UMassAmherst

Comprehensive Design Review

Mappa Signa

March 11, 2020

Introduction

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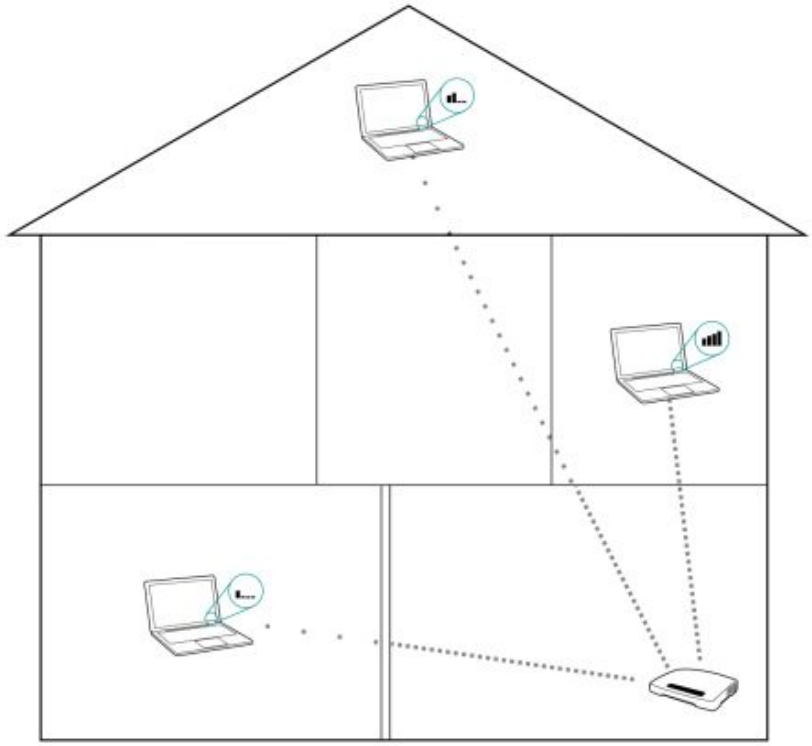
Team Advisor:
Prof. Jackson

Problem Statement

- WiFi signal is inconsistent throughout homes and offices
- Most homes have a single access point
- Houses are filled with walls and furniture that block WiFi signals
- Current solutions require copious manual input of data



System Specifications

1. **Battery lasts minimum of 3 hours or long enough to map entire building.**
2. Map creation and trajectory estimation without user input of pre-existing map.
3. Suggest optimal signal booster placement based on heatmap results.
4. Turn on and go functionality, no user intervention until data analysis.

