Engineering Notebook
Rachel Swan
Senior Design - Autonomous Vehicle for Survival Detection: Communication Team
Fall 2024

Sprint 1:

9/19

Lit Review. All resources, citations, papers used in Lit Review are available on the team Github.

a. Bibliography of references: https://docs.google.com/document/d/1N0dG5ggIYNqAYxFy4Y3gFA8iJIIVzb2reEV-PBrsIeg/edit?tab=t.0

Research on modulation

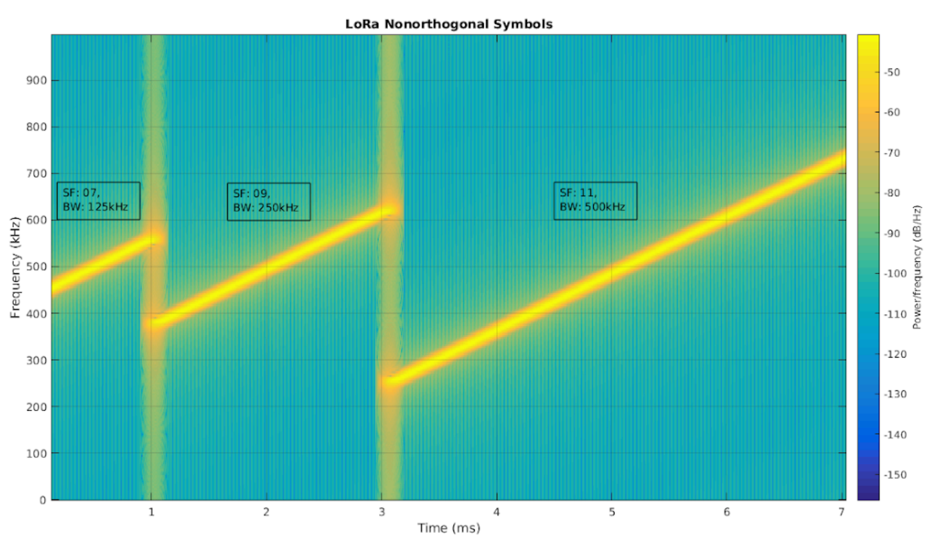
a. Wifi using raspberry pi 2.4 GHz SoC is a viable option
b. Backup option: Lora Communications
    i. Proprietary radio communication (owned by Semtech); good for communicating at a long range, outdoors, in a place with limited access to WiFi, cellular, and other communications that require large infrastructure. Due to this, it is a good modulation technique to use for a disaster survival area, because it will be able to communicate over long distances in an area with little infrastructure available.

9/22

Research on radios

c. RPI5 has 2.4 GHz WiFi SoC, added to parts list
d. LoRa hat to place on top of RPi5's for LoRa communications
e. Potential to use an SDR?

Example Lora Signal Plotted using MATLAB, with different Spreading Factors (7,9,11):



Sprint 2:

10/4

Additional research on LoRa

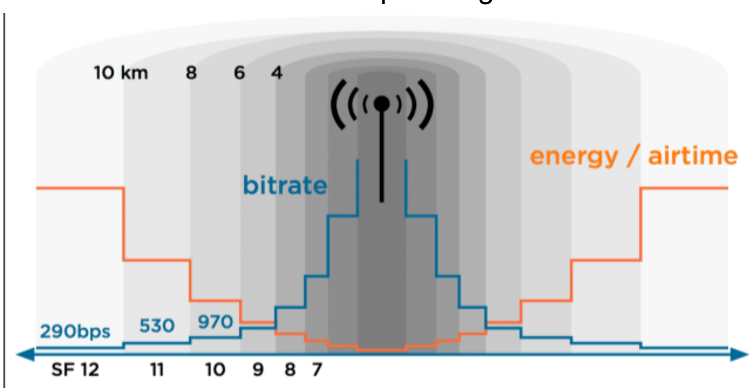
a. LoRa contains spreading factors (SF) from 7-12. Only SF 7-10 is legal in North America due to restrictions.
    i. We may want to use a higher SF (8,9, or 10) since we are simulating a disaster area. Higher spreading factor = slower data rate, but more reliable communication. LoRa with a SF of 12 can even be demodulated when the SNR is -20 dB! (that means the noise is 100x stronger than the signal power)
b. LoRa communicates in ISM bands. We will have the option to use the S-band ISM band (preferred) or UHF ISM band.

