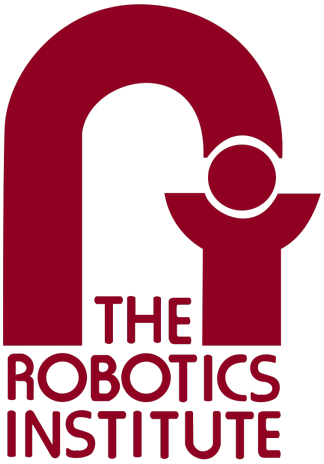
Individual Lab Report - 05



Lunar ROADSTER

Team I

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1 Individual Progress

1.1 Localization

1.1.1 Debugging Global Localization

In the previous ILR, I mentioned an issue where setting the global fixed frame to `map` caused the rover to behave erratically, suggesting a problem with global localization. William and I worked on debugging this, and we found that the TF tree on the TX2 relay was incorrectly configured: the `total_station_prism` frame was being published relative to the `base_link` frame. Since the `total_station_prism` and `base_link` frames are rigidly connected, this setup inadvertently caused the `base_link` frame to drift continuously. We resolved the issue by modifying the TF configuration on the TX2 to publish the `total_station_prism` frame relative to the fixed `map` frame instead. Figure 1 shows the corrected and now stable localization.

1.1.2 Yaw Calibration

After fixing the global localization, we observed a consistent yaw misalignment between the IMU-reported orientation and the expected orientation in the map frame, even when the rover was stationary. To correct this, I implemented a yaw calibration action that runs initially when the rover is not moving. During this time, several yaw readings are collected from the IMU. Since the rover wasn't turning and the prism stayed in the same place on the map, we knew the robot's true orientation shouldn't change. So, any steady difference in yaw from the IMU could be treated as an offset. These readings were averaged to find that yaw offset, and applied to future IMU data to correct the heading. This helped make the robot's orientation more accurate and improved the overall localization.

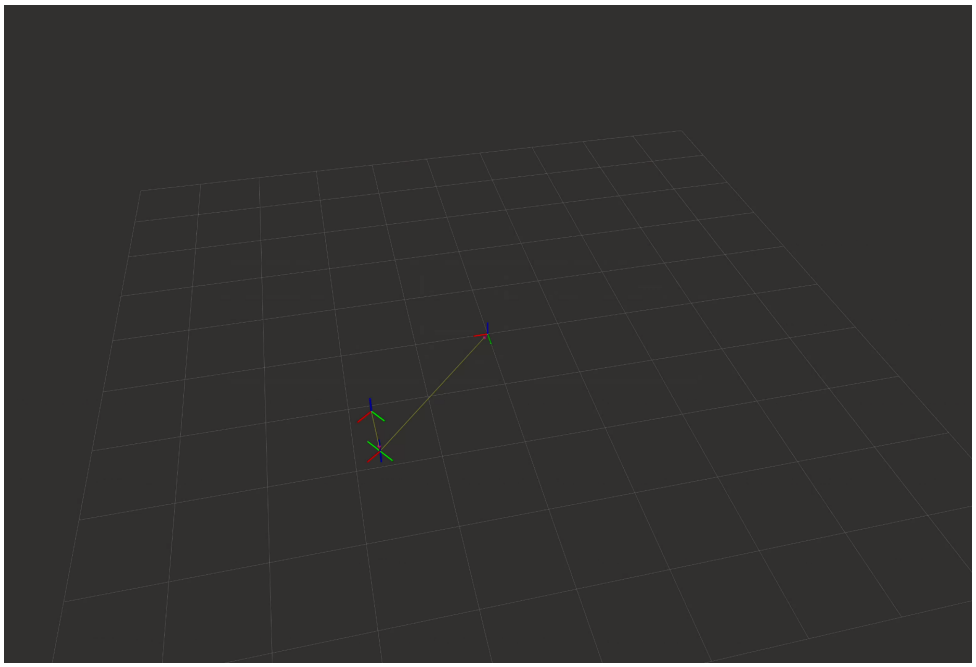

Figure 1: Before Yaw Calibration, Stable Localization

1.2 Moon Yard Mapping

Simson and I worked on remapping the Moon Yard to create a cleaner environment. The previous map contained too many rocks and not deep enough craters. This required

