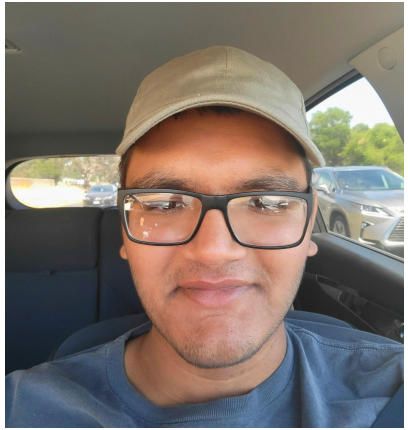
Project: Gotcha!

Team 14 FPR : Joseph Mitchell, Tirth Patel, Hakan Saplakoglu, Jackson Wallace

Advisor: Yadi Eslami

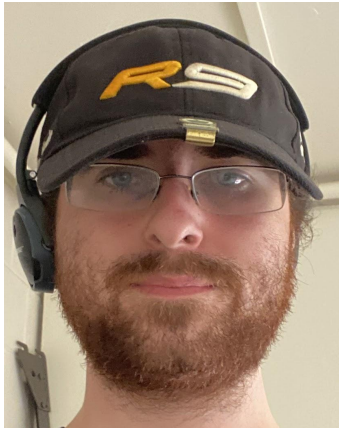
Team 14

Jackson Wallace (EE)



Tirth Patel (EE)

Hakan Saplakoglu (EE)



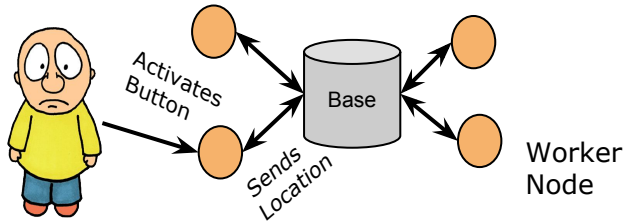
Joseph Mitchell (CompE)

Problem Statement

Natural disasters are an annual occurrence that cause people to lose their homes and loved ones. Even when a person survives a disaster they can go missing or get injured, which may lead to them not getting the help they need right away if communication networks are down. An example of this occurred with Hurricane Michael in 2018, where many people were in need of rescue, but the communication networks being down resulted in massive delays.

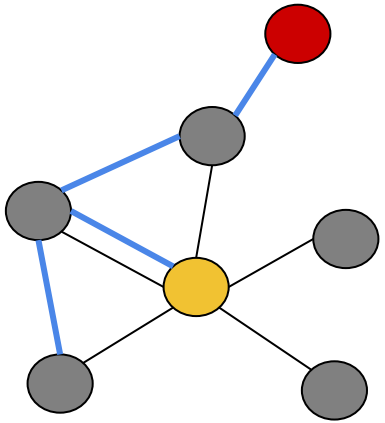
Our Solution

- Low-power worker nodes and base nodes connected through a mesh network.
- Each worker node will have a GPS module which would be manually activated by a person seeking rescue, and using LoRa a packet containing GPS coordinates of the worker node is sent through and goes to the base station.
- A frontend on the base station (web server for local use) for first responders to locate nodes after location is reported
  - Mapping UI with overlays of mesh network nodes
- The worker node can be deployed before or after a disaster occurs.



Mesh Network

- Set Parameters for LoRa
  - 915 MHz Frequency Band
  - +17dB Transmission Power (ranges from +2dB to +20dB)
- Simplified Mesh Network
  - All nodes have an address and all nodes relay all packets other than:
    - Packets that are from themselves
    - Packets that they have already relayed once
  - Different from traditional mesh network
    - No destination addressing
  - All nodes, including base node, act as relay host

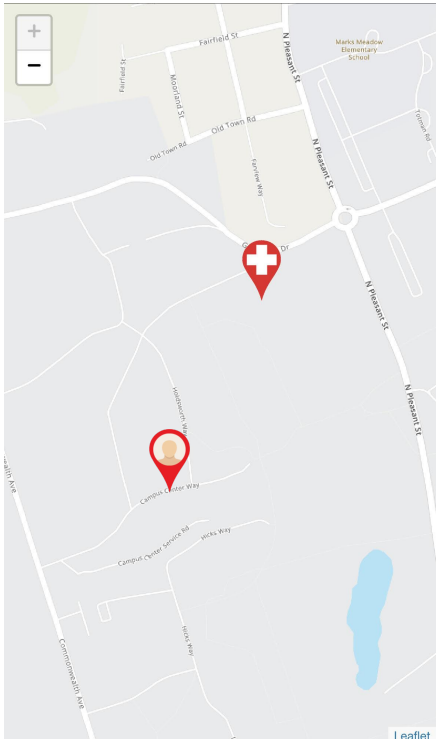


User Interface

1. Connect to “gotcha-base01”
2. Navigate to http://192.168.4.1
3. Use moving map
   a. Click on markers to get location information
   b. Worker nodes are marked as a person icon
   c. Base nodes are marked as a plus icon

Base Station

Worker Node



System Specifications

General Specifications for Each Node

1. Can communicate with any worker node or base node in range ✓
   a. Act as a relay host for other network traffic ✓
   b. Be able to differentiate individual nodes in the network ✓
   c. At least 1 km range in urban environment
2. Can locate itself using the GPS module ✓
   a. Within 10m ✓
   b. Within 60 seconds ✓

