New Mexico

SUPERCOMPUTING CHALLENGE

AVALANCHERS: Detection Device For Finding People After An Avalanche

Capital High School

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Executive Summary

All around the world many lives are being taken yearly due to avalanches. Many of the causes for this include things such as improper examination of the snow and not being able to effectively locate individuals after the snowpack has fallen on them. Our project wanted to explore the idea on how we can solve one of those problems and create a device to detect people under snow after an avalanche. We built the model completely by hand using cheap but effective parts and electronics. The ultimate idea behind our motive to complete this project was to help save the lives of many skiers and townsfolk that unknowingly get caught in this natural disaster.

At the beginning of the project we spent most of the time constructing the Yagi antenna setup. We constructed the Yagi antennas using a Yagi calculator allowing them to be fine tuned to work with 885MHz. With antennas in general they often lose signal when traveling and have a large bubble in which anything nearby can interfere with the signal. To compensate for the loss in signal through the area we used two amplifiers, (insert values of amplifiers here) which added enough gain to our system to be detected. As the time went on we gained more team members which was very helpful in the testing and programming on the antennas.

After everything we have completed this year we soon came to the conclusion that the system we have is still a very much work in progress and this will need to become a long-term project. The tests we conducted with our system proved that yes, we can detect people, but since the antennas are so close to each other there is a great amount of crosstalk. Another issue we encountered was creating code to take the data from the VNA (vector network analyzer) and plot it to detect changes in the gain or loss of the signal. Overall we have everything we need and know what we need to change but we need more time to finalize the system and get reliable data.

Research/Background

Through the years many lives have been taken by avalanches. Although the number is not large, around 150 people yearly according to the National Weather Service. Some of the most deadliest avalanches are the Huascarán avalanche in Peru with a death toll of ~30,000 people (1970), the "White Friday" avalanche in Italy with a death toll of 2,000-10,000 people (1916), and the Huascarán avalanche (1962) with a death toll of ~4000 people. Many of these numbers are startling to look at with such high values. It was important to understand the death tolls this natural disaster has taken to see what stopped people from being saved.

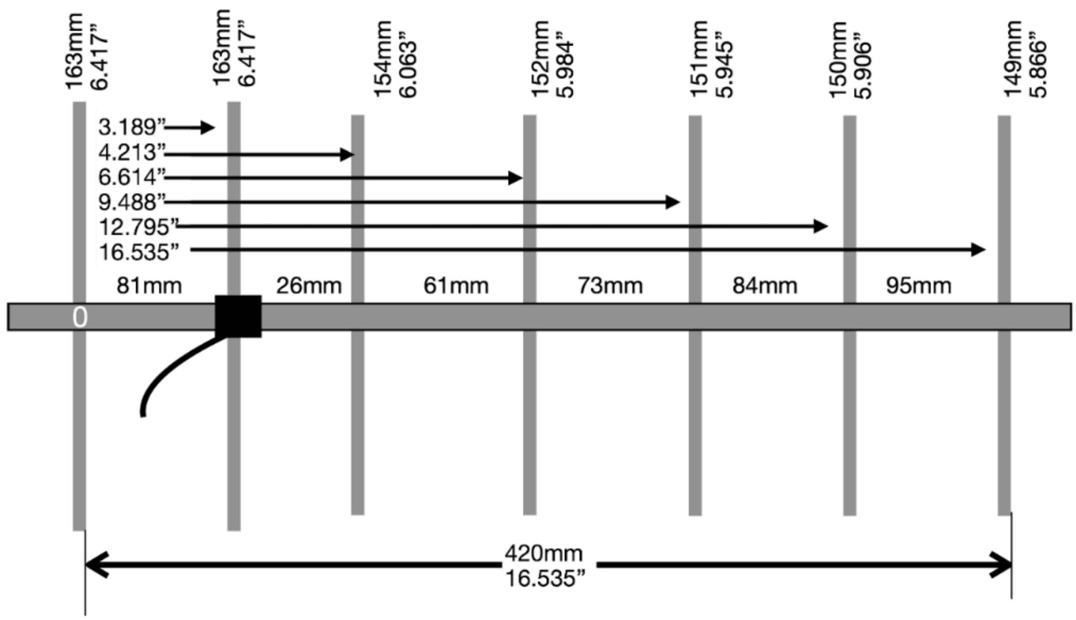
The idea for this project first began when our team member was talking about skiing but had to worry about avalanches. This simple statement had us thinking about how maybe we could create a device to save people's lives or to lower the death toll of avalanches. While researching avalanches we realized that many of the deaths are caused not by people dying on impact but getting lost underneath the snow. This led to our idea to create something to detect people under snow. Another thing we encountered when researching how to do this was a group called RECCO. RECCO is a company that creates tags to place on helmets that when hit with one of the RECCO detectors will signal there is a person in the general area it is pointed at (assuming they have a RECCO tag).

