

Autonomous Mobile Salt Spreading Robot

Team sdmay26-07

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PROJECT OVERVIEW

- Salt Spreading
- Autonomous Driving
- Multi-Sensor Localization
- Custom Pathfinding
- Mobile Companion App
- Safety Focus



1 DESIGN PROBLEM & CONTEXTUALIZATION

THE GOAL

Problem: Spreading salt can be dangerous for those the elderly or those with mobility constraints, and salt spreading services encroach on privacy and have recurring charges

Solution: An autonomous salt spreading mobile robot, with user needs and safety at the forefront



TARGET AUDIENCE

- Elderly
- Persons with mobility constraints
- Homeowners



2 REQUIREMENTS & STANDARDS

REQUIREMENTS

FUNCTIONAL REQUIREMENTS	
Driveway Area Serviceable	Must be able to spread salt over an area of up to 2000 sq. ft.
Tracking System	Localization must have accuracy +/- 5 cm at any given point during operations.
Salt / Battery Level Monitoring	The system must be able to detect if it does not have enough salt or battery to complete its task
Temperature Tolerance	The system must be able to operate in temperatures as low as 5 ℉ (minimum effective temperature for ice melt solutions)

ENVIRONMENTAL REQUIREMENTS	
Excess Salt	The system must not spread too much salt or misplace salt in order to reduce runoff and vegetation damage



REQUIREMENTS

PHYSICAL REQUIREMENTS	
Salt Capacity	Must be able to carry enough salt to meet driveway area requirement (2000 sq. ft)
Winter Conditions Traversal	The drivetrain must be able to traverse icy conditions and navigate within typical slopes of driveways and sidewalks
Waterproofing	The electronic system must be shielded from moisture and unaffected by wet environments
Corrosion Resistance	Materials must resist corrosion, even when exposed to moisture or salt

UI/UX REQUIREMENTS	
Salt Reservoir Access	The salt reservoir must be easy to refill by the user
Intuitive User Interface	The user interface must be simple and intuitive for users who are not overly familiar with technology



ENGINEERING STANDARDS



IEEE 7009:2024

- Fail-Safe Mechanisms For Autonomous Systems

ISO 13482:2014

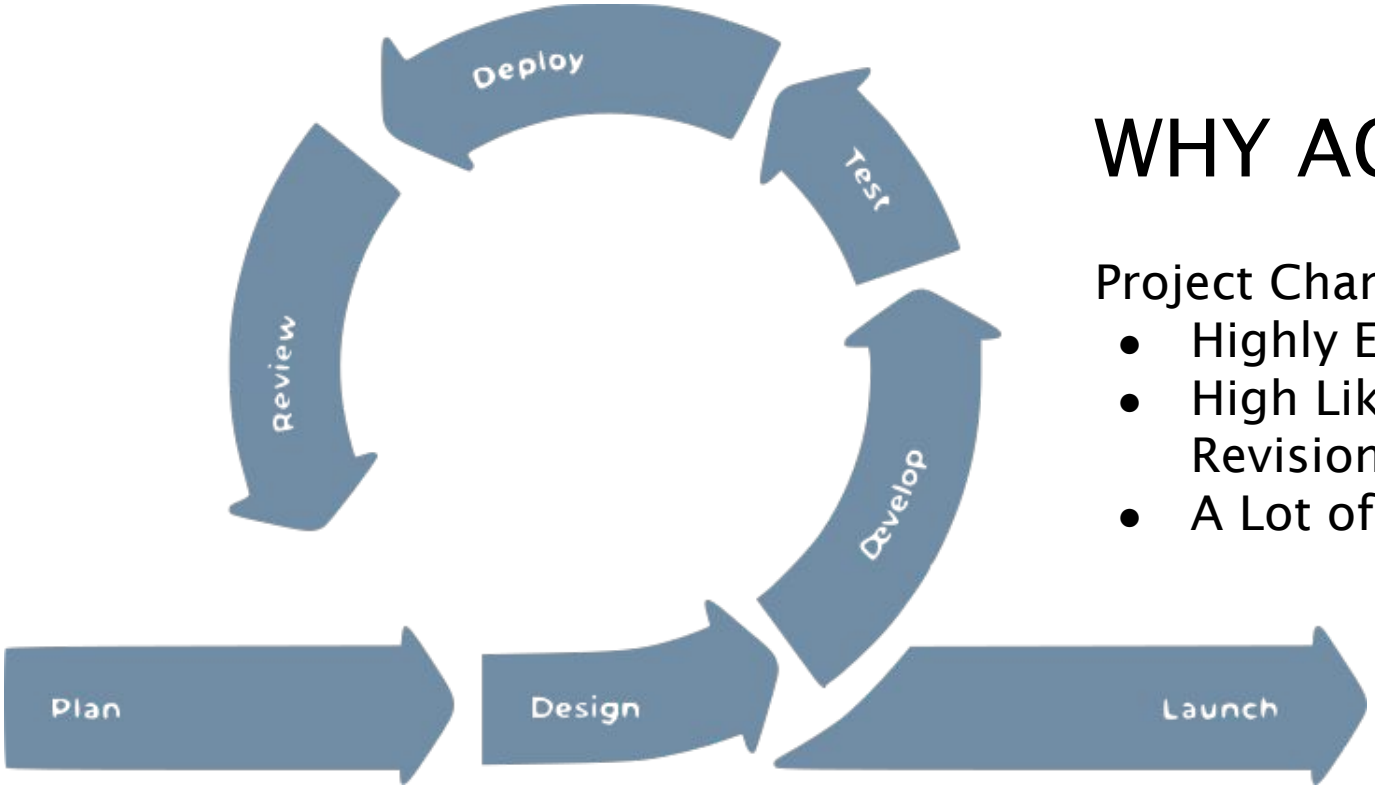
- Safety Standards for Service Robots

FCC Part 15

- Regulations on Wi-Fi and Bluetooth Communications.

3 DESIGN PROCESS

PROJECT MANAGEMENT METHODOLOGY



WHY AGILE?

Project Characteristics:

- Highly Exploratory
- High Likelihood of Revisions
- A Lot of Uncertainty

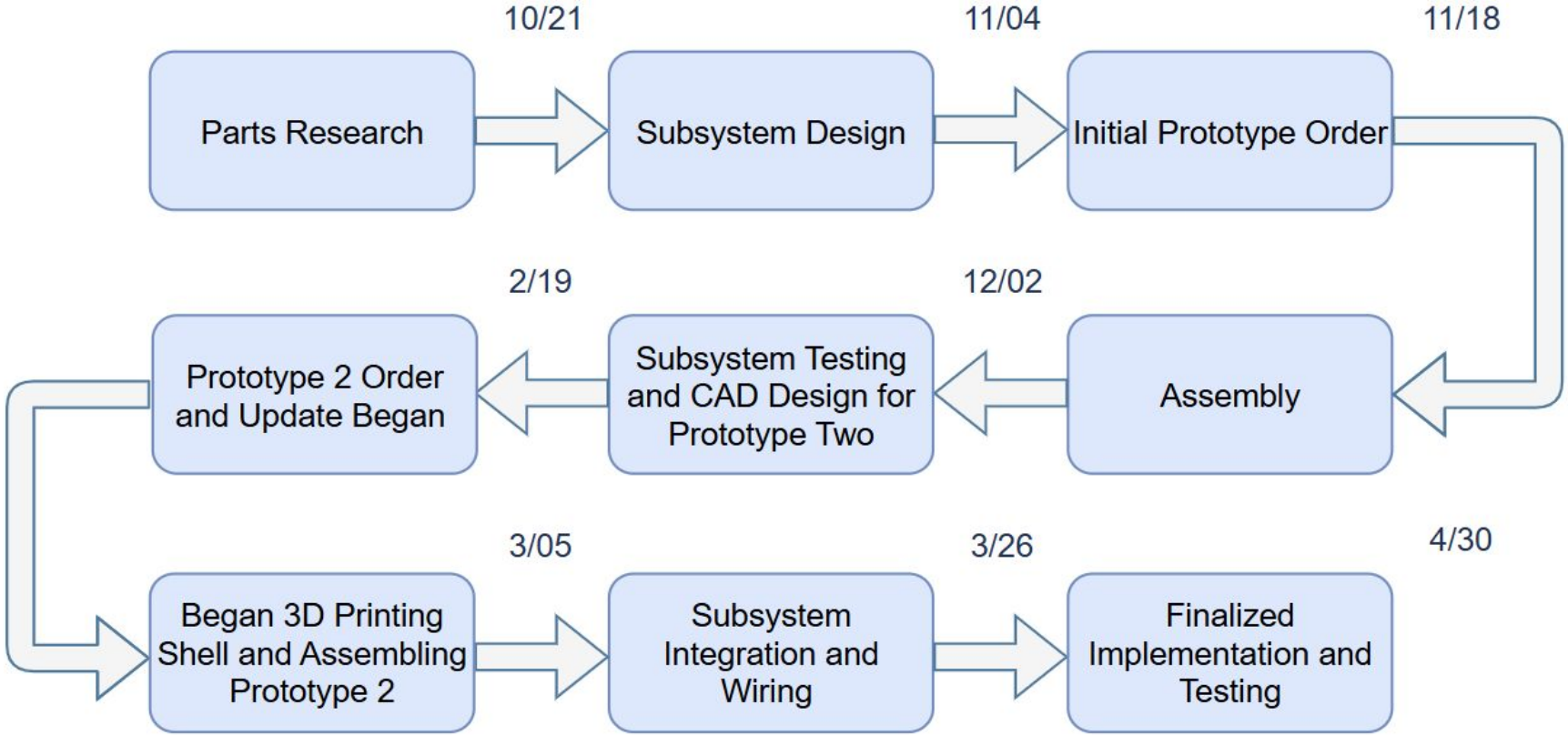
SYSTEM INTEGRATION METHODOLOGY

- Wide Project Scope With Many Subsystems
- Heavy initial design/research phase
- Mass integration near end



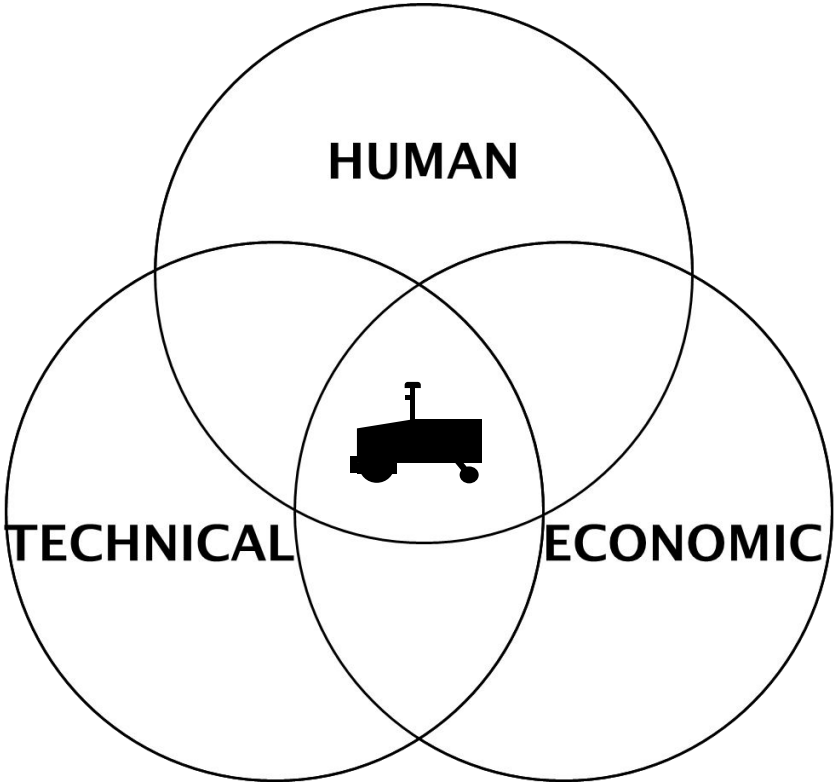
- Dynamic Team Structure: Integration Teams
- Planned Integration Time Windows
- Careful Integration Testing

TIMELINE


10/21
Parts Research
11/04
Subsystem Design
11/18
Initial Prototype Order
2/19
Prototype 2 Order and Update Began
12/02
Subsystem Testing and CAD Design for Prototype Two
Assembly
3/05
Began 3D Printing Shell and Assembling Prototype 2
3/26
Subsystem Integration and Wiring
4/30
Finalized Implementation and Testing

DESIGN TRADEOFFS

- Performance vs. Budget Constraints
- Design Depth vs. Time-to-Implementation
- Technical Complexity vs. User-Friendly UI/UX

