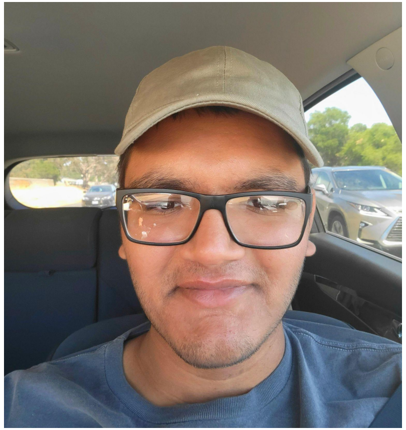
Project: Gotcha!

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

Advisor: Yadi Eslami

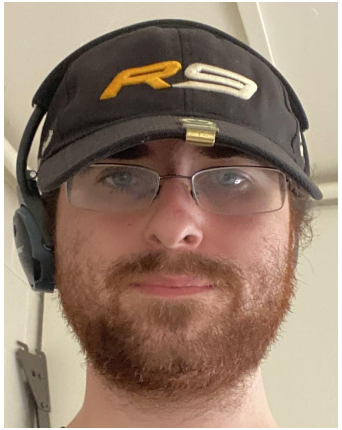
Team 14

Jackson Wallace (EE)



Tirth Patel (EE)

Hakan Saplakoglu (EE)



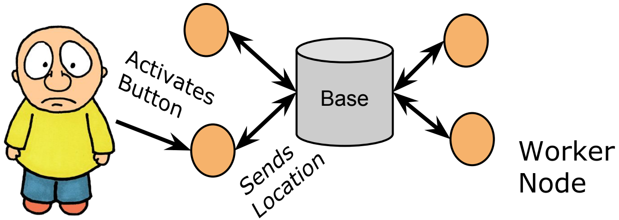
Joseph Mitchell (CompE)

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 API with overlays of mesh network nodes
- The worker node can be deployed before or after a disaster occurs.



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

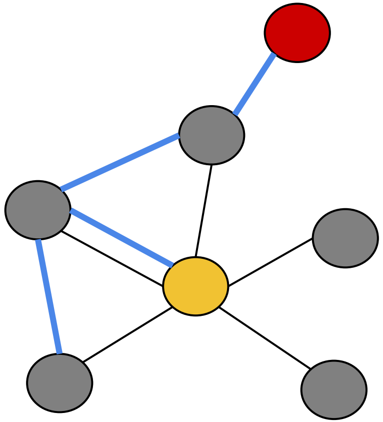
1. Less than 3x3" on the larger side
2. Battery capacity: At least 3 days of runtime in relay mode, 6 hours in active mode
3. LED for signalling current state to user
4. Button used to activate the device

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

Mesh Network Configuration

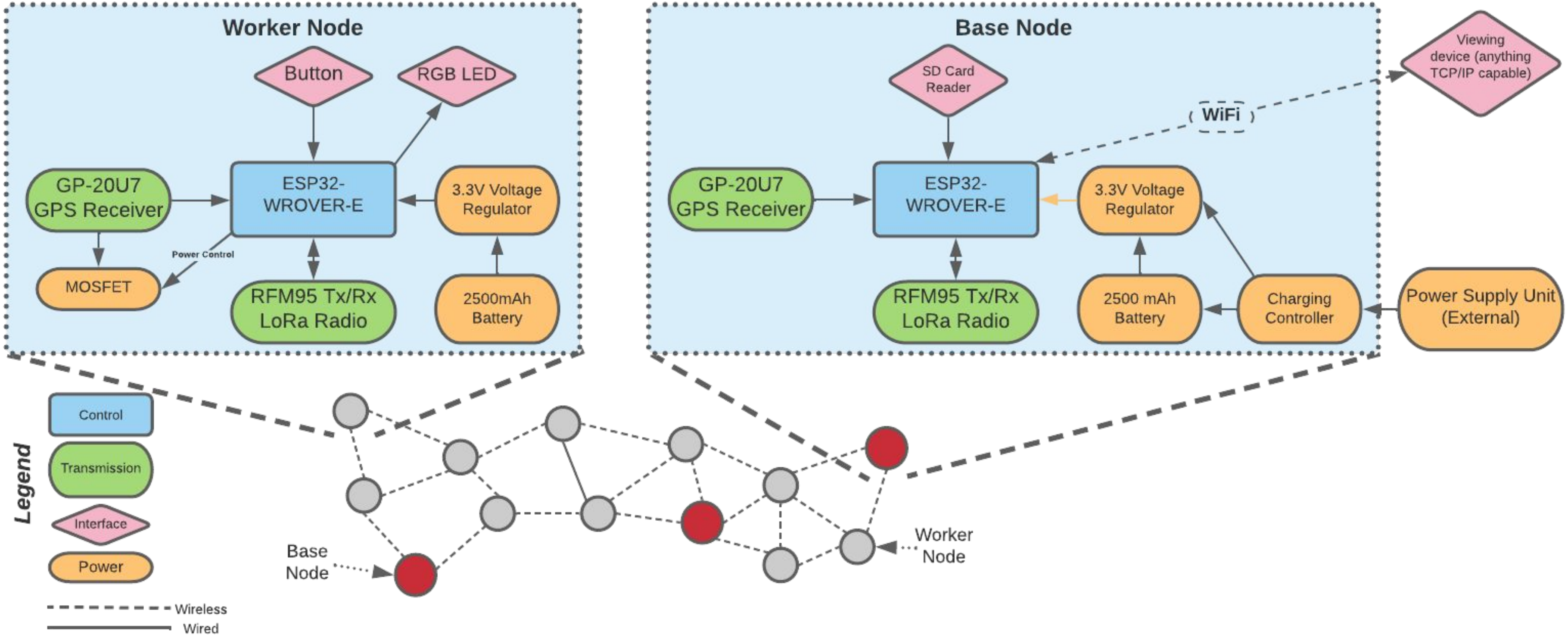
- Set Parameters for LoRa
  - 915 MHz Frequency Band
  - +17dB Transmission Power (ranges from +2dB to +20dB)
- Simplified Mesh Network
  - All nodes have an address and all nodes relay all packets other than:
    - Packets that are from themselves
    - Packets that they have already relayed once
 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



