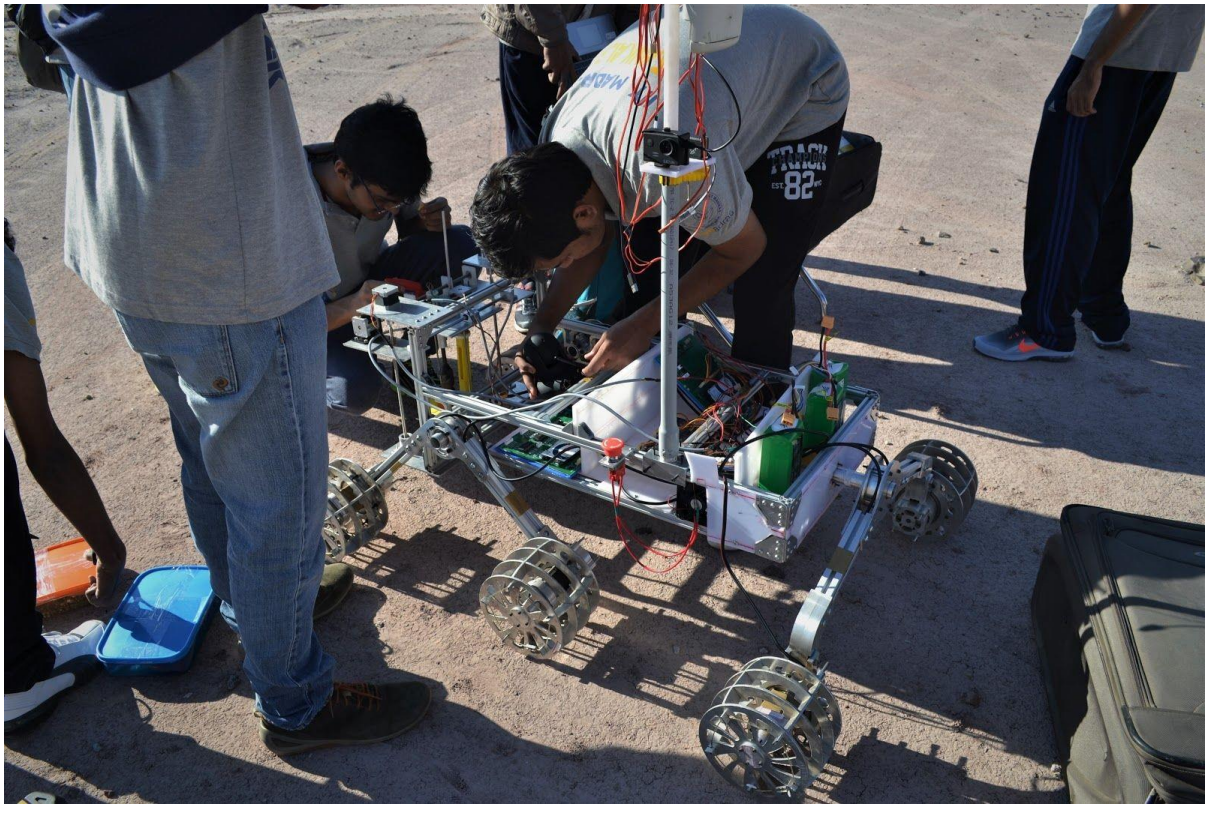
University Rover Challenge 2017 – Report

This report presents the performance of team Anveshak at the University Rover Challenge 2017 conducted at Mars Research Desert Station, Hanksville, Utah, USA .In summary, the team ended up at the 29th position of the points table with 36 teams.

Day 1 - Science Cache Task

Preparation

During preparation for the science task, the software team faced problems in acquisition of data from onboard sensors as well as operating all the stepper motors at the same time. This was due to the PCBs not functioning properly. Also, the individual chemicals bought in USA were not showing the expected color changes. It was decided to perform only sample collection and laboratory analysis of the sample using a commercial soil testing kit.



