University Rover Challenge 2018 – Report

Stages and Scores

The first stage of the competition was the **Preliminary Design Review(PDR)**, where the team had to submit a progress report explaining the basic features of the rover's design, a timeline in the form of a gantt chart, and a budget. The deadline for this milestone was the **1st of December.** This was not a competitive milestone and the team cleared it with ease.

The next stage was the **System Acceptance Review(SAR)**, where the team had to submit a five minute video, showing a completely built rover and it's capability to perform tasks. The video also explained the critical features of the rover. Along with this, the team had to submit a complete report on the design, consistency of project management, and finance details. The deadline for this milestone was the **1st of March**. This was a competitive milestone, where the top 36 teams were selected from 95 teams. The team scored **78.07 / 100** and was placed **20th.** This contributed to 100 pts out of the final score of 500.

Core Rover Score (21 max)	Tasks Score (21 max)	Programmatic Score (21 max)	Readiness Score (21 max)	Science Score (16 max)	Total Score (100 max)
18.34	15.4	16.45	13.48	14.4	78.07

As it is clear from the split up, our Readiness and Tasks scores were low, owing to the fact that our rover was not completely ready by the time of this milestone. Also, we did not show the rover performing much of the competition tasks in our video, which we were expected to.

The competition consisted of 4 tasks and the scores are:

Equipment Servicing Task : **11** / 100
Autonomous Traversal Task : **0** / 100
Science Cache Task : **91.5** / 100
Extreme Retrieval and Delivery Task : **7.5**/ 100

The total score obtained was **187.67** / 500, placing us at the **25th** position on the scoreboard.

Day 0 : Check-in and Safety Briefing

Emergency Services Building, Hanksville

The teams were required to send at least one representative for checking in to the competition, after which instructions were given to ensure the safety of the participants of the competition in the desert area where the MDRS was located. We were warned about the intense sun and related problems such as sunstroke, sandy and irregular roads leading to competition sites where one could easily get lost. After this, we were given a tour of the competition sites located within the desert where each of the tasks would take place.

Day 1 : Equipment Servicing and Autonomous Traversal Tasks

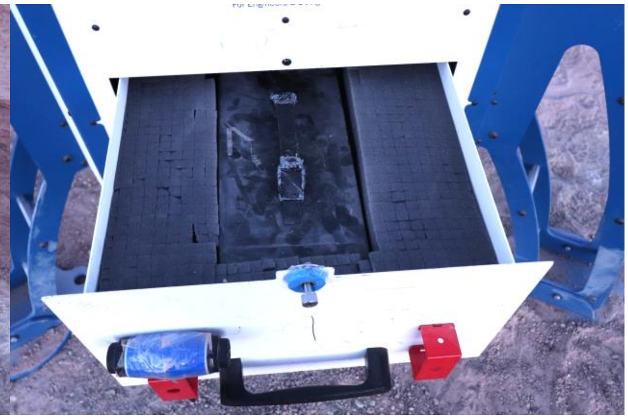
North Site, MDRS

We started off with the equipment servicing task, which was immediately followed by the Autonomous Traversal Task with only 10 minutes of buffer in between to set up.

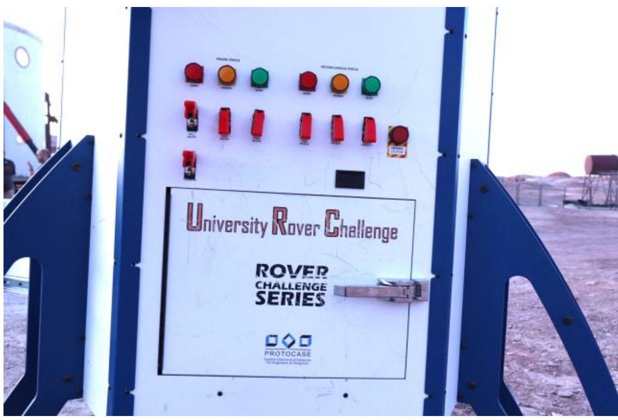
The equipment servicing task consisted of the following sub-tasks:

- Opening a drawer for holding a box (5 pts)
- Picking up and bringing a cache container placed in the vicinity of the panel (5 pts)
- Placing the container inside the drawer(5 pts)
- Closing the drawer (5 pts)
- Picking up an Allen key located just beside the handle (10 pts)

- Rotating a bolt with the key and locking the drawer (20 pts)



- Opening the lids of toggle switches and toggling the switch underneath (7 x 2pts each + 1 for toggling all= 15 pts)
- Opening the door of the keyboard panel (5 pts)
- Typing the password (MARS) and hitting enter(10)



- Sliding a heavy holder all the way out(10 pts)
- Pushing it back in and locking it (10 pts)

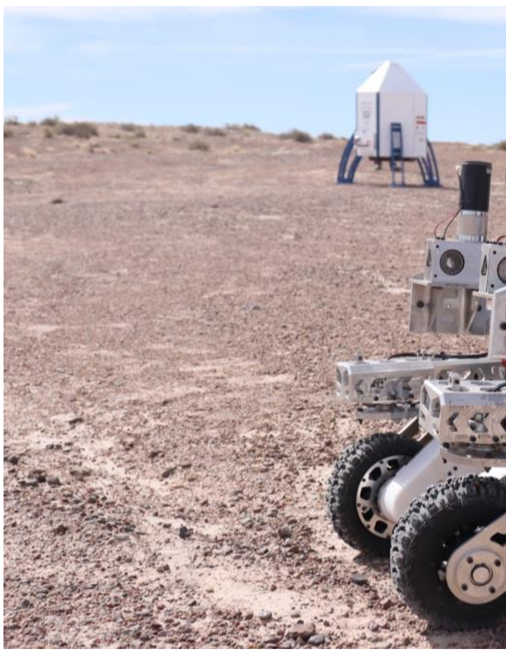
We were given 15 minutes for setting up the software and the communication systems. Meanwhile, the rover was weighed and it came out to be nearly 53 kg. A penalty of 10% was imposed on the total score obtained (5% per kg above 50 kg). We faced glitches when integrating the arm control codes

,causing the arm arduino to crash, and started out 3 minutes late. First, we attempted to open the drawer for the cache bag, but poor camera views and backlash present in the gripper prevented us from getting a solid hold of the drawer handle. We then diverted and picked up the cache bag successfully, which weighed around 3 kg. We left the first panel and attempted the toggle switches. We successfully toggled one completely and opened the lid of 2 others. But at this stage our communication system faced great lag when transmitting video feedback and hence it took a great deal of time to even toggle one switch. Also the arm and gripper crashed into the panel multiple times because of lag, causing the gripping motion to stall. With barely a few minutes left, we attempted the drawer again. We rolled the gripper and locked it onto the handle and pulled it out successfully.

After this, the task time was over and we had to start the set up for the autonomous traversal task. We earned 5 + 2 + 5 = 12 points and lost 1 pt due to the penalty imposed, leaving us at **11 pts**.

The autonomous traversal task was organised in stages, requiring the rover to complete a stage before moving onto the next. The time given for each stage was 10 minutes, and the difficulty increased across the stages. This difficulty included provision of less precise information on the location of the next marker, greater camouflaging of the physical marker, greater distances, and rougher terrain.

Immediately after the equipment servicing task, the arm was disassembled from the rover to reduce weight and enable us to move faster. This was done easily because of the modular nature of the arm. GPS and IMU were set up on the rover and the autonomous task started at a physical marker. The other gps coordinates were given to the base station on paper. The rover started moving properly, but after sometime the GPS module failed to get a proper fix on satellite signals and stopped giving position values . The wheels got misoriented and started running in opposite directions, causing the rover to stall at a point. We did not score any points in this task.



