

# **Project Summary**



Problem Statement: "You will start with a lawn mower shell, add motors to propel the wheels, microcontroller to control everything, comms to a wifi network where area to be covered and route will be entered, and a power mechanism (docking station or other)"

- Use lawn mower body and reconfigure for our needs
  - Electric motors for wheel and blade
  - Solar and grid tied charging
  - Docking station
  - Navigate autonomously using various sensors
  - Receive user information about area to mow and scheduling through app



## **Problems and Solutions**

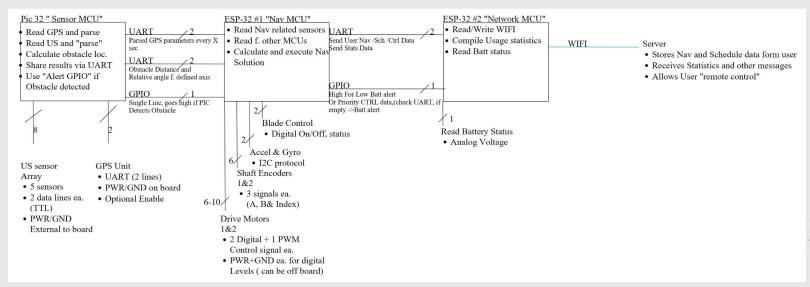


#### **Problems:**

- Obstacle detection issues
  - Insufficient sensors
- PCB miss print
  - Damaged IC
  - Insufficient IO lines
- Lost design files
- Low budget

#### **Solutions:**

- Multi MCU approach
  - allows multiple team members to develop and test simultaneously
  - removes wait time for PCB respin
  - Includes all needed functionality
- Shifting responsibility
  - Max takes over obstacle detection from sensor subsystem
  - Jonathan takes over WIFI from MCU subsystem
  - Vincent begins disassembling mower body now, so that it's integration ready when other subsystems are





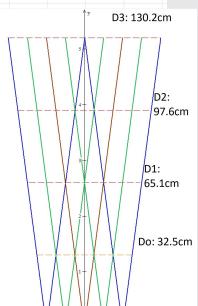
## **MCU Subsystem**





Object in region Do: distance: 61.1835 angle: -75.6016 Dadj: -15.7237 refAngle: 83.3492 Object in region D1: distance: 98.729 angle: 80.8704 Dadj: 15.8931 refAngle: 89.2904 Object in region D2: distance: 98.729 angle: 80.8704 Dadj: 15.8931 refAngle: 89.2904 Object in region D3: distance: 0 angle: 0 Dadj: 0

refAngle: 0



## Status and Plans

#### Right Now

- Sensor array geometry determined
- Front Facing Obstacle detection code
   85% done, some cases tested
- GPS function working and tested

#### Upcoming

- Finish & Implement obstacle detection on PIC-32
  - Detection Grouping
  - Area & point obstacle distinction
  - Transfer to PIC and validation in target
- Side Facing obstacle detection function
  - easier than front facing, only 2 sensors
  - can reuse most of the code from front facing
- Read Sensor array function
  - Pseudo code exists, as well as code from last semester
  - Need to integrate additional sensors
- Clean Up code on PIC

GOAL: Begin integration in 3 week (2/24/2021)



## **User Interface Update**



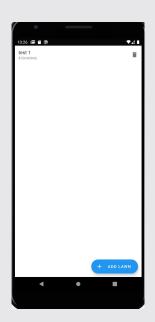
## **Android Application**

- Coded in Java through android studio
- Updates to server in realtime
- User can login through google account
  - Access current location
  - Set markers for each corner of lawn
  - Custom lawns
  - Statistics
  - Schedule Information

## Problems-currently fixing

- Bugs
- Getting statistics and scheduling information to communicate with server









