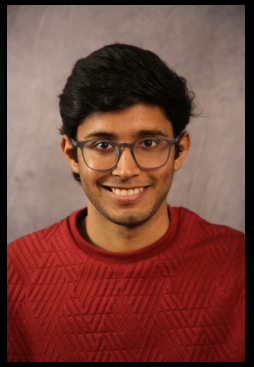
Lunar ROADSTER

(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"

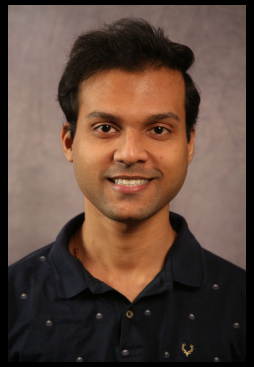
The Team

Ankit Aggarwal



Deepam Ameria

Bhaswanth Ayapilla



Simson D'Souza

Boxiang (William) Fu

Dr. William "Red" Whittaker

Agenda

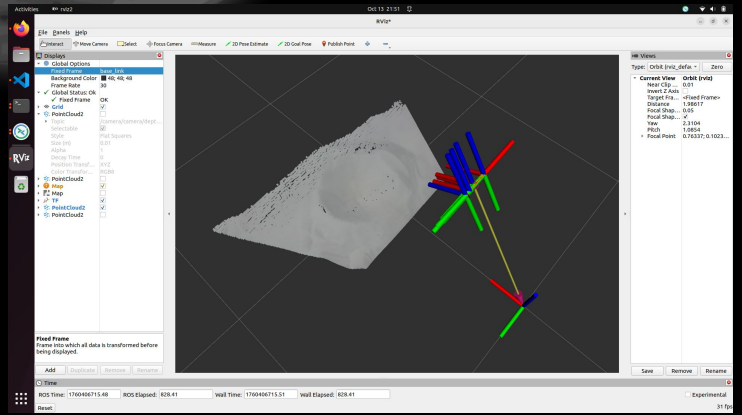
1. Validation: Tuning, testing and integration
2. Perception: Geometric feature extraction, online implementation
3. Navigation: Test and tune the global planners and controllers on the rover
4. Planning: Parsing robot poses and integrating perception, validation, and navigation
5. Localization: Implement SkyCam methodology

✅ PR10 Code Development Deadline

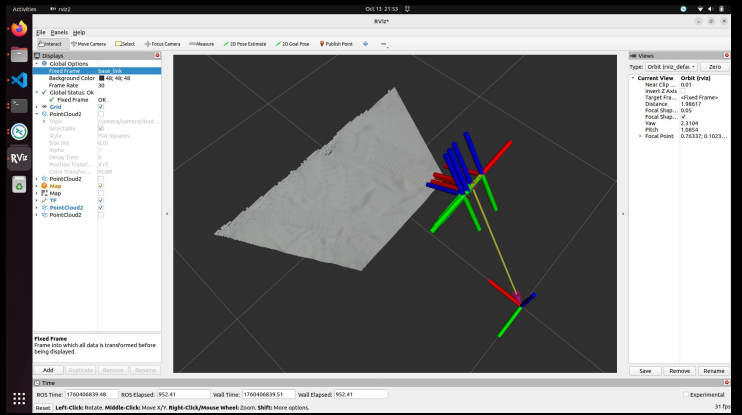
Goal: Validation Stack

Implementation:

- Obtains most recent point cloud feed from the ZED camera
- Voxel downsampling, and builds a KdTree
- Surface normal estimation and calculate per-point slope from the vertical z-axis
- Nearest neighbor smoothing and masking to filter out phantom points and walls/edges
- Compute aggregate slope statistics over several frames



