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NaviBot

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Presentation Overview

- Introduction
- Technical Case
- Business Case
- Risk Analysis/Management
- Adherence to Standards
- Self-Reflection
- Conclusion
- References

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Introduction - Team Members

CEO - Davis Hogg

Systems Eng. - Systems/UI

CIO - Mark Lavin

Systems Eng. - Navigation/Back-End

CHO - Alek Srdić

Systems Eng. - Mechanical

COO - Michael Kim

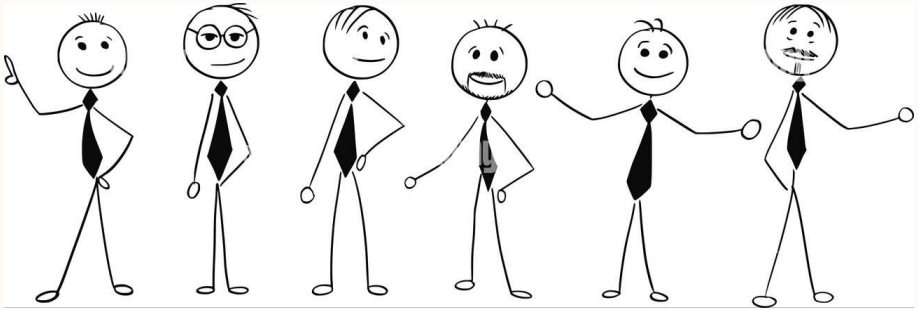
Electronics Eng. - Electronics/Power

CCO/CFO - Martin Yang

Electronics Eng. - Communications

CTO - Roy Zhong

Electronics Eng. - Electronics/Power



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Introduction - Background

- Over 86,000 workplace injuries caused by heavy lifting
- Increasing package intake requires more manpower
- Distractions arise from delivering packages in-house
- Waiting times increase as the package handler gets overwhelmed

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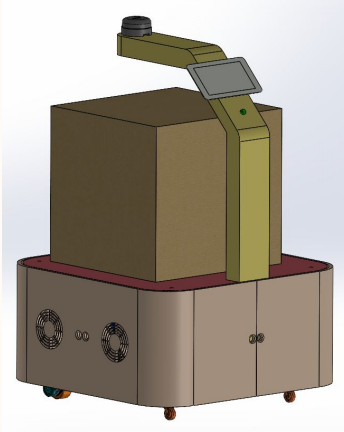
Introduction - Purpose

- Ease the burden of mundane tasks in the workplace
- Eliminate human hours needed to travel between points
- Reduce workplace injury from transporting heavy goods



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Introduction - Motivation

- To reduce the workplace injury
- Ease burden of mundane tasks
- Expensive delivery robots in current market
  - Enter market with lower prices
  - More warehouses can afford it

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Technical Case - System Design

- System control: RPi4B -> Jetson Nano
  - 32-core -> 128-core Maxwell GPU
  - Micro HDMI -> HDMI 2.0
- Navigation: Python & C++
- User Interface: Python -> KivyMD
  - Enable ROS

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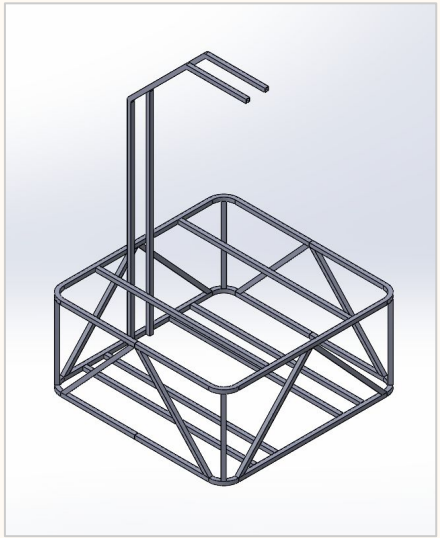
Technical Case - Mechanical Design