10/7

Scope location for testing of rover

c. LB 274 is inadequate. Why?: Indoors, small area, no terrain, too many people inside the room, tables are in the way
d. Potential locations for testing:
    i. If we must stay on campus, we could use one of the fields across the street or by O'connor dorms.
    ii. Backyard (cookout) with testing rover movement and detection (preferred); required to take off campus

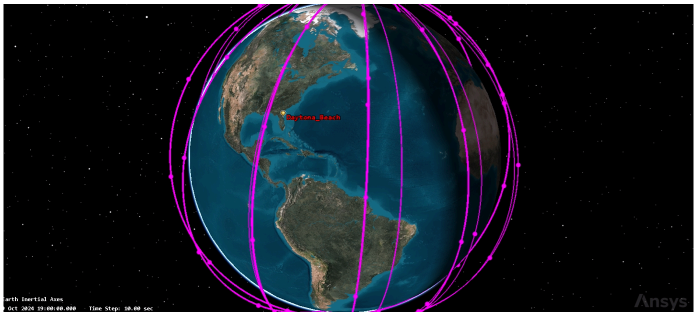
Illustration of different LoRa spreading factors data rate vs. time:

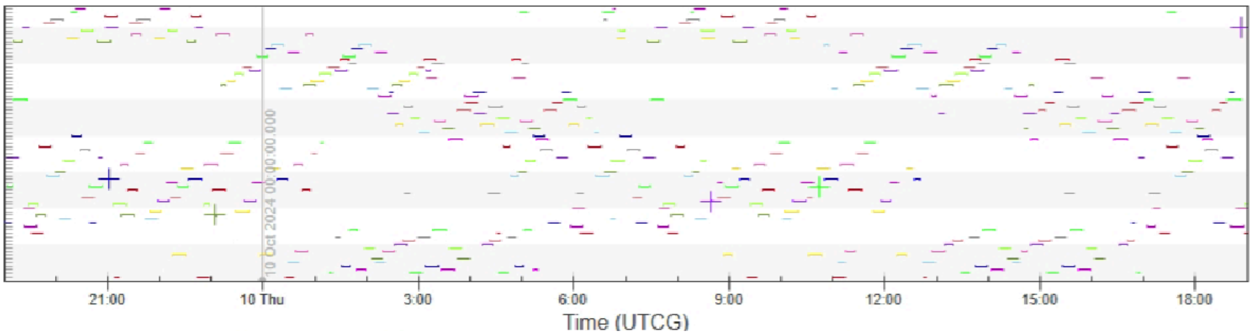


10/9

STK Sim

Our project got completely changed. It is now a requirement (?) to do satellite comms. So I made an STK simulation of both Iridium satellite constellation and Starlink satellite constellation to verify we have appropriate 24 hr coverage in the Daytona Beach area.





What this graph is showing: Each of the Iridium sats are on the left hand side. The lines are showing when each sat has access to the DB area. With a constellation of 80 satellites, we have full coverage to the Iridium constellation. The constellation is in LEO so we're only going to have a few minutes of coverage per satellite as you can see in the graph. However, with 80 satellites these add up to amount to a full coverage.

break for hurricane

Sprint 3:

10/16

1. Our project completely changed (again). It is no longer a requirement to do Sat Comms (?) so we will be using WiFi or LoRa as that is easier and makes more sense anyways.
    a. Anyways we need to make a decision on the modulation. For now we will use WiFi because we are using 2 RPi5's to communicate. We will also have a LoRa hat as a backup, in case the project changes (again again) and we have to have a long range communication (WiFi is a LAN so not gonna work for long range).
2. Finalized parts list and sent to Dr. T. We will only have 2 radars so only 240 degrees coverage instead of 360………
    a. Still working with the hardware team to decide where we will mount it (high up on a pole, or in the front of the vehicle?)

fall break

10/24

Ground station decision.

a. We're just going to have our own DIY ground station. We may need antennas to send/receive if the RPi5 or LoRa hat antenna isn't enough, but those can always be fabricated.
b. The Micaplex has a GS which I use for research, if we needed to use it we could ask permissions from Dr. Rojas. However, this is unlikely because it would

