

# Device, Uplifting, and Navigation Group.



# MEET THE TEAM



Yousif Alhajji ECE'25



Arnav Singh ME'25



Lorenzo Barale ME'25



Zaid Bhatti ME'25



Maysarah Sukkar ME'25



Zachary Wu ME'25

# Acknowledgements



Amazon Robotics  
Principal Engineer  
Gabriel Hebert



Mansfield Municipal  
Airport

Boston University  
Professor  
J. Scott Bunch



Boston University  
Professor  
Kenneth D. Sebesta





## The Problem

- Robotics-Related Project
- Realm of Aviation
- Solves a Real-World Problem



# Current Solutions



\$2,000



Small,  
portable  
devices

Knurled rod or an  
extra wheel for  
moving the plane.



\$4,000



Large,  
non-portable  
devices

Using larger hardware,  
powered by diesel  
generators/ large  
batteries.



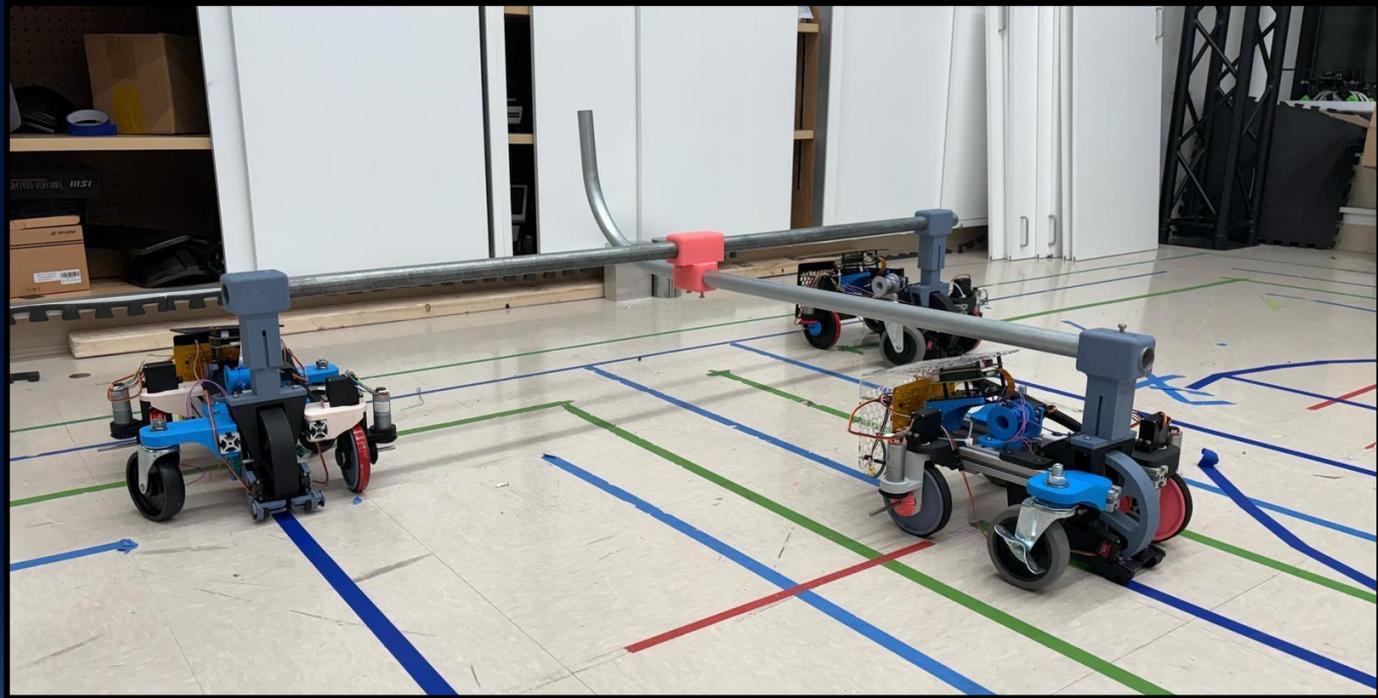
\$5,000-  
\$12,000



Remote  
controlled tugs

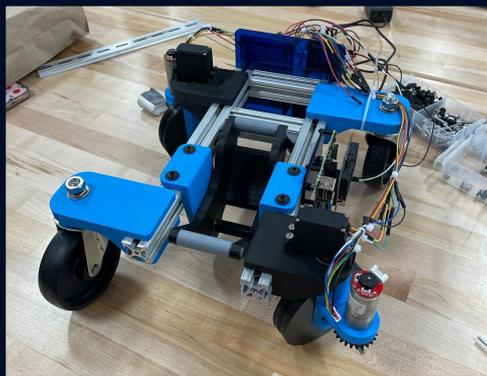
Can avoid collisions with  
other tugs, but not with  
hangar walls or other aircraft.

# *Our Solution*

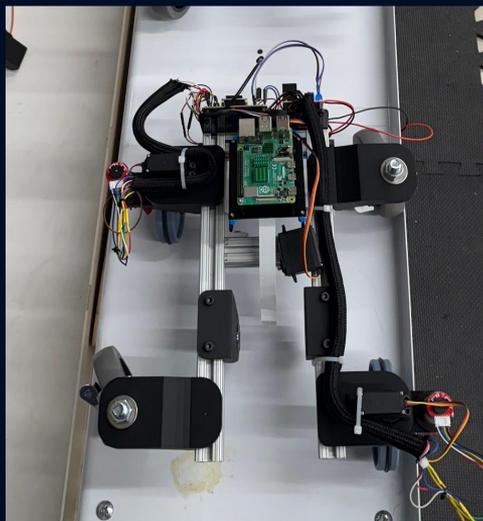




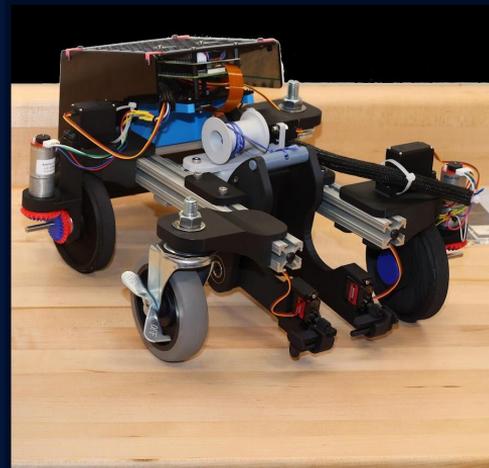
# Prototype Evolution



Initial Prototype



Second Prototype



Final Prototype

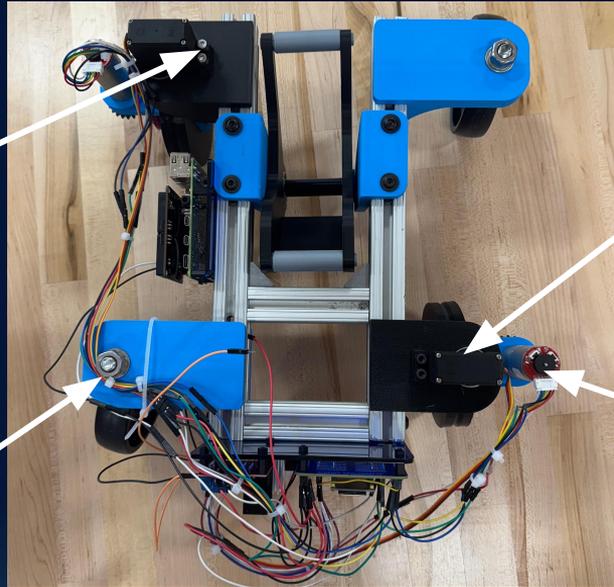




# Mobility

**Active Caster Wheel**  
- This wheel is made up of two motors, and it can turn to any direction and spin to drive the robot

**Passive Caster Wheel**- This wheel is for stability, and spins in the direction of the robot



**Servo Motor**- This motor is used to spin the wheel assembly to steer the robot.

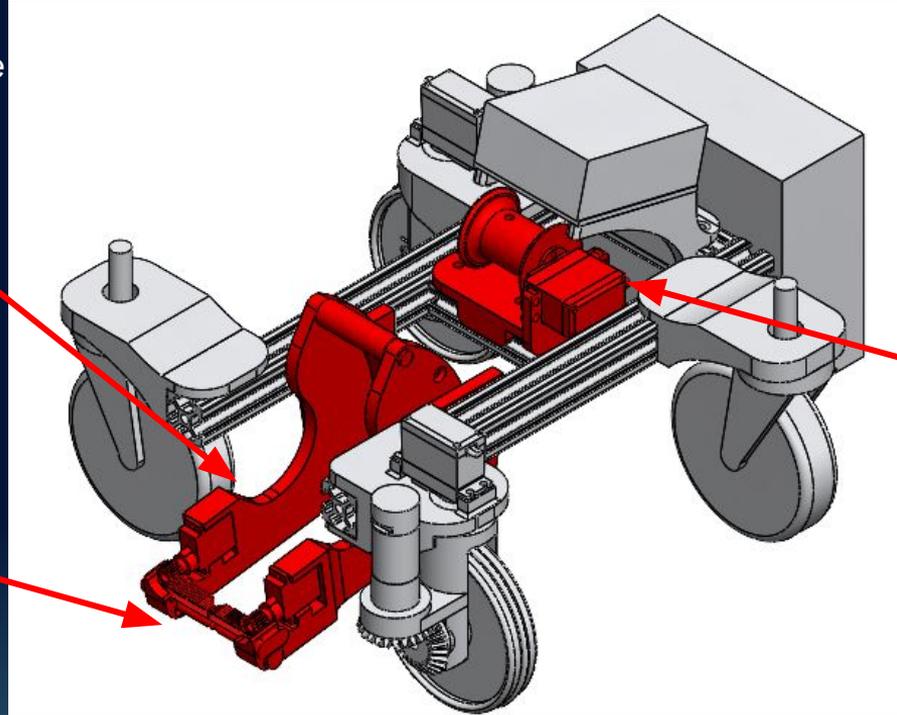
**DC Motor**- This motor spins the wheel of the active caster assembly, pushing the robot forwards



# Lifting and Attachment

Cradle - holds plane wheel in place during lifting and relocation of the plan.

