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ENGINEERING
TEXAS A&M UNIVERSITY

Team 14: RF Triangulation Bi-Weekly Update 2

Josh Broyles, Brandon Stokes,
Jack Parkinson, Kathleen Hutchinson

Sponsor: Max Lesser
TA: Souryendu Das

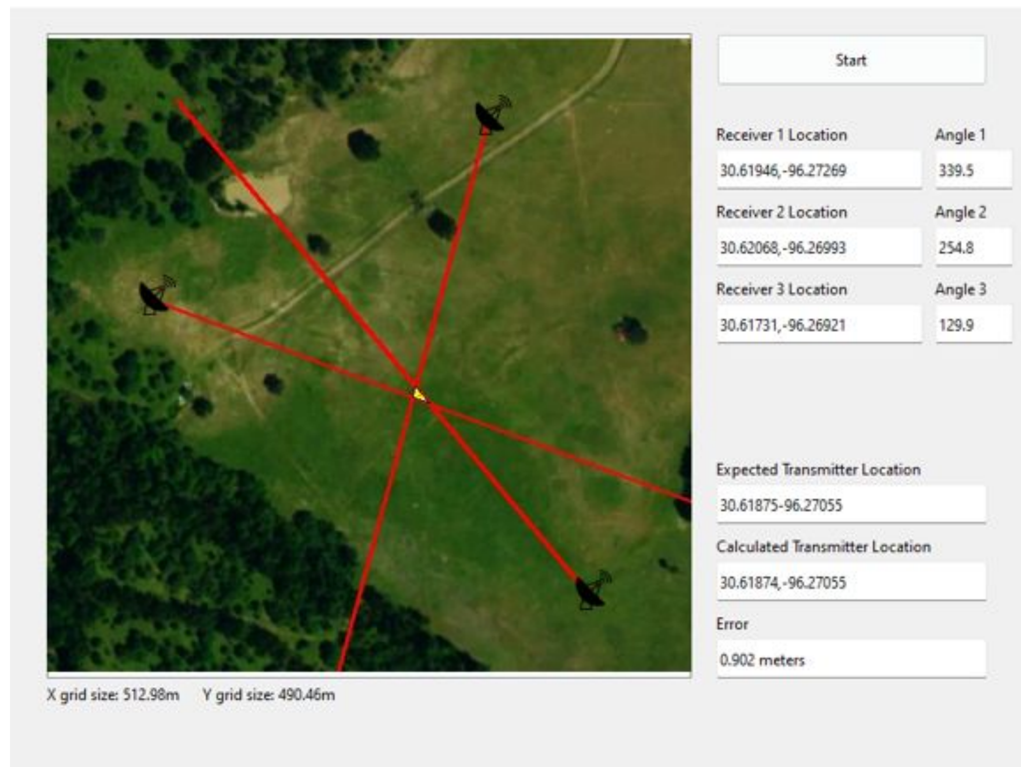
Project Summary

How do you accurately find a signal source in a ~100 meter area?

RF Triangulation uses **three receivers** with motors to scan an area for the **strongest radio frequency signal** from the transmitter and use their collective angles from "true" North to determine the location of the transmitter.

Within ~10% error

(currently calculating <5%)



Project/Subsystem Overview

Josh Broyles - Transmitter

- PCB design for Transmitter
- Programming Transmitter MCU
- Sends out Radio Frequency