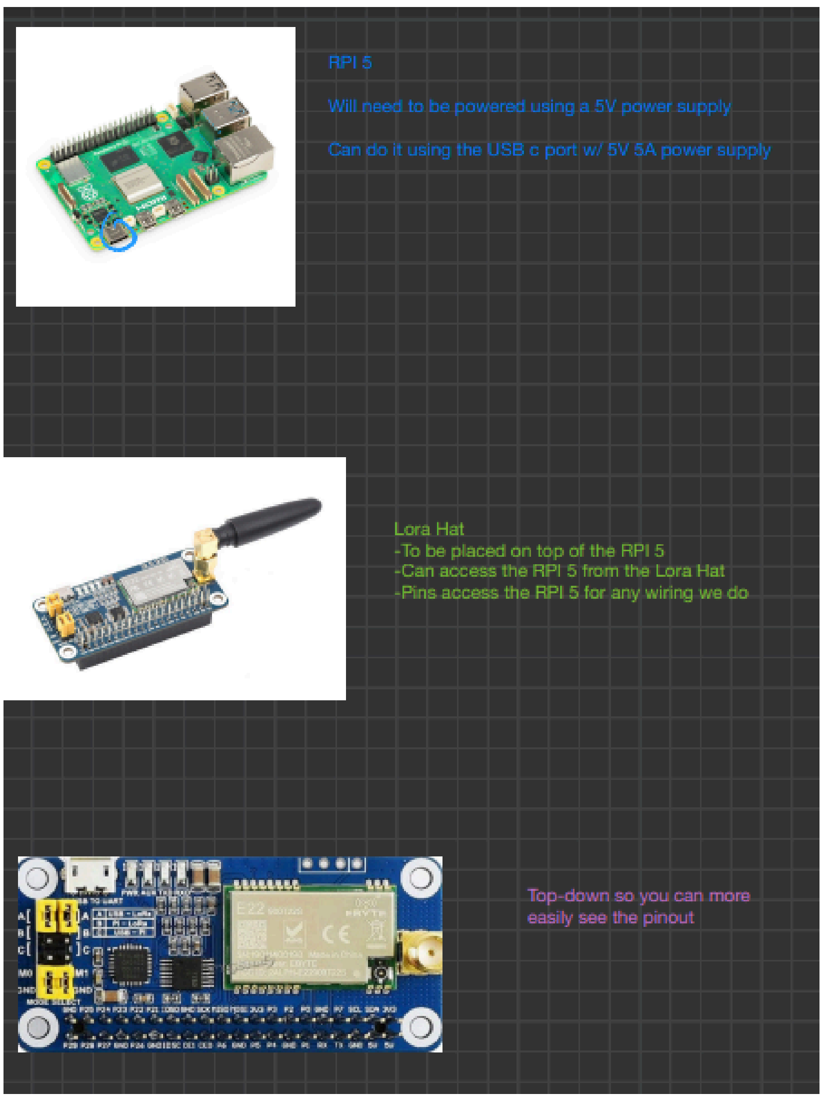
overcomplicate things, its ITAR, and also it was damaged in the hurricane so it will take some weeks to become operational again. It's just a backup option.

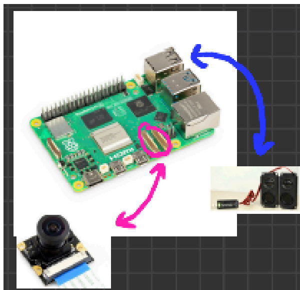
Sprint 4:

10/29: In this sprint we had a lot of documentation to do, so we worked on that a lot. We have the SRS and SDS. Today we worked on scrum and adding items to the backlog

10/31: I wrote requirements, mostly relating to the raspberry pi/LoRa, and the sensors. I wrote requirements relating to the hardware and communication interfaces. I also wrote requirements. I also wrote the related features section of the document.

11/5: I wrote out all the sensor components and all the wiring that needs to happen.



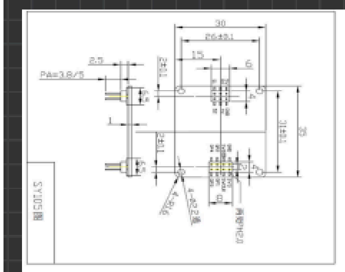


Camera and Speaker

-These are pretty straight-forward.