When we eventually finished our preliminary research we started to look into how exactly we are going to do this with no harm to the environment or individuals. We wanted to create something sort of like GPR (ground penetrating radar) that used radio waves to detect people under the snow. The very first thing we had to find was what type of antennas we would have to utilize to detect people under snow. We ultimately found Yagi antennas to be the most effective form of antenna because of their wide band ability and cheap/simple design. To calculate the length of the elements we used an online Yagi calculator to fine tune the antenna to 885MHz keeping it within the 900MHz range

Yagi Antenna Construction

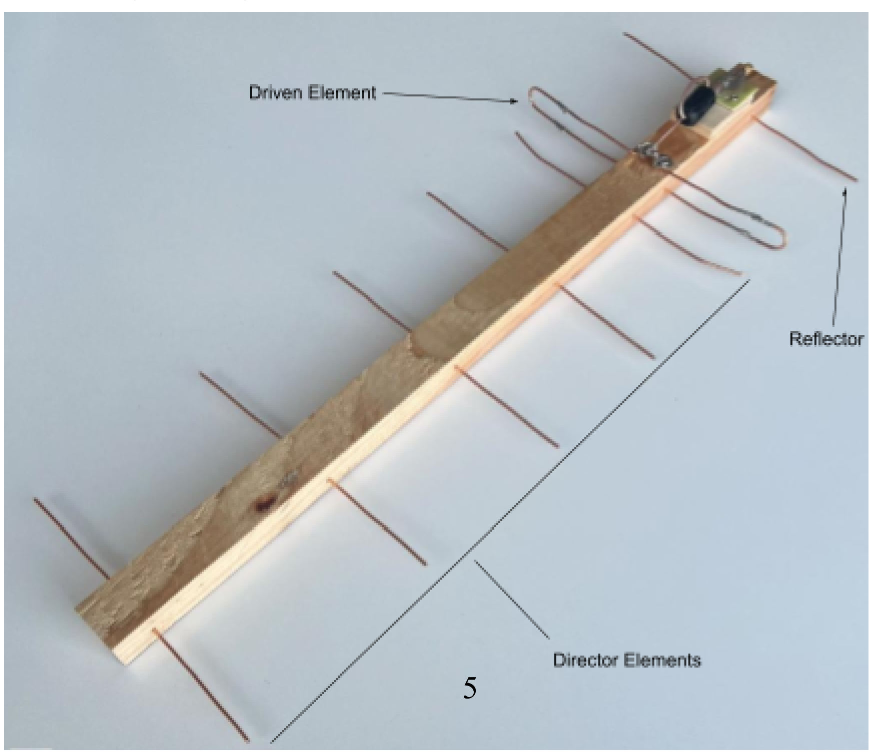
Element Lengths (inches)		
Decimal	Whole	32nds
6.417	**6**	**13**
6.417	6	13
6.063	6	2
5.984	5	31
5.945	5	30
5.906	5	28
5.866	5	27

Element Positions (inches)		
Decimal	Whole	32nds
0.000	**0**	**0**
3.189	3	6
4.213	4	6
6.614	6	19
9.488	9	15
12.795	12	25
16.535	16	17

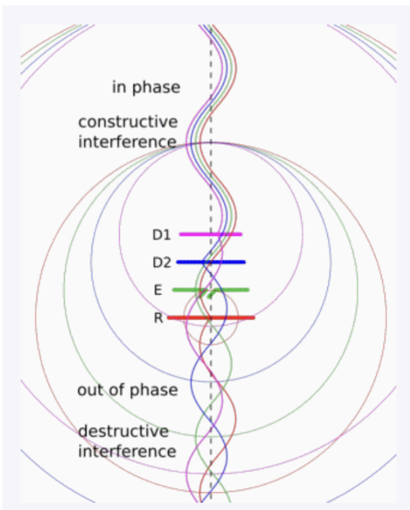


This diagram that the calculator pumped out gave us exact measurements for how to construct our Yagi antenna. It is also worth mentioning that to test the Yagi antenna we used a wide band frequency yagi antenna from amazon.

