Autonomous Lawnmower

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ECEN 404-904 Team 30

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 (looking towards interfacing):

- Attachment of major components
- MCU interface
  - O-Det MCU to Nav MCU
  - Nav MCU to WIFI MCU
- US sensors have issues detecting object with fabric
  - Readings for objects covered in fabric (f.e. person wearing sweatshirt) extremely inaccurate and unreliable
- Whole System Start Stop Logic

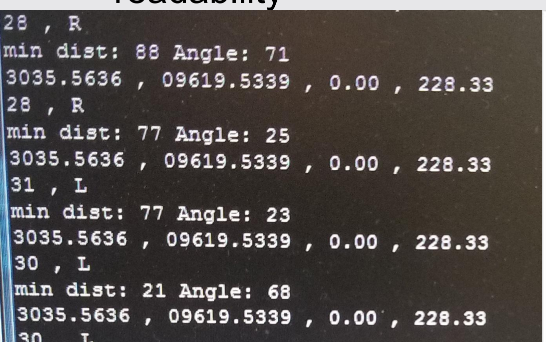
Solutions:

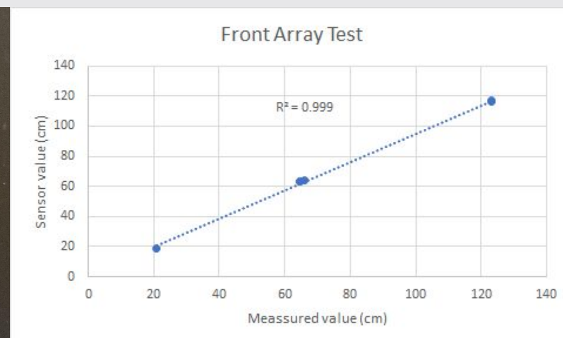
- Mounting of Major components: begin work next week
- MCU interface (Nav-ODet)
  - UART, Comma delimited fields
  - GPIO Pin to alert when obstacle is within close range
  - Need to specify remaining details (<CR><LF>s, order, frequency), easily adjustable in code
- MCU interface(ODet-Network)
  - Communicating through WiFi
  - Using Primary and Secondary IDE Files for each each ESP32
- Person detection
  - Include Bump/contact sensor in front
  - More extensive tests with full array, may be possible to determine fabric with multiple sensors.
- Start-Stop
  - WIFI MCU controls start/stop,
  - controls PSU relay to power on/off system as needed,

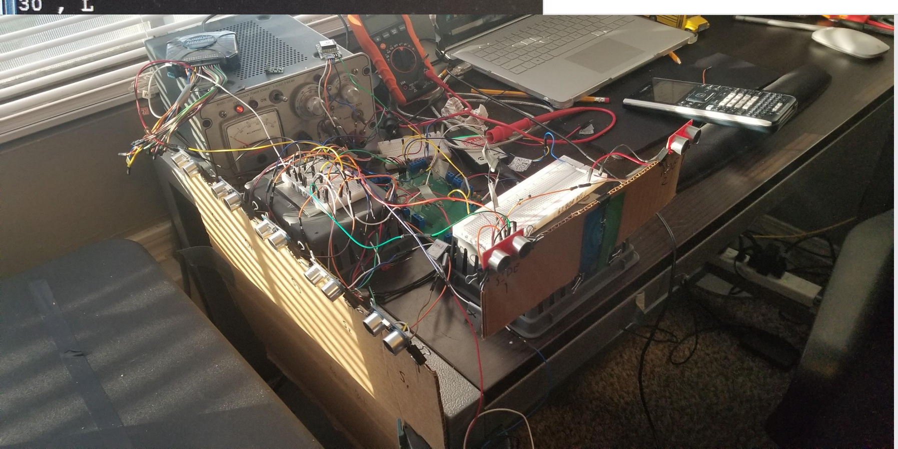
MCU Subsystem (Obstacle detection)

Object: Cardboard Box (11.4x13.4x31.75) cm (WxDxH)
Binder (26 X 29) cm (WxH

- Preliminary tests give distance error < 5cm
- detects correct side
- operates continuously (and produces accurate data) for 60+ minutes (not reported here as data taken with mockup array
- Side detect tested for functionality only due to current setup
- Sample output below, still formatted for Human readability