- Frame
  - Mild Steel Tubing
  - Space frame design



Material (Grade)	Cost [7] [8]	Strength [9] [10] [11] [12]	Ease of Assembly	Weight	TOTAL
Mild Steel (1018)	3 (6.94/ft)	3 (65 ksi)	3	2	11
Stainless Steel (304)	2 (18.21/ft)	4 (99 ksi)	2	3	11
Aluminum (6061)	1 (14.40/ft)	2 (45 ksi)	1	4	8
Wood (Pine)	4 (1.12/ft)	1 (11.3 ksi)	4	1	10

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Technical Case - Mechanical Design

- Load Platform
  - Aluminum Plate
- Side Cover
  - Rubber Garden Edging
- Cradle-to-Cradle
  - Mostly Recyclable Materials

Materials (Grade)	Cost	Strength	Weight	Ease of Work	Appearance
Aluminum Sheet (5052)	(15.71/ft)	33 KSI	2.68 g/cc	2	1
Steel Sheet (Cold rolled mild)	(14.15/ft)	40 KSI	7.87 g/cc	3	2
Veneer	(2.45/ft)	Low	Light	1	3

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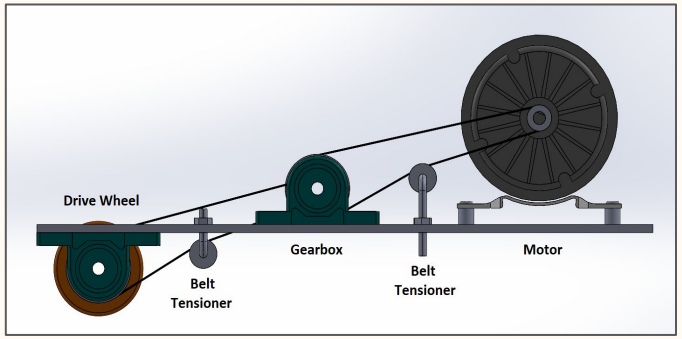
Technical Case - Mechanical Design

- 24V DC Motor x2
- Drive wheels x2
- Gearbox x2
- Belt tensioning system



Goal: Design and fabrication as close to final product as possible

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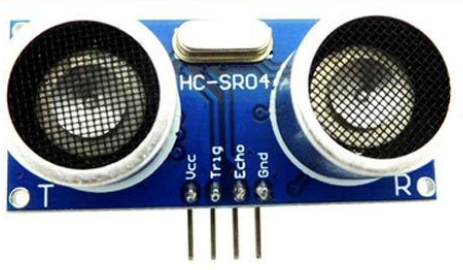
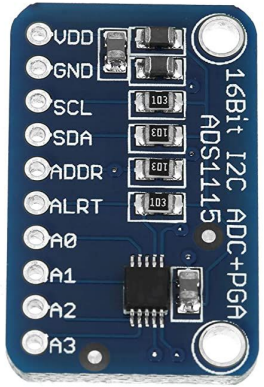
Technical Case - Hardware Design

- 360 degree detection Lidar
  - Mapping
- Ultrasonic sensors
  - 2 at front, 1 at all other sides
- Motor Driver x2
  - Drive 24V DC Motors
- ADC
  - Battery Monitoring





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Technical Case - Hardware Design

- 7 inch Touch screen
  - User Interface
- Battery & Charger
  - 12V Lead acid -> 24V LiFePO4
  - 24V LiFePO4 5A charger
- Speaker & Emergency stop button
  - Warning, Emergency

