Exit Presentation

Conor Gagliardi EV311

S.U.I.T.S. Intern

Fall 2023

Mentors: Geraldo Cisneros, Adam Peterson

About Me

From Waterford, New York

Senior Undergrad at RIT - Computer Science

Intelligence Analyst in NY Army National Guard


Tuna Puttanesca


Knafeh


Fish Taco

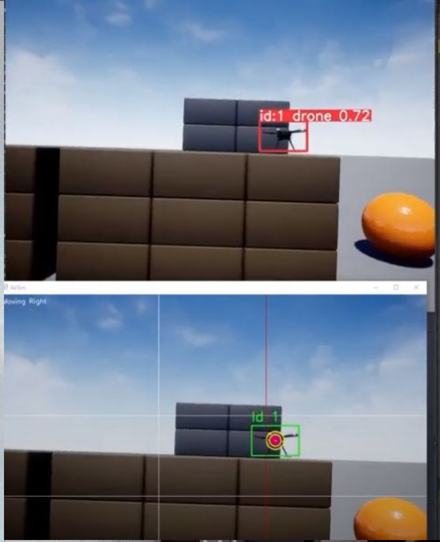
Houston RenFair - goblin

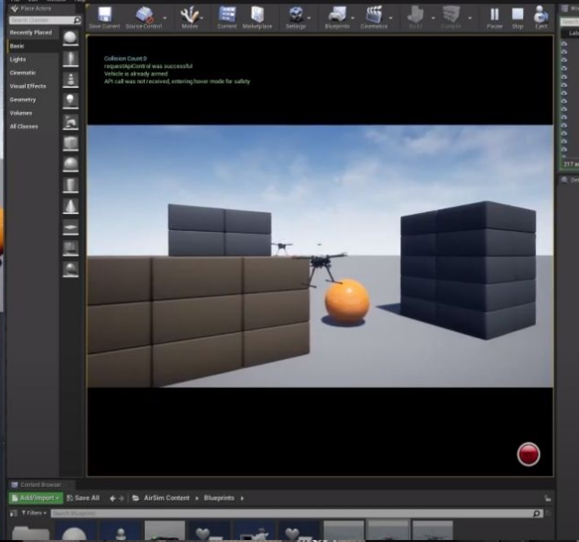
Why I’m Here

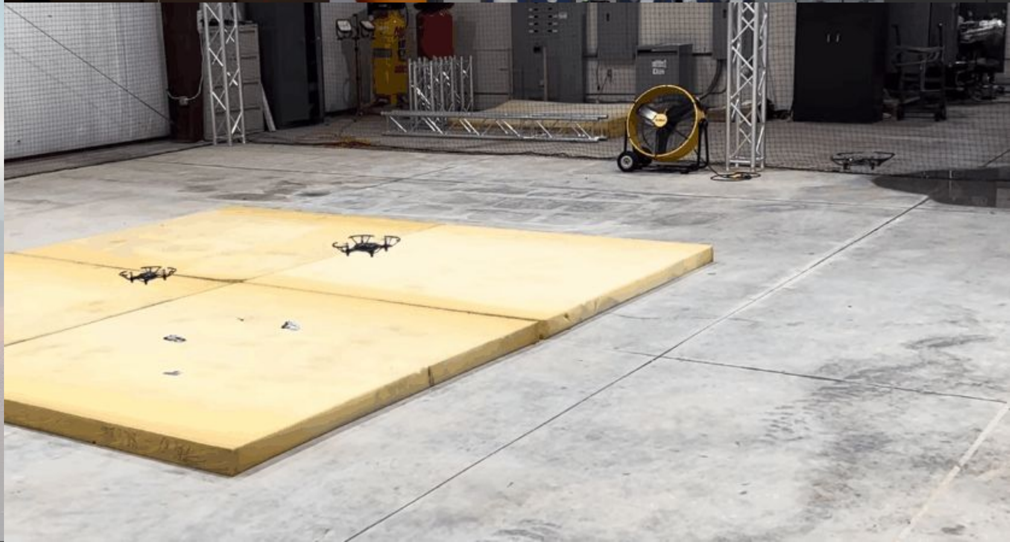
Interested in autonomous robotics, particularly in space exploration applications

Post deployment, did independent studies with robotics, as well as a part-time job as a computer vision engineer

Eager to pursue a PhD and research perception and control for autonomous systems







SUITS in brief

Spacesuit User Interface Technologies for Students (SUITS)

- Design challenge for national college students
    - Augmented reality heads up display and local mission control
- Eleven teams are selected to demonstrate their designs on a test week in May
- Their designs are meant to showcase capabilities of augmented reality in making crews more autonomous and efficient
- 2024 SUITS is a Mars EVA instead of Lunar as requested by EVA Human Surface Mobility Program (EHP)
- This year also features two simultaneous EVAs and LMCCs running at the same time
    - Designers can demonstrate collaboration possibilities