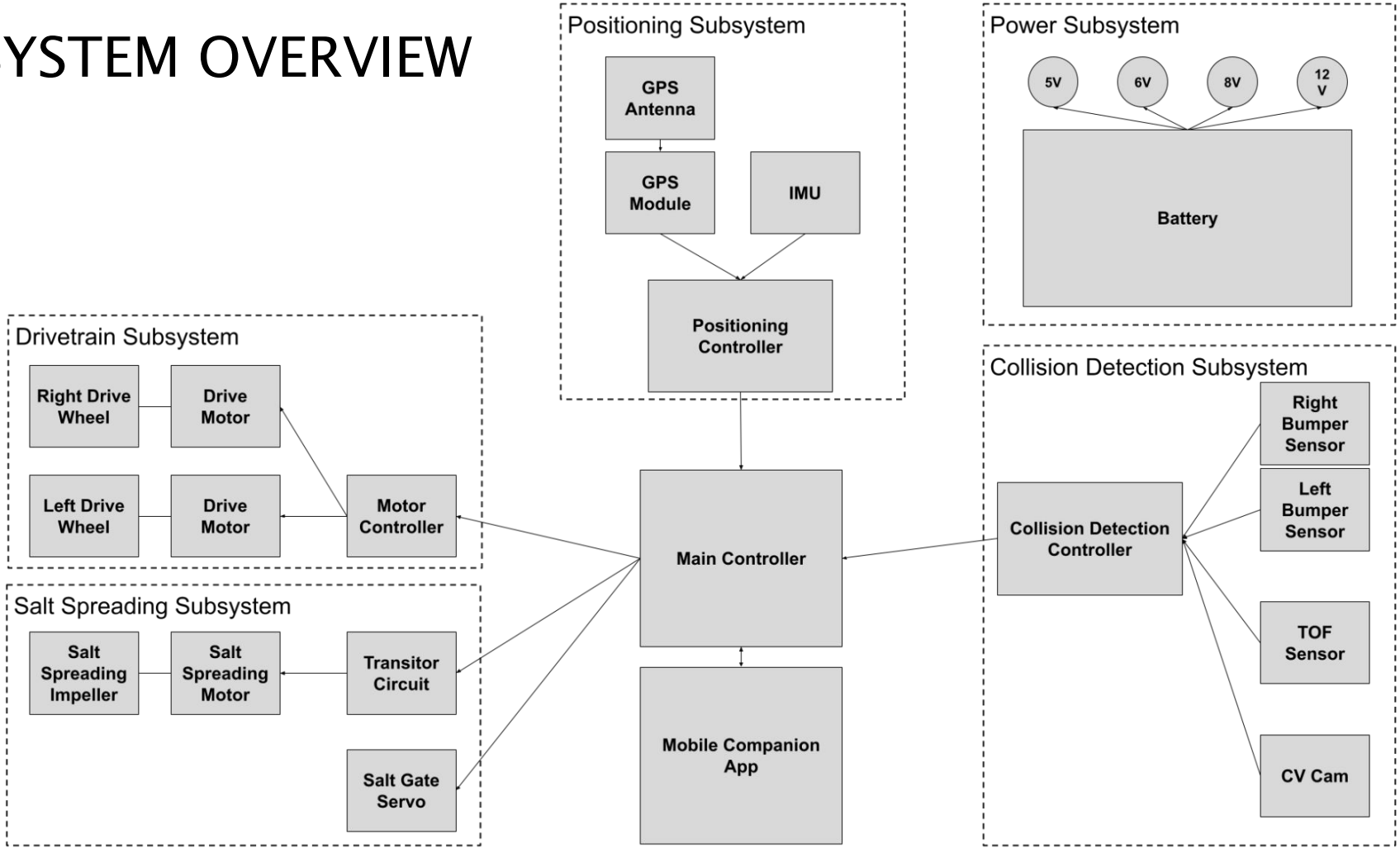


4 DESIGN

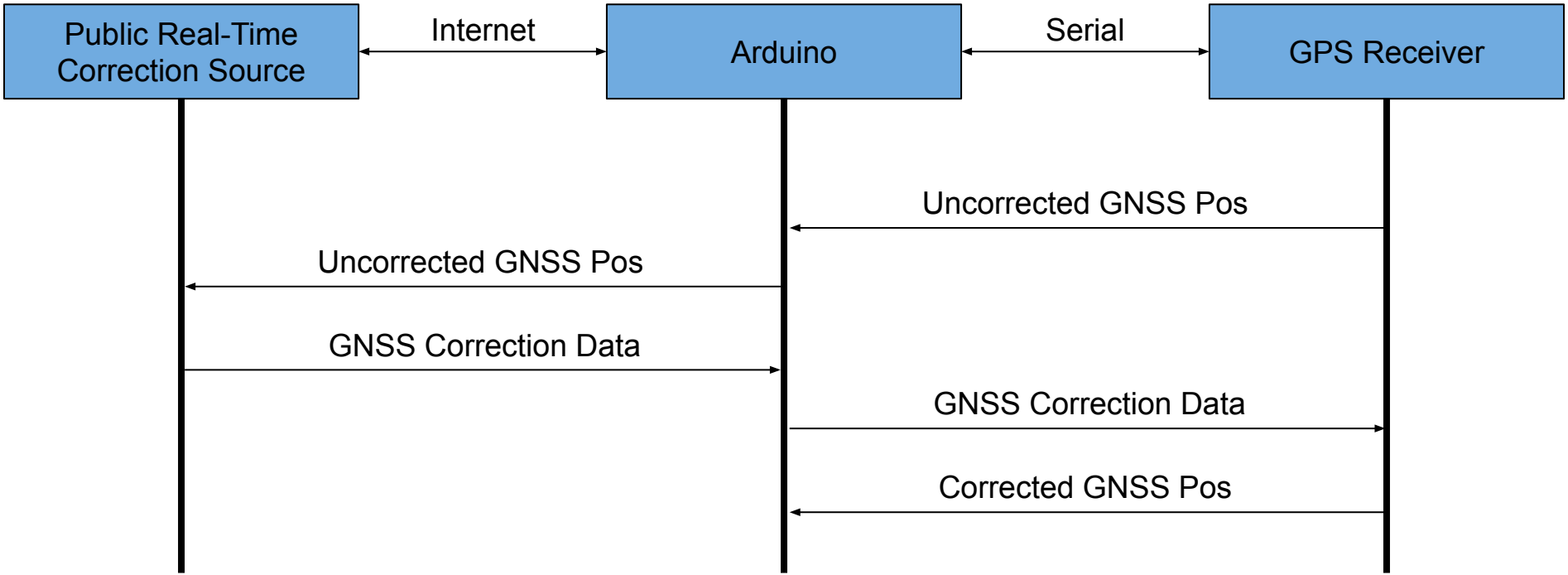
SYSTEM OVERVIEW



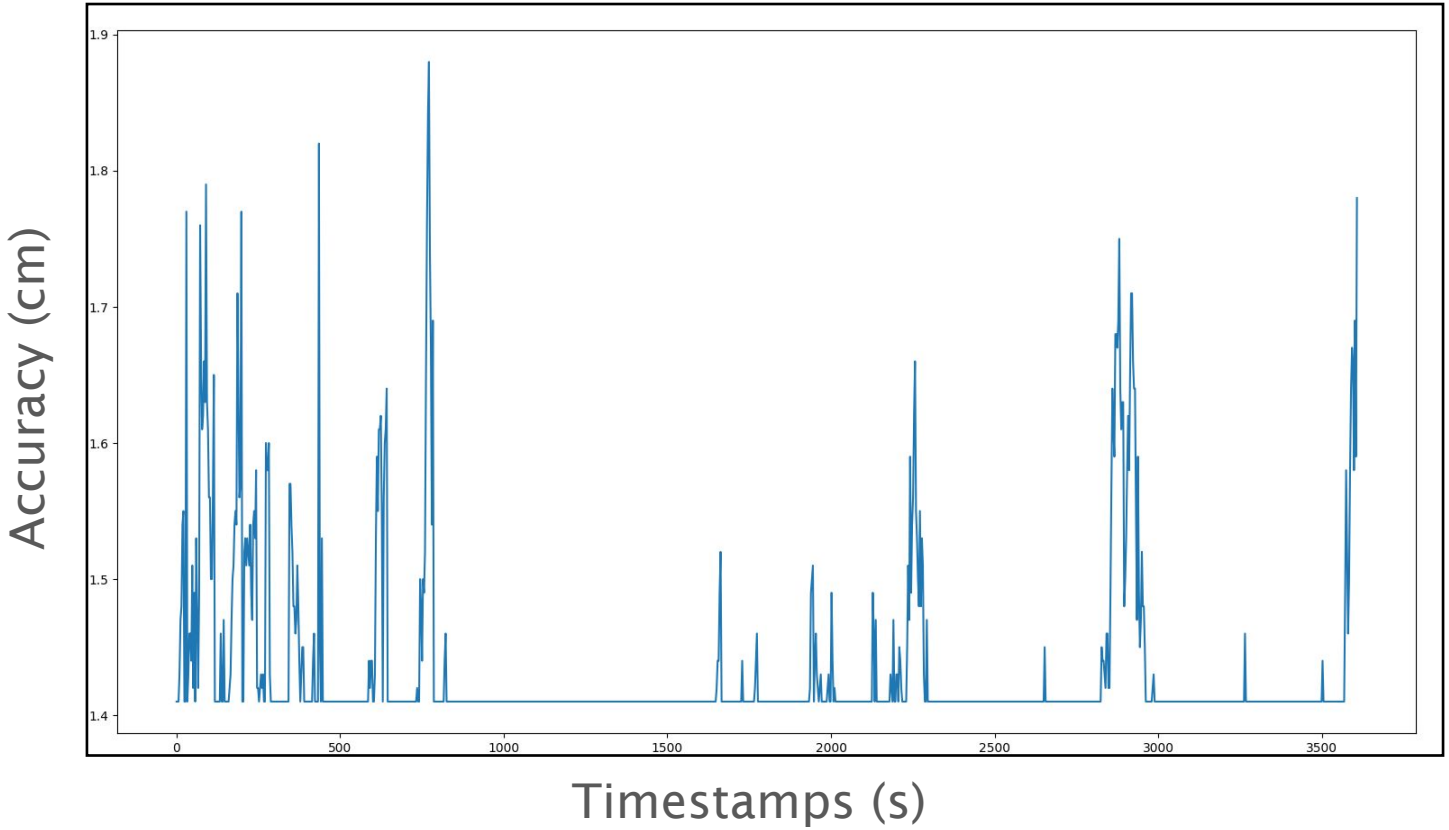
SYSTEM OVERVIEW



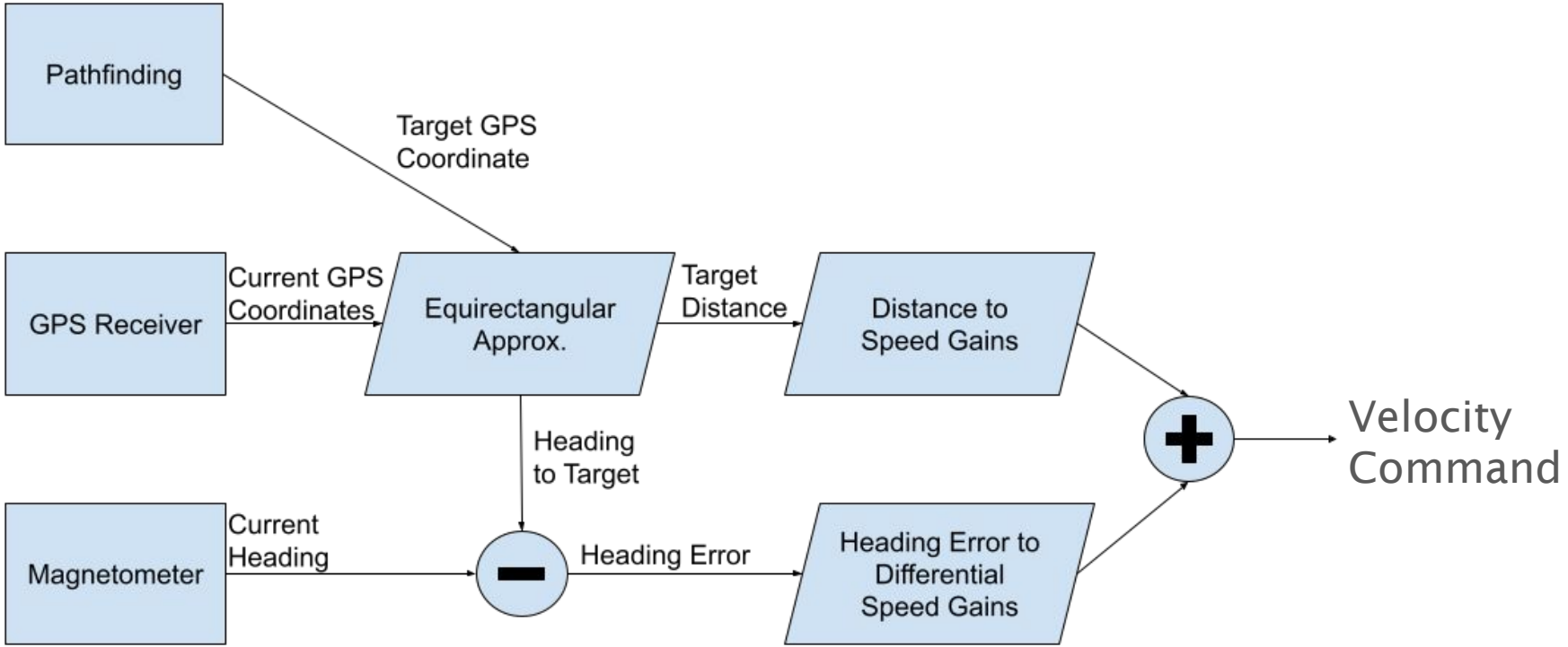
GPS POSITIONING



GPS POSITIONING



DRIVE CONTROL

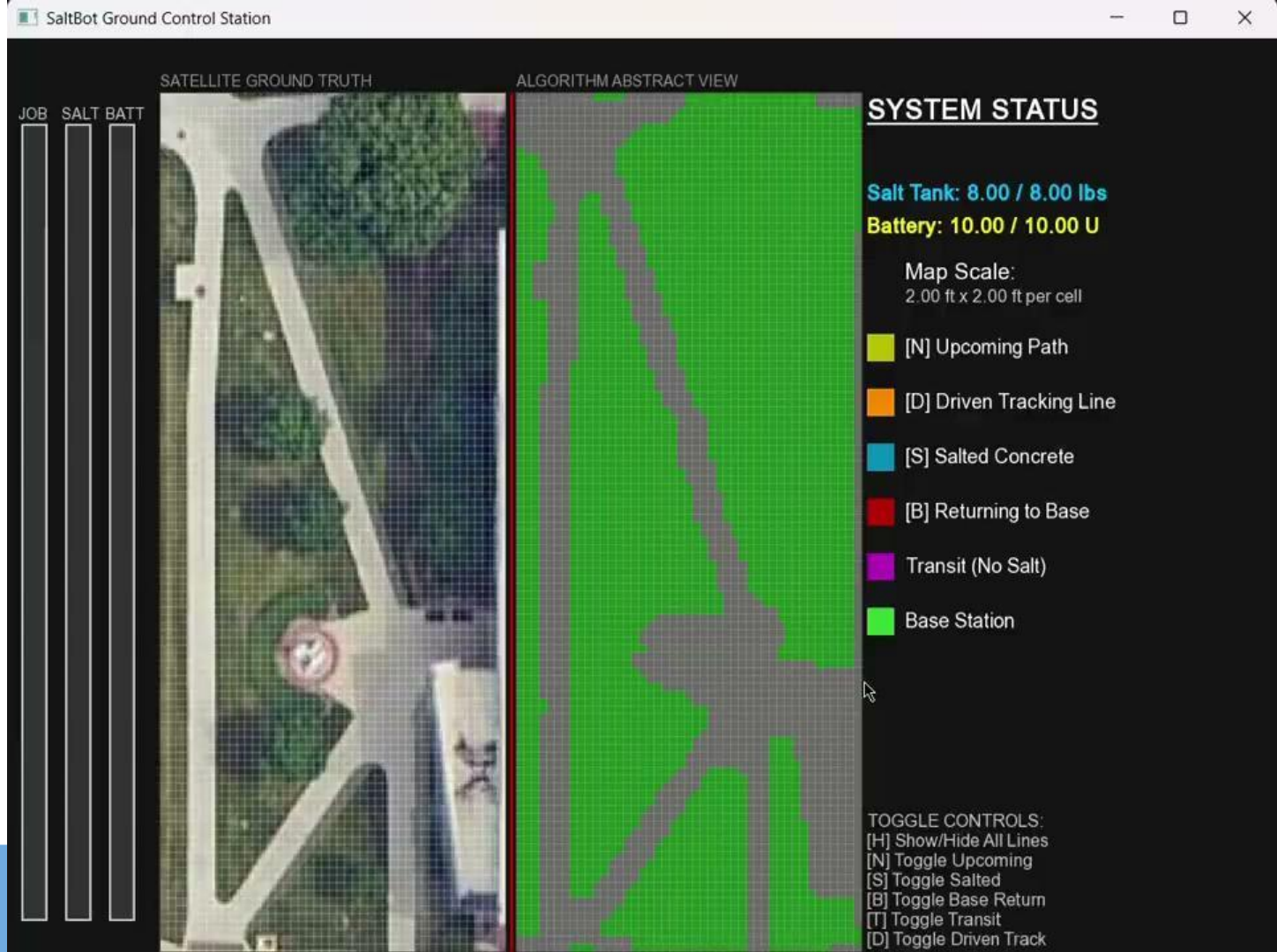


PATHFINDING

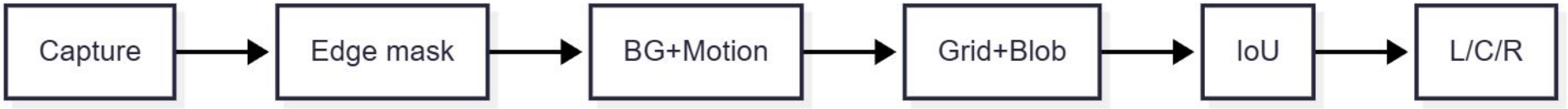
JOB -