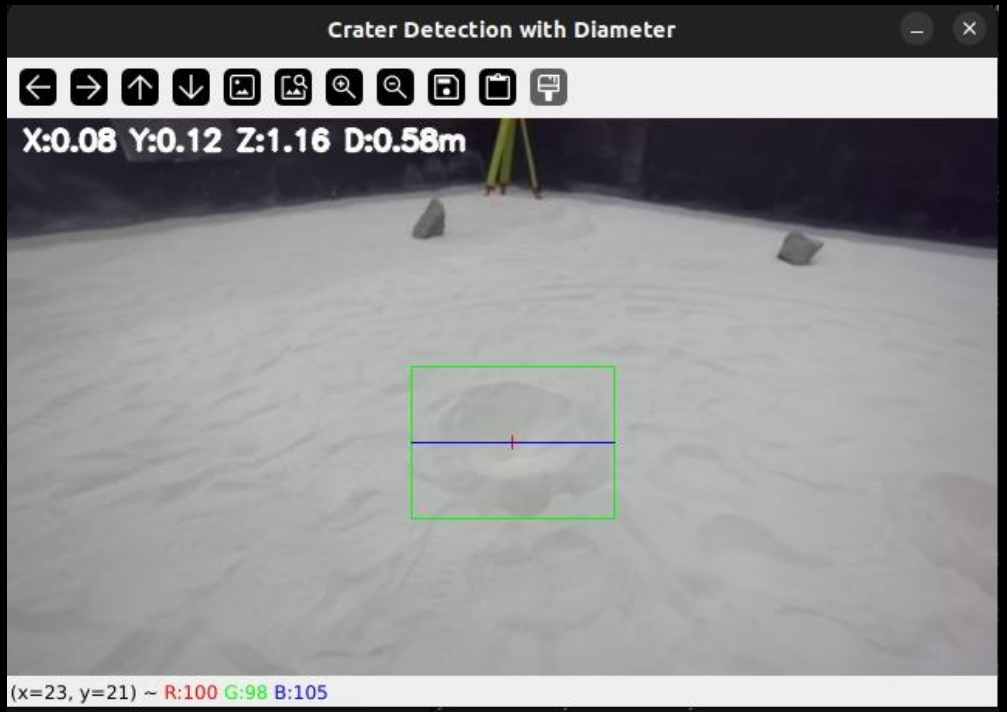
Validation Success = False
Max Slope = 17.93 deg



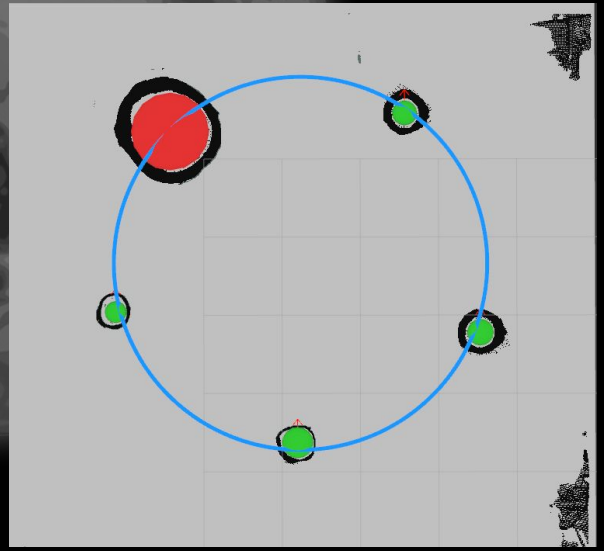
Validation Success = True
Max Slope = 1.73 deg

Goal: Perception Stack

- Online implementation on Orin - DONE
- Crater Center Coordinates in Camera Frame (X,Y,Z)- DONE
  - Transform to static world frame - IN PROGRESS
- Crater Diameter (in meters)- DONE

