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| **MEETING MINUTES – Sponsor & Team Meeting** |
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During this meeting held on 09/16/2014, ECE advisor Dr. Foo was present during the 70 minutes long teleconference with our contact Pete Stenger from Northrop Grumman.

All ECE and ME team members were present. IME team members were not able to attend.

During the meeting we went over the two documents provided by Northrop Grumman that were uploaded on BlackBoard.

**1) Quad-chart: He started out by talking about goals and objectives of this project.**

-Problem: Issues with people carrying weapons, whether they’re guns or concealed bombs.

-Example of imager: In the airport there is an imager where you stand with the hands up and the machine goes around, and it images any kind of reflective image off your body. There are radar signals illuminating your body and is being reflected off any metal or electric components. The receiver part of the radar is sensing that spatially.

-This project is a similar thing, but instead of going into a tube, where you have a sensor rotate around you and you know that you’re being imaged, the person is at a distance and you’re illuminating them with RF from a distance without them knowing and basically looking for scattering off the person’s body that would be indicative of a large piece of metal, like a gun. It’s called a stand-off imager.

-The tx (transmit) is going to generate a pulse signal. Underneath that pulse, instead of just being a DC voltage, there’s a sine wave that corresponds to a high frequency, like 10GHz. So that if you put a high frequency under that pulse, that high frequency has the property that enables you to efficiently radiate free space through an antenna.

-What you see in the transmit port is a PA (Power Amp) and a TX (transmit). The pulse is going to go out there and illuminate a target area with a certain beam width.

-The antenna is like a flashlight. With the RF, the antenna creates a beam and the intensity of the RF is a little circle out in space. Intensity varies with the distance you’re away from the source. The transmit beam is going to transmit a beam on to a target 20 ft away. It’s like shining a spotlight on somebody and then where the light illuminates the person at a high intensity, that’s the seam width and beam width but done with RF because it’s invisible.

-A very short pulse would be sent out, probably only about 10ns wide. RF travels at speed of light, so it’s about 1ns/foot in free space. Send out a pulse that’s 10ns. As it’s sent out, the front part of the pulse comes out, and then 10ns later, the pulse stops. What is out in front of a traveling signal is essentially a 10ft wide pulse. So there’s over 10ft of down range, and there’s the beginning of a pulse and then the back end of a pulse, energy that is occurring in time as it moves away from the transmit. That pulse is going to hit the target and reflect back. But before what is being scattered back can be received, the transmitter has to be turned off because a lot of the times, the scattering from the target is a very low signal, and the transmit signal that is left on will leak over to the receivers and swamp them out, so the scattering of the target can’t be measured. So send out short pulse, have it scatter off the target area, and turn off the PA. When the pulse returns, if the target is 20ft away, it’s going to send out a signal and the reflection of that target will occur 40ns later. So the transmit source is turned off after the pulse leaves, which then it travels out, reflects off the target, comes back, and 40ns later, the leaving edge pulse comes back to each one of the received horns, which is the same as the transmit horns. Then we would switch between them with the signal pulse n throw (SPnT) switch in one position and receive through one of the forms the pulse and it’ll go back through the Low-Noise Amplifier (LNA), which gives a signal gain and limits the amount of noise that can be added to it from other elements. That signal would get down-converted, and it will eventually measure the phase of the signal under the pulse relative to a reference.

-Radars are essentially phase machines, so only thing to worry about is phase. What is being detected is the traveling wave phase difference between what is received and what is transmitted. There’s a reference established so that all the received signals that come back when you switch between the horns, they all get related to that reference phase and they create a phase from across from all the receivers. The phase and amplitude that you receive through each one of the receivers when you switch between each independent receiver. You need that information to form an image.

-You send out a pulse, you receive it, you down-convert it to a low frequency and then you measure the phase and RMS amplitude. And then you measure the phase relative to a reference.

-One of the first steps would be to understand what a transmitter would receive where the phase is measured.

-He suggested to read up on radars, just simple transmit/receive radar and understand how they measure phase and a pulse and look at some radar fundamentals.

-We would do transmit/receive on one of the receiver positions, then switch to another receiver horn and then send out another transmit pulse and receive in the other receiver horn and measure the phase. We get an amplitude and phase across space, and that is the information we need to know  to determine where the scatterers are out in the scene.  The horns are to be vertical, placed on top of each other.

-For antennas, you use Fourier transforms to take amplitude and phase versus distance. When you go to the Fourier transform, you get amplitude vs angle.

