IRC INDIAN ROVER CHALLENGE

RULEBOOK 2019

FOR ANY RULEBOOK RELATED QUERY, CONTACT: rulesqueries@indianroverchallenge.in

Indian Rover Challenge 2019 - Requirements and Guidelines

Any issue not covered by these published rule sets will be addressed on a case-by-case basis by the Indian Rover Challenge (IRC) organizers. Rules are subject to change without prior notice. Please visit the Questions and Answers (Q&A) Section of the IRC web site for updates. All matters addressed in the Q&A are applicable to the requirements and guidelines.

1. Competition Overview

1.a. **The Indian Rover Challenge 2019 will be held from January 9 – January 12, 2019 at Manipal Institute of Technology, Manipal, Karnataka, India.** The competition is open to both graduate and undergraduate students, although teams are permitted to include secondary (high school) students. Students must be enrolled at least half-time in a degree or high school diploma granting course. 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.b. 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. Non-technical team management duties, including tracking finances, registration, submission of deliverables, and communication with IRC staff, fall within the duties of the students.

1.c. The rover shall be a stand-alone, off-the-grid, mobile platform. Tethered power and communications **are permitted at a 60% penalty of the total points scored by the team**. A single connected platform must leave the designated start gate. 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. At the completion of the task, a single connected platform should reach the designated end location. No airborne vehicles will be allowed at IRC 2019.

1.d. Teams will operate their rovers from designated command and control stations. These stations will be isolated units or structures at the competition site. Visibility of the course to the operators in the control station will be blocked. Basic power (220V, 50Hz), tables, and chairs will be provided. All of the competition events will be held in full daylight.

1.e. 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 and can activate an emergency kill switch (in the event of an emergency) or work on the rover in case of an intervention but may not otherwise participate in that task.

1.f. The GPS coordinates provided shall adhere to the WGS 84 datum standard. The format for the same will be latitude/longitude in decimal degrees.

1.g. There should be radio communication line-of-sight from the command station to the rover for all the on-site tasks. Rovers are not expected to travel more than 250m atmost from the command station.

1.h. Registration, Milestone Reviews and Down-Selections- Prospective teams will undergo a review and down-selection process, i.e only the teams which pass each milestone will be invited to compete in the field. Specific details and format for each deadline will be posted on the IRC web site.

1.h.i. Registration: -

Teams are required to register for the competition no later than September 1, 2018. General team details will be requested at this stage.

1.h. ii. System Review: -

Teams are required to submit a System Review package no later than October 20, 2018. The package will focus on the overall system design, science plan, and progress to-date of the final system. The package will consist of both written and video components. The System Review is a competitive milestone and packages will be judged against other teams' submissions by the judges. Teams who successfully clear this round will be invited to compete at the IRC.

1.i Teams shall be required to track all finances as related to this project, and submit a final expense record no later than December 15, 2018. Teams not submitting the same on or before December 15, 2018 will be penalized 20% of their points tally. Teams who do not submit the same will not be permitted to compete in IRC.

1.i.i. The maximum allowable cash budget to be spent on the project is ₹1,500,000 which shall include money components for the rover, rover modules, rover power sources, rover communications equipment, and command station equipment including the antenna and transceiver, and all command and control equipment (i.e. command station computers, monitors, controllers, etc.). The budget limit shall not apply to 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. Spare parts that are replaced one-for-one in the case of damage to the original are not counted against budget or mass limits.

1.i.iii. Corporate sponsorship is encouraged. Teams may acquire donations of equipment and services. However, such donations will count towards the cash budget.

1.i.iv. 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. Shipping and taxes should be included in the cost since these are a standard part of the cost of any item.

1.i.v. If used equipment is purchased commercially then as-bought price may be used. If the used equipment is donated to the team and no as-bought price exists for that particular component, then the cost of a new component must be used.

1.i.vi. Non-Indian teams have an allowable budget equivalent to ₹1,500,000 based on the most advantageous documented currency conversion rate between August 1, 2018 and December 15, 2018.

1.i.vii. Teams can submit updated cost reports any number of times before the start of the competition at no extra penalty.

2. Rover Guidelines

2. a. The battery powered systems shall be utilized only for the rovers. In case of use of any potential hazardous materials on the rover, proper documentation should be provided to the organizers to ensure safety at the competition site.