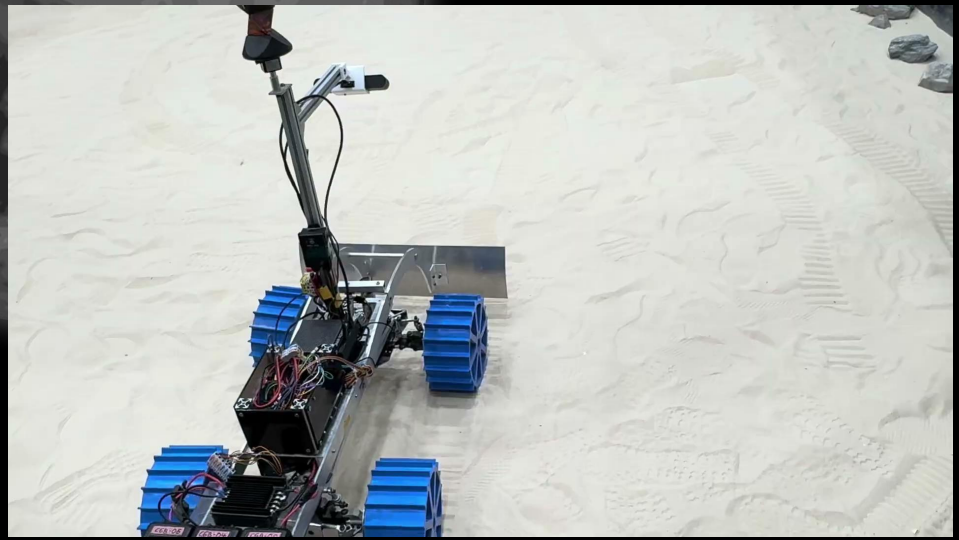


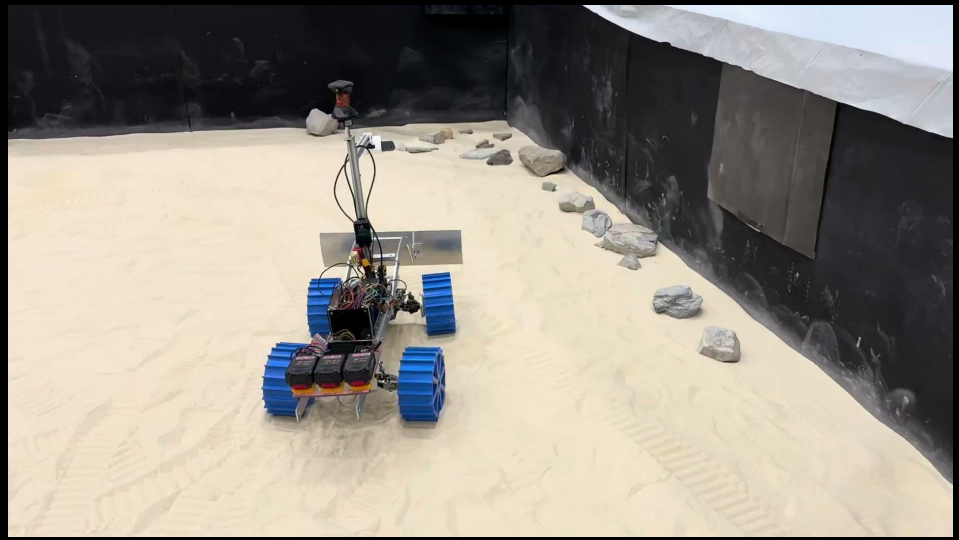
Goal: Navigation stack



- Global Planner tested and tuned
- Visualization shows gradable and ungradable craters
- Converted into ROS Service
- Blue line shows latitude
- Green line shows planned path
- Deviation statistics are calculated

Goal: Navigation stack





Global Controller tested and tuned

Goal: Planning Stack - now merged with Perception

Robot pose parsing complete (ROS Service)

a. Obtains crater geometry from perception (integrated)
b. Creates source, sink and offset poses for manipulation
c. All hyperparameters are in yaml files
d. Code developed with BEN in mind and will be easily integrated
e. Validation will be integrated into BEN directly.
f. **Next step** - testing and tuning parameters

