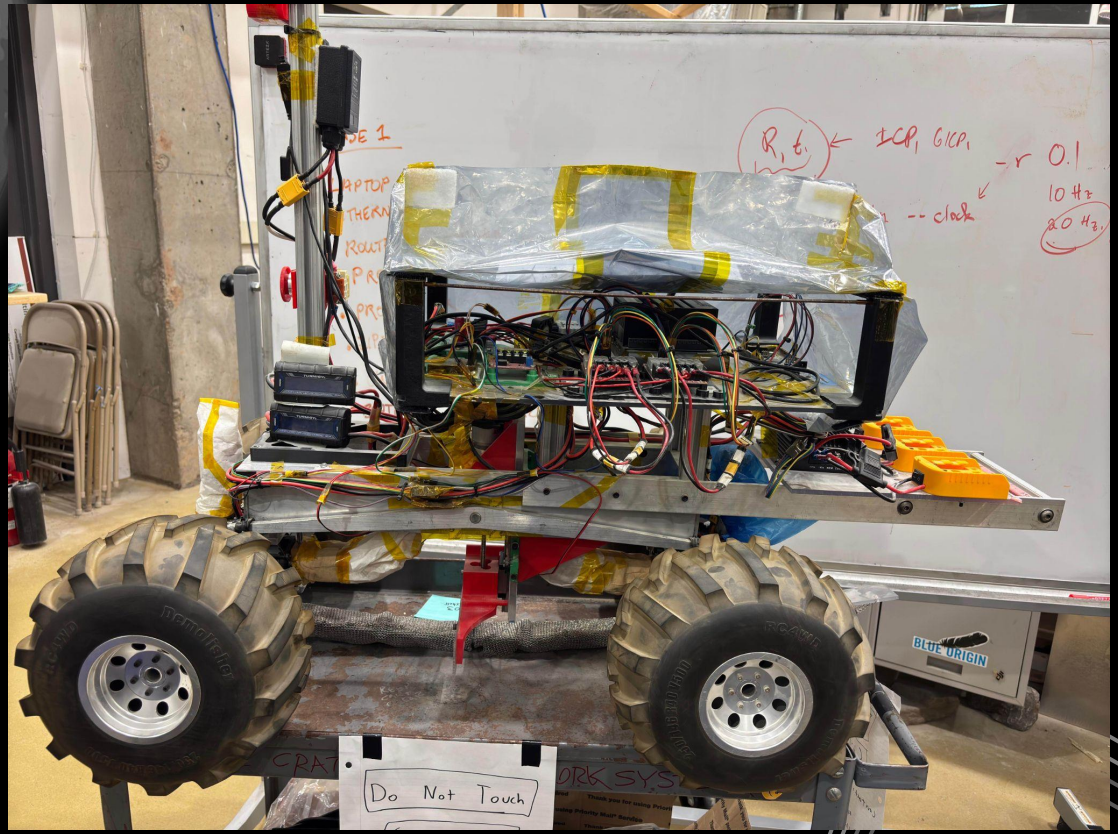
Lunar ROADSTER

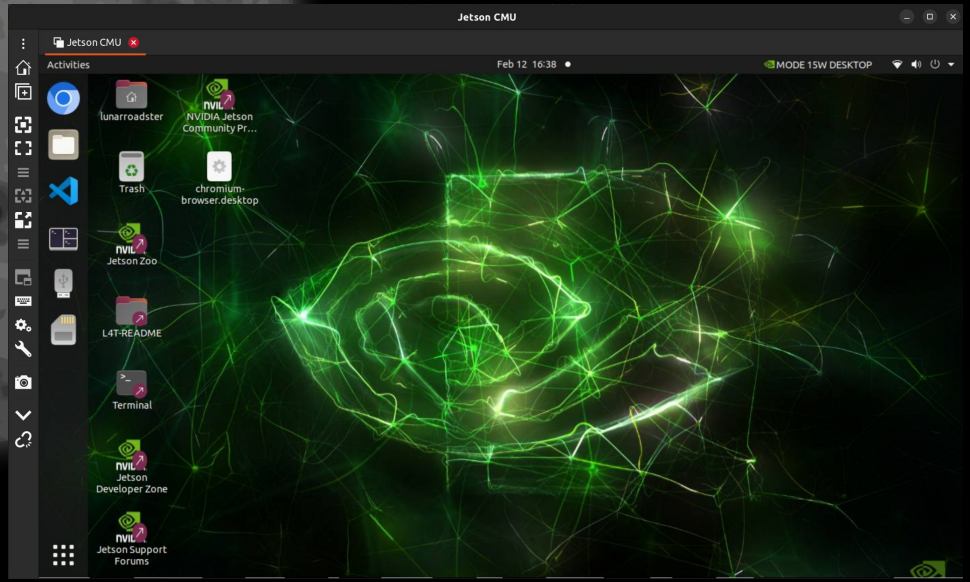
(Robotic Operator for Autonomous Development of Surface Trails and Exploration Routes)