Status and Plans

- **Right Now**
  - Front & Side Obstacle detection & GPS implemented
  - Full Program Stamina test: Runs for 90+ minutes continuously
  - Preliminary validation of Obstacle detection GPS Validated last semester
  - 3D Printing US Mounts
  - Code Cleaned Up & Simplified

  Set Backs
  - Major Bug causing system crash
  - Original Array assembly method cost prohibitive
  - Sensors to inaccurate, obstacles to ambiguous to work with previous code

  Upcoming
  - Build Array module
  - Finalize Nav MCU interface
    - Agreed on preliminary message format, need to finalize exact details
  - Integrate Obstacle detection with mower body
- **GOAL: Roughly Integrated by 3/9, (Yes, That's behind schedule,**

User Interface/Server Update

-Tested battery status

- Shows on android application

-Will calculate other statistics using battery

-Plan on adding default lawn option to application

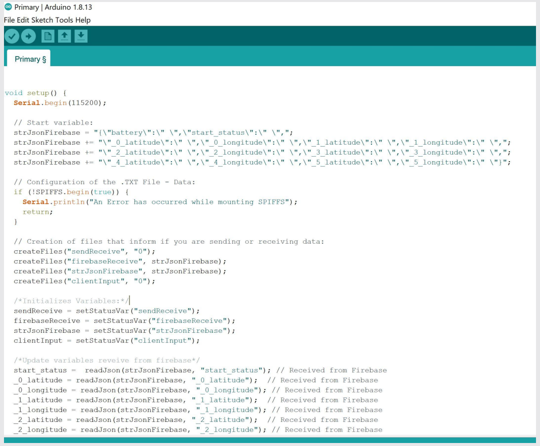
```
// Task TaskRemoteControl - Send and Receive Data from Firebase
void TaskRemoteControl( void * pvParameters ) {
  for (;;) {
    if (sendReceive.toInt() == 1) {
      // Send Firebase
      xSemaphoreTake(myMutex, portMAX_DELAY);
      if (Firebase.setString(fbdo, "/cfp1Uk5Vykbdgh44KVlkyFCyE4c2/battery", "low battery"))
      {
        //Success
        Serial.println("Set string data success");
      } else {
        //Failed?, get the error reason from fbdo
        Serial.print("Error string setString, ");
        Serial.println(fbdo.errorReason());
      }
```

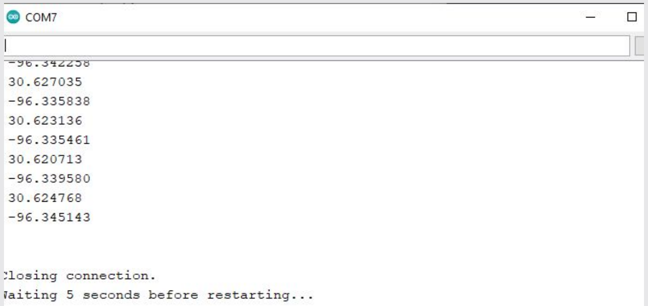
https://lawnmower-android-66b33.firebaseio.com/

lawnmower-android-66b33
battery: "low battery"
cfp1Uk5Vykbdgh44KVlkyFCyE4c2
  battery: ""
  custom_lawns
    test1
      locations
        mapPositions
          0
            latitude: 30.6251892326361
            longitude: -96.342258229851
          1
            latitude: 30.627035398151
            longitude: -96.335838362574
          2
            latitude: 30.62313558817
            longitude: -96.335460841655
          3
            latitude: 30.62071287796911
            longitude: -96.339580379426
          4
            latitude: 30.62476800537791
            longitude: -96.345142945647
      schedule
        daysInWeek
        startHour: 22
        startMinute: 1
  estimated_time_remain: "15h"
  home_status: false
  start_status: false

WiFi Update

- Wrote two arduino IDE files
  - **Primary (ESP 32 → Server)**
    - Will be able to receive statistics
  - **Secondary(ESP 32 → ESP 32)**
    - Tested sending coordinates
- Both Microcontrollers communicate through WiFi
- Josh, Max, and I have agreed on coordinate format.





