SFU

ROBO SNACKS

SNACK DELIVERY ROBOTS

Snack Bot 07

ENSC 405W & 440
Capstone Project

Final Demonstration

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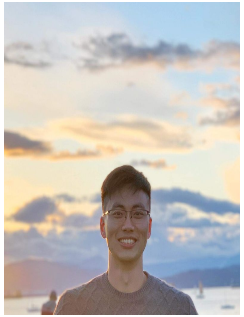
Introduction

Our Team & Roles

Team Members	Roles
Favour Amah-Nnachi	Firmware Lead
Sirpreet Kaur Dhillon	Automation Team, and Structure Team
Emmanuel Komolafe	Systems Lead, and Automation Team
Veronica Lund	Automation Team
Robert Smyczynski	Electronics, and Structure Lead
Eddie Zheng	Automation Lead





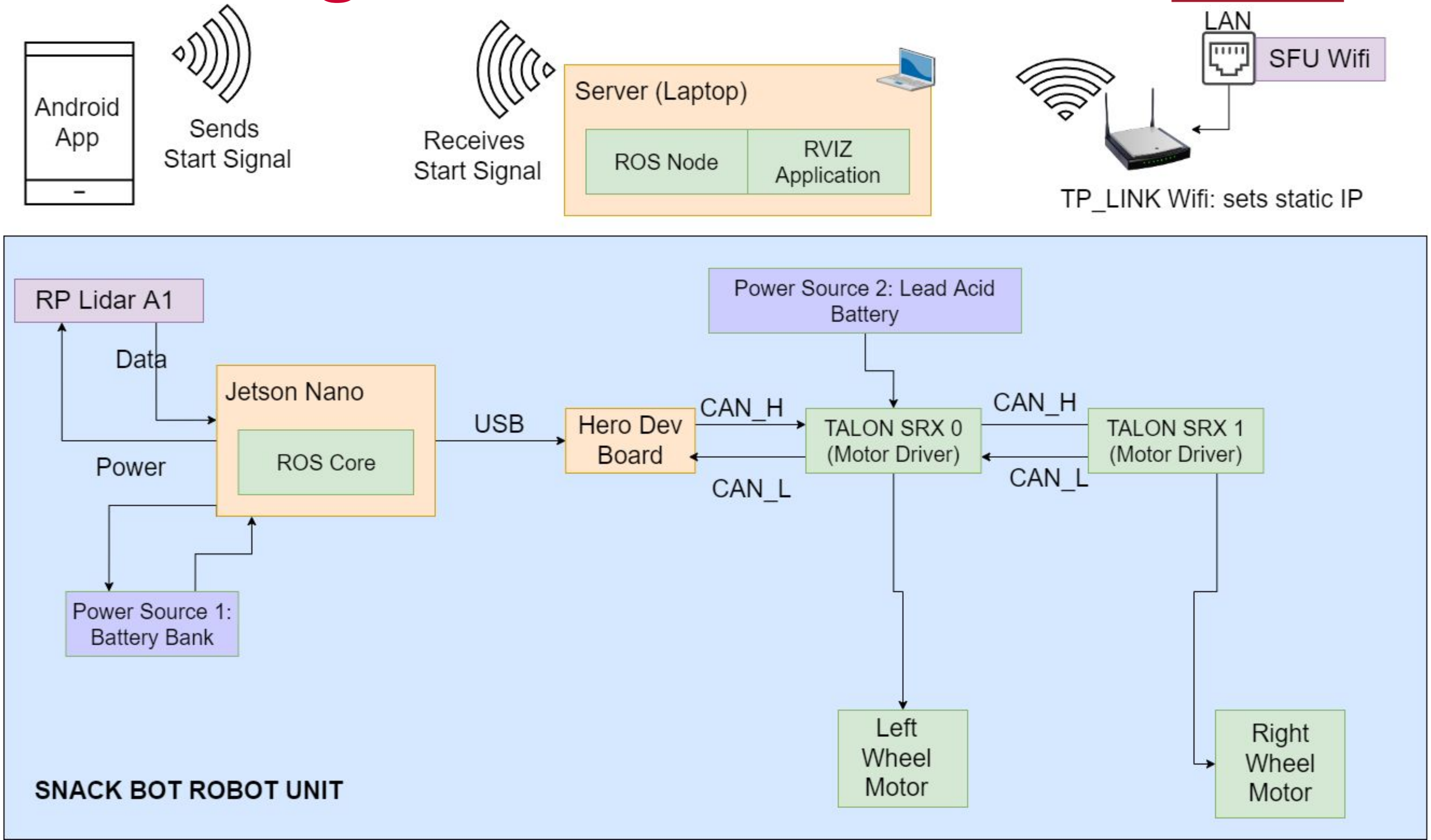



Introduction

- The **purpose**: Provide catering and vending services with an efficient way of delivering snacks to their customers.
- The **background**:
  - Waterproof Food Compartment
  - Delivers non-perishable foods and drinks
  - Autonomous food delivery robot
  - operates during off hours to avoid navigating around people
- The **motivation** for the project is:
  - curiosity driven: exploring indoor localization and mapping in autonomous robots.
- The **Market**:
  - Users: Catering Services (and their employees)
  - Users customers: Conference/Presentation Hosts and Attendees

Technical Case

System Design



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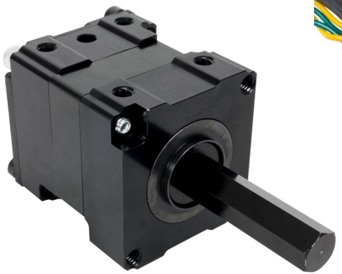
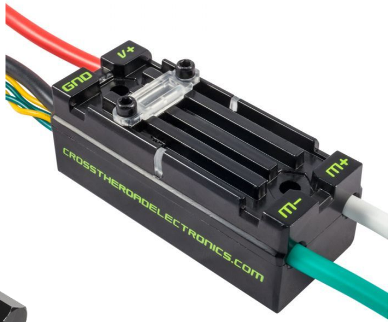
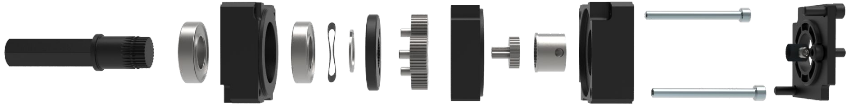
Hardware Construction & Progress

- First semester, BLDC motor, raspberry pi, and arduino
- Redesigned entire motor system:
  - **Heroboard**
    - Allows us to implement CAN BUS to interact with motor encoders
  - **Talon SRX motor**
    - 100:1 gear ratio provides ample torque and precise speed control
  - **Jetson Nano**
    - Computation power to support system
  - **RPlidar**
    - Laser odometry and mapping to localize robot