“Mandibles” - Servo driven jaws that lock the wheel into the cradle when necessary

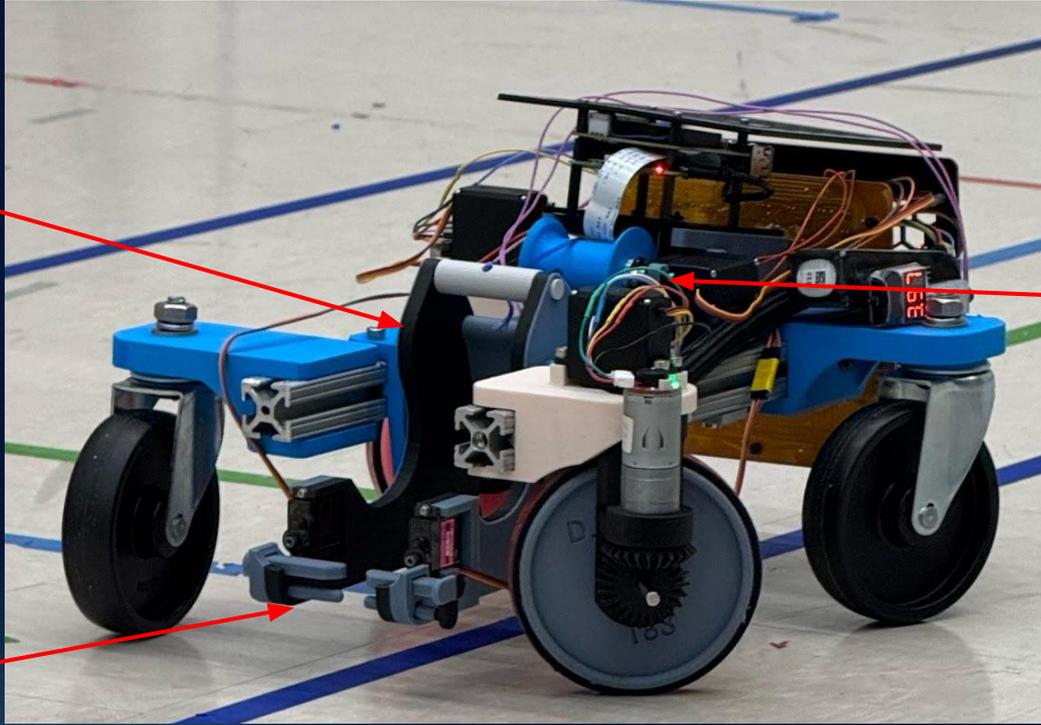


Winch - Lifts and drops the cradle to aid in picking up and releasing the plane



# Lifting and Attachment

Plane Wheel  
Cradle



Winch

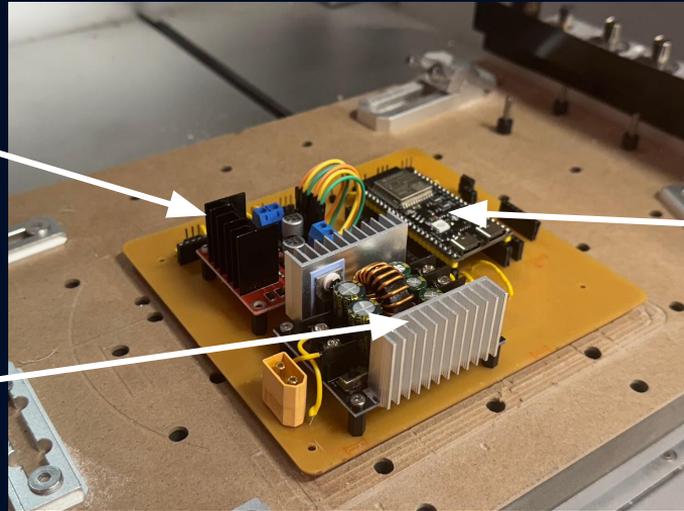
Mandibles



# The Embedded System: Control Board

Dual H Bridge Motor Driver- Allows for the Control of the Two DC Motors with PWM

Buck Converter- Steps down 12V for the motors to 5V for the rest of the system



ESP32- Is responsible for the control of all motors, and the reading of all sensors, as well as receiving the transmissions from the central computer





# The Embedded System: Camera Vision

Raspberry Pi 4B: A board capable of transmitting a stable video stream

Arducam IMX 219 and NeoPixel Ring Light

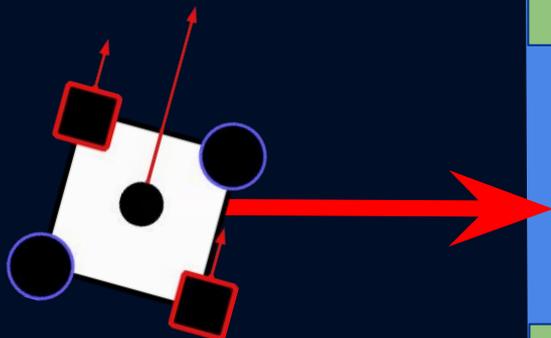


The video feed created by this system is accessible in MATLAB on the system's central computer, where it is processed.





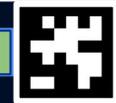
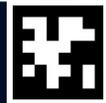
# Single Robot Formation



The robot has a PD controller that uses camera feedback to steer it back towards the line.

The robot will try to go from one fiducial tag to another, following a line of tape on the ground.

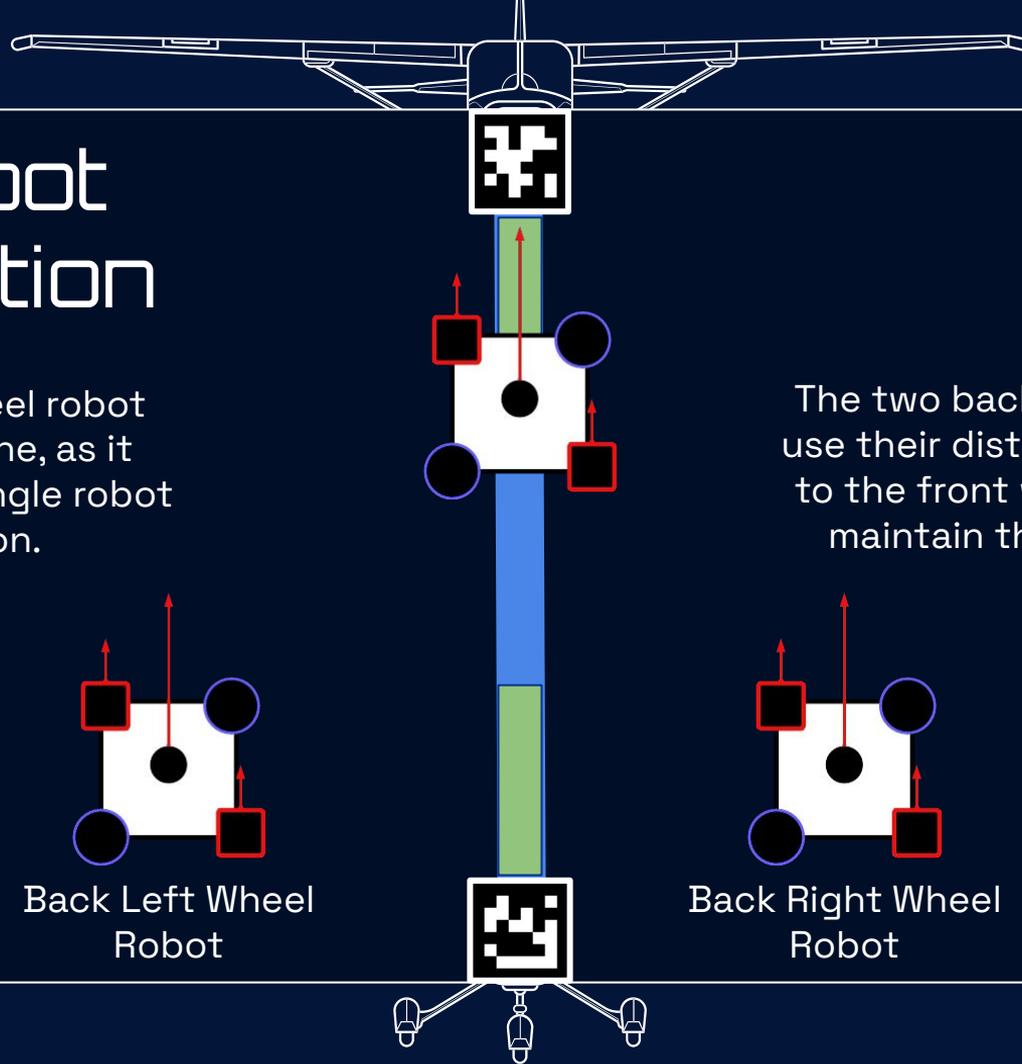
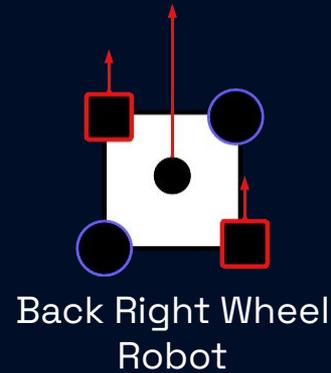
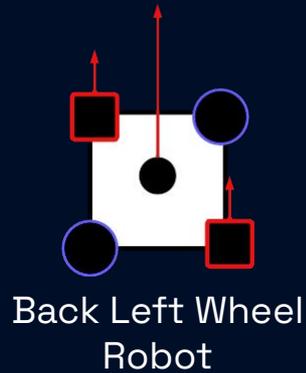
Once it reaches the destination tag, the robot turns to face its next destination.