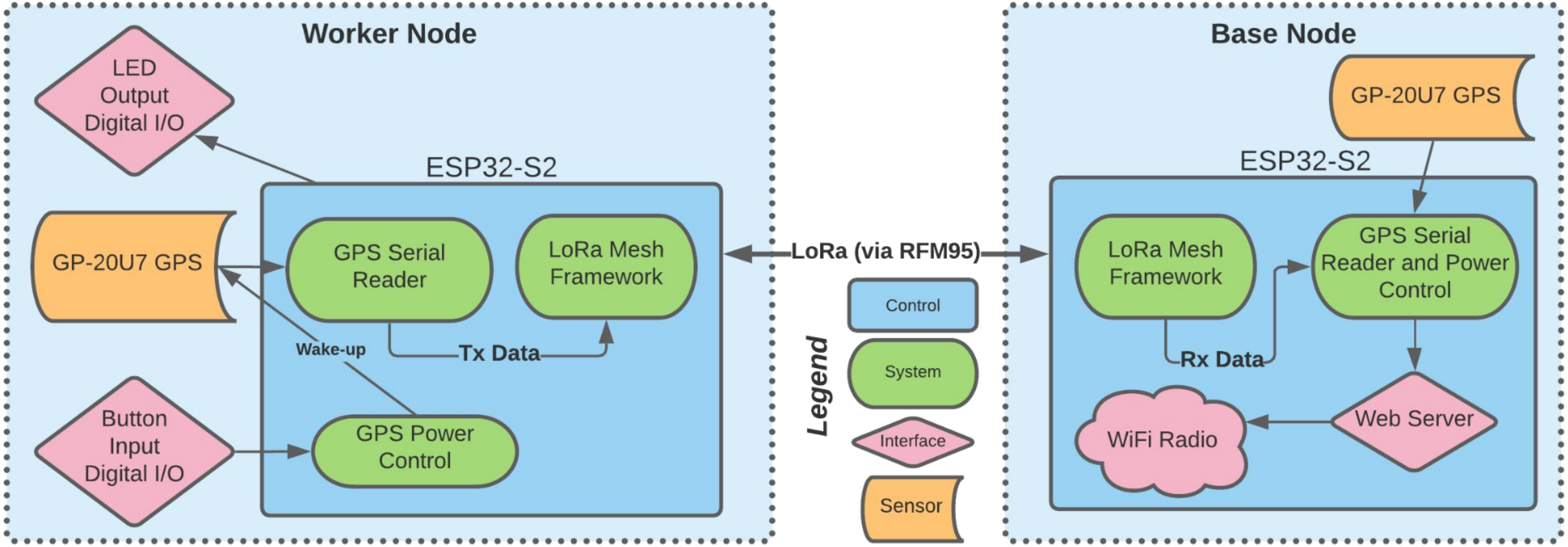
Power Consumption Estimates

- Worker Nodes have 2 modes
  - Active
    - GPS is on and receiving location (~99 mW)
    - LoRa radio is in Rx and Tx mode (Tx = 287 mW, Rx = 40 mW)
    - LED is blinking at 4 Hz (40 mW) w/ 100 ohm R
    - ESP32 at 80 MHz (39.6 mW)
    - Power
      - At 879 bits/s, 1024 bit packet, 1.16s in Tx mode
      - Send packet every 30 seconds
      - 2500 mAh, 30 hours runtime
  - Relay
    - GPS is off (0 mW)
    - LoRa is in Rx mode and switches to Tx if needed for relay (40 mW)
    - LED is blinking at 1 Hz (10 mW) w/ 100 ohm R
    - 2500 mAh battery, 150 hours runtime