Sample Collection

We reached the site at MDRS at 7:45 AM in the morning. We then started preparing for the task which was scheduled at 9:15 AM. The rover locomotion was running smoothly but the digger stepper motors were still giving problems. We found that we could not operate the drill as required. This was mainly because our electronic and software system was not able to interface the computer with multiple arduinos controlling the locomotion and drill successfully. Just before the task was about to start, only two out of four stepper motors were still operable. We therefore had to cut down on some functionality and keep the driller running throughout the task.

At 9:15 AM, we moved to the trailer and started setting up all communications. The rover was weighed at 45.6 kgs, well within the 50 kg limit. At 0940 hours, 5 mins into the task, we finished setting up communication and the rover was ready to go. The drill was connected directly to the battery and was switched on throughout the task. The rover moved into the field and smoothly traveled a distance of 50 meters. However, when we decided to collect the sample at a particular point, the digger did not move. After trying for 5 mins, it was decided to turn back and just take pictures for the stratigraphic profiling of the location. When performing a zero radius turn in loose soil, one of the drive motors stalled and the articulation joint got bent due to this. We finally returned to the starting point without having collected a soil sample. A disconnected Arduino cable was found to be the reason why the digger didn't run. The judges then allowed us to scoop up a sample by hand for laboratory analysis in the afternoon.

Laboratory Analysis

Adarsh & Sourya stayed back in Hanksville for the laboratory analysis while the rest of the team headed back to Hanksville. Sourya prepared the presentation while I read up on past Mars missions and Martian Soil. The analysis scheduled at 1455 hours started on time.

We were given 2 samples to analyse in 20 minutes. We were able to perform tests for N, P, K and pH within the given time and were called to present our analysis.

The presentation started off badly with the judges stating that our science objective was not in line with what they expected. While our science objective was related to plant biology they required us to focus on microbiology. This wasn't mentioned anywhere though. However, we then picked up and described our soil collection mechanism, onboard instruments and the lab tests performed. We showed them the panoramic images taken by the rover and answered well on the questions asked on the geology of the site in the image. Overall, we performed well in the presentation and were awarded 65/100 points for the day's work.

Day 1- Evening Meet & Greet

In the evening we attended a meet and greet organised by Protocase. It was attended by all teams as well as some companies such as SpaceX, Honeybee Robotics, Orbital ATK and SpaceFlight Industries. In a lucky draw, we won a sponsorship of $1000 from Protocase towards manufacturing of our next rover.

Day 2- Extreme Retrieval Task

Preparation

The arm was mounted onto the rover for this task. Testing was still done indoors. After trying for the whole night, the software team finally succeeded in running both the locomotion and the arm at the same time.

Extreme Retrieval

The task was scheduled to begin at 8:10 AM. We reached MDRS at 7:30 AM and started setting up. The rover was weighed to be 52.6 kgs without batteries for which a 10% penalty was awarded. The task setup time eventually began at 8:30 AM. Once again, we weren't able to run the locomotion through the routers and antenna. After trying for about 45 mins, the locomotion started working and we started the task. At that point, we had only 5-10 mins of task time remaining. Moving towards the first checkpoint, the rover wheels got stuck in sand. When trying to move it with a zero radius turn, the bogie joint inverted and the task was stopped. We weren't able to score any points in this task.

Post-Task

After the task, we decided to test the rover at MDRS itself to see what went wrong. The rover testing was carried out with tethered control and no issue was faced in control of the rover. The locomotion had no issue, unlike the actual task time.