# 3 Robot Formation

The front wheel robot follows the line, as it would in the single robot formation.

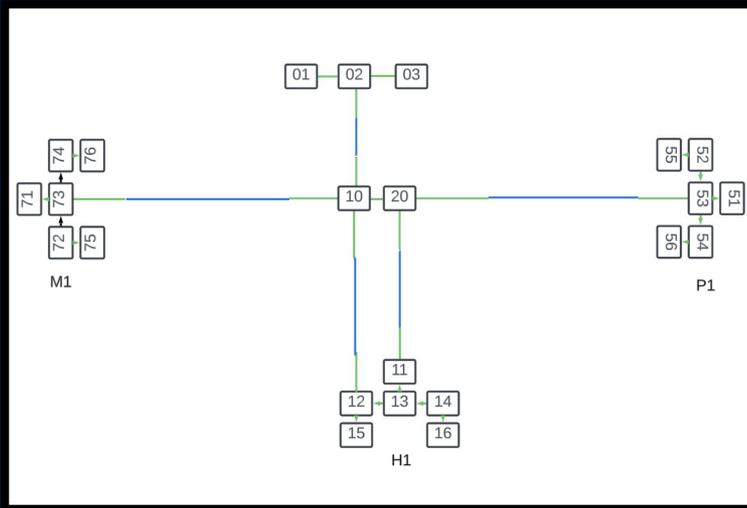
The two back wheel robots use their distance and angle to the front wheel robot to maintain this formation



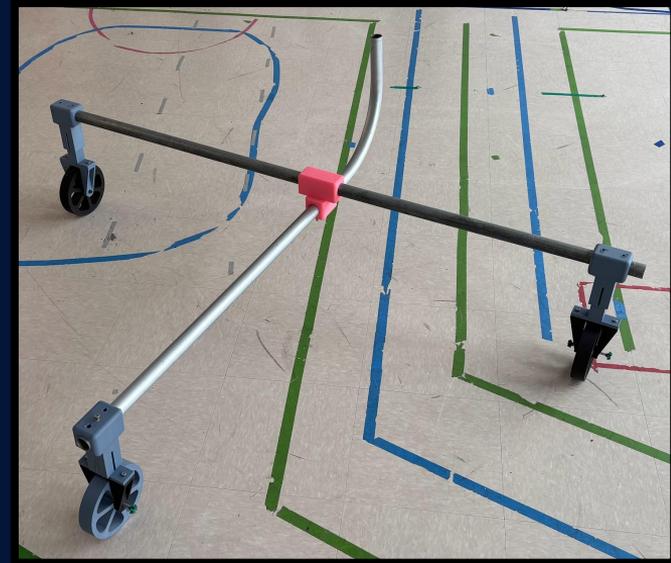


# Motion Planning: Infrastructure

## Mock Hangar Layout



## Mock Plane Design







# Motion Planning: Direction Encoding

## Junction Matrices

d1 =				d2 =			
	0	1	0		0	0	0
	1	0	2		2	0	1
	0	0	0		0	1	0

## Compass Matrix

```
rrm= ["0" "FF" "0" ;  
      "RL" "0" "RR";  
      "0" "BB" "0";];
```



# UI and UX

### DUNG. Create a new account

First name

Last name

Username

Password

Confirm password

I want to be a Maintainer

[Register](#)

[Already have an account? Login here](#)

### DUNG. Login to your account

Username

Password

[Login](#)

[Don't have an account? Sign up here](#)

Welcome, **Scott** MAINTAINER

## Planes

[+ Add](#) [- Delete](#) [Edit](#)

### Register New Aircraft

N-No.

Brand

Model

[Cancel](#) [Confirm](#)

### Delete Aircraft

Plane:

- Cessna 172S Skyhawk SP (N7294K)
- Cirrus SR20 (N367SR)
- Piper PA-28 Cherokee (N428LS)
- Diamond Aircraft DA40 Star (N515DA)

## Flights

[Schedule](#) [- Delete](#)

[Hangar Settings](#)

### Schedule Flight

April 2025

SUN	MON	TUE	WED	THU	FRI	SAT
30	31	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	1	2	3

Time: 22 : 00

Plane:

- N7294K (Cessna 172S Skyhawk SP)
- N367SR (Cirrus SR20) (🚩 Out of service)
- N428LS (Piper PA-28 Cherokee) (🚩 Out of service)
- N515DA (Diamond Aircraft DA40 Star)

### Delete Reservation

Filter by Plane:

April 2025

SUN	MON	TUE	WED	THU	FRI	SAT
30	31	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	1	2	3

#### Reservations for N367SR on Apr 24, 2025:

[Cancel](#) [Delete Selected](#)

Delete

Edit

### Flights

Schedule

Delete

### Others

Park Plane

Schedule Maintenance

### Park Plane

Select Plane (to Park):

-- Select a Plane --

Select a plane here "before" clicking an empty slot to park it.

Select Parking Slot:

A SR20 (N367SR)    B    C

Hangar Settings

Emergency Stop

### Hangar Settings

Number of Parking Slots (Current: 3)

3

Cancel    Save Changes

### Emergency Stop

Press and hold the button below for 3 seconds to activate.

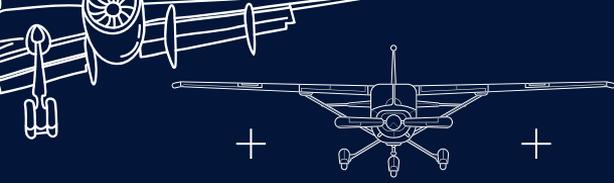
Hold Me

### Manage Planes Status

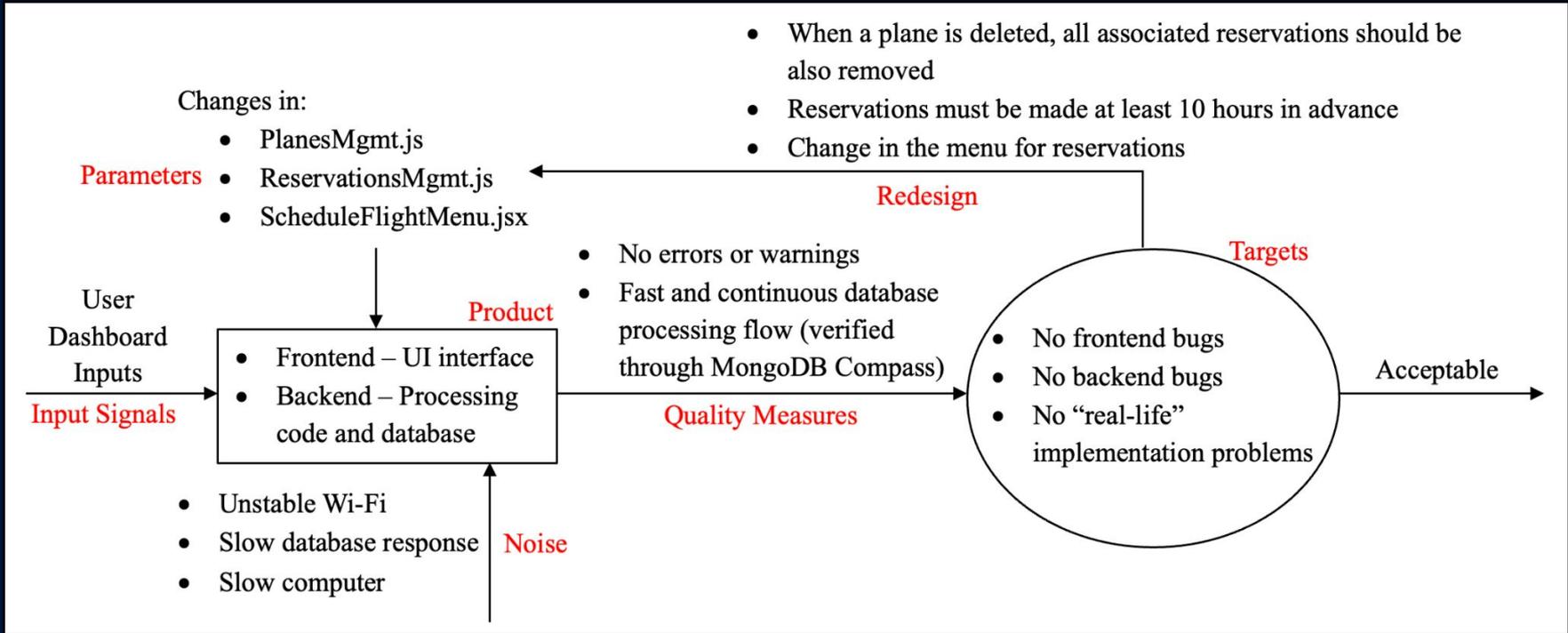
N7294K (Cessna 172S Skyhawk SP)	Ready	Maintenance
N367SR (Cirrus SR20)	Ready	Maintenance
N428LS (Piper PA-28 Cherokee)	Ready	Maintenance
N515DA (Diamond Aircraft DA40 Star)	Ready	Maintenance

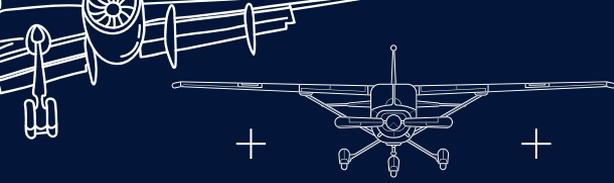
Cancel    Confirm Changes





# Testing Processes





# Video Demonstration

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TEAM D.U.N.G  
DEMONSTRATION



Boston University College of Engineering



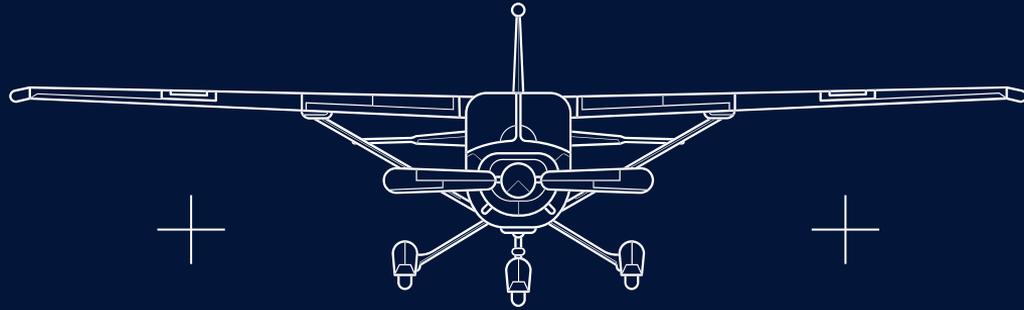


Thank You for  
Listening!