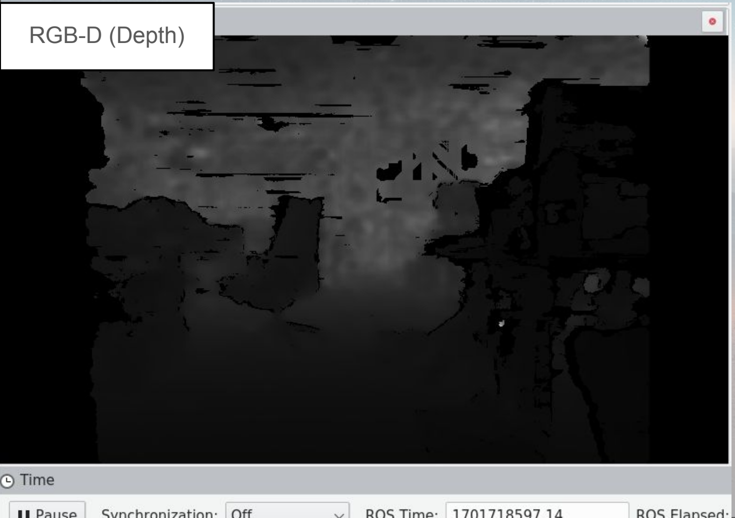
What I’m doing here

- Facilitating the Spacesuit User Interface Technologies for Students (SUITS) design challenge.
- Tasked with ensuring autonomous functionality of a rover for use in the SUITS EVA test week.
    - Subtasks include setting up manual control via joystick, LIDAR integration, web servers for streaming telemetry data including the rover’s position, video streams, and RGB-D streams.
- Additionally tasked with building Maps for the simulated Mars terrain field (rock yard) and voice communications for participants with the Local Mission Control Center (LMCC)

Rover

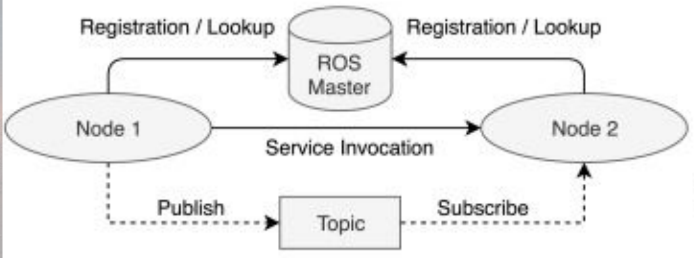
Goal: Autonomous navigation, QR scanning for sample detection, and manual control

- Using a Leo Rover which has a Raspberry Pi for processing
- Components include RealSense RGB-D camera and RPLidar
- Additionally uses a kill switch button for safety and redundant batteries for changing during use.



Robot Operating System (ROS)

- Allows for simple prototyping and deployment of robotics applications
- Uses Nodes (executable files) meant for specific tasks
- Nodes communicate to each other through topics and services
- Nodes can publish to topics, and subscribe to them
- Services allow nodes to request and receive information



(a) ROS Node Communication

Joystick Control

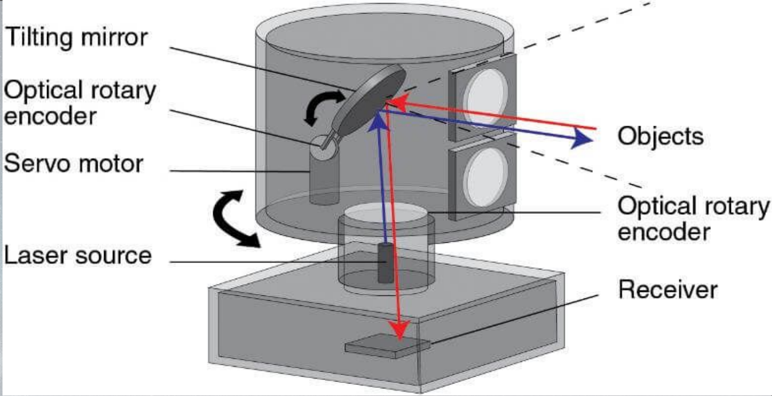
- Used Ubuntu on a virtual machine for ROS over a network
- Rover Subscribes to the topic “cmd_vel” for movement commands
- One of the tasks in the SUITS challenge is manually controlling the rover.

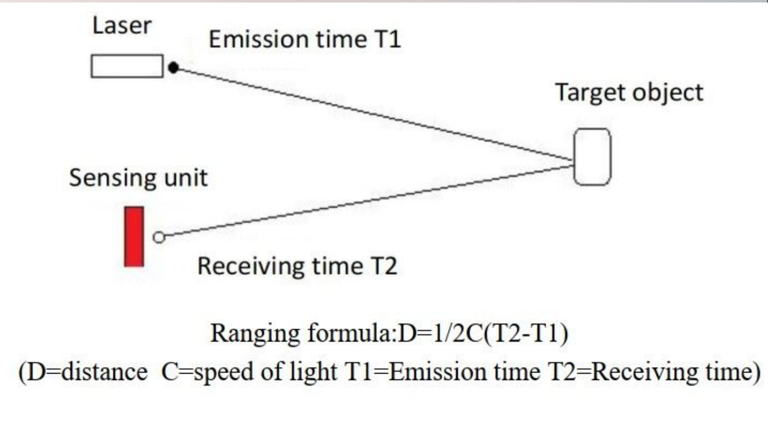
joy_node → sensor_msgs/Joy → teleop_twist_joy → geometry_msgs/Twist

LIDAR

Light Detection and Ranging

- RPLidar A3
    - 10k Samples per second
    - 10Hz rotation speed
    - 20 meter scan range