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

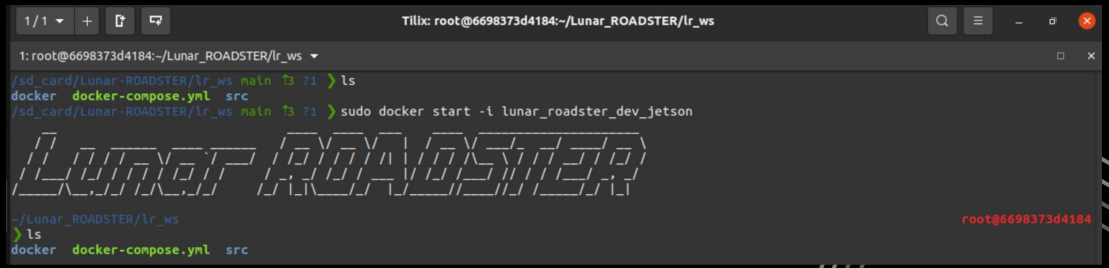
CraterGrader Rover



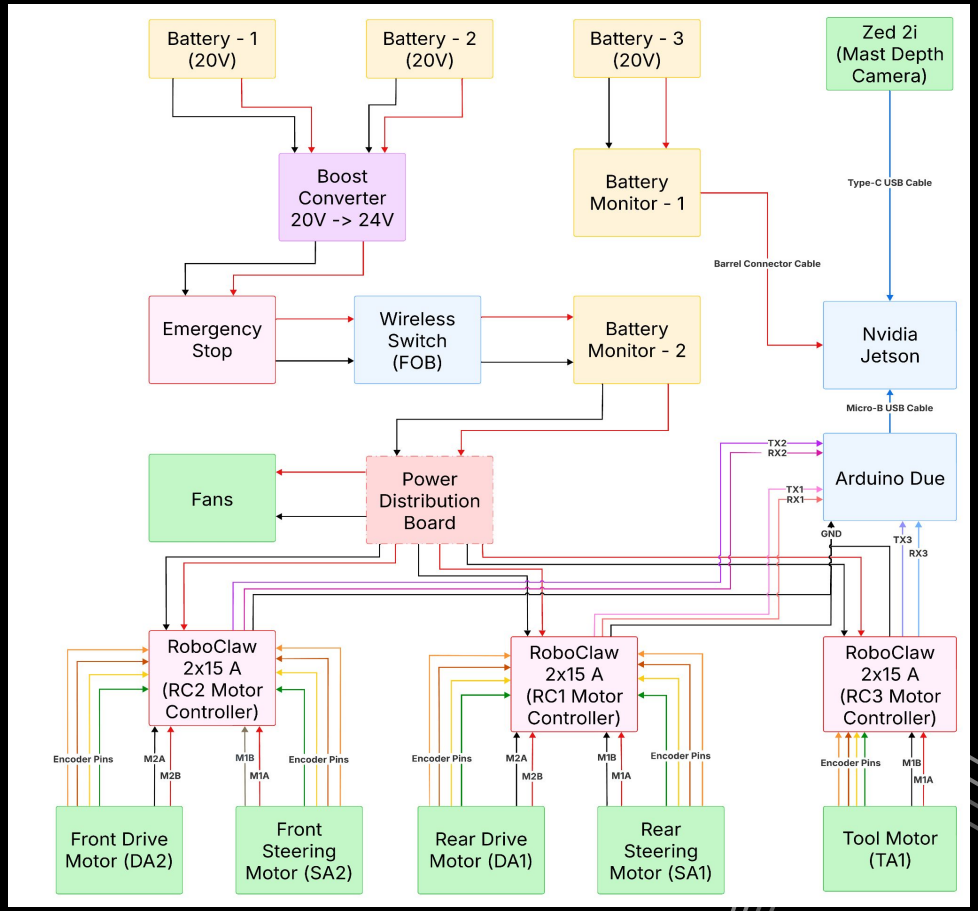
Software: Jetson and Docker




```
Lunar_ROADSTER
└─ lr_ws
      ├─ docker
      │     ├─ requirements.txt
      │     ├─ lrdev_jetson.dockerfile
      │     ├─ lrdev_linux.dockerfile
      │     └─ lrdev_entrypoint.sh
      ├─ docker-compose.yml
      ├─ .dockerignore
      └─ src
          ├─ arduino
          ├─ lr_msgs
          ├─ drivers
          ├─ localization
          ├─ sensing
          └─ teleop
```