System Specifications

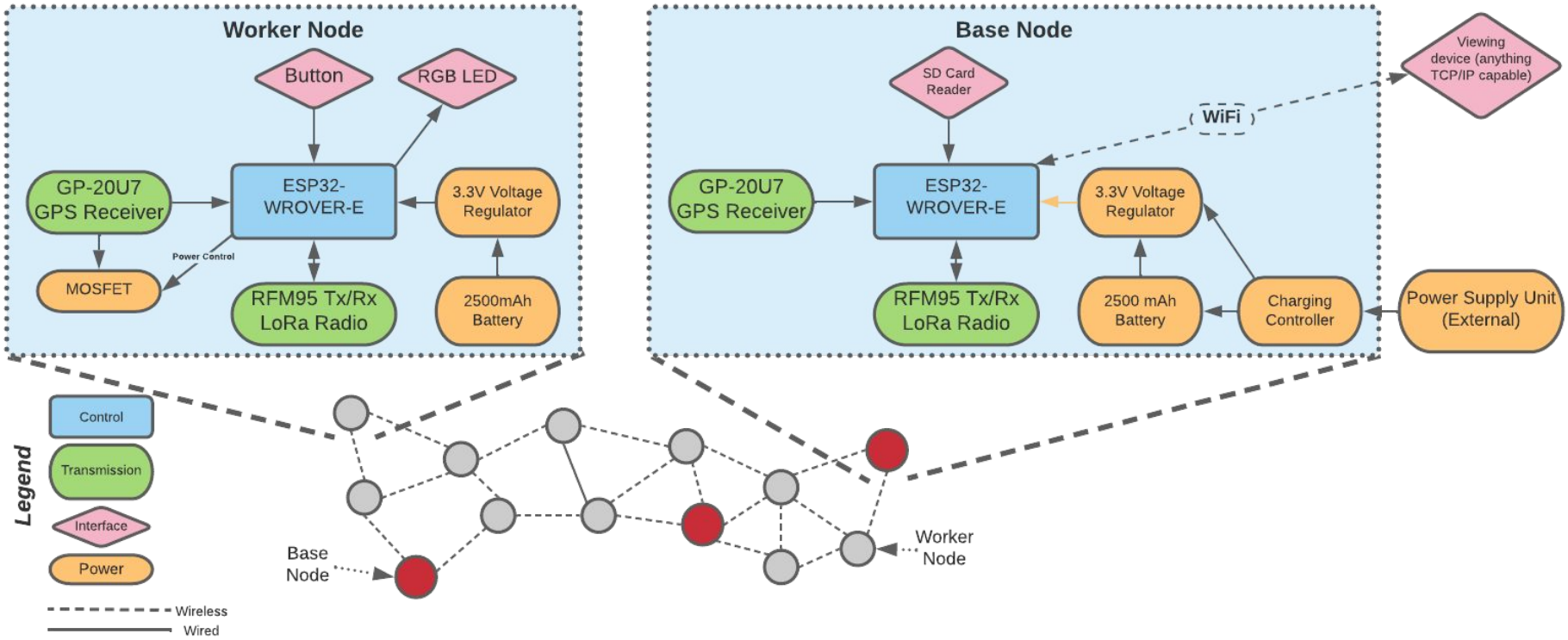
Worker Node

1. Less than 3x3” on the larger side
2. Battery capacity: At least 3 days of runtime in relay mode, 6 hours in active mode ✓
3. LED for signalling current state to user ✓
4. Button used to activate the device ✓