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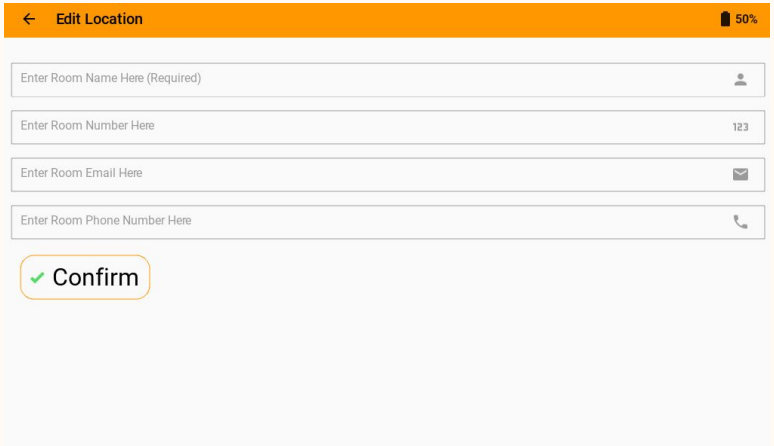
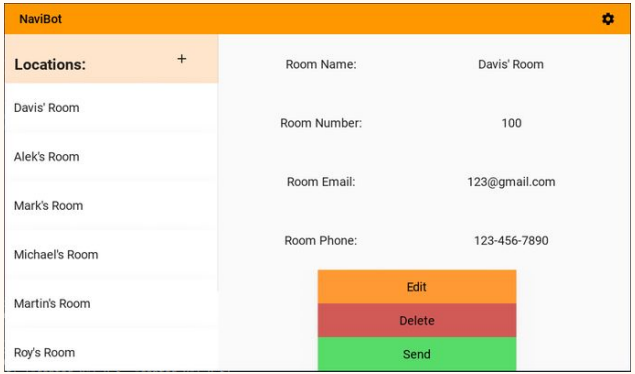
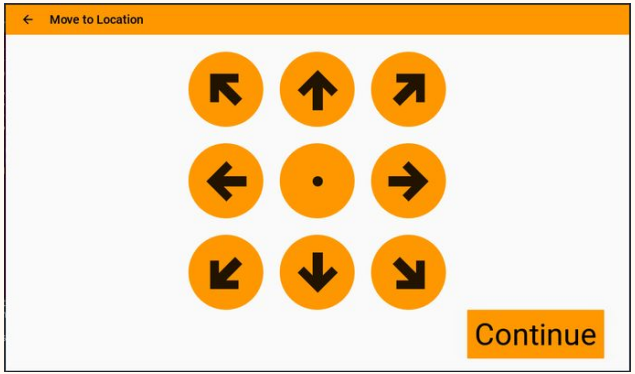
Technical Case - Software Design

- UI
  - User screen
  - Edit/Delete/Send locations







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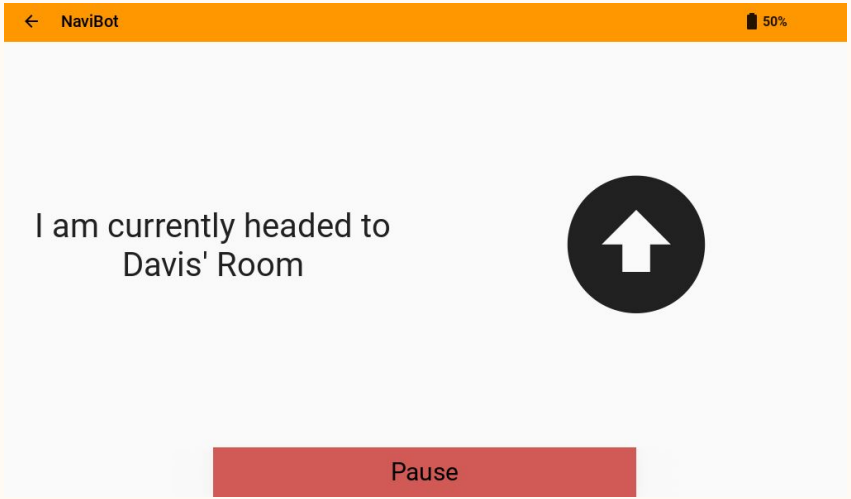
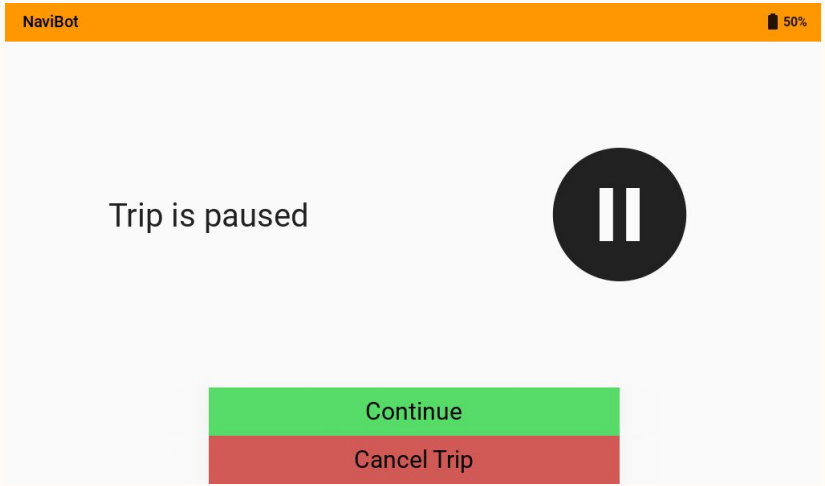
Technical Case - Software Design