This is a photograph of our first prototype which consisted of only one single frequency Yagi antenna we made using the diagram above for reference.



Our first prototype shown used a woodstock base, copper wire for the elements, and a balun converter. Yagi antennas work by connecting a signal to the balun of the system which connects ultimately to the driven element of the antenna. From here the signal travels down the director elements in sine and cosine waves. The reflector on the back acts as a stopper for the frequency bouncing part of the frequency back towards the front of the system.



This is a very great diagram from wikipedia depicting how exactly wave frequencies move on the antenna. The driven element is shown sending the signal to which the director elements of the system reinforce the signal.

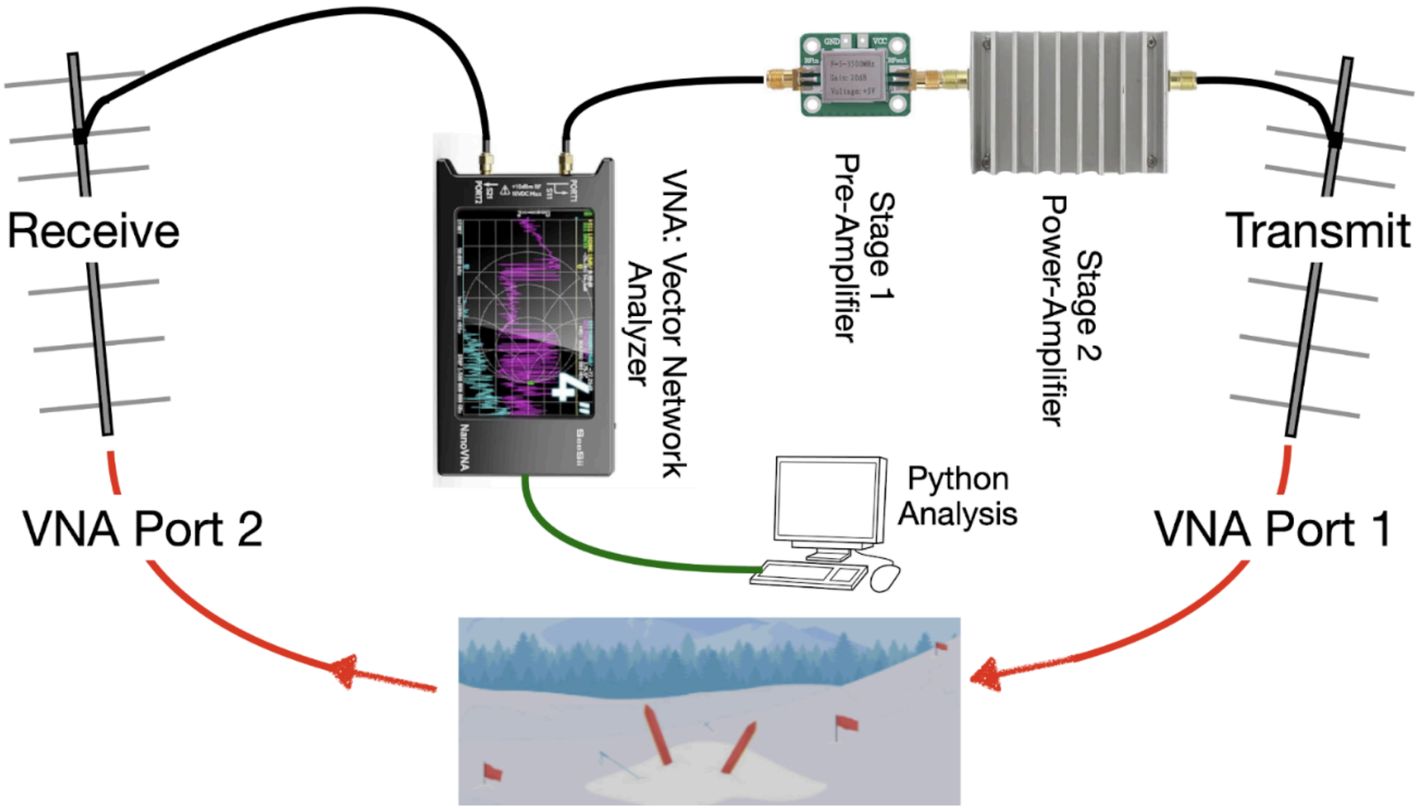
Physical Characteristics

Lamda (wavelength): 0.339m => 13.35 inches
Frequency: 885MHz - Old UHF channel 83
Boom length: 407mm => 16.02 inches
Practical construction will make this longer
Number of elements: 7
Gain: 10dB
Front to Back ratio: 25dB
Main Lobe angle width:
Horizontal (H plane (magnetic field)): ~45 to 60 degrees
Vertical (E plane (electric field)): 35 to 45 degrees
Element Spacing is 26mm to 95mm