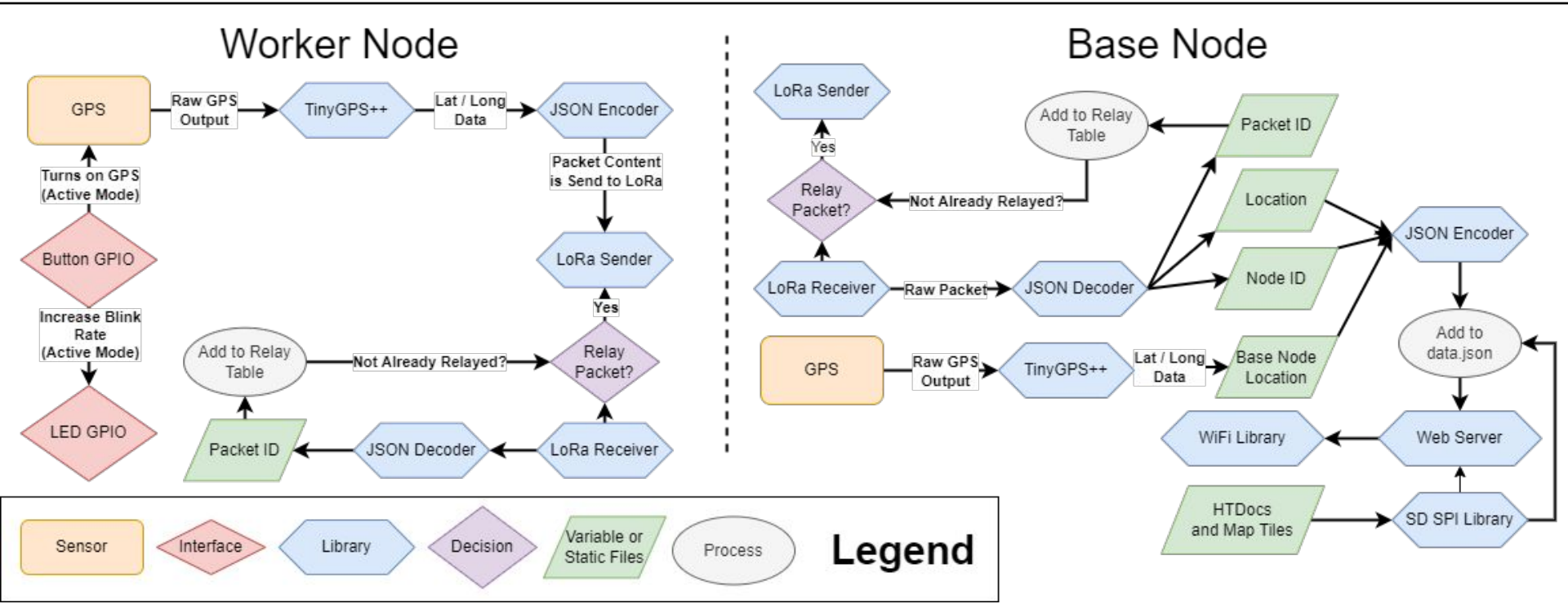
Base Station

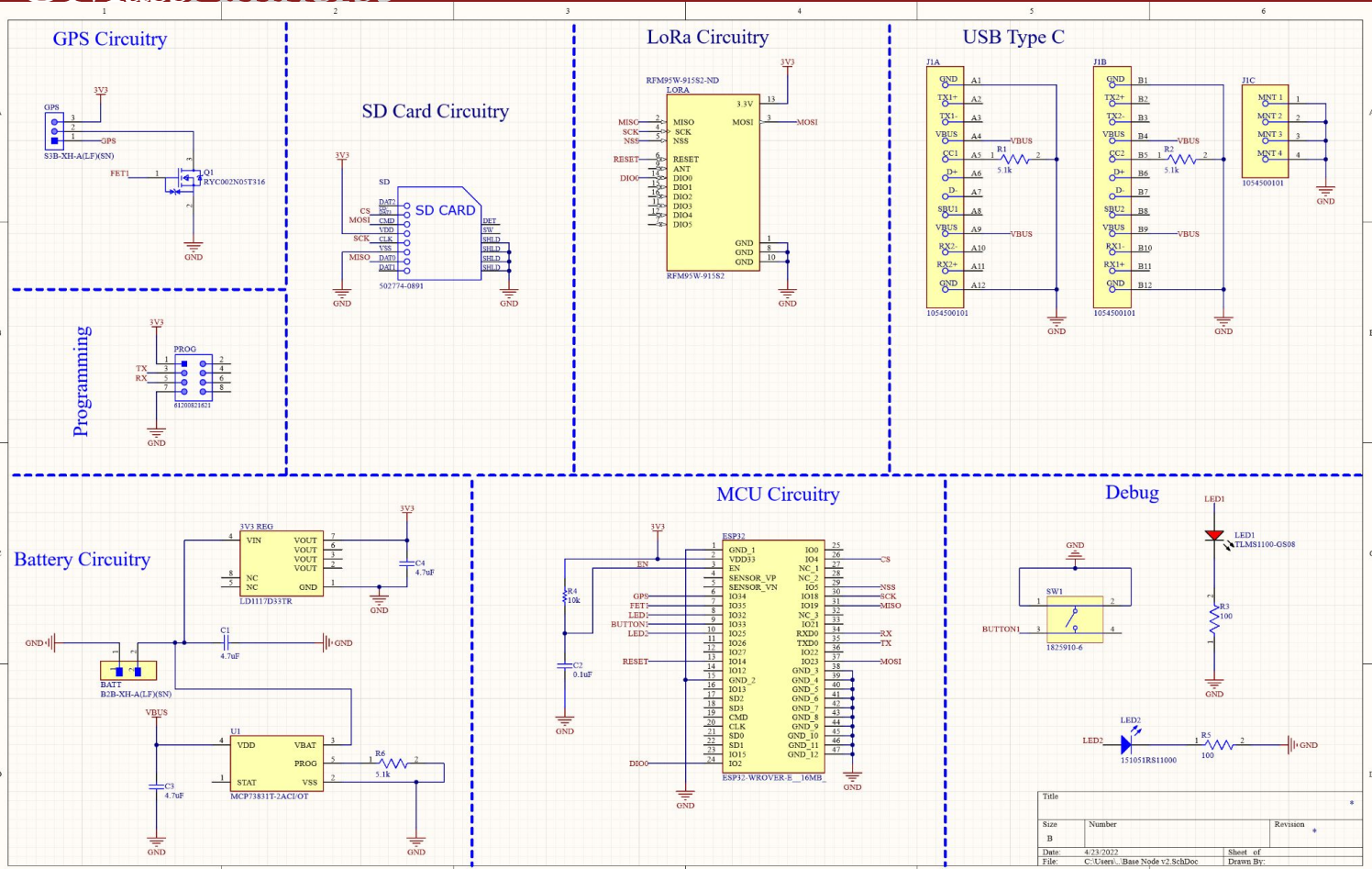
5. Less than 3x3” on the larger side
6. Serve a web server to act as a front-end for first responders ✓
7. Rechargeable Battery with enough capacity for 2 hours disconnected runtime ✓
8. Can display worker node information (location) with no connection to the internet on a mapping software ✓

