



2015 ROBO-OPS COMPETITION RULES

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The competition will take place at the NASA JSC Rock Yard described in the ***Planetary Analog Test Site (PATS) User's Guide***. Allowable rover systems can include a single rover or parent rover with supplementary/scouting micro-rovers ("daughter bots"). It is important to note that the entire rover system and everything used on the system during the competition must adhere to the established size and weight requirements below.

NEW THIS YEAR: Returning teams do NOT have to bring start with a new rover design, but they must demonstrate some improvement on previous years' design.

PLANETARY ROVER DESIGN CONSTRAINTS AND REGULATIONS

1. The rover system (and everything used on the rover during the competition) must be no larger than 1m x 1m x 0.5m in a stowed configuration
 - a. Camera masts must fit within the stowed configuration limits. Collapsible/foldable masts may be used, but will need the capability of deploying themselves - without human intervention - from the stowed configuration.
 - b. Note: "Stowed Configuration" is NOT the same as "Out of the Crate." Stowed configuration shall be the same as the "as landed" configuration. You will have time to unpack your rover and make necessary adjustments prior to being measured. However, at measurement, ALL items used on the rover must fit within the stowed configuration constraints, including camera masts.
 - c. Time penalties will be incurred for every cm over the established size limit. (See penalty section below)
2. The rover system (and everything used on the rover) must have a mass less than or equal to 45kg.
 - a. After the weigh-in at the beginning of the competition, no additional mass can be added to the rover.
 - b. Time penalties will be incurred for every kg over the established size limit and for any mass increase after the initial weigh-in.
3. The rover(s) must have one or more on-board cameras capable of transmitting visual data back to their home university Mission Control.
 - a. Teams are required to provide NIA with their Live Stream of their on-board camera feed (i.e., we want to see what Mission Control sees during the competition).
4. The rover(s) must have an on-board microphone capable of transmitting audio data back to their home university Mission Control.
 - a. Teams are required to have audio streaming, along with their visual Live Stream, up and running for the public to hear during their competition run.
5. The rover(s) should be able to traverse over obstacles up to 10cm in height.

6. The rover(s) should be able to negotiate upslopes and downslopes of 33% grades.
7. The rover(s) should be capable of selectively picking up irregularly shaped rocks with diameters ranging from 2 to 8 cm and masses ranging from 20 to 150 gm. The rover(s) must be capable of storing the rocks on the rover and/or daughter bots and transporting them throughout the course. The rover must also be capable of determining the color (red, purple, blue, green, yellow, or orange) of each of the rocks.
8. The rover(s) should be capable of traversing sand with no appreciable slope for a distance of at least 20 feet.
9. Each team will have at most an hour to complete the course and required tasks.
 - a. The rover(s) cannot be charged during this time. The total amount of operational time (within that hour) will vary depending on the strategy used by each team.
10. The rover(s) cannot be powered by an internal combustion engine.
11. The rover(s) should be able to operate in light rain, but the competition will be halted at the judges' discretion due to heavier rain.
12. The rover(s) will be controlled remotely based solely on data, including video, gathered from the rover itself.
 - a. The rover(s) will be controlled from the home campus of the university, with the video from the rover capable of being streamed through a web site.
13. A robust communications architecture should be incorporated. Communications with the rover system could be through use of a wireless broadband card, mobile hotspots, or USB broadband devices. Typical data rates at the site are ~0.6Mb/s download and ~0.4Mb/s upload, and latency of 150-300ms.
 - a. Teams are invited to use a broadband card/mobile hotspot/USB broadband device from any wireless carrier they desire.
 - b. Teams may incorporate more than one communications technology option onto their robot(s).
14. The rover(s) should be able to navigate the Rock Field, Lunar Craters, Sand Dunes, and the Mars Hill (see picture below).
 - a. The Gravel Pit, as depicted below, will NOT be used in the Robo-Ops Competition.
 - b. The Sand Dunes will be weeded and comprised solely of sand.



Figure 1: Rock Colors



COMPETITION TASKS, RULES and REGULATIONS

Course Duration: Each team will have one hour to complete the course.

Course Terrain: A minimum of 30 colored rock samples (of the size, mass, and color described in the Requirements document) will be placed throughout the Rock Field, Lunar Craters, Sand Dunes, and the Mars Hill shown in Planetary Analog Test Site (PATS) User's Guide. **Note:** the Gravel Pit will **NOT** be used in the competition.

Rock Point Values: Different colored rocks will be assigned different point values. In 2015, the higher value targets will be biased heavily in the Mars yard.