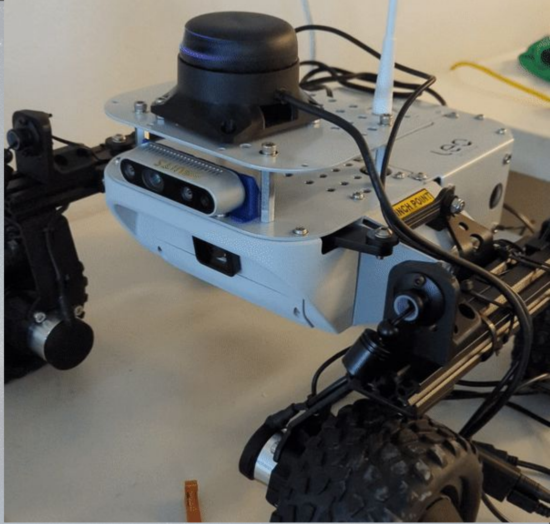


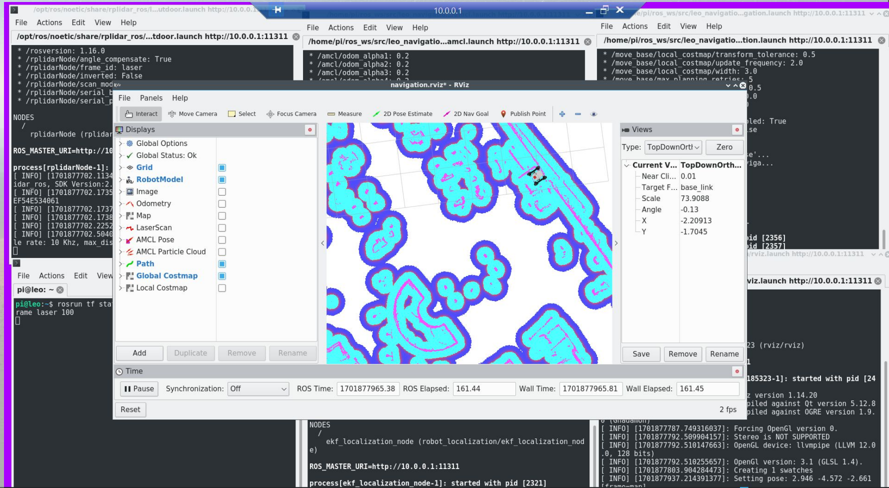


Setting Up Autonomous Navigation

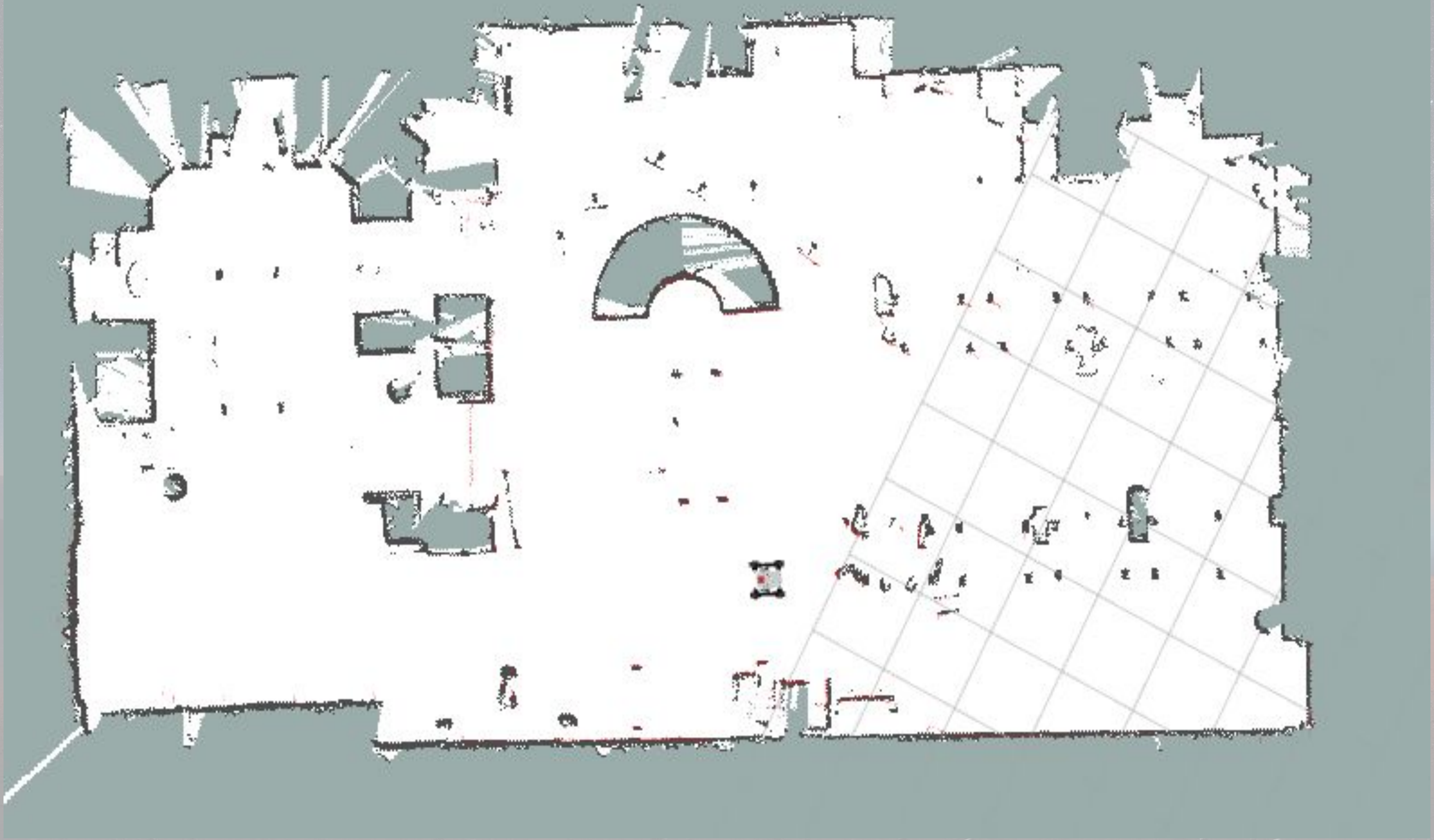
Autonomous navigation requires launching:

- Lidar
  - To build a pointcloud for map generation and/or localization
- Odometry
  - Using an Extended Kalman Filter to estimate position
- Map generator / loading prebuilt map
  - To gain context of surroundings
- Costmap Generator / Route planner
  - To find the safest “lowest cost” route to a destination





Hive Lab Map



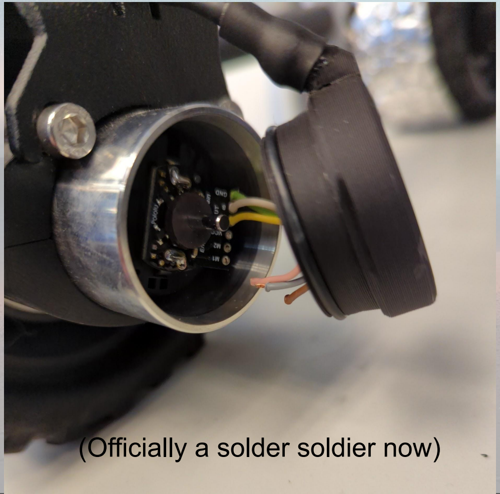
Testing Autonomous Navigation

Learning to Solder

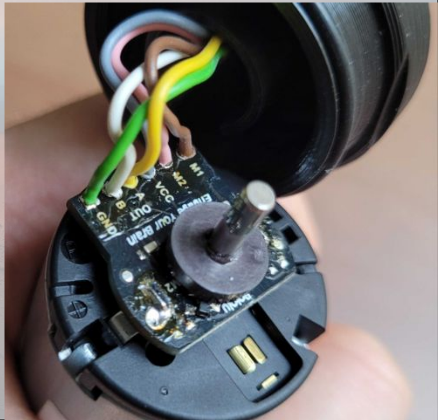
Previous experience with Jewelry making

Took a safety course in the HIVE lab proctored by Briana and Paromita

Communicated with Leo Rover Devs to find the best solution



(Officially a solder soldier now)

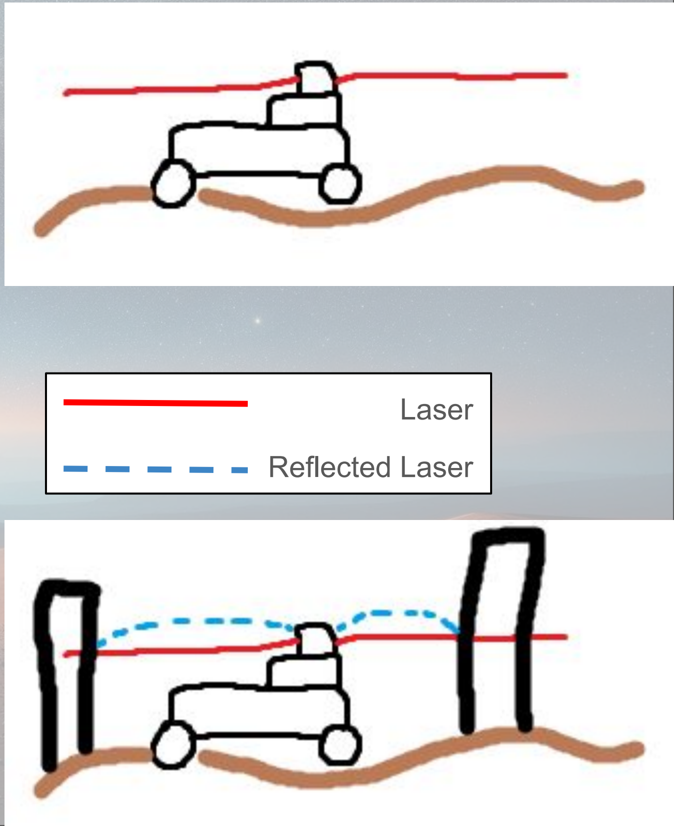


Challenges in Outdoor Testing

- Sunlight with lidar
- Flat terrain and sloped terrain with lidar
- IMU difficulties with sliding rocks
- Using Prebuilt Maps based off of Satellite Imagery caused problems with expected vs actual distances.