Hardware Block Diagram



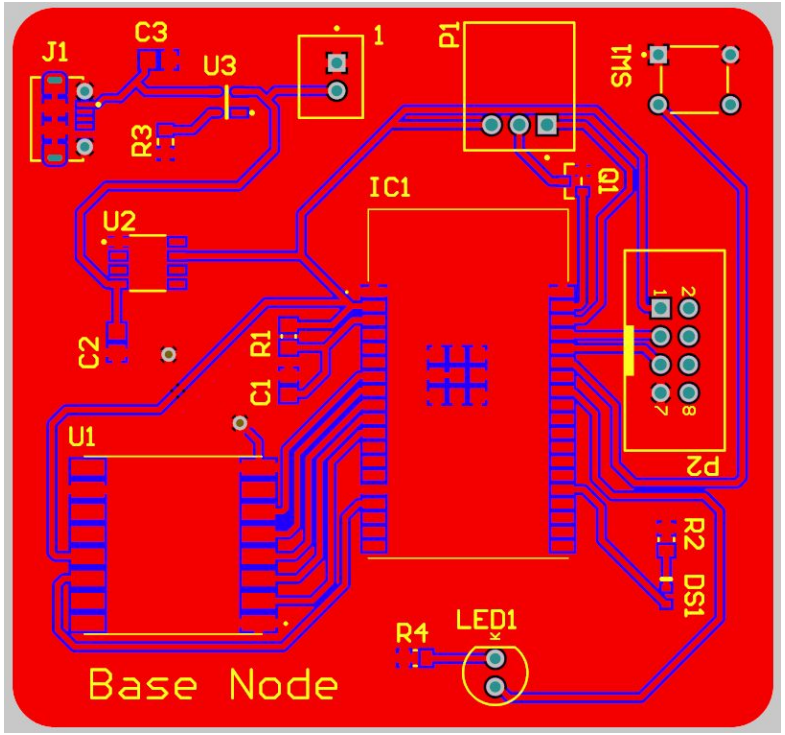
Software Block Diagram





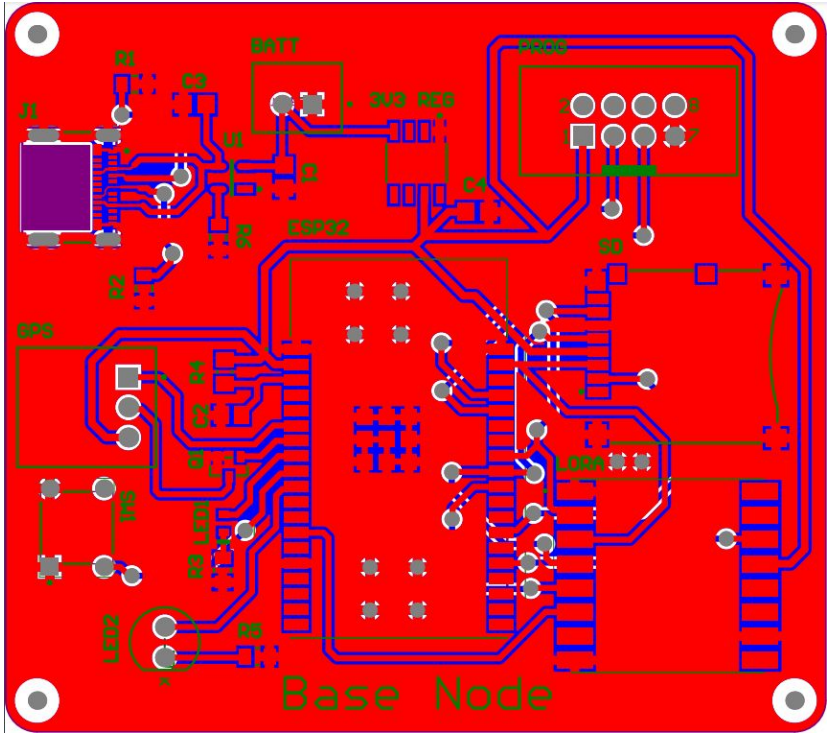
Base Node (Updated Schematic)