Any Questions?



# Slide Appendix



*Research, Benchmarking,  
and Competitive Assessment*

# Key Resources for Research

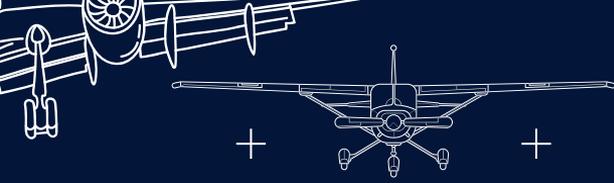
## Customer Insights



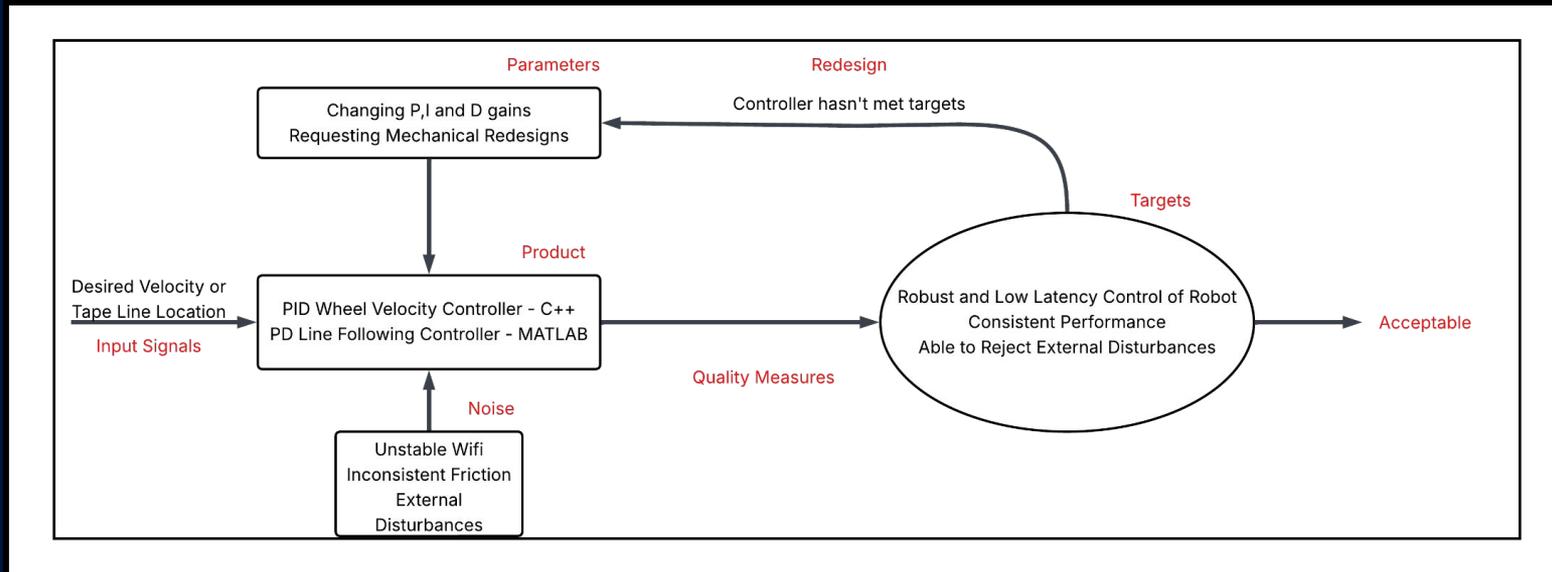
## Amazon Robotics Mentorship

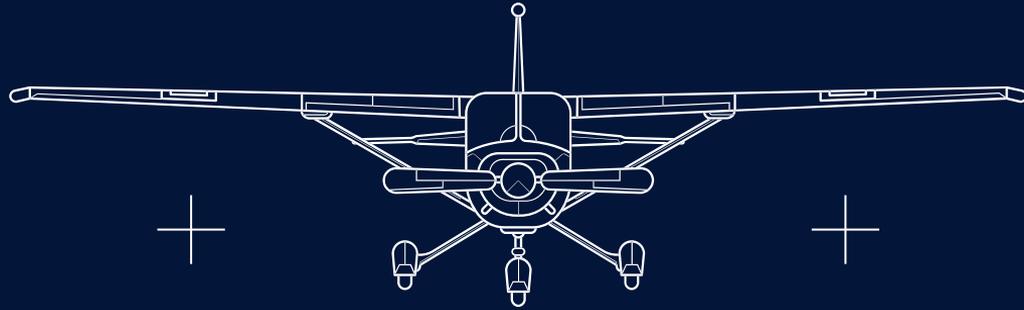


## Technical Papers



# Testing Processes (PID Controllers)





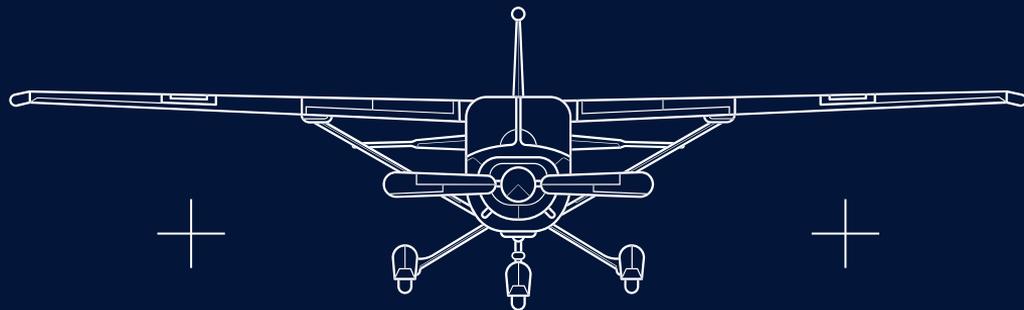
# *Customer Requirements*

# *Customer Requirement Threshold*

**Prevent Hangar Rash:** E-stop detection | Active avoidance

**Not Physically Demanding:** Minimal user input | No user input

**Maneuverable:** No added DOF | Additional DOF added



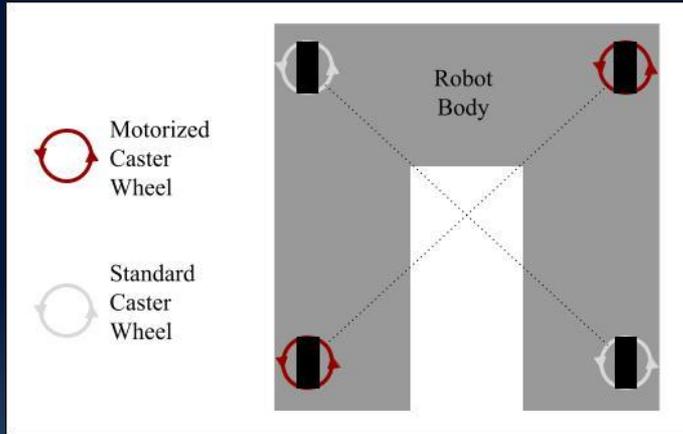
# *Conceptual Design Summary*



# Downselection - Hardware

## Mobility

2 Motorized/2 Standard Casters



## Lifting/Attachment

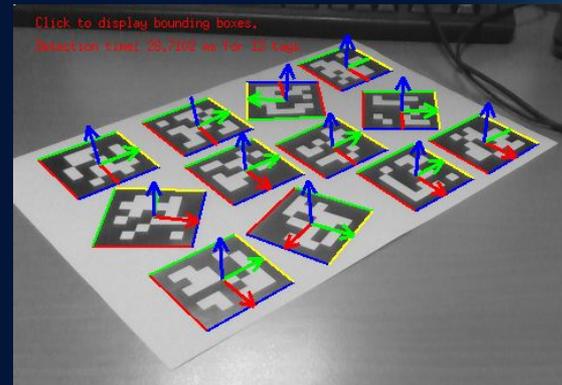
Ramp/Cradle



# Downselection - Sensing

## Sensing

Raspberry Pi Camera , Optical Encoders, Fiducial Markers



# Downselection - Software

## Web Application



Database



API



Front-end



Back-end

**DUNG.**

**Login to your account**

Username

Password

**Login**

[Don't have an account? Sign up here](#)

Welcome, Scott MANTAINER [Logout](#)

Planes

[Add](#) [Delete](#) [Edit](#)

Flights

[Schedule](#) [Delete](#)