- Red = 6 points
- Purple = 5 points
- Blue = 4 points
- Green = 3 points
- Orange = 2 points
- Yellow = 1 point

Each Team's score for the roving portion of the competition will be determined by how many points worth of rocks are collected and stored by the rover at the end of the competition. Bonus points will be awarded for returning with the rocks to the starting point on top of Mars Hill, for collecting at least one rock from each of the four terrains, and for acquiring an "alien life-form." Total Rock Yard points will be tallied, and the team with the highest number of actual points will receive a score of 60 points for the roving portion of the competition. All other teams will receive their score based on a linear scale proportional to their Rock Yard points.

Course Run: Teams will begin at the top of Mars Hill, which is approximately 3 meters in elevation above the Rock Field. From this altitude the rovers have the opportunity to survey the sites using on-board cameras to see where the samples of most interest are, allowing for more efficient collection. The rovers will then descend to the bottom of the Hill looking for rocks along the way. At the bottom of the Hill, the team members controlling the rover from the home campus will have to decide which of the other areas (Rock Field, Lunar Craters, or Sand Dunes) they wish to go to next.

Communication: Once the competition commences, on-site team members are not allowed to communicate any information about the course or the other teams' performance to their off-site team members. Teams are allowed to talk with mission control during the 15 minute set-up period at the top of Mars Hill, however, conversation will be limited to robot prep and trouble-shooting. Under no circumstances will course layout or rock placement be discussed during this time. Teams will be allowed to have one photographer (usually the advisor) to take pictures during their competition run, but he/she must remain behind the rover at all times. No other cameras, cell phones, or electronic devices will be allowed on the course, with the exception of the one cell phone being used by the official NASA relay. However, teams going later in the day can watch the camera feed from the other team's rovers.

Competition Time Slot Selection Process: NASA and NIA have developed a method for teams to compete for time slots they desire – based on the weight of the rovers. A 45-kg mass limit has been established for each rover. Because NASA has an interest in reducing mass wherever possible, we will allow the lightest rover to select the time slot of their choice. The second lightest will have second choice, and so forth. Teams going later in the competition are afforded an advantage, as they can watch the camera feed from the other team's rovers.

Transport Stations: Because of the difficulty in navigating from one area to the others, the on-site team members will be allowed to pick up and transfer the rover from a designated "transport station" with samples attached to another area. There will be two (2) one-square-meter pieces of plywood on the ground, at various points on the competition field, which will serve as the transport stations. Once any portion of the rover is touching one of the transport pads, it can be physically picked up and transported to the other transport pad (if the team desires to pick it up). If teams want to transport any daughter bots or micro rovers, they will also be required to touch the transport pads prior to being picked up. However, teams are not required to use the transport pads if they find it is more efficient to let the rover(s) move to the next location under the direction of their drivers at mission control.

- Special Note: Other than the 10 minute mulligan, this is the only time during the competition when the rover can be touched, and the only time during the competition when off-site team members can communicate to the onsite crew. The off-site team members can only transmit the name of the area they wish to go to next – and all communication will be conducted through a relay/NASA Official.

Battery Charging: No charging will be allowed during the hour-long competition.

Mulligan: If a rover needs to be repaired after initial operation begins, judges will allow one human intervention lasting up to ten (10) minutes. This is the only time a rover can be touched during the one-hour competition, other than during "transport." The ten minutes will be considered part of the overall time limit. In order to save time, teams are encouraged to bring a "doctor bag" of tools needed with them to the rover's starting point. A mulligan will not be permitted to extract a robot that has become stuck by the terrain (e.g. stuck in sand, overturned, etc.). The mulligan can be used in the event of lost communications to move the rover (parent rover only) to the nearest teleport pad. This will count as the team's only mulligan and a subsequent mulligan for repairs, should the need arise, will not be allowed.

If a team needs to use the mulligan, they are not required to utilize the entire 10 minutes and will be allowed to resume competition tasks as soon as they are able (as long as it is within the 10 minute window). Although teams will not be penalized for using the 10 minute mulligan, its use may become the deciding factor in the event of a tie (i.e., the team who chose NOT to use the mulligan will emerge as the winner).

WiFi usage by non-competitors: When a team is actively competing on the course, the remaining teams will be asked to limit their WiFi usage to reduce unnecessary complications in communication for the competing team.

EVALUATION/SCORING

The Robo-Ops Steering Committee, comprised of NASA experts, will evaluate and score the competition between participating teams. Robo-Ops projects will be evaluated and judged based on adherence to the Planetary Rover Design Requirements and the criteria below. The *2015 Robo-Ops Evaluation Form* provides a detailed explanation of the scoring approach.

Teams are responsible for thoroughly reviewing the *Guidelines for Deliverables* to ensure compliance in each area.

Sixty percent of the team's score will be related to rover performance. The remaining forty percent will be related to the technical paper, poster presentation, mission control operations, public/stakeholder engagement and participation.