Shown in the figure to the left are the physical characteristics of our antennas. This was also from the Yagi calculator we used. The data gathered from this helped us overall calculate different things such as how far we had to place the antennas and how far approximately we would need to stand in order to be noticed by the antenna.

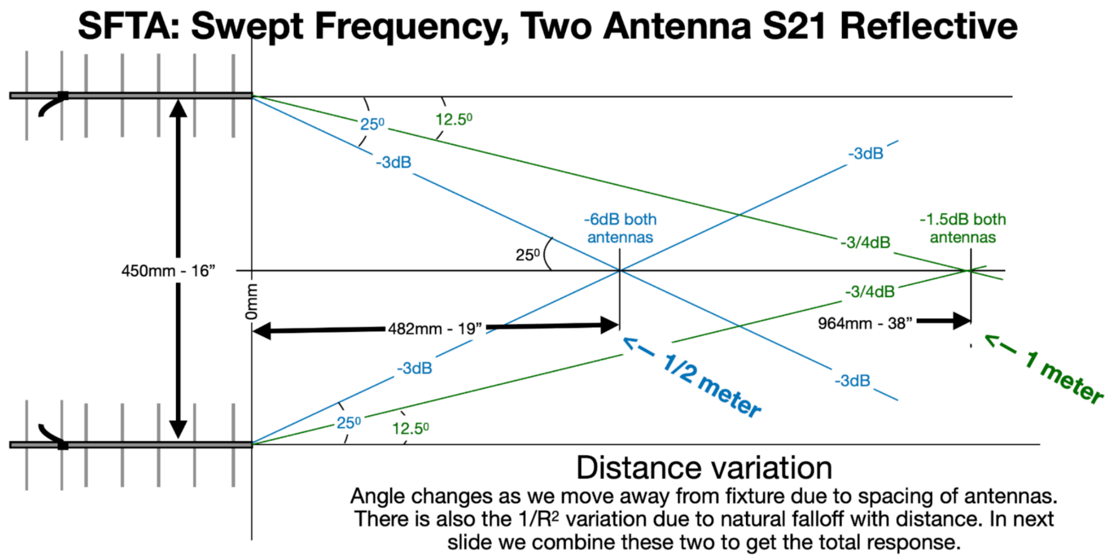
The next steps we took towards trying to detect people was making a system with a transmitting antenna and a receiving antenna.

Diagram Of System

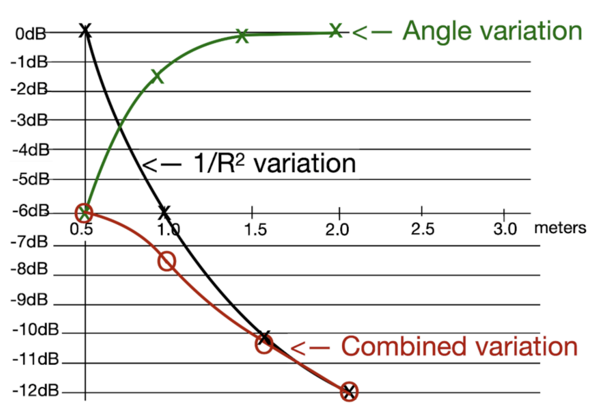


This diagram here is the basic idea of how we went about making the system. The signal first travels from the VNA (Vector Network Analyzer), moves through the first amplifier (+20db) and through the second amplifier (+30db) leading the signal to gain +50db. This decision was made to make sure the signal would hit the person and reflect back with no significant loss. Continuing through the system the signal would then travel through the transmitting antenna and reflect off of the person in the snow and come back to the receiving end of the system. The signal would then travel back to the VNA where our python code would end the sweep and tell us if there was a significant change in signal indicating a person was underneath the snow.