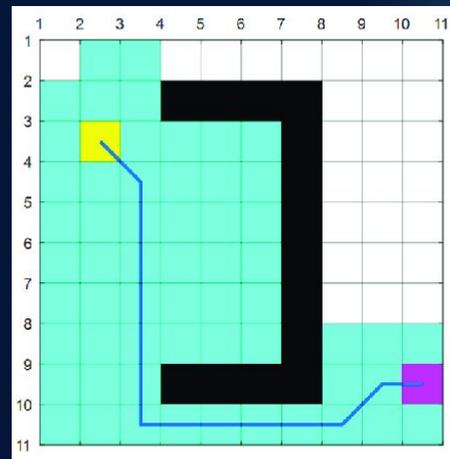
Others

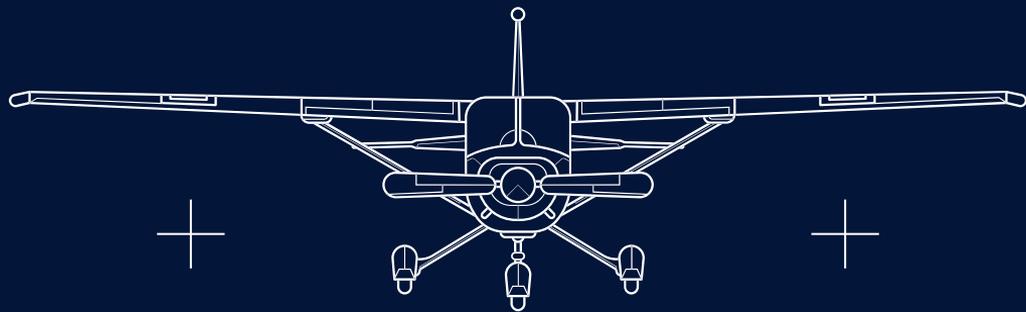
[Park Plane](#) [Schedule Maintenance](#)

[Hangar Settings](#) [Emergency Stop](#)