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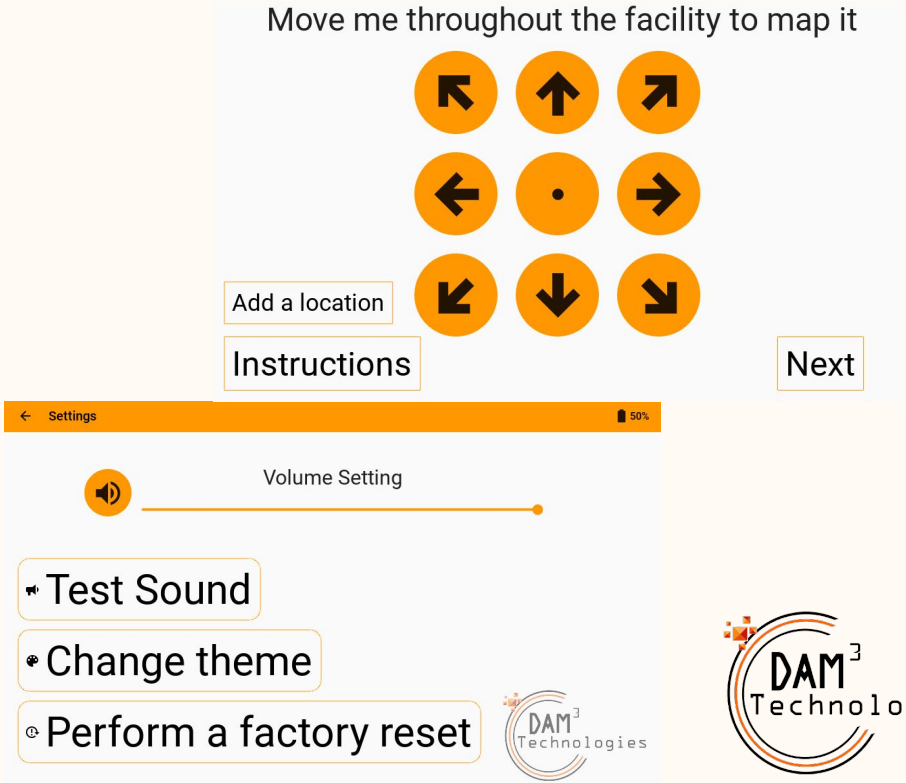
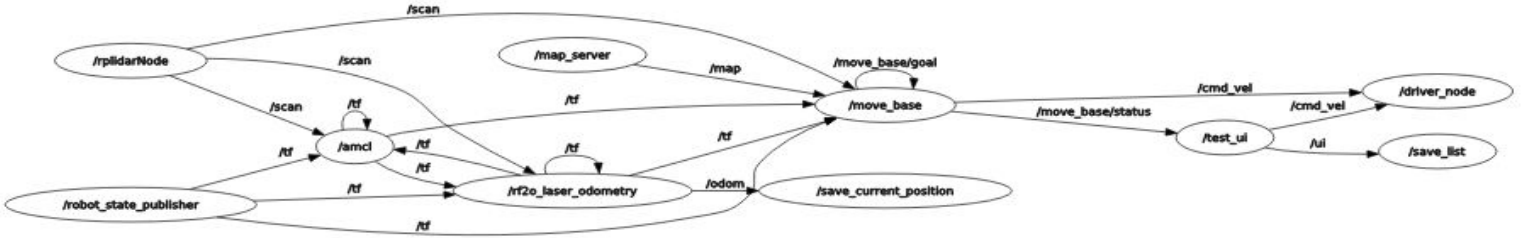
Technical Case - Software Design