Angular Geometry Of Antennas

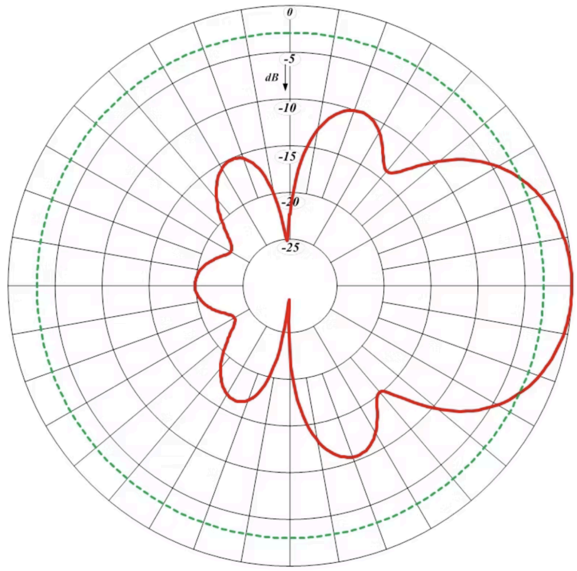


This diagram above accurately shows the dimensions in which you would get the most signal return from. We saw with the tests that we conducted that this diagram does accurately show how distance affects the signal that returns. We noticed this directly when we had our team member stand directly in front of the system and it appeared to not pick up his presence. aAlthough when he backed up farther away from the system it appeared to pick him up better.



This graph here is what the diagram above is represented as the green line. 1/R^2 is the inverse square law that essentially states that the farther away you are from the antenna the more signal loss you will have. The red line on this graph is what our antenna and the inverse square law would look like combined on the graph.

Yagi Angular Curve



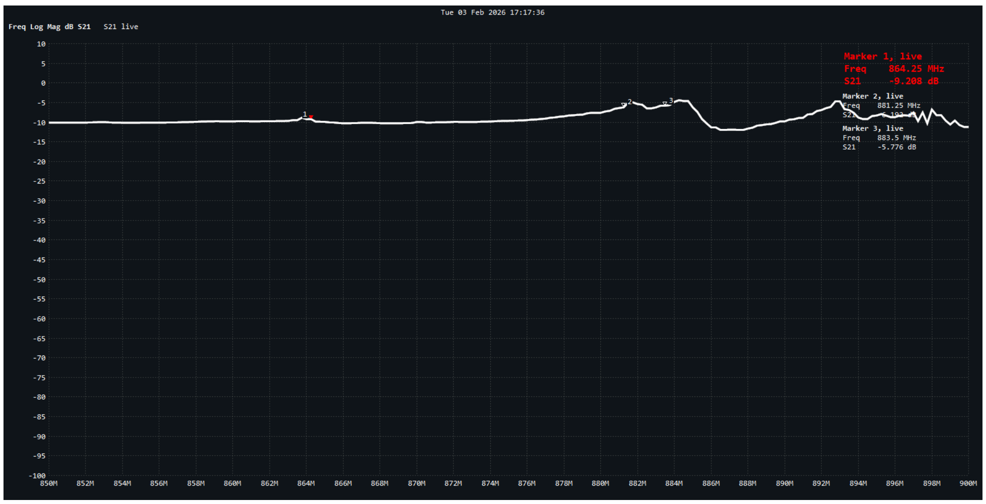
This graph here depicts the area the Yagi antenna covers. Picture this graph as sort of a top-down view of the antenna with the left being the back with the reflector elements and the right being where the signal is going through the director elements. This visual shows how the signal is mainly affected by things in front of the antenna but can still be affected by things behind it. This helped us create a plan on how to collect data without interfering with the data itself.