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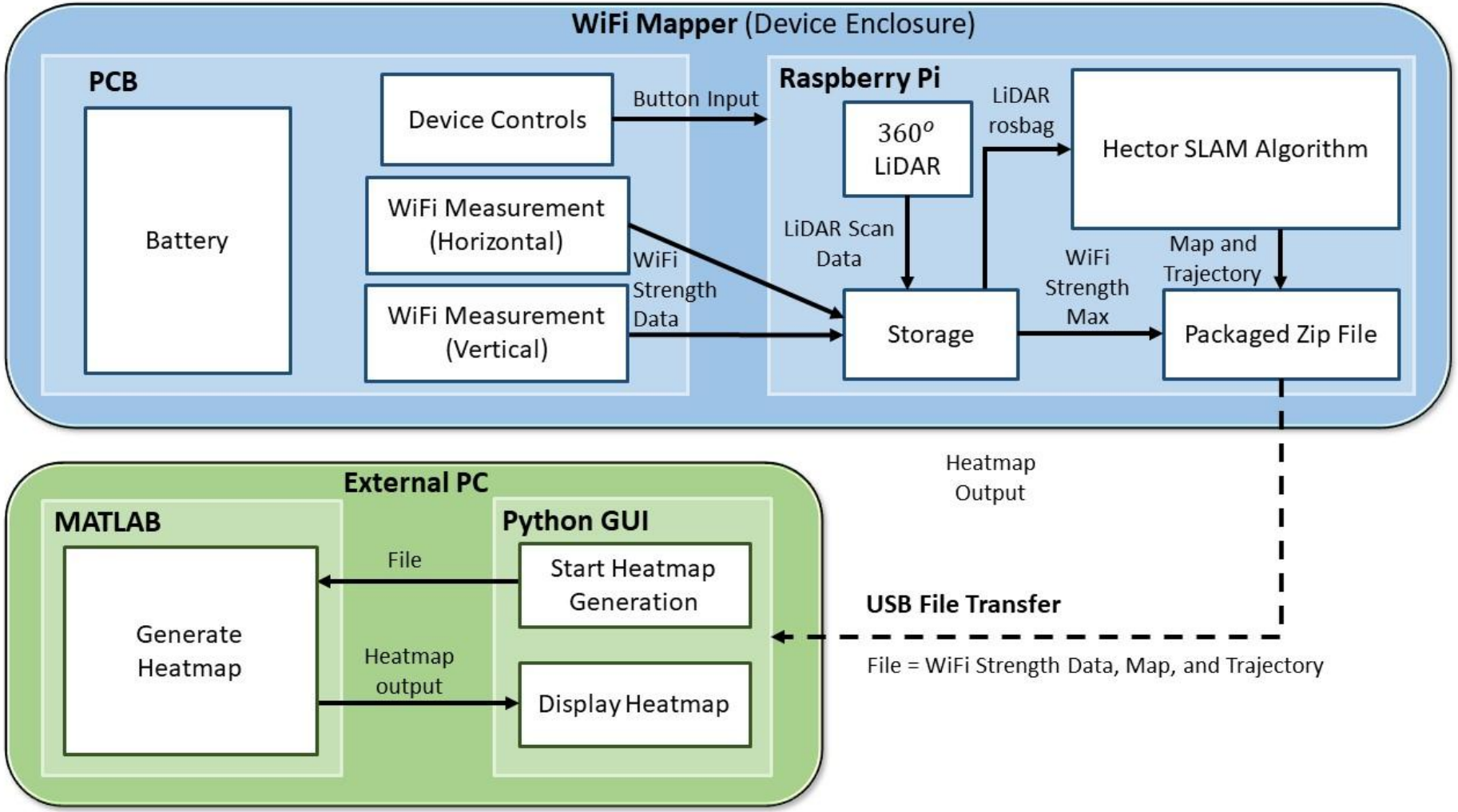
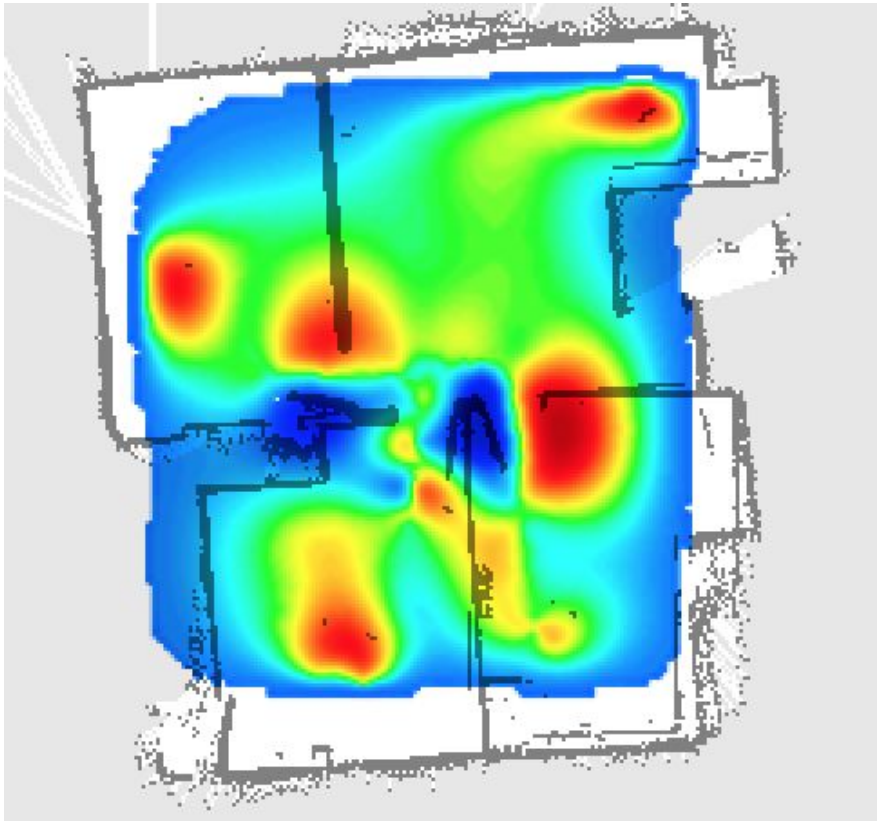
Block Diagram