- UI
  - Initialization protocol
  - Battery monitoring
  - Interactive sounds



Technical Case - Software Design

- Navigation - Stage 1
  - ROS
  - Driving
  - Laser Odometry
  - GAZEBO Simulator
  - Lidar Gmapping
  - Localizing



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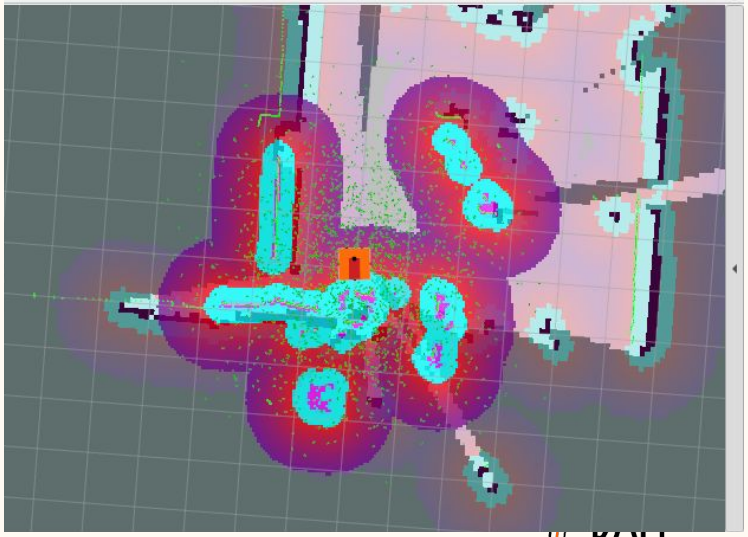
Technical Case - Software Design

- Navigation - Stage 2
  - Trajectory Planning
    - AMCL
    - Cost Map
  - Collision Detection
    - Lidar
    - Ultrasonic



