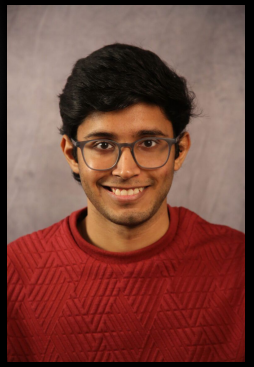
Lunar ROADSTER

(Robotic Operator for Autonomous Development of Surface Trails and Exploration Routes)

"Starting with a foothold on the Moon, we pave the way to the cosmos"

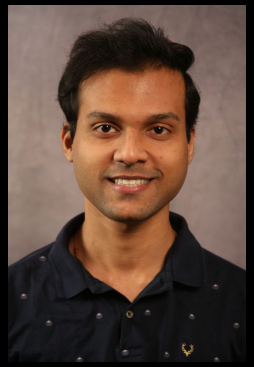
The Team

Ankit Aggarwal



Deepam Ameria

Bhaswanth Ayapilla



Simson D'Souza

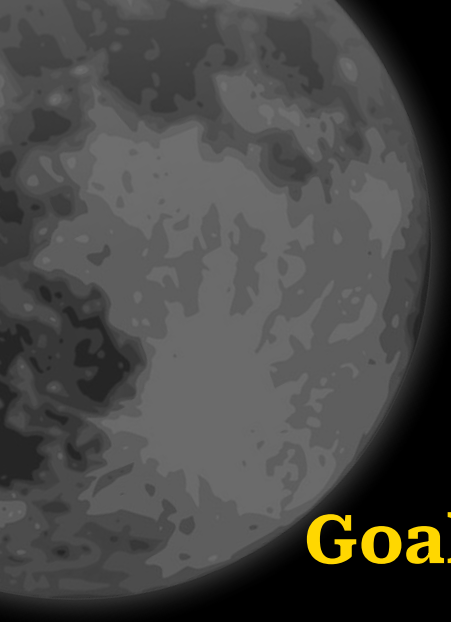
Boxiang (William) Fu

Dr. William "Red" Whittaker

Agenda

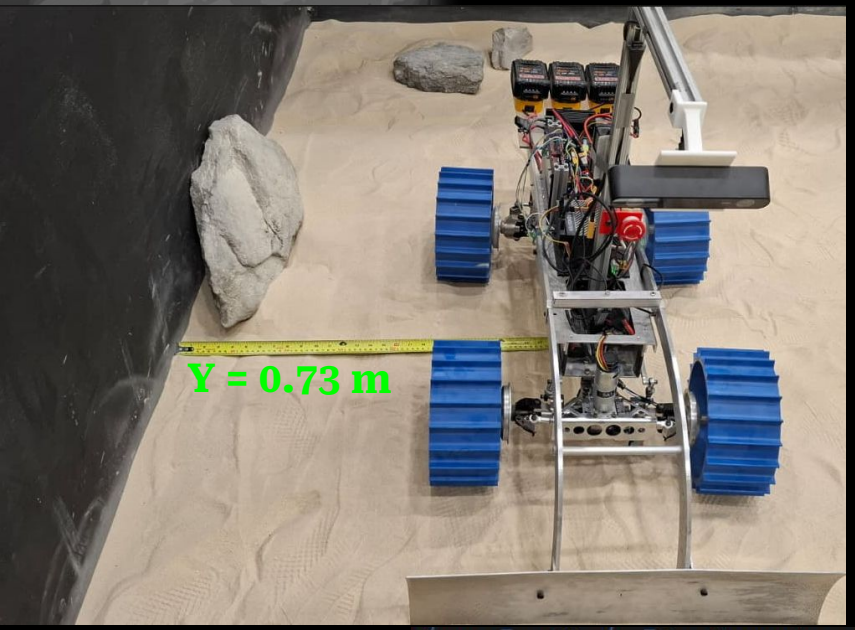
Quality assurance for the following modules was performed as per the FVD Test Plan to verify functionality, reliability, and performance

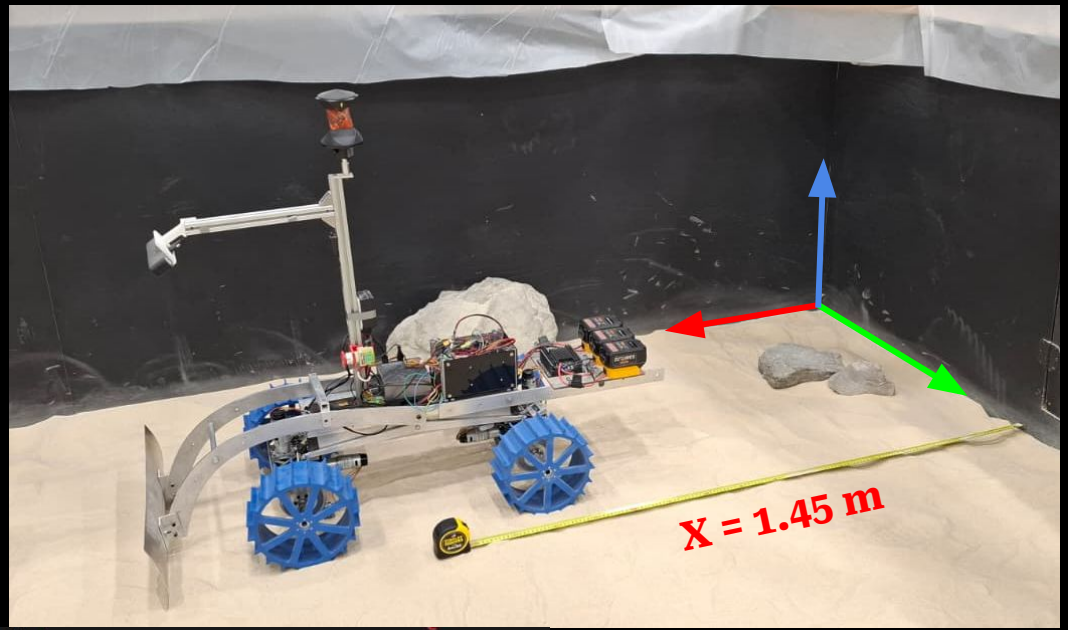
1. Localization (Total Station) QA
2. Localization (Skycam) QA
3. Validation QA
4. Navigation QA
5. Planning QA
6. Perception QA
7. Hardware QA