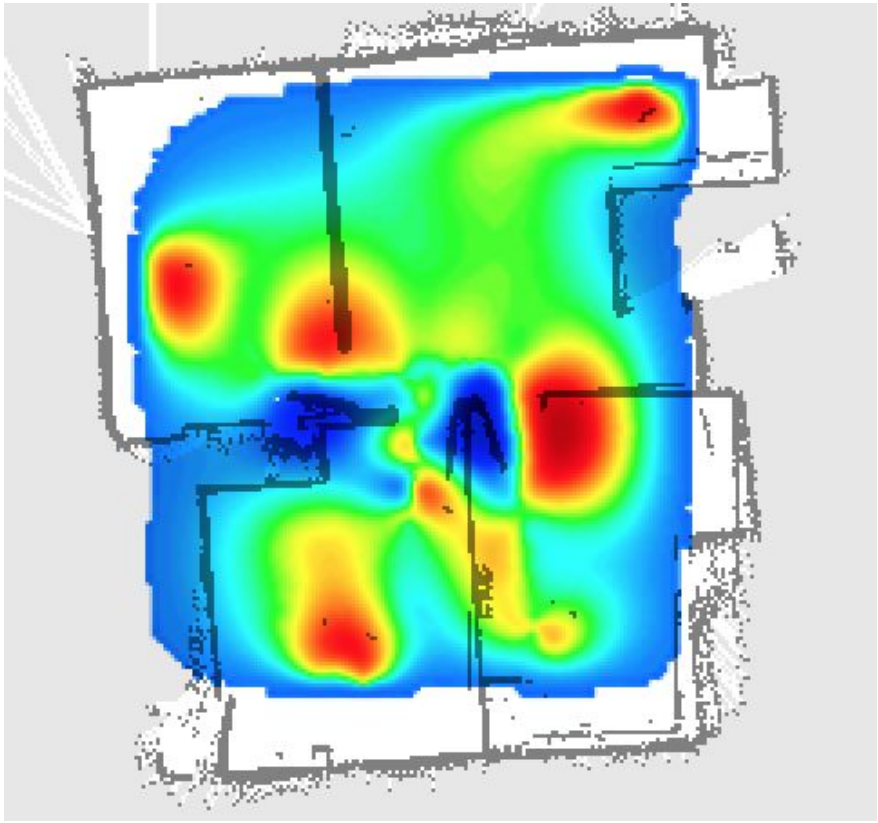
Proposed CDR Deliverables

- Convert power and device controls to PCB
- Create device enclosure for easier use
- Incorporate LCD display to show status of device



CDR Deliverables - Progress

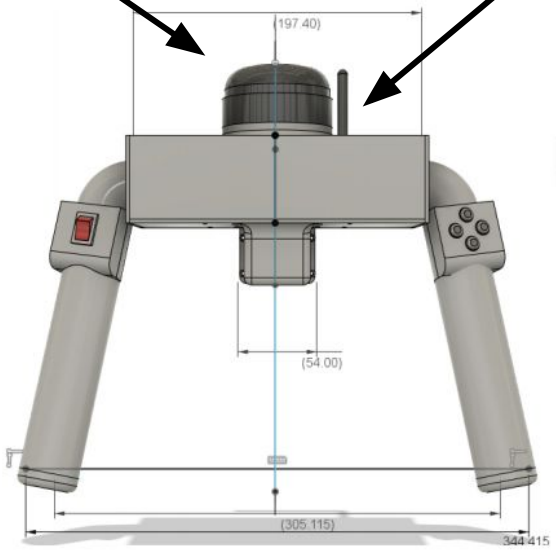
- Convert power and device controls to PCB
- Create device enclosure for easier use
- Incorporate LCD display to show status of device