## Embedded System

Full-Auto, Star Topology, A\*





*Prototype Generation*

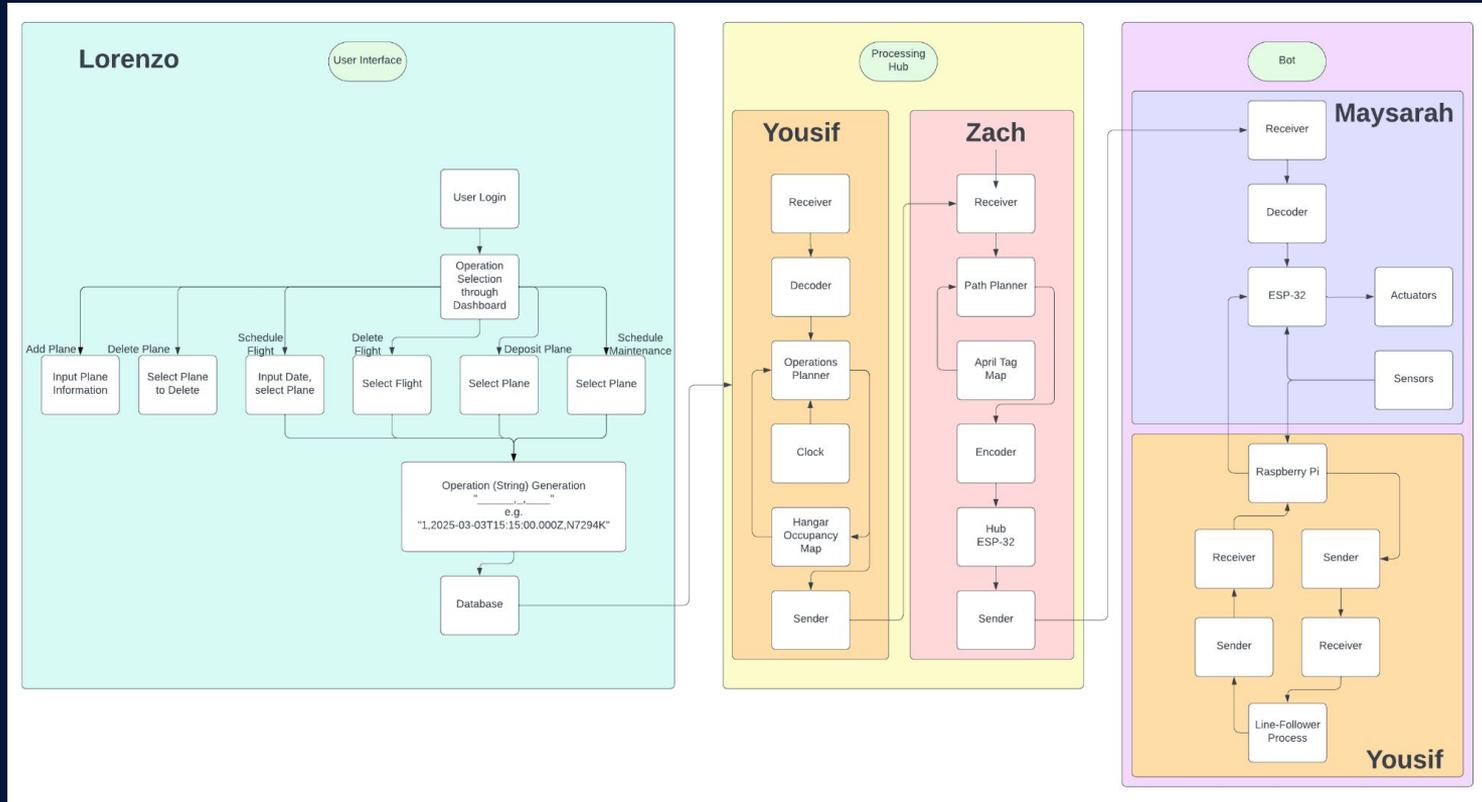
# The ARENA



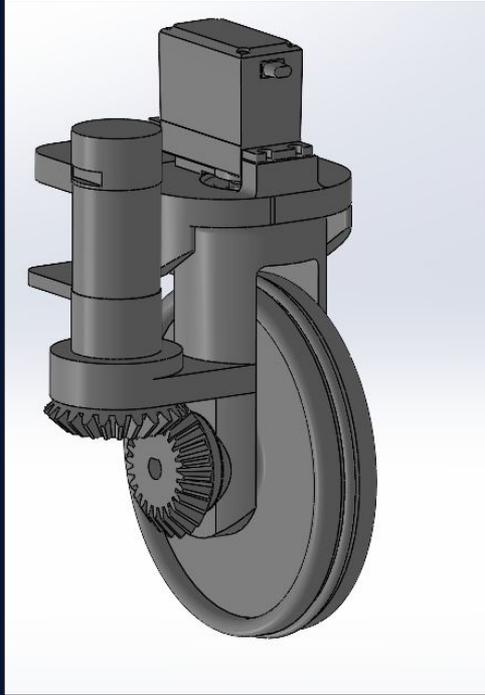
# Some Equipment Used



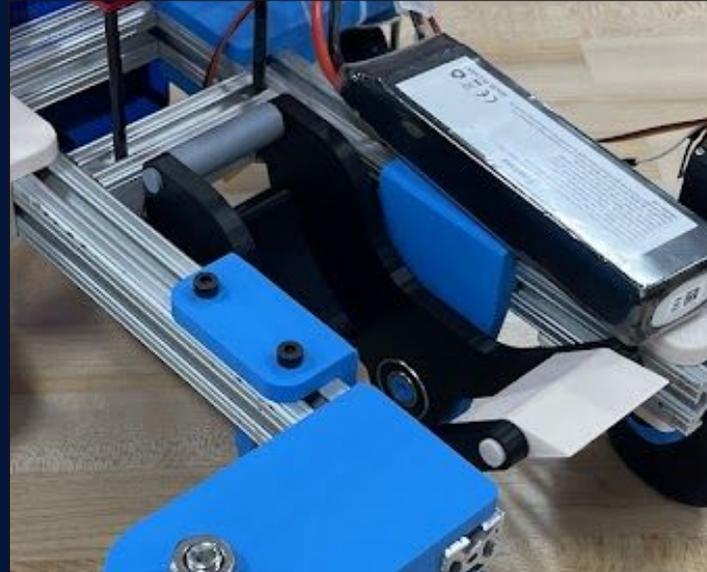
# System Design Approach



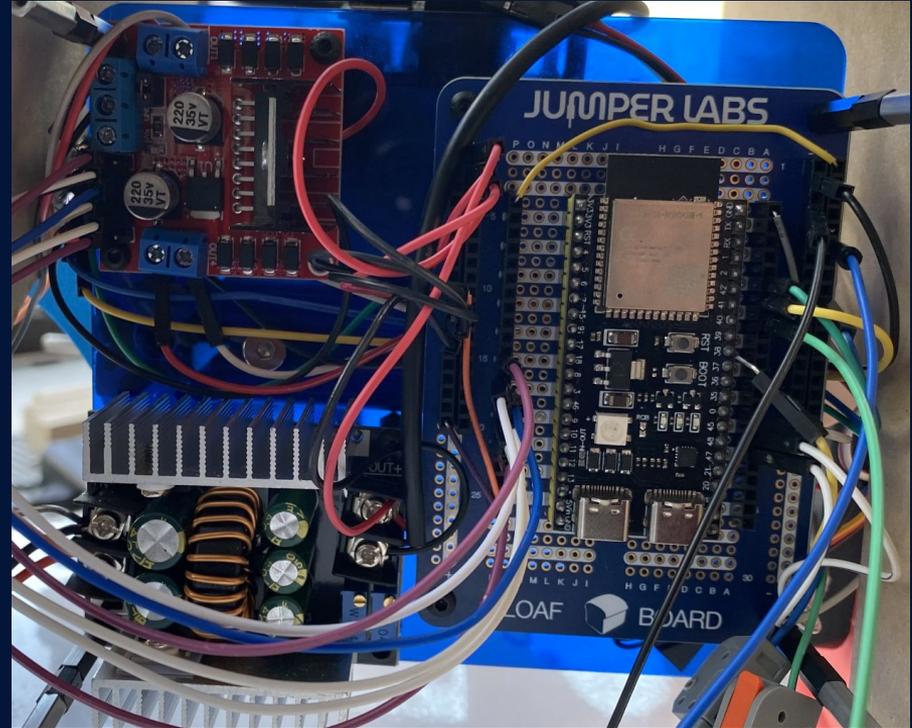
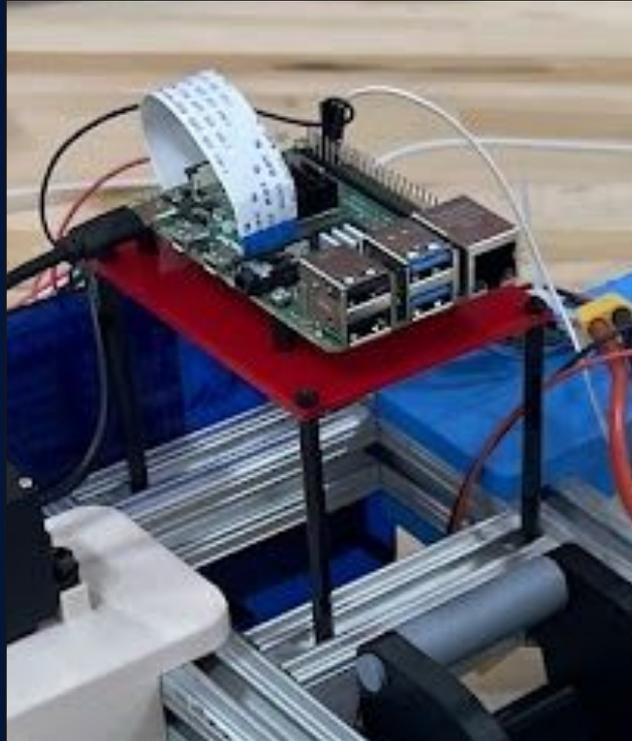
# Movement System



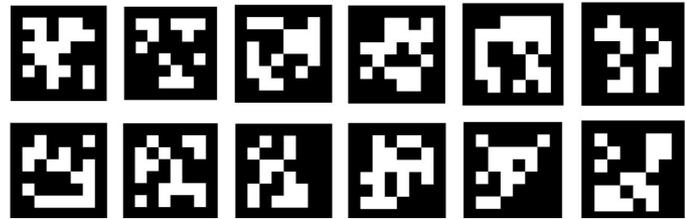
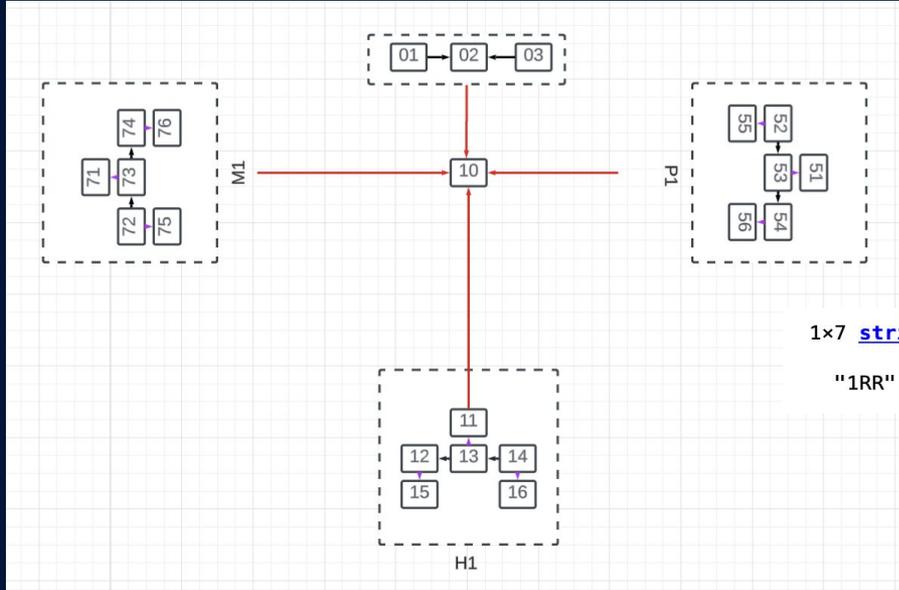
# Lifting System



# Electronics/Sensing



# Motion Planning and Layout



1x7 [string](#) array

"1RR" "2RR" "10FF" "11FF" "13RR" "12RL" "15S"



# UI and UX (1/2)

**DUNG.**

### Create a new account

First name

Last name

Username

Password

Confirm password

I want to be a Maintainer

**Register**

Already have an account? [Login here](#)

**DUNG.**

### Login to your account

Username

Password

**Login**

Don't have an account? [Sign up here](#)

Welcome, **Scott** MAINTAINER

### Planes

**Add** **Delete** **Edit**

### Flights

**Schedule** **Delete**

### Hangar Settings

**Emergency**

### Delete Aircraft

Plane:

- Cessna 172S Skyhawk SP (N7294K)
- Cirrus SR20 (N367SR)
- Piper PA-28 Cherokee (N428LS)
- Diamond Aircraft DA40 Star (N515DA)

### Register New Aircraft

N-No.

Brand

Model

**Cancel** **Confirm**

### Schedule Flight

April 2025

SUN	MON	TUE	WED	THU	FRI	SAT
30	31	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	1	2	3

Time:  :

Plane:

- N7294K (Cessna 172S Skyhawk SP)
- N367SR (Cirrus SR20) (⬇️ Out of service)
- N428LS (Piper PA-28 Cherokee) (⬆️ Out of service)
- N515DA (Diamond Aircraft DA40 Star)

**Park Plane** **Schedule Maintenance**

### Delete Reservation

Filter by Plane:

April 2025

SUN	MON	TUE	WED	THU	FRI	SAT
30	31	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	1	2	3

Reservations for N367SR on Apr 24, 2025:

**Cancel** **Delete Selected**

Delete

Edit

### Flights

Schedule

Delete

### Others

Park Plane

Schedule Maintenance

### Park Plane ✕

Select Plane (to Park):

-- Select a Plane --

Select a plane here "before" clicking an empty slot to park it.

Select Parking Slot:

**A**

SR20  
(N367SR)

**B**

**C**

### Manage Planes Status

N7294K (Cessna 172S Skyhawk SP)	<span style="border: 1px solid #ccc; padding: 2px 5px; background-color: #42a5f5; color: white;">Ready</span> <span style="border: 1px solid #ccc; padding: 2px 5px; background-color: #9e9e9e; color: white;">Maintenance</span>
N367SR (Cirrus SR20)	<span style="border: 1px solid #ccc; padding: 2px 5px; background-color: #9e9e9e; color: white;">Ready</span> <span style="border: 1px solid #ccc; padding: 2px 5px; background-color: #ffc107; color: white;">Maintenance</span>
N428LS (Piper PA-28 Cherokee)	<span style="border: 1px solid #ccc; padding: 2px 5px; background-color: #9e9e9e; color: white;">Ready</span> <span style="border: 1px solid #ccc; padding: 2px 5px; background-color: #ffc107; color: white;">Maintenance</span>
N515DA (Diamond Aircraft DA40 Star)	<span style="border: 1px solid #ccc; padding: 2px 5px; background-color: #42a5f5; color: white;">Ready</span> <span style="border: 1px solid #ccc; padding: 2px 5px; background-color: #9e9e9e; color: white;">Maintenance</span>

Cancel
Confirm Changes

⚙️ Hangar Settings

⚠️ **Emergency Stop**

### Hangar Settings

Number of Parking Slots (Current: 3)