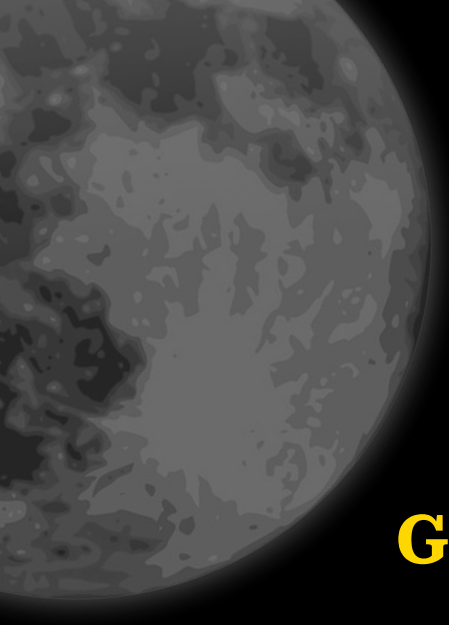
Goal: Localization (Total Station) QA

Goal: Localization (Total Station) Test Results






```
❯ ros2 run tf2_ros tf2_echo map base_link
[INFO] [1762911174.798349131] [tf2_echo]: Waiting for transform map ->  base_link:
ent target_frame - frame does not exist
At time 1762911175.521221384
- Translation: [1.430, 0.732, 0.318]
- Rotation: in Quaternion (xyzw) [0.003, -0.021, -0.061, 0.998]
- Rotation: in RPY (radian) [0.008, -0.041, -0.123]
- Rotation: in RPY (degree) [0.466, -2.333, -7.045]
```

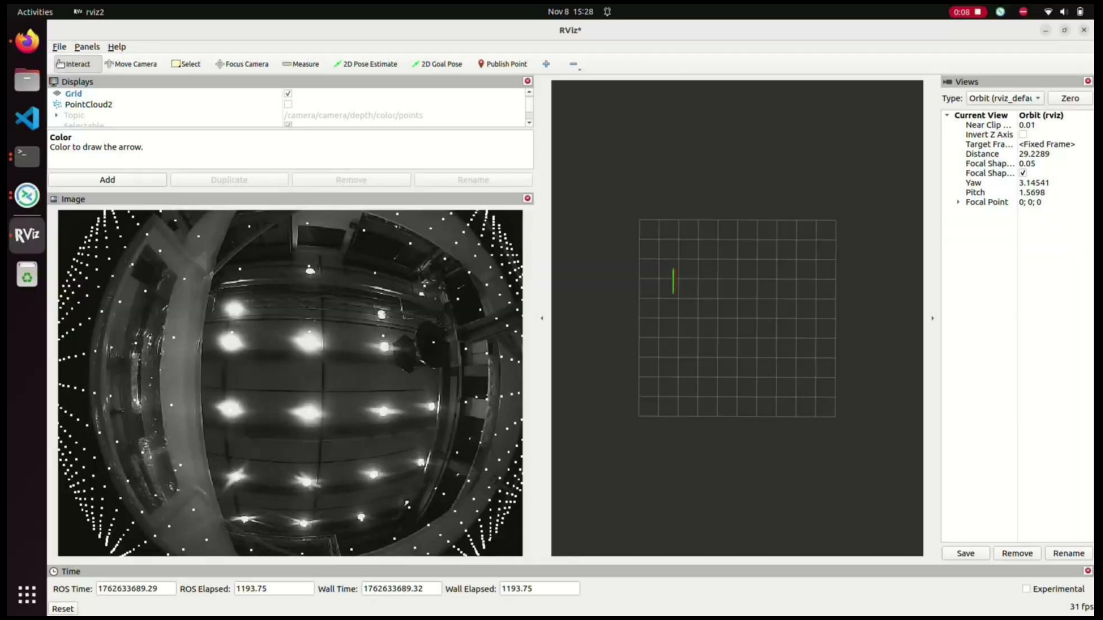


Goal: Localization (Skycam) QA

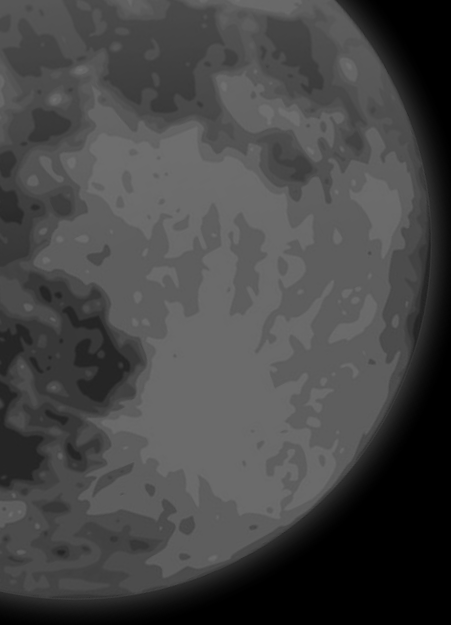
Goal: Localization (Skycam) QA

T08: SkyCam Localization Validation

Skycam Estimate → Total Station



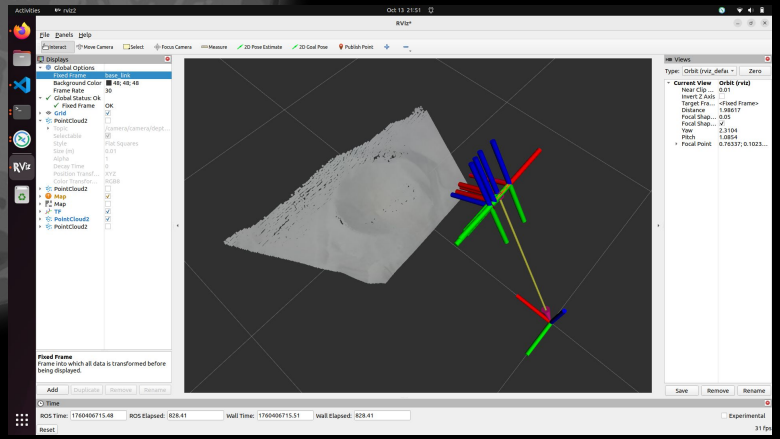
QA Result: Solved roll and pitch pose drifting issue with mechanical gimbal