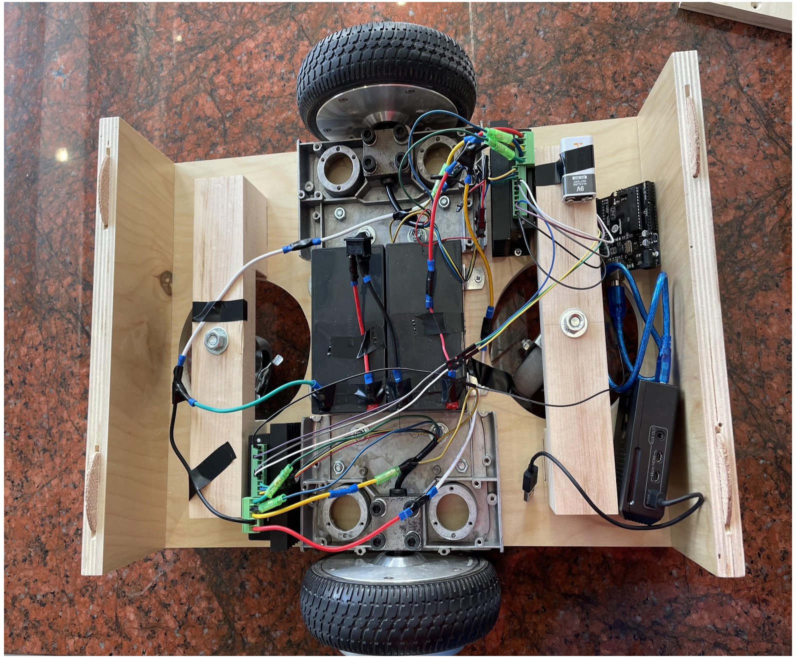




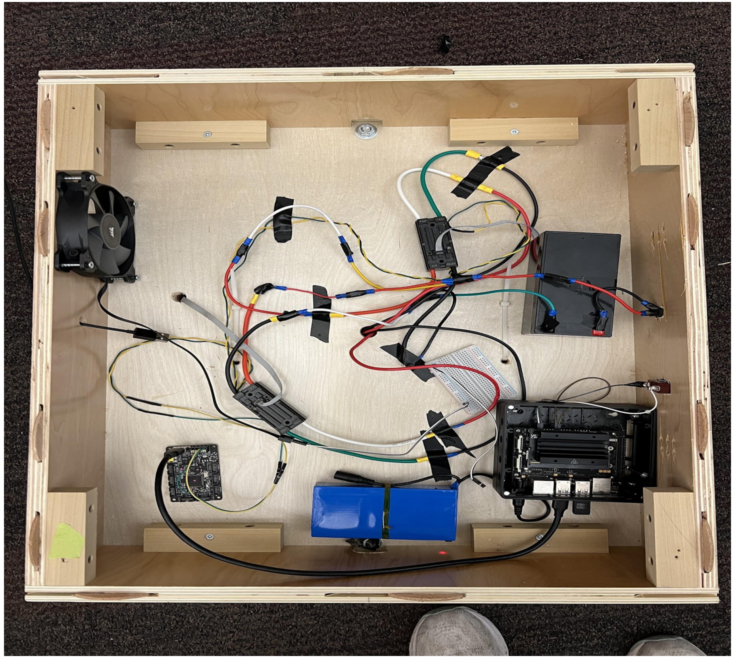


Chassis Structure Improvement

BEFORE



AFTER



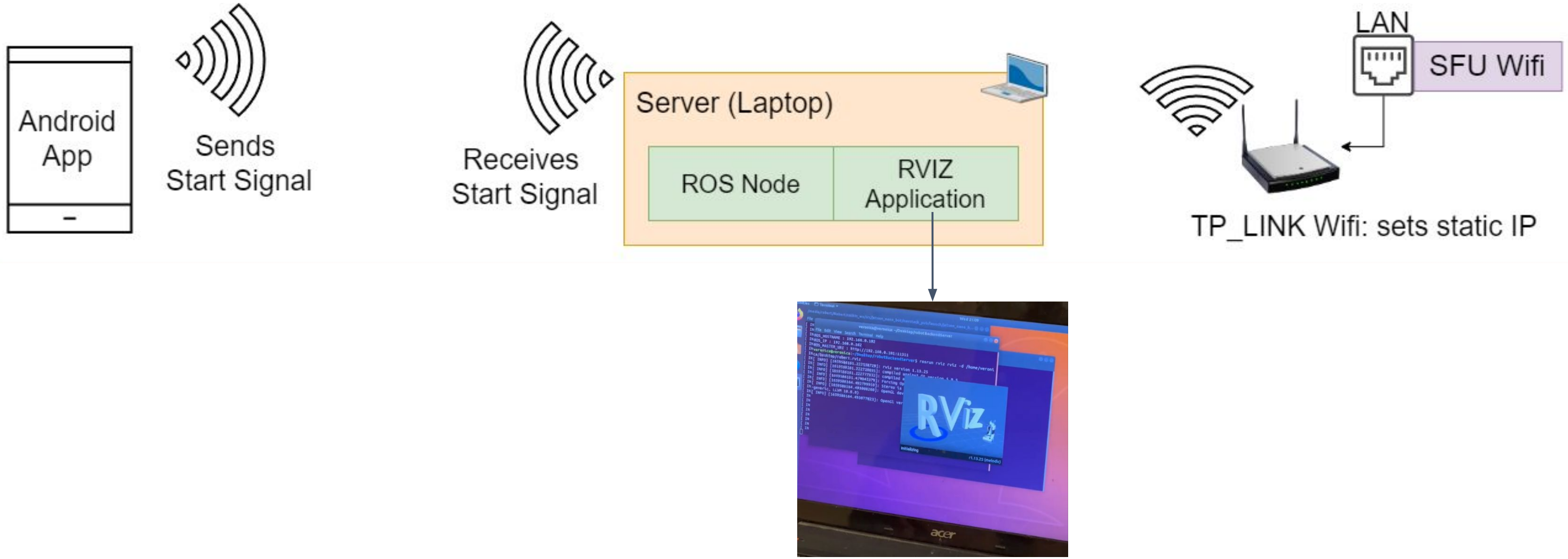
Software Construction & progress

- **Robot Operating System (ROS)**
  - A set of software frameworks for robot development
- **Gmapping: Simultaneous Localization and Mapping (SLAM)**
  - Constructs a map of an unknown environment while keeping track of the robots position
  - RF2o package provides real time odometry using LIDAR
- **Global Planner / Local Planner**
  - Provides pathing from initial position to goal using the mapped out environment
- **Cost maps**
  - Takes sensor data and constructs a 2D occupancy grid with cost values set for objects
- **Move_base**
  - Links the planners along with costmaps to provide movement commands for navigation

Some other paths that we tried

- Hector mapping package to create a static map and implement using only move base
- Adaptive Monte Carlo Localization (AMCL) to provide localization within the static map
- Odometry/mapping issues led to our final solution of a real time map