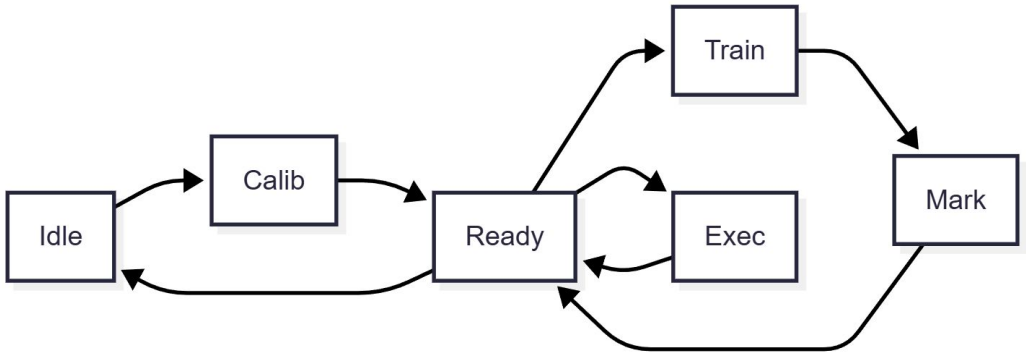
SALT -

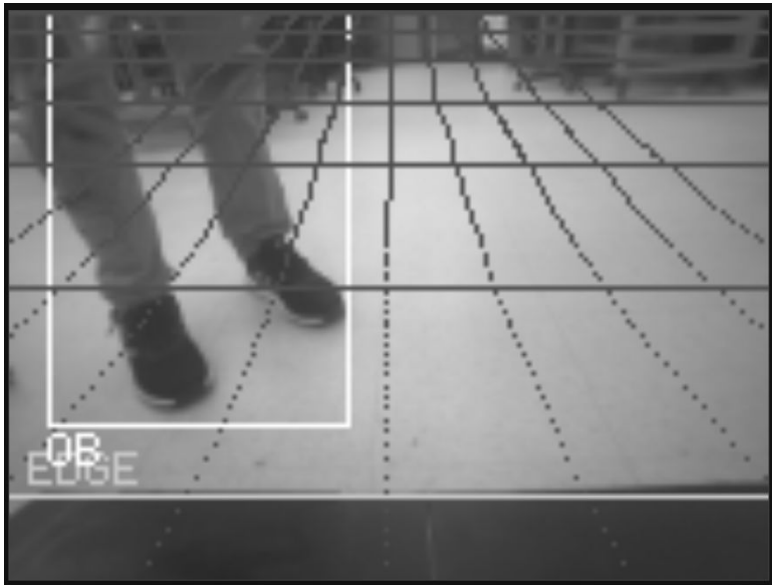
BATT -



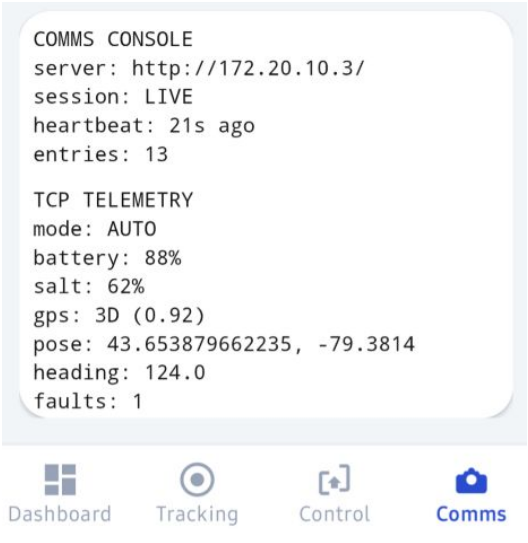
COLLISION AVOIDANCE & DETECTION

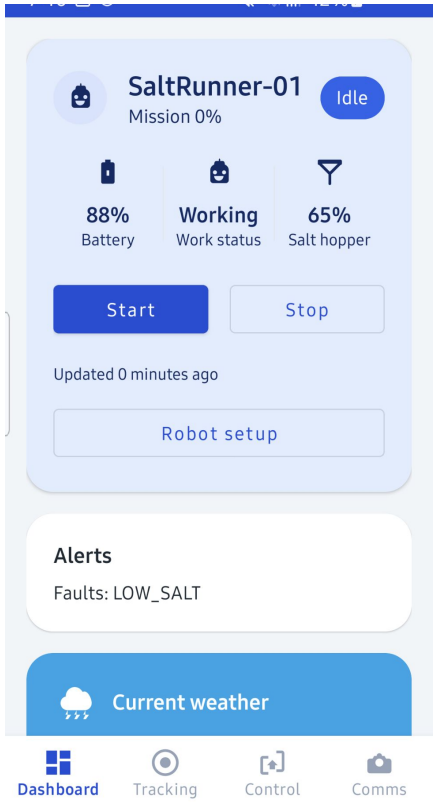


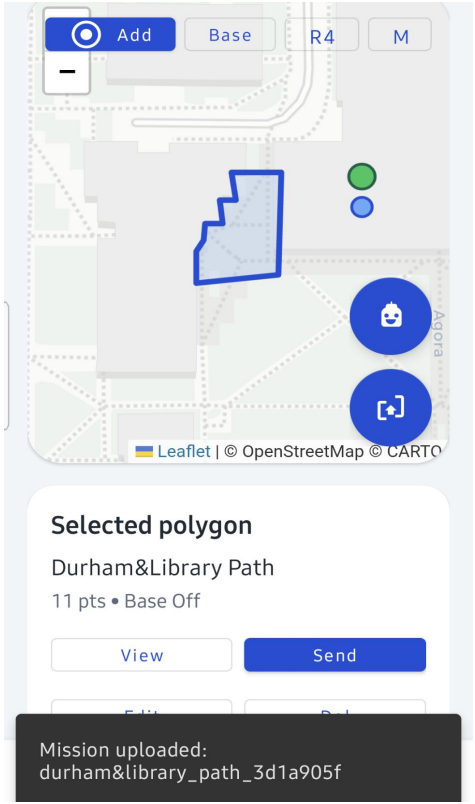




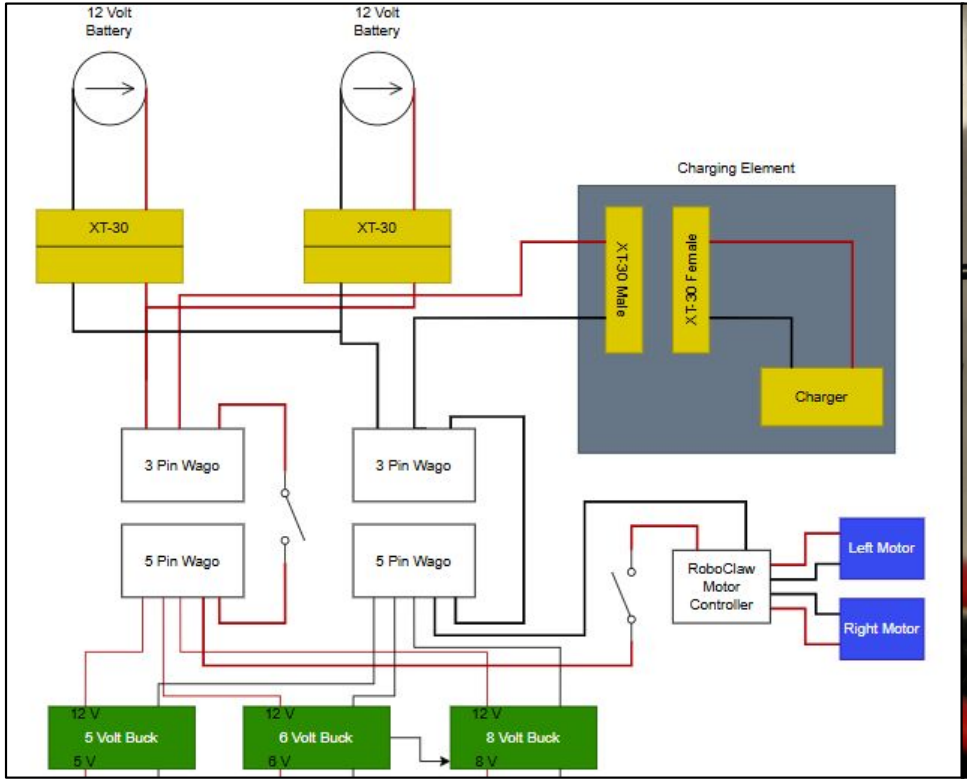
MOBILE COMPANION APP

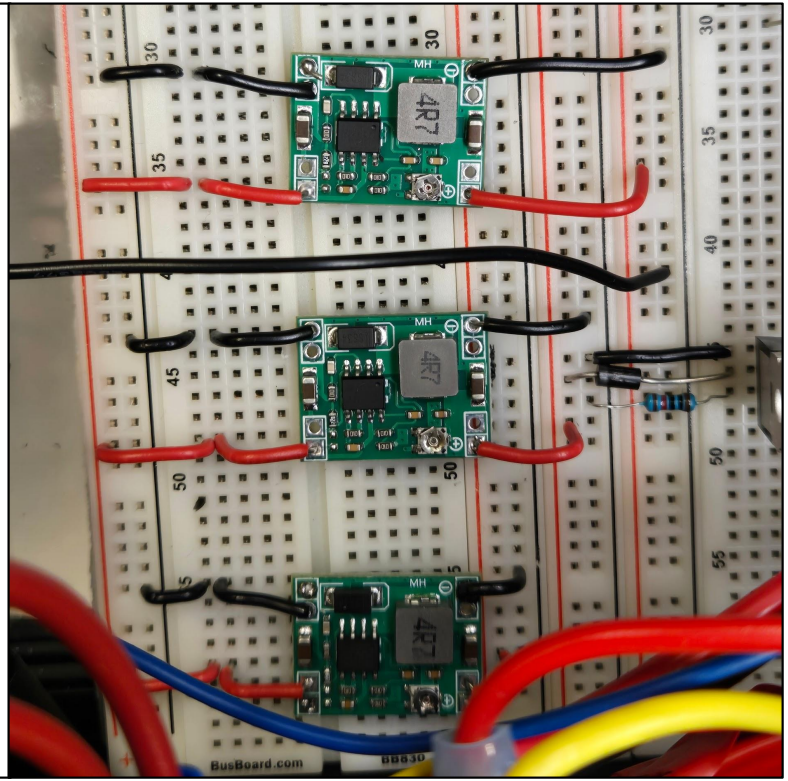