-As the target moves laterally out the scene, the distance from that scatterer changes each horn. I would get a slope of the phase vs distance across those horns, which corresponds to a scatterer that is shifted in phase and that’s how you form the image.

**Question: From a mechanical point, how do you want the SAR system to be structured?**

-There is going to be a series of horn antennas that are going to be equally spaced next to each other and there would have to be fixtures that would be aligned accurately relative to one another and oriented accurately. A pedestal with a structure that is like a T can be used. The arm of the T would contain the apertures, the horns. The horns would go across the arm of the T and fixture them somehow so that they’ll point at the scene. One of the first steps would be finalize a block diagram where the aperture would be, which will dictate how many horns and all the components. Worry about orienting those horns in a configuration where they’re aligned. Might need a laser to align them. Work on alignment techniques and configure the cabling that goes back to the switch and figure out how to mount the switch so that things aren’t dangling and risk breakage.  The components to be used should be put on some kind of plate and do the cabling in between them. Suggested to have a rendering of the whole thing on AutoCAD. ProE software typically used to do a 3D rendering in order to fit things in tight spaces and when there’s a lot of potential interference. There would be more room with this structure, but doing it in 3D could be useful in giving insight in how things would look when you build it. You see the antenna, the cabling, the structure, and the components, and you position all those and identify cable links, power lines, connectors to bring the power in, etc. The front end architecture and the antennas are mechanical. Get models of all the components and attach them to some kind of chassis in a manner where they’re easily interconnected to one another.  There’s usually a DC connector that you can plug on to the central line that feeds all the components, the LNA and the PA. The antennas are probably going to be about 6 – 8 ft. and there are going to be about 8 horn antennas but not exactly determined yet. They will need to be aligned to point about 20ft away. One of the challenges is to be point them there without any visibility, so probably going to have to put something in there for a laser that can provide a reference. It would be useful to point at least one small, single-beam laser as a reference in order to do one at a time. Another challenge is to research lasers and the quality and precision. Mechanical engineers would be responsible for the aperture and the packaging of the components needed.

-From an electrical point, we need to use ADS program. For example, put an out converter and the power amp into ADS and do a chain analysis. Would have to look at signal levels and ensure that when we apply the signal level, gain, and the output power, things will work properly. Also do a chain on receive, look at the gain of the LNA through the down-converter, which is a mixer. Research about mixers, especially in terms of conversion, and amplifiers. When you sample a signal at a certain clock rate, like 10MHz. With sampling, you get the information at 10MHz plus or minus the information, then get it at 20MHz plus or minus the information, and so on, and you get all these aliases. Same thing happens with the mixer. The LL is the sampling system, the sampling clock. So you get the LL plus or minus the input. Since it’s an RF mixer, those harmonics are very far attenuated since it’s usually at high frequencies. They’re there but you don’t see them.

-ADS has a tutorial on doing a chain analysis with their system components and learn how to inject a signal and look at the levels as you go through each component.

**-Question: Do you have a list of components that you’ve used, done research on, tested that might be helpful for us when we’re going to choose components to use for our design.**

-For components, he can give us companies to look at but research on our own. It’s usually up to the ECE to identify the parts we want/need and look at the price and performance for them. He would also be able to give us a list of vendors we can use. He’s going to put together some diagrams so we can have more details.

**-Question: Do you recommend a certain material for the structure?**

-No, we have to survey what we can do there. We have to put them together. We can use aluminum I beams that are very stiff since there are 8 horns to be put on the structure.

**- Question: Is high heat involved? Do we have to worry about heat transfer?**

- The only place we have to worry about heat is for the components, like the power amplifier, so we have to understand if it has a fan or mount it securely to a base that can conduct the heat out.

**-Question: Any specific FPGA boards to use or look at?**

-No. One of the decisions we make here is going to have to be whether we want to go for the simplest or most extreme option.

The simplest option: For the PC, scope, waveform generator: in a simplified form, what we can do for those elements is get a machine that generates the pulse waveform automatically that we can program. Then when we receive through the down converter, we can use the scope to sample the signal to get the phase and then we can get the amplitude vs phase functions that are across the array and derive the image on a PC kind of non-real time. Send out a pulse through the down converter to the scope and then send out another pulse to measure the phase and that record on the scope is what will be used to then process to generate where the scattering is in space. There will be a pulse generator to control the switches that we would switch and can be done statically. You can manually switch out the switch to another receiver and repeat the same thing. For the simplest option, we wouldn’t need any FPGA, just program test equipment essentially and get the data off the scope and coordinate that (this option would be the backup).