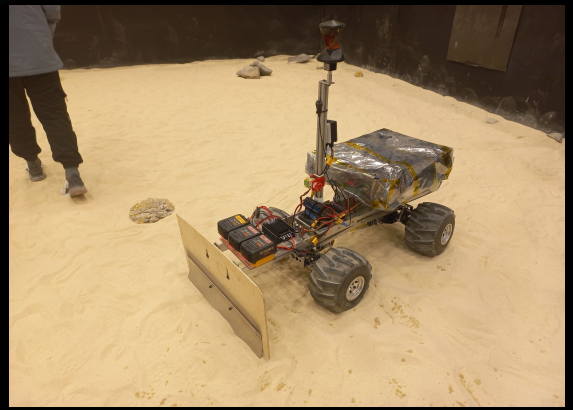


Hardware: Electrical Circuitry



Testing: Teleoperation

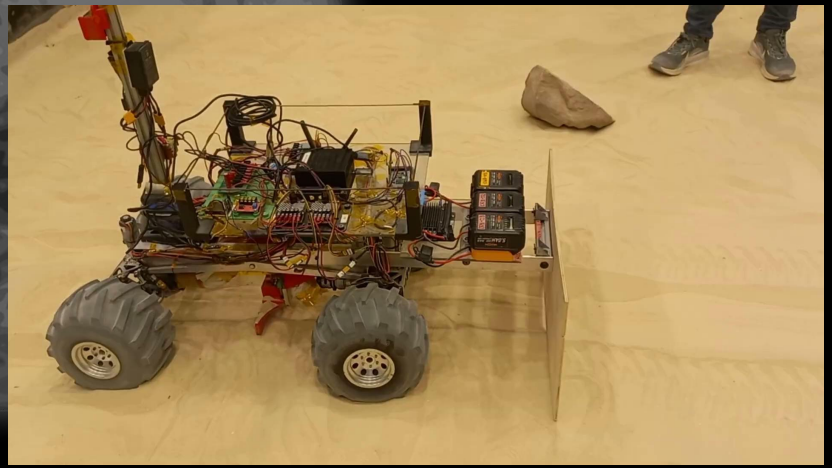
Testing: Mock-up Dozers using Teleoperation



- Dozer blade prototypes
  - Wood
  - Aluminum

- Key Takeaways
  - Dozer blade need not be too high
  - Having a cutting edge improves grading
  - The rover pitches forward and backward due to digging and pushing
  - Rear steering mechanism damaged
  - Wheel slippage and sinkage due to digging

Testing: Mock-up Dozers using Teleoperation



Actions taken based on tests

- Facilitate dozer blade and mechanism design
- High-torque motor selection
- Rear steering maintenance
- Weight balance

Grading Quality

Aluminium >> Wood

Hardware: Dozer Assembly Design

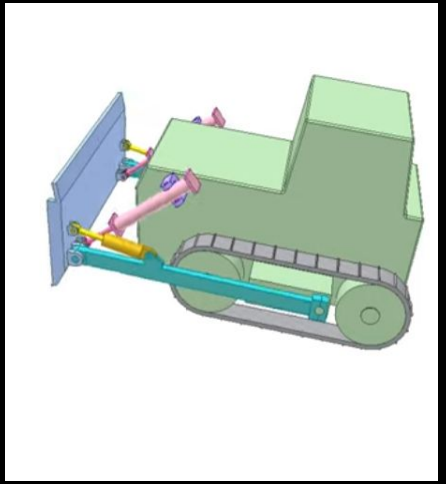
Researched dozers, loaders and chassis graders

Made preliminary sketches and design iterations based on brainstormed ideas and real-life inspiration