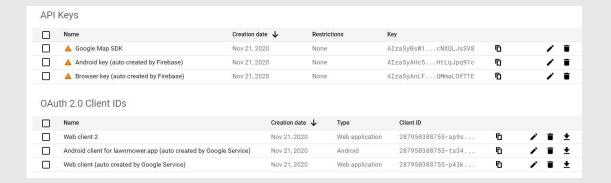


## **Server Update**



## Google Firebase Realtime Database

- Latitude and Longitude from markers placed in app
- Scheduling times
- Statistics from sensors



## Connecting Server to MC

- ESP32
  - WiFi built in-creates own wireless network
  - Just received MC from Max
- Get server to be in same format as input for ESP32
- Will be a priority when bugs and application is fully ready for integration (ET: 1 week)



← https://lawnmower-android-66b33.firebaseio.com/ lawnmower-android-66b33 - cfp1Uk5Vykbdgh44KVlkyFCyE4c2 - test 1 latitude: 30.625424945993725 longitude: -96.33683413267137 latitude: 30.626864025619923 longitude: -96,33480872958899 latitude: 30.626391739817688 longitude: -96.33353836834432 latitude: 30.62498871714939 longitude: -96.33595872670413 test 2 latitude: 30.626843541677534 longitude: -96.34311653673649 latitude: 30.631599162036323 longitude: -96.33817322552204 latitude: 30.627478541875483 longitude: -96.33362386375666 latitude: 30.625203946705884 longitude: -96.33697159588337

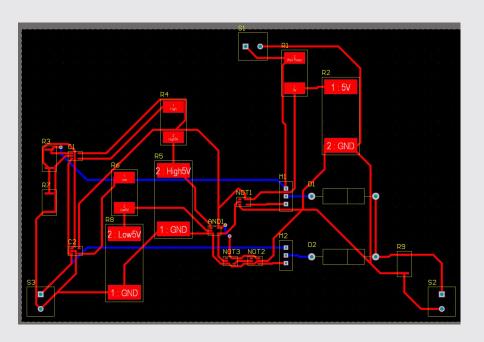
> - latitude: 30.62576481075448 - longitude: -96.34019862860443

P Database location: United States (us-central1)

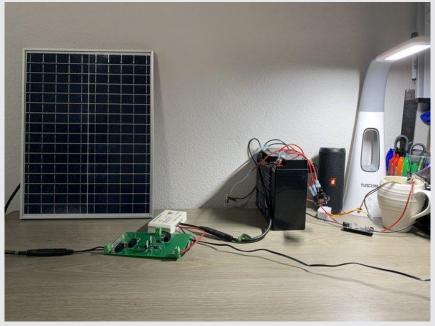


## **Power Supply Subsystem Status**





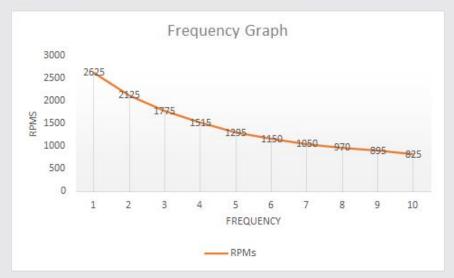
- Used car headlights to simulate the voltages, currents required
- Next Steps
  - Disassemble Lawn Mower
  - Docking Station Assembly

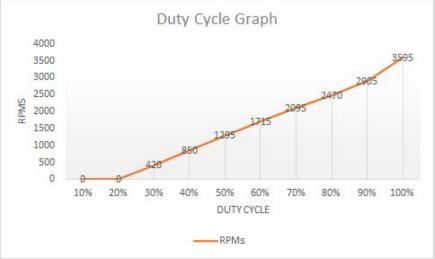




## **Motors Subsystem Status**







IN1	IN2	ENA1	Output	RPM's
0	0	х	Break	N/A
1	1	х	Floating	N/A
1	0	PWM	Forward speed	450
0	1	PWM	Reverse speed	450
1	0	1	Full speed	3500
			forward	
0	1	1	Full speed reverse	3500