3

Cancel
Save Changes

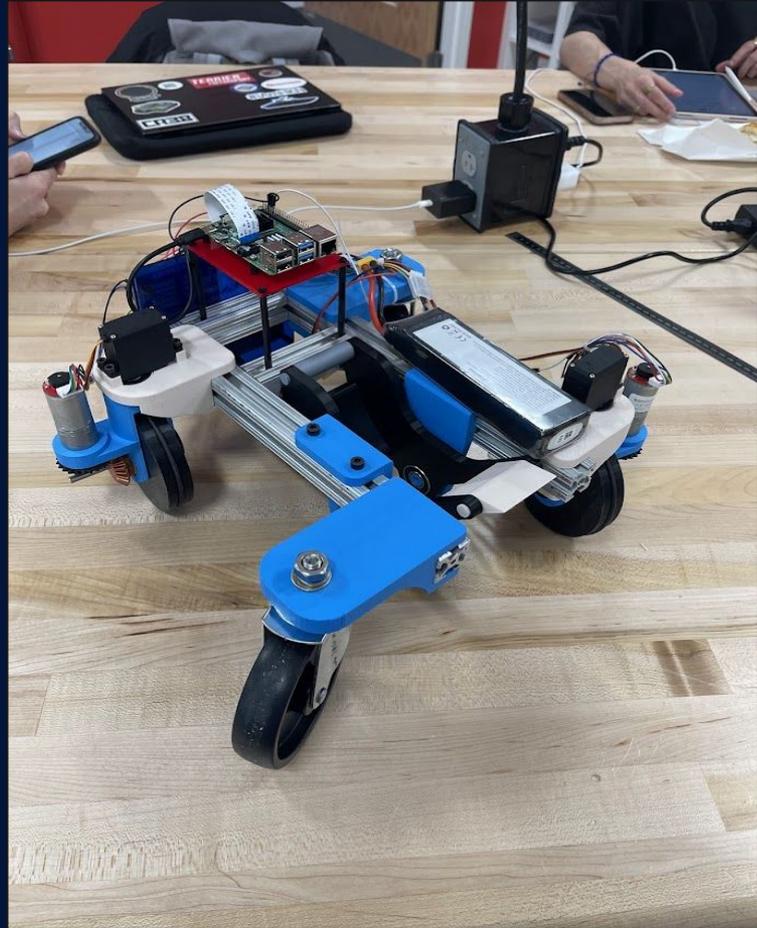
### Emergency Stop ✕

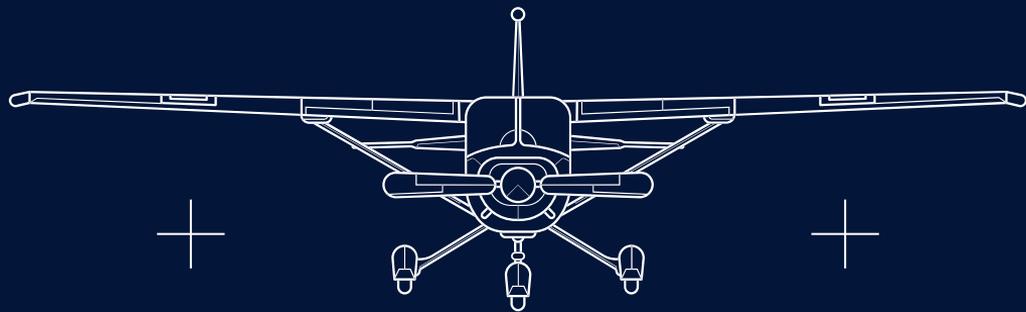
Press and hold the button below for 3 seconds to activate.

⚠️

Hold Me

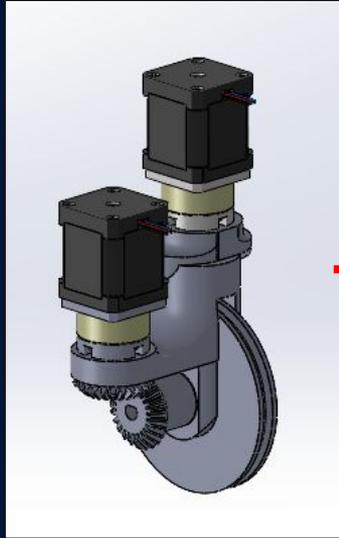
# First Prototype



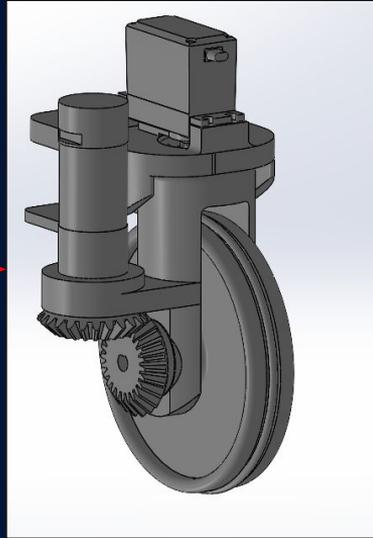


# *Prototype Evaluation*

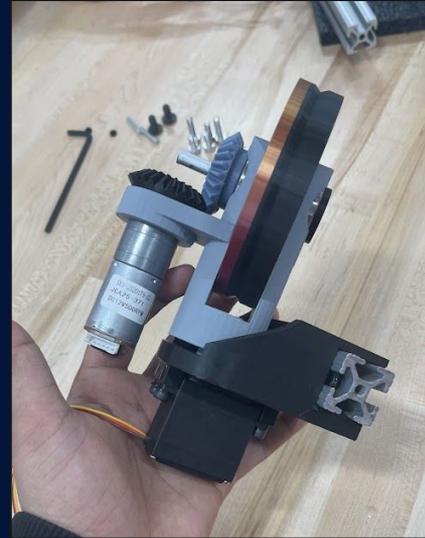
# Motorized Caster Testing



**Initial stepper motor  
design**

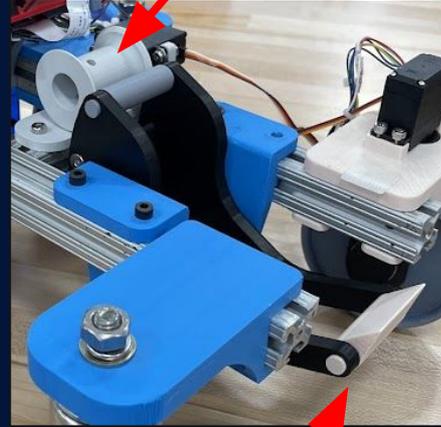
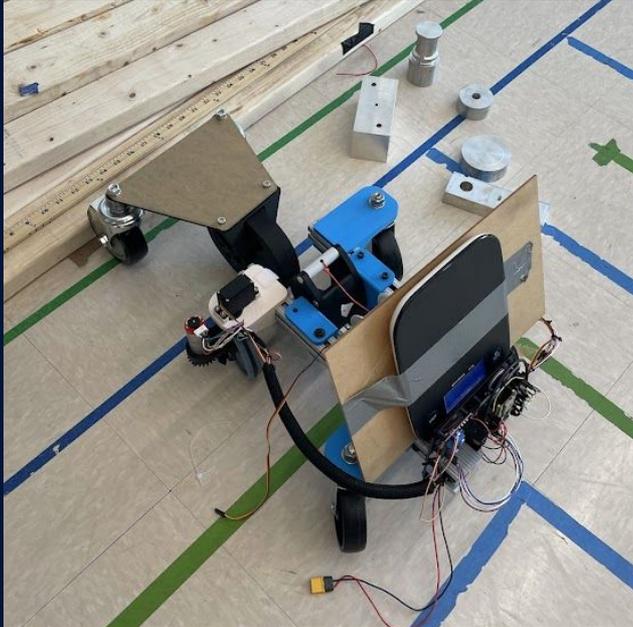


**Finalized design, servo motor  
steering and DC motor drive**

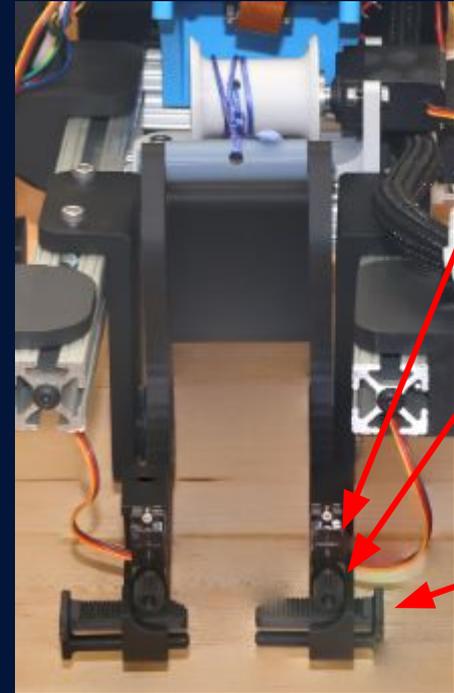


# Cradle Validation Testing

initial testing, mandible testing



**ENTRY  
RAMP**



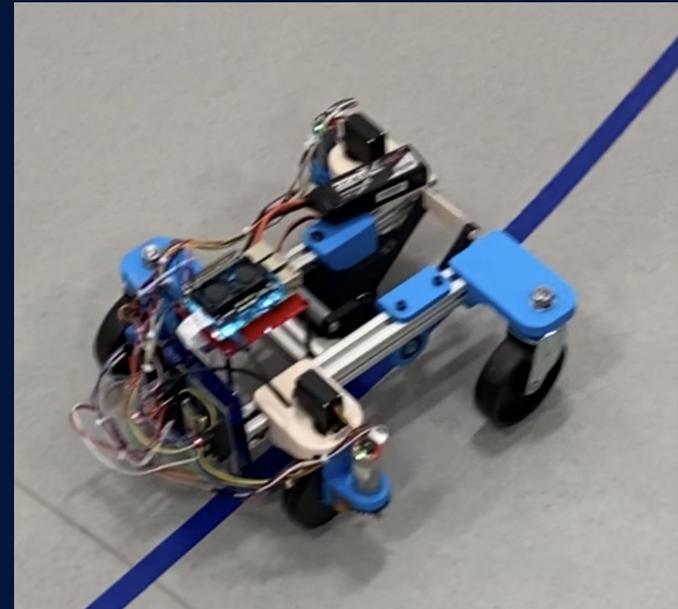
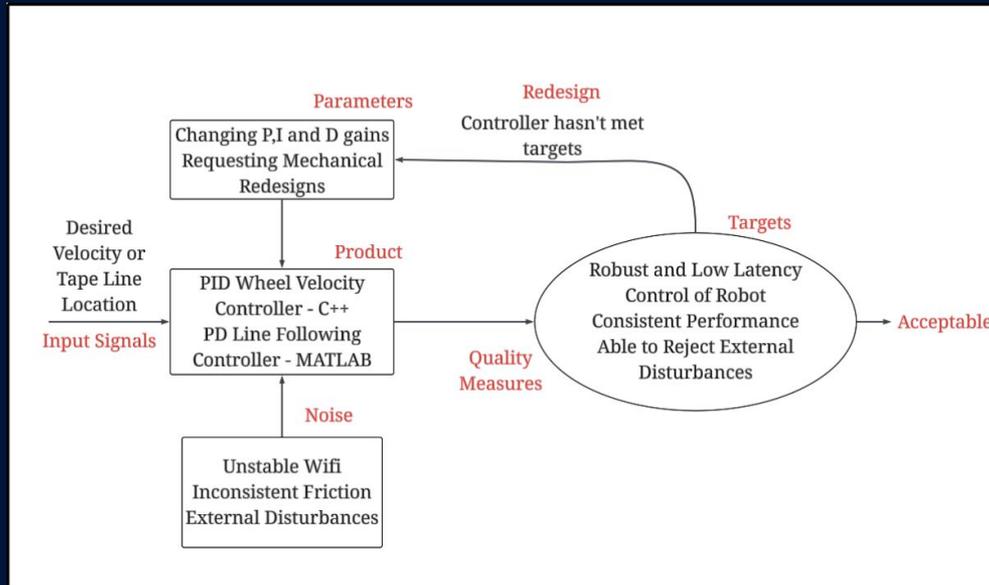
**MICRO  
SERVO**