Overcoming the Challenges of Outdoors

- Two-Dimensional Lidar is not very useful without a vertical reference to localize from.
    - To make up for this we Plan on using markers so that it does not have to solely rely on Inertial Measurement Unit (IMU) odometry data.
- Additionally, with excessive sunlight, the laser signal is washed out causing artifacts in the laserscan data.
    - To make up for this, the LIDAR running mode was changed from sensitive to stability which works better in an outdoor environment

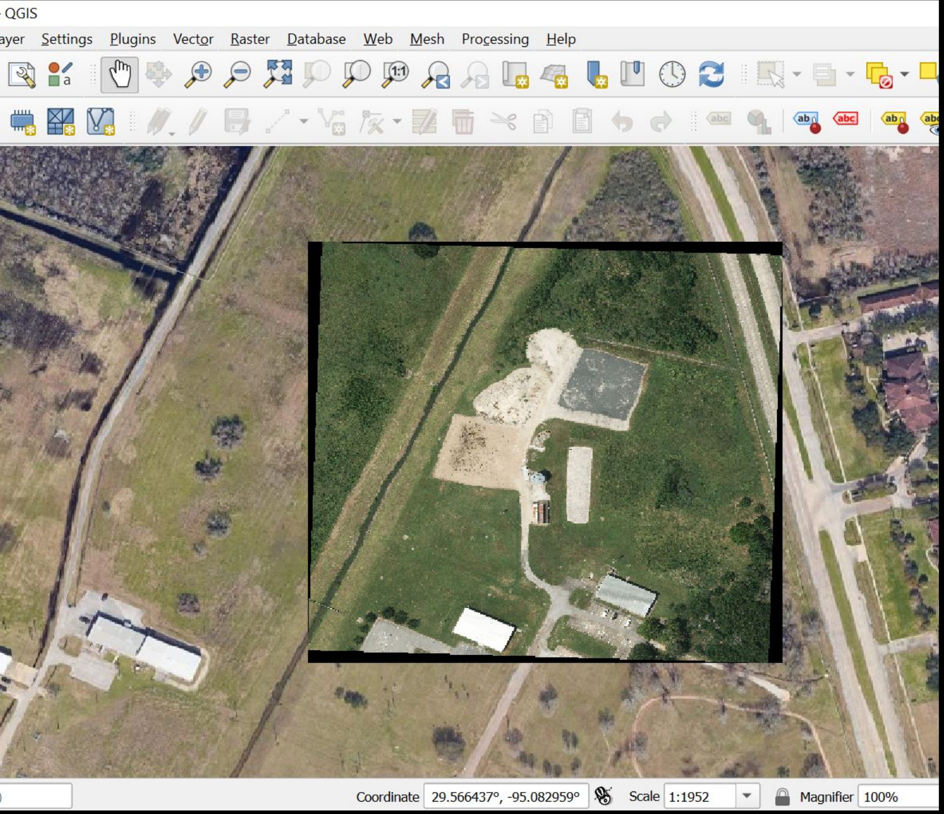


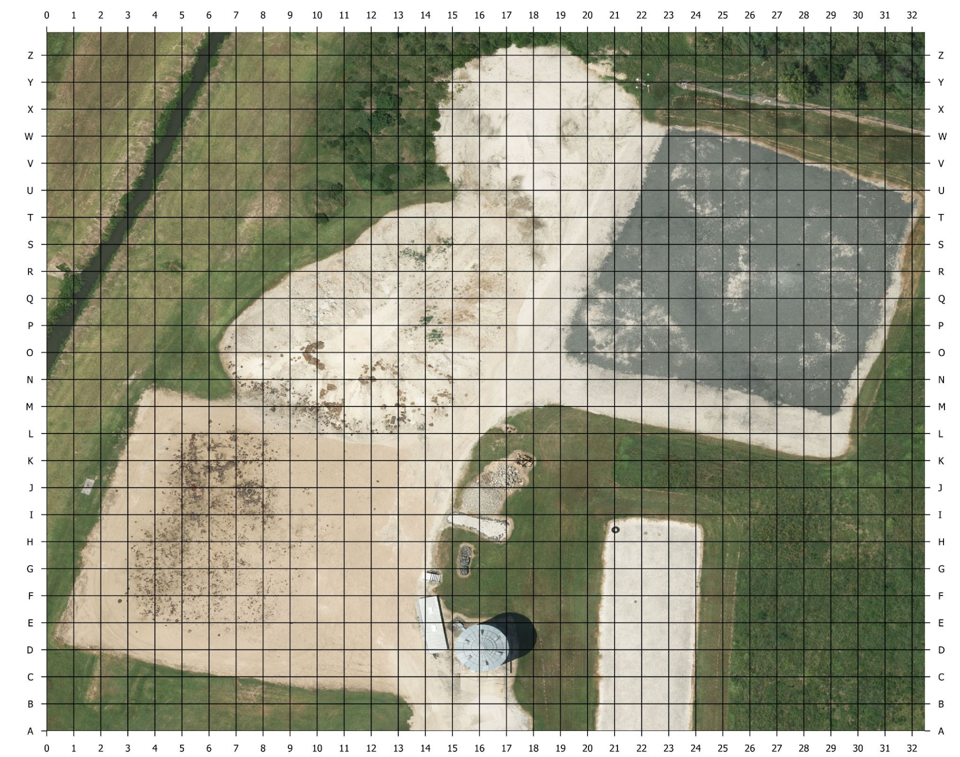
Overcoming the Challenges of Outdoors

- For the IMU a different package can be used that is meant for Uneven terrain
  - This wasn't required in the lab because the floors are level and solid.
  - Retesting the rover using this setting improved its self localization on the map.
- For the prebuilt map size, a manual mapping will be required.
  - Before testing the rover can be drove around manually and gather environmental context to create a point cloud map which can later be referenced during autonomous navigation.