Hardware Block Diagram

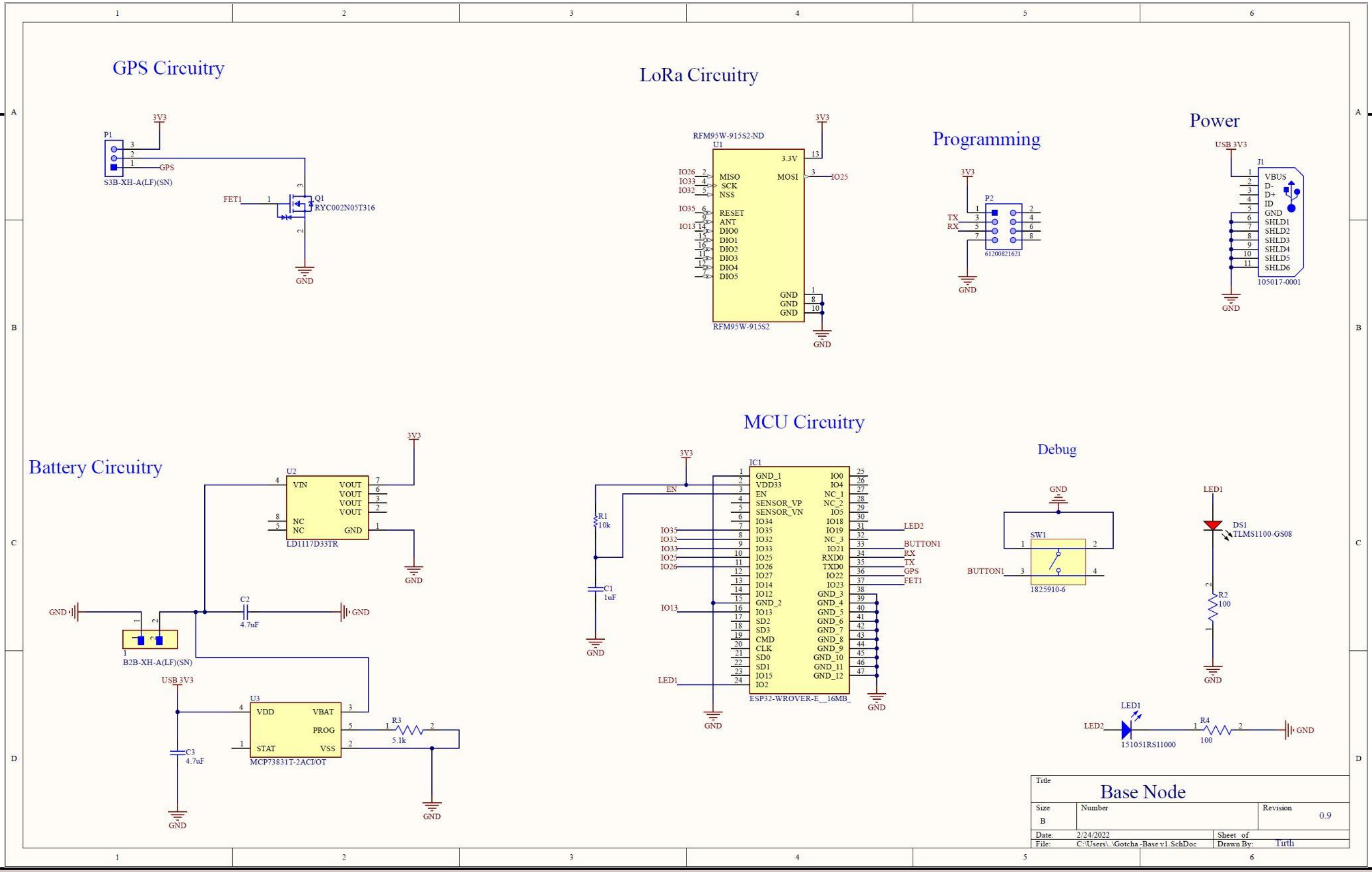


Software Block Diagram



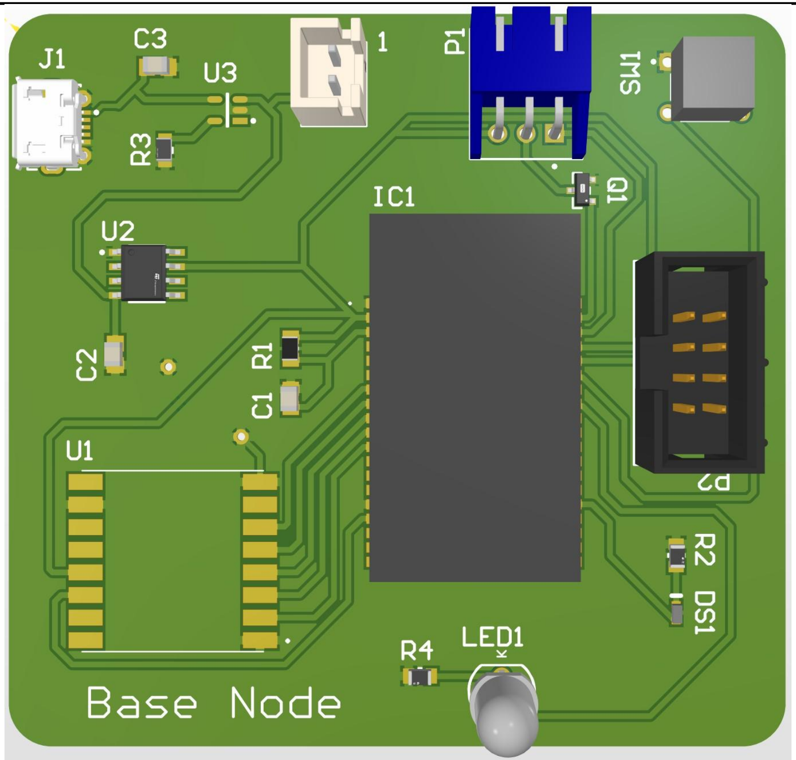
CDR Deliverables Accomplished

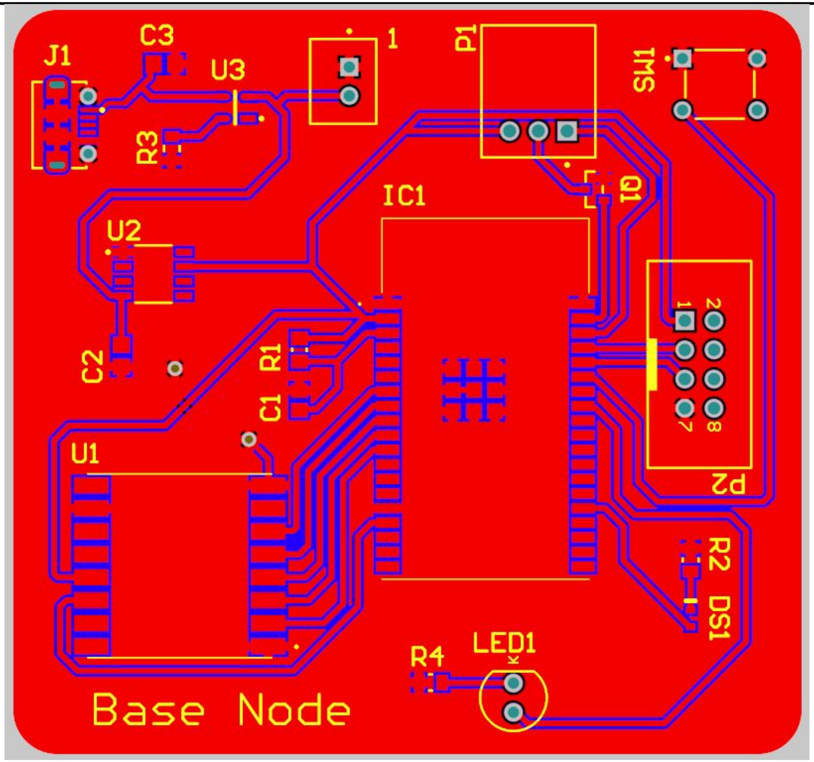
- **Hardware**
  - 1 base station node ✓
  - 3 worker nodes 2 worker nodes
  - Custom PCB hardware described previously with ESP32 as the MCU ✓
  - All devices use onboard battery Incompatible with dev board
- **Software**
  - GPS Receiver Code ✓
  - LoRa Mesh project ✓
  - Offline web server with coordinates received from worker nodes on a map Web server with GPS coordinates only
- **Demonstration**
  - Worker node is activated ✓
  - Front-end receives coordinates over at least 1 relay and show worker location ✓