Kathleen H. - Receiver - ESP32 Modules

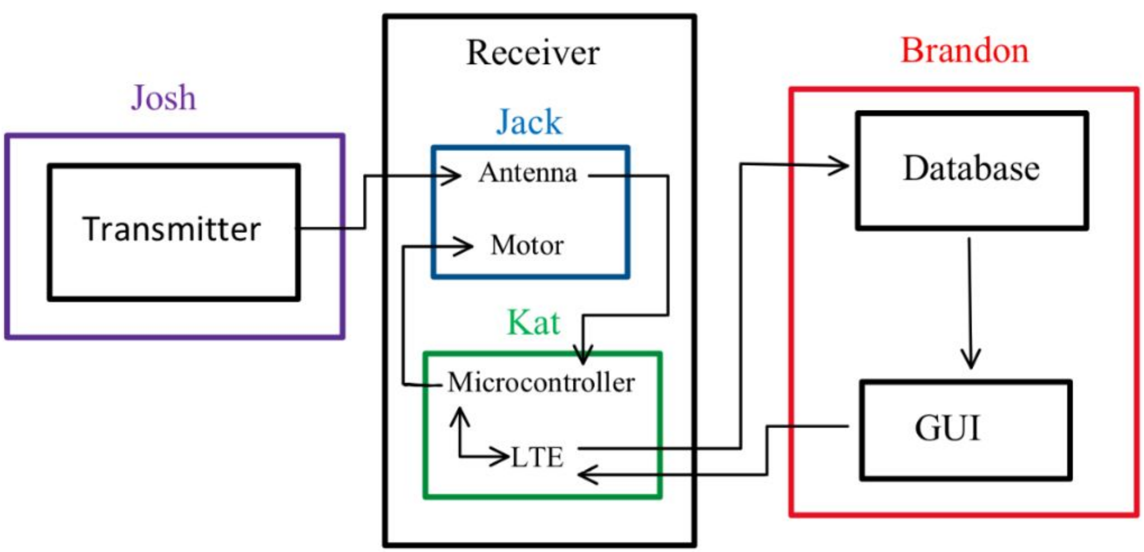
- PCB design for ESP32 and 4 modules
- Programming ESP32 for modules
- Sends signal to Database

Jack P. - Receiver - Antenna/Motor

- PCB design for motor driver
- Programming ESP32 for motor
- Receives signal

Brandon Stokes - Database & GUI

- Database creation
- Display of transmitter location to User
- Error calculation through GPS



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Project Timeline

The team will finalize and order parts/PCB

Finalize realistic goals with sponsor

[Complete before February]

Finalize Tasks and Objectives

Order all parts still needed

The team will finalize individual subsystems

[February]

Validate PCBs

Program MCUs /Modules

The team will debug any problems with code, power, etc. and begin integration

[March]

Debug and Integrate

Once fully integrated with all parts working, the team will begin validation testing.

[Late March through Mid April]

Validation

Once validation is complete with a working project, the team will complete a final demonstration

[Late April]

Final Demo

Completed

In Progress

Not Started

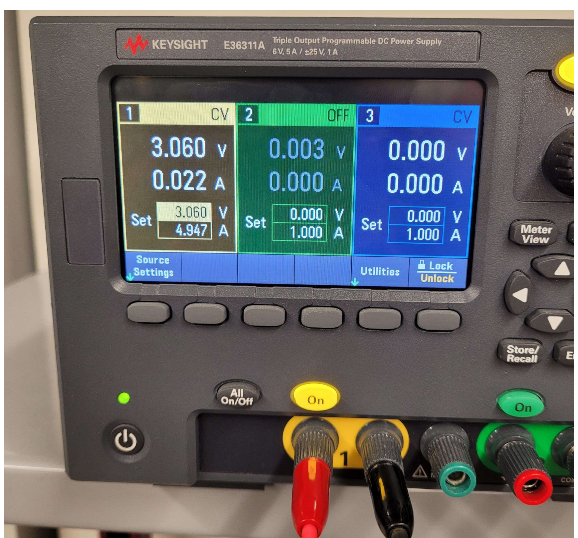
Transmitter

Josh Broyles

Accomplishments since 404 16 hrs of effort	Ongoing progress/problems and plans until the next presentation
3D Printed Radio Housing Tested GPS module, confirmed it is in standby mode Re-wrote MCU to interface with GPS	On-going test of GPS accuracy Begin soldering PCB together