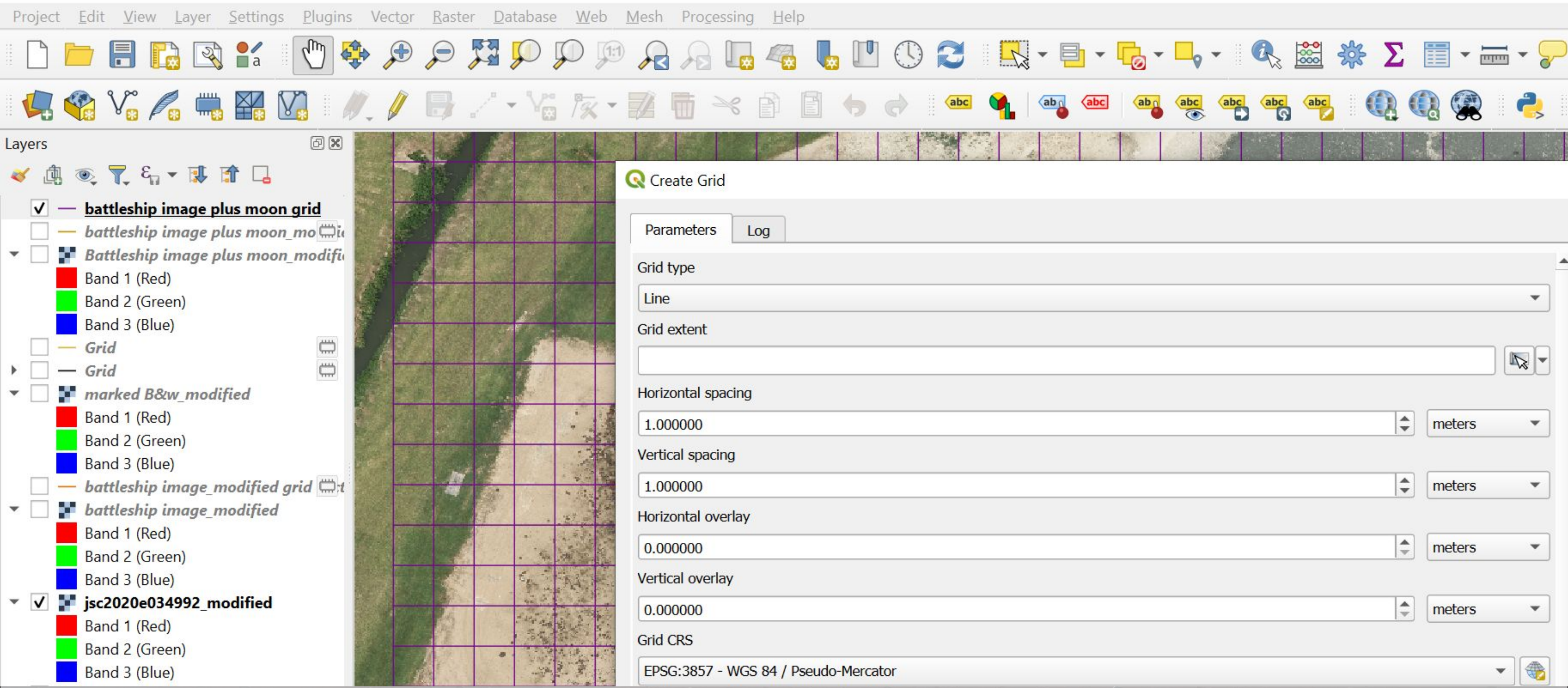
Maps

Goal: Georeference the rockyard and Produce a tessellated grid map that can be referenced through GEOJSON files.