Server Setup and RVIZ



Android Application

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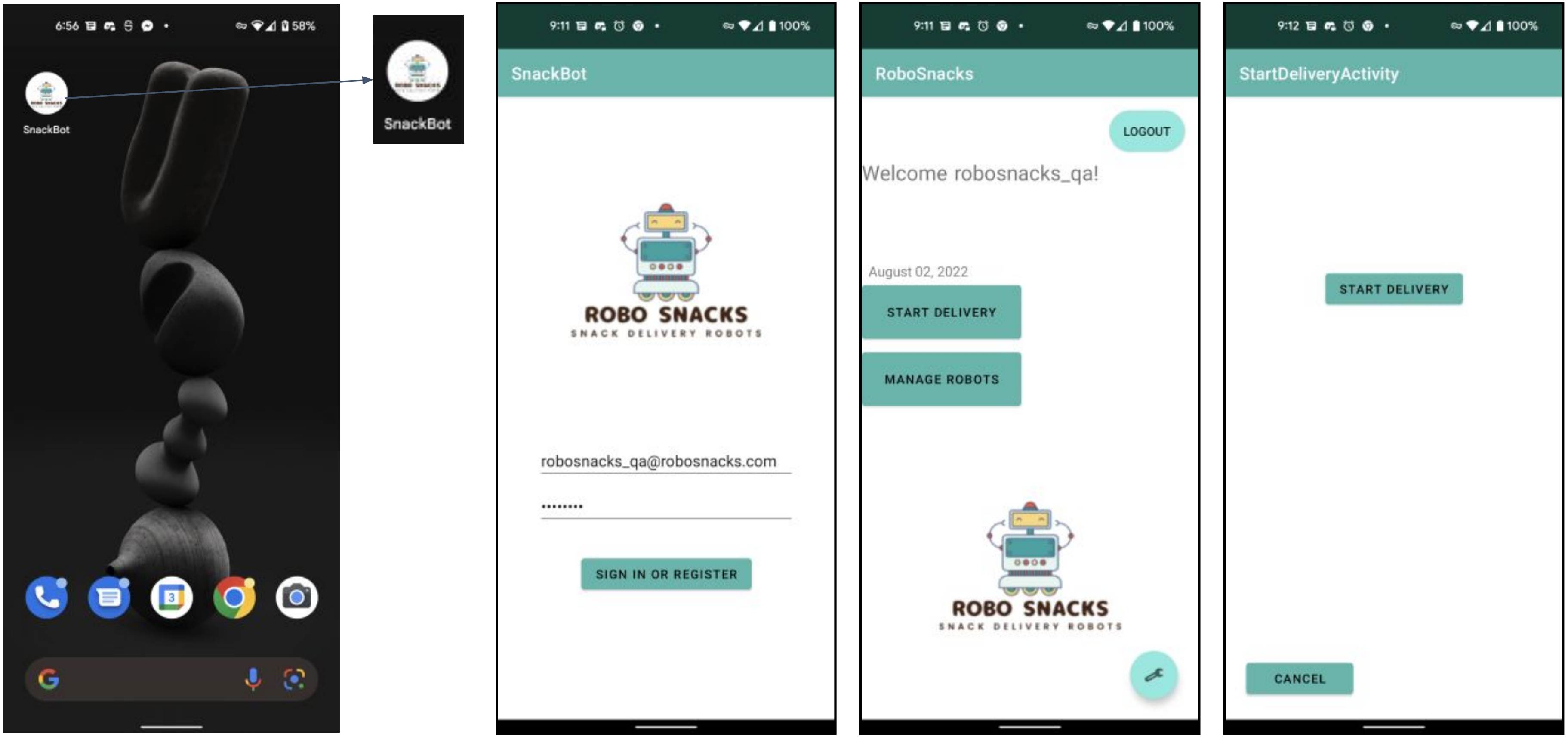
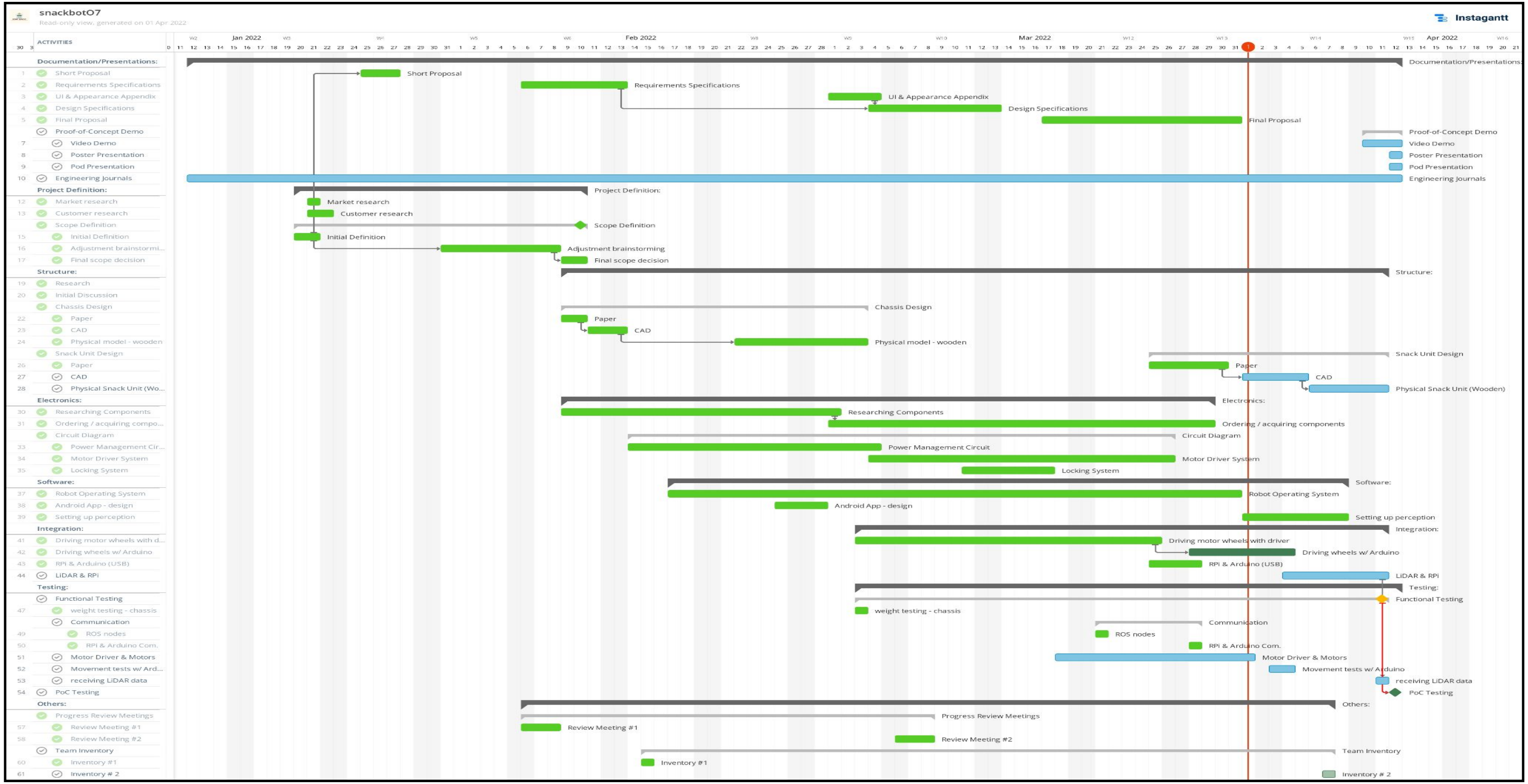