-The speaker is plug and play, just connect to USB

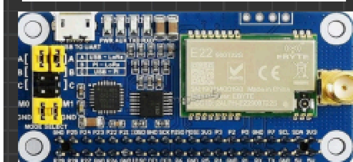
-The camera goes to the cam port

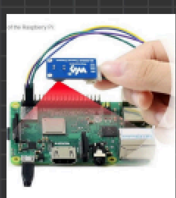


Heartbeat sensor

Wiring:

RPi 5		101990981
5V	⟷	VCC
Tx	⟷	Rx
Rx	⟷	Tx
GND	⟷	GND

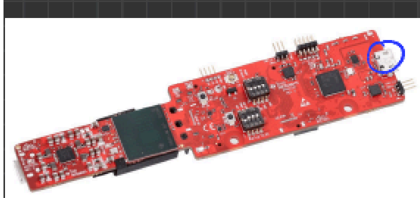


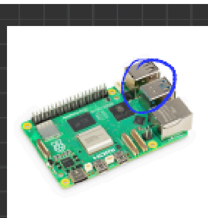


Thermal Camera:

Wiring:

RPi 5		MLX90640
5V or 3.3V	⟷	VCC
GND	⟷	GND
SDA	⟷	SDA
SCL	⟷	SCL



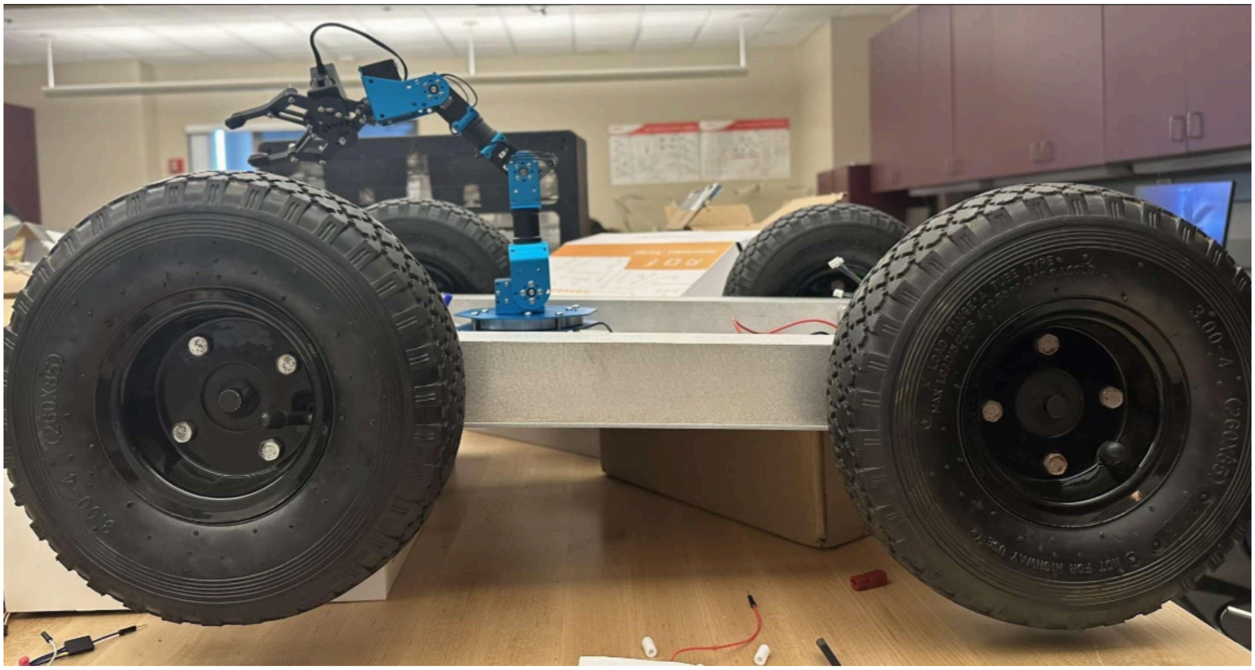


RADAR(s)
-Will connect to RPi5 via USB
-USB powered
-No external 5V supply needed

NOTE:
We need to be really careful about static when handling this (should use anti-static wristband)

Sprint 5

11/12: Started to work on poster. Looked through EECS hallways at example posters. Used template from my old SRS poster. Took photos for the poster.



11/14:

Worked on MATLAB script of LoRa simulation in MATLAB. It simulates the Tx and Rx of a LoRa modulated signal.