Maps Cont…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Layers
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Horizontal overlay
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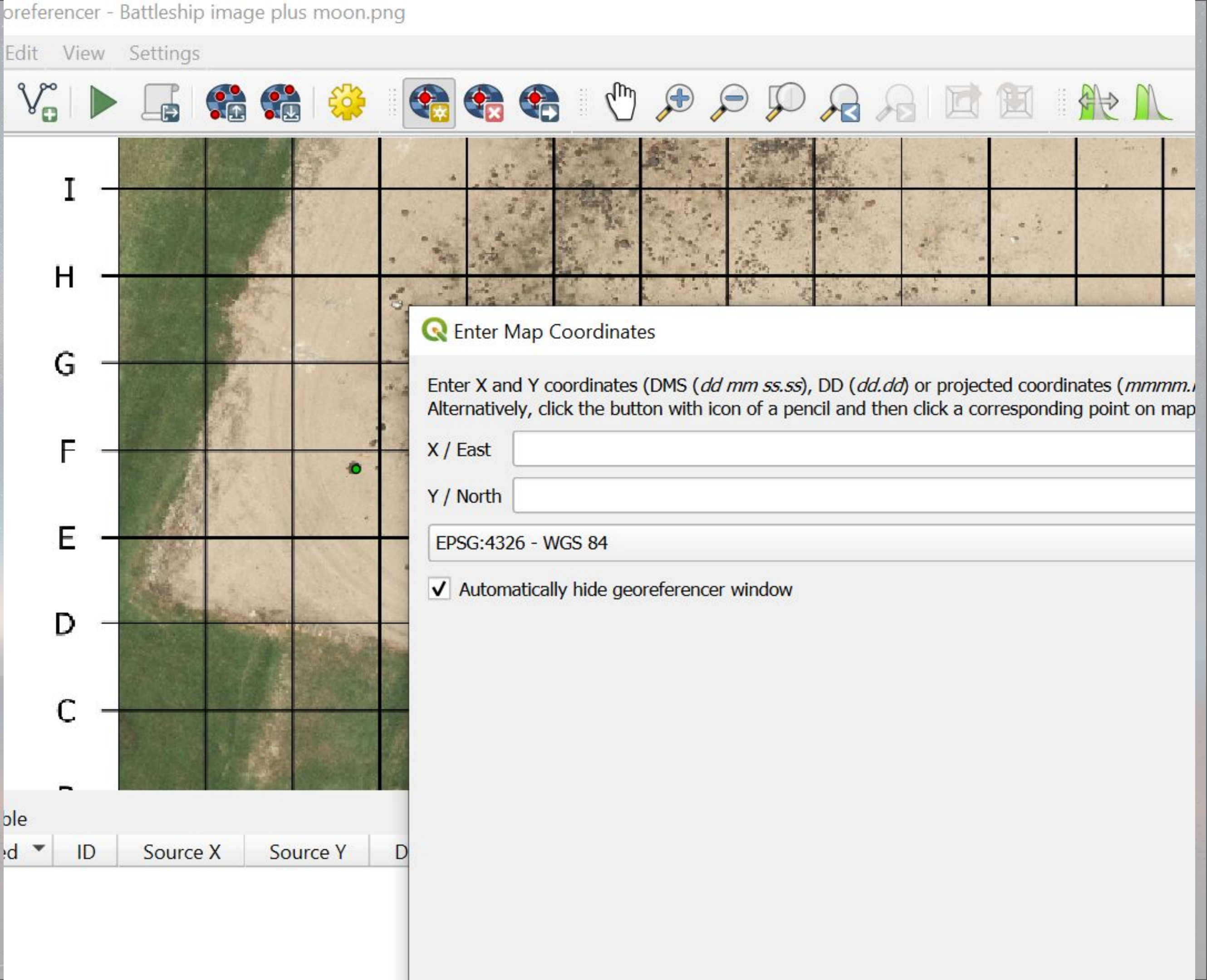
Grid CRS
EPSG:3857 - WGS 84 / Pseudo-Mercator

Maps Cont…

Participants must be able to drop pins and waypoints using the 2d map as well as interact with it on the head mounted display (HMD) using geo-data embedded into the map



Voice Comms

Goal:

- Create voice communication channels which design evaluators can communicate with LMCC
- Additionally, provide capability for evaluators to change voice channels via a switch on their Display Control Units (DCUs)
- Communications are simulated to go through a Comm Tower that will be on site during test week.

Mumble

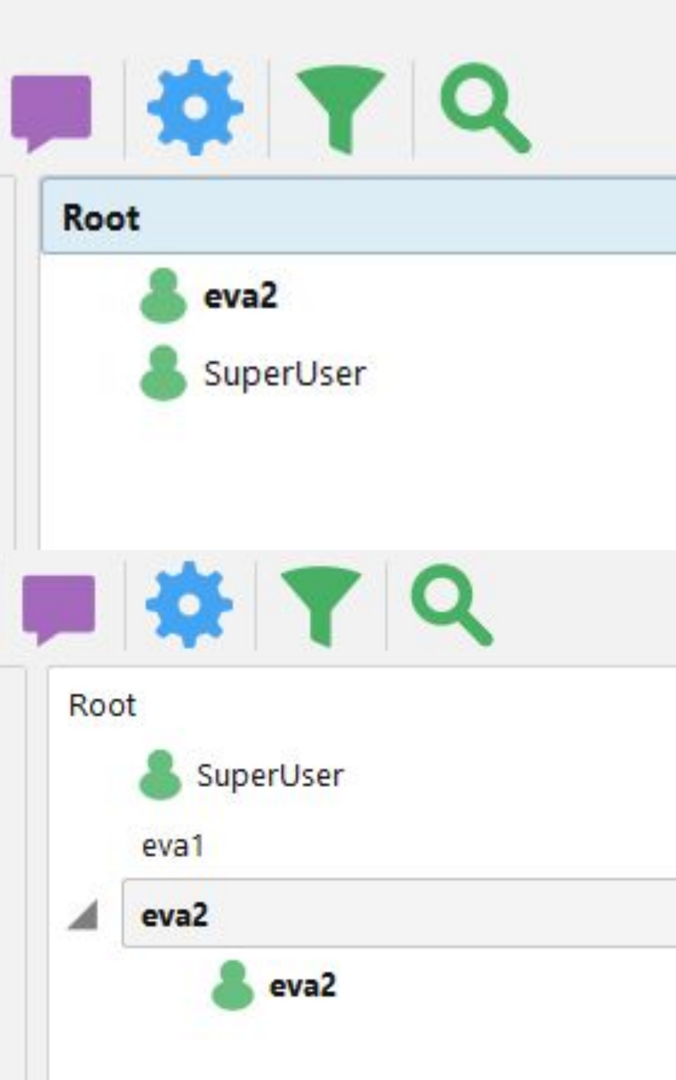
- Open source voice over IP (VOIP) software
- Has Python API with raspberry pi support
  - By using the API we can integrate voice communication software seamlessly into the DCUs for the design evaluators without any necessary input from users.