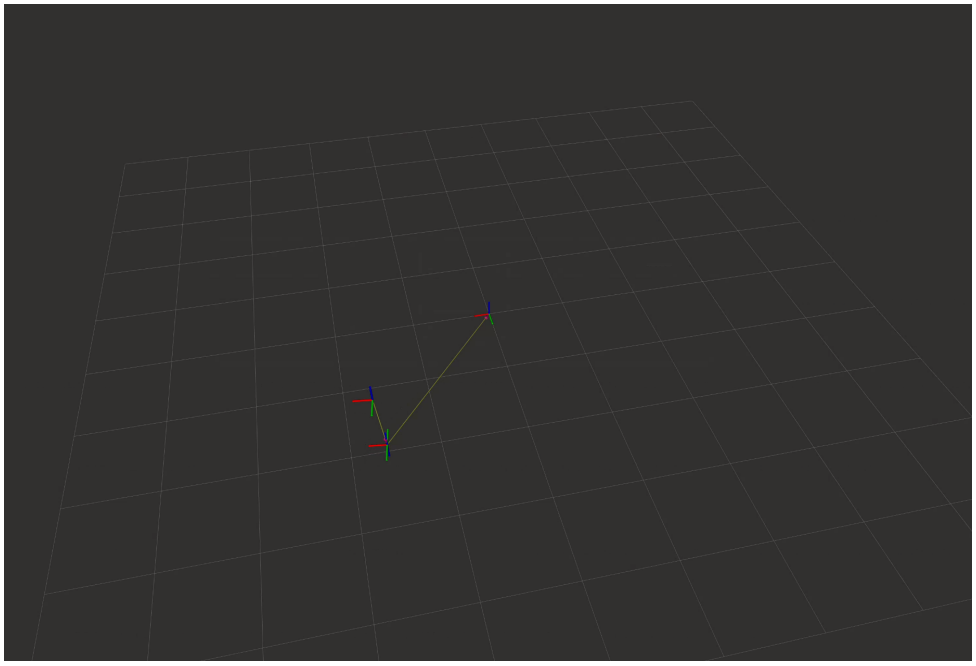

Figure 2: After Yaw Calibration

7. Start localization:
   a. Launch vectornav: `ros2 launch vectornav vectornav.launch.py`
   b. Launch IMU transformations: `ros2 launch imu imu_launch.py`
   c. Launch localization: `ros2 launch localization ekf_localization.launch.py`
   d. Calibrate IMU: `ros2 action send_goal /ts_prism_transformer/calibrate_imu lx_msgs/action/CalibrateImu "{dont_move_rover: false, time: 7}"`

Figure 3: Final Localization Setup

extensive fine tuning in order for the tool planner to work, and we don't want to spend too much time on something that is not too important right now. So we removed all the rocks, flattened the Moon Yard, and dug one deep crater. This new map will most likely serve as the final map moving forward.

1.3 Navigation Stack

Simson and I have been working on the navigation stack of our rover. We used the `nav2_bringup bringup_launch.py` launch file. This default launch file uses AMCL localization, but since we are using our own localization stack using the `robot_localization` package, we had to update the launch file. We configured the launch file to use the map correctly. We also updated the `nav2_params.yaml` file with relevant parameters that best suited our needs. We were able to autonomously navigate the rover to a given goal location. It worked really well for a straight path but a goal to the side causing the rover to turn didn't work out really well. We are working on debugging this now with the new E-box.