**PINION  
GEAR**

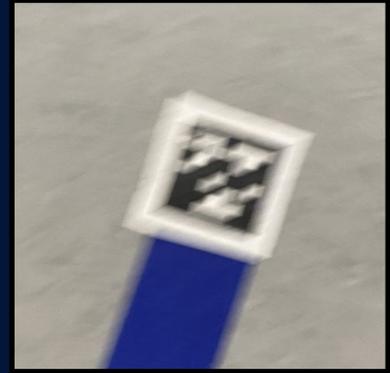
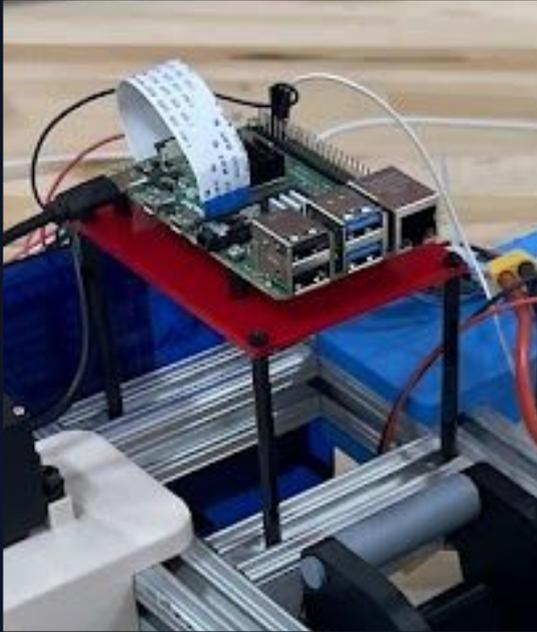
**GEAR  
RACK**

# Functional Software Testing

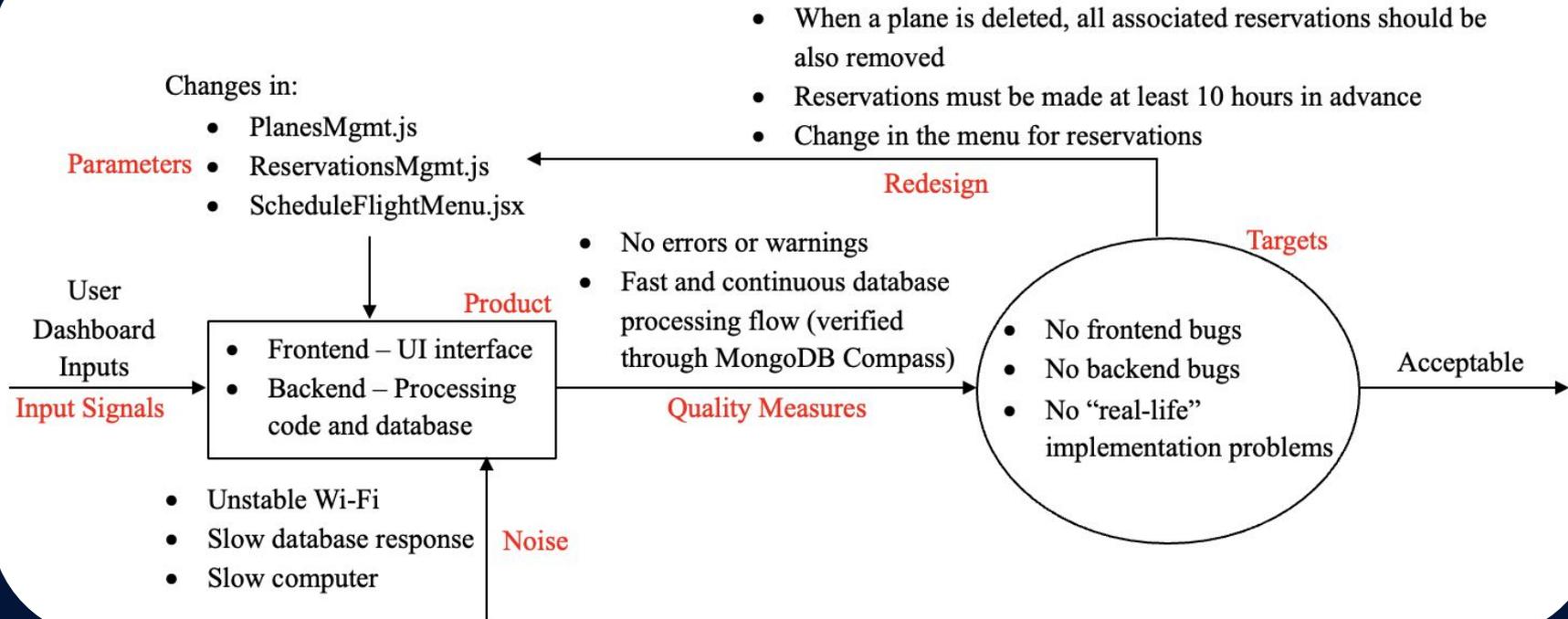
just line following, lifting, etc. simple tests to show it all works



# Camera Vision

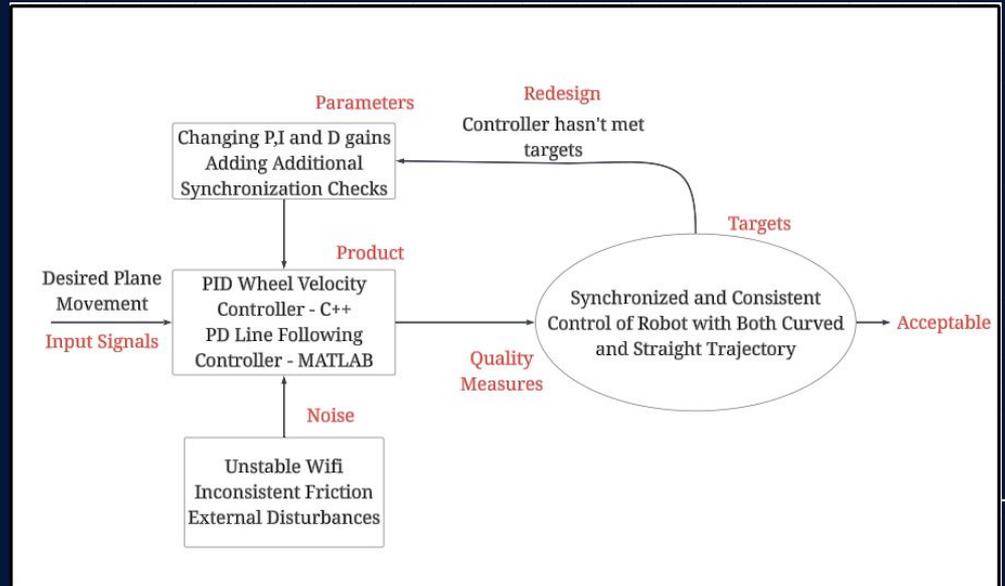
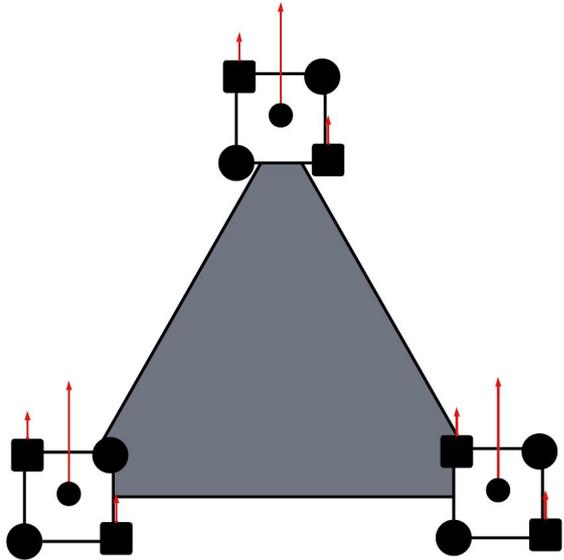


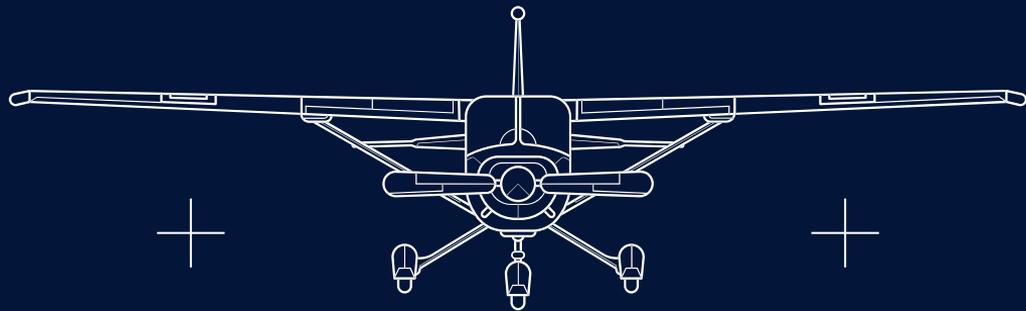
# Web App Testing



# Full System Testing

## Synchronisation and Maneuvering Testing





# *Design Summary*

# Final Conclusions

Final Conclusions and Recommendations. List and discuss your most important technical findings.