Technical Case - Estimated Schedule

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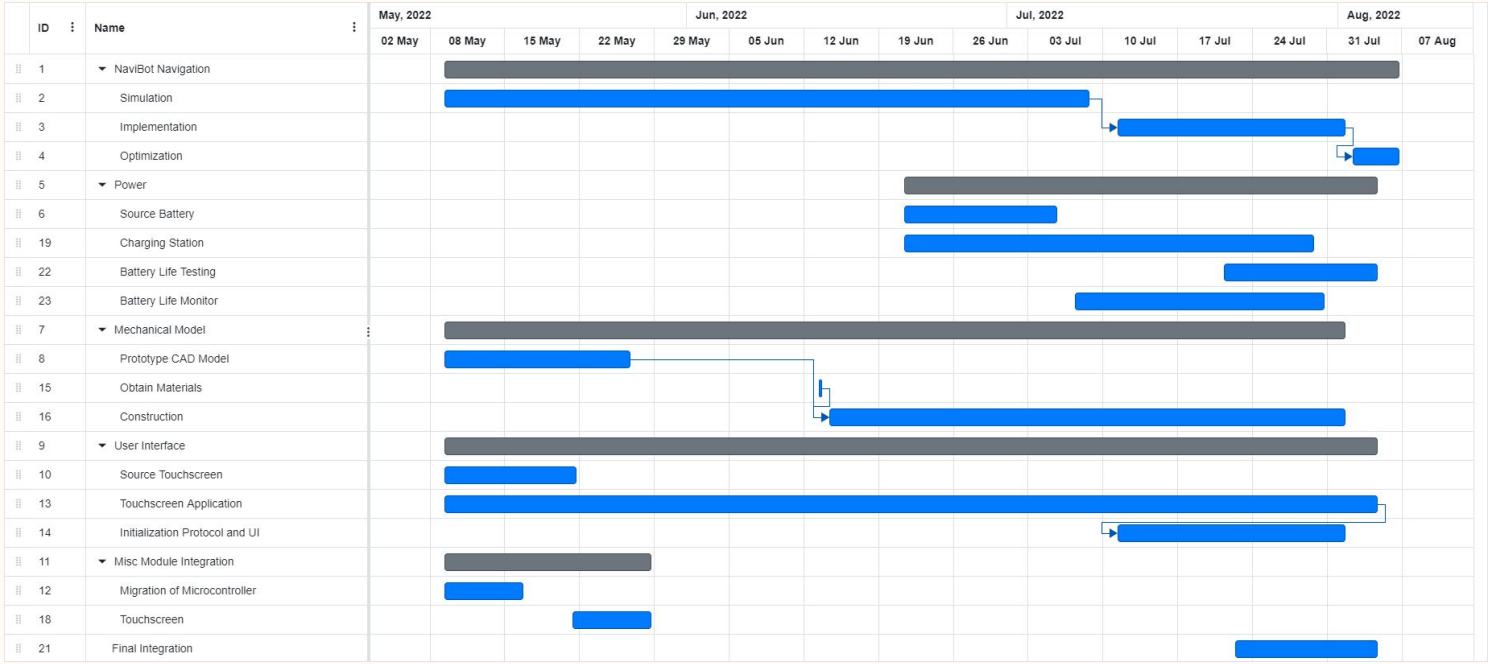
Technical Case - Actual Schedule



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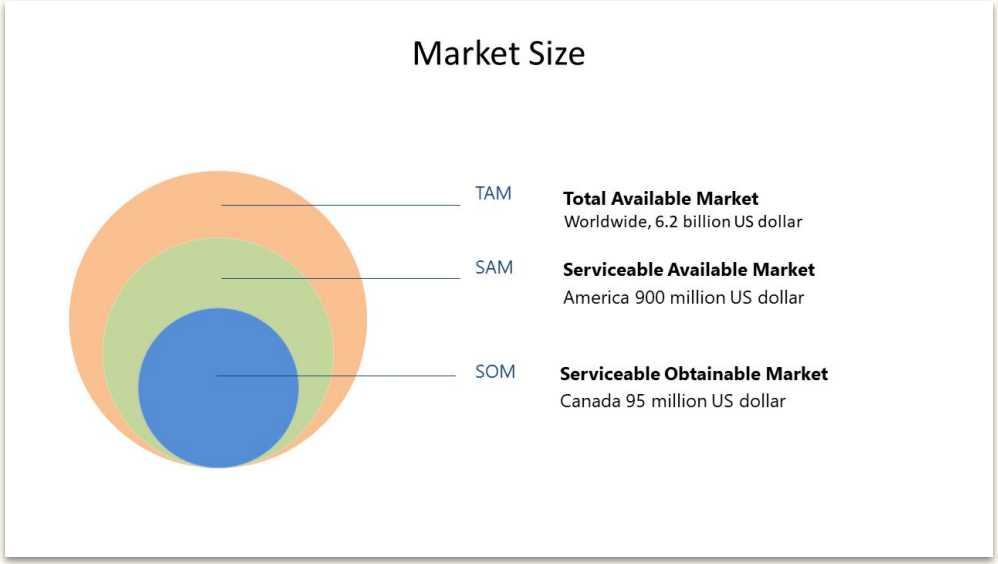
Business Case - Market

- Market Share
- Market Barriers
  - Financial worth
  - Lack of clarity
  - Potential disruption