Motors Subsystem Status

Motors subsystem ready to integrate

Navigation Subsystem Update

- Setup Arduino IDE
- Successfully compiled and uploaded a C test routine to control a GPIO pin on the ESP32 using LEDs
- Compiled and uploaded the navigation code to the ESP32 using Arduino IDE (no errors)
  - Inserted software to send PWM to the motor driver via GPIO
  - Created code to generate a hardware interrupt and a Interrupt Service Request (ISR) so that when channel A and channel B meet certain conditions, we increment the shaft encoder counts
- Plans are to incorporate the shaft encoder interface, GPS, and obstacle detection to the code and run a motor test before integration this weekend.

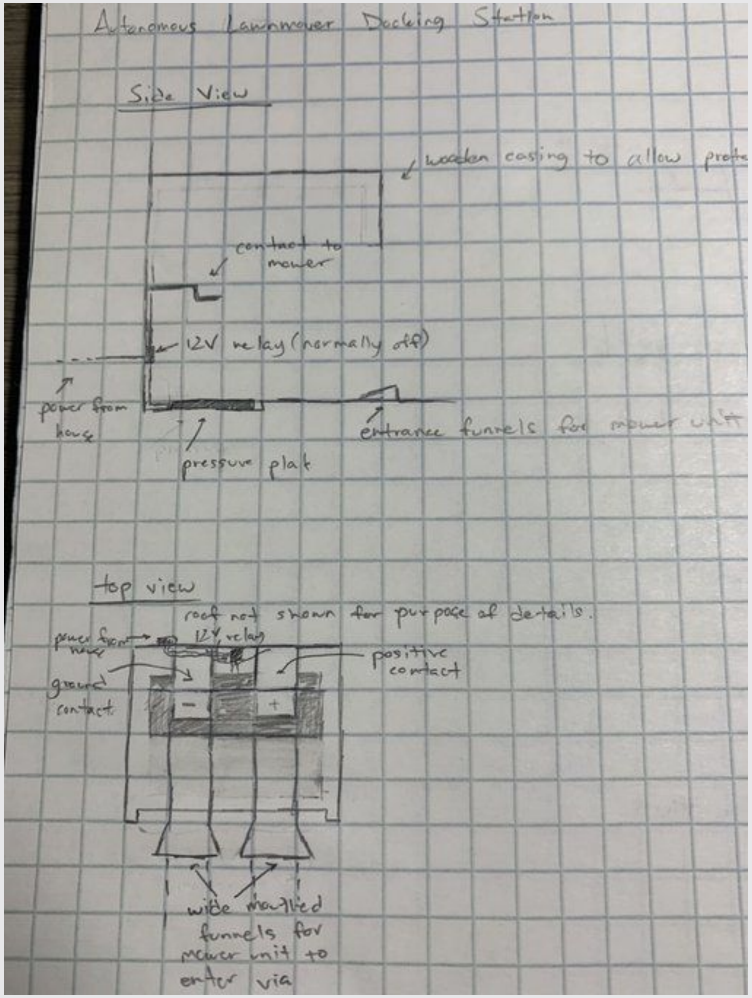
Navigation cont.