The target speed of the mower is 4 mph. Assuming wheels have an 8-inch radius, and assuming weight of the mower affects speed by a factor of 2, the following calculations can be made:

$$\frac{4 \, mi \, \times 2}{1 \, hr} \times \frac{1 \, hr}{60 \, min} \times \frac{5,280 \, ft}{1 \, mi} \times \frac{12 \, in}{1 \, ft} \times \frac{1 \, rev}{2 \pi (8) \, in} = 168.07 \, rev/min \approx 168 \, rev/min$$

- Found relationship between duty cycle and frequency for RPMs using tachometer
- Created control signal table for motor driver
- Created plots for these relationships
- · Given a desired speed and wheel size, a RPM was calculated
- This table shows the different inputs to the motor driver that output different motor speeds

## **Navigation Subsystem Update**



- Original design used GPS module for navigation measurements
- •Testing over the holidays revealed that 10-ft GPS "wander" error is not accurate enough for an "unmanned blade on the run"
- New design uses individual left and right wheel shaft encoders as primary measurement
- Some new math was needed to translate the wheel encoder measurements to the correct position and heading of the mower (rigid body constraint)
- A new Matlab simulation movie will be presented here to demonstrate the recent changes

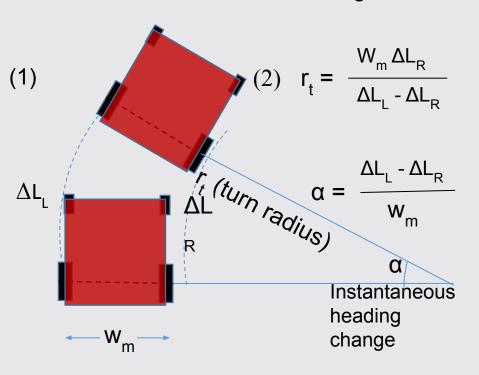


## Wheel Encoder Navigation Calculations



# Turning is initiated by the controller adjusting the relative speed of the right and left wheel motors

- 1. Compute delta distance each wheel moved ( $\Delta L_L$  and  $\Delta L_R$ ) using wheel radius and shaft encoder change
- 2. Convert distances to turn radius and heading change in mower coordinates (rigid body)
- 3. Convert turn radius and heading change to  $\{\Delta x, \Delta y\}$  (changes in mower coordinates)
- 4. Convert mower coordinates to ground coordinates (heading rotation)



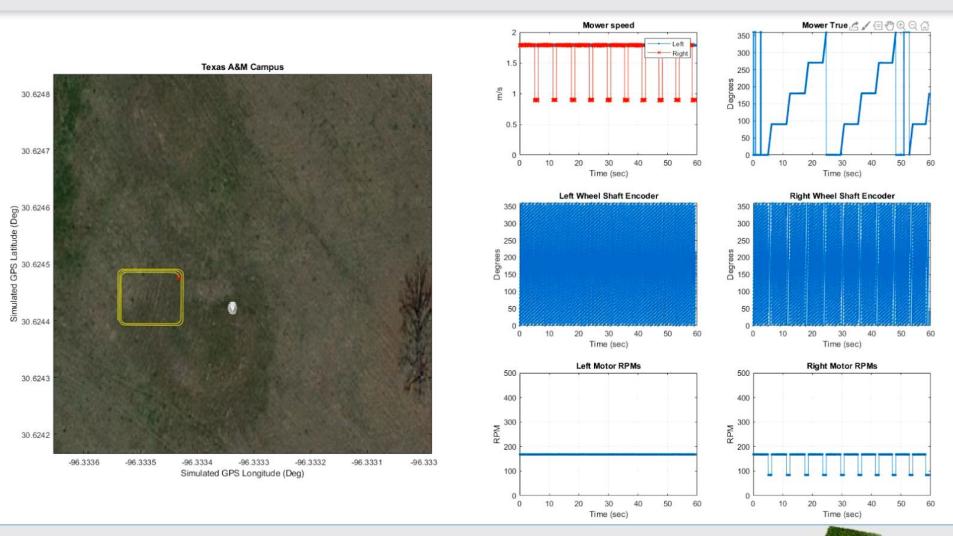
(3) 
$$\Delta x = (w_m/2 + r_t) (1-\cos\alpha)$$
  