Base Node Schematic

Base Station PCB



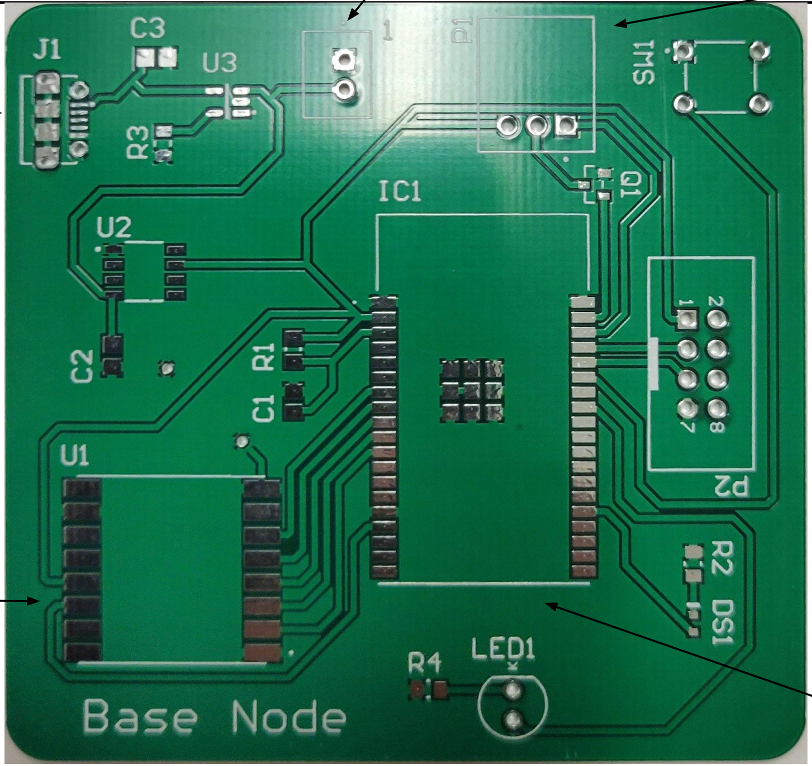


Base Station PCB

Battery Connection

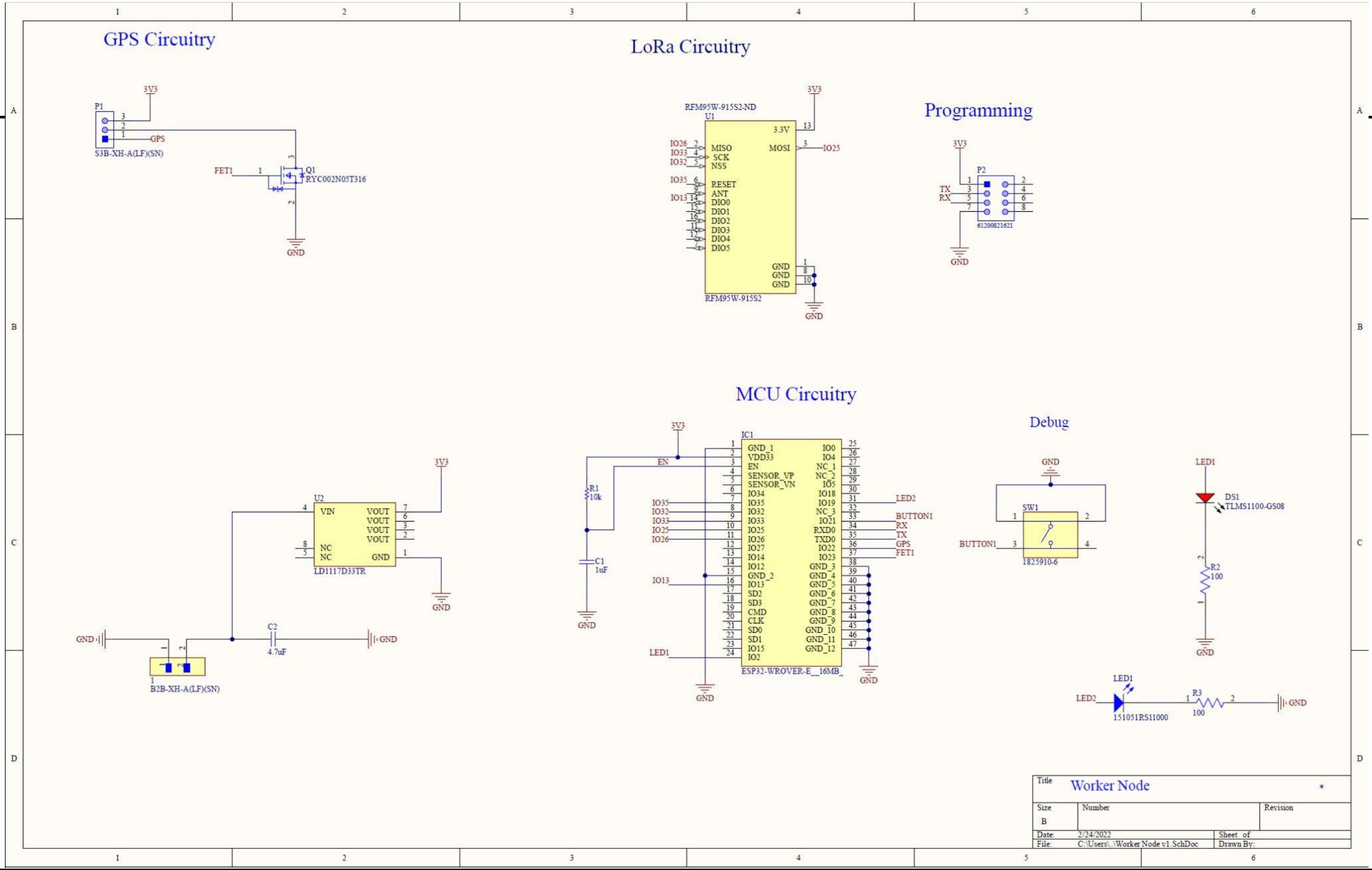
GPS Connection

Micro USB B



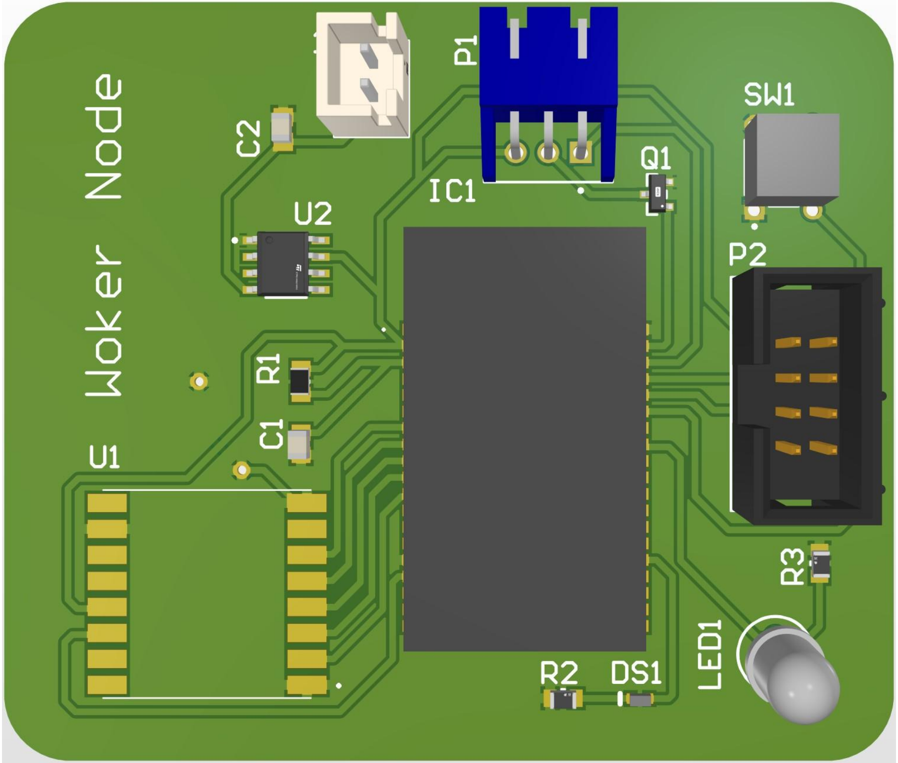
LoRa RFM chip

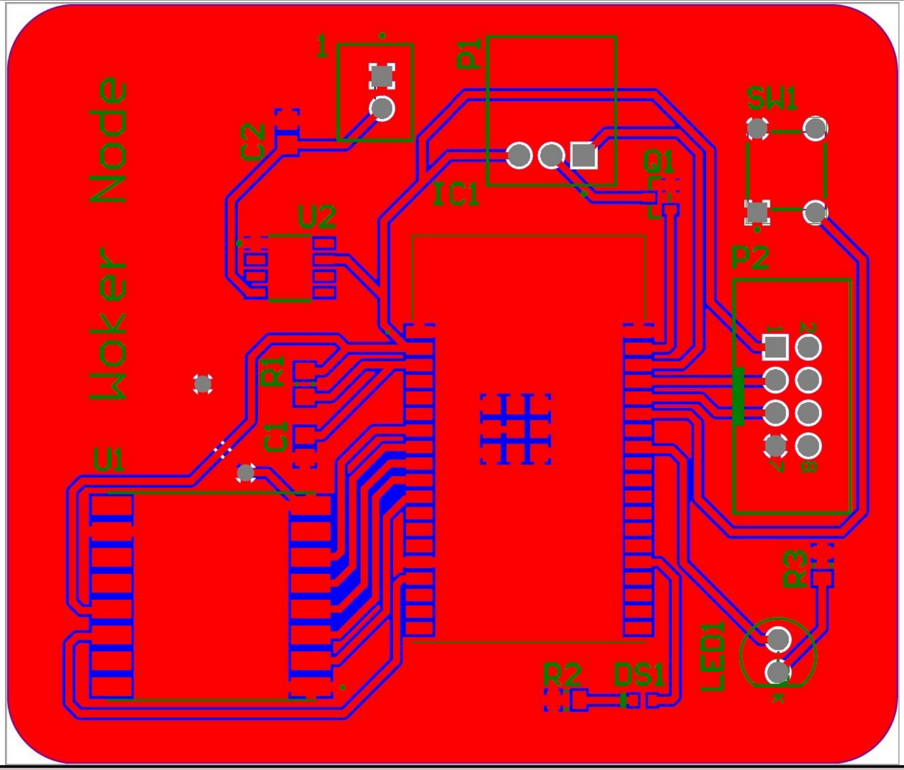
ESP32-WROVER-E



Worker Node
Schematic

Worker Node PCB