Overall Competition Score: The maximum possible points for the overall competition is 100.

- **Roving Portion:** A maximum of 60 points will be awarded for the roving portion of the competition.
Includes rock point values and bonuses (see Evaluation Form)
- **Technical Paper:** A maximum of 10 points will be awarded based on the quality of the written Technical Paper.
Key elements that the Technical Paper will be evaluated on are:
 - Technical quality, feasibility, innovation of rover design and quality of technical description (4 points max)
 - Quality of summary of production and testing approach (4 points max)
 - Adherence to Technical Paper Guidelines (2 points max)

- **Poster Presentation:** A maximum of 10 points will be awarded based on the quality of the oral Poster Presentation.

Teams will be required to bring a poster for their rover(s) (48"x36" or 48"x42") to display during the Poster Presentation Session.

Key elements that the Poster Presentation will be evaluated on are:

- Technical content, style, and coherence of poster (5 points max)
- Engagement with judges and quality of questions (5 points max)

- **Mission Control:** A maximum of 5 points will be awarded based on the quality of Mission Control Operations.
- **Competition Participation:** A maximum of 5 points will be awarded based on participation, attendance, and engagement at all competition activities.
- **Public and Stakeholder Engagement:** A maximum of 10 points will be awarded based on the activities described below.

One of NASA's objectives in this competition is to engage as many people as possible in space exploration missions. To support this objective, each team must include a public engagement effort to "bring the public along" with each team as they work on the concept, design and finally the competition. NASA and NIA will be looking for teams to partner with organizations (i.e., marketing and communication departments at their school) who can achieve the goals for this portion of the competition by increasing the exposure of their project. Metrics are required.

Key elements that the Robo-Ops Public and Stakeholder Engagement deliverables will be evaluated on include:

Team Blog or Social Media Page

Each Team will create a robust blog or social media page for the competition that will document the project for the general public. ***A maximum of 5 points will be awarded for the team blog or social media page.***

The Team Blog or Social Media Page will be evaluated on the following:

- Design and functionality
- Quality and quantity of content and activity
- Number of hits/fan size
- Relevance to the audience

Live Stream of On-Board Camera Feed & Mission Control

Teams are required to provide NIA with their Live Stream of their on-board camera feed (i.e., we want to see what Mission Control sees during the competition). This live stream will be made available to the public during the competition, and teams are required to also make the stream public via their networks as well (i.e., blog or social media page), etc. In the past, teams have even reserved auditoriums at their colleges, inviting classmates to view the live stream as a group. ***A maximum of 5 points will be awarded for the Live Stream of On-Board Camera Feed and Mission Control.***

Note: Teams will be required to include audio in their livestream, as well as to RECORD the livestream and provide the recorded footage to NIA for future use.

The Live Stream from the On-Board Camera feed will be evaluated on the following:

- Design and functionality
- Number of viewers watching the live stream
- ***NEW THIS YEAR*** – Quality of audio stream
- Display content
 - 'Display content' refers to what the public sees in addition to the simple camera view. Points will be awarded for additional displays, including a view of mission control operations (a required feature) and any controls that would be of interest to the viewer. For example, teams have displayed torque/roll/speed controls in the past.

BONUSES

During the roving portion of the competition, teams will be awarded bonus points for the following actions:

- 20 bonus points will be awarded for collecting one of the "alien life forms" on the field. 2 different "aliens" will be placed on the Rock Yard course, but bonus points are only received for acquiring one alien life form.
- 25 bonus points will be awarded for picking up a rock in each of the four sections of the Rock Yard:
 - Rock Field
 - Lunar Craters
 - Sand Dunes
 - Mars Hill
- 3 bonus points will be awarded for every rock brought to the landing point on top of the hill, up to a maximum of 15 points;
 - Rule is that the rover **must** come off the hill & back up to qualify for these bonus points.

PENALTIES

During the roving portion of the competition, teams can incur penalties in several ways:

1. Rovers will be have an initial weigh-in at the end of the competition test day, to determine eligibility and competition time slots. Rovers will also be weighed for the second time just prior to their competition time. If mass of rover is increased after initial weigh-in, teams will lose 10 minutes of roving time for every kg of extra weight.
2. Teams will also lose 10 minutes of roving time for every 1 cm over the size limit of 1m x 1m x .5 m (stowed configuration).
3. Teams must transmit both their audio and visual live stream during their hour competition run. If the live stream does not transmit for at least 50% of the run, teams will lose 50% of their total roving portion point value **before** linear scoring is conducted.

Note: Although teams will not be penalized for using the 10 minute mulligan, its use may become the deciding factor in the event of a tie (i.e., the team who chose NOT to use the mulligan will emerge as the winner).