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Business Case - Ideal Customer

- Companies requiring additional internal logistics capabilities
- Target companies with established logistics budget
- Market NaviBot as an addition to existing logistical infrastructure

Average Logistics Cost as a Percentage of Sales		Total
Transportation	3.68%	8.39%
Inventory Carrying	1.94%	
Warehousing	2.05%	
Supplies	0.33%	
Administration	0.38%	

Average Company Logistics Costs 2016 - 2020

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Business Case - Competitors

- OTTO Motors ($15,000 - $25,000)
- Locus Robotics ($35,000)
- Relay Robotics($2000 per month)
- NaviBot is easy to set up by the user

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Business Case - Sales Strategy

- Self-distribution
  - Promote through online and exhibition avenues
  - Direct contact to clientele
  - Acquire early adopters
  - Associated advertisement cost

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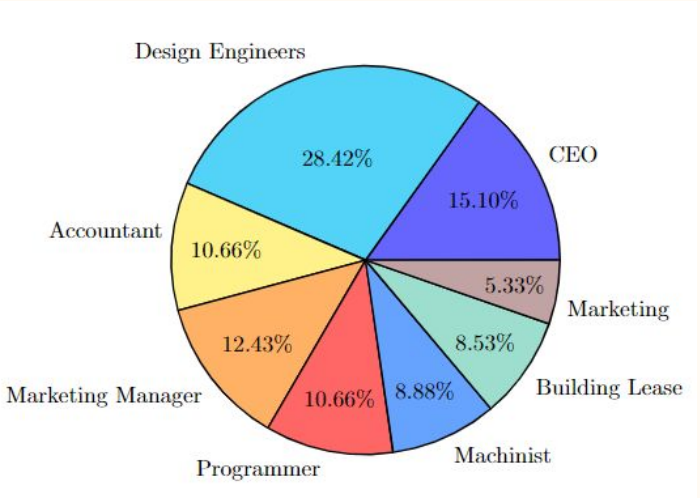
Business Case - Budget

Annual Expenses				Total
Salaries	CEO	$85,000	$485,000	$563,000
	Design Engineer x2	$160,000		
	Accountant	$60,000		
	Marketing Manager	$70,000		
	Programmer	$60,000		
	Machinist	$50,000		
Building Lease	2,500 sq.ft.	$48,000		
Marketing	$30,000			



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Business Case - Price

Retail price: $12,500

Unit manufacturing costs: $1240

Labour and shipping: ~$600

Profit: ~$10,660

Break-even point = $563000 / $10660 = 53 units/year

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Business Case - Company Growth

- Require ~5 months before production
- First few years will be to gain traction in the market
- Aim to be profitable within 5 years

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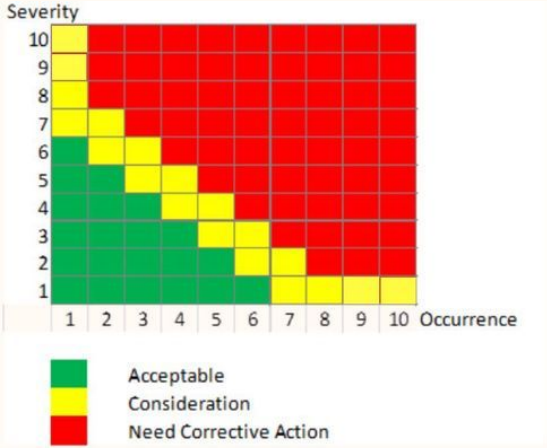
Risk Analysis/Management

Failure Mode	Likelihood	Severity	Corrective Action
Belt slip/break	3	6	No
Under-powered motors	3	4	No
Robot lost/stuck during navigation	6	5	Yes
Robot tipping over	3	6	No
System overheating	5	5	Yes
Battery overcharging	1	10	No
Battery permanently dies	2	7	No
Confusing/cumbersome UI	4	4	No
Exposed charging outlet	3	7	Yes
Low battery life	5	4	No
Robot loses control	4	6	Yes
Failed obstacle detection	6	6	Yes
Linux desktop accessible to user	8	5	Yes