1.4 PCB Soldering

I collaborated with Ankit, Deepam and Simson in soldering our PCB which is the Power Distribution Board (PDB). Upon our sponsor Red's suggestion, we purchased multiple spare components and PCBs too. We soldered all of these and began assembling the

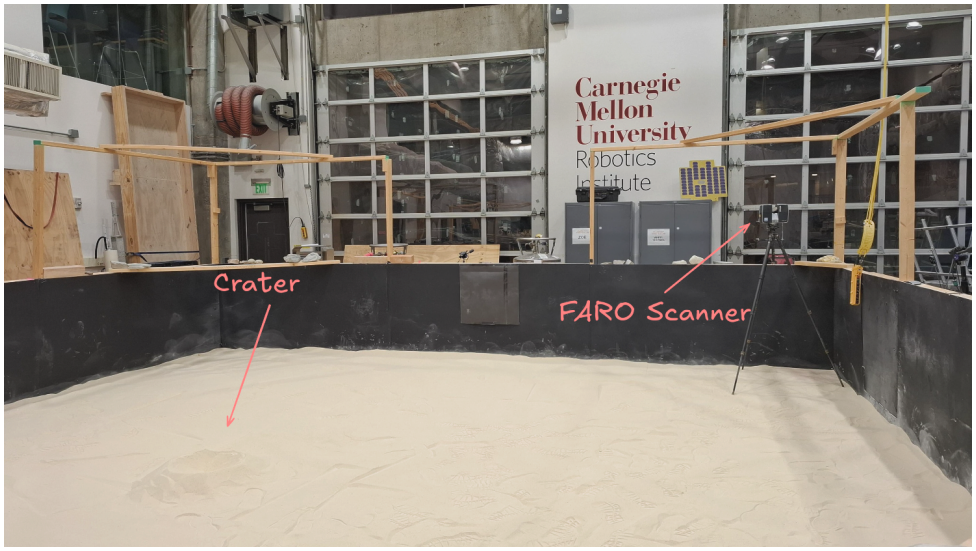

Figure 4: Mapping the Moon Yard using FARO Scanner

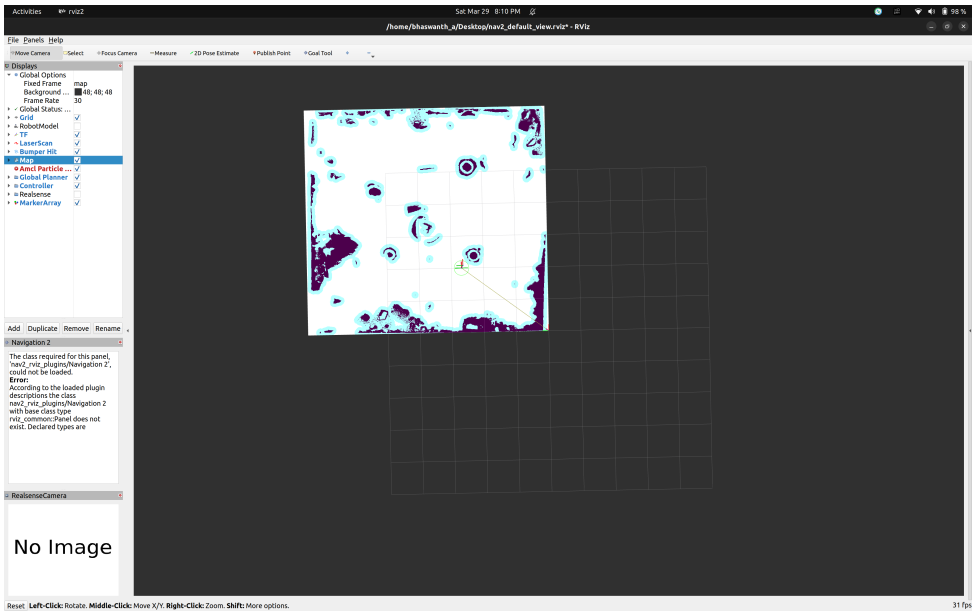

Figure 5: Visualization of Navigation Stack on Rviz

E-box. We initially faced the issue that the front and the rear steer motors were receiving different voltages, but this issue was solved with the new PDB.