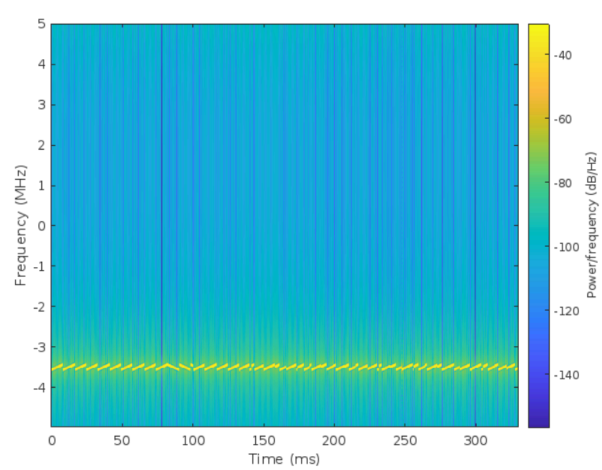
Example code and output:

```
clear
clc

SF = 10 ;
BW = 125e3 ;
fc = 915e6 ;
Power = 14 ;

message = "Hello World!" ;

%% Sampling
Fs = 10e6 ;
Fc = 921.5e6 ;
%% Transmit Signal
signalIQ = LoRa_Tx(message,BW,SF,Power,Fs,Fc - fc) ;
Sxx = 10*log10(rms(signalIQ).^2) ;
disp(['Transmit Power   = ' num2str(Sxx) ' dBm'])
%% Plots
figure(1)
spectrogram(signalIQ,500,0,500,Fs,'yaxis','centered')
figure(2)
obw(signalIQ,Fs) ;
%% Received Signal
message_out = LoRa_Rx(signalIQ,BW,SF,2,Fs,Fc - fc) ;
%% Message Out
disp(['Message Received = ' char(message_out)])
```



11/19: Worked on diagram for hardware. Shows the connections of all the hardware components.

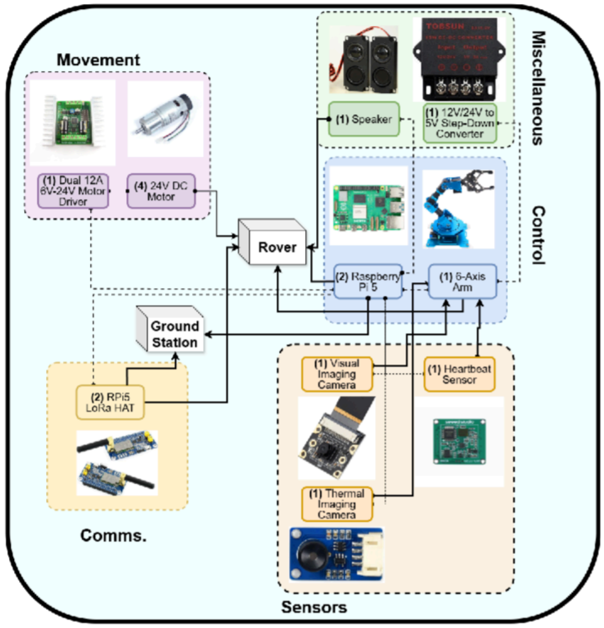


Figure 2. Hardware Architecture

We have all the components divided into categories: control, sensors, communications, movement, and other miscellaneous components. This shows how they all connect and interact with each other for the rover.

11/21: Made final edits to the poster and submitted it.

Sprint 6

11/26 - 12/2: Traveling for Thanksgiving Break

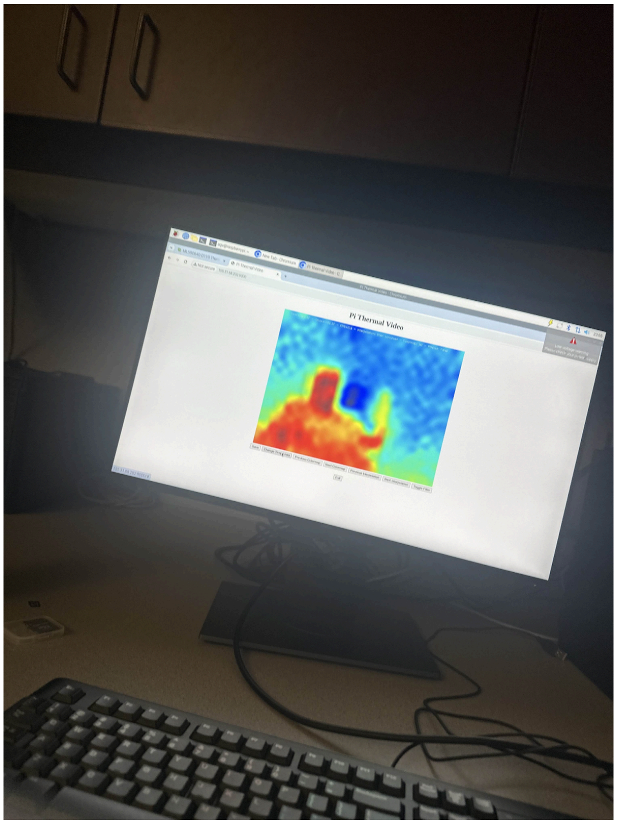
12/3: The semester is basically over… we just have a lot of things due.
We made the slides and filmed our part of the 10 minute video, with an intro, conclusion and work done. 12/5 we will present the poster… overall much of this sprint was consumed by Thanksgiving break. Will start up again next semester.