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 75 kg. The weight limits do not include any spares or tools used to prepare or maintain the rover, but does include any items deployed by the rover such as sub-rovers, cameras etc.

2. c. 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. d. The rover is required to be in the autonomous state for only the Autonomous Task. 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. Teams may use tethered communications instead of wireless, but will be penalized 60% of the points earned during that task. The rover will be expected to traverse up to a distance of 250m from the base station.

2. e. Teams must notify the organizers of the communications standards they will be using, including frequency bands and channels, by December 15, 2018.

2. f. In case of rover failure or communication loss, the team is allowed to call for an intervention but must adhere to the following guidelines:

2. f.i. Only the members at the base station are allowed to call for an intervention. The request for an intervention must be communicated to the judge present at the base station.

2. f.ii. A penalty of 15% of the total points scored will be levied for each intervention. There is no limit on the number of interventions.

2. f.iiii. If a spectating team member presses the emergency switch without an intervention being called by the base station, it will result in immediate suspension of the task and the team will be awarded the points scored up till that stage.

2. f.iv. Spectating team members may carry tools and equipment to carry out repairs on the rover.

2. f.v. 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 for data analysis, after this point for the current task. Runners will still be permitted to retrieve or repair the rover in future interventions.

2. f.vi. If the rover is returned to the command station, the 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.vii. 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.

2.g. All rovers 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. Field Tasks

3.a Overview

3. a.i. Challenge Tasks are independent. Teams will be permitted to change the rover configuration between tasks. A certain amount of time will be scheduled in between tasks to allow teams to modify, repair and optimize their rovers.

3. a.ii. The judges’ panel consists of a number of specialists selected by the Organizer. The judges shall act independently of the organizer, but they will adhere to the schedule provided by the organizer.

3. a.iii. Each event and the system review report shall be worth 100 points, for a total of 500 points. Penalties for overweight rovers, interventions, and other penalties are additive.

3.b Schedule

3. b.i. Teams will have to complete four tasks in a span of 3 days.

3. b.ii On the final day, team total scores are computed, winners are announced and the prizes are awarded accordingly.

3. b.iii. Detailed schedule, containing also the exact time window for each Task, will be specified by the organizer one week before the competition.

3. b.iv. Schedule is rigid – no team is allowed to exceed the permissible time limit or postpone tasks time window. A certain amount of time will be scheduled in between Tasks to allow Teams to modify, repair and optimize their rovers.

3.c Competition Site

3. c.i. All tasks will be organized at an outdoor stadium in daylight.

3. c.ii. The base station will be equipped with tables, chairs and a power strip with multiple 230V, 50Hz standard Indian sockets

3. c.iii. The Challenge field, where field Tasks will be held, will be artificially landscaped. Sandy, non-cohesive soil as well as hard, dry terrain should be expected. The rover should be built to handle such terrain including appropriate dust resistance.

3. c.iv. 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 for all tasks.

3.d Autonomous Task

Rovers shall be required to autonomously traverse between markers in this staged task across moderate terrain. Teams will be given a fixed amount of time for a given stage. 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. Teams will have between 25 and 35 minutes to complete this task.

3. d.i GPS coordinates for each destination will be provided.

3. d.ii. The first stage will feature simple terrain and no major obstacles whereas the second stage will include a more difficult terrain with small obstacles.

3. d.iii. To complete a stage, teams must start with their rover within 2m of the designated start point. Before proceeding, teams must formally announce to judges that they are entering into the autonomous mode. In autonomous mode team members may monitor video and telemetry information sent from the rover, but may not transmit any commands.

3. d.iv. The rover shall autonomously navigate from the start point to the finish point. The rover's on-board systems are required to decide when it has reached the finish marker, and transmit a message back to the operators that is displayed for the judge to observe. Teams can resume tele-operation at the end of each leg but must switch to autonomous mode before attempting the next stage.

3. d.v. At each destination point, at least one of the objects will be present - a red box, a yellow disc or a blue bottle. More than one object may also be present at the point; the rover should detect the presence of all the objects and relay the information back to the base station.

3. d.vi. 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. d.vii. Total number of the stages maybe revised by judges but will be informed in advance.

3. d.viii. Teams will be allowed to scout the site using teleoperation to collect information about the field. However, no extra time will be provided for the same.