Code

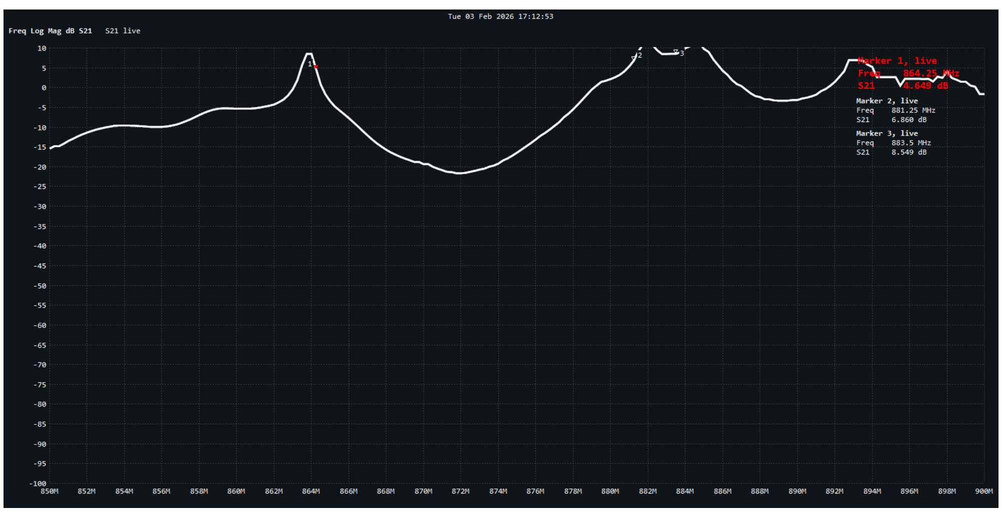
(Raul)

Testing And Analysis

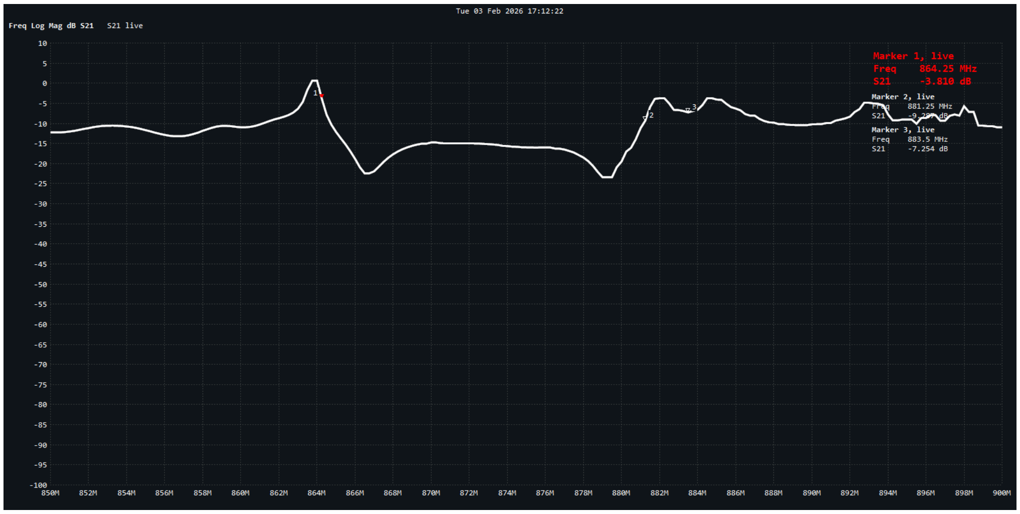
We conducted a number of tests during our time working on this project and many of the results we collected demonstrated that we can in fact detect people. This was aside from the idea of people under snow because we needed to first find a substitute for the snow as well as rule out any issues with our current prototype. The tests we conducted tested different environments, different types of Yagi antennas, and with different angles the antennas faced. The most important data we collected was on 2/3 where we tested our antenna's strength at different distances. We used one of our team members as the subject and conducted 5 tests. The first test we ran was with no subject in view. The next tests had our team member stand 1ft, 5ft, 10ft, and 15ft away. The data from our test is shown below.