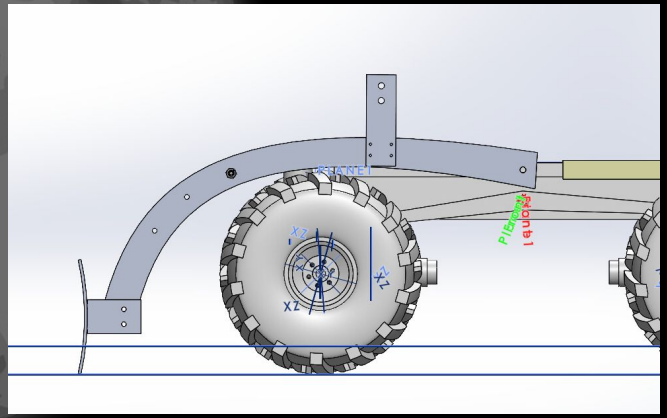
Used observations from tests and insights from sponsors to improve design

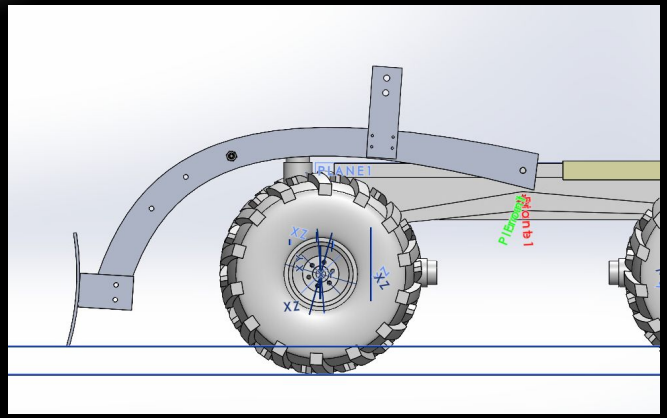
Developed final design and got reviewed by Timothy Angert

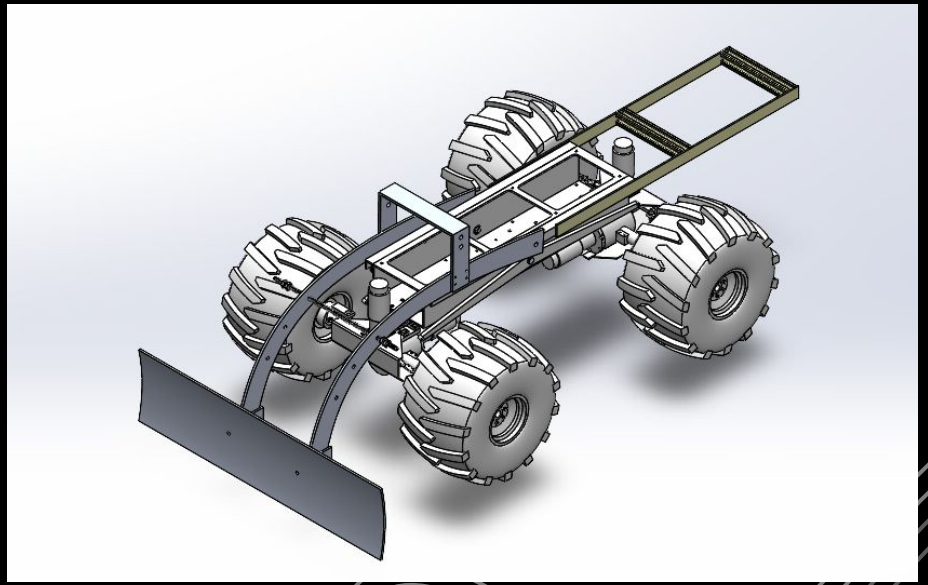
Currently working on manufacturing different parts, .viz dozer arms, yoke, dozer blade, etc.