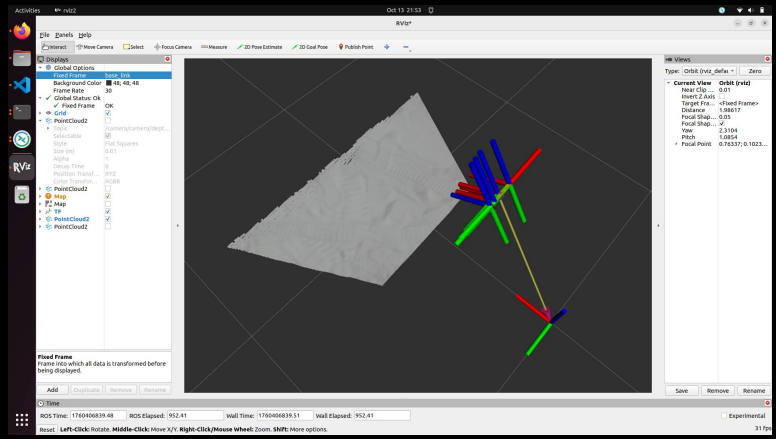
Goal: Validation QA

Goal: Validation Test Results

T07: Trail Grooming Slope Validation



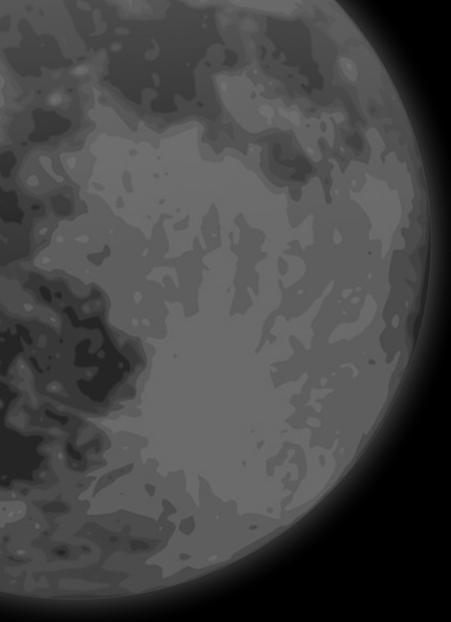
Validation Success = False
Max Slope = 17.93 deg



Validation Success = True
Max Slope = 1.73 deg

QA Result:

- Validation accurately detects slope gradient
- Correctly returns successfulness of grading run



Goal: Navigation QA

Goal: Navigation Test Results

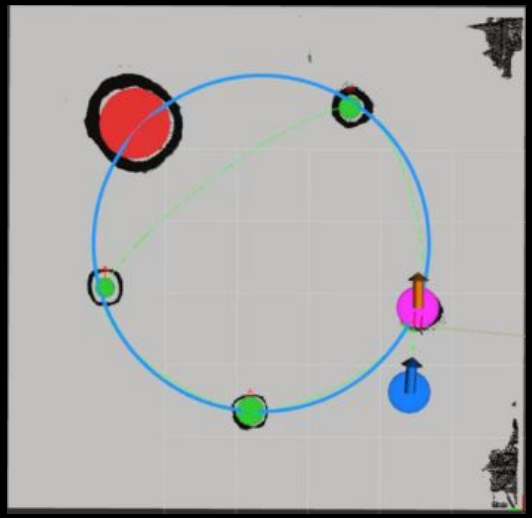
T02: Global Path Planner Accuracy Test

Deviation Statistics : T2 Global Planner

Test No.	Mean	RMS	Max	Cumulative	Length	% Deviation	Test Result
1	0.518	0.611	0.97	2.47	4.77	10.85953878	
2	0.505	0.626	1.058	3.78	7.48	6.751336898	
3	0.152	0.224	0.647	0.572	3.76	4.042553191	
4	0.433	0.481	0.81	0.52	1.2	36.08333333	Failed
5	0.071	0.081	0.135	0.238	3.37	2.106824926	
6	0.386	0.573	1.239	6.883	17.82	2.166105499	
7	0.145	0.172	0.302	0.486	3.36	4.31547619	
8	0.573	0.593	0.861	0.685	1.19	48.1512605	Failed
9	0.403	0.553	1.261	4.787	11.89	3.38940286	
10	0.339	0.501	1.139	3.825	11.3	3	

Result: Satisfies verification criteria (Cumulative deviation RMSE between reference latitude and planned path is < 25%). Will continue to tabulate statistics during CI/CD testing.

T03: Filtering and Selection of Gradable Craters



Red circles denote craters to avoid
Green circles denote craters to groom

Goal: Navigation Test Results

T04: Navigation Controller Maximum Deviation Test

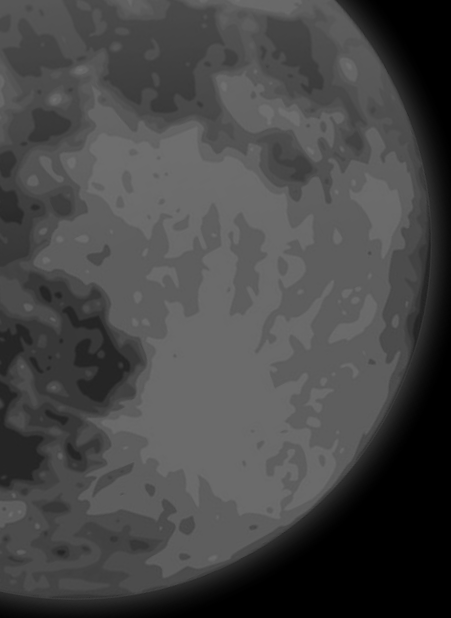
Deviation Statistics : T4 Global Controller

Test No.	Mean	RMS	Max	Cumulative	Length	% Deviation	Test Result
1	0.1	0.124	0.287	0.387	3.89	2.570694087	
2	0.097	0.122	0.287	0.389	4.03	2.406947891	
3	0.258	0.328	0.766	1.582	6.14	4.201954397	
4	0.393	0.515	0.992	1.165	2.96	13.27702703	Failed

Result: Satisfies verification criteria and rover follows planned path with maximum deviation ≤ 10%. Will continue to tabulate statistics during CI/CD testing.