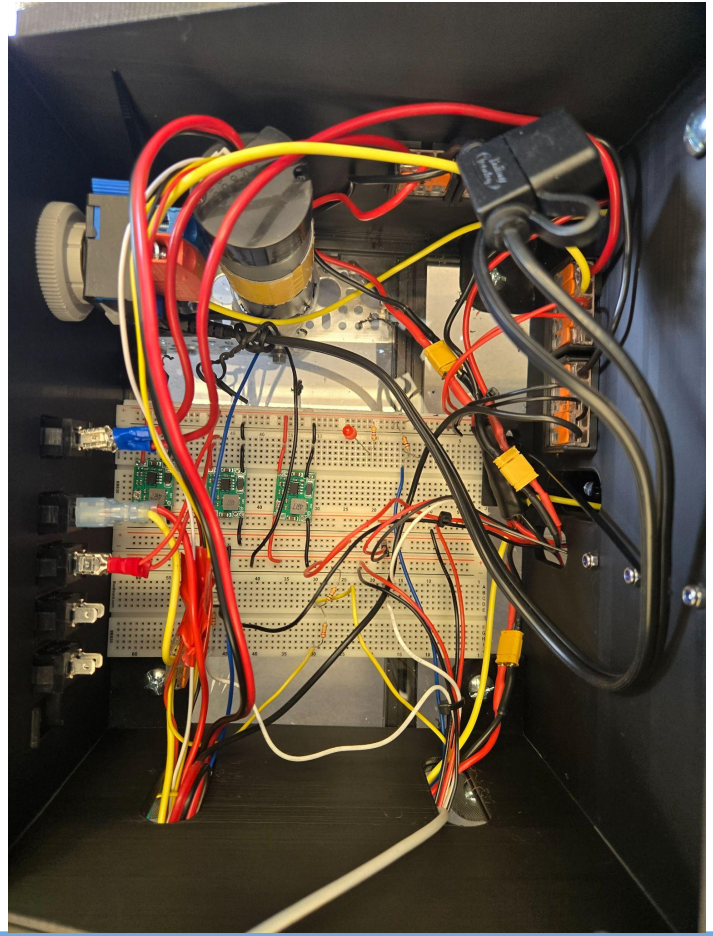
POWER DISTRIBUTION



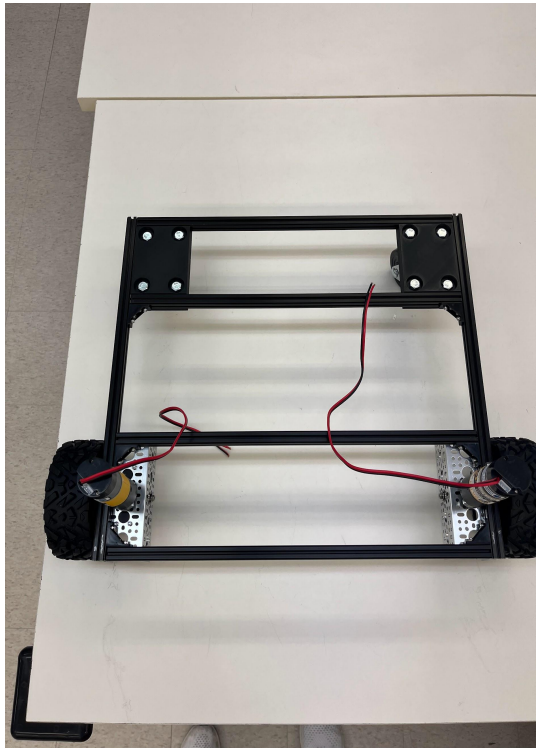


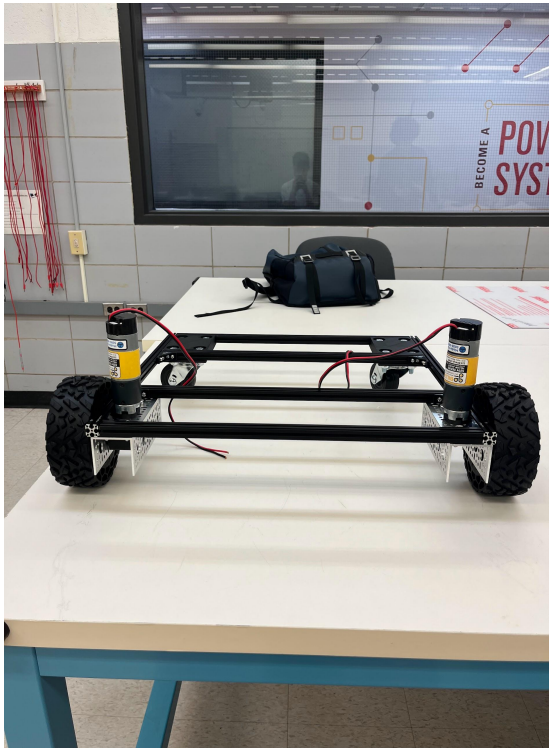
Power Distribution





DRIVETRAIN

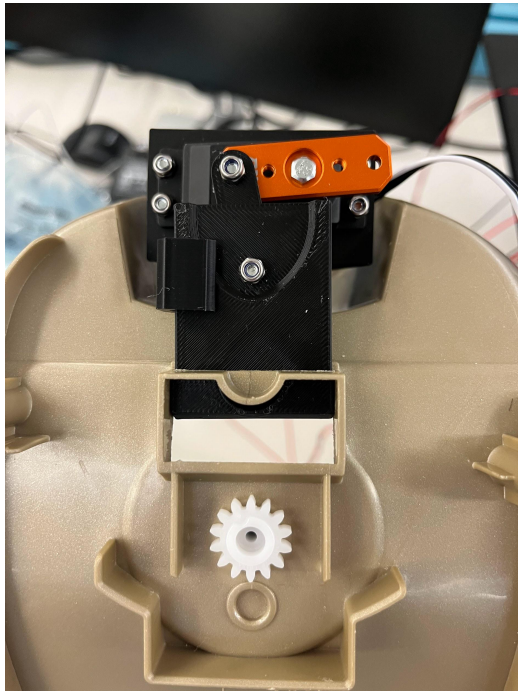


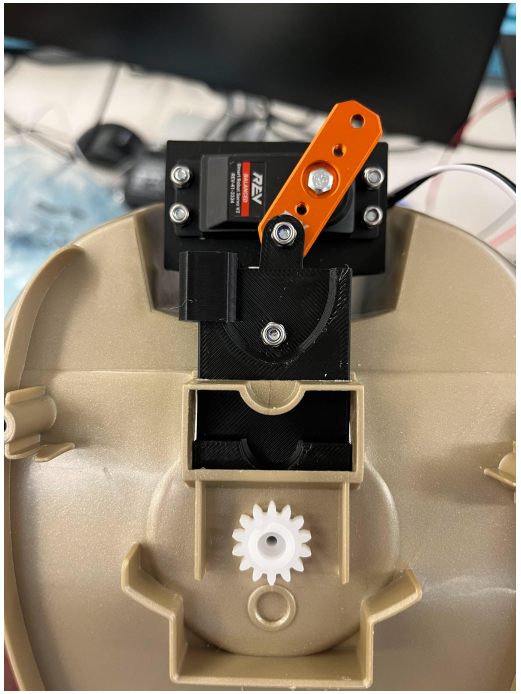




SALT DISTRIBUTION







PROTOTYPE 2.0



5 TESTING

TESTING METHODOLOGY

01

Unit Testing

- Sensors
- Actuators
- Algorithms