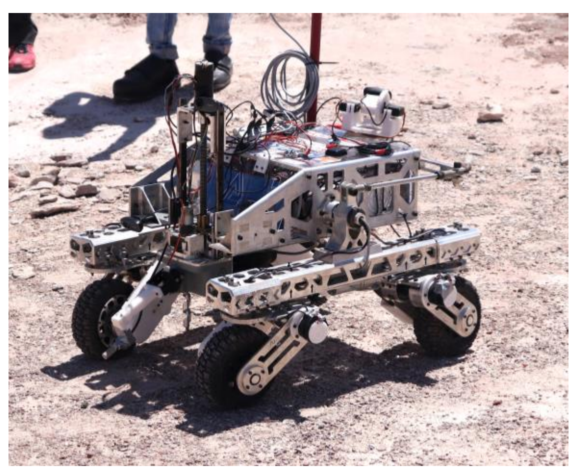
Day 2 : Science Cache Task

South Site, MDRS

This task consisted of 3 parts : soil collection, soil testing and the Science Presentation. The must rover **start at a point**, go around the specified site, take snapshots and panoramic pictures of the surroundings, collect sensor data from the vicinity, collect soil from **10 cm below** the ground level, and **return to the start point** within the time limit. There was also a bonus task present. A few stones which did not naturally belong to the surroundings of the site were stacked up at a location; such stones were too heavy to be carried there by the wind and such stacking was not possible with the help of water also. We were required to identify this stack using the cameras on the rover and take a snapshot. We also had to take pictures and panoramic shots of the surroundings to explain the stratigraphic profile of the place. Later in the evening, the soil had to be tested for the presence of various elements and compounds to prove the existence of microbial life. Our plan for proving the same had to be presented in front of a panel of judges.

We had to start out with the soil collection. For this purpose, the digger module was mounted on the rover, along with various sensors, such as temperature, humidity, pressure, uv intensity, luminosity (IR and visible range of wavelength) and cosmic radiation.

The weight came out to be **46 kg**, well below the competition limit of 50 kg. We were given a set up time of **12 min**, and a task time of **15 min**. We ventured into the terrain and attempted to collect soil. But the ground was hard after 4-5 cm of soft soil, causing the drill motor to stall. We had to scout around to find a location suitable enough.



Another issue was that the bar differential allowed for a certain amount of play of the chassis box, and at some point, the force required by the linear motion of drill to drill through the soil was more than that of tilting the chassis box, causing the box to tilt back rather than the drill moving inwards. Effectively we were able to drill through almost 10 cm at one location. But the mechanism allowed for the collector box to touch the ground only when the tip of the drill went 10 cm below ground level. So barely any soil was collected.

In this scouting process, there was a location where the soil was very loose at the top, causing the wheels to get buried slightly. So, while steering, one pinion got decoupled from the linear actuator, causing that wheel to be misaligned for the rest of the task. We had to drag the rover around with 3 wheels when scouting and when returning to the start point. Thankfully, the misaligned wheel assembly withstood this and no other damage was incurred.

We then removed the collector box from the soil and handed it over to the judges. Since the quantity was insufficient, we were allowed to go to the field and pick up soil for testing. While removing the soil collector box from the rover, gloves had to be worn, and the judges noted it as a special point.

The tests we performed could be classified into two parts - geological and biological . The aim of all the tests was to detect the presence of life from the soil. One way to infer that was to check whether water had flown through the soil in the past. This could be detected by testing for the presence of certain compounds in the soil such as sulphate, chloride, carbonate, nitrate, nitrite, iron, calcium, magnesium; and also from the amount of total dissolved salt (TDS). All these test were performed with the help of test strips which were bought commercially and through a TDS meter respectively.

To test the soil for presence of microbial life, pH and NPK strips were used. Certain pH favours the growth of bacteria. Nitrate and nitrite in the soil is indication of presence of the bacteria in the soil; with phosphorus and potassium being vital elements required for life. In science, we are required to co-relate the test performed with the possibility of presence of life. It was important to explicitly mention the test results in the presentation as the slides were used as the reference by the judges for the tests performed. Clay content in the soil was shown by dispersing soil in the water; a turbid nature indicated that the soil had more clay content in it. This implied either the presence of the water in the past or the presence of organic matter in the soil.