Snippet of PWM code

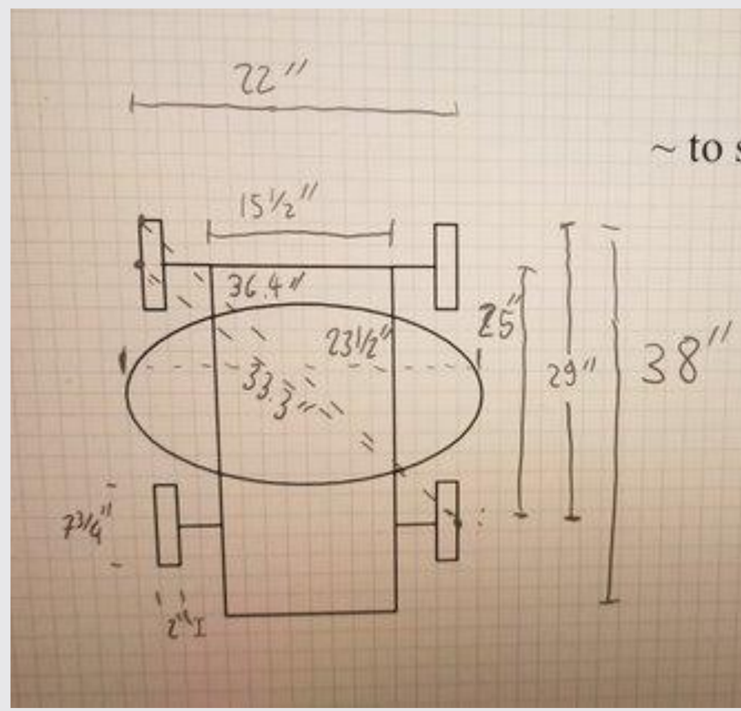
```
// configure PWM functionalitites

ledcSetup(L_Channel, freq, resolution);

ledcSetup(R_Channel, freq, resolution);

// attach the channel to the GPIO to be controlled

//ledcAttachPin(Pin, Channel);

ledcAttachPin(Pin2, L_Channel);

ledcAttachPin(Pin3, R_Channel);
```

```
L_rpms_desired[n] = v_mow_normal_mph * mph_to_mps * mps_to_rpms;

R_rpms_desired[n] = v_mow_turn_mph * mph_to_mps * mps_to_rpms;

L_duty[n] = (L_rpms_desired[n] / 43.0) + 20.0;

R_duty[n] = (R_rpms_desired[n] / 43.0) + 20.0;


dutyCycle = round(L_duty[n] / 100.0 * 255.0);

ledcWrite(L_Channel, dutyCycle);

dutyCycle = round(R_duty[n] / 100.0 * 255.0);

ledcWrite(R_Channel, dutyCycle);
```