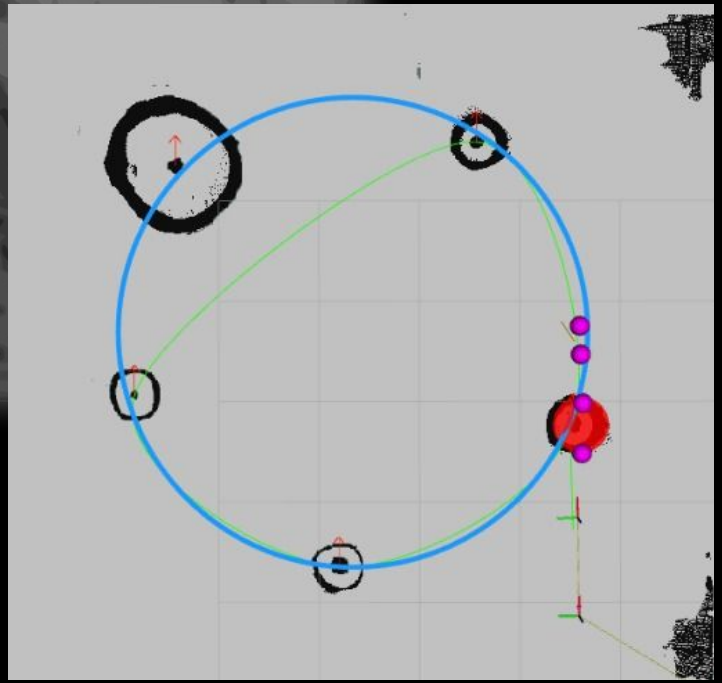
T06: Repeatability Test of Local Navigation Controller

Result: Rover follows consistent local paths across repeated runs and reaches every crater accurately.