Initial Schedule



Actual Schedule

- **May**
  - Redesigned our entire hardware system
  - Setup LIDAR on Raspberry Pi
- **June**
  - Parts order placed in and parts delivered
  - Hardware implemented
  - Ran into problems with feedback from encoders
  - Started exploring CAN bus
- **July**
  - First two weeks were spent implementing CAN bus
  - Discussed the load with Dr.Hegedus and decided to move to a Jetson
  - Started setting up Jetson
  - Work on setting up CAN signals using usb
    - Had a backup in RPI and CAN HAT
  - Implemented CAN using Hero Development Board
  - Movement with joystick
  - Ros packages for Navigation and lidar and movement were setup
  - System put together - testing resulted in problems
  - Moved from Hector SLAM to gmapping
  - Removed encoders from odometry
- **August**
  - Jetson broke down and system wiped (had to reset everything)
  - Setup server
  - Setup static IPs with a router
  - Created android application
  - Final assembly and testing around obstacles and moving through doors

Business Case

Business Case

- **Market Description:**
  - Snack bot 07 belongs to the food catering/delivery industry market.
  - In Canada, market size in 2022 for the food catering industry is $3.8 Billion CAD, growth rate of 3.9%.
- **Competitors:**
  - Main competitors are Starship Technologies, PepsiCo's snackbot and Kiwibot.
  - Measures such as delivering food at off hours and a waterproof compartment have been put in place to minimize risk of accidents.
- **Budget:**

Expense	Amount per year(CAD)
Cost Per Robotic Unit	$800
Labour - (6 Engineers)	$300,000
Admin/Accounting	$45,000
Utilities and Miscellaneous	$10,000

Business Costs

- **Price:**
  - Each robotic unit will be sold for $2100. Includes a 3 month free subscription for the SnackBot-07 Mobile application.
  - After 3 month trial, monthly pricing is $9.99.
  - 3 Months subscription: $27 ($9/month).
  - 6 Months subscription: $50 ($8.33/month).
- **Financing:**
  - Through sales from the robotic unit.
  - Through sales from monthly subscription.
  - Through investors.
  - Through friends and family.
- **Alternative Market:**
  - Robot can also be used to deliver parcels as well

RISK ANALYSIS / MANAGEMENT

Hardware Risks

Below outlines potential risks associated with Snackbot-07, action to mitigate the risk and an alternative Plan B.