-The extreme thing to do would be to do the PC and the waveform generator with an FPGA, and the scope would be a VGA display. The FPGA would generate the timing, can switch between the different receive horns and would be coordinated with actually sampling the down-converted signal, measuring the phase in the FPGA using an on-board processor, like a microblaze or picoblaze. Storing that memory and operating on that to get the phase and then building up memory of the amplitude and phase vs distance for each horn and then FFT-ing that and sending it to the display and doing it real time so that we get through all these receive horns in real-time fashion and we get a display showing a real-time scene of all the scattering. It would be like watching a video of the scene. If there’s metal on a person, you can see it while the person is moving. Somewhere in between the easy and extreme options.

-Ideally, we want to do something with an FPGA that controls the timing to the single pole multiple throw (SPnT) switch and some of the sampling and maybe stores some of the data and memory that we can then output and then operate on. Take the sampled data and go to memory and then we capture and then send it to a PC for processing and then do the image. That would be an in-between scenario.

-He suggested that we investigate microblaze and how to do complex multiplications or discrete Fourier transforms. If we had some amplitudes and phases in memory, we would DSP those and basically generate a significant part of the image. Based on that result, you can coordinate with the display. Investigate talking to a VGA display. We can use Matlab since it has DSP routines that can be used. But if you just run these routines, then you can’t really analyze all the results very well.

-He will try to make a diagram where everything is low frequency, low sample rates, and try to make it as simple as possible for real-time approach.

-He will make diagrams so we can go over what’s feasible and what’s not, and he can be pretty specific and what we would need to do for a particular scenario here, whether it’s a simple scenario where everything gets done with test equipment, advanced one, where everything gets done in an FPGA real-time, or in-between.

**2) Second chart: Radar Imager Performance Characteristics**

-He said having requirements established this early is not feasible. We’re going to have some TBDs for some requirements.

-Frequency: What does the FCC say about radiating in our facility? We would have to check with the FSU regulations to determine what radiation levels can be tolerated. Some of the tasks aren’t specific to the hardware design, some are involved in just using it in an environment. Research what policies there are with FSU in order to determine the frequency range. Also check the FCC charts on the frequency allocations and there’s bands for radar and bands for other various functions. Learn how frequencies are allocated.

-Distance to scene to be imaged: 20ft

-Scene extent: if you want to image somebody, would it be 1 person? 2? 3? Ideally as wide as possible, but it’s harder to do. So what would be the narrowest scene extent we want to image. If we were to take a picture, what would be the narrowest field of view we would want to image? What makes sense for looking for weapons on somebody? For example, people are walking by an area in an airport and as they walk by, you image them. So the field of view is basically the width of a person and maybe their torso? And as they walk by, that’s what you image. The smaller the better, but it has to be useful in the context of imaging someone with a weapon or a bomb. Scene extent to be decided by us, just make it as small as possible.

-Cross range resolution: what kind of resolution do I want to divide my scene up into? If I have a scene that’s 2x2ft, I’m taking a picture of that area of the metal that’s in that scene and how many pixels do I want to divide it into so that I can discern that there is a possible threat there. Maybe 3x3in cells? You don’t want to outline that there’s a particular type of weapon, you just want to show that there’s a pretty big scatter there on a portion of the body.

-Down range resolution (depth): Is it important that you determine how far off the body it projects? Do we care about that? Do you want to measure the height of the weapon or where the threat is on the body? The lower the resolution, the harder it is to do. Not all the details on the body is necessary, just enough to determine weapon on body.

-Pulse width: if it’s 20ft away, then it’s basically 40ns away, so we’ll need to pulse it less than 40 ns, maybe like 20 ns would give you time to switch between to turn the transmit off so that the pulse has already left the transmit but you haven’t received yet. So when you turn the transmit on, now you have 20ns to turn the receiver on so that you can start receiving.

-Transmit power: Will have TBD. He’ll help without.

-Safe radius: if we’re going to transmit, then what’s the safe amount of power to transmit out of a horn. There’s a mW/square cm rating for safety. Learn what that is and then you’ll be able to associate it that… Leave that TBD since we won’t know until we determine the antenna size. Maybe comment that 10mW/cm squared is the max we can have radiate.

-The rest of them leave TBD until we get more in depth.

-Decided to have a teleconference every week. He would rather have a teleconference with a rotating team of about 2 -3 members at a time in order to concentrate on what they’re doing in order to make better use of time. He can make it Monday through Thursday after 4p.m. so we will determine who is going to be at the meetings. Dr. Foo would attend as well if he can make it.