Concept Design

LiDAR scans room

Measure WiFi Strength

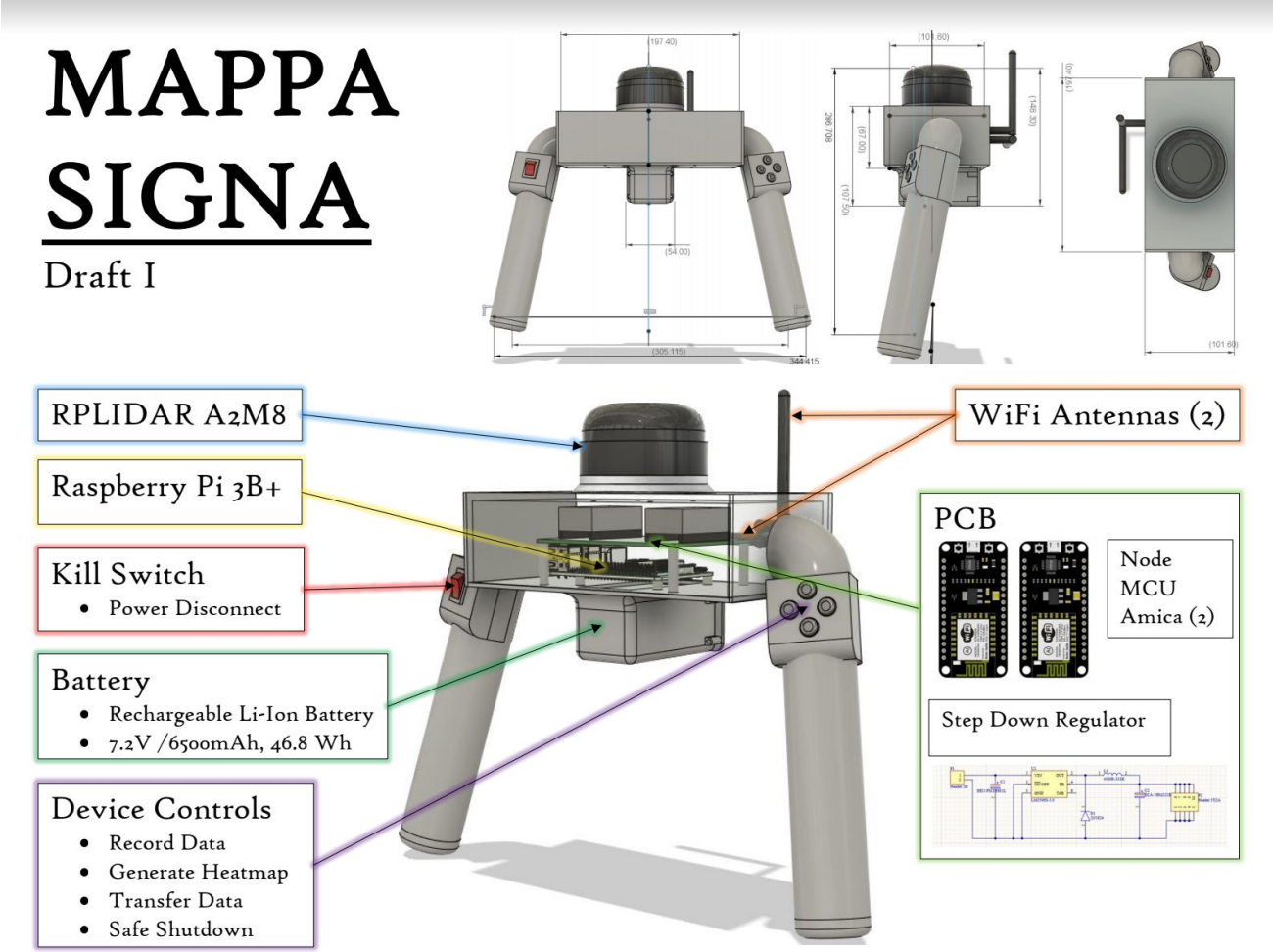


Sketch of Handheld Device Concept Design

Transfer Map, Trajectory, and WiFi strength data to External PC

External PC Generates Heatmap

Device Design



WiFi Measurements

- Added a second WiFi board
  - Antennas are oriented perpendicular to each other
  - Prevent perceived dead-spots due to polarization of signal and orientation of antenna

WiFi boards

- We now connect to the network we want to measure
  - Without connecting, max measurement frequency was ~1.5 sec
  - With connecting, max frequency is each clock cycle of board
    - We only measure every .75 sec, writing to 2 files every millisecond froze the RPi
- Both connect via USB
  - Plan is to use UART serial communication for one in the future, but there's only one accessible UART device on our Pi
  - No UART right now due to troubles with software

LCD Display

- 16x2- 16 letters, 2 lines
- Gives information on what is happening at each moment in the software's life after start

360° LiDAR: Problems and Solutions

- Supplying LiDAR Power:
  - Supply power to LiDAR directly from PCB
- LiDAR Rotation Speed:
  - Default: 600 rpms
    - thought to have caused strain on Pi CPU
  - Tested Range: 300rpms - 900 rpms
  - Conclusion:
    - Decreasing rotation speed worsens generated map

Hector SLAM: Generating a Map

- Map Generation
- Hector SLAM Simulated Time:
  - Instead of real-time, use simulation-time
  - Scaling down simulated-time speed (scale t by (0.25,0.5)) improves performance of map generation