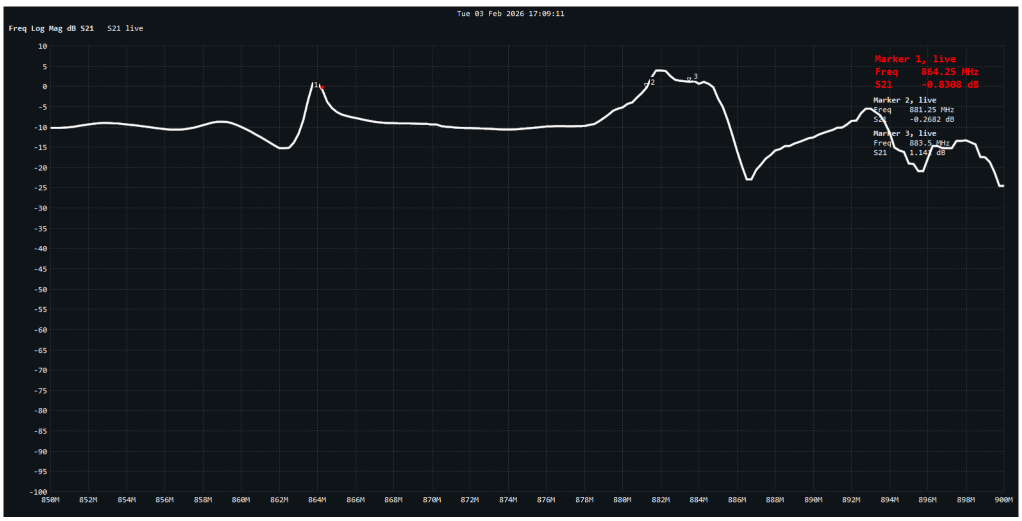
No person in sight - S21:-9.208 dB



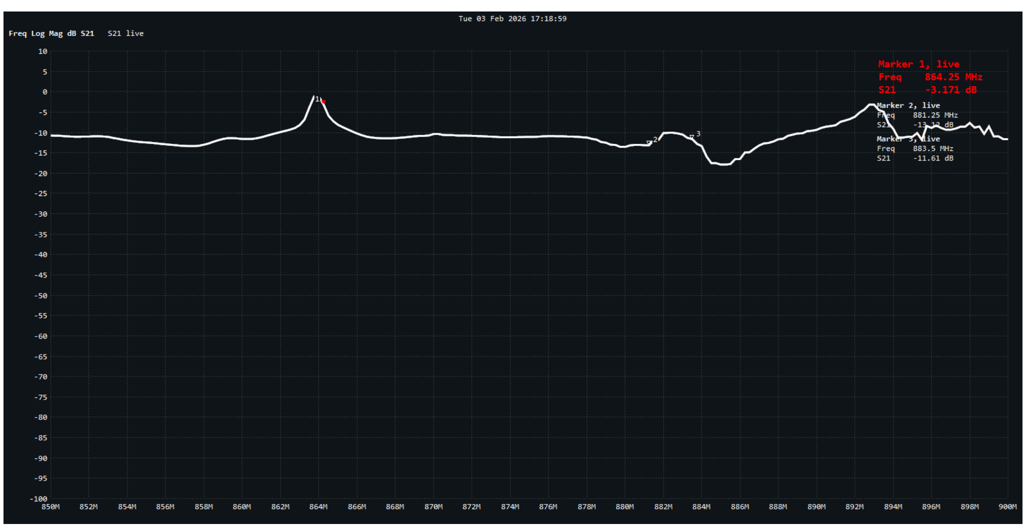
Subject 1ft away - S21:4.649 dB



Subject 5ft away - S21:-3.810 dB



Subject 10ft away - S21:-0.8308



Subject 15ft away - S21:-3.171 dB

These results showed us that our antennas did have the capabilities of detecting people but not effectively. After completing some more research after the experiment we learned that the shield we had between the antennas was not large enough to stop the cross talk between the antennas.

Next Steps

The next steps for us in this project are to find a way to mitigate the amount of crosstalk between the antennas, attempt to test this using a substitute for snow, and finish creating code for the detection. We plan on making this a multi-year project and returning again next year with much more preparation and progress. Our final goal is to be able to say that we made a new device to save lives one way or another.

Acknowledgements

This project would not be where it is now if it wasn't for our mentor David Ritter. Mr. David was our guide and supplied us with the materials we needed to complete this project. He had previous experience with antennas and allowed us to ask him any questions we had to understand the system that we needed to make. We would also like to thank our teacher sponsors Ms. Cislaru and Ms. Teterycz. Both teachers helped us come in contact with new team members as the time went on as well as allow us time during the day to work on our project. Lastly, we would like to thank MAKE Santa Fe for allowing us to use their makerspace to construct our antennas. They allowed us to use the tools to put together our prototype. Without any of these people we would not have such an advanced project as we do have now.

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