12/5: Presented the poster; wrote test cases. Happy to be done

Sprint 1 (Semester 2)

1/9: Basically there was just a meeting for the class and the presentation by the professors. So we discussed things like, planning for this sprint and also the requirements of the SRS. There are new things we need to add in the SRS to appease ABET, so we will have to work that out and figure out how we are going to divide the sections between 9 people.

1/12: The thermal camera was working; we can stream it to a webpage (pictured below). We are now asking the software team to integrate it into their GUI.



1/14: We have mostly been working on the SRS, responding to Walter's critiques/comments about it. We want to make several revisions before the due date so that we can earn the most points possible.

1/16: We are trying to test the camera and make it work but it is not working. For some reason it doesn't interface well with the pi which is frustrating. If we spend too much more time on this we will consider ordering another camera. We are pondering this because it would be more cost-effective, taking into account the "cost" of time. Ordering another camera would be less than $5 so it doesn't make sense to spend 10+ hrs doing this if we can just get a different one.

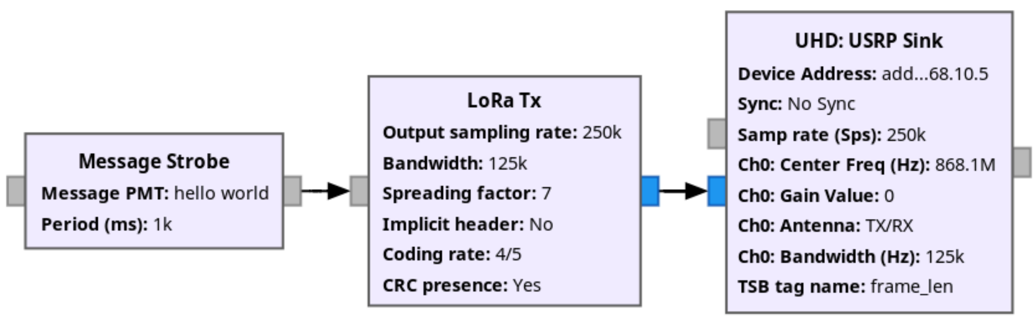
--3 day holiday for MLK day, I was traveling for 5 days---

1/21: Over the holiday Alessia and George did a lot of work while I was skiing (I feel bad). So we spent a lot of today going over what they were able to accomplish. They showed me the speaker was working, and we played sounds to check. We also messed around more with the camera and it just wasn't working. So we are going to order a new one that works better with the pi because it's really cheap.

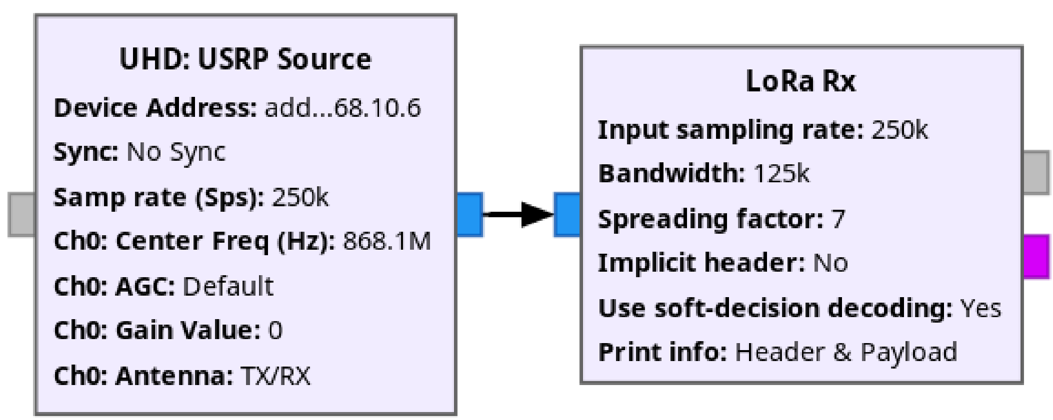
Sprint 2 (Semester 2)

1/23: I worked on GNU radio block diagram for LoRa modulation. It all works in my sim to code, mod, transmit, receive, demod, decode, in my simulation. Figuring out issue with pi with the USRP recognition. Block diagram:

Tx



Rx



1/26: Microphone testing, it works, we realized the speakers we got came with a built-in microphone which helps a lot because then we don't have another extra thing to plug in.

 speaker/microphone

1/28: We decided and assigned the parts for the SRS. Mine was the social aspect/impact of our project. The hardware team is evaluating how this project would be done at a “real” company. George is doing the budget. The rest of us split up the writing part.