Goal: Planning QA

Goal: Planning Test Results

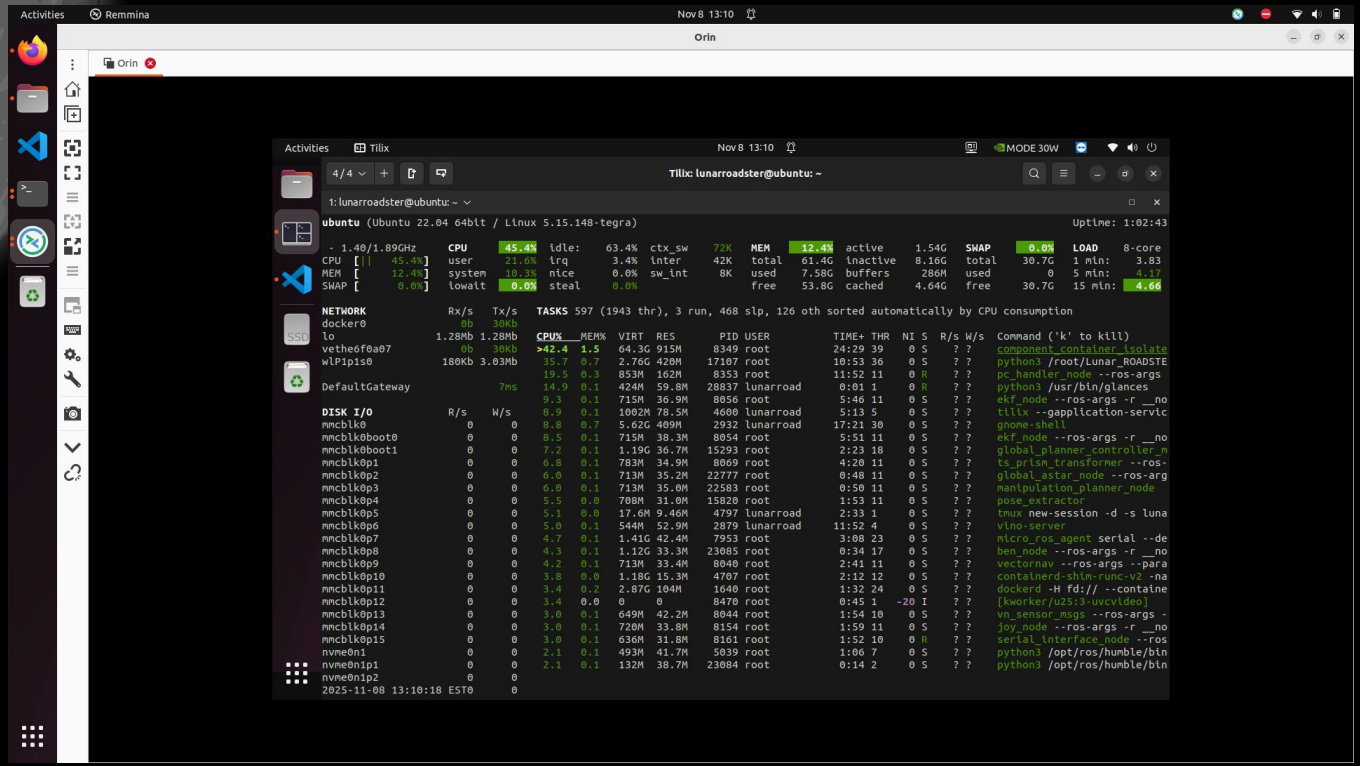


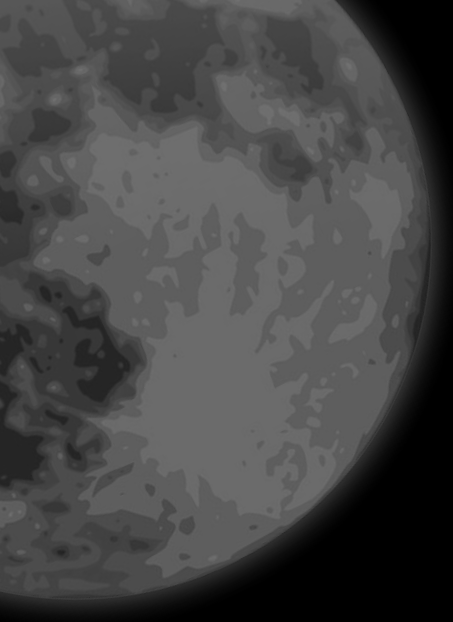
```
[ben_node]: --------------------------------------------------------------------------
[ben_node]: [FSM] Current State: PERCEPTION
[ben_node]: [FSM: PERCEPTION] Requested crater goals from service.
[ben_node]: [FSM: PERCEPTION] Transitioning to MANIPULATION_PLANNER.
[ben_node]: [FSM: PERCEPTION] Pose extraction succeeded: Generated 4 goal poses.
[ben_node]: [FSM: PERCEPTION] Verbose: goal[0] type=source x=2.08 y=1.43 yaw=6.27
[ben_node]: [FSM: PERCEPTION] Verbose: goal[1] type=sink x=2.97 y=1.42 yaw=6.27
[ben_node]: [FSM: PERCEPTION] Verbose: goal[2] type=source_backblade x=3.87 y=1.41 yaw=6.27
[ben_node]: [FSM: PERCEPTION] Verbose: goal[3] type=sink_backblade x=2.52 y=1.43 yaw=6.27
[ben_node]: --------------------------------------------------------------------------
[ben_node]: [FSM] Current State: MANIPULATION_PLANNER
[ben_node]: [FSM: MANIPULATION_PLANNER] Running manipulation planner...
[ben_node]: [FSM: MANIPULATION_PLANNER] Skipping goal 0 (type=source).