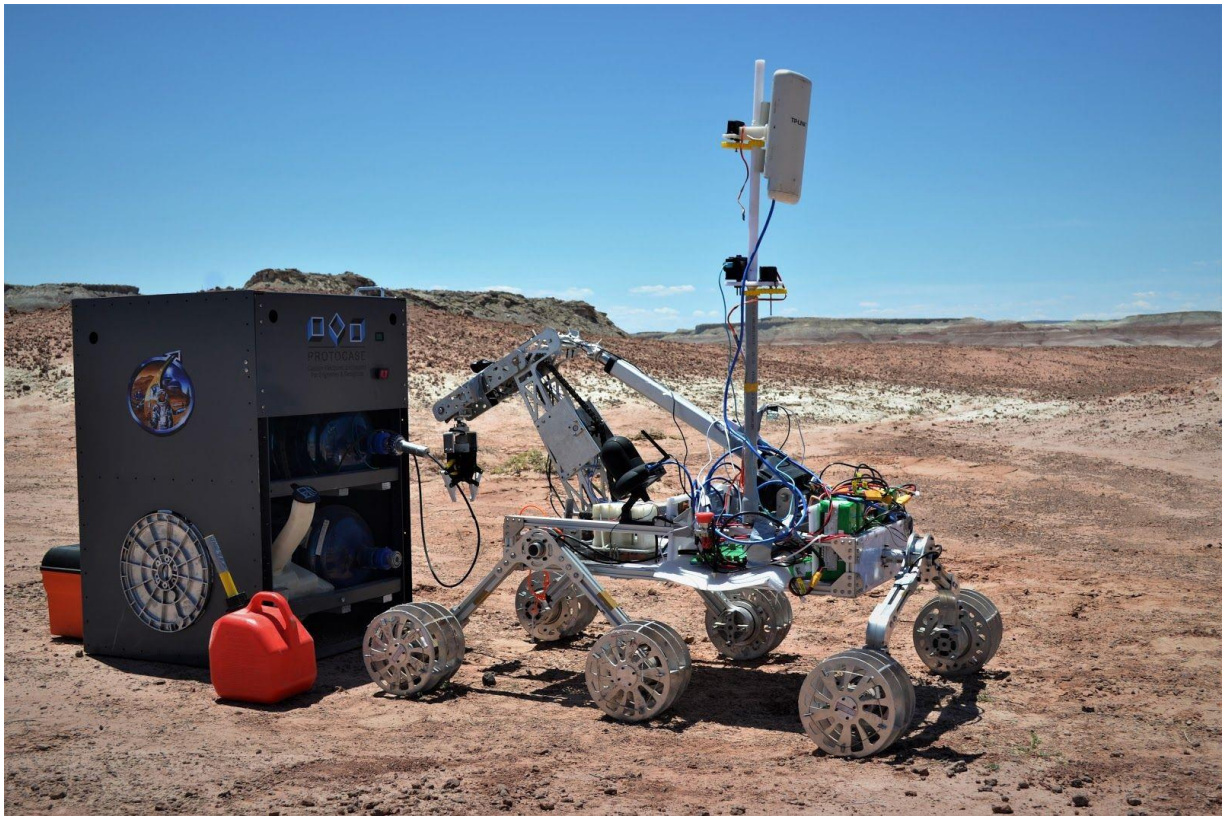
Day 3- Equipment Servicing and Autonomous Traversal

Preparation

After 2 disappointing days, the team was demotivated and didn't put sufficient effort towards preparing for day 3. No field testing was done for either of the tasks. The software team weren't able to get the arm and locomotion running together even after repeated tests and trials round the clock.

Equipment Servicing

The task was scheduled at 1:00 PM in the afternoon. We reached MDRS at around 12 PM and started setting up. The arm and locomotion were not working together again. We got the locomotion running and started the task at 1:30 PM. We started the task without attaching the carabiner to the gripper. After moving to the wagon, we started operating the arm. Once we did that, locomotion stopped working. We decided to take a 50% penalty and lift the rover to the servicing station. At the station, we disconnected the locomotion Arduino. We took pictures of the meter at the station which was worth 10 points. As the gripper was connected to the locomotion PCB, we couldn't operate the gripper. We couldn't perform any other tasks on equipment servicing and ended up with only 5 points due to the 50% penalty.



Autonomous Traversal

7 waypoints' GPS coordinates were given to us for autonomous navigation. We entered them in the multipoint navigation code which was never tested before. We removed the arm and moved over to the start point of the autonomous task. Aniket's laptop was used in place of Akshit's laptop. The rover was supposed to orient itself in the direction of the first waypoint and go straight towards it, but when we lift it, it was continuously doing zero radius rotation in one direction. As the rover didn't move at all, we tried hardcoding it to move to the first marker. Still, the rover didn't move. The clock ticked past 2:30 PM and we didn't get any points in the task.