Hardware Risks	Control Action / Mitigation	Probability (1-10)	Severity (1-10)
LiDAR, Jetson and Hero stops working	Connect disconnected power cables	7	1
LiDAR, Jetson and Hero stops working	Ensure component does not overheat	4	8
Motors get jammed	Motor threads are cleaned	4	9
Gearbox malfunction	Apply lubricant to gearbox	3	6
Power supply stops working (i.e dead battery)	Replace battery to generate power	6	4
Short Circuit	Make use of an electric fuse to protect electrical circuit from overloading	3	9
Water/Drink spillage into the chassis	Food compartment would be waterproof	2	10

Software Risks

Software Risks	Control Action / Mitigation	Probability (1-10)	Severity (1-10)
LiDAR is unable to detect objects at lower heights.	Position the lidar at a reasonable height for optimal object detection	5	3
Robot stops unexpectedly midway during the delivery	Software frequently checks the status of the robot during delivery, when an unexpected stop is detect robot returns home and the trip is restarted	5	3
Inaccurate angles for left/right turns	Lidar compensates for it2	4	3
Wifi stops working	Troubleshoot and Reconnect to wifi	6	1

Safety Risks

The following are the risks relating to safety:

- Likelihood of hitting a person is low
- Navigates to specific locations without human contact
- Power supply and electrical parts are enclosed in chassis
- Ensure food compartment is clean

STANDARDS

Adherence To Standards

Standard	Description
IEEE/ISO/IEC 12207-2017	Systems and software engineering - Software life cycle processes [1]
CAN/CSA-C22.2 No. 94.2-07 (R2012)	Enclosures for Electrical Equipment, Environmental Considerations [2]
CAN/CSA-ISO/IEC 9126-1:02 (R2007)	Software Engineering - Product Quality - Part 1: Quality Model [3]
ISO 31022:2020	Risk Management [4]
ISO/IEC TR 25060:2010	Systems and Software Engineering - Product Quality Requirements and Evaluation [5]
GNU General Public License version 2 (GPL-2.0)	Open Source Initiative: Open Standards Requirement for Software [6]
FDA-2020-D-1920	Guidance for Industry: Sanitary Transportation of Food [7]

DEMO

- Android Application
- Normal Run - Empty Room → Real Time Mapping
- Test Run with an Obstacle
- Going through Doorway Test

SELF - REFLECTION

Self-Reflection

- **Planning**
- **Communication using CAN**
- **User Interface Design (Robot + Application)**
- **Decision making**
  - Hardware: massive change in our design
  - Moving from Rpi to Jetson Nano to server plus Jetson Nano
  - Software: Moving from Hector SLAM / AMCL to gmapping
- **Learned Navigating around unknowns**
- **Testing each part individually before putting the system together**
- **Having to change parts because they do not fit with the system**

CONCLUSION AND ACKNOWLEDGEMENT

Conclusion

To summarise our project, SnackBot O7's is an autonomous delivery robot. It's entire system is controlled by Jetson Nano which connects to a LiDAR for perception and the motor driver using through a USB to CAN connection provided by the Hero Development Board.

We have learnt how to create a movement system using an Jetson and vex parts, how to integrate ROS (Robot Operating System) with Lidar for indoor localization and mapping using gmapping and LiDAR.

It was a tough journey embarking on this project. We made mistakes, had to redesign, as well as change many components (hardware and software) of our entire system but all in all, it was a good learning experience.

Acknowledgement

We would like to thank and appreciate Andrew Rawicz, Mike Hegedus, Chris Hynes and Usman Iqbal Ahmed for their consistent support and feedback throughout the 8-month Capstone course.

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References

[1] "IEEE/ISO/IEC 12207-2017 - ISO/IEC/IEEE International Standard - Systems and software engineering -- Software life cycle processes," [Online]. Available: https://standards.ieee.org/standard/12207-2017.html. [Accessed 19 June 2022].

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[8] Business Pitch Presentation - Robo Snacks Company 7. [Online] Available at: https://docs.google.com/presentation/d/1V283P9VtYmz-xXUh70fMtIsaTHno05fx0eBcvseRkbk/edit#slide=id.g13c28c3314e_0_45 Accessed: Aug 3, 2022.

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Thank You