Transmitter

Josh Broyles




```c
#include <msp430.h>
#include <TI_USCI_I2C_master.h>
#define TXD BIT2
#define RXD BIT1
//Take in GPS send to RX Uart

void main(void)
{

    WDTCTL = WDTPW | WDTHOLD;       // stop watchdog timer
    P1SEL  |= BIT6 + BIT7;          //SCL and SDA
    P1SEL2 |= BIT6 + BIT7;
    P1SEL = TXD | RXD;              // P1.1 = RXD, P1.2=TXD
    P1SEL2 = TXD | RXD;



    UCB0CTL1 |= UCSWRST;            //set UCA0 in reset to configure
    UCB0CTL0 = UCMST + UCMODE_3 + UCSYNC;
    UCB0CTL1 |= UCSSEL_2;           //use the SMCLK
    UCB0BR0 = 208;                   //Change the number (12) fSCL = SMCLK/12 = 100kHz
    UCB0BR1 = 0;
    UCB0I2CSA = 0x48;               //Change to slave address I2C

    UCA0MCTL = UCBRS1;                        // Modulation UCBRSx = 1

    UCB0CTL1 &= ~UCSWRST;
    IE2 |= UCB0RXIE;                //allow RX interrupt


    while(1)
    {
        UCB0CTL1 |= UCTXSTT;        //Start I2C connection

        __bis_SR_register(CPUOFF + GIE); //Go into Low Power Mode and stay there

        __delay_cycle(100000);      //100ms delay
    }
```

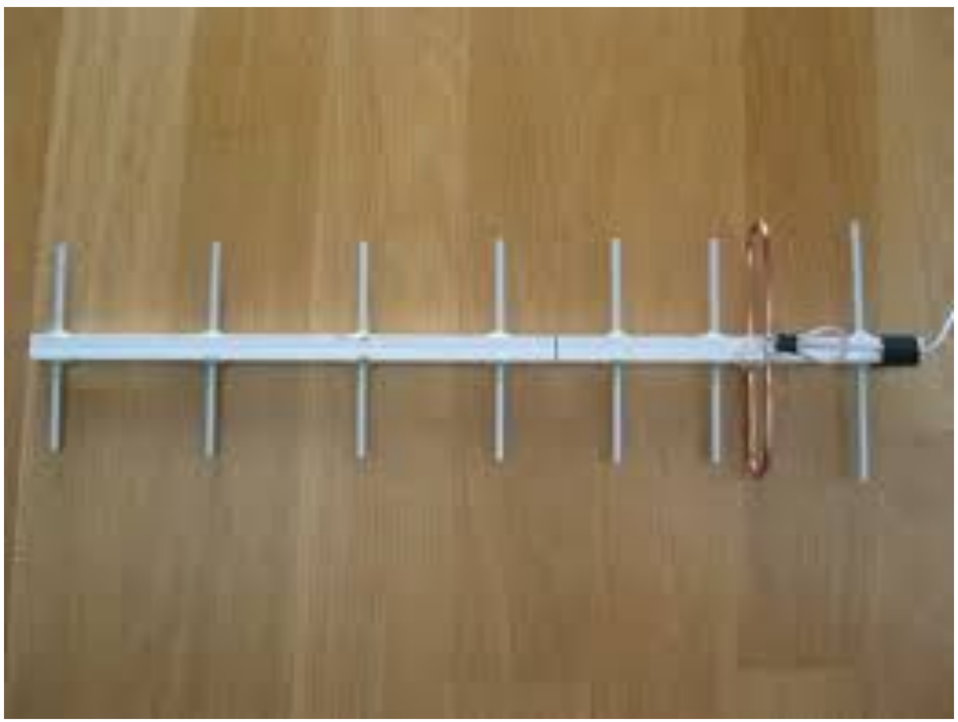
Receiver: Antenna & Motor

Jack Parkinson

Accomplishments since 404 18 hours	Ongoing progress/problems and plans until the next presentation
Final parts list for PCB has been ordered PCB has been ordered Antenna design has been decided and created	Simulate the antenna design Buy parts and assemble antenna in preparation for testing Assemble PCB