Day 3 - Final Day Rover Scouting

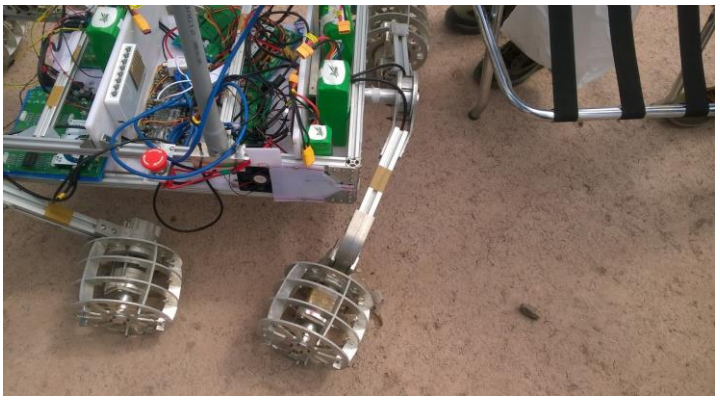
In the evening of the final day, several teams set up tents to display their rovers. We went about speaking to different teams and got a lot of different perspectives about how different teams function and how they went about building their rovers. We received our participation certificates and returned back to the hotel.

Issues Faced

Electronics and Software	Identified	Fixed
Malfunctioning of the Kill switch PCB **Noticed on:1 June 2017** The kill switch board stopped working for the pair of wheels in the rear part of the rover due to failure of a MOSFET or the track of the PCB gets burnt leading to loss of conductivity in that path involved in the circuitry.Most probable reason for this is a careless electrical connection.So the kill switch was redundant for the back set ofwheels. The only solution is the replace the faulty MOSFET or solder the track which got burnt away.It was replaced at a later stage.	**Yes**	**No**
Two ports of the digger stepper motor PCB not working Noticed on:1 June 2017 The reason for this is a track of 12V supply on the PCB got burnt away because of some testing on the previous night. Even the spare PCB were faulty. Another possible reason might be non functioning motor drivers or a few battery and PCB connectors. After various trials with different ports and PCB, we got three stepper motor ports to work Steps to fix this issue: 1)Changing the connectors 2)Using new stepper motor drivers 3)And soldering the tracks which got burnt in the issue faced. To eliminate this problems permanently: 1)Use safer and robust connectors. 2)Increase track width in the areas required 3)Implementing PCB protection with the use of some current limiting elements wherever necessary and isolating the power board from the main control board.	**Yes**	**No**
Wire stripping of the terminals of the motor Noted on:1 June 2017 The soldering on the motor terminal couldn't hold the the wire in its place. This happened because of poor soldering. Steps to fix the issue: 1)Proper soldering by curling the wire around the motor terminal several times and then put good amount of solder till it seeps in and holds firmly.	**Yes**	**Yes**

2)Also sealing the motor terminal ends with glue gun so that wire tangling doesn't strip the wire off from its place. 3)Due to lack of time and no electrical ports for a soldering iron, we had to attach the wire to the terminal with anabond temporarily just before the competition started.		
Drive system motor driver failure Noted on:2 June 2017 The motor driver stopped working because the motor got stalled for a little duration,burning out the mosfets and diodes on the motor drivers.That motor driver couldn't be used anymore. Fixing the issue temporarily: 1)Change the motor driver. A permanent solution is change the motor with a better suited motor and this is essential.The present motor is over rated in torque and current. A better motor with a rated torque of around 5Nm is suffice.	**Yes**	**Yes**
Malfunctioning of multiple or even single arduino when interfaced with ROS and Joysticks Noticed on:28 May 2017 This is one the biggest failure on the side of electronics not allowing us to run the rover for more than 10 seconds at a stretch. Observations: 1)The arduino would lose sync with the computer on board. 2)ROS nodes would stop working on their own. 3)Single arduinos would run for about 30 to 50 seconds and then stop working all of a sudden. 4)In case of two arduinos one to control arm and the other for locomotion,both of them would work for around 15 seconds and then the one of them functions while the other doesn't for a little while and then nothing works.We also saw cases when both of them stop working together. 5)Even the digital port number of arduino get changed,so we have to restart the nodes a fresh. 6)Faulty arduino cables or arduinos also do not allow us to even upload the code into these micro controllers sometimes. Temporary fixes to get them working: 1)Would remove the arduino cables from the computer on boards and plug them back in. 2) Reset the arduinos 3) Kill all the running arduino nodes and restart them again after	**No**	**No**