Base Node Footprint



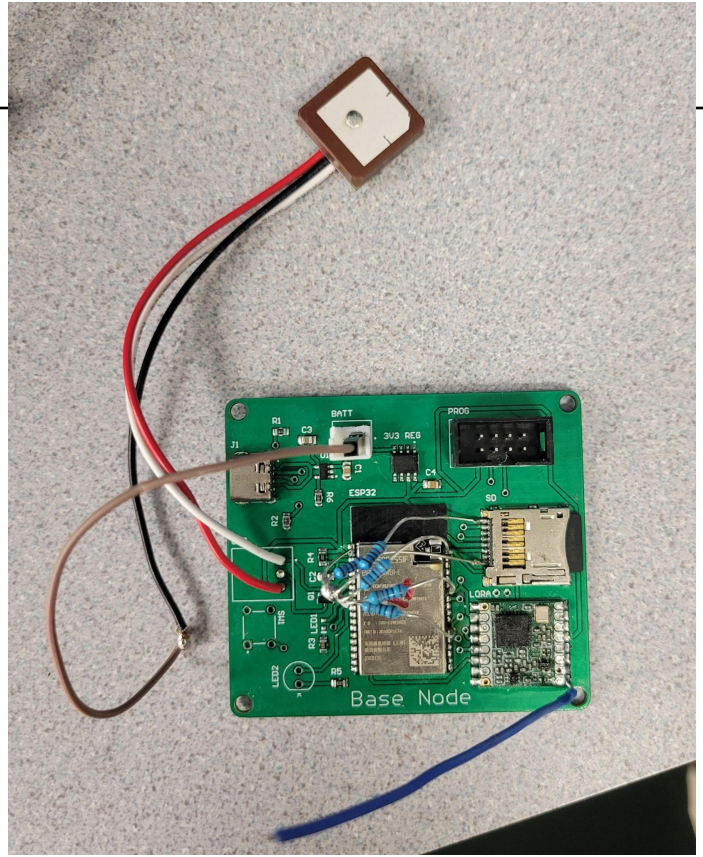
Old PCB Footprint

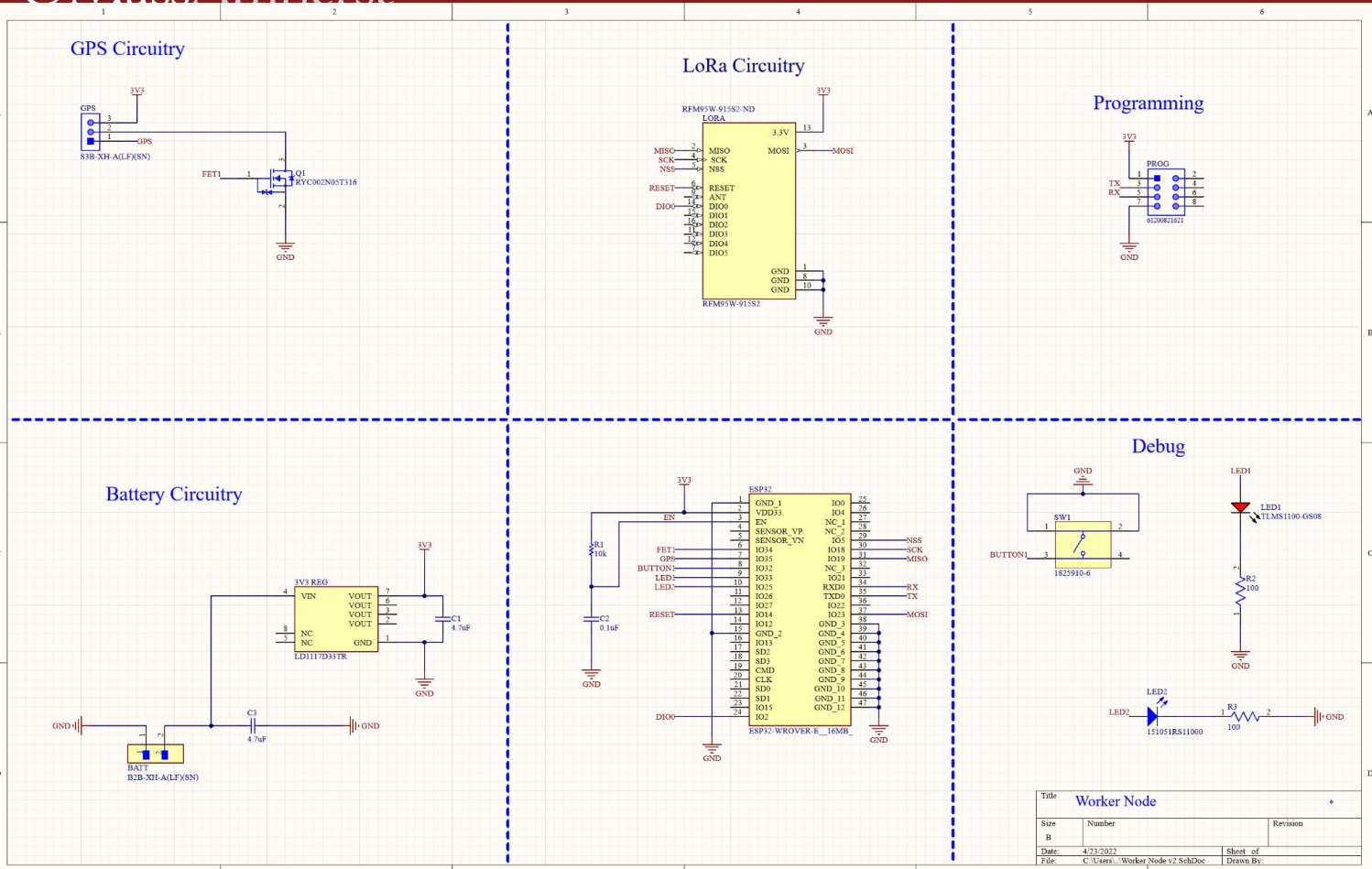
New PCB Footprint



Base Node PCB