  $\Delta y = (w_m/2 + r_t) \sin\alpha$ 

(4) Rotate mower coordinates into ground coordinates using previous heading

$$\begin{bmatrix} x_{g} \\ y_{g} \end{bmatrix} = \begin{bmatrix} +\cos h \sin h \\ -\sin h \cos h \end{bmatrix} \begin{bmatrix} x_{m} \\ y_{m} \end{bmatrix}$$

# **Simulation Updates Using Navigation Updates**





Next step: Convert Simulation code to C for MCU to test on lawnmower

# **Schedule for the Semester**



Pink: Presentation Week	1/19/2021	1/26/2021	2/2/2021	2/9/2021	2/16/2021	2/23/2021	3/2/2021	3/9/2021	3/16/2021	3/23/2021	3/30/2021	4/6/2021	4/13/2021	4/20/2021	4/27/2021
Entire system															
Final Demo															
Final Presentation															
Final Report															
Obstacle detection construction															
Obstacle detection validated															
Obstacle detection & GPS MCU validation															
Obstacle detection & GPS MCU integration															
Power Supply Testing and Validation															
Lawnmower Shell Deconstruction															
Lawnmower Shell Cleaning															
Docking Station Data Collection															
Docking Station Assembly						Ī									
Docking Station Testing															
Docking Station and Power Supply Integration															
Docking Station and Power Supply Testing															
Docking Station and Power Supply Integration with other systems															
User Interface Bug Fixing															
User Interface Integration, Validation															
ESP32 MC Setup, Integration, & Validation															
Navigation subsystem design and testing															
Navigation subsystem integration															
Motors subsystem integration															
COLOR LEGEND															
Subsystem construction and testing															
Integration															
System Validation															
Buffer															
Paperwork															



# **Validation Plan**



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3.2.1.2 Duty cycle The system shall perform operations a least every 7 days. 3.2.1.3 Duty cycle The system shall parform operations a least every 7 days. 3.2.1.3 Distacle Avoidance The system shall avoid all obstacles that are harmful to the coverall system, running over small obstacles that only impact blade sharpness or appearance is acceptable 3.2.1.9 Distacle detection Range and Threshold The system shall avoid all obstacles that are harmful to the coverall system, running over small obstacles that only impact blade sharpness or appearance is acceptable 3.2.1.4 Distacle detection Range and Threshold The system shall be aware of any obstacle in the hypothetical box extending forward from the front of the mower to 2M, as wide as the widest point of the mower 3.2.2 Physical characteristics The moving unit shall not exceed a maximum weight of 70lbs 3.2.2.1 Mass The moving unit shall not exceed a maximum weight of 70lbs 3.2.2.2 Notume Envelope The volume envelope of the Lawmnower shall be least than or equal to 30 inches in height, 25 inches in width, and 40 inches in length. 3.2.3.2 Bleatrical Characteristics Definitions of expected external inputs and outputs 3.2.3.3.1 Power Consumption The system shall not be damaged by any possible inputs or signals produced by the system, No user input shall result in the system engaging in unsafe or damaging operations 3.2.3.1.1 Power Consumption The power consumption of the lawmnower unit shall not exceed 200 Watts. 3.2.3.1.1 Exput Voltage Level The input voltage level of the lawmnower unit shall not exceed 200 Watts. 3.2.3.1.2 Expute Consumption The power consumption of the lawmnower unit shall not exceed 200 Watts. 3.2.3.2.1 Disput Consumption The work of the lawmnower shall be 142 VDC to 14.4 VDC. 3.2.3.3.1 Event Consumption The winning of signal and antibodic power of the shall be avoid to signal produced by a will connection. Details will be outlined in the ICD. 3.2.3.2.1 Disput Ordinal Provides Level The moving unit shall inform the user of problems and fault condit	Requirement title and heading, as found in the FSR	Abridged text of requirement (see FSR for full text)	tatus										
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