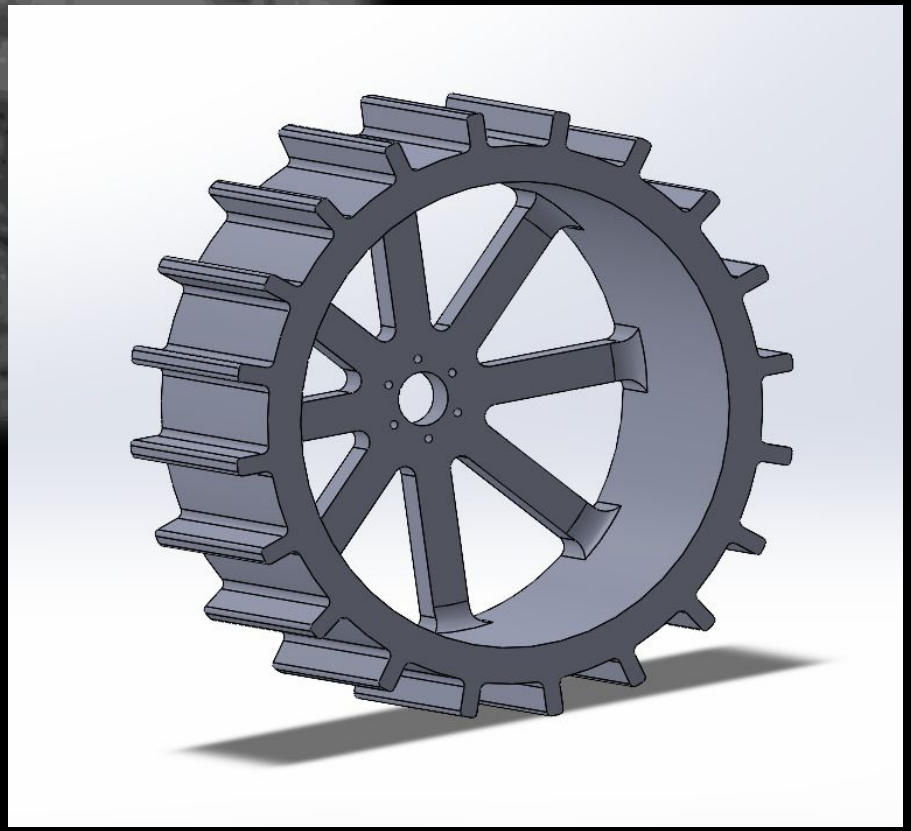
Hardware: Dozer Assembly Development



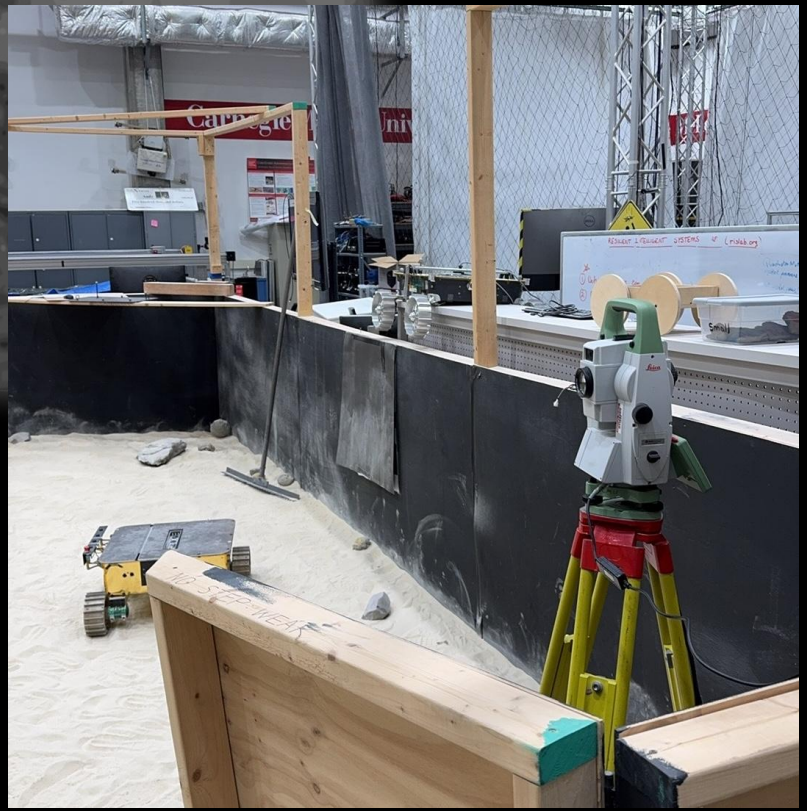




Hardware: Wheel Prototyping



Localization: Total Station Setup - Leica TS16



william_fu@williamfuubuntu: ~

william_fu@williamfuubuntu: ~/Deskto... × | william_fu@williamfuubuntu: ~ ×

```
william_fu@williamfuubuntu:~$ ros2 topic info /total_station_prism
Type: geometry_msgs/msg/PoseWithCovarianceStamped
Publisher count: 1
Subscription count: 0
william_fu@williamfuubuntu:~$ ros2 topic hz /total_station_prism
average rate: 8.395
        min: 0.095s max: 0.148s std dev: 0.01877s window: 10
average rate: 7.968
        min: 0.095s max: 0.257s std dev: 0.03608s window: 18
average rate: 3.992
        min: 0.095s max: 3.157s std dev: 0.60696s window: 24
average rate: 4.511
        min: 0.092s max: 3.157s std dev: 0.52852s window: 32
average rate: 5.042
        min: 0.092s max: 3.157s std dev: 0.46907s window: 41
average rate: 5.443
        min: 0.092s max: 3.157s std dev: 0.42595s window: 50
average rate: 5.656
        min: 0.087s max: 3.157s std dev: 0.39633s window: 58
average rate: 5.908
        min: 0.087s max: 3.157s std dev: 0.36933s window: 67
william_fu@williamfuubuntu:~$
```