Receiver: Antenna & Motor

Jack Parkinson



Frequency : 2400 MHz, (useful from 2352 to 2448)
Wavelength : 125 mm
Rod Diameter : 10 mm
Boom Diameter : 20 mm
Boom Length : 213 mm
d/lambda : 0.040 (min.: 0.002 , max.: 0.01)
D/lambda : 0.050 (min.: 0.01 , max.: 0.05)
Elements : 8
Gain : 10.61 dBd (approx.)

Reflector Length : 65 mm
Reflector Position : 0 mm

Dipole Position : 30 mm

Director #1 Position : 39 mm , Length : 61 mm
Distance Dipole - Dir. #1 : 9 mm

Director #2 Position : 62 mm , Length : 61 mm
Distance Dir. #1 - Dir. #2 : 23 mm

Director #3 Position : 89 mm , Length : 60 mm
Distance Dir. #2 - Dir. #3 : 27 mm

Director #4 Position : 120 mm , Length : 60 mm
Distance Dir. #3 - Dir. #4 : 31 mm

Director #5 Position : 155 mm , Length : 59 mm
Distance Dir. #4 - Dir. #5 : 35 mm

Director #6 Position : 193 mm , Length : 59 mm
Distance Dir. #5 - Dir. #6 : 38 mm

Directors / Parasitics are not isolated.
The length has been increased to compensate for that.