[ben_node]: --------------------------------------------------------------------------
[ben_node]: [FSM] Current State: MANIPULATION_PLANNER
[ben_node]: [FSM: MANIPULATION_PLANNER] Running manipulation planner...
[ben_node]: [FSM: MANIPULATION_PLANNER] Planning to pose 1/4 (x=2.97, y=1.42) type_raw=sink

[ben_node]: [FSM: MANIPULATION_PLANNER] Sent plan request for pose index 1.
 [ben_node]: [FSM: MANIPULATION_PLANNER] Planning failed for pose index 1: TF lookup failed
target_frame does not exist.
[ben_node]: --------------------------------------------------------------------------
[ben_node]: [FSM] Current State: MANIPULATION_PLANNER
[ben_node]: [FSM: MANIPULATION_PLANNER] Running manipulation planner...
[ben_node]: [FSM: MANIPULATION_PLANNER] Planning to pose 1/4 (x=2.97, y=1.42) type_raw=sink
```

Goal: Planning Test Results

Test 09: CPU/GPU Usage of Orin & Compute Limits

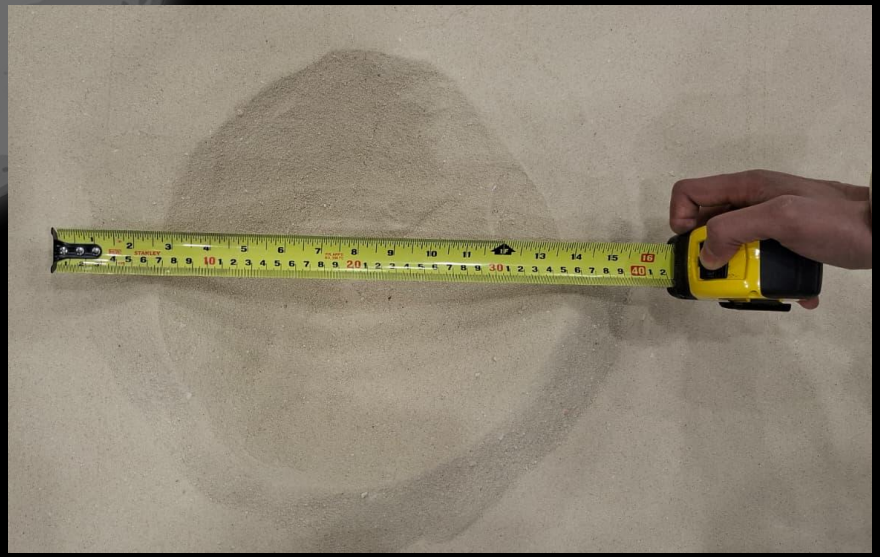


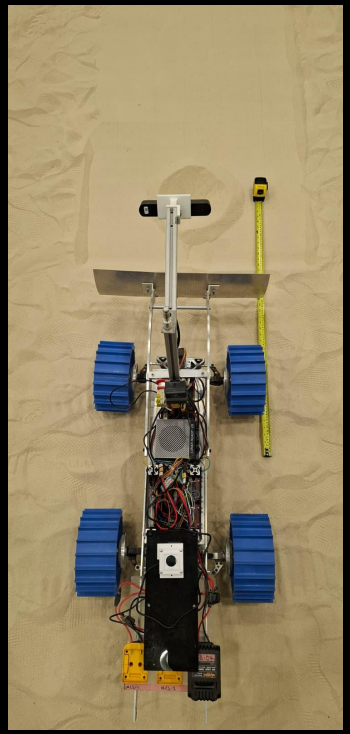


Goal: Perception QA

Goal: Perception Test Results

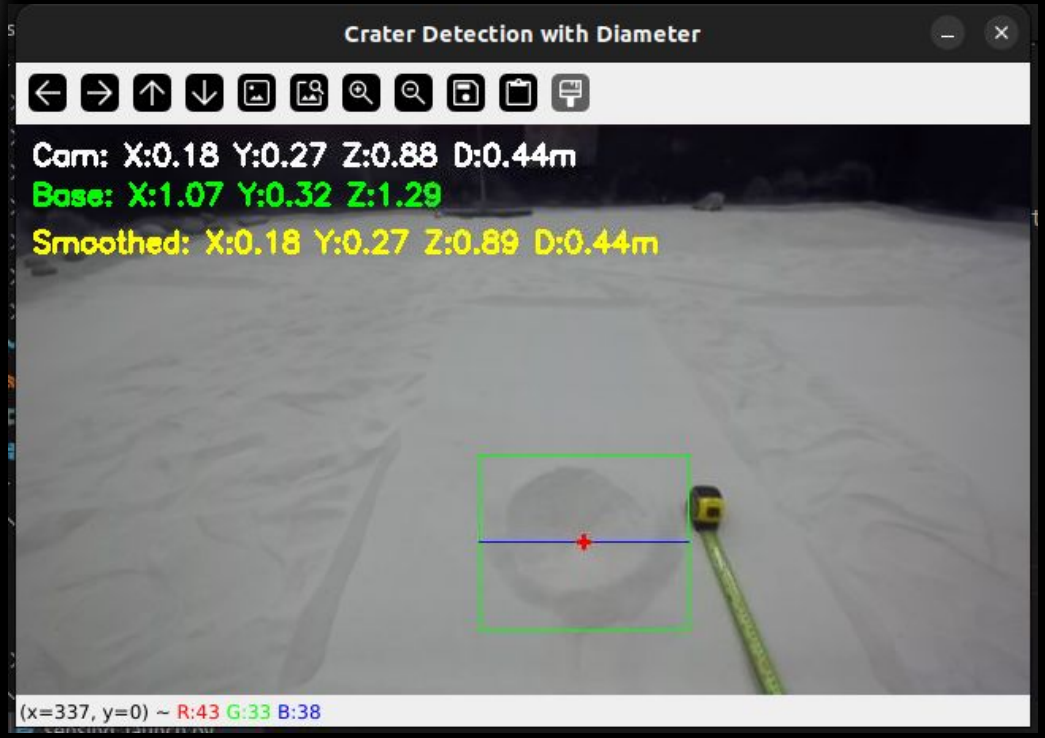
- T05: Perception Stack Crater Geometry Extraction Test