1/30: Heartbeat sensor testing, and now we are getting data, but it seems like random ASCII data and we don’t know what it means.

2/2: Wrote my part for the SRS for the extra part we got assigned.

2/3: Worked with Alessia on creating high level diagram for communications system for SDD.

2/4: Sprint planning, final review of SRS before submitting

Sprint 3 (Semester 2)

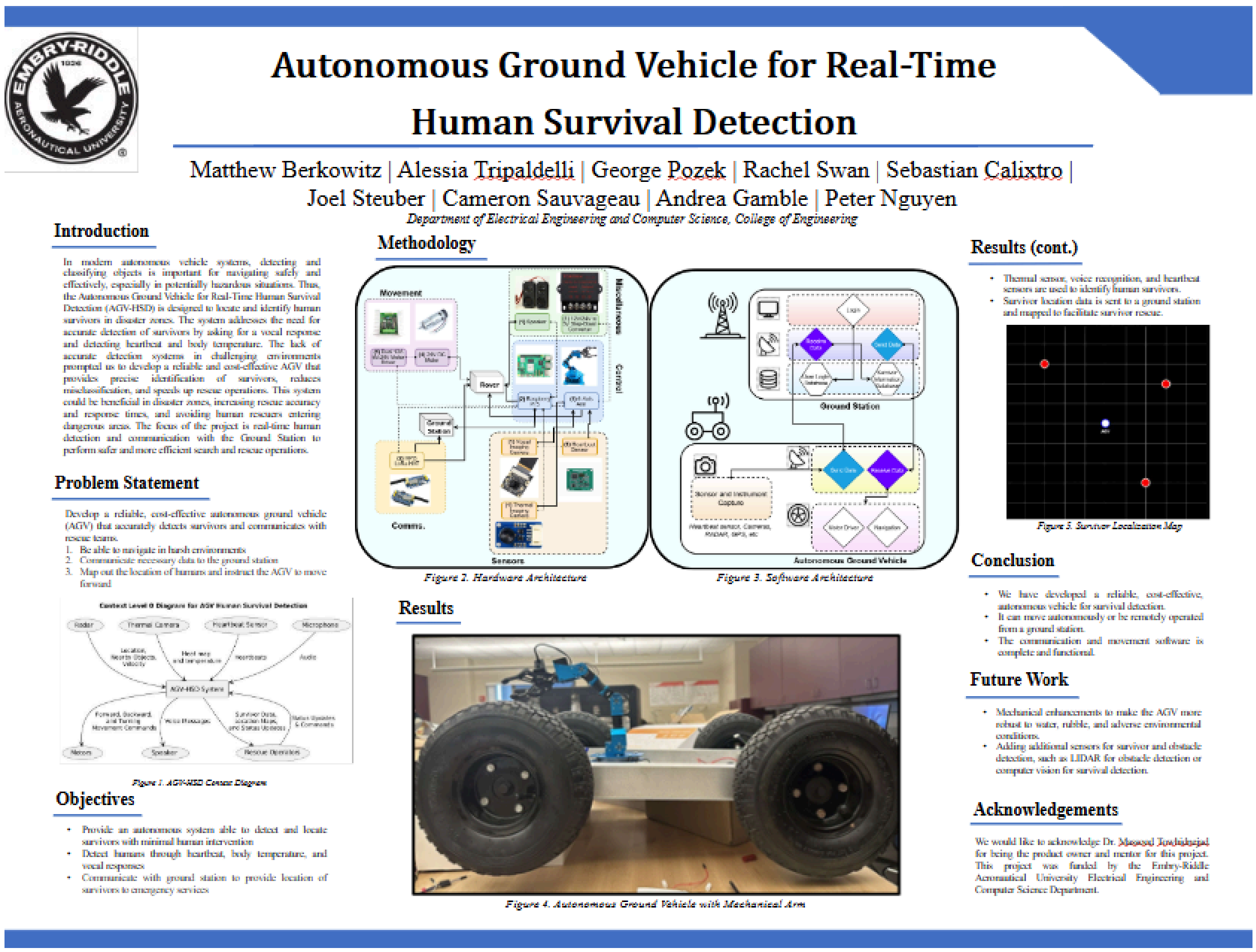
2/6: Began thinking about conference submission, and if we are doing a paper or a poster. We worked on troubleshooting the code for the heartbeat sensor.