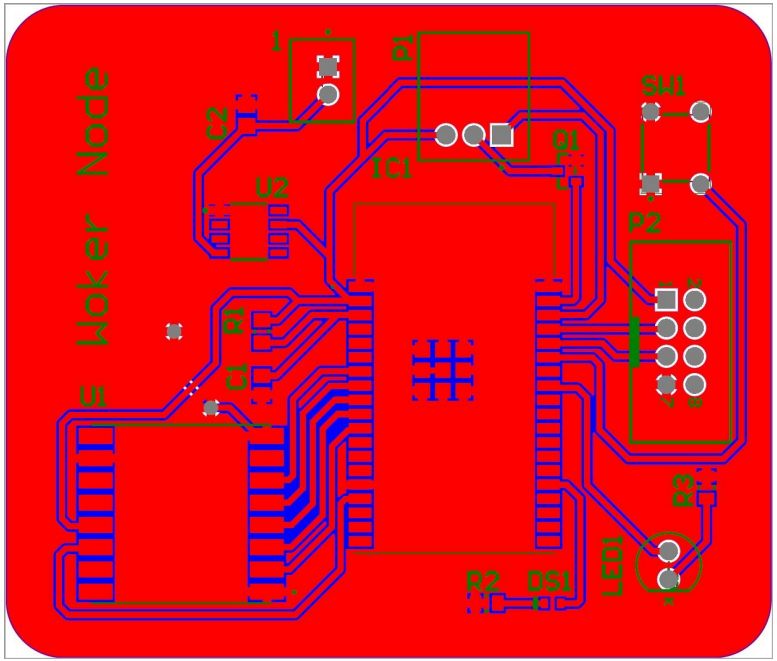
Base node PCB with some minor modifications





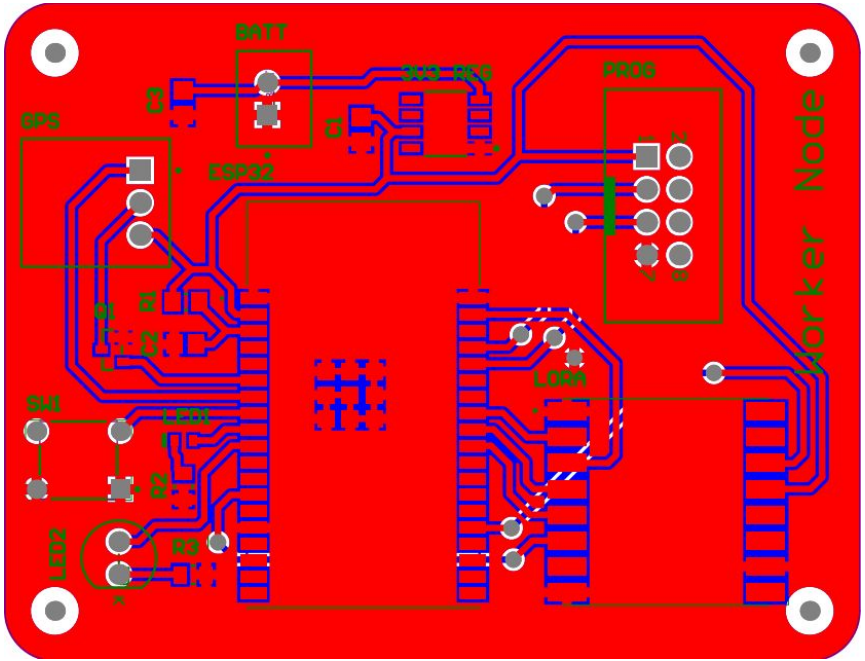
Worker Node (Updated Schematic)