Biomarkers such as proteins, lipids, lactose were tested for. Protein was tested through biuret test and also shown in the microscope by using protein stain eosin y . It was originally planned to be done through bradford reagent which is a mixture of orthophosphoric acid and methanol; but we were not able to obtain the latter and hence that test was substituted with biuret test and staining. Biuret test gave a positive result and protein was shown in the microscope also. Lipids were tested through calcium saponification test, which also gave a positive result with white precipitate formation. Lactose was tested using iodine, but the soil contained a quantity below the detectable limit, and hence no colour change was obtained. Presence of life was directly tested using nucleic acid stain, which can detect presence of DNA or RNA using the stain methylene blue.

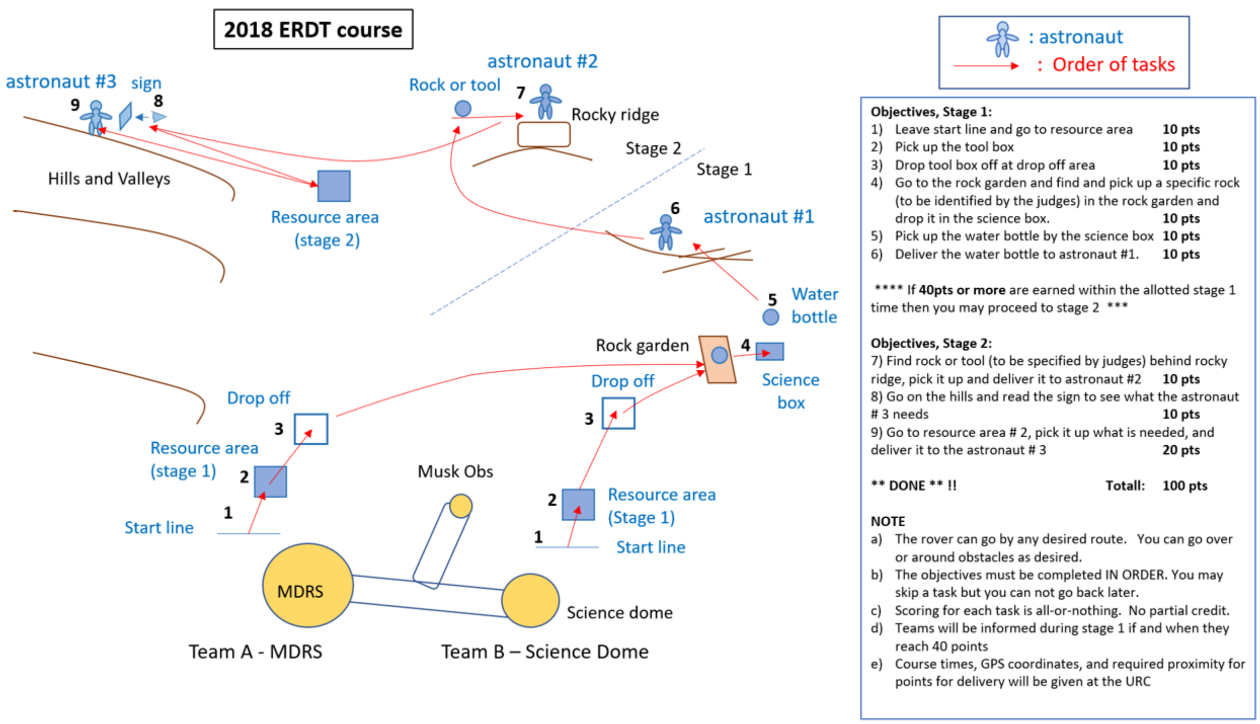
Advantages, limitation, accuracy and detection limit of each test had to be known as they were potential questions during the presentation. During presentation, all the results from the on-board and lab test had to be presented along with the appropriate reason for choosing the same. The presentation majorly had three parts; first part explained the tests for detection of presence of water; second part was the detection of flow of energy for life formation and sustainability through the data collected from the sensors onboard; and finally the presence of life detected biologically, with a detailed explanation and justification for each test. The Judges had very few questions pertaining to the tests performed. The only question that we could not answer was what the purple colour of the soil indicated, the answer to which was magnesium. They also asked what the red and white colours indicated, and we answered with Iron and Calcium Carbonate. Judges said that they were satisfied with the astrobiology part. A suggestion given by them was to perform life detection tests through on-board experiments or sensors. Marking the stratigraphic profile in the panorama captured(based on the stripes and coloured layers present in the hills), apart from indicating the features of water flow was another suggestion. All the lab test has to be completed in 20

mins and result has to be entered in the powerpoint presentation as well.