1.5 E-Box Manufacture

I collaborated with Deepam and Simson to assemble the E-box, where we laid out the entire electronics system, replaced all wires with stronger crimps, and ensured reliable connections throughout. Ankit joined us to carry out comprehensive quality assurance on the completed hardware.

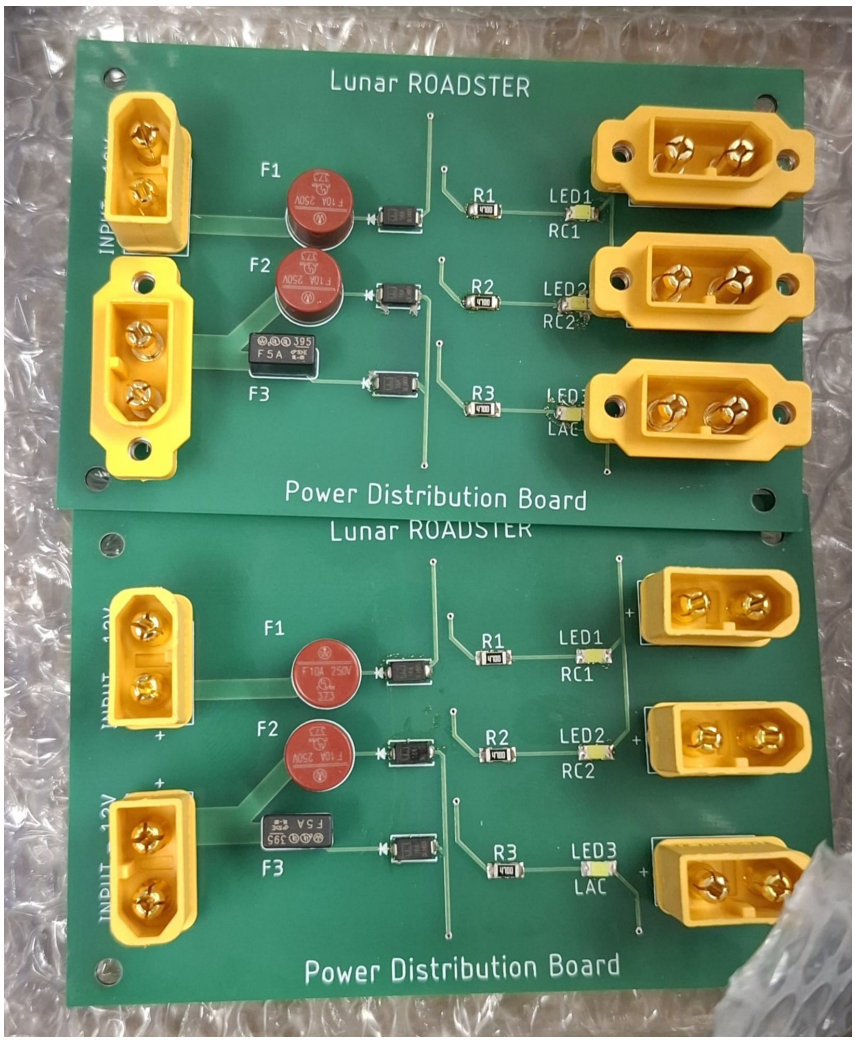

Figure 6: Power Distribution Board and spare

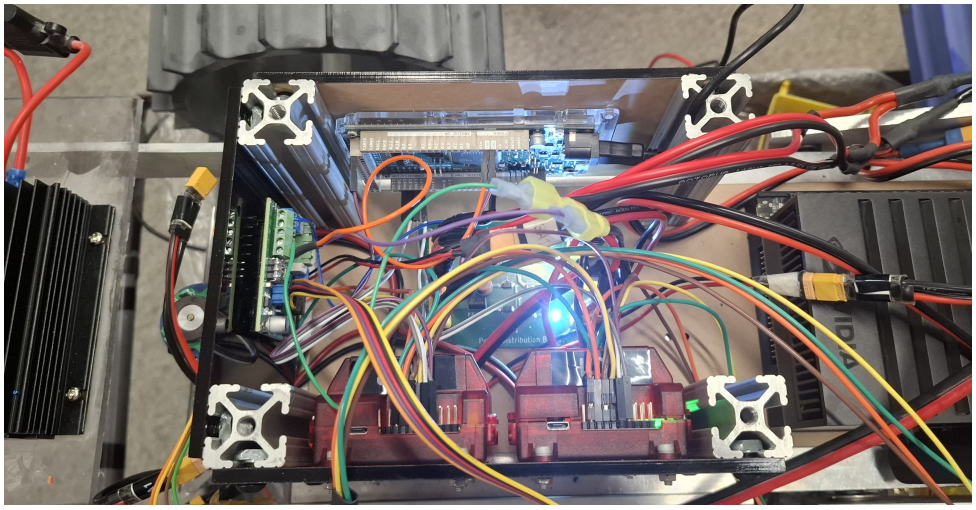

Figure 7: Assembled E-Box

2 Challenges

The biggest challenge Simson and I faced while working on the navigation stack was that the rover failed to reach the goal correctly when the target was placed to its side. Instead of navigating smoothly, it oscillated back and forth at the same location and eventually aborted the plan. During this time, the odometry frame from the local localization started to drift, which we think could be the root cause. Upon checking, we found that the front and the rear steers moved at different RPMs. This led to us performing unit testing of the complete electronics, to check if the motors were receiving encoder data correctly, and we found that the issue is with the front steer motor itself. So we are now working on replacing this motor with a new one, and we will be testing the navigation stack again.

3 Team Work

- **Bhaswanth Ayapilla:** My initial work was in collaboration with William in debugging the global localization stack and correcting the yaw of the rover. I worked with Simson on the navigation stack and integrating it with localization. We also set up a clean environment in the Moon Yard by removing rocks, flattening the area, and remapping it. This map will serve as the final map for the tool planner to work on. I collaborated with Ankit, Deepam and Simson in soldering the PCBs, assembling the E-box, testing it and troubleshooting issues, and performing quality assurance of the entire hardware setup.

- **Ankit Aggarwal:** Ankit's main work was implementing the tool planner and testing it using the FARO laser scan. He worked with William to integrate the Tool Planner into the FSM and William helped him visualize the planner outputs in RViz. He collaborated with Simson, Deepam and me to solder the PCBs. He also worked with us to debug and finalize the wiring connections in the new manufactured E-Box and general hardware debugging of the rover.