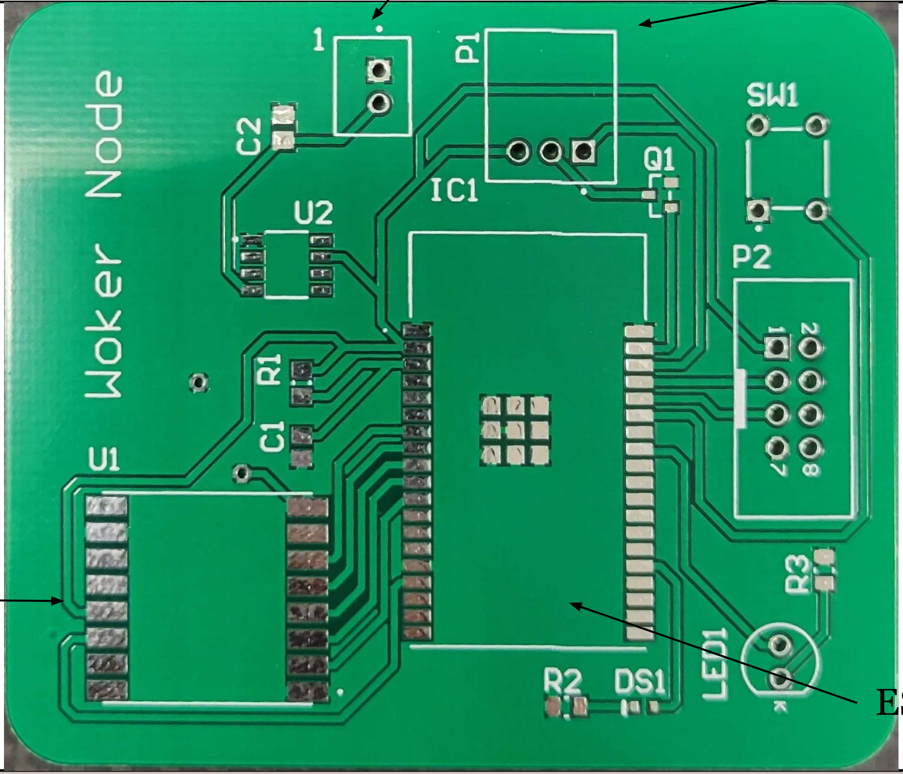




Worker Node PCB

Battery Connection

GPS Connection



LoRa RFM chip

ESP32-WROVER-E

Hardware and Software Used

Breadboard Hardware

- GP-20U7 GPS Modules
- RFM95W LoRa Transceiver
- ESP-32-S2-SAOLA-1
- BJTs
- Pushbuttons
- LED

PCB Hardware

- ESP32-WROVER-E
- GP-20U7 GPS Modules