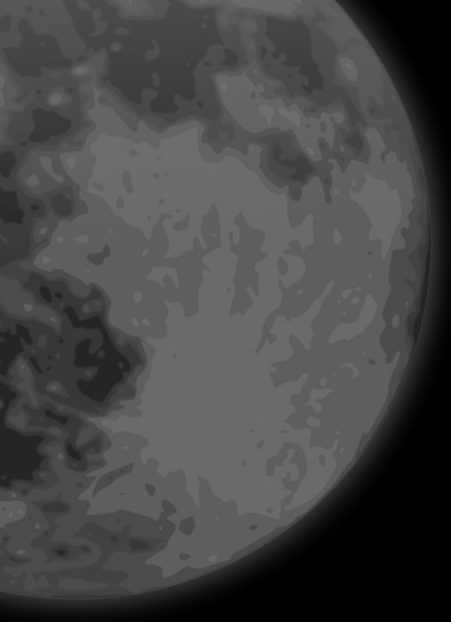




Goal: Perception Test Results

- T05: Perception Stack Crater Geometry Extraction Test

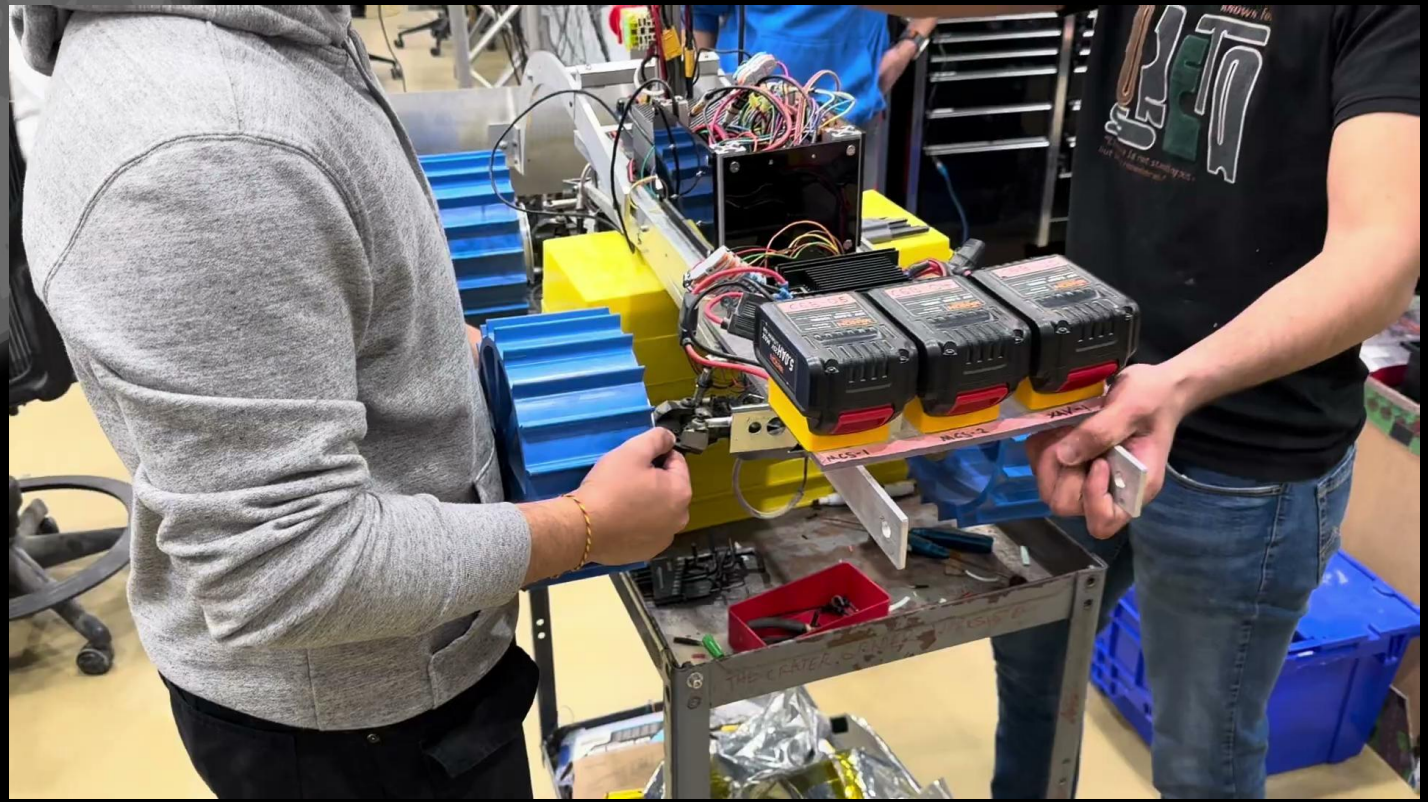




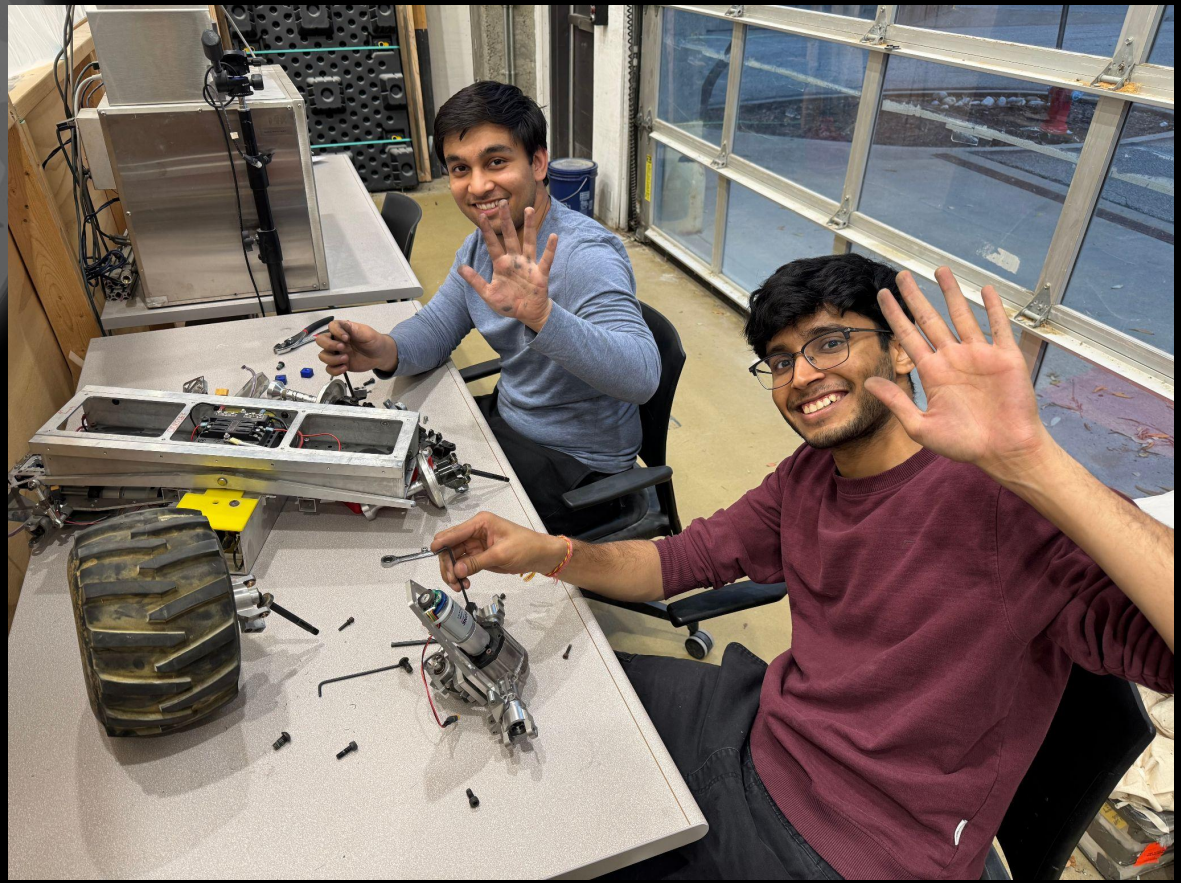
Goal: Hardware QA

Goal: Hardware Test Results

T10: Complete Hardware Test and QA

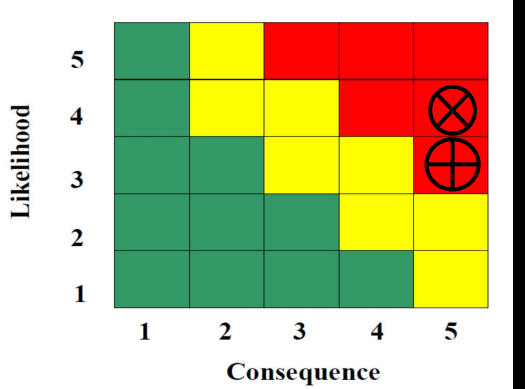


Goal: Hardware Test Results



Risk Management

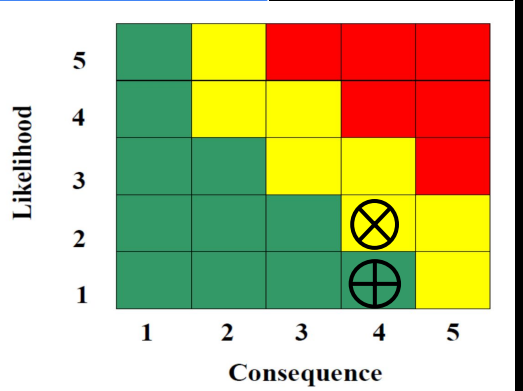
Risk ID	Risk Title	Risk Owner	Risk Type:	Logistics
R30	No spares available	Team		
Description		**Date Added**		
Discontinued model, spare parts unavailable		3/4/2025		
		Date Updated		
		8/30/2025		
Consequence				
The whole project falling through, or redo almost all subsystems on a different rover.				



Action/Milestone	Success Criteria	Date Planned	Date Implemented
Check out eBay and other similar platforms for spares	Successfully find exact spares on these platforms	3/6/2025	9/22/2025
Check out and stock similar parts if not same	Successfully find and stock similar parts	3/6/2025	9/22/2025
Find a twin rover that was used by a previous team on campus	Successfully find the twin rover and scavenge parts	3/6/2025	3/7/2025
Find similar parts - a slightly smaller pinion and motor set	Spares problem will be solved	9/10/2025	9/22/2025

Risk Management

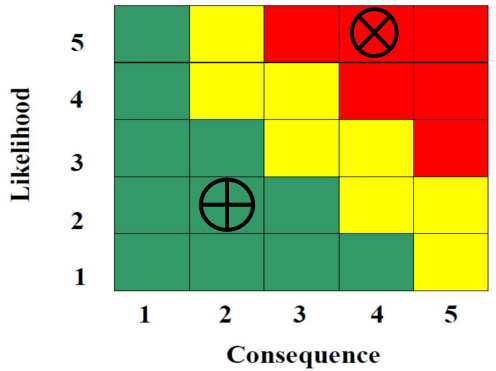
Risk ID	Risk Title	Risk Owner	Risk Type:	Logistics
R36	PRL Moonyard Access	William		
Description		**Date Added**		
Securing Moonyard access for testing/demos will be restricted and challenging		8/29/2025		
		Date Updated		
		8/29/2025		
Consequence				
No testbed available for testing and/or FVD				