- **Deepam Ameria:** Deepam worked with Ankit, Simson and me to solder the PCBs and also for manufacturing, assembling, testing and debugging the E-box and the other hardware of the rover. He also worked on understanding and charting out the software architecture, mainly to understand how the planning stack fits into the whole system. He was working on figuring out the visualization the planning outputs. However, he was running into blockers and ultimately, William was able to complete that task.

- **Simson D'Souza:** Simson's primary responsibility was setting up the navigation stack and integrating it with the localization stack, which was done in collaboration with me. Additionally, the moon yard was scanned using a FARO scanner with my assistance. He stitched the scans together and defined a new map frame origin. This new FARO scan data will be used with the navigation stack and the tool planner stack. Alongside me, Deepam, and Ankit, he contributed to soldering PCBs, assembling the E-box, wiring new connections based on the updated E-box design, and troubleshooting hardware issues on the rover.

- **Boxiang (William) Fu:** William's initial work was mainly in collaboration with me in debugging the global localization stack of the rover. We have solved this and moved on with our tasks. His next task was mainly individual work on finalizing the sensing stack and integrating it with the active mapping stack. However, he worked with me on integrating localization with the mapping stack to output a global elevation map. His next task was on writing up the skeleton code for the FSM

behavior tree. This was in collaboration with everyone in the team. He listened to what each subsystem's expected inputs and outputs are and dictated what should flow in and out of each state of the FSM.

4 Plans

The primary goal for me now is to fine-tune the navigation stack. I will be collaborating with Simson on this task. I will also be working with the entire team to ensure end-to-end integration of all the subsystems. We will focus on rigorous testing until SVD.