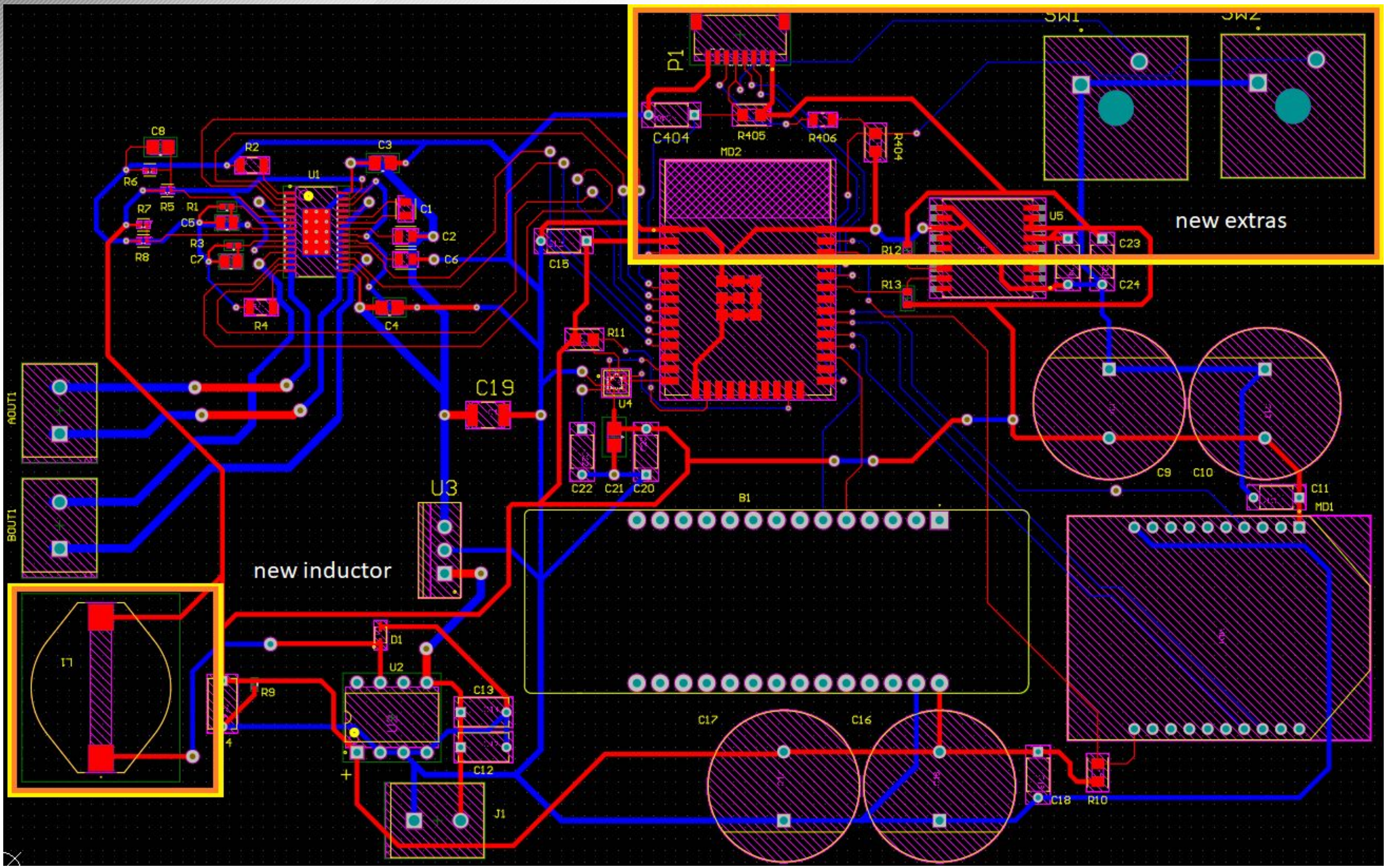
Receiver: ESP32 & Modules

Kathleen Hutchinson

Accomplishments since 404 20 hrs of effort	Ongoing progress/problems and plans until the next presentation
Completed ordering parts in preparation for PCB (received today) PCB Ordered	1. Work on connection between ESP32 and Pycom (UART) 2. Work on connection between ESP32 and XBEE (SPI) Problems: Getting RX/TX to send messages between Pycom & ESP32

Receiver: ESP32 & Modules

Kathleen Hutchinson



Database & GUI

Brandon Stokes

Accomplishments since 404 17 hrs of effort	Ongoing progress/problems and plans until the next presentation
• Fixed out of bounds situation to not need to press start again • Reworked the database to be a single table to do multiple runs in preparation for integration	• Communicating from the Pycom to Database • Adding a percentage error instead of raw error • Problems: Connecting Pycom to my local computer