- RFM95W LoRa Transceiver
- Rechargeable Batteries
- Voltage Regulator and Charging Controller

Current Software

- VSCode
  - Mesh Network
  - Website
- C/C++ Libraries
  - LoRa
  - TinyGPS++
- Python for reverse geolocation

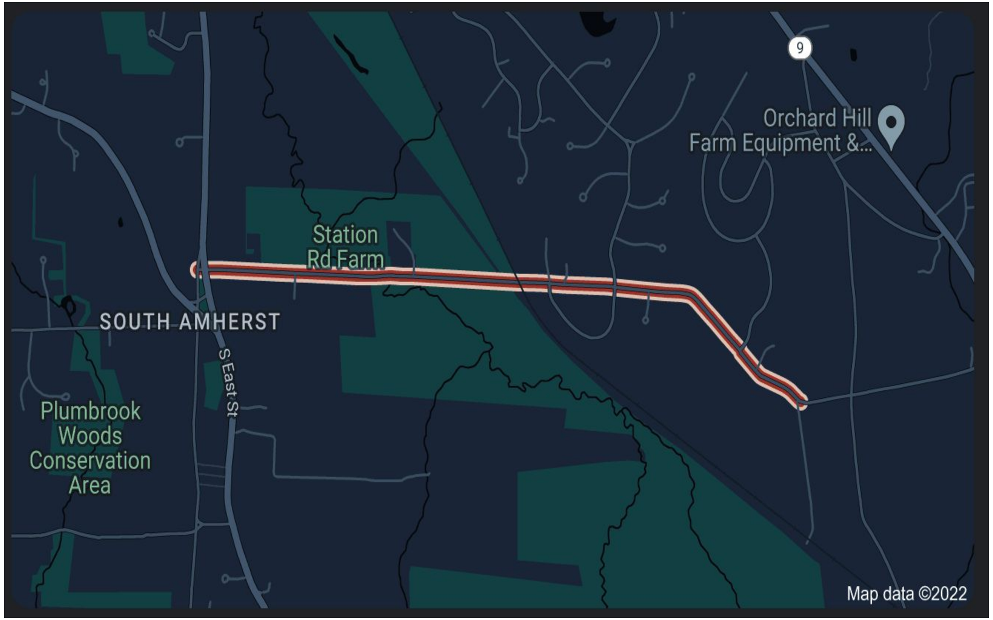
Future Software

- OpenStreetMap mapping of GPS locations
  - Reverse Geocoding?