Mumble Clients

- A switch on the DCU is designated to switch channels from main to local.
- Onboard the Raspberry Pi, a program runs which communicates with the Mumble server and provides capability to swap voice channels based on comm tower availability.

Comm Tower

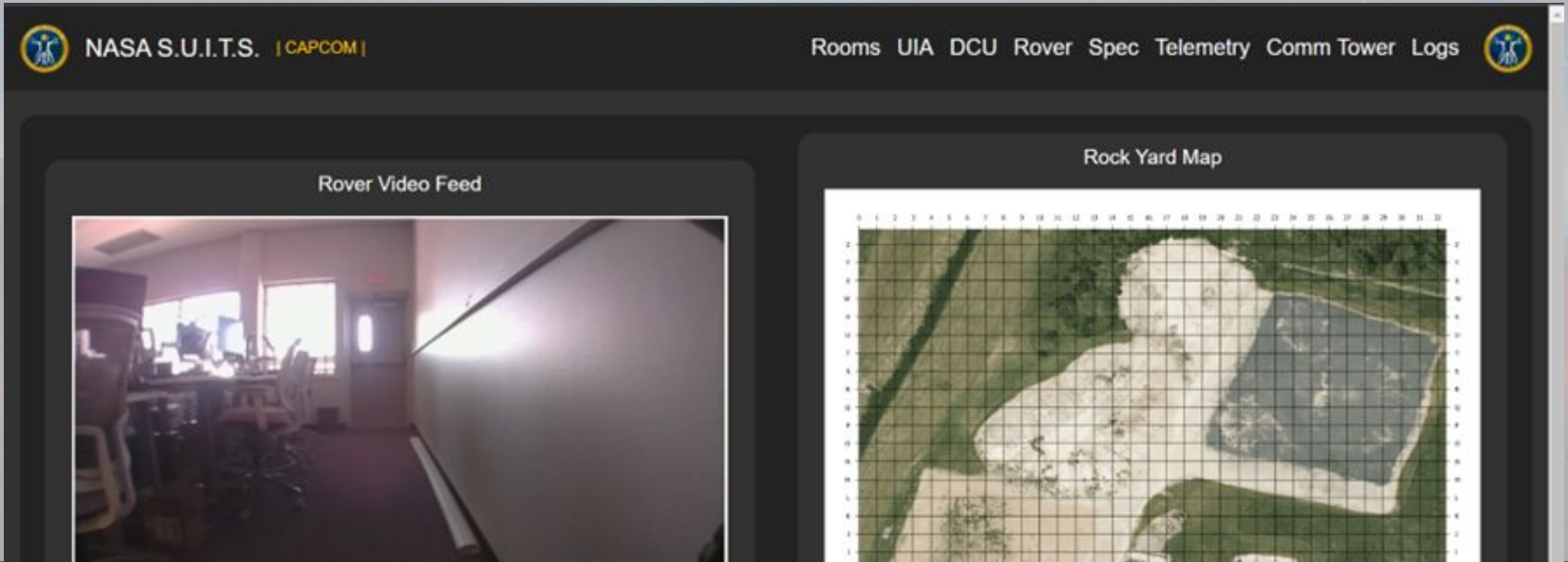
- The Comm Tower is an event during the EVA that will cause local communications to go down and require the design evaluators to “repair.”
- This event will cause the one-to-one channels on the Mumble server to go down simulating a real communication failure.



Telemetry Stream

To the Telemetry Stream, I provide:

- Webserver on the LeoRover which streams the onboard monocular camera footage and the RGB-D mounted camera footage
- Position updates based on an x y occupational grid
- Updates when the rover scans a QR code representing a discovered sample



Grading and Evaluating Submitted Proposals

Reviewed and scored half of the SUITS proposals which was used in deciding final selections

Among the parts evaluated are:

- Design Description
- Concept of Operations
- Feasibility
- Effectiveness of Proposed Schedule
- Human-In-The-Loop (HITL) Testing
- Technical References

The practice in evaluation will be helpful as I pursue a graduate degree and have to think objectively and critically of others' work

What I’ve Learned

- Ubuntu / Linux
- Robot Operating System (ROS)
- Raspberry Pi development
- LiDAR usage
- Soldering
- Mapping / GEOJSON
- Python, C, and javascript programming
- Websockets
- Unity Development

PIPE/SCUM intern activities

Astronaut Chair on the Tours and Lectures committee

- Johnny Kim Lecture
- Set up an astronaut lecture date for early Spring to make up for the buffer in the start of PIPE/SCUM

NBL Tour

Spacesuits Tour

Starship Launch

Wrapping up the internship

Working on a Demo program for the Microsoft Hololens 2 using Unity that can connect to our TSS and display sample data.

Will be on site during the spring to help with Test Week

Future Plans

In spring, I will be doing another internship in EG2 working in the Simulation, Emulation, Navigation, Sensors and STAR (SENSS) Laboratory, working on Guidance Navigation and Controls projects using ROS

I will also be pursuing a PhD in autonomous Robotics. I hope to study at Caltech and do research in JPL on collaborative robotics swarms and their applications in space.

Acknowledgements

A big thanks to…

Michael Lankford

Geraldo Cisneros

Adam Peterson

Dillon Fisher

Paromita Mitra

Nicholas Davis

James Semple

Briana Krygier

Cory Simon

And you, the viewer!

Q&A