Goal: Sky Cam Localization

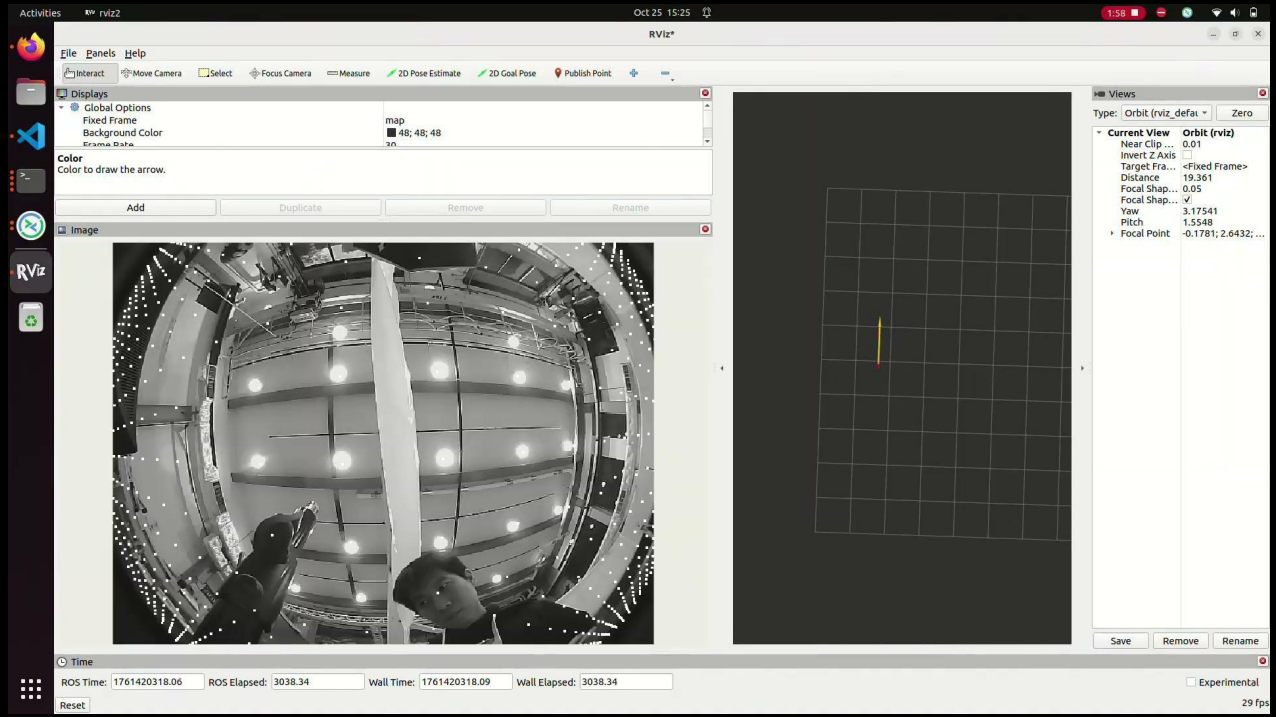
Implementation:

- Detects ceiling light pattern using fisheye camera
- Filters “of interest” pixels by brightness
- Levenberg–Marquardt optimization to fit ceiling grid
- Convert camera 2D coordinates to 3D coordinates using ceiling height

Issues:

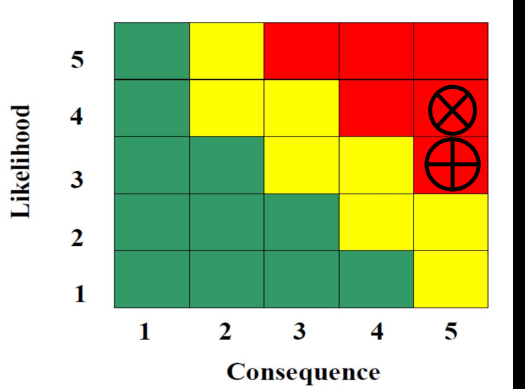
- Roll and pitch causes pose to drift, trying mechanical gimbal and software fixes