02

Integration Testing

- Intercontroller Communications
- Algorithm Interaction
- Software-Mechanical

03

System Testing

- Full Functionality

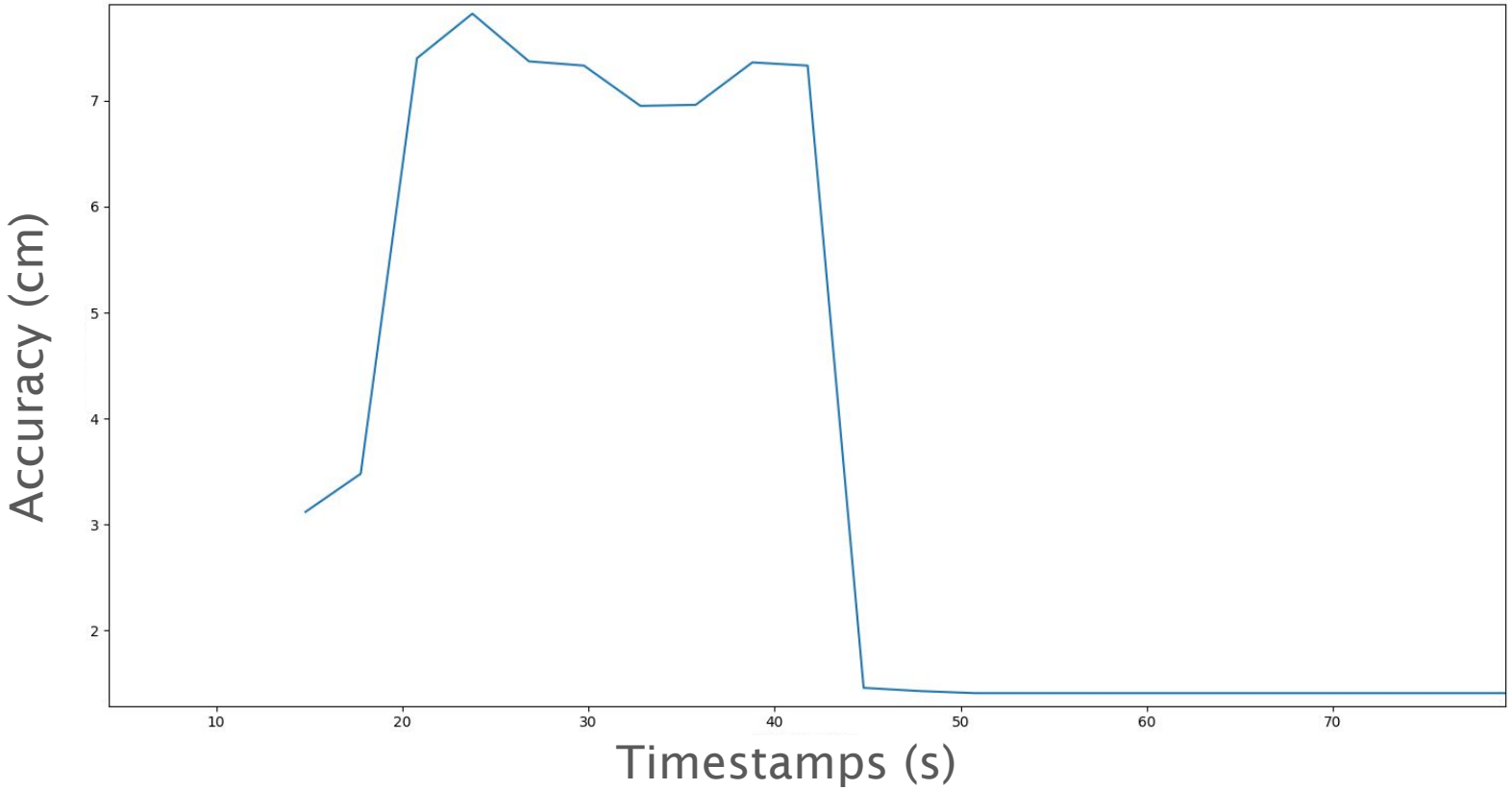
04

User Testing

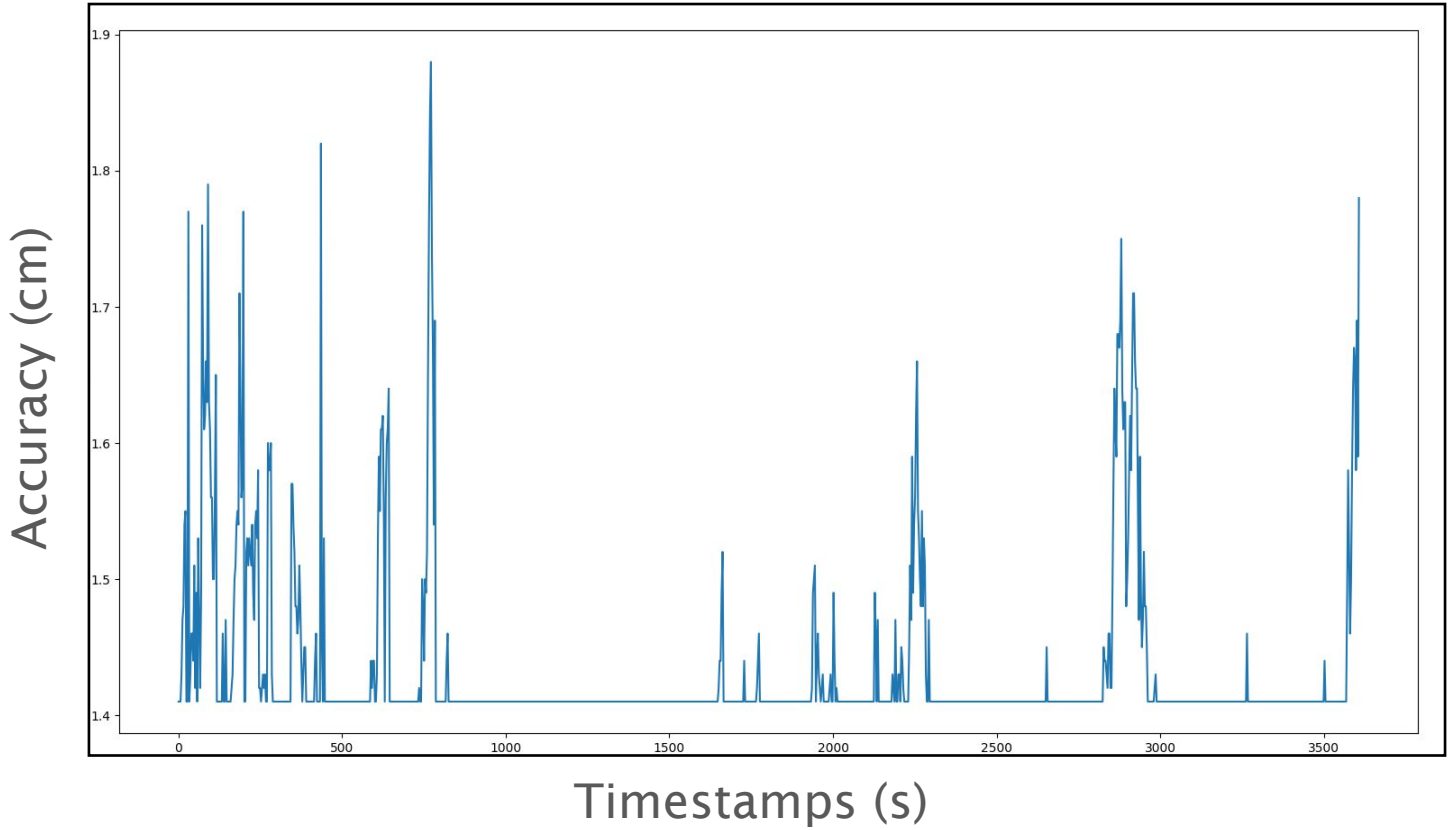
- User Acceptance
- UI/UX



GPS ACCURACY TESTING - START UP

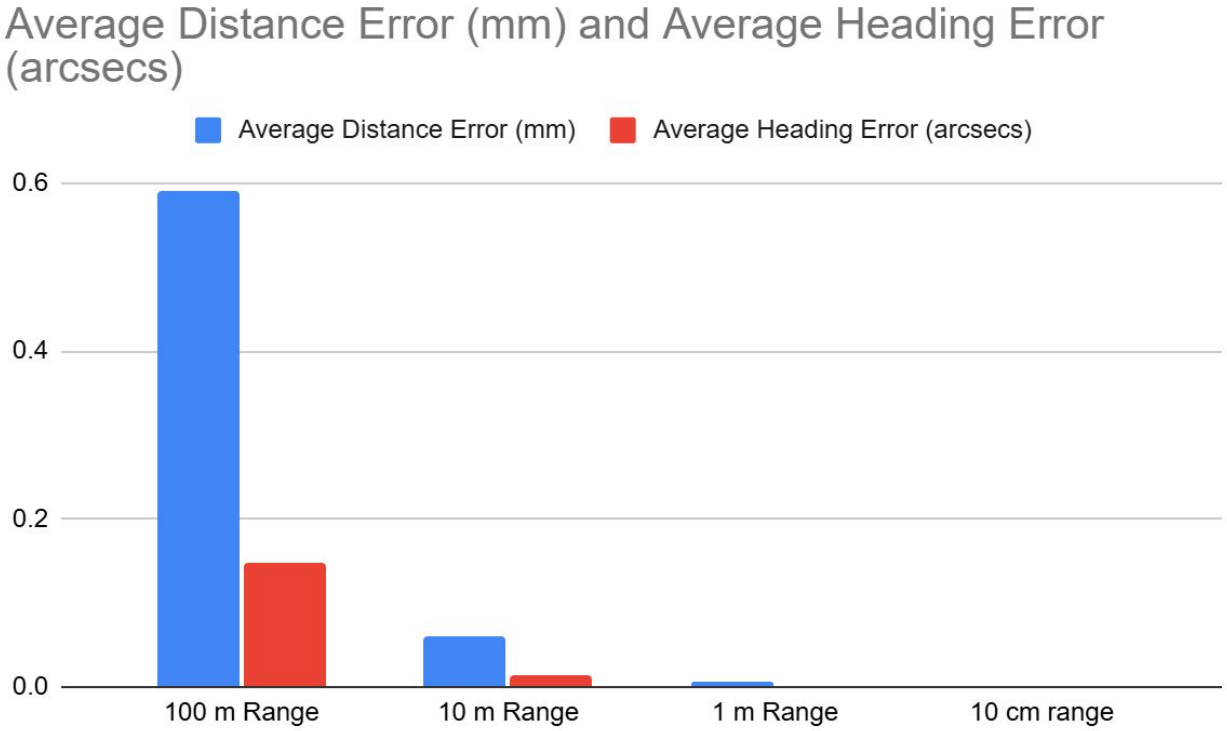


GPS ACCURACY TESTING - WITH RTK FIX