Worker Node Footprint

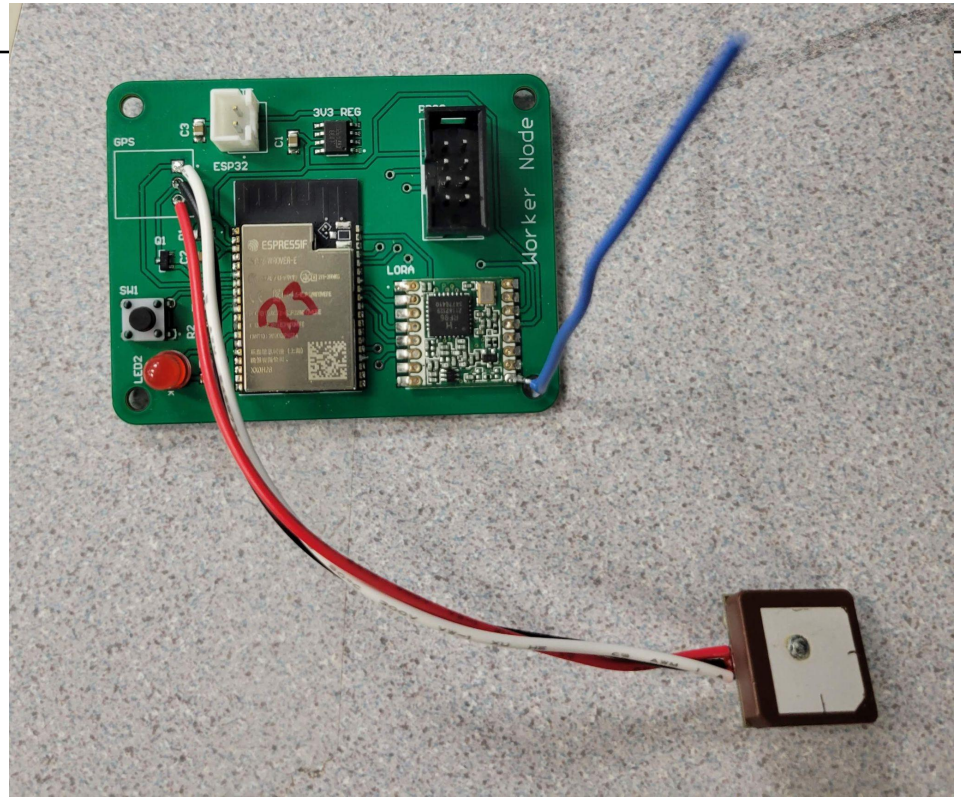


Old PCB Footprint

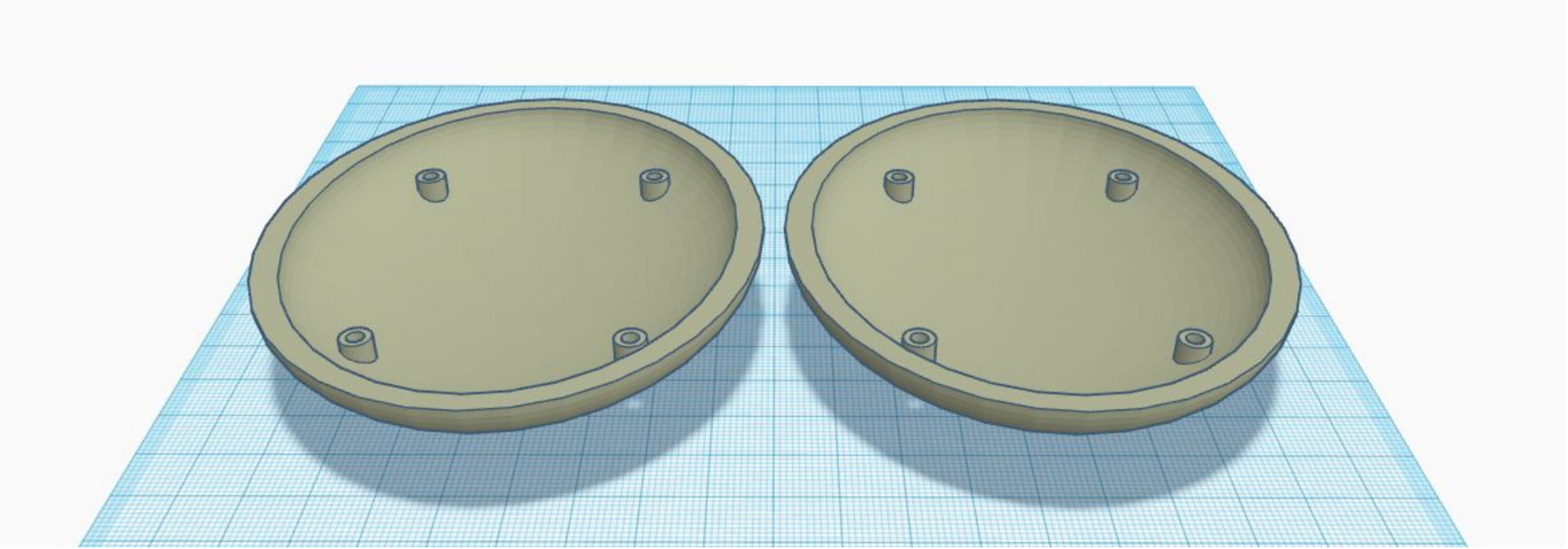
New PCB Footprint



Worker Node PCB



Housing for Worker Nodes



Hardware and Software Used

Hardware Components

- ESP32-WROVER-E
- GP-20U7 GPS Modules
- RFM95W LoRa Transceiver
- 2500 mAH Rechargeable Batteries
- Voltage Regulator
- Charging Controller
- LED
- Pushbutton
- Passives
  - Resistors
  - Capacitors

Software Used

- PlatformIO
  - Worker node code
  - Base node code
- C/C++ Libraries
  - LoRa
  - TinyGPS++
  - EspSoftwareSerial
  - Json
- Offline Map Maker
  - Used to create offline map tiles
  - Server used was Open Mapquest

FPR Testing Plan

1. Ensure that a signal from a worker node at least 1 km away is received at a base station (test)
2. Ensure that a worker node location update can reach the base node without being adjacent (test) ✓
3. Measure how long it takes for gps to get an accurate reading at various times of day and weather conditions, readings should take less than 60 seconds (test) ✓
4. Compare various gps coordinate readings to that of a phone or other computer to determine accuracy, which should be within at least a 10 meter radius of the device's true location (test) ✓
5. Use the completed worker node until battery death to determine lifetime of nodes and compare results to projected battery life of 3 days (test) ✓

Verification: Mesh Network

- 1KM Range
  - Not met - max range during testing 300m
- Packets are able to reach a base node in the network within 60 seconds
  - Verified (Video)