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Risk Analysis/Management

- Robot Lost / Stuck During Navigation
  - Auto recalibration, Homebase return
- System Overheating
  - Heatsink, Ventilation, Cooling fan
- Exposed Charging Outlet
  - Removable, Lockable, Mechanical covers

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Risk Analysis/Management

- Robot Loses Control
  - Emergency stop button switch
  - 0.5s Motor timeout
- Failed Obstacle Detection
  - More sensors, Optimal placement
- Linux Desktop Accessible to User
  - Remove admin permission and lock settings

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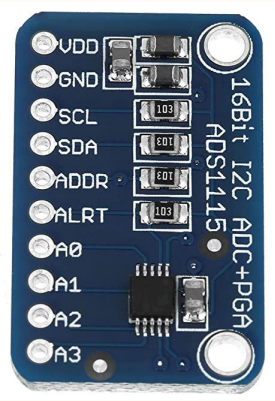
Risk Analysis/Management - Plan B

- Power consumption monitor
  - INA3221 voltage monitor burned while testing
    - Plan B(used) -> ADS1115 ADC converter
- Navigation mapping
  - G-mapping detection
    - Plan B(unused) -> Hector slam (need wheel encoder)



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Risk Analysis/Management - Commercial Plan B

- Lower retail price
  - Coupons, Promotion code
- Cooperation with other companies
  - Bundle sales
- Change target customer
  - Nurse Assistance - Carry food, pills, etc.

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Adherence to Standards

- Battery and charging system - General Requirements for battery-power appliances battery chargers
- Drive Mechanism - Adjustable Speed Electrical Drive System
- Robot Navigation - IEEE Standard for Robot Map Data Representation for Navigation
- User Interface - Design and development of information for users

Adherence to Standards

- Battery and Charger
  - Warning labels, secure connections, overvoltage and current protection
  - Protection from abnormal use, proper insulation, chassis ground, SAE charging connector
- Drive Mechanism
  - No direct contact during operation
  - Properly secured components

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Adherence to Standards

- Robot Map Data Representation for Navigation
  - Standards for a 2D map in autonomous delivery
  - Global map with coordinate references implemented
- Design of information for users
  - Process of building an API
  - Formatting, layout, and interface

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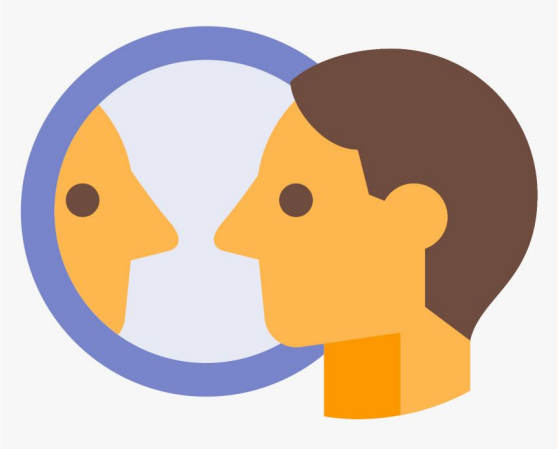
Self Reflection



- Feedback from the course
  - Collision-safe robot siding
  - Fuses for overcurrent protection
- What would we do differently?
  - Improve project management
  - More in depth battery research, selection and testing

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Self Reflection

- What our team learned
  - Action rather than discussion
    - Led to delays in testing
  - Don’t take shortcuts
    - Fast +Easy = Headache

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Conclusion

- What team members learned
  - Time management
  - Communication and documentation
  - Relative hardware & software skills

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Conclusion

- Future Plan for NaviBot
  - Nice looking cover
  - Better battery
    - Sensitive overcurrent, low battery life(30mins)
  - More ultrasonic sensors
    - Increase detection accuracy

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References

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Questions?

Thank you