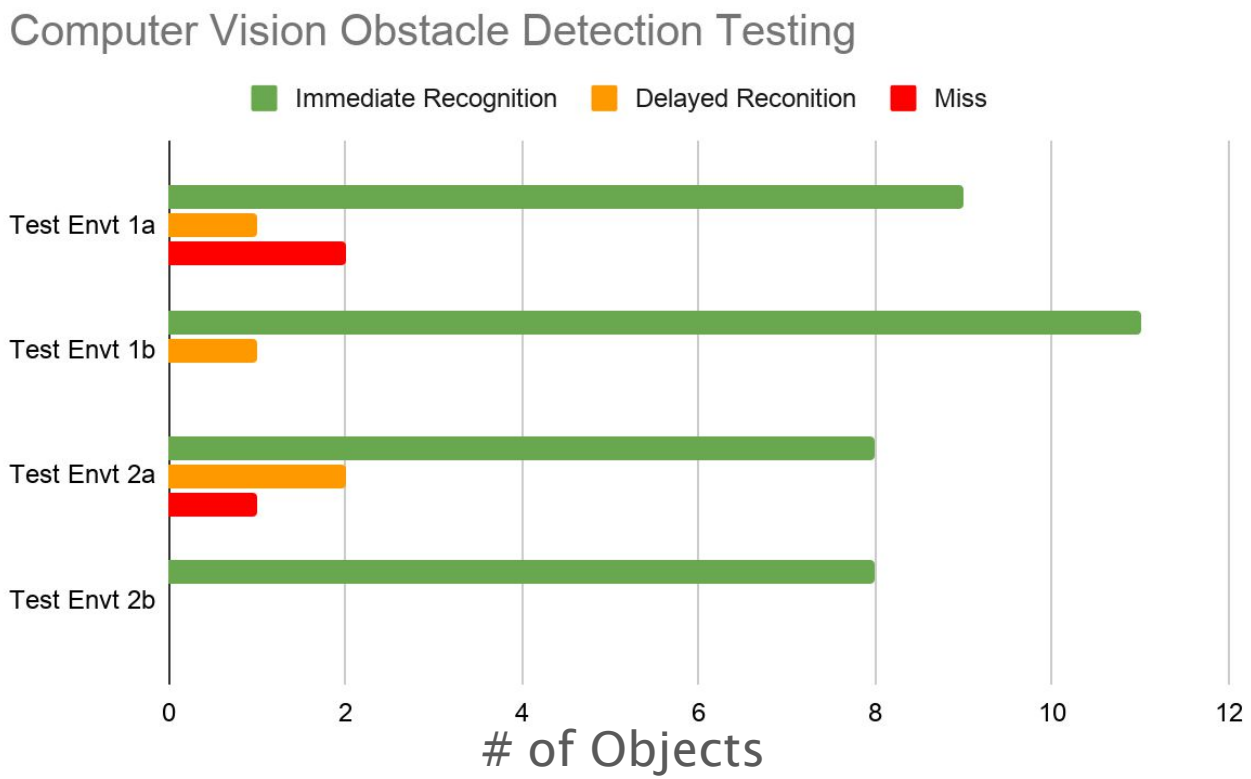


EQUIRECTANGULAR APPROXIMATION

- Vs. Round-Earth Calculations
- Average Runtime: 565.1 microseconds



COMPUTER VISION TESTING



DRIVE TESTING



SALT SPREADING



6 CONCLUSION

CHALLENGES & FUTURE MITIGATION

- Mechanical Part Failure
  - Solution: Critical Part Spares, System Simulations
- Communication
  - Solution: More Willing to Follow-Up, Upfront Specifications
- Integration Strain
  - Solution: Simulations, More Buffers for Setbacks in Timeline
- Scope
  - Solution: Account for Potential Risks



NEXT STEPS

- Full System Integration
- Sensor Fusion with Error-Bound Sensors
- Electronic System Finalization
- Water/Weatherproofing
- Environmental Testing



QUESTIONS?

THANK YOU!