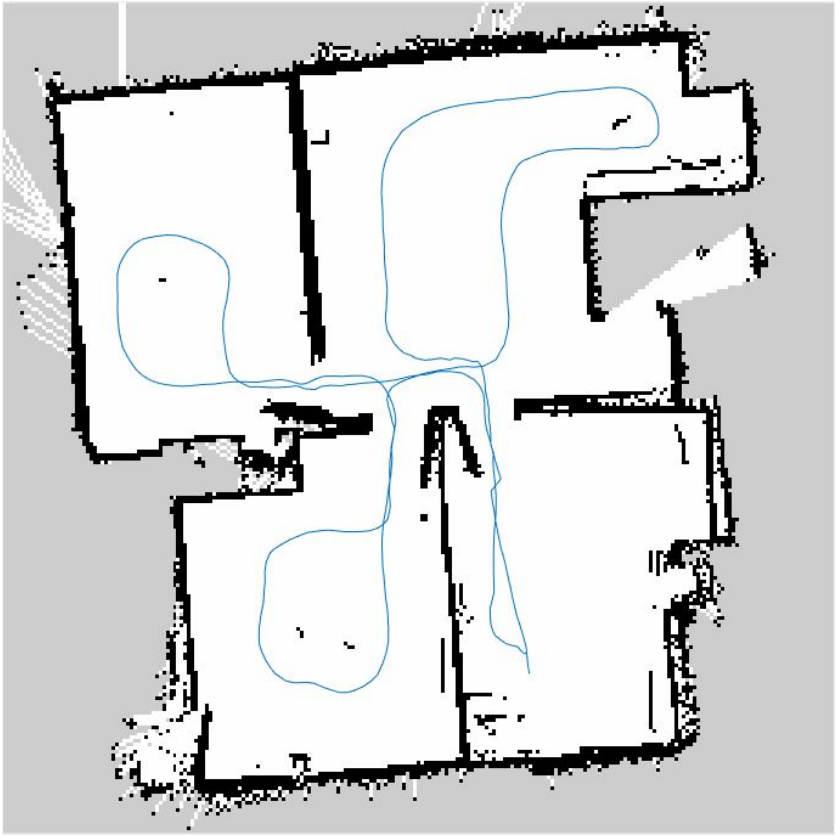
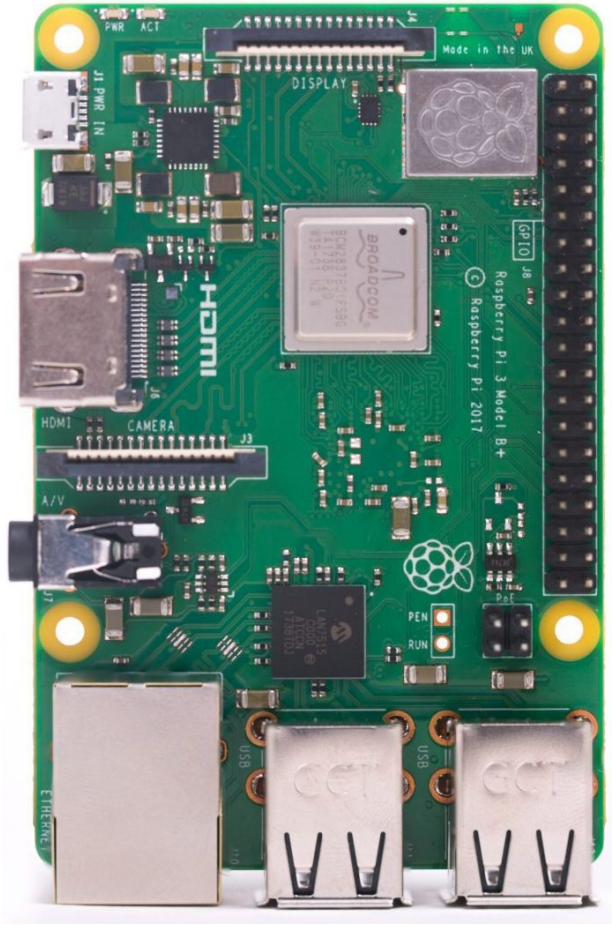


Fig. 5: Hector SLAM Map and Trajectory results from Cliffside apartment.