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.

Future Changes to Design

Hardware:

- The USB connector on the PCB will be changed to type C instead of Micro
- An SD card port will be added the the PCB so map data can be stored in the system instead of needing to be accessed from online
- Mounting holes to secure PCBs to casing or space for ridges in the housing case to slide it in
- Antenna will be fit to the inside of the casing due to water resistance

Software:

- The mapping software should be able to display a location from given GPS coordinates and refreshes every instant

FPR Testing Plan

1. Ensure that a signal from a worker node at least 1 km away is received at a base station (demo)
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. Measure how long it takes for a signal to reach a base node after activation of a worker node (test)
6. Use the completed worker node until battery death to determine lifetime of nodes and compare results to projected battery life of 3 days (test)

Project Expenditures

Components	Units Bought	Cost Spent
Pre-MDR Expenditures	NA	$228.98
PCBs w/shipping	15	$67.84
PCB Hardware w/shipping	-	$122.16
3D Printed Housing	0	$0
Other Shipping + Tariff	-	$26.01
Total	**-**	**$444.99**

Will Need	Units Bought	Estimated Cost
Remaining Funds	-	$55.01
Total	**-**	**$500.00**

Member Responsibilities

Hakan Saplakoglu

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

Joseph Mitchell

- Geolocation Software, Web Development, Network Comms

Tirth Patel

- PCB Population and Testing, MCU Programming, Budget Manager

Jackson Wallace

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

Gantt Chart

Team 14 CDR-FPR

Gotcha

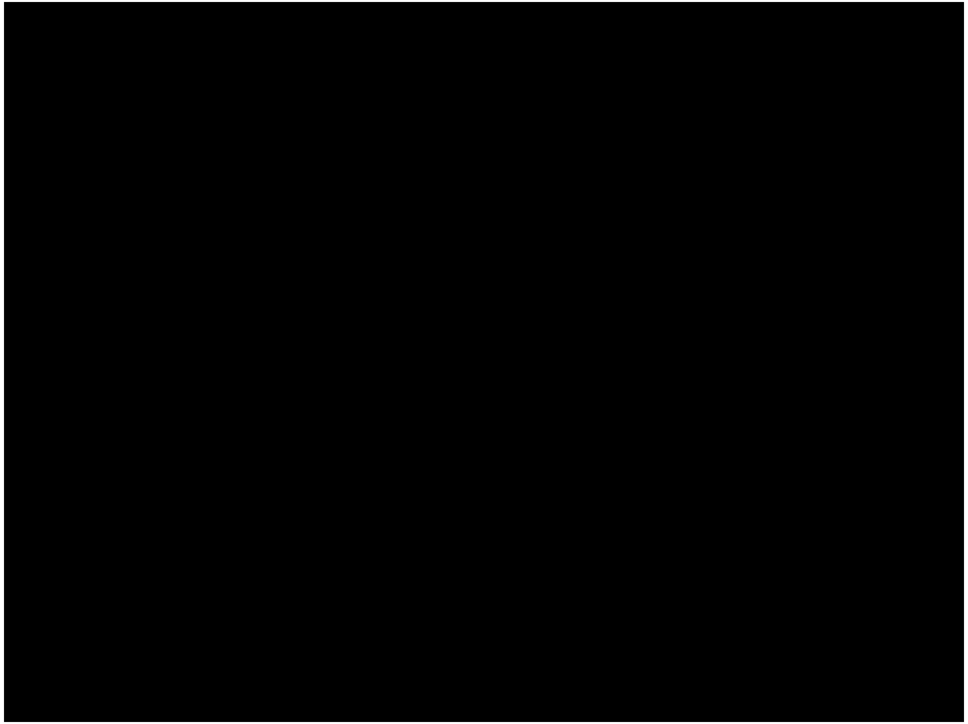
Project Start: Mon, 3/21/2022

Display Week: 1

TASK	ASSIGNED TO	START	END
Finalize MCU Software (ESP and UI)	JM, HS	3/21/22	4/1/22
PCB Population and Revisions?	JW, TP, HS	3/21/22	4/1/22
Housing/Antenna Design	JW, TP	3/28/22	4/15/22
Testing / Revisions	All	4/4/22	4/22/22

WEEK 1					WEEK 2					WEEK 3					WEEK 4					WEEK 5 (FPR)				
21	22	23	24	25	28	29	30	31	1	4	5	6	7	8	11	12	13	14	15	18	19	20	21	22
M	T	W	TH	F	M	T	W	TH	F	M	T	W	TH	F	M	T	W	TH	F	M	T	W	TH	F

Demo



Questions? Comments? Concerns?