Day 3 : Extreme Retrieval & Delivery Task and URC Closing Ceremony

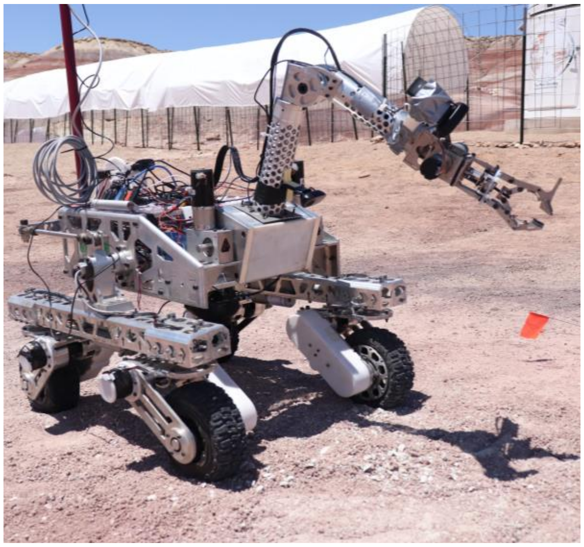
Hab Site, MDRS

This task consists of picking up and delivering various objects, traversing through rough terrain, hilly areas, and running long distances (of almost 1 km) which included a lot of **NON-LOS** locations. The course for this task was posted earlier on the URC website, and a screenshot of the same has been attached below.

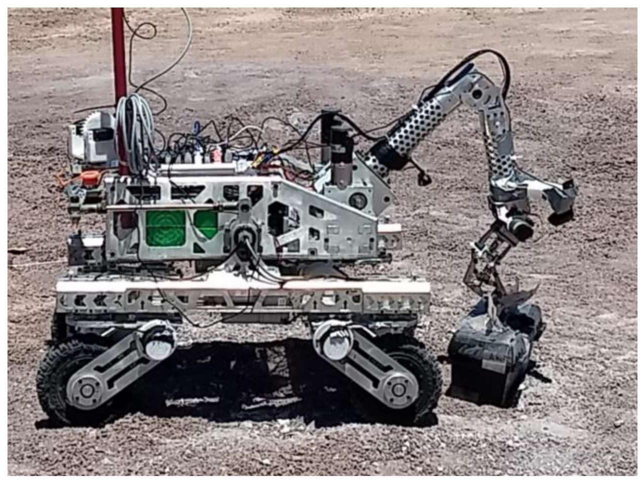


The directions to each of the pick up and drop points were given through **GPS**, which again caused issues. We had to call an intervention just a few minutes after the task started to resolve some connection issue, resulting in a **15%** penalty in addition to the **10%** penalty of being overweight, owing to the mounting of the arm and gripper.

We were able to successfully navigate to the first point, earning us 10 points. We had to pick up a toolbox, which weighed nearly **5 kg**. But under this load, the motor coupling failed for the gripper as it was not strong enough along the axial direction, causing the the linkage to fall apart. This was effectively the end of task. We tried to use the arm as a plough



and we somehow managed to move the box to the required coordinates. But the base station faced problems with gps and they moved past the required point, and only towards the end did they return to the right location. But we were not awarded any points as pushing the box was not considered as picking it up. The gripper got further damaged due to this maneuver and fell off the arm.



After the 25% penalty, we ended at 7.5 points in this task. This marked the end of the competition.

The closing ceremony was held on the evening of the same day. Here we had the opportunity to interact directly with all the other teams, and take a look at their systems and discuss the competition. We learnt that mechanically, most of their systems were very simple. Emphasis was placed on robustness and functionality. They ensured that there were no issues. They got the rover ready and gave sufficient time for testing and for practising competition tasks. All teams assembled at the hab site for a group photoshoot, after which certificates were distributed, and the results announced.