Microcontroller: Raspberry Pi 3B+

- Purpose:
  - Simultaneously record WiFi strength and LiDAR scan data
  - Perform Hector SLAM
  - Transfer map, trajectory, and wifi strength data to PC.
- Issue:
  - Short between 5V and 3.3V pins fries Pi

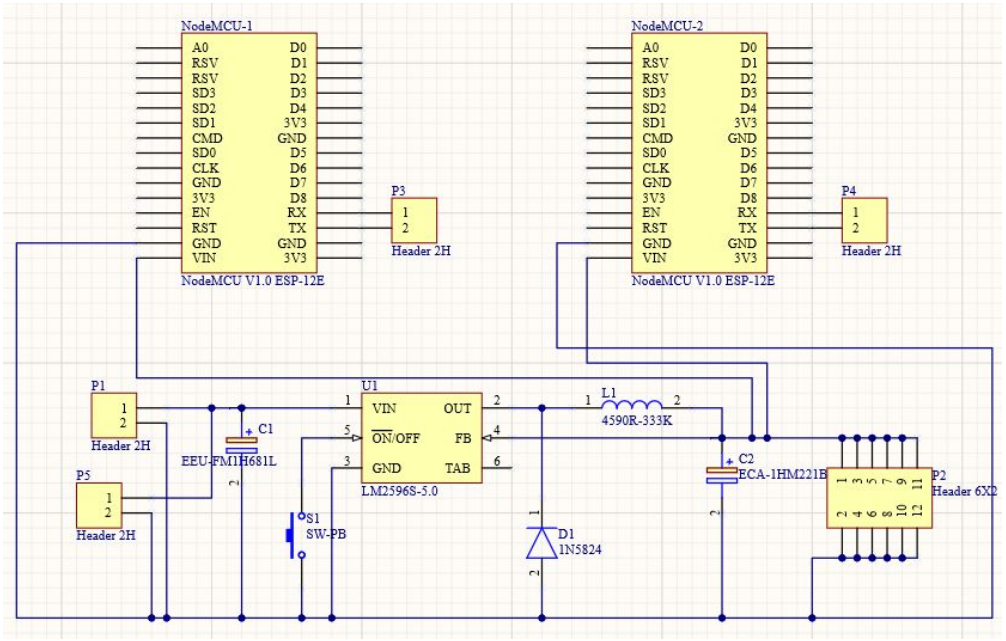


Power

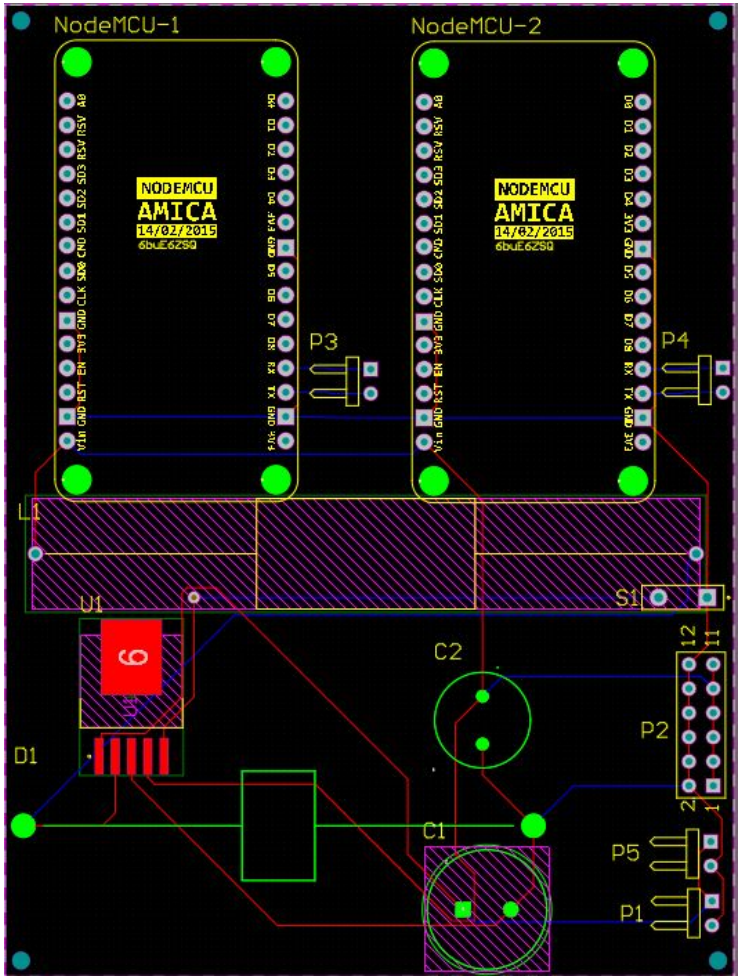
- 7.2V 6500mAh Lithium-Ion battery powers:
  - Raspberry Pi 3
  - LiDAR Scanner
  - NodeMCU Amica WiFi x2
- Total system power usage about 900mA when idle
- Buck regulator used to step down voltage from 7.2V to 5V

PCB

- PCB Development in Altium Designer
  - Accomodations for 2 WiFi board
  - Charging
  - Power Switch



