that a human should be able to see them readily at close range, but not so obvious that they can be spotted from a distance. They will be flat with the terrain but not buried. There will be no other markers (cones, etc) of their location. Fossils will be of different types of animals or plants.
- ii. The judges will place the fossils randomly in the sub-portion of the yard prior to each team's operation without the team operators being able to observe them (ie: behind a temporary screen). The team will then attempt to locate, photograph, identify, and describe the fossil found. - type of fossil (fish, mollusk, sponge, coral, arthropod, plant, etc.). The judges will award points based on the number of fossils found and accuracy and specificity of the identification. Points will be deducted for damaging or running over the fossils with the rover, or for misidentifying rocks as fossils. A negative score for this task is not possible regardless of the number of point deductions.