Action/Milestone	Success Criteria	Date Planned	Date Implemented
Devise and discuss a testing and demo plan with Prof. Red and Prof. David Wettergreen beforehand and reserve slots	Successfully meet and discuss the schedule of high priority projects	9/11/2025	9/11/2025
Complete Medical Evaluation to get unrestricted but controlled access	Successfully complete the Medical Evaluation and get unrestricted access to the Moonyard	9/5/2025	9/11/2025
Respirator Training	Complete training and get custom masks	9/30/2025	

Risk Management

Risk ID	Risk Title	Risk Owner	Risk Type:	Technical
R34	Arduino requires reset before operation	Bhaswanth		
Description		**Date Added**		
Arduino needs to be manually reset each time before starting autonomy or switching between autonomy and teleoperation modes.		3/4/2025		
		Date Updated		
		4/10/2025		
Consequence				
Slows down setup time and impacts operational readiness, delaying mission start and mode transitions.				



Action/Milestone	Success Criteria	Date Planned	Date Implemented
Check USB port permissions and drivers issues on Jetson	Successfully establish consistent serial connection without reset	4/26/2025	9/5/2025
Verify that Arduino is connected via USB 3.0 instead of USB 2.0 port	Ensure stable high-speed communication	4/26/2025	9/5/2025
Check for ROS node frequency mismatches causing packet loss to Arduino	Match ROS publish/subscribe rates	4/26/2025	9/5/2025
Implement a software reset trigger	Reset can be called from the operations terminal	9/7/2025	

Issues Log

I16	10/04/2025	10/18/2025	**Team**	Unable to obtain rear steer motor encoder feedback	1. Recheck wiring permutations to see which one is correct 2. Retrace wiring to make sure everything is wired correctly	Rechecked wiring	Hardware working as intended
I17	10/04/2025	10/18/2025	**Team**	Front steer has power issue	1. Recheck front steer power connections with the RoboClaw connectors 2. Check how the rear steer power connections are connected and try to copy	Rechecked power connections	Hardware working as intended
I18	10/25/2025	11/01/2025	**Team**	Steer pinion dislocates during large steer commands	1. Mount the steer motor to be closer to the drive shaft 2. By a larger sized steer pinion	Drilled new holes to mount the steer motor to be closer to the drive shaft	Solved problem entirely
I19	11/05/2025	11/07/2025	**Team**	New RoboClaw adaptor is too high, the E-box lid is not able to be screwed on	1. Increase the height of the support pillars 2. Switch to a thermal space blanket instead of an acrylic lid	Added spacers to raise the plate	Hardware working as intended

Future Work

FVD Goals:

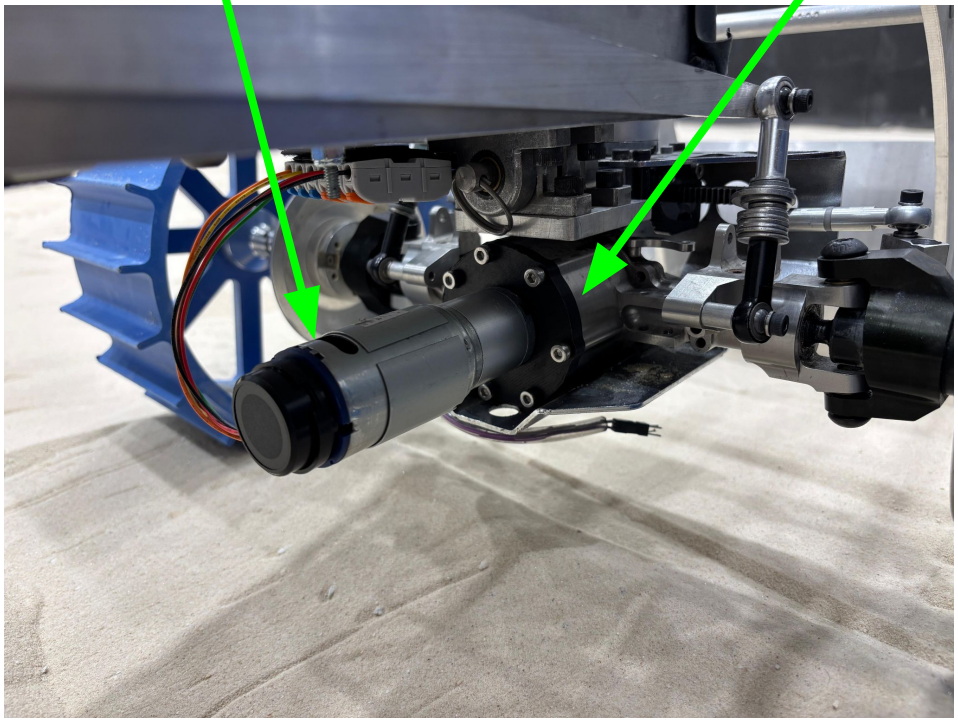
- Conduct the Fall Validation Demonstration, verifying rover performance in navigation, grading, and validation tasks.

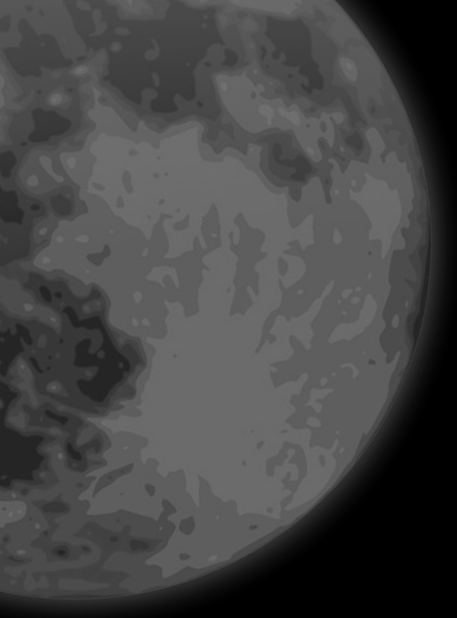
FVD Encore Goal:

- Localization (Skycam) Integration

Front Drive Motor

Front Drive Mechanism





THANKS!

Team Lunar ROADSTER