3. e. Equipment Servicing Task

In this task, the rover is expected to operate on a mock-up panel and perform a specified set of operations that includes:

- Pick up an object and traverse to the panel. Cache will have a handle at least 10cm long and not more than 5cm in diameter weighing less than 3 kgs.
- Open a drawer, place the object inside it and close the drawer.
- Push buttons, flip switches, turn knobs.
- Read the values from a digital display and report them to the judges.

3. e.i. Teams will have up to 30 minutes to complete the task. Points will be awarded for completing each sub-task successfully.

3. e.ii. The maximum height of the panel will be 1m from the ground.

3. f. Astronaut Assistance Task

In this task, teams are expected to traverse from a specified point to another, collecting and delivering objects on its way. Teams should expect moderate to extreme terrain that the rover must overcome to complete the task. Teams will have up to 30 minutes to complete this task.

3. f.i. GPS coordinates will be provided for all the points that the rover needs to complete the task.

3. f.ii. The rover can take any path it wants but certain parts of the terrain will be compulsory to complete the task. These will be marked by green tennis balls - the rover should not move out of the path defined by these markers to avoid penalty.

3. f.iii. Objects 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. f.iv. All the objects in the field must be retrieved and delivered to the specified destination.

3. f.v. Teams will have to ensure the rover returns to the starting point after collecting the task is completed.

3. g. Science 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 in addition to the data obtained from the on-board instrumentation.

3. g.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 biological interest within a 200 m radius of the command station.

3. g.ii. Teams shall document each site investigated by: A wide-angle panorama showing the full context of the site. The panorama must indicate cardinal directions, and have some indication of scale, 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. g.iii. Based upon investigation of the selected sites, teams shall then collect a sub-surface sample from a depth of 5 cm or deeper. Sample(s) must be at least 10g 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. g.iv. After collection of the sample(s), the rover must then store them and return to the command station.

3. g.v. The onsite analysis should conduct subsurface soil temperature and any science capability of the team's choice and additional sensors, subsystems, and test procedures are left to the discretion of the teams to meet the science-driven objectives of this task.

3. g.vi. Any chemicals used onboard, including water and any reaction products, must not spilt on the ground as well as the rover.

3. g.vii. Teams will be given between 20-25 minutes to collect data (of scientific relevance in context to Martian biosphere), and collect the sample. Teams may investigate as many sites as time allows.

3. g.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 time of the competition.

3. g.ix. The onsite task would be followed by a 10-15 minute discussion (presentation) with the judges. The discussion with the judges is allowed even if the team was unsuccessful in obtaining samples with their rover.

3. g.x. The Presentation and discussion should include: -

- Evidence of water in the profile
- Reasoning for sample site selection and documentation of each site
- Results of on-board rover analysis
- Meaning of data collected with respect to the habitability potential, the geology of the site (past and present).
- Scientific knowledge of Mars based on responses to judges' questions

3. g.xi. The score for this task will be based on the following components:

- Thoroughness of the investigation of sites (panoramas, site selection)
- Analysis of the geographical profile of the site.
- Quality and applicability of the onboard analysis (temperature, science capability of choice) of scientific relevance that points out the planetary habitability.
- Reasoning for site selection, and collection of the particular sample
- Scientific knowledge of astrobiology.

- A close up, well focused, high-resolution picture with some indication of scale (scale can be indicated post-capture) at the sampling site.
- Images of each sampling location or sample just after the collection.
- Relevance of the onsite analysis performed in context to Martian biosphere.
- Store the collected sample in a sealed (air tight) container.

4. Design Task

This will be a stand-alone task which will not affect the points tally but serve as an opportunity for teams to share the conceptualize and design rovers. This task will offer teams an opportunity to explore the field of space robotics beyond the constraints of developing an actual rover for the competition. The task will be focused on the following aspects:

1. Innovation & Research
2. Design Process
3. Development Strategy
4. Future potential
5. System engineering

4. a. All interested teams can register for this event separately. The teams will be required to make a 20-minute presentation to a panel of judges.

4. b. Three teams will be adjudged the winners of the round. The results will be announced along with the winners of rover challenge.

4. c. There is no separate registration fee for this event. Teams interested in participating only in the design task can also do so.