changing the port numbers accordingly. 4)Changing the arduinos and cables. 5)Re-upload the code in a new arduino and then plug it back on the arduino shield port on the main control board. 6)Comment out a few parts of code related to ROS functions and try again. Reasons for the issue: 1)A plausible theory is when arduinos are connected as a shield on the board,and we interface motors and actuators with the main control board through the motor drivers,due to sudden current or potential surges,there are some back currents through the ground to the arduino boards,changing the port of the board and going out of sync with the computer. 2)Could be a problem of compatibility of ROS with arduino boards.Most likely an issue with the rosserial node available online.In short a problem with the software system and architecture we used. 3)Could be a problem with the electronic design and architecture,we predict it might be a fundamental mistake of using the idea of arduino shield on the custom made PCBs. 4)Could have been a problem with the PCB boards. 5)Could be a problem with the idea of connecting multiple arduino to a single computer,thus internally establishing a common ground between those arduinos. Permanent fix to the issue: Not yet rectified Need to do a detailed analysis on possible reasons,test the PCBs out again and figure out the solution.		

Mechanical	Identified	Fixed
Bending of Aluminum plates **Noticed on**: 1 June 2017  The articulation joint plates got bent while doing zero radius rotation. Steps for fixing the issue: 1. After removing the plates, hammer them to make them flat. 2. Make a through hole through the T-slot and use a 6mm bolt instead of T-bolt. This ensures a rigid joint which won't let the aluminium plate to slip on the T-slot.	**Yes [1/6]**	**Yes [1/6]**
Flipping of Bogie Joint **Noticed on**: 2 June 2017 The bogie joint underwent complete rotation while trying to do zero radius rotation. The problem was faced because the wheels got stuck in the soil as they were trying to dig the soil when the rover was driven at slow speed. Steps for fixing the issue: 1. Not yet rectified.	**No**	**No**
Bending of the Chassis box **Noticed on**: 2 June 2017 The chassis box was bending at the points where bogie joints are mounted. This was happening when we place arm on the chassis. It was because of lack of support at the front part of the chassis Steps for fixing the issue: 1. Place a T-slot at the front end of the chassis box	**Yes**	**Yes**
Vibrations of the Digger when Drill is Switched On **Noticed on:** 3rd week of May: After testing digger	**No**	**No**

The digger vibrates too much when the drill is connected. The clamping needs to be improved and number of moving parts needs to be reduced. Steps for fixing the issue: Not yet rectified		
Backlash in Worm ftears -Arm **Noticed on**: June 2017 The arm's base rotation had a heavy backlash due to which it had to be locked for the task and rely on the		
Packaging of the Rover The rover was carried in wooden boxes. Which were marginally inside the dimension limit and exceeding the weight limit Choose a professional courier service for the transportation	**N/A**	**N/A**

CONCLUSION

As we conclude the report, the team thanks all the professors, companies, Alumni and the Institute for supporting their journey throughout. The team has utilized this opportunity to learn from the other teams about the technologies they were using and to apply it to our rover. This will indeed enable the team to perform much better in the next year's edition and reach new heights. The team is confident that the next rover built will boast of several new features and mechanisms that the team has learnt from other teams.

The team's journey had been made possible by the travel funds arranged by the office of I&AR. I&AR has made a significant contribution of Rs. 3.3 Lakhs to the team for the travel. I&AR has also helped the team raise Rs. 1.73 Lakhs by setting up an online portal for collecting funds from the alumni.

31st Aug, 2017