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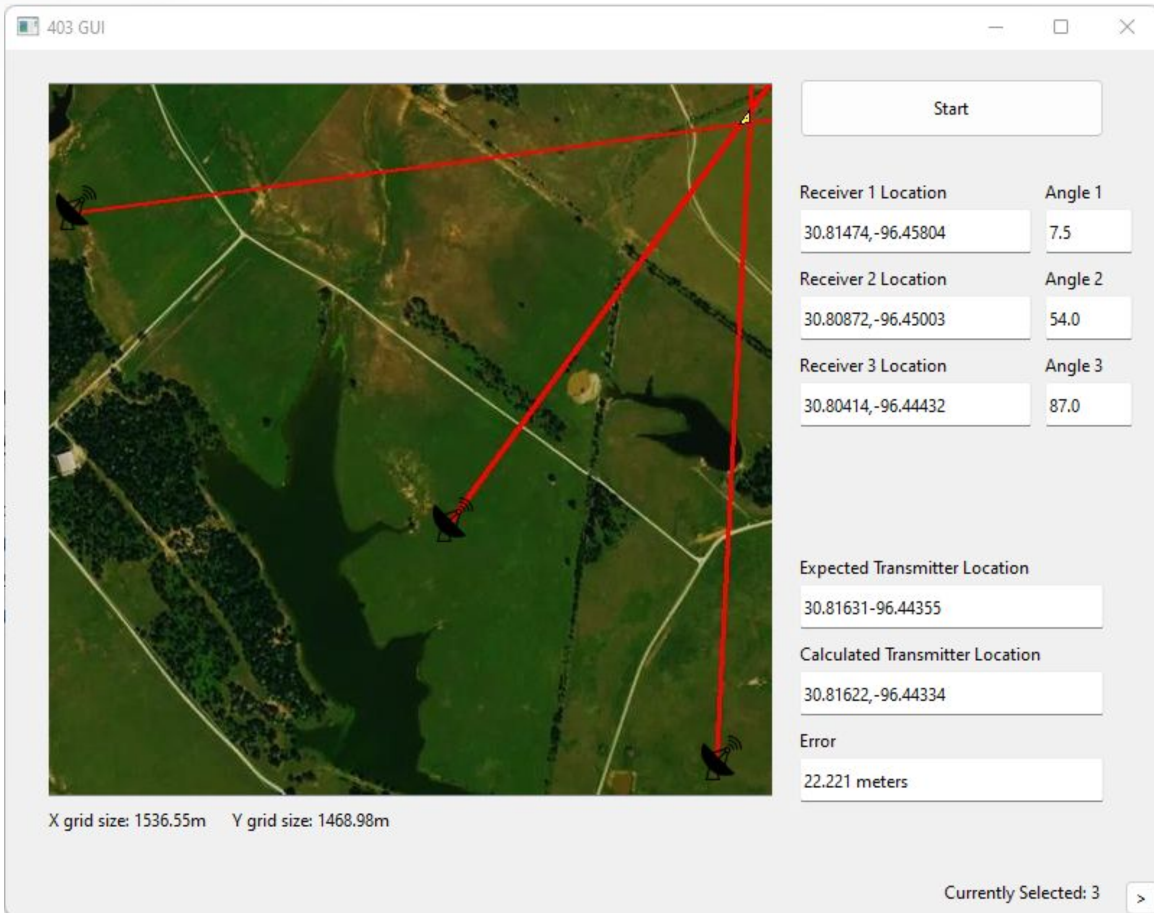
Database & GUI

Brandon Stokes

	recname smallint	rec_lat double precision	rec_long double precision	trans_lat double precision	trans_long double precision	sig_angle double precision	time_last_updated text
1	1	30.61946	-96.27269	30.61875	-96.27055	339.5	2023-02-06 02:33:37.7
2	2	30.62068	-96.26993	30.61875	-96.27055	254.8	2023-02-06 02:33:37.7
3	3	30.61731	-96.26921	30.61875	-96.27055	129.9	2023-02-06 02:33:37.7



Execution & Plan

	1/24/23	1/31/23	2/7/23	2/14/23	2/21/23	2/28/23	3/7/23	3/14/23	3/21/23	3/28/23	4/4/23	4/11/23	4/18/23
Ring out PCB													
Test Radio Distance													
Finish Programing MCU													
Assemble PCB													
Validate PCB													
Validate Messages to Receivers													
Finalize Schematic/PCB Design													
Order/Print PCB													
Program Modules													
Validate PCB													
Finish ESP32													
Connect Antenna													
Finalize Antenna Design													
Order/ Build Antenna													
Test Antenna													
Test Motor Controller													
Database to Single Table													
Rework out of bounds situation													
Finish Pycom													
Add Resetability													
Add Error checking to data													
Integrate Reciever Modules													
Test Inter-Communication													
Complete System Validation													
Final Demo													
Final Report													