→ **Skycam Estimate** → **Ground Truth**



Risk Management

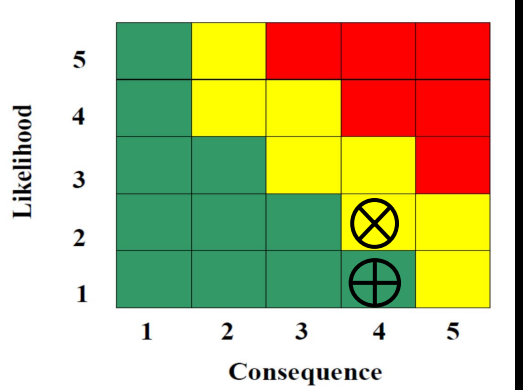
Risk ID	Risk Title	Risk Owner	Risk Type:	Logistics
R30	No spares available	Team		
Description		**Date Added**		
Discontinued model, spare parts unavailable		3/4/2025		
		Date Updated		
		8/30/2025		
Consequence				
The whole project falling through, or redo almost all subsystems on a different rover.				



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

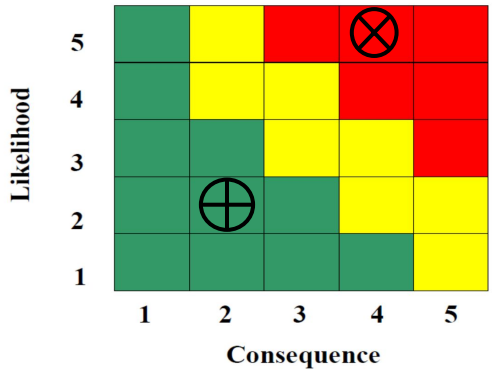
Risk ID	Risk Title	Risk Owner	Risk Type:	Logistics
R36	PRL Moonyard Access	William		
Description		**Date Added**		
Securing Moonyard access for testing/demos will be restricted and challenging		8/29/2025		
		Date Updated		
		8/29/2025		
Consequence				
No testbed available for testing and/or FVD				



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	

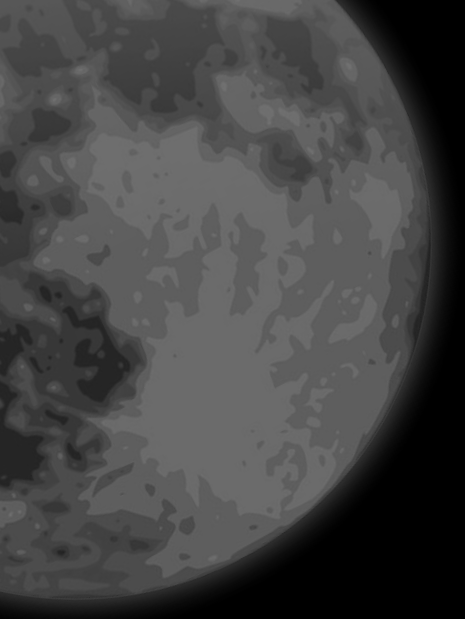
Issues Log

I14	09/14/2025		**Team**	Steer pinion tooth chipped and worn-out due to wear-and-tear. Unable to find exact replacement for the pinion	1. Replace with similar pinion that has different tooth count 2. Switch to using another chassis		
I15	09/14/2025	10/07/2025	**Ankit Aggarwal** **Deepam Ameria** **Simson D'Souza**	Wires keep on coming loose during operations due to bad soldering	1. Re-solder every wire 2. Switch to plug connectors and buy adaptors for the RoboClaws and motors	Switched wiring to use plug connectors	This allows us to stop worrying about loose wiring due to bad soldering
I16	10/04/2025		**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		
I17	10/04/2025		**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		

Future Work

PR 11 Goals:

- Localization QA & compensation for roll and pitch
- Validation QA & integration with BEN stack
- Navigation QA
- Planning QA
- Perception QA
- Hardware QA



THANKS!

Team Lunar ROADSTER