Localization: VectorNav IMU VN-100 Setup

Interfaced VectorNav SDK with a ROS2 Wrapper

Publishes bias-corrected roll, pitch and yaw to a ROS2 Topic

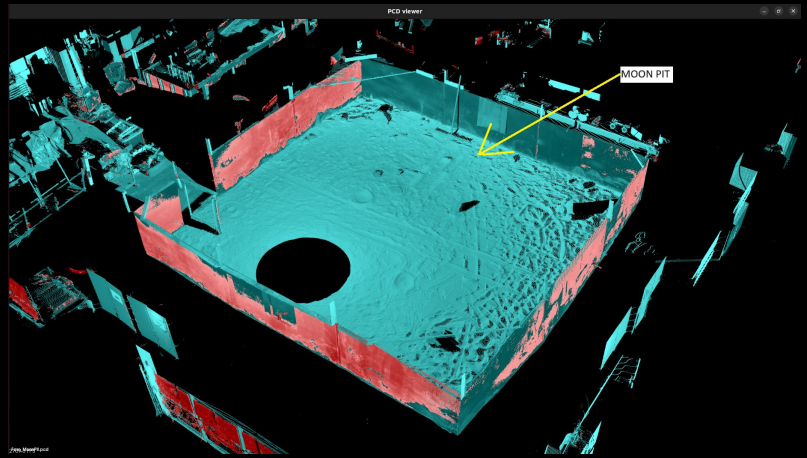
Also reports linear and angular acceleration - to be used as input to the Extended Kalman Filter

Problems Faced:

- Outdated firmware and unavailability of open-source updates

Localization: FARO Scanner (Survey LiDAR)

FARO outputs (.fls) format, incompatible with ROS.
Converted (.fls → .pts → .pcd) using Autodesk Recap Pro and the PCL library for ROS compatibility.



Point Cloud Optimization:

- Downsampled using a Voxel grid to reduce complexity.
- Using the thresholding approach to classify large craters as occupied and free space as traversable.

Current Work:

- Setting up the Intel RealSense and scanning the Moon Yard.
- Optimizing point cloud data to generate a 2D costmap for navigation.

Localization: Initial Stack Setup

Global Localization

- Leica TS16: Provides precise x, y, z coordinates using a total station
- Used for absolute positioning in a known reference frame

Local Localization

- VectorNav IMU: Measures acceleration and angular velocity for state estimation
- Wheel Encoders: Tracks wheel rotations for relative movement estimation
- Helps in odometry-based localization

Sensor Fusion with Extended Kalman Filter (EKF)

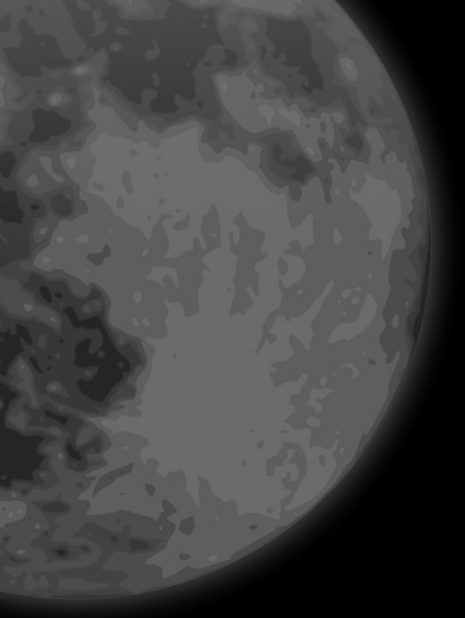
- Integrates measurements from IMU, encoder, and Leica TS16
- Handles noisy sensor data and non-linear motion models

Challenges & Considerations

- IMU and encoders suffer from drift over time
- Tuning covariances and offsets in odom frame and map frame

Project Management

- Daily Stand Ups
- Weekly meetings with Sponsor
- Task tracking using Notion
- Internal Wiki also on Notion for documentation



THANKS!

Team Lunar ROADSTER