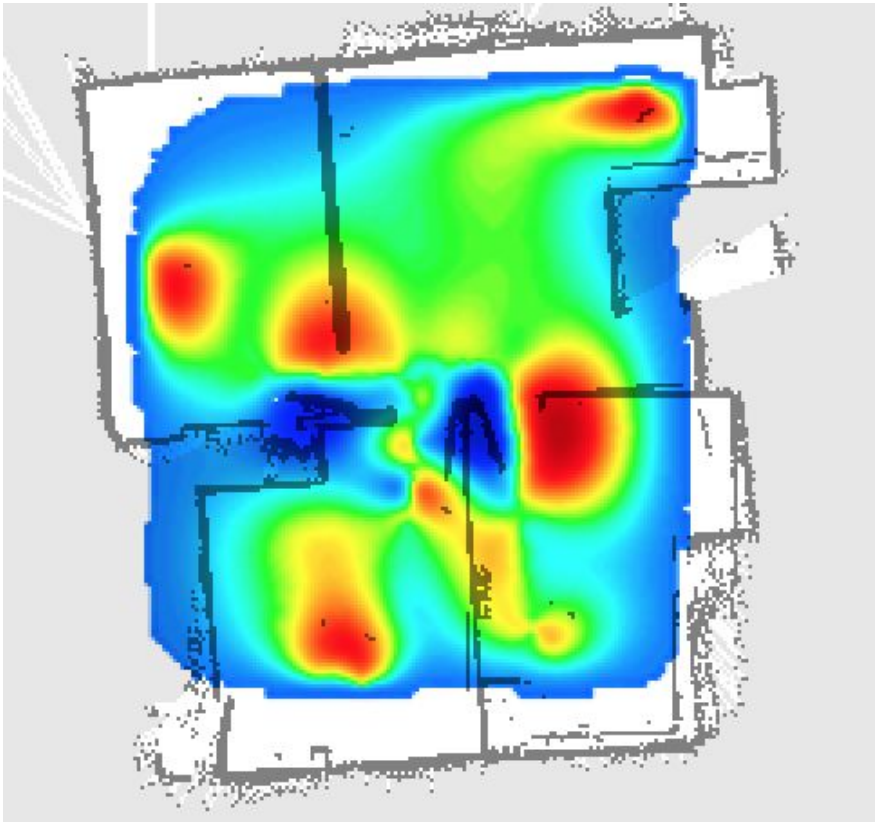
PCB


NodeMCU-1
NodeMCU-2
NODEMCU
AMICA
14/02/2015
P3
P4
L1
U1
S1
C2
D1
P2
C1
P5
P1

MATLAB Generated Heatmap

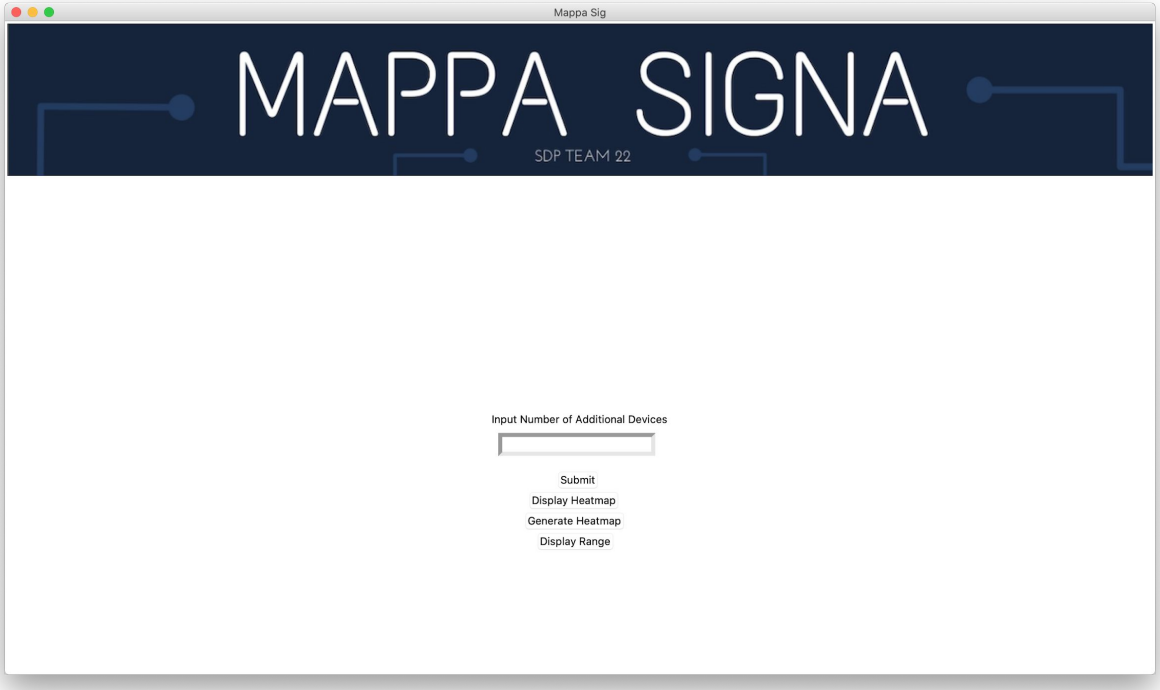
Before

Current



Computer Application

- Provides GUI to bridge MATLAB and user input



Parts Used

- Raspberry Pi 3b+: $40
- RPLiDAR A2M8: $319
- WiFi Breakout Board: $25
- PCB & Components: $75
- 3D printing: $210

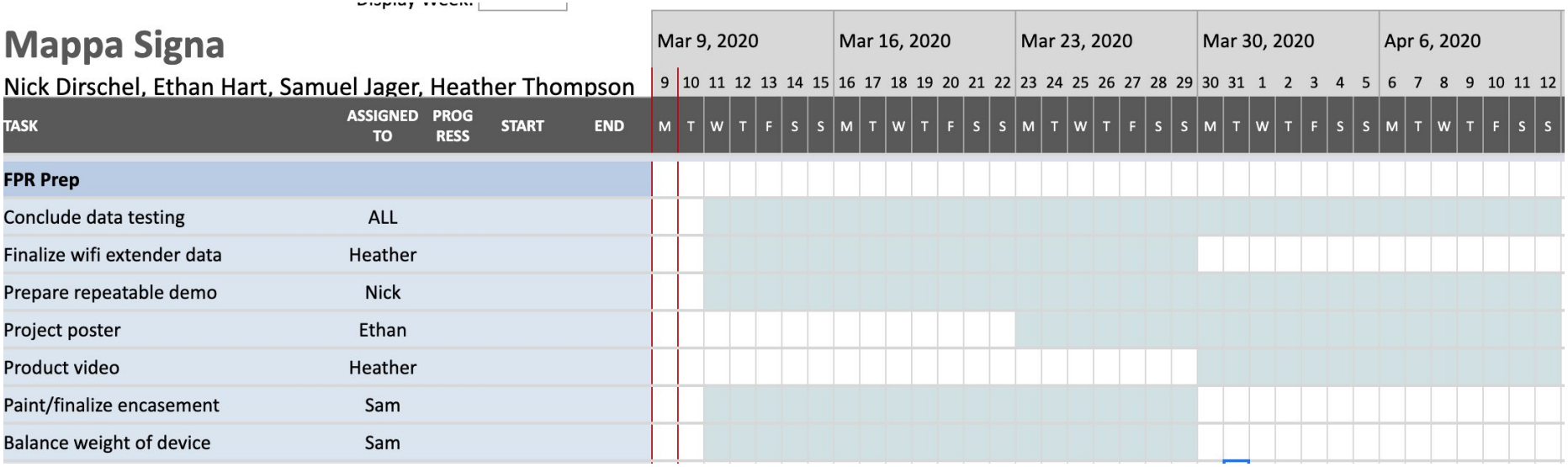
Team Roles + Responsibilities

- Nick Dirschel (CSE)
  - WiFi Data Processing
  - GPIO Pin Configuration
- Ethan Hart (CSE)
  - PCB Development
  - Power Management
- Samuel Jager (CSE)
  - LIDAR, SLAM Implementation, & process automation
  - 3D Modelling and Fabrication of Encasement
- Heather Thompson (CSE)
  - Heatmap Generation (Matlab)
  - Application Development: Signal Booster Placement

Gantt Chart

Mappa Signa

Nick Dirschel, Ethan Hart, Samuel Jager, Heather Thompson



TASK	ASSIGNED TO	PROGRESS	START	END
FPR Prep				
Conclude data testing	ALL			
Finalize wifi extender data	Heather			
Prepare repeatable demo	Nick			
Project poster	Ethan			
Product video	Heather			
Paint/finalize encasement	Sam			
Balance weight of device	Sam			

FPR and Demo Day

- Final Product
  - Painted and evenly distributed device
  - Organized internal assembly
  - Improved scripts and code for running *Mappa Signa* processes -> increase performance and efficiency

- Demonstration of Mappa Signa
  - Create 2D map of current room
  - Generates heatmap from newly acquired data
  - Usable application interface

DEMO

Questions?