Verification: Location and GPS

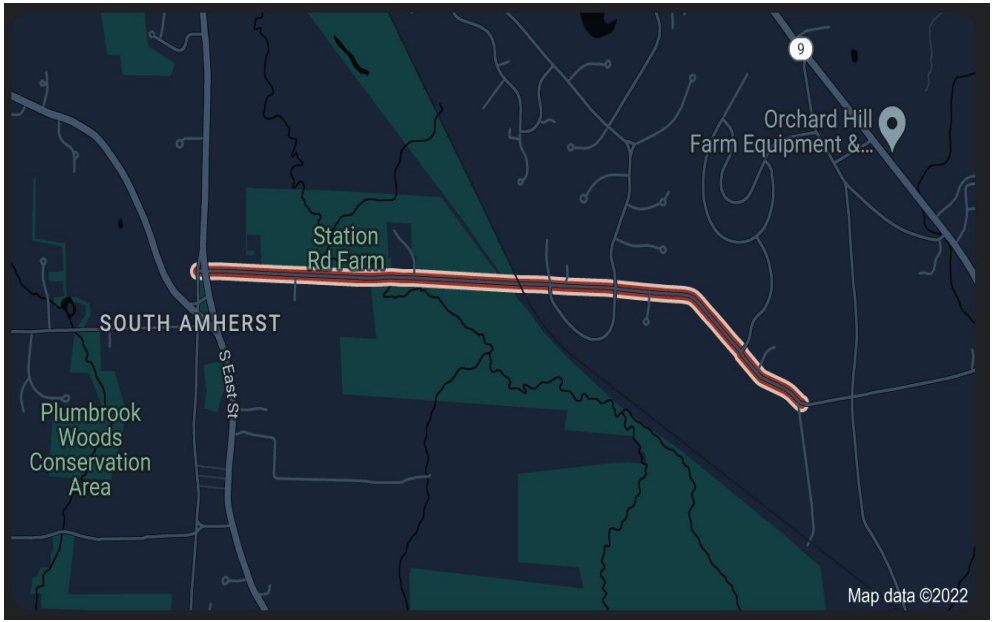
- Location transmitted within 60 seconds
  - Rainy conditions
  - Clear conditions
  - Verified (Video)
- Location is accurate within 10 meters
  - Verified

Verification: Power

- Worker node lasts at least 6 hours in active mode on battery
  - Testing with a 500mAh battery
  - Worker node lasted 6 hours in Active Mode
  - Extrapolating to the 2500maH battery we should be able to achieve ~30 hours
- Base node last at least 2 hours in active mode on battery
  - Testing with 2500mAh battery
  - Base node lasted over 6 hours

Reverse Geolocation

We can find the nearest street name with the use of python geocoder library




```
>>> import geocoder
>>> g = geocoder.osm([42.340382,-72.496819],method='reverse')
>>> g.json['street']
'Station Road'
```

As we can see we can send gps coordinates through python's geocoder library to obtain the nearest street name, for ease of use for the first responders in the trying to get to the destination.

Reverse Geolocation Lookup Table

- We can design a lookup table for offline use for our system

```
43.005785089999996,-72.51634435000346,On The Rocks Way
43.005785089999996,-72.51471938000347,On The Rocks Way
43.005785089999996,-72.51309441000348,On The Rocks Way
43.005785089999996,-72.51146944000348,On The Rocks Way
43.005785089999996,-72.50984447000349,Pine Ridge Drive
43.005785089999996,-72.50821950000349,Pine Ridge Drive
43.005785089999996,-72.5065945300035,Pine Ridge Drive
43.005785089999996,-72.5049695600035,East Town Farm Road
43.005785089999996,-72.50334459000351,East Town Farm Road
43.005785089999996,-72.50171962000351,East Town Farm Road
43.005785089999996,-72.50009465000352,Lower Cassidy Road
43.005785089999996,-72.49846968000352,Lower Cassidy Road
43.005785089999996,-72.49684471000353,East Putney Brook Road
43.005785089999996,-72.49521974000353,East Putney Brook Road
```

The issue is that we cannot get an accurate enough street name

Future Improvements

- Desktop application to populate SD card with map tiles automatically
- Decrease the size of worker nodes
  - Ideally keychain sized
- Increase range of mesh network nodes
- Increase durability/weather proofing of worker nodes
- More accurate reverse geolocation
- Final revision for PCB
- Framework can be adapted for other applications
  - Forest fire detection
  - Search and rescue

Project Expenditures

Components	Units Bought	Cost Spent
Pre-MDR Expenditures	NA	$228.98
1st Revision PCBs w/shipping	15	$67.84
PCB Hardware w/shipping	-	$122.16
2nd Revision PCBs w/shipping	20	$57.19
Post-CDR Expenditures	-	$151.85
3D Printed Housing (M5)	0	$0
Other Shipping + Tariff	-	$26.01
Total	**-**	**$654.03**

Member Responsibilities

Hakan Saplakoglu

- MCU Programming, Mesh Network, Network Comms, Web Server Development

Joseph Mitchell

- Geolocation Software, Web Development

Tirth Patel

- PCB Population and Testing, MCU Programming, Budget Manager

Jackson Wallace

- Team Coordinator, PCB Population and Testing, Power/Battery Management, 3D Housing Design

Demo

Questions? Comments? Concerns?