Heartbeat sensor

2/9: Worked with George over weekend on WiFi communication so we can ensure it works (then switch to LoRa later) for the demo. We decided to do SSH because its easy, and we were able to transfer the file. So we will show it to the software team later this week.

2/11: Worked on the RADAR, found a linux code of the software we wanted to use (only runs on windows) so hopefully we can make that work.

2/13: We worked on showing SSH to the software team so they can send files and access the other pi to send commands/run code during the demo for Dr. T. Made changes to the poster to update it for the conference with our new results.



2/16: Alessia and I changed the poster and made the final submission to the ASEE regional conference.

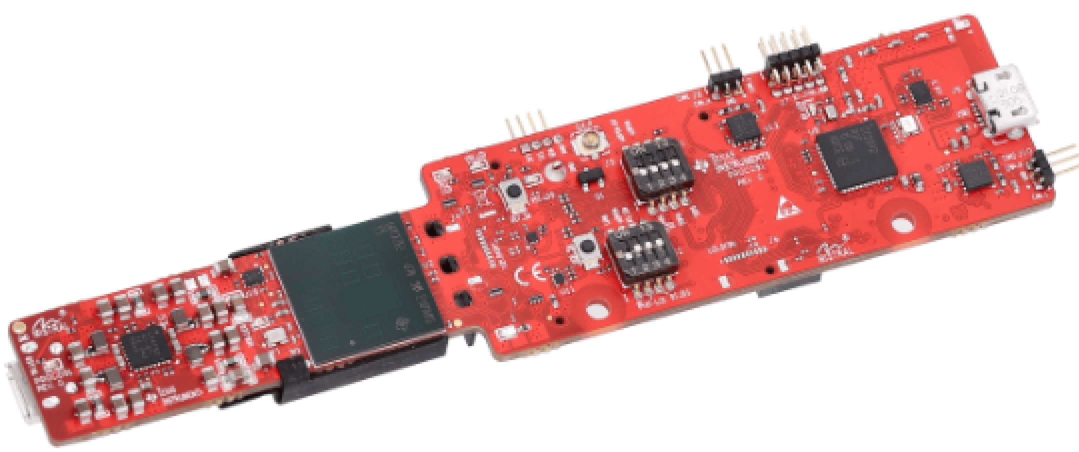
2/18:

We worked on the RADAR and troubleshooting it. We are not sure if we need another piece or not to connect it via USB port/bluetooth, so we are looking into that.

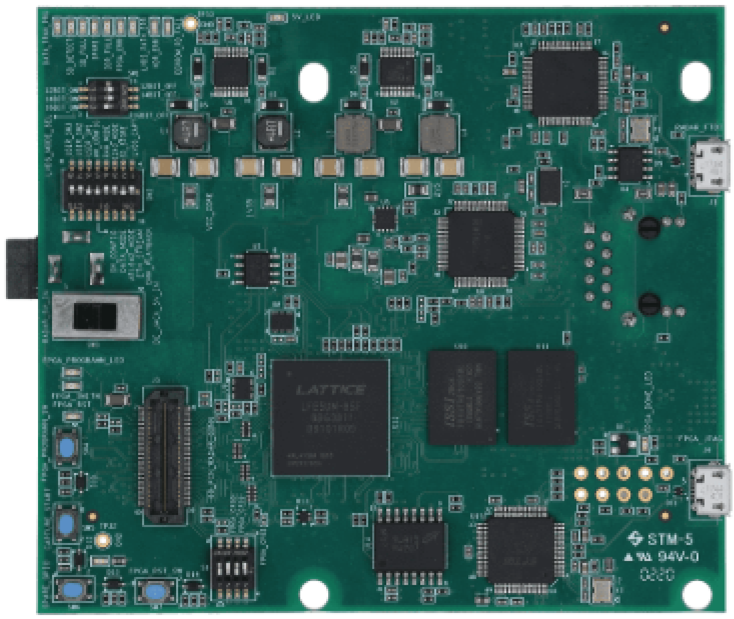
Sprint 4 (Semester 2)

2/20:
We asked Dr. Butka about the radar (he recommended we buy this specific model). We aren't sure because although I've worked with this radar before, it was in conjunction with other boards. I have never used this one as a stand-alone module. So we are emailing him to ask for guidance.

Stand-alone radar module:



Additional board im used to using: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