Docking Station Update

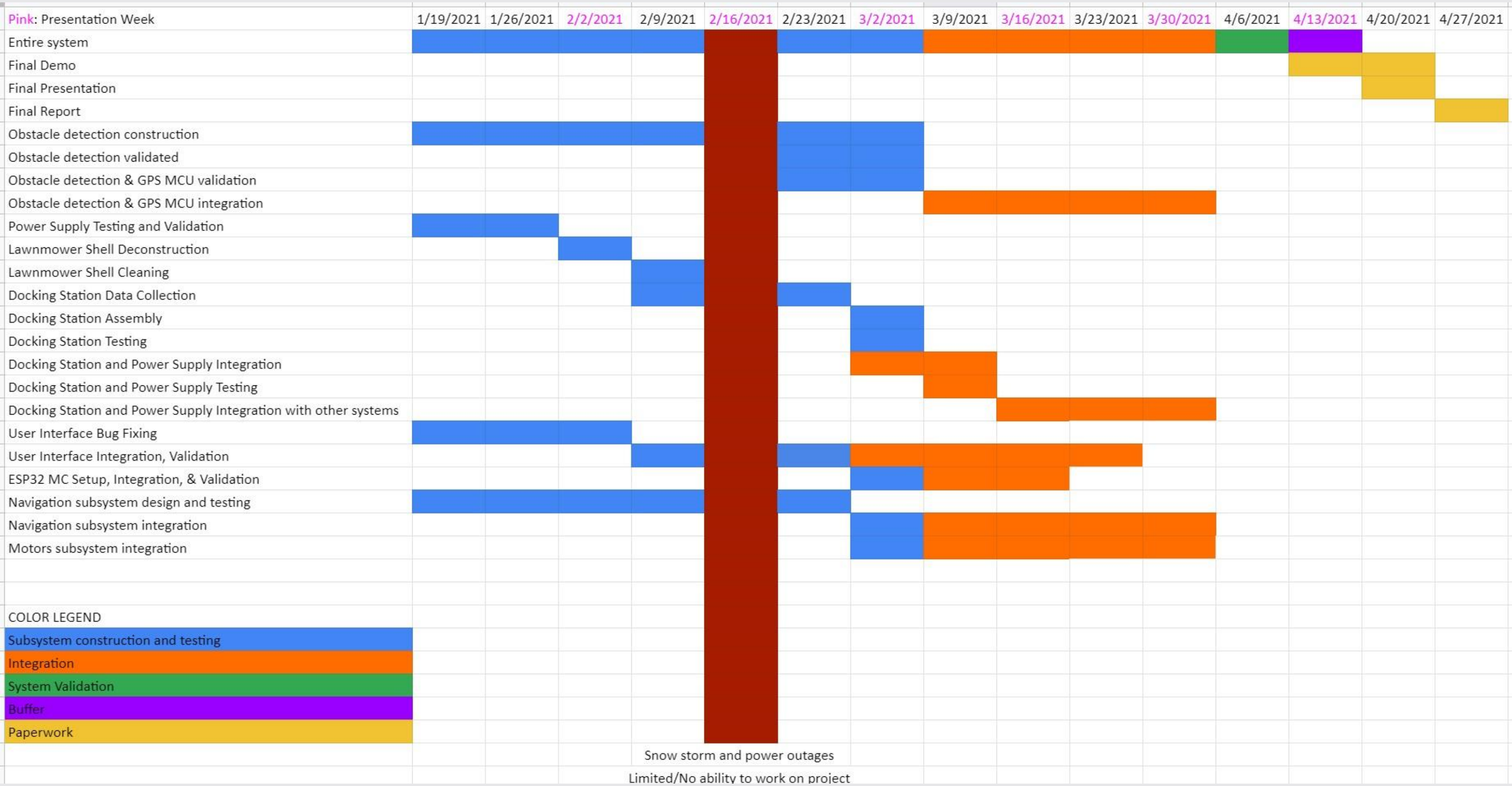


- Lawnmower has been disassembled and cleaned
  - Need to figure out when it can be brought to the FEDC
- Next step is to assemble the docking station