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Validation Plan

Paragraph #	Test Name	Success Criteria	Methodology	Status	Responsible Engineers
3.2.1.1	Battery Operating Time	The antennas shall be able to operate for at least an hour on battery power. For receivers, this includes an operating step motor and the microcontroller. For the transmitter, this includes the ability to continuously operate the radio and the microcontroller.	Team will power on the device and test it for long periods of time to ensure it lasts as long as it should.	TESTED	Full team
3.2.1.2	RF Transmission Time	The receiving, processing, and output of signals to give an approximate location shall not exceed 30 seconds.	A timer function will be used to time delay between sweep and approximate location calculation and display.	UNTESTED	Full team
3.2.1.3	Operational Search Range	The RF triangulation System shall support a search range of at least 100 meters.	The antennas will be placed greater than or equal to 100 meters from each other.	UNTESTED	Full team
3.2.1.4	Time to load for GUI	The RF Triangulation system will take <15 seconds to fully load the interface	A timer function will be used to time delay between start up and interface display.	TESTED	Brandon Stokes
3.2.1.5	Time to pull map from web	The RF Triangulation interface should be able to take in the receivers location and grab a reasonable box from the web to get the background map in less than 10 seconds	A timer function will be used to time delay from location approximation calculation to location point display on background map.	TESTED	Brandon Stokes
3.2.1.6	Directional Antenna Accuracy	The directional receiver antenna will be accurate to within at least 5 degrees of the transmitter.	Measure difference between calculated angle of transmitter versus given GPS coordinates of transmitter.	TESTED	Jack Parkinson
3.2.1.7	Time for initial sweep at startup	The 360 degree sweep at the start of the locating process should take a maximum of 15 seconds to complete.	A stopwatch will be used to time 360 sweep completion.	UNTESTED	Jack Parkinson
3.2.1.8	Time for regular sweeps	The sweeps following the initial sweep should take a maximum of 7 seconds to complete.	A stopwatch will be used to time individual sweeps.	UNTESTED	Jack Parkinson
3.2.2.1	Antenna Movement Degrees	The signal receiving antennas of the RF Triangulation system will operate with the ability to search 360 degrees.	Ensure motor parts can accurate sweep 360 degrees.	TESTED	Jack Parkinson
3.2.3.1.1	Power Consumption	The maximum peak power of the system shall not exceed 0.36 watts.	Use multimeter to validate peak power of system.	TESTED	Kathleen Hutchinson
3.2.3.1.2	Input Voltage Level	The input voltage level for the RF Triangulation System shall be at least +5V.	Use multimeter to validate input voltage level.	TESTED	Kathleen Hutchinson
3.2.3.3	Transmitter	The Transmitter part of the system will output a constant radio signal at 2.4 GHz of its GPS location that will be used to calculate the error of the calculated location versus the actual system	Measure radio signal from Transmitter.	UNTESTED	Josh Broyles
3.2.3.5	Error on output	The RF Triangulation interface should not exceed an error of 10% for the given locations of the receivers and then error on the actual and given transmitter	Measure difference between calculated angle of transmitter versus given GPS coordinates of transmitter.	UNTESTED	Jack Parkinson and Kathleen Hutchinson
3.2.3.1	Pressure (Altitude)	The RF Triangulation System shall be designed to withstand and function properly at altitudes from sea level to 400 feet above sea level.	Ensure system can sit at ground level in field or other flat area in College Station/Bryan, TX.	UNTESTED	Full team
3.2.3.2	Thermal	The RF Triangulation System shall be designed to withstand and function properly at temperatures from 50°F to 90°F.	Use heating device to raise temperature to 90F and test system functionality. Use freezer to cool system to 50F and test system.	UNTESTED	Full team
3.2.3.3	Humidity	The RF Triangulation System shall be designed to withstand and function properly at humidity from 0% to 100%.	Ensure system functionality when outdoors in field in College Station/Bryan, TX.	UNTESTED	Full team
3.2.5.1.1	Built In Test (BIT)	The RF Triangulation System shall have an internal subsystem that will generate test signals and evaluate the RF Triangulation System responses and determine if there is a failure.	Built in error detection in code.	TESTED	Brandon Stokes
N/A	Full System Demo	A user is able to initialize the tracking of a transmitter and watch its location updates as it moves around a large area.	Run a full test of the system after development of each subsystem and test that they interact with each other successfully	UNTESTED	Full team

Thank you for your attention!

Feel free to ask us questions