Approximately to scale, each square represents 2 inches by 2 inches

Schedule for the Semester



Validation Plan

Requirement title and heading, as found in the FSR	Abridged text of requirement (see FSR for full text)	Methodology	Status	Responsible team member	Validated By
3.2.1 Functional/Performance requirements	Performance requirements for the compelates system				
3.2.2.1 Operational Stamina	The system shall mow grass continuously for no less than 1 hour in flat, obstacle free terrain	Time operation of system under normal conditions		All	
3.2.1.2 Duty cycle	The system shall perform operations at least every 7 days.	Validate Solar/grid charging rate against power consumption in above test		All	
3.2.1.3 Obstacle Avoidance	The system shall avoid all obstacles that are harmful to the overall system, running over small obstacles that only impact blade sharpness or appearance is acceptable	Individual evaluation of obstacle detection and navigation function under realistic input. Full system validation in Realistic terrain		J. Samaniego & M. Lesser	
3.2.1.4 Navigation	The system shall use internal sensors to follow a spiral pattern within the boundaries outlined by the user	Simulation of Nav-code, Full system test under realistic conditions		J. Samaniego	
3.2.1.5 Obstacle 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	Individual test of Obstacle detection function, in final configuration		M. Lesser	
3.2.2 Physical characteristics	Physical Requirements on the completed system				
3.2.2.1 Mass	The mowing unit shall not exceed a maximum weight of 70lbs	Weigh final system		All	
3.2.2.2 Volume Envelope	The volume envelope of the Lawnmower shall be less than or equal to 30 inches in height, 25 inches in width, and 40 inches in length.	Measure final system		All	
3.2.2.3 Mounting	All components shall be mounted in a fashion to resist vibration incidental to lawnmowing, with service once every 6 months when used weekly	Test connection manually, not able to perform full test, will have to extrapolate results gained from other tests		All	
3.2.3 Electrical Characteristics	Definitions of expected external inputs and outputs				
3.2.3.1 Inputs	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	Provide mower with all possible input signals and observe performance		All	
3.2.3.1.1 Power Consumption	The power consumption of the lawnmower unit shall not exceed 200 Watts.	Measure battery discharge level after use		V. McMasters	
3.2.3.1.2 Input Voltage Level	The input voltage level for the Lawnmower shall be 14.2 VDC to 14.4 VDC.	Measure input voltage to battery from charging station		V. McMasters	
3.2.3.1.3 External Commands	The Lawnmower system shall receive external commands from the User Interface via a WIFI connection. Details will be outlined in the ICD.	Attempt to transmit Nav/Schedule commands from app and see if mower responds		J. Poulose	
3.2.3.2.1 Data Output	The mowing unit shall inform the user of problems and fault conditions through the UI app via WIFI.	Generate Fault conditions on mower and see if reports to user		J. Poulose	
3.2.3.2.2 Diagnostic Output	The MCU shall include a hardware debugging port that may be interfaced to a computer for Diagnostics.	Physical validation of hardware access ports		M. Lesser	M. Lesser
3.2.3.3 Connectors	(Electrical) Connectors shall be resistant to vibration incidental in lawnmowing, with service no more than once per 6 months when used weekly	Extrapolate from other physical trials		All	
3.2.3.4 Wiring	The wiring for signal and power interfaces shall be routed clear of any moving internal parts, and clear of all possible outside interference. And protected as appropriate	Visual inspection of completed system		All	
3.2.4 Environmental Requirements	The Lawn mowing system shall operate in all environmental conditions that traditional residential lawn mowers operate and lawn care activities take place.	Test in as many environmental conditions as possible and extrapolate			
3.2.4.1 Thermal	The Lawnmower shall operate in temperatures ranging from 40°F to 120°F.	see 3.2.4		All	
3.2.4.2 External Contamination	The Lawn mower shall be immune to dust and debris. The Lawn mower systems shall either be protected from, or insensitive to ingress of debriess 1mm or larger, as well as dust.	see 3.2.4		All	
3.2.4.3 Rain and extreme weather	The Lawn mower shall not operate in rain. It shall be able to withstand exposure to the elements when parked in the docking station.	see 3.2.4		All	
3.2.4.4 Humidity	The Lawnmower shall function temporarily in conditions of up to 100% humidity, but requires lower humidity or higher maintenance for long term storage and performance.	see 3.2.4		All	
3.2.4.5 Soil Moisture	The Lawn mower shall be able to operate on moist, but not wet solid, on level terrain.	see 3.2.4		All	
3.2.4.6 Distance from Router (WIFI connection distance)	The Lawnmower shall be able to communicate with the network at the operating site from at least 100 ft and through at least 1 wall of wood/drywall construction	see if mower responds when specified distance from WIFI router		J. Poulose	
3.2.4.7 Sky clearance	The Lawnmower shall be able to operate with light to medium foliage overhead	test GPS unit in mounting configuration under specified overhead cover		M. Lesser	
3.2.4.8 Vibration	The Lawnmower system shall operate without failure, under vibration incidental to lawn mowing for at least 6 months, when operated once weekly for 1 hour.	see 3.2.4		All	
3.2.5 Failure Propagation and protocols	No failure shall cause to mower to endanger bystanders				
3.2.5.1 Blade error	The lawnmower's user interface will notify the user if the blade is stuck on an obstacle. In this case the blade will shut down automatically	Simulate stuck blade and validate mower sends error message and disabled blade drive		J. Samaniego & J. Poulose	
3.2.5.2 Mower stuck	If the mower becomes stuck in terrain it shall power down, disabling the blade and alert the user.	simulate/force mower to become stuck and monitor response		J. Samaniego & J. Poulose	
3.2.5.3 Lost Wifi connection	In cases where the WIFI connection to the user device is lost the mower will continue on its planned route and return to the rest position.	disable WIFI router and monitor response		All	
3.2.5.4 Lost GPS connection	If the mower loses GPS connection it shall attempt to follow the planned route to the best ability.	disable GPS module and monitor response		M. Lesser & J. Samaniego	
3.2.5.5 System Failure	In cases of system failure the mower shall alert the user through the UI, disable the main blade and return to the start position, if possible	Simulate system failure, (f.e. by disconnecting sensors O.S.) and monitor response		All	
3.2.5.6 Critical System Failure	In Critical Failure cases, that is situations in which the MCU loses all ability to control the mower or it's subsystems the lawnmower blade will shut off.	Power down MCU during operation and monitor response		All	

Legend	
Not Yet Validated	
Falied	
Passed	
Revised/adjusted	